Revised Draft 2

Remedial Investigation Report
for Soil, Sediment, and Surface Water
at RVAAP-43 Load Line 10

Ravenna Army Ammunition Plant
Ravenna, Ohio

Contract No. W912QR-04-D-0028
Delivery Order No. 0001

Prepared for:

United States Army Corps of Engineers
Louisville District

Prepared by:

Leidos Engineering of Ohio, Inc.
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

April 17, 2014

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)* 17-April-2014	**2. REPORT TYPE** Technical	**3. DATES COVERED** *(From - To)* 1996 to 2014

4. TITLE AND SUBTITLE Revised Draft 2 Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-43 Load Line 10 Ravenna Army Ammunition Plant Ravenna, Ohio	**5a. CONTRACT NUMBER** W912QR-04-D-0028 **5b. GRANT NUMBER** NA **5c. PROGRAM ELEMENT NUMBER** NA
6. AUTHOR(S) Heather R. Miller Sharon K. Robers	**5d. PROJECT NUMBER** Delivery Order No. 0001 **5e. TASK NUMBER** NA **5f. WORK UNIT NUMBER** NA
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Leidos Engineering of Ohio, Inc. 8866 Commons Boulevard Twinsburg, Ohio 44087	**8. PERFORMING ORGANIZATION REPORT NUMBER** 13-049(E)/04172014
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) USACE - Louisville District U.S. Army Corps of Engineers 600 Martin Luther King Jr., Place PO Box 59 Louisville, Kentucky 40202-0059	**10. SPONSOR/MONITOR'S ACRONYM(S)** USACE **11. SPONSOR/MONITOR'S REPORT NUMBER(S)** NA

12. DISTRIBUTION/AVAILABILITY STATEMENT

Reference distribution page.

13. SUPPLEMENTARY NOTES

None.

14. ABSTRACT

This Remedial Investigation Report for Load Line 10 presents physical characteristics, geology, and hydrogeology of Load Line 10; compiles historical and newly acquired environmental data; summarizes nature and extent of contamination in soil, sediment, and surface water; evaluates contaminant fate and transport; and provides human health and ecological risk assessments. These evaluations indicate there are no CERCLA-related chemicals of concern (COCs) that pose unacceptable risk for the Resident Receptor. Therefore, this report recommends No Further Action (NFA) with respect to soil, sediment, and surface water to attain Unrestricted (Residential) Land Use.

15. SUBJECT TERMS

Cleanup goals, risk assessment, weight of evidence, nature and extent, fate and transport, no further action

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Mark Nichter
U	U	U	U	298	**19b. TELEPHONE NUMBER** *(Include area code)* 502.315.6375

DISCLAIMER STATEMENT

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Leidos has completed the Revised Draft 2 Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-43 Load Line 10 at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing United States Army Corps of Engineers (USACE) policy.

H Miller

4/17/2014

Heather Miller — Date
Study/Design Team Leader, Main Author

4/17/2014

Marcy Larriva, P.E. — Date
Independent Technical Review Team Leader

Significant concerns and the explanation of the resolution are as follows:

Internal Leidos Independent Technical Review comments are recorded on a Document Review Record per Leidos quality assurance procedure QAAP 3.1. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leader. As noted above, all concerns resulting from independent technical review of the project have been considered.

4/17/2014

Lisa Jones-Bateman — Date
Senior Program Manager

PLACEHOLDER FOR:

Documentation of Ohio EPA Approval of Final Document

(Documentation to be provided once approval is issued.)

Revised Draft 2

Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-43 Load Line 10

Ravenna Army Ammunition Plant
Ravenna, Ohio

Contract No. W912QR-04-D-0028
Delivery Order No. 0001

Prepared for:
United States Army Corps of Engineers
Louisville District

Prepared by:
Leidos Engineering of Ohio, Inc.
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

April 17, 2014

DOCUMENT DISTRIBUTION
for the
Revised Draft 2 Remedial Investigation Report
for Soil, Sediment, and Surface Water
at RVAAP-43 Load Line 10
Ravenna Army Ammunition Plant
Ravenna, Ohio

Name/Organization	Number of Printed Copies	Number of Electronic Copies
Vicki Deppisch, Ohio EPA DERR	1	2
Justin Burke, Ohio EPA CO	0	1
Brett Merkel, ARNG	0	1
Katie Tait, OHARNG; Kevin Sedlak, ARNG	1	1
Glen Beckham, USACE – Louisville District	1	1
Mark Nichter, USACE – Louisville District	1	1
Gail Harris, Vista Sciences Corporation	2	2
Kevin Jago, Leidos	1	1
Pat Ryan, Leidos-REIMS	0	1
Leidos Project File W912QR-08-D0008	1	1
Leidos Central Records Facility	0	1
Rodney Beals, Ohio EPA DERR	Transmittal letter only	
Nancy Zikmanis, Ohio EPA DERR	Transmittal letter only	

ARNG = Army National Guard
OHARNG = Ohio Army National Guard
Ohio EPA CO = Ohio Environmental Protection Agency, Central Office
Ohio EPA DERR = Ohio Environmental Protection Agency, Division of Environmental Response and Revitalization
REIMS = Ravenna Environmental Information Management System
USACE = United States Army Corps of Engineers

THIS PAGE INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

THIS PAGE INTENTIONALLY LEFT BLANK.

ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
ADR	Automated Data Review
amsl	Above Mean Sea Level
AOC	Area of Concern
ASTM	American Society for Testing and Materials
AT123D	Analytical Transient 1-, 2-, 3- Dimensional
bgs	below ground surface
BHC	Benzene Hexachloride
BSV	Background Screening Value
Camp Ravenna	Camp Ravenna Joint Military Training Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMCOC	Contaminant Migration Chemical Of Concern
CMCOPC	Contaminant Migration Chemical of Potential Concern
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CUG	Cleanup Goal
DAF	Dilution Attenuation Factor
DERR	Division of Environmental Response and Revitalization
DFFO	Director’s Final Findings and Orders
DNT	Dinitrotoluene
DoD	U.S. Department of Defense
DPT	Direct Push Technology
DQO	Data Quality Objective
Eh	Oxidation-reduction Potential
ELAP	Environmental Laboratory Accreditation Program
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERS	Ecological Risk Screening
ESV	Ecological Screening Value
EU	Exposure Unit
FCR	Field Change Request
FPA	Former production area (FPA)
FS	Feasibility Study
ft	feet
ft^2	square feet
FWCUG	Facility-wide Cleanup Goal
FWERWP	Facility-wide Ecological Risk Work Plan
FWGWMP	Facility-wide Groundwater Monitoring Program

ACRONYMS AND ABBREVIATIONS (CONTINUED)

FWHHRAM	Facility-wide Human Health Risk Assessors Manual
FWSAP	Facility-wide Sampling and Analysis Plan
gpm	gallons per minute
GPS	Global Positioning System
GSSL	Generic Soil Screening Level
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	Human Health Risk Assessment
HHRS	Human Health Risk Screening
HI	Hazard Index
HLC	Henry’s Law Constant
HMX	Octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
IDW	Investigation-derived Waste
ILCR	Incremental Lifetime Cancer Risk
INRMP	Integrated Natural Resource Management Plan
IRIS	Integrated Risk Information System
ISM	Incremental Sampling Method
Kd	Soil/Water Partitioning Coefficient
K_{oc}	Water/Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
MARC	Multiple Award Remediation Contract
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
MI	Multi-increment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
NPA	Non-production area
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PAH	Polycyclic Aromatic Hydrocarbon
PBA	Performance-based Acquisition
PBA08 RI	Performance-based Acquisition 2008 Remedial Investigation
PBA08 SAP	Performance-based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1
PBT	Persistent, Bioaccumulative, and Toxic
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
PP	Proposed Plan
PRG	Preliminary Remediation Goal

ACRONYMS AND ABBREVIATIONS (CONTINUED)

QA	Quality Assurance
QC	Quality Control
R	Retardation Factor
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Dietary Allowance
RDI	Recommended Daily Intake
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REIMS	Ravenna Environmental Information Management System
RfD	Reference Dose
RI	Remedial Investigation
ROD	Record of Decision
RRSE	Relative Risk Site Evaluation
RSL	Regional Screening Level
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SESOIL	Seasonal Soil Compartment Model
SOR	Sum-of-Ratio
SRC	Site-related Contaminant
SRV	Sediment Reference Value
SSL	Soil Screening Level
SSSL	Site-specific Soil Screening Level
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TestAmerica	TestAmerica Laboratories, Inc.
TNB	Trinitrobenzene
TNT	2,4,6-Trinitrotoluene
TR	Target Risk
UCL	Upper Confidence Level
URF	Unit Risk Factor
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
U.S. Army	U.S. Department of the Army
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USAEHA	U.S. Army Environmental Hygiene Agency
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USP&FO	U.S. Property and Fiscal Officer
VOC	Volatile Organic Compound
WOE	Weight-of-Evidence

THIS PAGE INTENTIONALLY LEFT BLANK.

EXECUTIVE SUMMARY

ES.1 INTRODUCTION AND SCOPE

This document was prepared by Leidos, formerly a part of Science Applications International Corporation (SAIC), under the U.S. Army Corps of Engineers (USACE), Louisville District, Multiple Award Remediation Contract (MARC) W912QR-04-D-0028, Delivery Order No. 0001, entitled 2008 Performance-based Acquisition (PBA) for Environmental Investigation and Remediation at the Ravenna Army Ammunition Plant (RVAAP).

This Remedial Investigation (RI) report addresses soil, sediment, and surface water at Load Line 10 at the former RVAAP. Load Line 10 is designated as area of concern (AOC) RVAAP-43. This RI report was prepared in accordance with the Ohio Environmental Protection Agency (Ohio EPA) Director's Final Findings and Orders (DFFO) for RVAAP, dated June 10, 2004, and conforms to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirements.

This RI report for Load Line 10 presents the following:

- A description of the operational history and environmental setting for Load Line 10;
- A summary of all Load Line 10 historical investigations;
- A summary of field activities and results of the Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) conducted from February 2010 through March 2010 at the AOC;
- A description of the nature and extent of contamination, including the identification of site-related contaminants (SRCs) by screening all eligible historical and PBA08 data against RVAAP background screening values (BSVs), essential human nutrients, and frequency of detection/weight-of-evidence (WOE) screening;
- An evaluation of contaminant fate and transport that identifies contaminant migration chemicals of potential concern (CMCOPCs) and contaminant migration chemicals of concern (CMCOCs) that may pose a future threat to groundwater;
- A human health risk assessment (HHRA) to identify chemicals of potential concern (COPCs) and chemicals of concern (COCs);
- An ecological risk assessment (ERA) to identify chemicals of potential ecological concern (COPECs) and chemicals of ecological concern; and
- Conclusions of the report.

Under the scope of this RI report, the term "sediment" refers to frequently or permanently inundated wet sediment, as defined by RVAAP guidelines. The scope of this report does not include a full evaluation of groundwater contamination, nature and extent, risk assessment, and remedial alternatives (if required). Groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/feasibility study (FS) report. However, the potential for soil contaminants to leach to and migrate in groundwater is evaluated in this RI report to determine whether soil remedial actions to protect groundwater may be necessary. The storm and sanitary sewers present at Load Line 10 will also be evaluated separately under RVAAP-67 Facility-wide Sewers.

ES.2 EVALUATION OF FUTURE USE

In February 2014, the U.S. Department of the Army (U.S. Army) and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the RVAAP Installation Restoration Program (ARNG 2014) identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process. These three Land Uses and Representative Receptors are presented below.

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child) (formerly called Resident Farmer)
2. Military Training Land Use – National Guard Trainee
3. Commercial/Industrial Land Use – Industrial Receptor [U.S. Environmental Protection Agency’s (USEPA) Composite Worker]

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of the Commercial/Industrial Land Use as an Alternative, if it achieves no further action (NFA) for Unrestricted (Residential) Land Use.

ES.3 AOC DESCRIPTION

Load Line 10 is a 36-acre AOC. Load Line 10 was formerly known as the Percussion Element Manufacturing Line, which operated as an initiator blending and loading line from 1941 to 1945. At the end of World War II, the process equipment and production line were placed on standby status. The line was reactivated in 1951 and was used to produce primers and percussion elements until it was placed on standby status again in 1956. The line was reactivated in 1969 to produce primers until 1971, when the line was deactivated permanently and the production equipment was removed. No historical data or information exists to indicate Load Line 10 was used for any process other than percussion element/primer manufacturing (MKM 2007).

Historical facilities at Load Line 10 included 29 production and support buildings ranging in size from 36-13,413 ft^2. Demolition and removal of buildings at Load Line 10, including building slabs and foundations, was completed in 2007. Areas disturbed by building demolition activities were regraded and seeded following demolition. The AOC is currently overgrown by trees and successional scrub vegetation.

ES.4 FINDINGS OF THE REMEDIAL INVESTIGATION

This section presents the data used in this RI and the SRC, COPC, and COC screening and evaluation processes. Summaries of the contaminant nature and extent, fate and transport, HHRA, and ERA are also presented, followed by the conclusions of the RI.

ES.4.1 Data Use and Sample Selection Process

Quality-assured sample data from the Characterization of 14 AOCs (MKM 2007) and Investigation of the Under Slab Surface Soils (USACE 2009a) were used with data from the PBA08 RI to evaluate nature and extent of contamination at Load Line 10. These investigations used incremental sampling methods (ISM) and discrete sampling methods.

All available sample data collected at the locations were evaluated to determine suitability for use in various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment). Evaluation of data suitability for use in the PBA08 RI involved two primary considerations: (1) how the current AOC conditions are represented; and (2) sample collection methods (e.g., discrete vs. ISM).

Samples from the 2004 (Characterization of 14 AOCs) and 2007 (Investigation of Under Slab Surface Soils) datasets were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 PBA08 RI, as building demolition activities occurred in 2007. The samples collected in 2004 were collected (1) within ditchlines adjacent to buildings and (2) in large areas encompassing but also extending substantially beyond the footprint of the buildings. Subsequent to the 2004 sampling, the buildings were demolished and removed at Load Line 10 in 2006 and 2007. The 2007 sampling was conducted within the footprints of the demolished buildings after slab removal. Therefore, both datasets were considered representative of current conditions within and surrounding the footprints of the former buildings at Load Line 10. No samples from the 2004 and 2007 datasets were eliminated from the SRC screening process.

New data collected in 2010 as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil [0-1 ft below ground surface (bgs)] during prior investigations, characterizing subsurface soil (1-13 ft bgs) (not previously sampled), and obtaining contemporaneous sediment and surface water data to represent current AOC conditions. Since ISM was used for surface soil (0-1 ft bgs) as part of the Characterization of 14 AOCs, ISM was also used for surface soil sampling during the PBA08 RI. The PBA08 RI sampled locations with the greatest likelihood of contamination (e.g., adjacent to production buildings or within sediment accumulation areas, such as ditches). Samples were analyzed for chemicals identified in the historical investigations.

Subsurface soil, sediment, and surface water samples were collected using discrete sampling methods. Soil samples were analyzed for Target Analyte List (TAL) metals, explosives, and polycyclic aromatic hydrocarbons (PAHs). Additionally, 15% of the soil samples and all sediment and surface water samples were analyzed for RVAAP full-suite analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and nitroguanidine), semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and pesticides]. Data quality objectives (DQOs) and the scope of the PBA08 RI were outlined in the PBA 2008 Supplemental Investigation Sampling Analysis Plan Addendum No. 1 (USACE 2009b). The PBA08 RI completed for Load Line 10 included:

- A total of 15 ISM surface soil samples taken from 0-1 ft bgs to delineate the extent of contaminants detected above screening levels in previously collected samples and characterize areas not formerly sampled;
- Three discrete surface soil samples from 0-1 ft bgs for chromium speciation analyses;
- Nine soil borings to depths up to 13 ft bgs or until encountering bedrock for surface and subsurface soil sampling;
- One soil boring to collect undisturbed samples for geotechnical analysis;
- One co-located surface water grab sample and composite sediment sample (0-0.5 ft depth interval) from the main conveyance ditch exiting the AOC at the south boundary to delineate contaminant nature and extent; and
- One co-located surface water grab sample and composite sediment sample (0-0.5 ft depth interval) from the main drainage conveyance about 1,800 ft downstream (south) of the AOC to evaluate potential contaminant migration off of the AOC via surface water.

ES.4.2 SRC/COPC/COC and Selection Processes

The process presented in Figure ES-1 was used to identify the SRCs and COPCs used in the COC selection process. The SRCs, COPCs, and COCs for each exposure medium are presented in Tables ES-1 through ES-3.

ES.4.2.1 <u>SRC Screening Process</u>

The steps involved in the SRC screening process are summarized below.

- Data quality assessment: PBA08 RI data were produced, reviewed, and reported by the laboratory in accordance with specifications in the PBA08 Sampling and Analysis Plan (SAP), the Louisville District analytical quality assurance (QA) guidelines, and the laboratory's QA manual. TestAmerica Laboratories, Inc. performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. Leidos performed a systematic process, utilizing automated data review software for data verification to ensure the precision and accuracy of the analytical data were adequate for their intended use. “Definitive Data” were reported consistent with the deliverables identified in the project SAP. In addition to the Leidos data review, USACE performed a 10% validation of all data to evaluate data usability. Historical data quality assessments can be found in their respective investigation reports.

- Background screening: The maximum detected concentrations (MDCs) of inorganic chemicals were compared to RVAAP BSVs. If BSVs were exceeded, the respective inorganic chemicals were retained as SRCs. No BSVs were established for organic chemicals. As such, all detected organic chemicals were retained as SRCs.
- Screening of essential human nutrients: Chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. Essential nutrients detected at or below their recommended daily allowance or recommended daily intake (RDA/RDI) screening levels were eliminated as SRCs.
- Frequency of detection/WOE screening: Chemicals that were not detected in a given medium were eliminated as SRCs. For chemicals with at least 20 discrete samples and a frequency of detection of less than 5%, a WOE approach was used to determine if the chemical was related to the AOC. This screening was applied to all organic and inorganic chemicals with the exception of explosives and propellants; all detected explosives and propellants were considered SRCs regardless of frequency of detection. At Load Line 10, 20 discrete subsurface soil samples were available for frequency of detection screening; however, no SRCs were screened out on this basis. The frequency of detection/WOE screening was not applied to ISM samples.

ES.4.2.2 <u>COPC Screening Process</u>

To determine COPCs, the MDC of all SRCs was screened against the most stringent chemical-specific facility-wide cleanup goals (FWCUGs) at a target cancer risk level of 1E-06 and a non-carcinogenic target hazard quotient (HQ) of 0.1 for the Resident Adult and Child, and National Guard Trainee. If no FWCUGs existed for an SRC, the USEPA Residential Regional Screening Level (RSL) (from RSL table dated November 2012) was used. If the MDC exceeded the FWCUG or RSL screening, the chemical was identified as a COPC.

ES.4.2.3 <u>COC Selection Process</u>

The COC determination process is as follows:

- Report all carcinogenic- and non-carcinogenic-based FWCUGs corresponding to a target risk (TR) of 1E-05 and target HQ of 1.0 using the most stringent FWCUGs of the Resident Receptor Adult and Resident Receptor Child to evaluate Unrestricted (Residential) Land Use for each COPC. If no FWCUG is available for a COPC, the Residential RSL, adjusted to represent a TR of 1E-05 or target HQ of 1.0, is used.

- Report critical effect and target organ for each non-carcinogenic-based FWCUG.
- Compare selected FWCUG to the exposure point concentration (EPC), including a sum-of-ratios (SOR):
  - For non-carcinogens, compare the EPC to the target HQ FWCUG. Sum the ratios of the EPC/FWCUG for COPCs that affect similar target organs or do not have an identified target organ.
  - For carcinogens, compare the EPC to the TR FWCUG. Sum the ratios of the EPC/FWCUG for all carcinogens.
- The COPC is identified as a COC if:
  - The EPC exceeds the Resident Receptor (Adult and Child) FWCUG for either the 1E-05 target cancer risk or the 1.0 target HQ; or
  - The SOR for all carcinogens or all non-carcinogens that may affect the same organ is greater than 1. Chemicals contributing at least 10% to the SOR are also considered COCs. Chemicals contributing greater than 5% but less than 10% to the SOR must be further evaluated before being eliminated as COCs.

ES.4.3 Summary of Contaminant Nature and Extent

The 2004 Characterization of 14 AOCs, 2007 Investigation of Under Slab Surface Soils, and 2010 PBA08 RI data provides effective characterization of the nature and extent of the contamination at the AOC, and no further sampling is required.

This RI report evaluates all available data with respect to usability and identifies SRCs. Data were grouped (aggregated) by environmental media (e.g., soil, sediment, and surface water) and spatially to account for AOC-specific data types and physical characteristics. Soil was evaluated as surface soil (0-1 ft bgs) and subsurface soil (> 1 ft bgs). Figure ES-2 illustrates all sample locations used in the evaluation of contaminant nature and extent.

The predominant SRCs in surface and subsurface soil at Load Line 10 were PAHs, which were observed in all surface soil samples analyzed across the entire AOC. Inorganic chemicals were also observed in soil at concentrations above their respective background concentrations throughout the AOC. A limited number of SRCs were observed in sediment and surface water, relative to soil at Load Line 10. Detections of explosives, propellants, VOCs, pesticides, and PCBs were limited in frequency. A summary of observations for each medium is presented below.

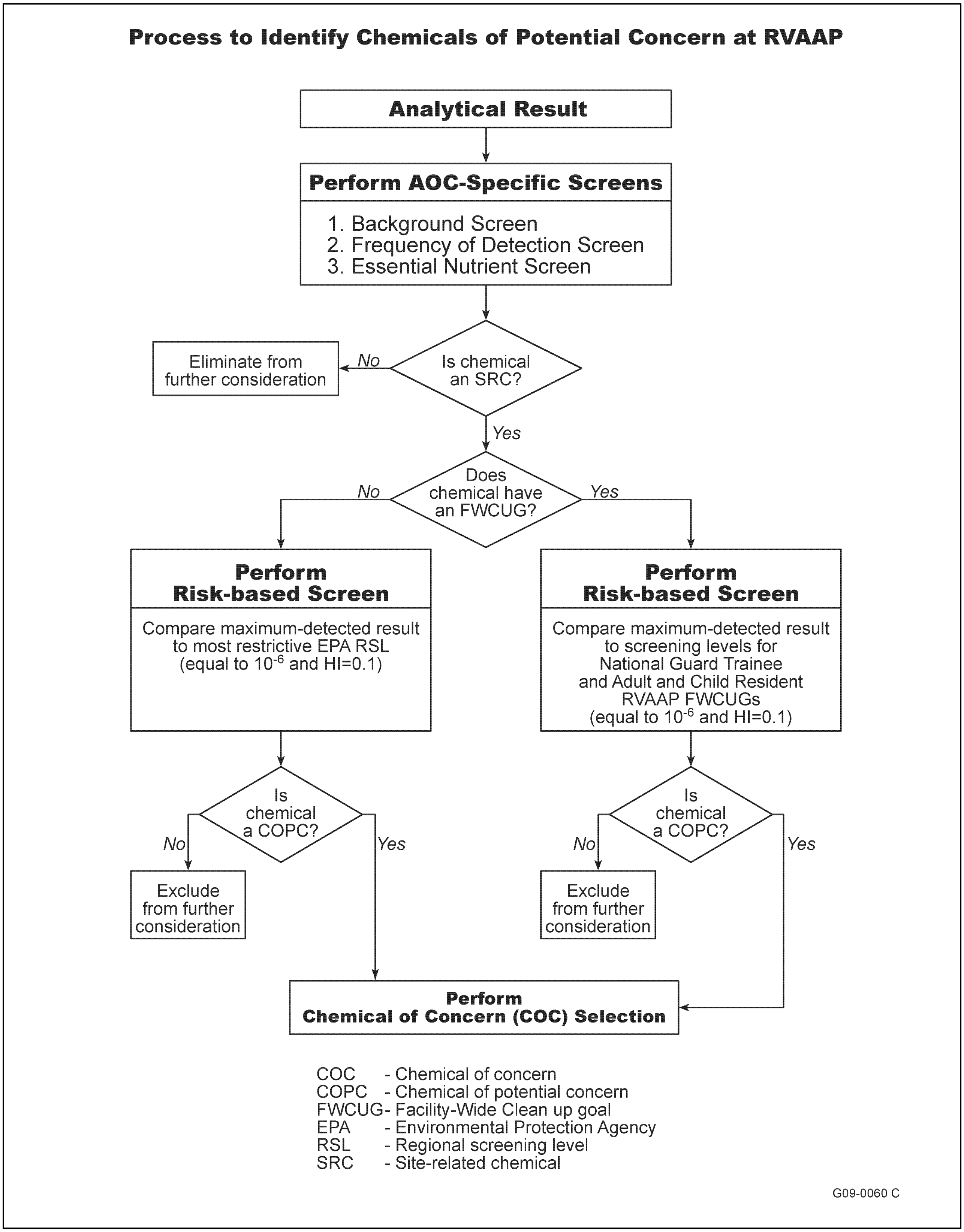


Figure ES-1. Process to Identify RVAAP COPCs in the Human Health Risk Assessment (USACE 2010a)

Table ES-1. SRCs, COPCs, and COCs in Surface Soil

Detected Analyte	SRCs[a]		COPCs[b]		COCs[c]	
	0-1 ft bgs	**1-13 ft bgs**	**0-1 ft bgs**	**1-13 ft bgs**	**0-1 ft bgs**	**1-13 ft bgs**
Inorganic Chemicals						
Aluminum	X	--	X	--	--	--
Antimony	X	X	--	X	--	--
Arsenic	X	--	X	--	--	--
Barium	X	X	--	--	--	--
Beryllium	X	X	--	--	--	--
Cadmium	X	X	--	--	--	--
Chromium	X	--	X	--	--	--
Cobalt	X	--	X	--	--	--
Copper	X	--	--	--	--	--
Cyanide	X	--	--	--	--	--
Lead	X	X	X	--	--	--
Mercury	X	--	--	--	--	--
Nickel	X	--	--	--	--	--
Selenium	X	X	--	--	--	--
Silver	X	X	--	--	--	--
Thallium	X	--	--	--	--	--
Zinc	X	X	--	--	--	--
Explosives and Propellants						
1,3,5-Trinitrobenzene	--	X	--	--	--	--
2,6-Dinitrotoluene	X	--	--	--	--	--
3-Nitrotoluene	X	--	--	--	--	--
2-Amino-4,6-Dinitrotoluene	--	X	--	--	--	--
4-Amino-2,6-Dinitrotoluene	--	X	--	--	--	--

Table ES-1. SRCs, COPCs, and COCs in Surface Soil (continued)

Analyte	SRCs[a]		COPCs[b]		COCs[c]	
	0-1 ft bgs	1-13 ft bgs	0-1 ft bgs	1-13 ft bgs	0-1 ft bgs	1-13 ft bgs
Nitrocellulose	X	--	--	--	--	--
Nitroglycerin	X	--	--	--	--	--
PETN	--	X	--	--	--	--
Tetryl	X	--	--	--	--	--
Semi-volatile Organic Compounds						
2-Methylnaphthalene	X	--	--	--	--	--
Acenaphthene	X	X	--	--	--	--
Acenaphthylene	X	--	--	--	--	--
Anthracene	X	X	--	--	--	--
Benz(a)anthracene	X	X	X	X	X	X
Benzenemethanol	X	--	--	--	--	--
Benzo(a)pyrene	X	X	X	X	X	X
Benzo(b)fluoranthene	X	X	X	X	X	X
Benzo(ghi)perylene	X	X	--	--	--	--
Benzo(k)fluoranthene	X	X	--	X	--	--
Bis(2-ethylhexyl)phthalate	--	X	--	--	--	--
Carbazole	X	X	--	--	--	--
Chrysene	X	X	--	--	--	--
Di-n-butyl phthalate	X	X	--	--	--	--
Dibenz(a,h)anthracene	X	X	X	X	X	X
Dibenzofuran	X	X	--	--	--	--
Diethyl phthalate	X	--	--	--	--	--
Fluoranthene	X	X	--	--	--	--
Fluorene	X	X	--	--	--	--
Indeno(1,2,3-cd)pyrene	X	X	X	X	--	--
Naphthalene	X	X	--	--	--	--
Phenanthrene	X	X	--	--	--	--
Phenol	X	--	--	--	--	--
Pyrene	X	X	--	--	--	--

Table ES-1. SRCs, COPCs, and COCs in Surface Soil (continued)

Analyte	SRCs[a]		COPCs[b]		COCs[c]	
	0-1 ft bgs	1-13 ft bgs	0-1 ft bgs	1-13 ft bgs	0-1 ft bgs	1-13 ft bgs
Pesticides and Polychlorinated Biphenyls						
Heptachlor epoxide	X	--	--	--	--	--
PCB-1254	X	--	--	--	--	--
alpha-Chlordane	X	--	--	--	--	--
gamma-Chlordane	X	--	--	--	--	--
Volatile Organic Compounds						
2-Butanone	--	X	--	--	--	--
Acetone	X	--	--	--	--	--
Bromomethane	--	X	X	--	--	--
Carbon disulfide	X	--	--	--	--	--
Methylene chloride	X	--	--	--	--	--

[a] SRCs determined for surface soil (0-1 ft bgs) and all subsurface soil depths (> 1 ft bgs) based on RVAAP facility-wide soil background values.
[b] COPCs determined using most restrictive Facility-Wide Cleanup Goals (total risk = 10^{-6}/hazard index =0.1) for either Resident or National Guard Trainee receptors.
[c] COCs determined using most restrictive Facility-Wide Cleanup Goals (total risk = 10^{-5}/hazard index =1.0) for Resident Adult or Child and Sum-of-Ratios.
bgs = Below ground surface.
COC = Chemical of concern.
COPC = Chemical of potential concern.
PCB = Polychlorinated biphenyl.
PETN = Pentaerythritol Tetranitrate.
SRC = Site-related contaminant.
X = Chemical identified as a SRC, COPC, or COC.
-- = Chemical not identified as a SRC, COPC, or COC.
Screening methods, receptors and exposure depths defined in the RVAAP Facility-Wide Human Health Risk Assessor's Manual (USACE 2005) and Facility-Wide Human Health Cleanup Goals Report (USACE 2010) and Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program (ARNG 2014).

Table ES-2. SRCs, COPCs, and COCs in Sediment

Analyte	SRCs[a]	COPCs[b]	COCs[c]
Inorganic Chemicals			
Antimony	X	--	--
Beryllium	X	--	--
Cadmium	X	--	--
Organics – Explosives			
Nitroguanidine	X	--	--
Organics – Semi-volatile			
3+4-Methylphenol	X	--	--
Benz(a)anthracene	X	--	--
Benzo(a)pyrene	X	--	--
Benzo(b)fluoranthene	X	--	--
Chrysene	X	--	--
Fluoranthene	X	--	--
Pyrene	X	--	--
Organics – Volatile			
Toluene	X	--	--

[a] SRCs in sediment based on RVAAP facility-wide soil background values.
[b] COPCs determined using most restrictive Facility-wide Cleanup Goals (total risk = 10^{-6}/hazard index =0.1) for either Resident or National Guard Trainee receptors.
[c] No COPCs were identified; therefore, no COC evaluation was needed.
COC = Chemical of Concern.
COPC = Chemical of Potential Concern.
SRC = Site-related Contaminant.
X = Chemical identified as a SRC, COPC, or COC.
-- = Chemical not identified as a SRC, COPC, or COC.
Screening methods, receptors and exposure depths defined in the RVAAP Facility-Wide Human Health Risk Assessor's Manual (USACE 2005) and Facility-Wide Human Health Cleanup Goals Report (USACE 2010) and Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program (ARNG 2014).

ES.4.3.1 Surface Soil

The predominant SRCs for surface soil at Load Line 10 were inorganic chemicals and SVOCs. Of 52 SRCs identified in surface soil, 17 were inorganic chemicals and 23 were SVOCs, the majority of which were PAHs. The other 12 SRCs were comprised of explosives, propellants, pesticides, VOCs, and PCBs detected at estimated concentrations below laboratory reporting limits. Five of 17 inorganic chemicals were detected at their maximum concentrations at historical sample location L10ss-002M, adjacent to the former Building PE-1. The highest concentrations of PAH SRCs are observed at PBA08 RI sample location L10ss-080M in the vicinity of former Building PE-1. Petroleum staining was noted in a soil boring during installation of nearby and downgradient monitoring well L10mw-001 under the 2004 historical investigation. No PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

Table ES-3. SRCs, COPCs, and COCs in Surface Water

Analyte	SRCs[a]	COPCs[b]	COCs[c]
Inorganic Chemicals			
Antimony	X	--	--
Chromium	X	--	--
Cobalt	X	--	--
Lead	X	--	--
Nickel	X	--	--
Vanadium	X	--	--
Pesticides and Polychlorinated Biphenyls			
beta-BHC	X	--	--

[a] SRCs in sediment based on RVAAP facility-wide soil background values.
[b] COPCs determined using most restrictive Facility-Wide Cleanup Goals (total risk = 10^{-6}/hazard index =0.1) for either Resident or National Guard Trainee receptors.
[c] No COPCs were identified; therefore, no COC evaluation was needed.
BHC = Benzene Hexachloride.
COC = Chemical of Concern.
COPC = Chemical of Potential Concern.
SRC = Site-related Contaminant.
X = Chemical identified as a SRC, COPC, or COC.
-- = Chemical not identified as a SRC, COPC, or COC.
Screening methods, receptors and exposure depths defined in the RVAAP Facility-Wide Human Health Risk Assessor's Manual (USACE 2005) and Facility-Wide Human Health Cleanup Goals Report (USACE 2010) and Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program (ARNG 2014).

ES.4.3.2 Subsurface Soil

A total of 33 SRCs were identified in subsurface soil at Load Line 10, the majority of which were SVOCs. There were 19 SVOCs (15 of which were PAHs) detected and identified. The maximum detections for all 15 PAHs were observed at L10sb-071 in the 1.0-4.0 ft bgs interval; all 15 PAHs were also detected in the 4.0-7.0 ft bgs interval at this soil boring location at lower concentrations. Soil boring L10sb-071 was located in the footprint of former Building PE-7. However, there are no CERCLA-release related sources of PAHs at this AOC.

Eight inorganic chemicals were identified as SRCs. Elevated inorganic chemicals (particularly lead) occurred predominantly at two soil boring locations, L10sb-066 and L10sb-071. L10sb-066 is associated with the former Building PE-1. L10sb-071 is located adjacent to former Building PE-7. Construction debris including brick and gravel were observed in boring L10sb-071 that was terminated at 6.5 ft bgs due to concrete refusal. No propellants, PCBs, or pesticides were detected in subsurface soil at Load Line 10. The other six SRCs were comprised of explosives and VOCs that were detected at estimated concentrations below the laboratory reporting limits. The PBA08 RI investigation adequately characterized the vertical extent of contamination at Load Line 10. No chemicals exceeded the most stringent risk-based screening criteria (e.g., FWCUGs or RSLs) below a depth of 7 ft bgs.

ES.4.3.3 Sediment

One discrete sediment sample was collected at Load Line 10 from the main ditch draining to the southwest of the AOC during the PBA08 RI and compared to off-AOC facility-wide samples to assess if the AOC has impacted conditions downstream.

A total of 12 SRCs were identified in sediment at Load Line 10, the majority of which were PAHs that were all below laboratory reporting limits. All SVOC SRCs, with the exception of 3+4-methylphenol, were also identified as SRCs in surface soil. Three inorganic chemicals (antimony, beryllium, and cadmium) were identified as SRCs in sediment and are also SRCs for other media.

One VOC (toluene) and one propellant (nitroguanidine) were identified as SRCs, but not identified in any other media. No explosives, pesticides, or PBCs were identified as SRCs.

Only two SRCs (antimony and beryllium) were identified in sediment at the off-AOC sediment sample location (FWSsd-102). Both were detected at the upstream location at similar concentrations; there appears to be no migration of sediment SRCs from Load Line 10 to the off-AOC location. Additionally, any PAHs within the Load Line 10 AOC have not migrated off site as sediment.

ES.4.3.4 Surface Water

Six of the seven SRCs identified in surface water at Load Line 10 were inorganic chemicals. All had concentrations below laboratory reporting limits; however, these chemicals were identified as SRCs, and since they do not have an established background concentration, the background concentration is listed as 0 mg/kg. All of the inorganic SRCs for Load Line 10 surface water were detected at higher concentrations in the downstream off-AOC sample location. One pesticide [beta-benzene hexachloride (BHC)] identified as an SRC was detected at a concentration below the laboratory reporting limit but was not detected at the downstream off-AOC location. No explosives, propellants, SVOCs, VOCs, or PCBs were identified as SRCs in surface water at Load Line 10, and none were detected at off-AOC location FWSsw-102.

ES.4.4 Summary Of Contaminant Fate And Transport

All SRCs identified in the surface soil, subsurface soil, and sediment at Load Line 10 were evaluated through the stepwise contaminant fate and transport evaluation. The evaluation included analysis of two contaminant migration pathways: (1) leaching and migration from soil to groundwater; and (2) partitioning contaminants from sediment to surface water within the main drainage ditch exiting the AOC with transferal to groundwater through surface water/groundwater interaction.

Maximum concentrations of SRCs identified in surface and subsurface soil were evaluated using a series of generic screening steps to identify initial contaminant migration CMCOPCs. Initial CMCOPCs for soil were further evaluated using the Seasonal Soil Compartment (SESOIL) model to predict leaching concentrations and identify final CMCOPCs based on RVAAP BSVs and the lowest risk-based screening criteria among USEPA maximum contaminant levels (MCLs), USEPA tap water RSLs, or RVAAP groundwater FWCUGs for the Resident Receptor Adult. Final CMCOPCs were evaluated using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model to predict groundwater mixing concentrations beneath source areas and concentrations at the nearest downgradient groundwater receptor to the AOC (e.g., stream). Maximum SRC concentrations in sediment were evaluated using an analytical solution to identify final CMCOPCs for evaluation using AT123D. The AT123D modeling results were evaluated with respect to AOC groundwater monitoring data, as well as model limitations and assumptions, to identify chemicals to be retained as CMCOCs that may warrant further evaluation in an FS.

Conclusions of the soil and sediment screening, leachate modeling, and groundwater modeling are as follows:

- The AT123D model predicted maximum future groundwater concentrations for the final soil CMCOPCs alpha-chlordane, gamma-chlordane, pentaerythritol tetranitrate (PETN), 3-nitrotoluene, 4-amino-2,6-dinitrotoluene (DNT), 2,6-DNT, phenantherene, naphthalene, dibenzofuran, 2-methylnaphthalene, and selenium that exceed groundwater screening criteria beneath soil source areas, but do not exceed groundwater screening criteria at the downgradient receptor location (unnamed tributary to Sand Creek 1,875 ft north of the AOC). Predicted groundwater concentrations of the final sediment CMCOPCs cadmium, benz(a)anthracene, benzo(b)fluoranthene, and nitroguanidine also do not exceed groundwater screening criteria at the downgradient receptor location (unnamed tributary 1,000 ft south of the AOC).
- Evaluation of modeling results with respect to current AOC groundwater data and model limitations indicate that identified CMCOPCs are not currently impacting groundwater beneath the source areas and that modeling assumptions are conservative. Evaluation of predicted breakthrough curves show peak concentrations for PAHs would have occurred in the past. Potential future impacts predicted by the model for remaining CMCOPCs would likely be mitigated by factors such as chemical and biological degradation, lateral dispersivity, and AOC–specific variations soil geochemistry.

All SRCs were eliminated as posing future impacts to groundwater, and NFA is necessary for surface soil, subsurface soil, and sediment to protect groundwater.

ES.4.5 Summary of the Human Health Risk Assessment

The HHRA identified COCs and conducted risk management analysis to identify COCs requiring potential remediation based on potential risks to human receptors. Camp Ravenna is a controlled access facility. Load Line 10 is located in the south-central portion of Camp Ravenna and is not currently used for training. The anticipated future use is Military Training. An evaluation using Resident Receptor (Adult and Child) FWCUGs was used to evaluate Unrestricted (Residential) Land Use. Unrestricted (Residential) Land Use is considered protective for all categories of Land Use on the former RVAAP/Camp Ravenna

Media of concern evaluated in the HHRA are surface soil (0-1 ft bgs), subsurface soil (1-13 ft bgs), sediment, and surface water. No COPCs, and therefore no COCs, were identified for sediment or surface water at Load Line 10. The only soil COCs identified were four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene]. Concentrations of these chemicals detected in soil either exceeded FWCUGs or contributed to an SOR greater than 1. However, no PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

Evaluation of PAH concentrations associated with common anthropogenic (non-CERCLA) sources using available data from RVAAP background soil samples and other regional environmental studies of environmental concentrations of PAHs indicate the PAH concentrations at Load Line 10 are indicative of releases from road dust, vehicle exhaust, tire wear particles, pavement, and slag used as fill. No CERCLA-release related COCs pose an unacceptable risk to human health; therefore no COCs require remediation or evaluation in an FS.

ES.4.6 Summary of the Ecological Risk Assessment

The ERA Level I presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. There are 23 integrated soil COPECs based on the historical and current information at the Load Line 10. There are three integrated COPECs (mercury, nitroguanidine, and 3+4-methylphenol) identified in sediment at Load Line 10. Beta-BHC was identified as an integrated COPEC in surface water as it is a persistent, bioaccumulative, and toxic (PBT) compound. Ecological resources at Load Line 10 were compared to the list of important ecological places and resources. None of the 39 important places were present, and there is nothing ecologically significant at Load Line 10. The ERA summarizes the chemicals and resources in detail to demonstrate there is contamination but no important or significant ecological resources at Load Line 10. Consequently, the Level 1 Scoping Level Risk Assessment concluded that NFA is necessary to be protective of ecological resources.

ES.4.7 Conclusions of the Remedial Investigation

Historical investigations and the PBA08 RI have adequately characterized Load Line 10. Further investigation is not warranted at this AOC for the following reasons: (1) the nature and extent of impacted media has been sufficiently characterized; (2) the fate and transport modeling did not identify soil CMCOCs requiring further evaluation or remediation to protect groundwater; (3) there are no CERCLA-release related human health COCs identified in soil, sediment, or surface water requiring further evaluation in an FS or remediation; and (4) remedial actions to protect ecological resources are not warranted. Accordingly, NFA is necessary for soil, sediment and surface water at Load Line 10 to attain Unrestricted (Residential) Land Use.

Unrestricted (Residential) Land Use is considered protective for all categories of Land Use at Camp Ravenna. Therefore, since Load Line 10 meets the requirements for Unrestricted (Residential) Land Use, the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation. As stated in Paragraph 6.d of the Technical Memorandum, since this RI Report was in progress at the time of the Technical Memorandum's approval on February 11, 2014 and Load Line 10 achieves NFA for Unrestricted (Residential) Land Use, this report is not required to include an evaluation of the Commercial/Industrial Land Use.

The next step in the CERCLA process is to prepare a proposed plan (PP) to solicit public input with respect to NFA for soil, sediment, and surface water. The PP will provide a brief summary of the history, characteristics, risks, and the basis for NFA. Comments on the PP received from state and federal agencies and the public will be considered in preparation of a record of decision (ROD) to document the final remedy. The ROD will also include a responsiveness summary addressing comments received on the PP.

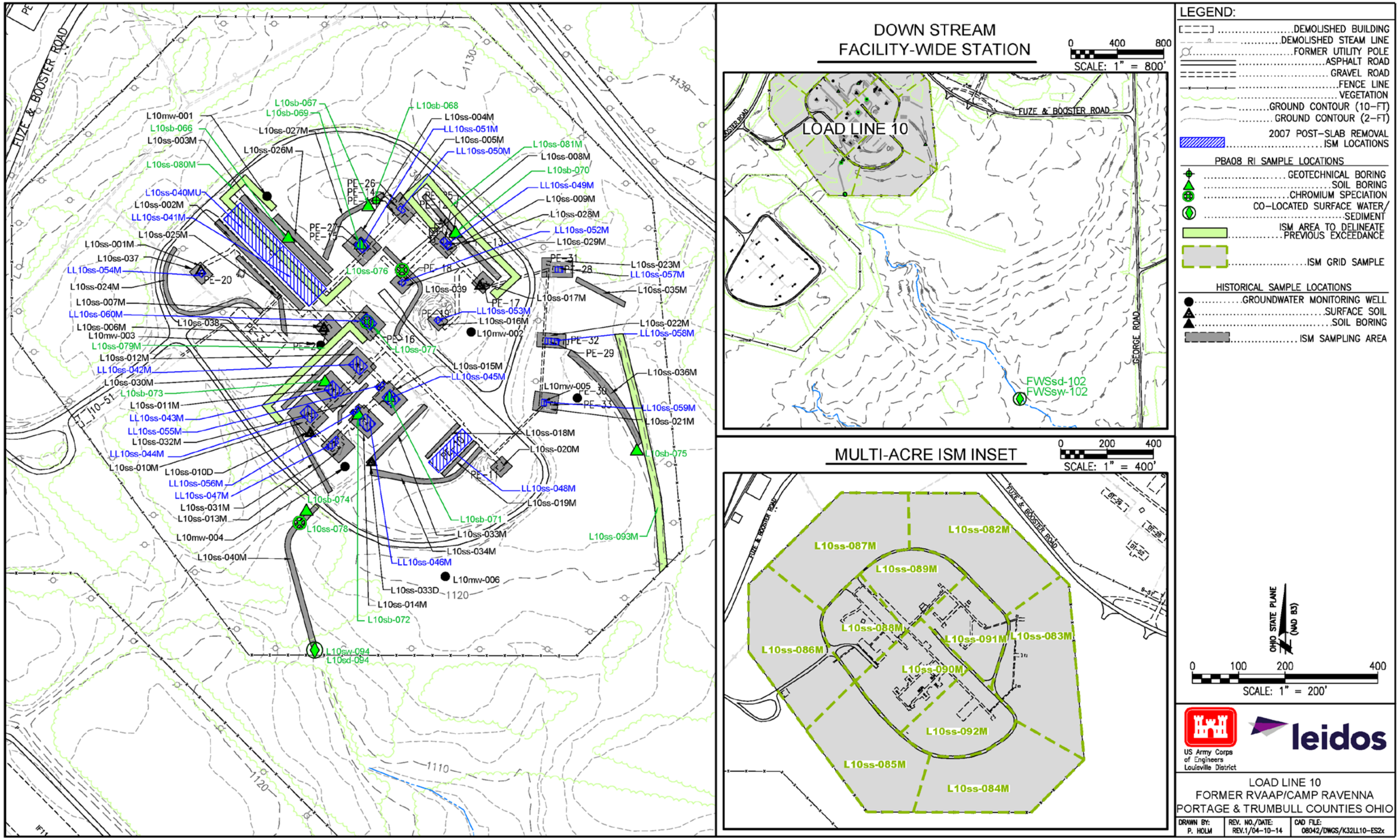


Figure ES-2. Load Line 10 Map Showing Historical and PBA08 RI Sampling Locations - Former RVAAP/Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

1.0 INTRODUCTION

This document was prepared by Leidos, formerly a part of Science Applications International Corporation (SAIC), under the U.S. Army Corps of Engineers (USACE), Louisville District, Multiple Award Remediation Contract (MARC) W912QR-04-D-0028, Delivery Order No. 0001, entitled 2008 Performance-based Acquisition (PBA) for Environmental Investigation and Remediation at the former Ravenna Army Ammunition Plant (RVAAP).

This Remedial Investigation (RI) Report addresses soil, sediment, and surface water at Load Line 10 at the former RVAAP. Load Line 10 is designated as area of concern (AOC) RVAAP-43 within the former RVAAP (now known as Camp Ravenna) in Portage and Trumbull counties, Ohio (Figures 1-1 and 1-2). Planning and performance of all elements of this PBA are in accordance with the requirements of the Ohio Environmental Protection Agency (Ohio EPA) Director's Final Findings and Orders (DFFO) for RVAAP, dated June 10, 2004 (Ohio EPA 2004). The DFFO requires conformance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to implement an RI to characterize the AOC, develop a feasibility study (FS) report (if necessary) and evaluate remedial alternatives to address contamination presenting unacceptable risk to human health and the environment, present a preferred alternative in a proposed plan (PP), and document stakeholder selection and acceptance of the preferred final remedy in a record of decision (ROD). Figure 1-3 presents this process.

This RI report includes the following:

- A description of the operational history and environmental setting for Load Line 10;
- A summary of all Load Line 10 historical investigations;
- A summary of field activities and results of the Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) conducted from February through April 2010 at the AOC;
- A description of the nature and extent of contamination, including the identification of site-related contaminants (SRCs) by screening all eligible historical and PBA08 data against background concentrations, essential human nutrients, and frequency of detection/weight-of-evidence (WOE) screening;
- An evaluation of contaminant fate and transport by identifying contaminant migration chemicals of potential concern (CMCOPCs) and contaminant migration chemicals of concern (CMCOCs) that may pose a future threat to groundwater;
- A human health risk assessment (HHRA) to identify chemicals of potential concern (COPCs) and chemicals of concern (COCs);
- An ecological risk assessment (ERA) to identify chemicals of potential ecological concern (COPECs) and chemicals of ecological concern; and
- Conclusions of the RI report.

Based on the outcome of the evaluation in this RI Report, the preferred alternative will be submitted for public review and comment in a PP. Public comments will be considered in the final selection of a remedy, which will be documented in the ROD.

1.1 EVALUATION OF LAND USE

In February 2014, the U.S. Department of the Army (U.S. Army) and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the RVAAP Installation Restoration Program (ARNG 2014) identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process. These three Land Uses and Representative Receptors are presented below.

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child) (formerly called Resident Farmer)
2. Military Training Land Use – National Guard Trainee
3. Commercial/Industrial Land Use – Industrial Receptor [U.S. Environmental Protection Agency's (USEPA) Composite Worker]

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of the Commercial/Industrial Land Use as an Alternative, if it achieves no further action (NFA) for Unrestricted (Residential) Land Use.

1.2 PURPOSE

The purpose of the PBA08 RI at Load Line 10 was to supplement data from previous sampling events to delineate the nature and extent of contamination, evaluate contaminant fate and transport, and complete an HHRA and ERA to support remedial decisions. Depending on the results of the RI, a conclusion of NFA will be provided or an FS will be completed to evaluate potential remedies and future actions.

1.3 SCOPE

The scope of this RI report is to present: (1) the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface soil, subsurface soil, sediment, and surface water at Load Line 10, and (2) a conclusion of NFA or remedial alternatives for meeting remedial action objectives for any CERCLA-related COCs requiring remediation at the AOC.

For the purposes of this report, the term “surface soil” includes dry sediment. Dry sediment refers to unconsolidated inorganic and organic material within conveyances, ditches, or low lying areas that occasionally may be covered with water, usually following a precipitation event or due to snowmelt. Dry sediment is not covered with water for extended periods and typically is dry within seven days of precipitation. Dry sediment does not function as a permanent habitat for aquatic organisms, although it may serve as a natural medium for the growth of terrestrial organisms. Dry sediment is addressed the same as surface soil [0-1 ft below ground surface (bgs)] in terms of contaminant nature and extent, fate and transport, and risk exposure models. The term “sediment,” as used in this report, refers to wet sediment within conveyances, ditches, wetlands, or water bodies that are inundated for extended periods of time. These definitions and terminology usage are consistent with the *Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2010a) (herein referred to as the FWCUG Report).

Potential impacts to groundwater from soil, sediment, and surface water (e.g., contaminant leaching) are evaluated in this report, as protectiveness to groundwater is included in the fate and transport analysis. However, groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS report. All buildings and structures at Load Line 10 have been demolished; therefore, they are not evaluated as continuing sources of contamination in this report.

Storm and sanitary sewers are present at Load Line 10. As part of the RVAAP-67 Facility-wide Sewers RI, sampling and evaluation of the sewer sediment, sewer water, outfall sediment, outfall water, and pipe bedding material media was performed and identified inorganic chemicals and polycyclic aromatic hydrocarbons (PAHs) as the predominant sewer SRCs. Fate and transport modeling was performed, and an HHRA and ERA were conducted for sewers at the Load Line 10. These evaluations conclude that NFA is necessary with respect to the Facility-wide Sewers within Load Line 10. The full evaluation and conclusion are presented in the *Draft Remedial Investigation/Feasibility Study Report for RVAAP-67 Facility-Wide Sewers* (USACE 2012a).

1.4 REPORT ORGANIZATION

This report is organized in accordance with Ohio EPA and USEPA CERCLA RI/FS guidance and applicable USACE guidance. The following is a summary of the components of the report and a list of appendices:

- Section 2.0 provides the history of the former RVAAP and Load Line 10 and a summary of previous investigations.
- Section 3.0 describes the environmental setting at Camp Ravenna and Load Line 10, including the geology, hydrogeology, climate, population, and ecological resources.
- Section 4.0 describes specific methods used for collecting field data during the PBA08 RI and the approach to managing analytical data and laboratory programs.
- Section 5.0 presents the data generated during historical investigations and PBA08 RI, methodology for screening data, and discusses the occurrence and distribution of contamination at the AOC.
- Section 6.0 presents an evaluation of contaminant fate and transport.
- Section 7.0 includes methods and results of the HHRA and ERA.
- Section 8.0 provides conclusions of the RI.
- Section 9.0 presents the references.
- Appendices:
    - Appendix A. Field Sampling Logs;
    - Appendix B. Project Quality Assurance Summary;
    - Appendix C. Data Quality Control Summary Report;
    - Appendix D. Laboratory Analytical Results and Chains-of-Custody;
    - Appendix E. Fate and Transport Modeling Results;
    - Appendix F. Investigation-derived Waste Management Reports;
    - Appendix G. Human Health Risk Assessment Tables; and
    - Appendix H. Ecological Risk Assessment Information and Data.

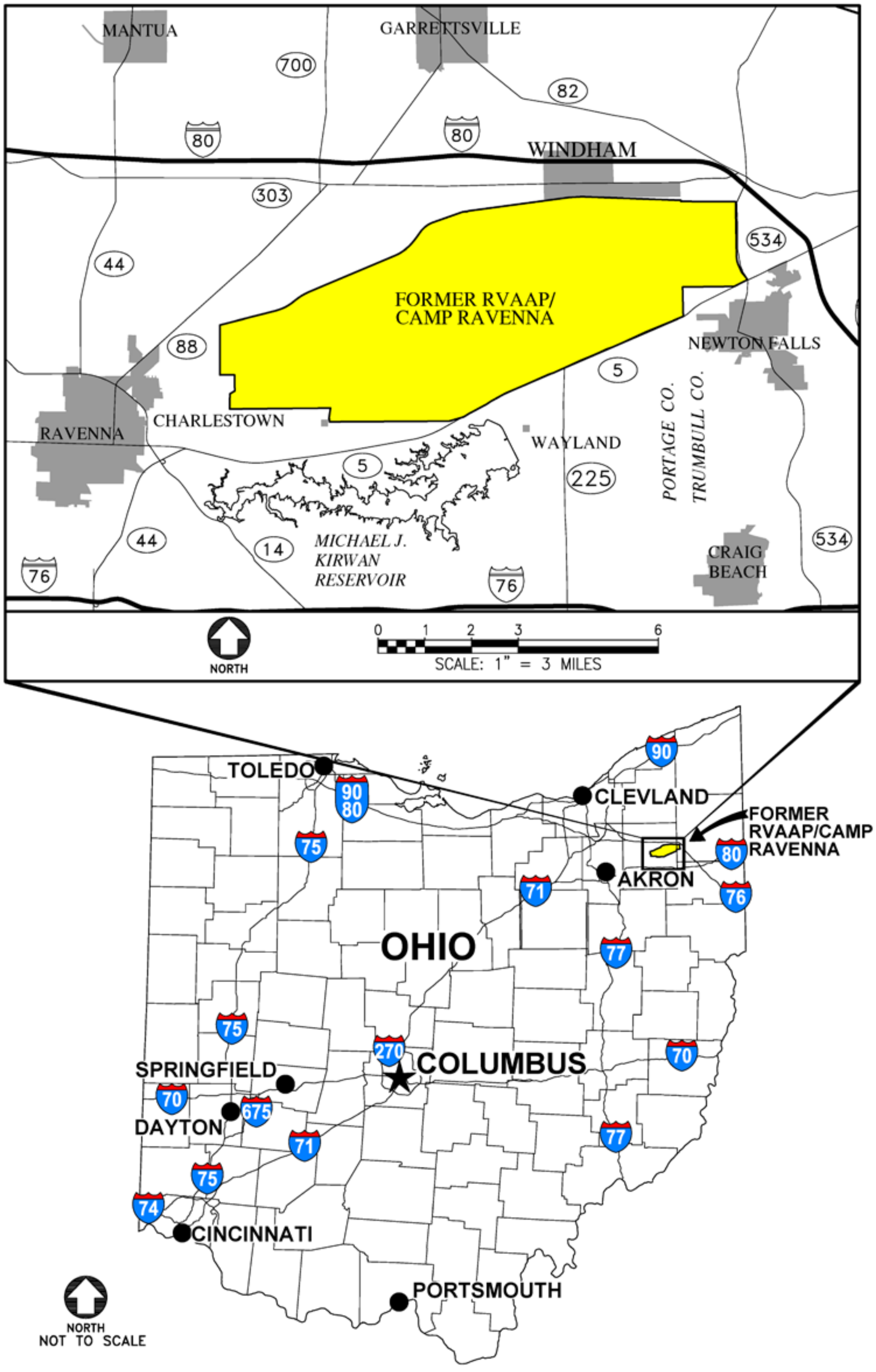


Figure 1-1. General Location and Orientation of Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

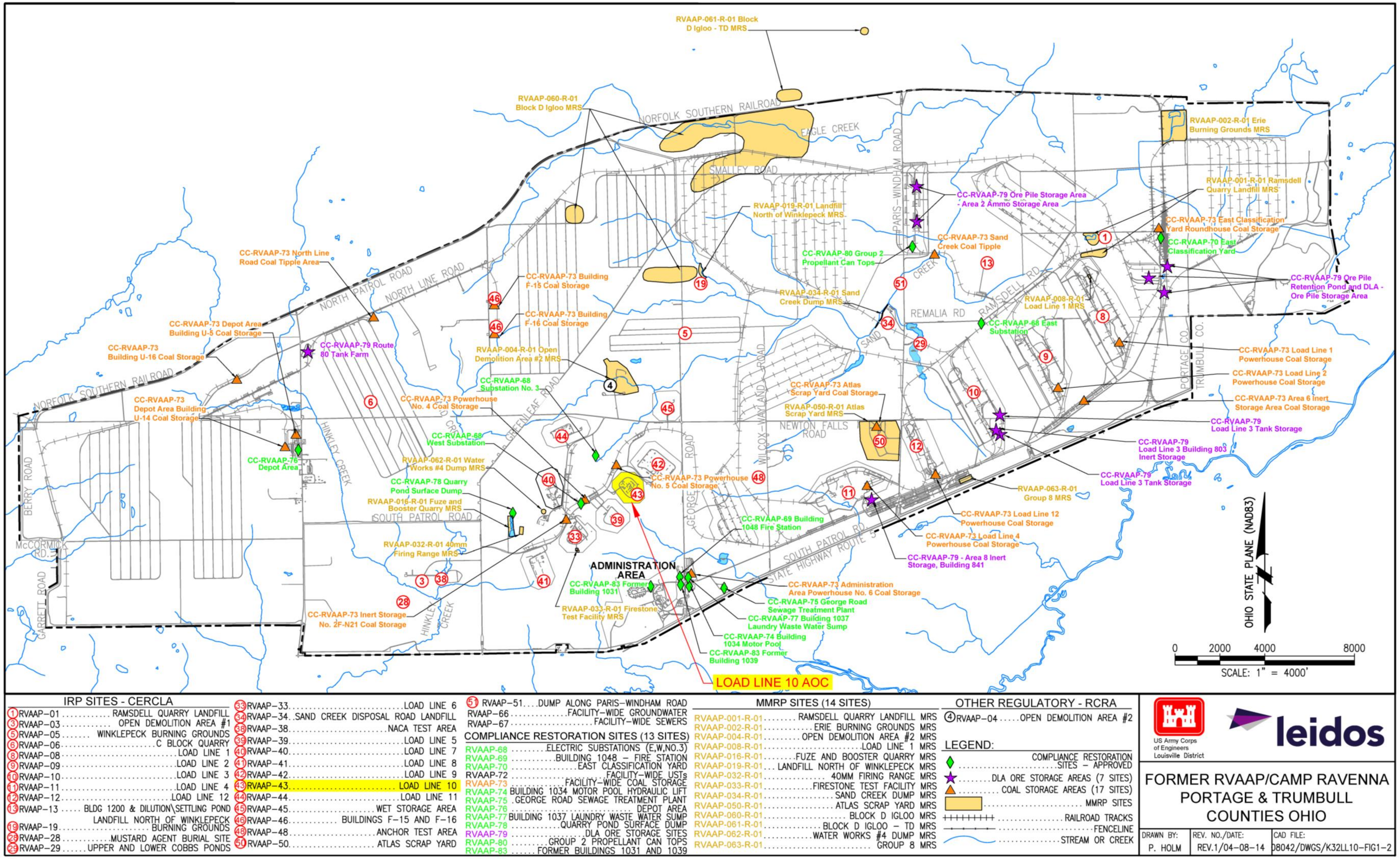


Figure 1-2. Location of AOCs and Munitions Response Sites at Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

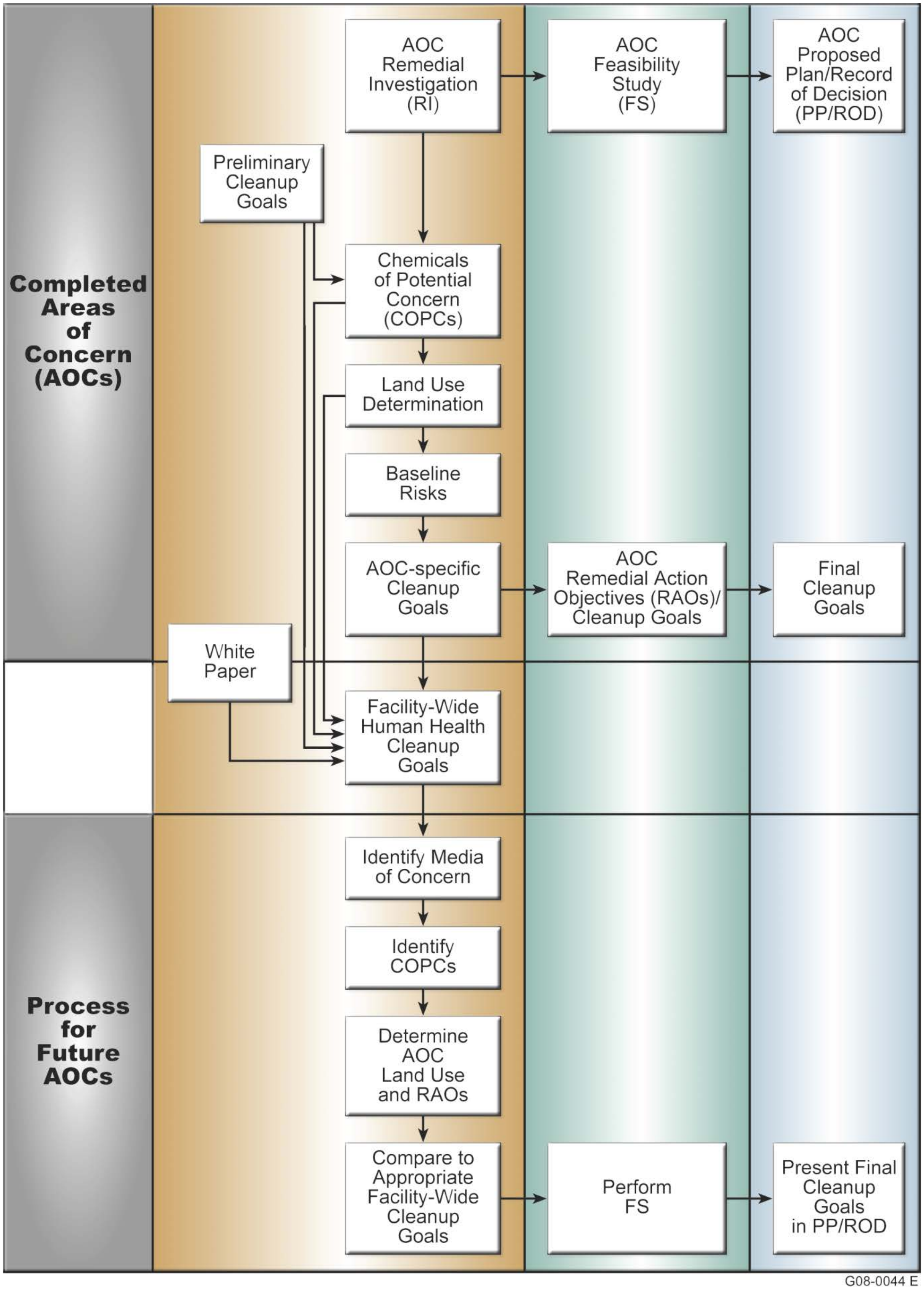


Figure 1-3. Process for Developing Remedial Decisions at Areas of Concern (USACE 2010a)

THIS PAGE INTENTIONALLY LEFT BLANK.

2.0 BACKGROUND

This section provides a description of the facility and Load Line 10. This section also provides a description of the operational history, building demolition activities, and previous investigations at Load Line 10.

2.1 FACILITY-WIDE BACKGROUND INFORMATION

2.1.1 General Facility Description

The facility, consisting of 21,683 acres, is located in northeastern Ohio within Portage and Trumbull counties, approximately 4.8 kilometers (3 miles) east/northeast of the City of Ravenna and approximately 1.6 kilometers (1 mile) northwest of the City of Newton Falls. The facility, previously known as RVAAP, was formerly used as a load, assemble, and pack facility for munitions production. As of September 2013, administrative accountability for the entire acreage of the facility has been transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the Ohio Army National Guard (OHARNG) for use as a military training site (Camp Ravenna). References in this document to RVAAP relate to previous activities at the facility as related to former munitions production activities or to activities being conducted under the restoration/cleanup program.

2.1.2 Demography and Land Use

Camp Ravenna occupies east-central Portage County and southwestern Trumbull County. Census projections for 2010 indicate the populations of Portage and Trumbull counties are 161,419 and 210,312, respectively. Population centers closest to Camp Ravenna are Ravenna (population of 11,724) and Newton Falls (population of 4,795).

The facility is located in a rural area and is not close to any major industrial or developed areas. Approximately 55% of Portage County, where the majority of Camp Ravenna is located, consists of either woodland or farmland acreage. The closest major recreational area, the Michael J. Kirwan Reservoir (also known as West Branch Reservoir), is located adjacent to the western half of Camp Ravenna, south of State Route 5.

Camp Ravenna is federally owned and is licensed to the OHARNG for use as a military training site. Restoration activities at Camp Ravenna are managed by the Army National Guard and OHARNG. Training and related activities at Camp Ravenna include field operations and bivouac training, convoy training, maintaining equipment, C-130 aircraft drop zone operations, helicopter operations, and storing heavy equipment.

2.2 LOAD LINE 10 BACKGROUND INFORMATION

2.2.1 Operational History

Load Line 10, formerly known as the Percussion Element Manufacturing Line, is a 36-acre, fenced AOC located south of Fuze and Booster Road, southwest of Load Line 9, and northeast of Load Line 5 in the south-central portion of Camp Ravenna (Figure 2-1). Load Line 10 was operational during 1941-1945, 1951-1957, and 1969-1971 to manufacture percussion elements and primers. In 1971, Load Line 10 was deactivated permanently, and the production equipment was removed.

No historical data or information exists to indicate Load Line 10 was used for any process other than percussion element/primer manufacturing (MKM 2007). No fuel storage tanks were present at the AOC during operations. Additionally, no fuel materials were used operationally at Load Line 10, and no burning was conducted.

All buildings, including slabs and foundations, were removed in 2007. Remaining features at Load Line 10 include a one-lane asphalt perimeter road that enters the AOC from the west and encircles the former production area, buildings, and access roads within the AOC. The Load Line 10 perimeter fence is still in place, although it is not currently maintained. Small construction drainage ditches border the access road and are also located within the former production area.

In 1978, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an Installation Assessment of RVAAP to review potential for contaminant release at multiple former operations areas, as documented in *Installation Assessment of Ravenna Army Ammunition Plant* (USATHAMA 1978). The installation assessment indicated historical operations may have utilized lead azide or lead styphnate, which are primary explosives. The Relative Risk Site Evaluation (RRSE) for Newly Added Sites (USACHPPM 1998) indicated lead thiocyanide was used in production operations at this AOC. The two primer mixes that were utilized were FA 70 and FA 90A. Each mixture contained the primary chemicals potassium chlorate, antimony sulfide, and lead thiocyanate in similar quantities. The secondary explosives used within the primers were 2,4,6-trinitrotoluene (TNT) in FA-70 and pentaerythritol tetranitrate (PETN) in FA-90A (USACHPPM 1998). Load Line 10 was the only AOC to use lead thiocyanate in primer production, as lead azide and lead styphnate were not used at the AOC. From 1941-1945, Load Line 10 produced 226,387,306 M36 percussion elements (USATHAMA 1978). During 1951-1957, Load Line 10 produced 49,286,628 percussion elements and 165,262,465 primers. Unknown quantities of primers were produced during 1969-1971.

Historical facilities at Load Line 10 included 36 production and support buildings ranging in size from 35-13,745 ft^2. The locations of the former primary operational buildings are shown on Figure 2-1. A utilization summary of the principal production buildings is as follows.

- 1941-1945 and 1951-1956 Production Eras:
    - Building PE-1 – Percussion Element Manufacturing
    - Buildings PE-2 and PE-20 – Solvent Storage
    - Buildings PE-4, PE-5, PE-6, and PE-9 – Dry Houses
    - Buildings PE-7 and PE-8 – Canned Primer Storage
    - Buildings PE-12 and PE-13 – Potassium Chlorate and Other Ingredients Mixing Buildings
    - Buildings PE-14 and PE-15 – Fuel Mixing Building and Inspection
    - Building PE-16 – Gum Solution Building
    - Buildings PE-17, PE-18, and PE-19 – Storage Magazines
    - Buildings PE-21 and PE-22 – Primer Canning Buildings
    - Buildings PE-28 and PE-29 – PETN Processing
- 1969-1971 Production Era:
    - Buildings PE-1 and PE-14 – Percussion Element Mixing and Manufacturing
    - Buildings PE-2 and PE-20 – Solvent Storage
    - Buildings PE-4, PE-5, PE-6, and PE-9 – Dry Houses
    - Buildings PE-12, PE-13, PE-14, and PE-15 – Fuel Compound Blending and Inspection
    - Building PE-16 – Binder Blending
    - Buildings PE-17, PE-18, PE-19, PE-21, and PE-22 – Storage
    - Buildings PE-28 and PE-29 – PETN Processing
- Non-production Buildings:
    - Buildings PE-10, PE-11, PE-23, and PE-24 – Packing and Shipping and Storage
    - Building PE-3 – Change House
    - Building 10-51 – Time Clock
    - Buildings PE-25, PE-26, and PE-27 – Heater Houses

Soil in the vicinity of former production buildings was disturbed during building demolition activities, and the work areas were re-graded and vegetated following demolition activities. Demolition activities are described in Section 2.2.2. The AOC is currently overgrown by trees and successional scrub vegetation.

2.2.2 Building Demolition

Demolishing and removing buildings at Load Line 10, which included building slabs and foundations, was initiated in May 2006 and completed in July 2007 by the U.S. Army Tank-Automotive and Armaments Command. This was documented in the *Munitions Response for the Demolition of RVAAP-41 Load Line 8 and RVAAP-43 Load Line 10* (PIKA 2007). Prior to demolition and disposal, all hazardous and non-hazardous material (e.g., fluorescent light fixtures and mercury switches) from the buildings were removed. Polychlorinated biphenyl (PCB)-contaminated material was removed and disposed off site. Asbestos-containing material (ACM) was removed from all buildings prior to initiating building demolition and removal operations. ACM removal operations occurred in June 2006. Due to the existence of asbestos in former buildings at the AOC, a visual inspection for residual asbestos was performed at Load Line 10 in October 2011 by a Certified

Asbestos Hazard Evaluation Specialist. The visual inspection report is included in Appendix A of this report.

All concrete floor slabs, subsurface concrete foundations, steam stanchions, overhead steam lines, telephone poles, and surface debris were removed. Explosive decontamination was performed on drains and process pipes at Load Line 10. Floor slabs and footers were completely removed, and precautions were taken to avoid disturbing soil beneath the slabs and footers. The basements associated with Buildings PE-3 through PE-6 were demolished in place to a depth of 4 ft bgs (PIKA 2007).

Soil surrounding the former buildings was extensively disturbed during building demolition and restoration activities. The work areas were re-graded, and the area was vegetated in 2007. Fill dirt was not needed to fill cavities or former building footprints at Load Line 10.

USACE completed the Investigation of Under Slab Surface Soils following completion of demolition and disposal activities (USACE 2009a). The interior of the AOC is currently vegetated with shrub/scrub vegetation in unpaved areas and forested around its perimeter.

2.2.3 Previous Investigations

Since 1978, Load Line 10 has been included in various assessments and investigations conducted at RVAAP, including:

- Installation Assessment of Ravenna Army Ammunition Plant (USATHAMA 1978);
- Resource Conservation and Recovery Act (RCRA) Facility Assessment (Jacobs 1989);
- Preliminary Assessment Screening of Boundary Load Line Areas (USAEHA 1994);
- Preliminary Assessment for the Characterization of Areas of Contamination (USACE 1996);
- Relative Risk Site Evaluation for Newly Added Sites (USACHPPM 1998);
- Lead Azide Screening (MKM 2007);
- Characterization of 14 AOCs (MKM 2007); and
- Investigation of the Under Slab Surface Soils (USACE 2009a).

2.2.3.1 Installation Assessment of Ravenna Army Ammunition Plant

The *Installation Assessment of Ravenna Army Ammunition Plant* incorporated a review of historical operational information and available environmental data to assess the potential for contaminant releases from operational facilities. No sampling was performed at Load Line 10 as part of the assessment. The assessment identified the following conditions at RVAAP applicable to Load Line 10 (USATHAMA 1978):

- Areas of RVAAP, including production areas (i.e., Load Line 5, Load Line 7, Load Line 8, Load Line 10, and Load Line 12), burning grounds, test areas, and demolition areas were identified as sites contaminated with explosive waste that included TNT, Composition B, lead azide, lead styphnate, and black powder.

- Explosives, antimony sulfide, and lead thiocyanate were also identified as the potential contaminants for Load Line 10;
- No environmental stress was identified at RVAAP.

2.2.3.2 RCRA Facility Assessment

The purpose of the RCRA Facility Assessment was to perform a visual inspection of known AOCs and conduct historical documentation research to identify new AOCs and solid waste management units, as applicable (Jacobs 1989). No sampling was performed at Load Line 10 as part of the assessment.

Load Line 10 was addressed in the assessment with respect to nine former concrete settling tanks (SWMU 26) used as settling basins for explosive-contaminated wastewater during production activities. The tanks were located at Buildings PE-1 (2 tanks), PE-13, PE-14, PE-27, PE-28 (3 tanks), and PE-30.

The assessment indicated a high potential for releasing contamination into soil, groundwater, and surface water. The RCRA Facility Assessment recommended analyzing inorganic chemicals and explosives in subsurface soil from depths below the bottom of the tanks. Installing groundwater monitoring wells was recommended if releases were identified.

2.2.3.3 Preliminary Assessment Screening of Boundary Load Line Areas

Load Line 10 was included in the Preliminary Assessment Screening of Boundary Load Line Areas conducted by the U.S. Army Environmental Hygiene Agency (USAEHA). This assessment included reviewing historical records and facility personnel interviews. No sampling was performed at Load Line 10 as part of the assessment.

The assessment indicated potential contaminants could be expected on building interiors, in exterior soil, and in holding tanks and settling ponds. In addition, as wastewater was discharged to the storm sewer following treatment, storm sewer and surface water discharge points were identified as potential contaminant pathways. The assessment recommended further environmental investigation for Load Line 10 (USAEHA 1994).

2.2.3.4 RVAAP Preliminary Assessment

The Preliminary Assessment for the Characterization of Areas of Contamination researched RVAAP history, process operations, and historical data to identify AOCs (USACE 1996). Load Line 10 was only addressed in the assessment with respect to nine documented former concrete settling tanks (designated as RVAAP-26, Fuze and Booster Area Settling Tanks), which were formerly documented in the *RCRA Facility Assessment* (Jacobs 1989). No sampling was performed at Load Line 10 as part of the assessment.

The assessment provided the following general conclusions for RVAAP AOCs:

- COPCs at RVAAP AOCs were identified as explosives [TNT; hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); composition B; and lead azide] and heavy metals (lead and mercury).
- The primary sources of potential contamination were identified as wastewater effluent from the munitions assembly and demilitarization process, open burning and detonation of explosives, and landfill operations. Primary contaminant release mechanisms from load lines were process effluent discharges to surface water (drainage ditches, settling ponds, and streams) and process building wastewater wash-out to surface soil. Media of concern were identified as soil, sediment, groundwater, and surface water.
- The greatest potential for release of contaminants from load lines to groundwater likely occurred from wastewater effluent discharge to unlined earthen settling ponds. Concrete settling tanks, open drainage ditches, and storm sewers were also identified as concerns relative to groundwater.
- Known releases of contamination to surface water and soil have occurred from load line (assembly and demilitarization) operations.
- The greatest potential for historical off-site contaminant migration during load line operations was identified as surface water. The greatest potential for current off-site contaminant migration was identified as groundwater and surface water.

2.2.3.5 Relative Risk Site Evaluation

In 1998, the U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) completed the *Relative Risk Site Evaluation for Newly Added Sites* (USACHPPM 1998), which identified and provided a risk evaluation for 13 newly discovered and previously uninvestigated AOCs for the purpose of prioritizing future remedial or corrective activities. Of the 13 identified AOCs, five were assigned an RRSE score of “high,” and the remaining eight were assigned a score of “medium.”

The RRSE evaluated the soil pathway (human receptor endpoint) using data from the six surface soil samples collected near the former production buildings at Load Line 10. These samples were analyzed for explosives and inorganic chemicals. The groundwater pathway (human receptor endpoint) was evaluated using data from one subsurface soil sample collected from 10-12 ft bgs, west of Building PE-6. This sample was analyzed for explosives and inorganic chemicals. One sediment sample was planned for collection during this evaluation, but since no settling ponds or sediment pathways were evident, sediment and surface water were not evaluated as part of the RRSE.

Groundwater concentrations were calculated by modeling analytical data from a subsurface soil sample collected from 10-12 ft bgs. Five inorganic chemicals (arsenic, barium, chromium, copper, and zinc) were identified for groundwater based on model calculations. No other analytes were identified for groundwater. A total of 17 inorganic chemicals and three explosives were detected in surface soil. Concentrations of analytes detected in surface soil and groundwater are presented in Appendix D of the RRSE (USACHPPM 1998).

Human receptor endpoints were evaluated based on the available surface soil and groundwater data. The RRSE scored Load Line 10 as a “medium-priority” AOC with two media of concern and recommended additional investigative sampling (USACHPPM 1998).

2.2.3.6 Lead Azide Screening

The U.S. Army Operations Support Command contracted MKM Engineers, Inc., in conjunction with USACE, to perform a lead azide screening operation at Load Lines 6, 9, and 10 for health and safety purposes and to obtain additional information on areas of potential contamination. In 2002, three surface soil samples near former buildings and five co-located sediment and surface water samples near ditchlines were collected from within Load Line 10 and analyzed for primary (azide) and secondary (TNT and RDX) explosives. Results indicated there were no detectable safety concerns related to azide contamination and no significant contamination from secondary explosives at Load Line 10.

2.2.3.7 Characterization of 14 AOCs

The Characterization of 14 AOCs [as documented in the *Characterization of 14 AOCs at the Ravenna Army Ammunition Plant* (MKM 2007)] was performed to accomplish the following:

- Provide data for future assessments that may be conducted;
- Develop a conceptual site model (CSM);
- Identify key elements to be considered in future actions;
- Assess potential sources of contamination;
- Identify whether releases of contamination extend beyond the AOC boundary;
- Provide an initial assessment of the nature and lateral extent of contamination; and
- Provide a preliminary human health risk screening (HHRS) evaluation and ecological risk screening (ERS) evaluation.

Results of this characterization are presented in the Characterization of 14 AOCs report. The following investigation field activities were conducted from October 2004 to May 2005 to assess the potential impacts from former operations at Load Line 10 (MKM 2007):

- Collected 37 multi-increment (MI) surface soil (0-1 ft bgs) samples from ditches (14) and around former buildings (13);
- Collected seven discrete surface soil (0-1 ft bgs) samples for volatile organic compound (VOC) analyses;
- Collected six surface soil quality assurance/quality control (QA/QC) samples;

- Collected six sediment samples from sumps and basins, building basements, and sanitary sewers;
- Collected 19 surface water samples from sumps and basins (12), sanitary sewers (6), and basement structures (1);
- Installed, developed, and sampled six groundwater monitoring wells;
- Excavated four test trenches until saturated soil was encountered (12-14 ft bgs);
- Collected geotechnical samples from monitoring well borings;
- Completed in-situ permeability testing (slug tests); and
- Completed sampling location and monitoring well survey.

The Characterization of 14 AOCs utilized MI samples. This sampling technique is currently referred to as “incremental sampling method” (ISM). All ISM surface soil and sediment samples were analyzed for target analyte list (TAL) metals, explosives, and cyanide. In addition, four ISM surface soil samples were analyzed for semi-volatile organic compounds (SVOCs), propellants, pesticides, and PCBs. Table 2-1 presents a summary of the analytes detected in the ISM samples during the Characterization of 14 AOCs.

Discrete surface soil samples were collected from seven ISM sample areas for VOC analyses to fulfill requirements to conduct a full-suite analysis for 10% of the ISM sample population. There were no detections of VOCs within these surface soil samples.

Water samples from sumps and basins, sanitary sewers, and basement structures were analyzed for TAL metals, explosives, propellants, VOCs, SVOCs, pesticides, and PCBs and sediment samples were analyzed for TAL metals, explosives, and cyanide. Groundwater samples were analyzed for TAL metals, explosives, VOCs, SVOCs, cyanide, pesticides, and PCBs.

During test trench excavation, trenching was halted upon encountering saturated soil. Saturation was encountered in trench L10tr-001 at 12 ft bgs, trench L10tr-002 at 12 ft bgs, trench L10tr-003 at 13 ft bgs, and trench L10tr-004 at 14 ft bgs (MKM 2007). Bedrock was not encountered in the test trenches. No visual evidence of contamination or munitions and explosives of concern were encountered during trenching activities. Data from monitoring wells installed during the characterization showed the depth to the groundwater table was between 12-20 ft bgs.

An HHRS and ERS for Load Line 10 were included in the Characterization of 14 AOCs report. The HHRS compared chemical concentrations detected in samples to RVAAP screening criteria in effect at that time, which included facility-wide background concentrations for inorganic constituents and USEPA Region 9 residential preliminary remediation goals (PRGs). Constituents were retained if they did not have screening values. The results of the HHRS identified contaminants above screening criteria in surface soil and groundwater, as summarized in Table 2-2. Sediment and surface water samples collected during the investigation were associated only with infrastructure (i.e., sumps, basins, and sewers) and are not included in Table 2-2. Sediment and surface water were not present within drainage conveyances during the Characterization of 14 AOCs investigation.

The ERS compared chemical concentrations detected in Load Line 10 environmental media to RVAAP facility-wide background concentrations for inorganic chemicals and ecological screening values (ESVs). The ERS followed screening methodology guidance presented in the *2003 RVAAP Facility-Wide Ecological Risk Work Plan* (USACE 2003c) (herein referred to as the FWERWP) and *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003). Constituents were retained if they did not have screening values. Table 2-3 presents the chemicals identified in the ERS as exceeding screening values for Load Line 10. Sediment and surface water samples collected during the investigation were associated only with infrastructure (i.e., sumps, basins, and sewers) and are not included in the Table 2-3. Sediment and surface water were not present within drainage conveyances during the Characterization of 14 AOCs investigation.

The Characterization of 14 AOCs report recommended that full HHRAs and ERAs should be considered to assist in the overall risk management decisions for Load Line 10.

2.2.3.8 Investigation of the Under Slab Surface Soils

The *Investigation of the Under Slab Surface Soils Post Slab and Foundation Removal at RVAAP-39 Load Line 5, RVAAP-40 Load Line 7, RVAAP-41 Load Line 8, and RVAAP-43 Load Line 10* (USACE 2009a) provides a summary of the surface soil analytical results with detected chemical concentrations compared to USEPA Region 9 residential PRG and RVAAP background concentrations. This investigation was performed after the buildings and structures at Load Line 10 were demolished and removed.

A total of 21 ISM samples (plus four QA/QC samples) were collected from the footprints of 21 former production buildings to assess potential impacts on surface soil. Each building consisted of one ISM grid, with the exceptions of process Building PE-1 (which was divided into two grids based on its size) and Buildings PE-12 and PE-13 (which were combined into one grid). All ISM samples collected were analyzed for TAL metals and explosives, and 15% were also analyzed for VOCs, SVOCs, pesticides, PCBs, and propellants. Table 2-4 presents a summary of the analytes detected in the ISM samples during the Investigation of the Under Slab Surface Soils. Two discrete samples (plus one QA/QC sample) were collected for VOCs and were not subject to ISM processing.

The report concluded the following three process buildings at Load Line 10 had COPCs in the surface soil remaining after building demolition and removal:

- Building PE-15 footprint [benz(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene];
- Building PE-19 footprint [benz(a)anthracene and benzo(b)fluoranthene]; and
- Building PE-22 footprint [benzo(b)fluoranthene].

Table 2-1. Analytes Detected at Load Line 10 ISM Surface Soil Samples - Characterization of 14 AOCs

Analyte (mg/kg)	Freq of Detect	Minimum Detect	Maximum Detect	Average Detect
Inorganic Chemicals				
Aluminum	37/ 37	7000	22000	11000
Antimony	10/ 32	0.47	2.5	1.08
Arsenic	37/ 37	4.9	18	11.7
Barium	37/ 37	46	190	70.1
Beryllium	37/ 37	0.54	5.3	0.903
Cadmium	22/ 37	0.06	0.89	0.315
Calcium	37/ 37	290	100000	8860
Chromium	37/ 37	12	33	20.2
Cobalt	37/ 37	2.9	13	8.36
Copper	37/ 37	9.1	42	20.2
Cyanide	13/ 37	0.19	1.3	0.365
Iron	37/ 37	14000	28000	20900
Lead	37/ 37	15	430	56.1
Magnesium	37/ 37	1700	23000	3520
Manganese	37/ 37	250	1400	584
Mercury	26/ 37	0.03	0.08	0.0512
Nickel	37/ 37	10	31	19.5
Potassium	37/ 37	680	1900	1130
Selenium	32/ 37	0.45	1.8	0.729
Sodium	37/ 37	230	960	312
Thallium	4/ 37	0.22	0.23	0.225
Vanadium	37/ 37	9	24	18.9
Zinc	37/ 37	53	220	86.1
Explosives				
2,6-Dinitrotoluene	1/ 37	0.14	0.14	0.14
Semi-volatile Organic Compounds				
2-Methylnaphthalene	2/ 4	0.011	0.019	0.015
Anthracene	1/ 4	0.012	0.012	0.012
Benz(a)anthracene	3/ 4	0.018	0.04	0.03
Benzenemethanol	1/ 4	2.1	2.1	2.1
Benzo(a)pyrene	4/ 4	0.012	0.047	0.0298
Benzo(b)fluoranthene	4/ 4	0.02	0.063	0.0408
Benzo(ghi)perylene	3/ 4	0.015	0.023	0.0193
Benzo(k)fluoranthene	2/ 4	0.027	0.035	0.031
Chrysene	4/ 4	0.016	0.054	0.035
Dibenzofuran	1/ 4	0.018	0.018	0.018
Fluoranthene	4/ 4	0.022	0.11	0.0665
Fluorene	1/ 4	0.012	0.012	0.012
Indeno(1,2,3-cd)pyrene	3/ 4	0.014	0.022	0.0193
Naphthalene	2/ 4	0.0092	0.021	0.0151
Phenanthrene	3/ 4	0.028	0.056	0.046
Phenol	1/ 4	0.18	0.18	0.18
Pyrene	4/ 4	0.017	0.074	0.0465

mg/kg = Milligram per kilogram.

Table 2-2. Human Health COPCs- Characterization of 14 AOCs

Surface Soil	Groundwater
Aluminum	Carbon tetrachloride
Arsenic	Phenanthrene
Chromium	
Iron	
Lead	
2-Methylnaphthalene	
Benzo(g,h,i)perylene	
Phenanthrene	

Adapted from Table L10-14: Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).

Table 2-3. Chemicals Exceeding ESVs per the Characterization of 14 AOCs Report

Surface Soil		Groundwater
Aluminum	Nickel	Not evaluated
Arsenic	Selenium	
Chromium	Zinc	
Iron	2, 6-dinitrotoluene	
Lead	Dibenzofuran	
Mercury		

Adapted from Table L10-14: Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).

Table 2-4. Analytes Detected in Under Slab Surface Soil Samples

Analyte (mg/kg)	Freq of Detection	Minimum Detect	Maximum Detect	Average Detect
Inorganic Compounds				
Aluminum	21/ 21	7260	10600	8900
Arsenic	21/ 21	9.9	20	12.4
Barium	21/ 21	44.7	90.9	66.3
Calcium	21/ 21	2570	20200	8040
Chromium	21/ 21	15.8	28.8	20.3
Cobalt	21/ 21	5.8	9.1	7.72
Copper	21/ 21	17.2	22.9	20.1
Iron	21/ 21	14900	22600	18900
Lead	21/ 21	21.1	124	60.8
Magnesium	21/ 21	1710	4830	2980
Manganese	21/ 21	417	842	569
Mercury	17/ 21	0.014	0.1	0.0381
Nickel	21/ 21	19.1	37.4	27.6
Potassium	7/ 21	714	1180	937
Vanadium	21/ 21	11.9	18.5	14.6
Zinc	21/ 21	67.3	146	98
Explosives and Propellants				
Nitrocellulose	2/ 2	2.2	4	3.1
Nitroglycerin	1/ 21	0.6	0.6	0.6
Semi-volatile Organic Compounds				
Benz(a)anthracene	2/ 3	1.6	2.4	2
Benzo(a)pyrene	1/ 3	2	2	2
Benzo(b)fluoranthene	3/ 3	1.8	2.6	2.23
Chrysene	2/ 3	1.6	2.4	2
Fluoranthene	3/ 3	3.6	7.5	5.43
Phenanthrene	3/ 3	2	6.7	4.23
Pyrene	3/ 3	2.6	5.2	3.87
Volatile Organic Compounds				
Carbon disulfide	1/ 2	0.00061	0.00061	0.00061
Methylene chloride	1/ 2	0.001	0.001	0.001

mg/kg = Milligrams per kilogram..

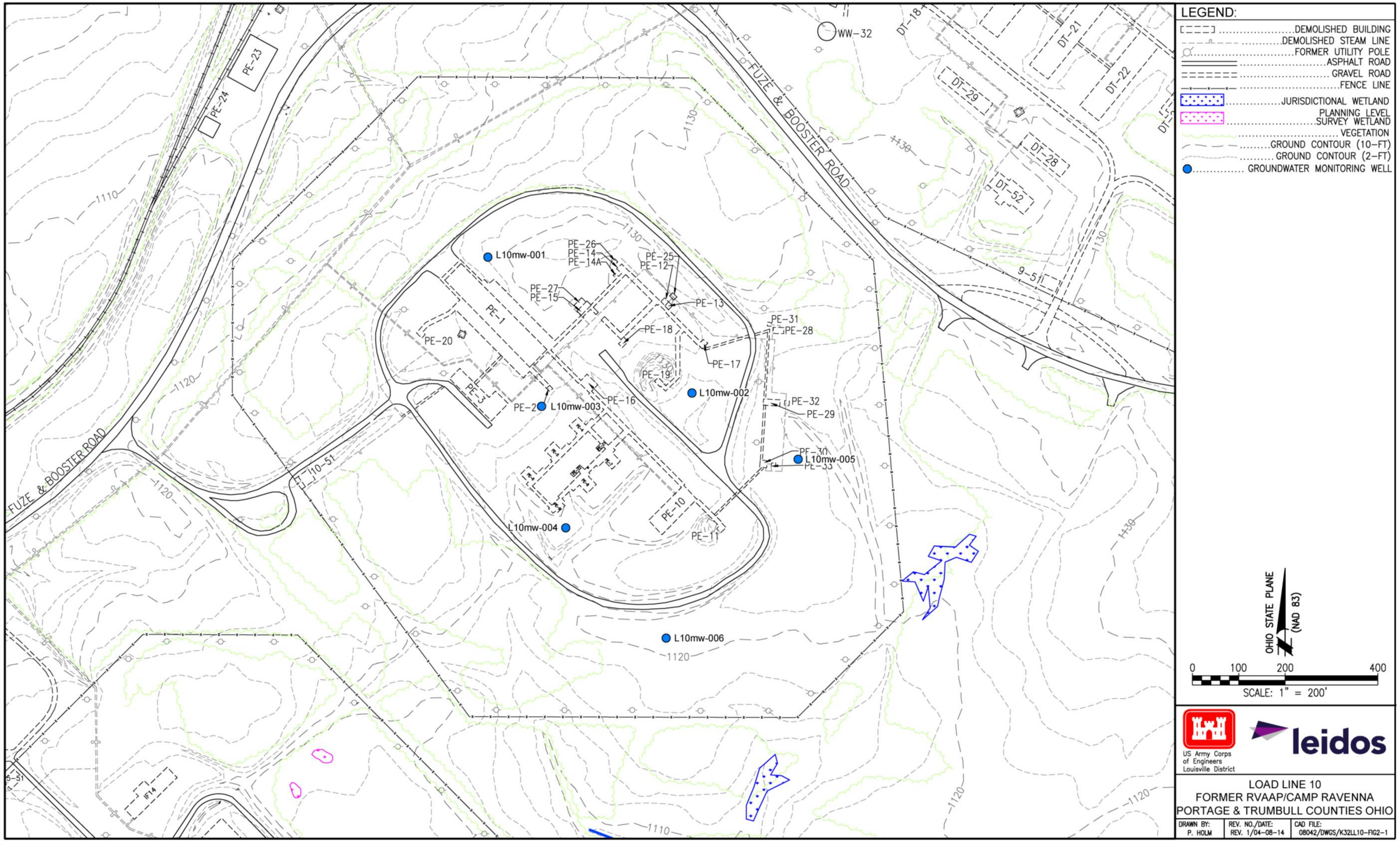


Figure 2-1. Site Features

THIS PAGE INTENTIONALLY LEFT BLANK.

3.0 ENVIRONMENTAL SETTING

This section describes the physical features, topography, geology, hydrogeology, and environmental characteristics of Camp Ravenna and Load Line 10 that are factors in identifying the potential contaminant transport pathways, receptor populations, and exposure scenarios to evaluate human health and ecological risks. This section also presents a preliminary CSM based on Load Line 10 characteristics and historical investigation data to provide a framework to evaluate contaminant nature and extent, fate and transport, and human health and ecological risk. An updated CSM is presented in Section 8.0 to integrate the results of evaluations performed in this report.

3.1 CAMP RAVENNA PHYSIOGRAPHIC SETTING

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

3.2 SURFACE FEATURES AND SITE TOPOGRAPHY

The topography of Camp Ravenna is gently undulating with an overall decrease in ground elevation from a topographic high of approximately 1,220 ft above mean sea level (amsl) in the far western portion of the facility to low areas at approximately 930 ft amsl in the far eastern portion of the facility. USACE mapped the facility topography in February 1998 using a 2 ft (60.1 cm) contour interval with an accuracy of 0.02 ft (0.61 cm). USACE based the topographic information on aerial photographs taken during the spring of 1997. The USACE survey is the basis for the topographical information illustrated in figures found in this report.

Load Line 10 is located south of Fuze and Booster Road, southwest of Load Line 9, northeast of Load Line 5, in the south-central portion of Camp Ravenna (Figure 1-2). All buildings and structures have been demolished and building slabs and footers have been removed. Remaining features at Load Line 10 include a one-lane asphalt access road that enters the AOC from the west and encircles the former production area, buildings, and access roads within the AOC (Figure 2-1). The Load Line 10 perimeter fence is still in place, although it is not currently maintained. Small construction drainage ditches border the access road and are also located in the former production area. Ground elevations within Load Line 10 range from 1,114-1,133 ft amsl (Figure 3-1). The central portion of Load Line 10 is a topographic high (or divide) with gentle slopes to the northwest and southeast outside of the former production area.

3.3 SOIL AND GEOLOGY

3.3.1 Regional Geology

The regional geology at Camp Ravenna consists of horizontal to gently dipping bedrock strata of Mississippian and Pennsylvanian age overlain by varying thicknesses of unconsolidated glacial deposits. The bedrock and unconsolidated geology at Camp Ravenna and geology specific to Load Line 10 are presented in the following subsections.

3.3.2 Soil and Glacial Deposits

Bedrock at Camp Ravenna is overlain by deposits of the Wisconsin-aged Lavery Till in the western portion of the facility and the younger Hiram Till and associated outwash deposits in the eastern portion. Unconsolidated glacial deposits vary considerably in their character and thickness across Camp Ravenna, from zero in some of the eastern portions of the facility to an estimated 150 ft (46 m) in the south-central portion (Figure 3-2).

Thin coverings of glacial material have been completely removed as a consequence of human activities at locations such as Ramsdell Quarry. Bedrock is present at or near the ground surface in many locations, such as at Load Line 1 and the Erie Burning Grounds (USACE 2001a). Where this glacial material is still present, its distribution and character indicate its origin is ground moraine. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments. Lacustrine sediment from bodies of glacial-age standing water has also been encountered in the form of deposits of uniform light gray silt greater than 50-ft thick in some areas (USACE 2001a).

Soil at Camp Ravenna is generally derived from the Wisconsin-age silty clay glacial till. Distributions of soil types are discussed and mapped in the *Soil Survey of Portage County, Ohio* (USDA 1978). Much of the native soil at Camp Ravenna was disturbed during construction activities in former production and operational areas of the facility.

The Sharon Member of the Pennsylvanian Pottsville Formation is the primary bedrock beneath Camp Ravenna. In the western half of the facility, the upper members of the Pottsville Formation, including the Connoquenessing Sandstone (also known as the Massillon Sandstone), Mercer Shale, and uppermost Homewood Sandstone, have been found. The regional dip of the Pottsville Formation measured in the western portion of Camp Ravenna is between 5-11.5 ft per mile to the south.

3.3.3 Geologic Setting of Load Line 10

The bedrock formation at Load Line 10, as inferred from existing geologic data, is the Pennsylvanian age Pottsville Formation, Homewood Sandstone Member, Mercer Member, and Sharon Sandstone (Figure 3-3). The northern third of Load Line 10, closest to Load Line 9, is Homewood Sandstone. The central portion is composed of the Mercer Member, and Sharon Sandstone is observed in the southern third of Load Line 10. Bedrock was encountered at Load Line 10 at 12.5-23 ft bgs during monitoring well installation activities as part of the Characterization of 14 AOCs (MKM 2007). During the PBA08 RI, top of bedrock was encountered in three soil borings (L10sb-066, L10sb-068 and L10sb-075) at 7-12 ft bgs (Appendix A).

The Homewood Sandstone Member, the uppermost unit of the Pottsville Formation, exhibits irregular and widely spaced bedding planes and vertical joints. The Homewood is fine-grained sandstone composed of well-rounded quartz grains and substantial quantities of mica. It is bonded with iron oxides and clay matter. The Mercer Member of the Pottsville Formation lies unconformably under the Homewood Sandstone and consists of silty to carbonaceous shale with abundant thin, discontinuous sandstone lenses in the upper portion. The oldest bedrock unit observed at Load Line 10 is the Sharon Shale Member. The shale unit of the Sharon Member is a gray, sandy to micaceous shale containing seams of siderite, coal, sandstone, and underclay.

Load Line 10 is located within Hiram Till glacial deposits. At Load Line 10, unconsolidated zone characteristics may vary in character due to site disturbances, including building construction, demolition, and re-grading. The soil type covering more than 98% of Load Line 10 is the Mahoning silt loam (MgB) (2-6% slopes). The Mahoning silt loam is a gently sloping, poorly drained soil formed in silty clay loam or clay loam glacial till, generally where bedrock is greater than 6 ft bgs. Mahoning silt loam has low permeability with rapid runoff and seasonal wetness (USDA 2010).

Geologic descriptions of subsurface soil samples collected during the PBA08 RI are generally consistent with the conclusions from the Characterization of 14 AOCs. As observed in PBA08 RI soil borings, the composition of unconsolidated deposits at the AOC generally consist of gray medium dense silt with sand content generally increasing with depth. Groundwater, when encountered, ranged from 6.8-18.9 ft bgs within fine- to medium-grained sand in the PBA08 RI soil borings. PBA08 RI boring logs containing geologic descriptions of unconsolidated deposits at Load Line 10 are contained in Appendix A.

Geotechnical analyses of subsurface soil samples conducted during the Characterization of 14 AOCs classify the samples as follows: L10mw-001 at 6-8 ft bgs was a brown silt with sand, L10mw-004 at 8-10 ft bgs was a brown sandy silt, and L10mw-005 at 4-6 ft bgs was brown, sandy lean clay with sand and trace gravel (MKM 2007). Analysis of one undisturbed geotechnical sample (Shelby tube) occurred during the PBA08 RI. The sample L10SB-068 from 4-5 ft bgs was categorized as a sandy silt; this is consistent with the results from the Characterization of 14 AOCs. A summary of PBA08 RI geotechnical analysis, including porosity, density, and moisture content, is presented in Section 5.2.4.

3.4 HYDROGEOLOGY

3.4.1 Regional Hydrogeology

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

The thickness of the unconsolidated interval at Camp Ravenna ranges from thin to absent in the eastern and northeastern portion of Camp Ravenna to an estimated 150 ft in the central portion of the facility. The groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones and desiccation cracks and partings within the soil column. Laterally, most groundwater flow likely follows topographic contours and stream drainage patterns, with preferential flow along pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeability than surrounding clay or silt-rich material. Figure 3-4 illustrates facility-wide potentiometric surface data in the unconsolidated interval from the January 2010 contemporaneous measurement event (EQM 2010).

Within bedrock units at Camp Ravenna, the principle water-bearing aquifer is the Sharon Sandstone/Conglomerate. Depending on the existence and depth of overburden, the Sharon Sandstone/Conglomerate ranges from an unconfined to a leaky artesian aquifer. Water yields from on-site water supply wells completed in the Sharon Sandstone/Conglomerate ranged from 30-400 gallons per minute (gpm) (USATHAMA 1978). Well yields of 5-200 gpm were reported for on-site bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer 1982). Other local bedrock units capable of producing water include the Homewood Sandstone, which is generally thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells completed in the Connoquenessing Sandstone in Portage County have yields ranging from 5-100 gpm but are typically less productive than the Sharon Sandstone/Conglomerate due to lower permeability (Winslow et al. 1966).

Figure 3-5 shows the potentiometric surface within bedrock strata at Camp Ravenna in January 2010 (EQM 2010). The bedrock potentiometric map shows a more uniform and regional eastward flow direction than the unconsolidated zone that is not as affected by local surface topography. Due to the lack of well data in the western portion of Camp Ravenna, general flow patterns are difficult to discern. For much of the eastern half of Camp Ravenna, bedrock potentiometric elevations are higher than the overlying unconsolidated potentiometric elevations, indicating an upward hydraulic gradient. This evidence suggests that there is a confining layer that separates the two aquifers. In the far eastern area, the two potentiometric surfaces are at approximately the same elevation, suggesting that hydraulic communication between the two aquifers is occurring.

3.4.2 Load Line 10 Hydrologic/Hydrogeologic Setting

Six monitoring wells were installed at Load Line 10 during the Characterization of 14 AOCs. All groundwater monitoring wells were installed to monitor groundwater in the shallow bedrock aquifer. The bedrock aquifer is observed at L10mw-006. Initial depths to groundwater encountered during groundwater monitoring well installation varied from 14 ft bgs in L10mw-002 to 24 ft bgs in L10mw-004. Groundwater monitoring wells at the AOC ranged from 23.5-31 ft bgs. All monitoring wells are currently sampled under the Facility-wide Groundwater Monitoring Program (FWGWMP). Potentiometric data indicate the groundwater table occurs within bedrock throughout most of the AOC (wells L10mw-001 through L10mw-005), with the exception of well L10mw-006.

The potentiometric surface of the AOC from the January 2010 monitoring event is shown in Figure 3-1. The estimated groundwater flow directions reflect the January 2010 facility-wide potentiometric data presented in the *Facility-Wide Groundwater Monitoring Program Report on the January 2010 Sampling Event* (EQM 2010). Water level elevations at the AOC ranged from 1107.14-1111.05 ft amsl (10.15-22.86 ft bgs) with the highest elevation at well L10mw-006. Available historical data does not show large seasonal fluctuation changes in the general groundwater flow direction. The potentiometric surface is a subdued replica of the topographic surface and shows a flow divide through the central portion of the AOC. Groundwater flow from this divide is to the north and south. Hydraulic gradient across the AOC ranges from 0.0015 ft/ft to the south of the divide to 0.0065 ft/ft to the north-northwest of the divide, with an average value of 0.003 ft/ft.

Results of slug tests performed at the six monitoring wells during the Characterization of 14 AOCs indicate an average hydraulic conductivity of 2.55E-04 cm/s (MKM 2007). Table 3-1 presents the hydraulic conductivities for each groundwater monitoring well at Load Line 10.

Table 3-1. Hydraulic Conductivities Measured During the Characterization of 14 AOCs

Monitoring Well ID	Screened Interval (ft bgs)	Geologic Material Adjacent to Screen	Hydraulic Conductivity (cm/s)
L10mw-001	17-27	Sandstone	1.76E-04
L10mw-002	17-27	Sandstone	3.04E-04
L10mw-003	16-26	Sandstone	2.60E-04
L10mw-004	21-31	Sandstone	3.17E-04
L10mw-005	16.5-26.5	Sandstone	2.76E-04
L10mw-006	13.5-23.5	Sand, sandy silt, and silty sand	1.97E-04

Source: Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007)
AOC = Area of concern.
bgs = Below ground surface.
cm/s = Centimeters per second.
ID = Identification.

3.4.3 Surface Water

The following sections describe the regional and AOC-specific surface water.

3.4.3.1 Regional Surface Water

Camp Ravenna resides within the Mahoning River watershed, which is part of the Ohio River Basin. The west branch of the Mahoning River is the main surface stream in the area that flows adjacent to the west end of the facility, generally in a north to south direction, before flowing into the Michael J. Kirwan Reservoir, located to the south of State Route 5 (Figure 1-1). The west branch of the Mahoning River flows out of the reservoir and parallels the southern Camp Ravenna boundary before joining the Mahoning River east of Camp Ravenna. The western and northern portions of Camp Ravenna display low hills and a dendritic surface drainage pattern. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection of the surface drainage. The facility is marked with marshy areas and flowing and intermittent streams whose headwaters are located in the upland areas of the facility.

The three primary watercourses that drain Camp Ravenna are (Figure 1-2):

1. South Fork Eagle Creek;
2. Sand Creek; and
3. Hinkley Creek.

These watercourses have many associated tributaries. Sand Creek has a drainage area of 13.9 square miles (36 km^2) and generally flows in a northeast direction to its confluence with South Fork Eagle Creek. In turn, South Fork Eagle Creek continues in a northerly direction for 2.7 miles (4.3 km) to its confluence with Eagle Creek. The drainage area of South Fork Eagle Creek is 26.2 square miles (67.8 km^2), including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Route 88 and State Route 303 to the north of the facility. Hinkley Creek, with a drainage area of 11.0 square miles (28.5 km^2), flows in a southerly direction through the facility and converges with the west branch of the Mahoning River south of the facility (USACE 2001a).

Approximately one-third of Camp Ravenna meets the regulatory definition of a wetland, with the majority of the wetland areas located in the eastern portion of the facility. Wetland areas at Camp Ravenna include seasonal wetlands, wet fields, and forested wetlands. Many of the wetland areas are the result of natural drainage or beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas.

Approximately 50 ponds are scattered throughout the facility. Many were constructed within natural drainage ways to function as settling ponds or basins for process effluent and runoff. Others are natural in origin, resulting from glacial action or beaver activity. Water bodies at Camp Ravenna support aquatic vegetation and biota as described in Section 3.6.2. Storm water runoff is controlled primarily by natural drainage except in former operations areas where an extensive storm sewer network helps to direct runoff to drainage ditches and settling ponds. In addition, the storm sewer system was one of the primary drainage mechanisms for process effluent while production facilities were operational.

3.4.3.2 Load Line 10 Surface Water

Surface water drainage generally follows the topography of Load Line 10 and drains toward the south-southwest. No perennial surface water features are present within Load Line 10 or in the immediate vicinity. Intermittent surface water flows in small drainage ditches bordering roads and within the former production area (Figure 3-1). These ditches contain water for short periods of time only during precipitation or periods of snow melt. Surface water drainage from the southern two-thirds of Load Line 10 exits to the south through a drainage channel that flows south-southeast and eventually gains sufficient base flow to become a perennial stream about 1,800 ft south of the AOC. This stream merges with others draining the south-central portion of the facility and flows southeast past the former Administrative Area, exits the facility beneath State Route 5 east of the former Administrative Area, and ultimately discharges into the west branch of the Mahoning River downstream of the Michael J. Kirwan Reservoir dam (Figure 1-2). In the northern portion of Load Line 10, several small drainage ditches direct surface runoff to the northwest, ultimately into larger drainage ditches that border Fuze and Booster Road.

3.5 CLIMATE

The general climate of Camp Ravenna is continental and characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. The climate data presented below for Camp Ravenna were obtained from available National Weather Service records for the 30-year period of record from 1981 to 2010 at the Youngstown Regional Airport, Ohio (http://www.weather.gov/climate/xmacis.php?wfo=cle). Wind speed data for Youngstown, Ohio, are from the National Climatic Data Center for the available 53-year period of record from 1950 through 2002 (http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html).

Average annual rainfall in Camp Ravenna is 38.86 inches, with the highest monthly average occurring in July (4.31 inches) and the lowest monthly average occurring in February (2.15 inches). Average annual snowfall totals approximately 62.9 inches with the highest monthly average occurring in January (17.1 inches). Due to the influence of lake-effect snowfall events associated with Lake Erie (located approximately 35 miles to the northwest of Camp Ravenna), snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in Camp Ravenna is 49.3ºF, with an average monthly high temperature of 70.9ºF in July and an average monthly low temperature of 26.1ºF in January. The highest daily maximum temperature of 100ºF occurred in July 1988, and the record low temperature of -22ºF occurred in January 1994. The prevailing wind direction at Camp Ravenna is from the southwest, with the highest average wind speed occurring in January (11.4 miles per hour) and the lowest average wind speed occurring in August (7.4 miles per hour). Thunderstorms occur approximately 35 days per year and are most abundant from April through August. Camp Ravenna is susceptible to tornadoes; minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

3.6 POTENTIAL RECEPTORS AT LOAD LINE 10

The following sections discuss potential human and ecological receptors at Load Line 10.

3.6.1 Human Receptors

Camp Ravenna is a controlled-access facility. Load Line 10 is located in the south-central portion of the facility and is not currently used for training. Three Land Uses for the RVAAP restoration program are considered during the RI as specified in the *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program* (ARNG 2014) along with Representative Receptors:

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child)
2. Military Training Land Use – National Guard Trainee
3. Commercial/Industrial Land Use – Industrial Receptor (USEPA's Composite Worker)

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of the Commercial/Industrial Land Use as an Alternative, if it achieves NFA for Unrestricted (Residential) Land Use.

3.6.2 Ecological Receptors

Camp Ravenna has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas. The vegetation and habitat resources referenced in this report are taken from and documented in the *Integrated Natural Resources Management Plan and Environmental Assessment for the Ravenna Training and Logistics*

Site, Portage and Trumbull Counties, Ohio (OHARNG 2008) (herein referred to as the INRMP). Revisions to this document and the Rare Species List are underway; however, documents associated with PBA08 will reference and utilize information from the 2008 INRMP.

Vegetation at Camp Ravenna can be grouped into three categories: herb-dominated, shrub-dominated, and tree-dominated. Approximately 60% of the facility is covered by forest- or tree-dominated vegetation. The facility has a total of seven forest formations, four shrub formations, eight herbaceous formations, and one non-vegetated formation (OHARNG 2008).

Surface water features within Camp Ravenna include a variety of streams, ponds, floodplains, and wetlands. Numerous streams drain the facility, including approximately 19 miles of perennial streams. The total combined length of streams at the facility is 212 linear miles. Approximately 153 acres of ponds are found on the facility. These ponds provide valuable wildlife habitat and support wood ducks, hooded mergansers, mallards, Canada geese, and many other birds and wildlife species. Some ponds have been stocked with fish and are used for fishing and hunting (OHARNG 2008).

Wetlands are abundant and prevalent throughout the facility. These wetland areas include seasonal wetlands, wet fields, and forested wetlands. Most of the wetland areas on the facility are the result of natural drainage and beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas.

An abundance of wildlife is present on the facility; 35 species of land mammals, 214 species of birds, 41 species of fish, and 34 species of amphibians and reptiles have been identified. No federally listed species are known to reside at the facility, and no critical habitat occurs (OHARNG 2008). Ohio state-listed plant and animal species have been identified through confirmed sightings and/or biological inventories at the facility and are presented in Table 3-2. Load Line 10 is surrounded by forest with the exception of the former perimeter and access roads within the AOC around the former buildings. Additional information specific to ecological resources at Load Line 10 is included in Section 7.3.

Table 3-2. Federal- and State-listed Species List

CAMP RAVENNA JOINT MILITARY TRAINING CENTER (CRJMTC) RARE SPECIES LIST
27 April 2010

I. Species confirmed to be on CRJMTC property by biological inventories and confirmed sightings.

A. State Endangered

1. American bittern, *Botaurus lentiginosus* (migrant)
2. Northern harrier, *Circus cyaneus*
3. Yellow-bellied Sapsucker, *Sphyrapicus varius*
4. Golden-winged warbler, *Vennivora chrysoptera*
5. Osprey, *Pandion haliaetus* (migrant)
6. Trumpeter swan, *Cygnus buccinators* (migrant)
7. Mountain Brook Lamprey, *Ichthyomyzon greeleyi*
8. Graceful Underwing, *Catocala gracilis*
9. Tufted Moisture-loving Moss, *Philonotis Fontana var. caespitosa*
10. Bobcat, *Felis rufus*
11. Narrow-necked Pohl's Moss, *Pohlia elongata var. elongate*
12. Sandhill Crane, *Grus Canadensis* (probable nester)
13. Bald Eagle, *Haliaetus leucocephalus* (nesting pair)

B. State Threatened

1. Barn owl, *Tyto alba*
2. Dark-eyed junco, *Junco hyemalis* (migrant)
3. Hermit thrush, *Catharus guttatus* (migrant)
4. Least bittern, *Ixobrychus exilis*
5. Least flycatcher, *Empidonax minimus*
6. *Psilotreta indecisa* (caddis fly)
7. Simple willow-herb, *Epilobium strictum*
8. Woodland Horsetail, *Equisetum sylvaticum*
9. Lurking leskea, *Plagiothecium latebricola*
10. Pale sedge, *Carex pallescens*

C. State Potentially Threatened Plants

1. Gray Birch, *Betula populifolia*
2. Butternut, *Juglans cinerea*
3. Northern rose azalea, *Rhododendron nudiflorum var. roseum*
4. Hobblebush, *Viburnum alnifolium*
5. Long Beech Fern, *Phegopteris connectilis (Thelypteris phegopteris)*
6. Straw sedge, *Carex straminea*
7. Water avens, *Geum rivale*
8. Tall St. John's wort, *Hypercium majus*
9. Swamp oats, *Sphenopholis pensylvanica*
10. Shining ladies'-tresses, *Spiranthes lucida*
11. Arbor Vitae, *Thuja occidentalis*
12. American Chestnut, *Castanea dentate*

Table 3-2. Federal and State-Listed Species List (continued)

D. State Species of Concern

1. Pygmy shrew, *Sorex hovi*
2. Star-nosed mole, *Condylura cristata*
3. Woodland jumping mouse, *Napaeozapus insignis*
4. Sharp-shinned hawk, *Accipiter striatus*
5. Marsh wren, *Cistothorus palustris*
6. Henslow's sparrow, *Ammodramus henslowii*
7. Cerulean warbler, *Dendroica cerulea*
8. Prothonotary warbler, *Protonotaria citrea*
9. Bobolink, *Dolichonyx oryzivorus*
10. Northern bobwhite, *Colinus virginianus*
11. Common moorhen, *Gallinula chloropus*
12. Great egret, *Ardea alba* (migrant)
13. Sora, *Porzana carolina*
14. Virginia Rail, *Rallus limicola*
15. Creek heelsplitter, *Lasmigona compressa*
16. Eastern box turtle, *Terrapene carolina*
17. Four-toed Salamander, *Hemidacrylium scuta/um*
18. *Stenonema ithica* (mayfly)
19. *Apamea mixta* (moth)
20. *Brachylomia algens* (moth)
21. Sedge wren, *Cistothorus platensis*

E. State Special Interest

1. Canada warbler, *Wilsonia canadensis*
2. Little blue heron, *Egretta caerula*
3. Magnolia warbler, *Dendroica magnolia*
4. Northern waterthrush, *Seiurus noveboracensis*
5. Winter wren, *Troglodytes troglodytes*
6. Back-throated blue warbler, *Dendroica caerulescens*
7. Brown creeper, *Certhia americana*
8. Mourning warbler, *Oporornis philadelphia*
9. Pine siskin, *Carduelis pinus*
10. Purple finch, *Carpodacus purpureus*
11. Red-breasted nuthatch, *Sitta canadensis*
12. Golden-crowned kinglet, *Regulus satrapa*
13. Blackburnian warbler, *Dendroica fusca*
14. Blue grosbeak, *Guiraca caerulea*
15. Common snipe, *Gallinago gallinago*
16. American wigeon, *Anas americana*
17. Gadwall, *Anas strepera*
18. Green-winged teal, *Anas crecca*
19. Northern shoveler, *Anas clypeata*
20. Redhead duck, *Aythya americana*
21. Ruddy duck, *Oxyura jamaicensis*

NOTE: There are currently no federally listed species or critical habitat on CRJMTC property. There are a few species currently under federal observation for listing, but none listed.

3.7 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary CSM was developed in the *Performance Based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1* (herein referred to as the PBA08 SAP) to develop sampling rationales and data quality objectives (DQOs) for the PBA08 RI at Load Line 10 (USACE 2009b). The preliminary CSM included a description of primary (active) and secondary (e.g., residual contaminants in soil) contaminant sources, migration pathways, contaminant discharge points, and potential receptors based on operational history and prior investigations. This preliminary CSM, summarized below, is further refined in Section 8.0 to integrate results of the contaminant nature and extent evaluation, fate and transport modeling, HHRA, and ERA.

3.7.1 Contaminant Sources

No primary contaminant sources from building structures remain at Load Line 10. Secondary sources (contaminated media) identified in previous investigations and further characterized during the PBA08 RI are described in the following sections.

3.7.1.1 Soil

Based on previous characterization, contaminated surface and subsurface soil in Load Line 10 may represent a potential secondary source of contamination to surface water and groundwater. Analysis of Load Line 10 surface soil data under the Characterization of 14 AOCs identified the presence of several metals as COPCs for human and ecological receptors. Subsurface soil has not been previously evaluated. A total of 15 surface soil ISM samples, three chromium speciation samples, nine soil borings, and one geotechnical boring were installed during the PBA08 RI to further define the horizontal and vertical extent of contamination.

3.7.1.2 Sediment and Surface Water

Perennial surface water features with associated sediment are not present within Load Line 10. Surface water at Load Line 10 occurs as intermittent storm water runoff within natural and constructed drainage ditches or conveyances (Figure 3-1). Sediment within these drainage ditches is considered dry sediment and is addressed with surface soil as a potential secondary source of contaminants. Overland flow associated with storm events generally follows the topography of the AOC and drains to the north and south away from a topographic high area within the former production area. No sediment or surface water samples, with the exception of samples collected from building structures (i.e., sumps and sewers), have been previously collected at Load Line 10. A sediment and surface water sample were collected from a ditch exiting the AOC to the south after significant snowmelt during the PBA08 RI to define the extent of contamination.

3.7.1.3 Groundwater

Previous groundwater sampling results at Load Line 10 identified one VOC (carbon tetrachloride) and one SVOC (phenanthrene) as COPCs (MKM 2007). Groundwater discharge to surface water features (e.g., via baseflow to streams or springs) does not occur within the AOC. The closest potential groundwater discharge locations are a tributary to Sand Creek approximately 1,875 ft to the north and an unnamed stream approximately 1,000 ft to the south.

Leaching soil chemicals to groundwater with subsequent lateral migration to a surface water receptor represents a potential contaminant release mechanism and migration pathway.

Groundwater at Camp Ravenna is evaluated on a facility-wide basis, sampled under the FWGWMP, and will be evaluated through the CERCLA process in a separate report. Potential leaching of soil contaminants to groundwater is evaluated through fate and transport modeling in this RI.

3.7.2 Migration Pathways

Two contaminant migration pathways were identified based on AOC characteristics and historical data: lateral migration of surface soil through storm water runoff, and vertical migration of soil contaminants to groundwater. Surface water represents a periodic mechanism for lateral migration of residual contaminants from surface soil within the former operations area to the drainage conveyances across the AOC. Contaminants in surface water may migrate in a dissolved phase or be adsorbed to particulates and re-suspended during periods of heavy runoff. Leaching sediment and soil contaminants to groundwater (vertical migration) with subsequent lateral migration is also a potential migration pathway. Modeling of contaminant leaching from soil and sediment sources and transport via groundwater is included in this RI; however, a full evaluation of the groundwater pathway will be addressed in a separate report.

3.7.3 Contaminant Discharge Points

Contaminants are not confined within the AOC boundary, as surface water runoff flows towards drainage ditches that exit the AOC. Intermittent surface water flows within the southern two-thirds of Load Line 10 and discharges to a natural drainage channel at the south boundary of the AOC. The southern drainage channel eventually gains sufficient base flow to become perennial approximately 1,800 ft to the south-southeast of Load Line 10 (Figure 1-2). In the northern portion of the AOC, several small drainage ditches, primarily along the former production area perimeter road, direct surface water flow to the northwest toward larger ditches along Fuze and Booster Road that flow to the northeast and southwest (Figure 3-1). The closest identified potential discharge points for groundwater are an unnamed tributary to Sand Creek approximately 1,875 ft to the north of Load Line 10 and the unnamed southern drainage channel at the point where groundwater base flow to the channel becomes sufficient to maintain perennial flow. Leaching soil and sediment contaminants to groundwater, with subsequent lateral migration to either surface water discharge or exposure points, are potential migration pathways and are further evaluated in Section 6.0.

3.7.4 Potential Receptors

Potential human health and ecological receptors for the AOC, based on current land use, future use, and present-day ecological resources, were discussed in Section 3.6. The future potential for human exposure to contaminants associated with this AOC is primarily for Military Training, and terrestrial and aquatic receptors are present in the AOC’s vicinity. Therefore, an HHRA and ERA were conducted as part of the PBA08 RI, and the results are integrated into the updated CSM presented in Section 8.0.

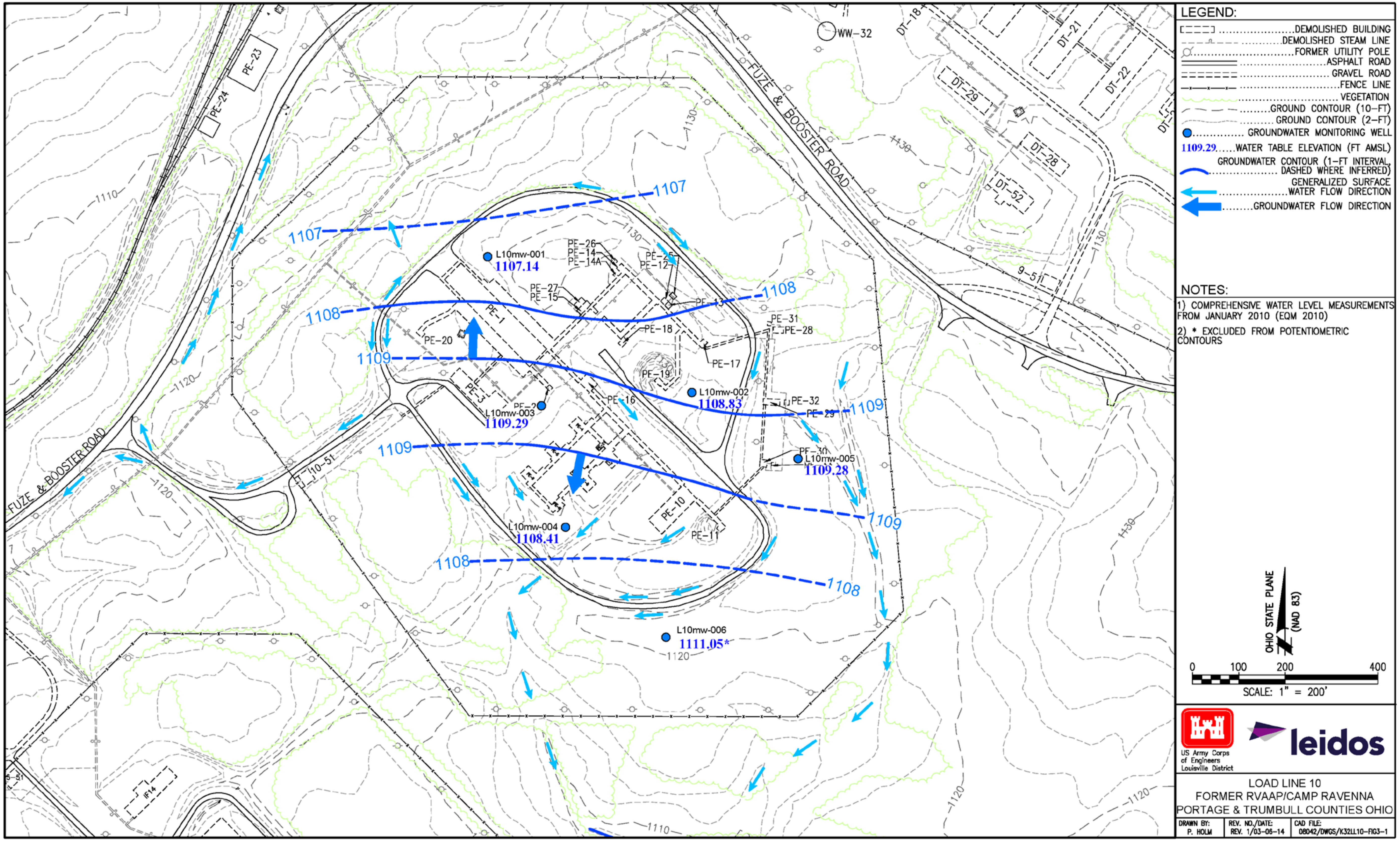
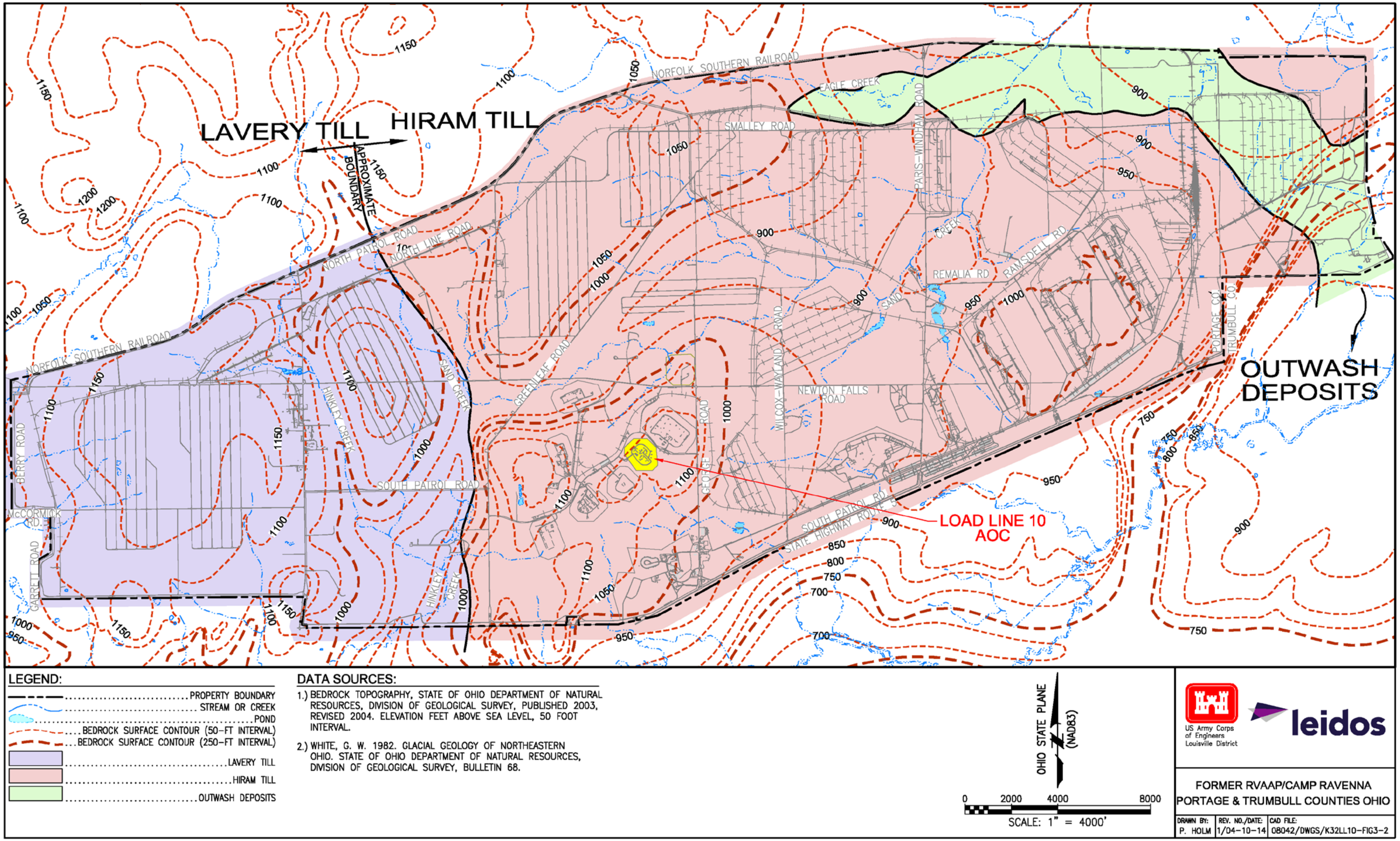


Figure 3-1. Topography, Groundwater Flow, and Surface Water Flow at Load Line 10

THIS PAGE INTENTIONALLY LEFT BLANK.



DATA SOURCES:

1.) BEDROCK TOPOGRAPHY, STATE OF OHIO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, PUBLISHED 2003, REVISED 2004. ELEVATION FEET ABOVE SEA LEVEL, 50 FOOT INTERVAL.

2.) WHITE, G. W. 1982. GLACIAL GEOLOGY OF NORTHEASTERN OHIO. STATE OF OHIO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, BULLETIN 68.

Figure 3-2. Geologic Map of Unconsolidated Deposits on Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

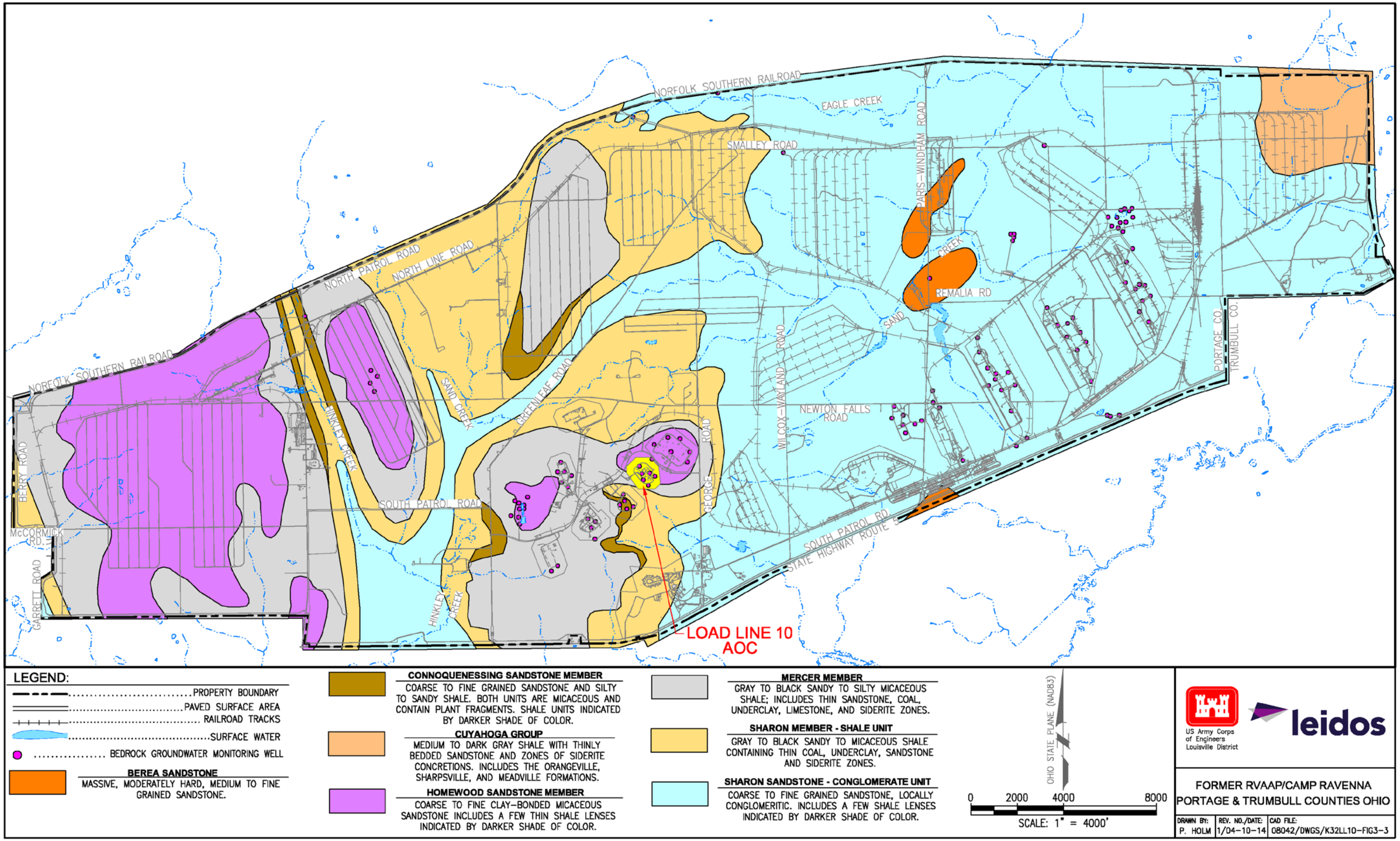


Figure 3-3. Geologic Bedrock Map and Stratigraphic Description of Units on Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

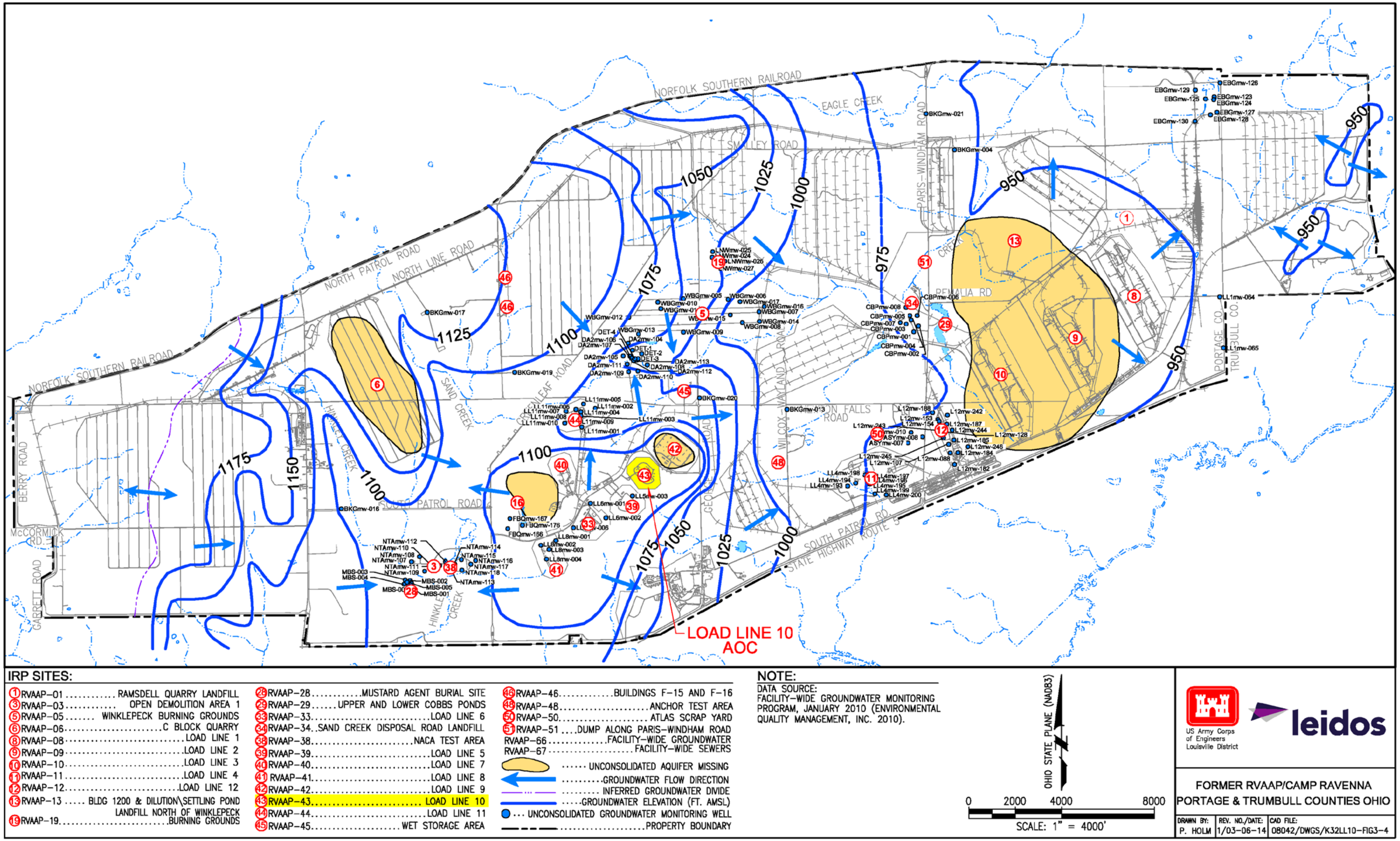


Figure 3-4. Potentiometric Surface of Unconsolidated Aquifer at Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

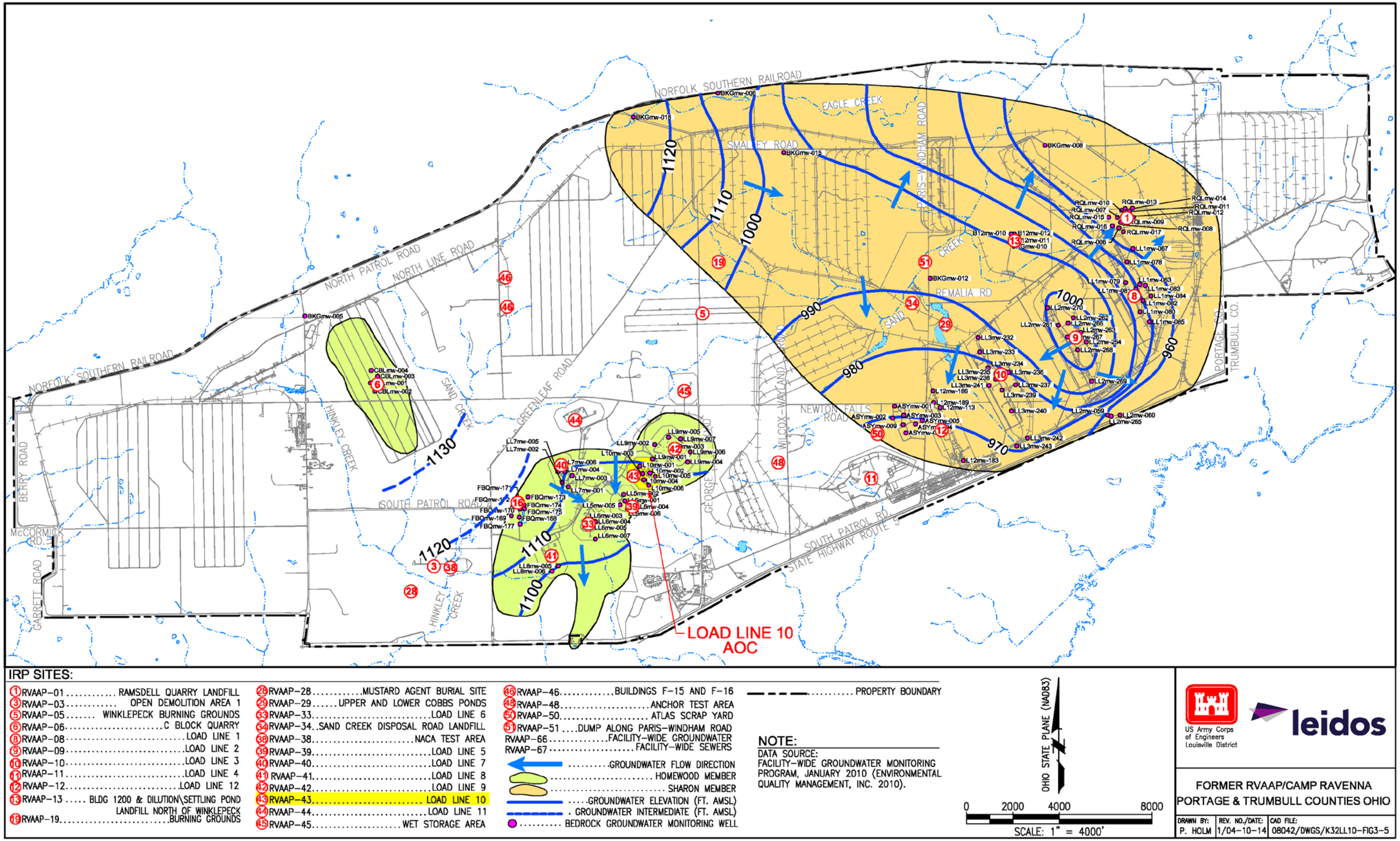


Figure 3-5. Potentiometric Surface of Bedrock Aquifers at Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

4.0 REMEDIAL INVESTIGATION

This section presents the methods used for developing DQOs, collecting field data, and managing analytical data and laboratory programs for the PBA08 RI at Load Line 10. The PBA08 RI was implemented in accordance with the PBA08 SAP to supplement historical data and complete the RI phase of the CERCLA process. The results of the PBA08 RI sampling are combined with the results of 2004 and 2007 sampling events to evaluate the nature and extent of contamination, assess potential future impacts to groundwater, conduct HHRAs and ERAs, and evaluate the need for remedial alternatives.

As presented in Section 2.2.3, there have been several investigations at Load Line 10, including the HHRS and ERS presented in the Characterization of 14 AOCs report. As part of the PBA08 RI DQOs, an initial screening approach was used to help focus the investigation on specific chemicals and areas to be further evaluated by assessing the nature and extent of contamination observed in historical samples (Section 3.2.2 of the PBA08 SAP). The screening approach presented in the PBA08 SAP compared sample results from previous investigations at Load Line 10 to the most protective chemical-specific Facility-wide Cleanup Goals (FWCUGs) at the 1E-06 cancer risk level and non-carcinogenic risk Hazard Quotient (HQ) of 0.1, as presented within the Chemical of Ecological Concern (FWHHRAM). The most protective FWCUGs are referred to as “screening criteria”. Previous results were also compared to FWCUGs at the higher target risk (TR) of 1E-05 and HQ of 1.0 to facilitate identifying potential source areas that may require additional sampling to refine the extent of contamination. Table 4-1 lists the chemicals with detected concentrations that exceed screening criteria in historical soil samples. Sediment and surface water samples collected during the previous investigation were only associated with infrastructure (i.e., sumps and sewers) and not with ditches, so they were not used in the evaluation of this RI Report.

Samples collected in support of the building slab removal (USACE 2009a) presented in Section 2.0 were not considered in the DQO evaluation since these data were not received and validated at that time. These data are not included in Table 4-1. However, these samples and any additional chemicals detected in samples collected historically and during the PBA08 RI are further evaluated in this report.

Representatives of RVAAP, Ohio EPA, USACE Louisville, and Camp Ravenna reviewed and approved the PBA08 RI sample locations and rationale as part of the approval process for the PBA08 SAP in December 2009. The PBA08 RI, conducted from February through April 2010, included collecting surface water, sediment, surface soil, and subsurface soil using discrete sampling techniques. Additionally, surface soil was collected using ISM techniques. No groundwater samples were collected during the PBA08 RI, as the current conditions of groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS report. The following sections describe the rationale and sample collection methods for each component of the PBA08 RI field investigation.

Table 4-1. Chemicals Detected at Concentrations above Screening Criteria in Previous Investigations

Surface Soil	Subsurface Soil
Aluminum Arsenic Chromium Cobalt Lead Benzo(a)pyrene	Medium not sampled

4.1 SOIL CHARACTERIZATION

Soil samples were collected during the PBA08 RI to assess contaminant occurrence and distribution in surface and subsurface soil. The decision-making matrices for the surface soil and subsurface soil sampling plans are presented in Figures 4-1 and 4-2, respectively.

4.1.1 Surface Soil Sampling Rationale and Methods

Since ISM was used for surface soil (0-1 ft bgs) as part of the Characterization of 14 AOCs, ISM was also used for surface soil sampling during the PBA08 RI. The PBA08 RI sampled locations with the greatest likelihood of contamination (e.g., adjacent to production buildings or within sediment accumulation areas, such as ditches). Each ISM result was evaluated separately against the screening criteria for each chemical analyzed. Surface soil sampling to define the lateral extent of contamination was conducted according to the decision rules approved in the PBA08 SAP and is depicted in Figure 4-1. All PBA08 RI surface soil samples were collected using ISM or discrete sampling techniques.

A total of 22 surface soil (19 ISM and three discrete) samples were collected at Load Line 10 during the PBA08 RI. Three ISM samples were collected around former ISM sample areas to delineate locations where chemicals were detected above FWCUGs and to further define the lateral extent of contamination (Figure 4-3). A total of 14 multi-acre ISM samples, including QA/QC samples, were collected to complete characterization of the AOC. Multi-acre ISM sample locations ranged from 1.8-4.1 acres in extent, encompassing the entirety of the AOC as defined by the Load Line 10 fence line. Additionally, three discrete samples were collected to evaluate chromium speciation.

ISM samples were analyzed for TAL metals, explosives, and PAHs. Discrete samples for chromium speciation were analyzed for total and hexavalent chromium. Three ISM samples (15% of the total number of ISM samples collected) were analyzed for RVAAP full-suite analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and nitroguanidine), SVOCs, VOCs, PCBs, and pesticides]. Nitroglycerin was analyzed under USEPA Method 8330 and is reported as an explosive chemical. Table 4-2 presents the specific rationale for each surface soil sample collected for the PBA08 RI.
For the PBA08 RI, the corners of each of the designated ISM sampling areas were located using a digital global positioning system (GPS) and were marked using wooden stakes. Sampling crews selected aliquot locations by walking over the entire ISM sampling area and marking the requisite

number of points using flagging. At least 30 aliquots were collected for each ISM sample. Aliquot locations were randomly selected in the field and were not predetermined using a grid.

Approximately equal sample volume aliquots were collected from a depth of 0-1 ft bgs using a decontaminated ⅝-inch diameter push probe. A soil description was completed for each ISM sample and is included in Appendix A.

All aliquots collected from a given ISM sample area were combined in a labeled container for transport to the laboratory in accordance with the PBA08 SAP. At the laboratory, each sample was air-dried, sieved, and ground for specified non-volatile chemical analyses.

QC field duplicate and QA split samples were collected from the ISM sample areas at 10% frequency (two samples). The QC field duplicate samples were submitted to the laboratory as “blind” and were used to determine whether the field sampling technique was reproducible, and as an indicator of sample heterogeneity. The QA split samples were sent to a USACE QA laboratory for independent analysis and evaluation of analytical results obtained by the primary laboratory.

QA/QC samples were collected as replicate ISM samples requiring three separate ISM samples from the same sample area. The QA/QC samples were collected from a set of 30 aliquot locations that were positioned adjacent to the location used for the initial ISM sample. Aliquots for QA/QC samples were collected in separate stainless steel bowls and were placed into separate labeled containers.

ISM was not utilized for samples collected for VOC analysis because the air drying, mixing, and sieving of aliquots required by the method could result in the loss of VOCs from the sample. For ISM sample areas designated for VOC analysis, one discrete sample was collected from a depth of 0-1 ft bgs within the ISM sample area using the bucket hand auger method described in the PBA08 SAP. The specific location of the discrete sample was randomly chosen. Soil portions designated for VOC analyses were not homogenized in the field but were placed directly in the sample container and compacted to zero headspace.

In addition to the ISM surface soil samples, three discrete chromium speciation samples were collected to evaluate the potential contribution of hexavalent chromium to the total chromium concentrations in soil. Samples from 0-1 ft bgs were collected in accordance with the bucket hand auger method described in Section 4.5.2.1.1 of the *Facility-Wide Sampling and Analysis Plan* (USACE 2001a) (herein referred to as the FWSAP). An updated version of the FWSAP was developed in February 2011 and approved by the Ohio EPA; however, the PBA08 RI was implemented prior to approval of this updated version. Two samples were collected from areas previously identified as having elevated total chromium concentrations, and one sample was collected from an area previously identified as having a total chromium concentration near background concentrations. Field duplicate samples were not collected for chromium speciation samples. A sample log including soil description was completed for each sample, and all logs are included in Appendix A.

Following collection of discrete samples, excess soil was designated as investigation-derived waste (IDW) and placed in lined, labeled 55 gallon drums that were sealed after use and staged at Building 1036. IDW management practices for all media are discussed in Appendix F.

Hand auger borings were backfilled to the ground surface with dry bentonite chips and hydrated with the project-approved potable water.

4.1.2 Subsurface Soil Sampling Rationale and Methods

The PBA08 RI used discrete samples from soil borings to complete the characterization of subsurface soil. The subsurface soil decision rules are presented in Figure 4-2 and were based upon prior surface soil sampling results to define the vertical extent of contamination. The subsurface soil was characterized by placing borings in various areas, including areas with previous results greater than the screening criteria, areas with previous results only slightly greater than the screening criteria, and areas not previously sampled. Subsurface soil sampling was conducted according to the decision rules approved in the PBA08 SAP.

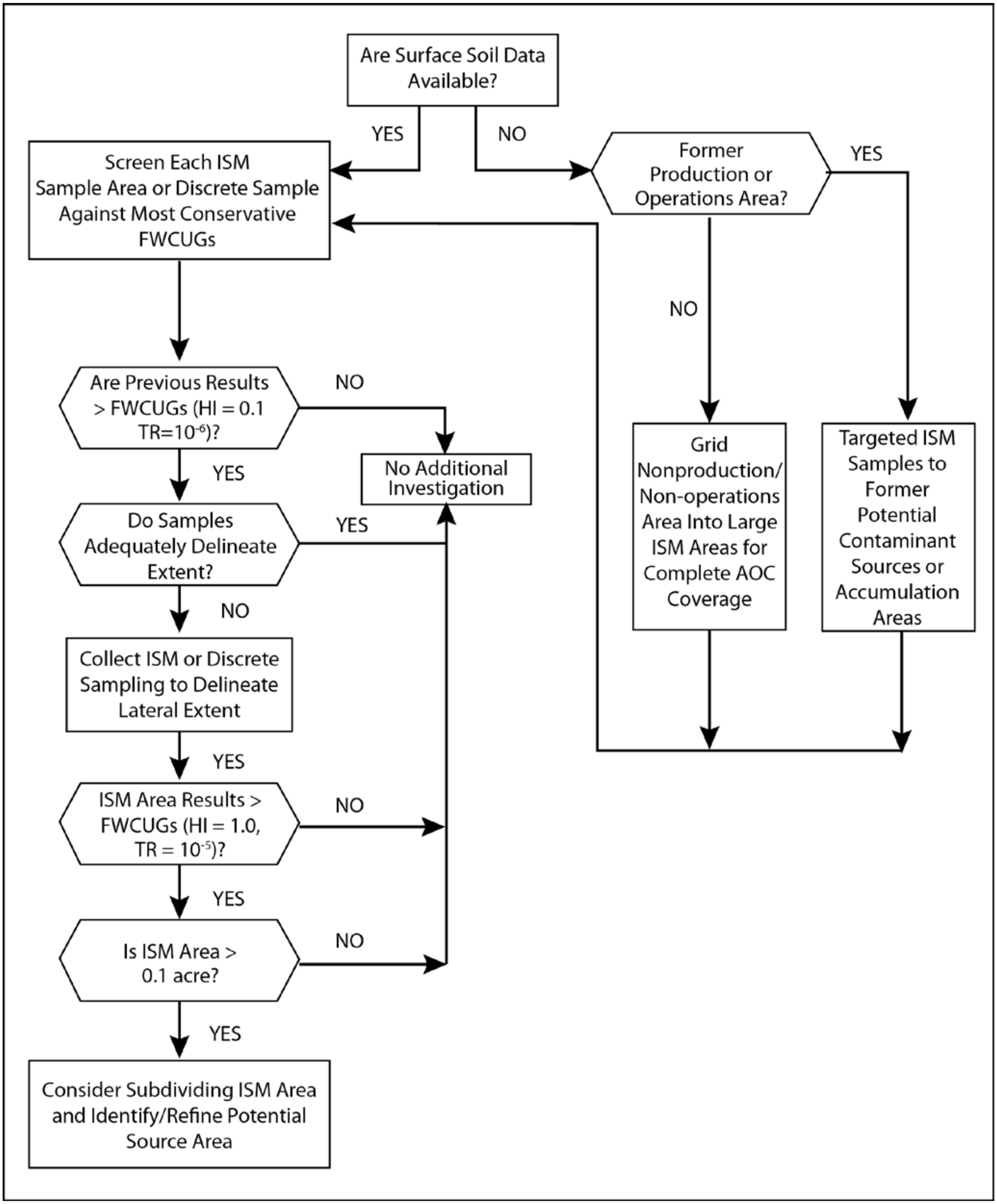
In all cases, subsurface borings were biased toward areas where contamination from historic uses or site drainage was most likely. Soil samples from nine soil borings installed in ISM areas with historical screening criteria exceedances were collected to further delineate the vertical extent of contamination in subsurface soil at the AOC (Figure 4-3). These included three samples in downgradient drainage ditches and six samples in previous ISM areas. Table 4-3 presents the specific rationale for each subsurface soil sample collected for the PBA08 RI.

Subsurface soil borings were completed by direct push technology (DPT) using a Geoprobe® and/or hand auger. DPT soil samples were collected in a single-use acetate liner at discrete sample locations and hand auger samples were collected in a chemically decontaminated 3-inch diameter stainless steel auger bucket. The sampling depth intervals were presented in the PBA08 SAP. Each soil boring was sampled at the following intervals: 0-1 ft bgs, 1-4 ft bgs, 4-7 ft bgs, and 7-13 ft bgs. Each interval was composited and homogenized in a stainless steel bowl, with the exception of VOC samples. The sample collected from the 7-13 ft bgs interval was archived on site, while the 4-7 ft bgs interval sample was analyzed under an expedited five day turnaround time. As specified in the PBA08 SAP, if there was one chemical concentration that exceeded screening criteria in the 4-7 ft bgs sample, the 7-13 ft bgs sample was analyzed. In addition, at least 10% of all subsurface samples from 7-13 ft bgs were submitted for laboratory analysis to ensure adequate characterization of the subsurface soil to 13 ft bgs. Two samples collected from the 7-13 ft bgs sample interval were submitted for laboratory analysis for Load Line 10.

Table 4-2. PBA08 RI Surface Soil Samples and Rationales

Sample Type	Depth (ft bgs)	Station	Sample	Date Sampled	Comments/Rationale
ISM	0-1	L10ss-079M	L10SS-079M-5536-SO	4/13/2010	Delineate lateral extent of previously identified contamination
ISM	0-1	L10ss-080M	L10SS-080M-5537-SO	4/13/2010	Delineate lateral extent of previously identified contamination. Analyzed for RVAAP full-suite analytes
ISM	0-1	L10ss-081M	L10SS-081M-5538-SO	4/13/2010	Delineate lateral extent of previously identified contamination
ISM	0-1	L10ss-082M	L10SS-082M-5539-SO	4/13/2010	Characterize former non-operational area
ISM	0-1	L10ss-083M	L10SS-083M-5540-SO	4/13/2010	Characterize former non-operational area
ISM	0-1	L10ss-084M	L10SS-084M-5541-SO	4/13/2010	Characterize former non-operational area
ISM	0-1	L10ss-085M	L10SS-085M-5542-SO	4/13/2010	Characterize former non-operational area
ISM	0-1		L10SS-085M-6169-FD	4/13/2010	QA/QC
ISM	0-1		L10SS-085M-6168-QA	4/13/2010	
ISM	0-1	L10ss-086M	L10SS-086M-5543-SO	4/13/2010	Characterize former non-operational area.
ISM	0-1	L10ss-087M	L10SS-087M-5544-SO	4/13/2010	Characterize former non-operational area
ISM	0-1	L10ss-088M	L10SS-088M-5545-SO	4/13/2010	Characterize former operational area. Analyzed for RVAAP full-suite analytes
ISM	0-1	L10ss-089M	L10SS-089M-5546-SO	4/13/2010	Characterize former operational area
ISM	0-1		L10SS-089M-6171-FD	4/13/2010	QA/QC
ISM	0-1		L10SS-089M-6170-QA	4/13/2010	
ISM	0-1	L10ss-090M	L10SS-090M-5547-SO	4/13/2010	Characterize former operational area.
ISM	0-1	L10ss-091M	L10SS-091M-5548-SO	4/13/2010	Characterize former operational area
ISM	0-1	L10ss-092M	L10SS-092M-5549-SO	4/13/2010	Characterize former operational area. Analyzed for RVAAP full-suite analytes
ISM	0-1	L10ss-093M	L10SS-093M-5550-SO	4/13/2010	Characterize ditch area
Discrete	0-1	L10ss-076	L10SS-076-5532-SO	4/12/2010	Previous Cr result represents elevated Cr concentration
Discrete	0-1	L10ss-077	L10SS-077-5533-SO	4/12/2010	Previous Cr result represents elevated Cr concentration
Discrete	0-1	L10ss-078	L10SS-078-5534-SO	4/12/2010	Previous Cr result represents Cr near background concentration

bgs = Below ground surface.
Cr = Chromium.
ISM = Incremental Sampling Methodology.
QA/QC = Quality Assurance/Quality Control.
RVAAP = Ravenna Army Ammunition Plant.



1 **Figure 4-1. PBA08 RI Surface Soil Sampling Decision Flowchart**

All subsurface soil samples were analyzed for TAL metals, explosives, and PAHs. A total of 15% of samples (six) were analyzed for the RVAAP full-suite analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and nitroguanidine), SVOCs, VOCs, PCBs, and pesticides]. Three QC field duplicate and three QA split samples were collected to satisfy the QA/QC sample requirements of 10% frequency for subsurface soil samples. A lithologic soil description was completed for each soil boring and is included in Appendix A.

One geotechnical sample was collected from boring location L10sb-068 to provide soil data for fate and transport modeling. A pilot boring was installed with a Geoprobe® to a depth of 20.0 ft bgs to allow lithologic characterization of the soil and determine the appropriate geotechnical sample intervals (Appendix A). The geotechnical sample location was offset from the pilot boring and drilled with hollow stem auger attachments. Geotechnical samples were collected from 4.0-4.8 ft bgs through the hollow stem augers directly into the Shelby tube. Several attempts were made to recover a second Shelby tube from 16-18 ft bgs directly above the only moist zones observed in the pilot boring, but were not successful due to poor recovery.

The undisturbed Shelby tube was sealed with wax, capped, and submitted for laboratory geotechnical analysis for porosity, bulk density, moisture content, total organic carbon, grain size fraction analysis, and permeability. Laboratory analytical results for geotechnical samples are presented in Appendix D. QA/QC samples were not collected for the geotechnical sample.

Following collection of the samples, excess soil was designated as IDW and placed in lined and labeled 55 gallon drums that were sealed after use and staged at Building 1036. IDW practices for all media are discussed in Appendix F. Subsurface borings were backfilled to the ground surface with dry bentonite chips and hydrated with the project-approved potable water.

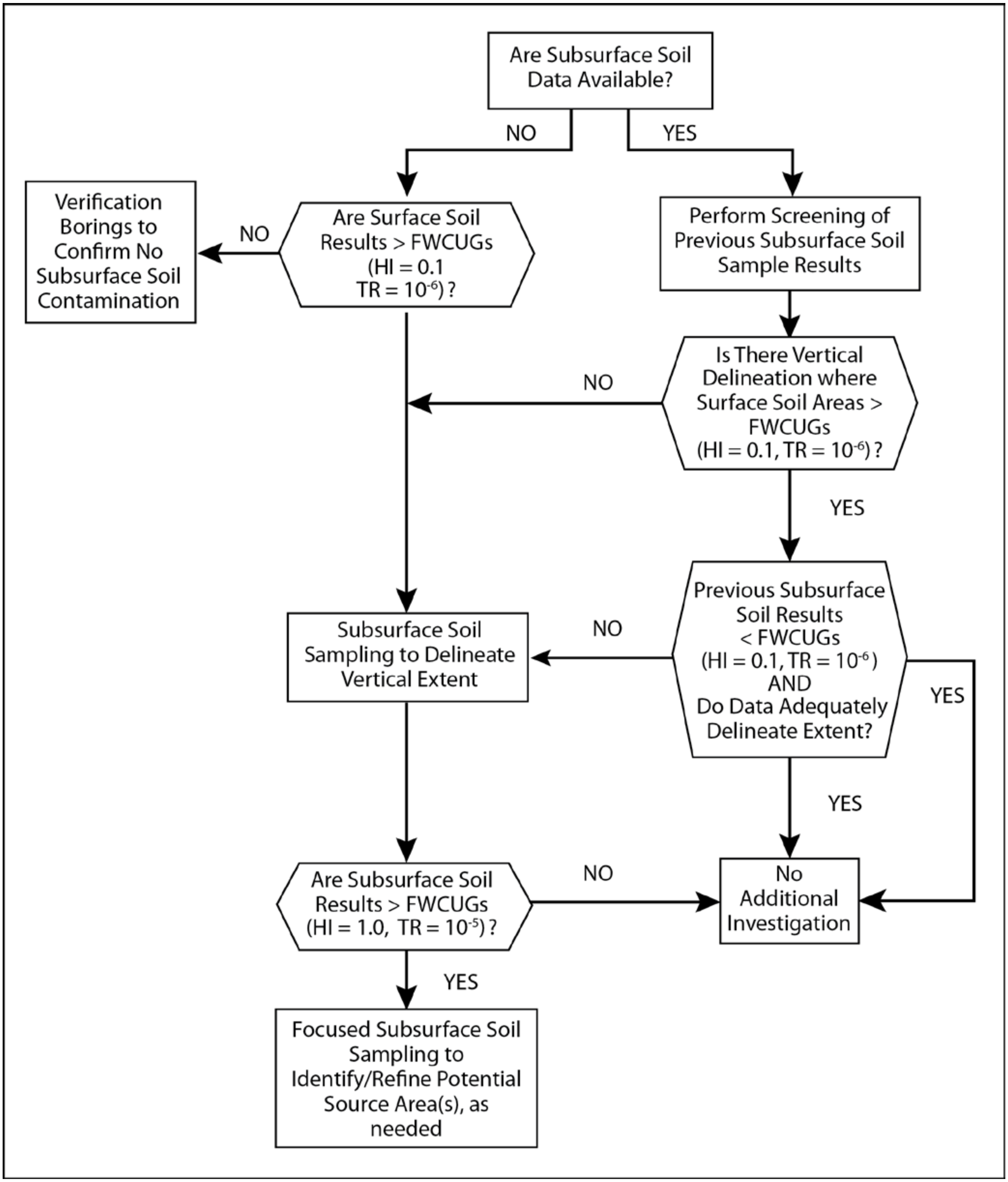
Table 4-3. PBA08 RI Subsurface Soil Samples and Rationales

Sample Type	Depth (ft bgs)	Station	Sample	Date Sampled	Comments/Rationale
Discrete	0-1	L10sb-066	L10SB-066-5493-SO	3/16/2010	Delineate vertical extent of previously identified contamination; bedrock encountered at 12 ft bgs
Discrete	1-4		L10SB-066-5494-SO	3/16/2010	
Discrete	4-7		L10SB-066-5495-SO	3/16/2010	
Discrete[a]	7-12		L10SB-066-5496-SO	3/16/2010	
Discrete	0-1	L10sb-067	L10SB-067-5497-SO	3/17/2010	Delineate vertical extent of previously identified contamination
Discrete	1-4		L10SB-067-5498-SO	3/17/2010	
Discrete	4-7		L10SB-067-5499-SO	3/17/2010	
NA	7-13		L10SB-067-5500-SO	NA	
Discrete	4-4.8	L10sb-068	L10SB-068-5501-SO	3/17/2010	Geotechnical sample. Several attempts were made to collect a geotechnical sample from 16-18 ft interval, but were unsuccessful due to poor recovery
NS	NS		L10SB-068-5502-SO	NS	
Discrete	0-1	L10sb-069	L10SB-069-5503-SO	3/16/2010	Delineate vertical extent of previously identified contamination
Discrete	1-4		L10SB-069-5504-SO	3/16/2010	
Discrete	4-7		L10SB-069-5505-SO	3/16/2010	

Table 4-3. PBA08 RI Subsurface Soil Samples and Rationales (continued)

Sample Type	Depth (ft bgs)	Station	Sample	Date Sampled	Comments/Rationale
NA	7-13		L10SB-069-5506-SO	NA	
Discrete	0-1	L10sb-070	L10SB-070-5507-SO	3/16/2010	Delineate vertical extent of previously identified contamination
Discrete	1-4		L10SB-070-5508-SO	3/16/2010	
Discrete	4-7		L10SB-070-5509-SO	3/16/2010	
Discrete[b]	7-13		L10SB-070-5510-SO	3/16/2010	
Discrete	4-7		L10SB-070-6174-FD	3/16/2010	QA/QC
Discrete	4-7		L10SB-070-6178-QA	3/16/2010	
Discrete	0-1	L10sb-071	L10SB-071-5511-SO	3/16/2010	Delineate vertical extent of previously identified contamination; entire boring installed in fill material containing building material and concrete refusal was encountered at 6.5 ft bgs
Discrete	1-4		L10SB-071-5512-SO	3/16/2010	
Discrete	4- 6.5		L10SB-071-5513-SO	3/16/2010	
NS	7-13		L10SB-071-5514-SO	NS	
Discrete	0-1	L10sb-072	L10SB-072-5515-SO	3/16/2010	Delineate vertical extent of previously identified contamination
Discrete	1-4		L10SB-072-5516-SO	3/16/2010	
Discrete	4-7		L10SB-072-5517-SO	3/16/2010	
NA	7-13		L10SB-072-5518-SO	NA	
Discrete	0-1		L10SB-072-6173-FD	3/16/2010	QA/QC
Discrete	0-1		L10SB-072-6177-QA	3/16/2010	
Discrete	0-1	L10sb-073	L10SB-073-5519-SO	3/16/2010	Delineate vertical extent of previously identified contamination. All samples analyzed for RVAAP full-suite analytes
Discrete	1-4		L10SB-073-5520-SO	3/16/2010	
Discrete	4-7		L10SB-073-5521-SO	3/16/2010	
NA	7-13		L10SB-073-5522-SO	NA	
Discrete	0-1		L10SB-073-6172-FD	3/16/2010	QA/QC, analyzed for RVAAP full-suite analytes
Discrete	0-1		L10SB-073-6176-QA	3/16/2010	
Discrete	0-1	L10sb-074	L10SB-074-5523-SO	3/16/2010	Delineate vertical extent of previously identified contamination; bedrock encountered at 7 ft bgs. All samples analyzed for RVAAP full-suite analytes
Discrete	1-4		L10SB-074-5524-SO	3/16/2010	
Discrete	4-7		L10SB-074-5525-SO	3/16/2010	
NS	7-13		L10SB-074-5526-SO	NS	
Discrete	0-1	L10sb-075	L10SB-075-5527-SO	3/17/2010	Delineate vertical extent of previously identified contamination; bedrock encountered at 9 ft bgs
Discrete	1-4		L10SB-075-5528-SO	3/17/2010	
Discrete	4-7		L10SB-075-5529-SO	3/17/2010	
NA	7-9		L10SB-075-5530-SO	NA	

[a] Sample analyzed by the laboratory based on an exceedance of preliminary screening criteria of the 4-7 ft bgs sample interval.
[b] One sample (10%) from 7-13 ft bgs was submitted for laboratory analysis to characterize subsurface soil to 13 ft bgs.
bgs = Below ground surface.
NA = Sample not analyzed by the laboratory based on preliminary screening criteria of the 4-7 ft bgs sample interval.
NS = Sample not collected.
QA/QC = Quality Assurance/Quality Control.
RVAAP = Ravenna Army Ammunition Plant.



1 **Figure 4-2. PBA08 RI Subsurface Soil Sampling Decision Flowchart**

4.2 SURFACE WATER AND SEDIMENT CHARACTERIZATION

Surface water and sediment samples were collected to characterize current conditions and assess potential entrance and exit pathways from the AOC (Figure 4-3). One co-located surface water and sediment sample (L10sd/sw-094) was collected during the PBA08 RI from the drainage ditch exiting the AOC at the south end, and one facility-wide, co-located surface water and sediment sample (FWSsd/sw-102) was collected during the PBA08 RI from a stream that drains the Fuze and Booster Hill area.

4.2.1 Surface Water and Sediment Sampling Methods

The surface water grab samples were collected by the hand-held bottle method in accordance with Section 4.3 of the PBA08 SAP and analyzed for the RVAAP full-suite analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and nitroguanidine), SVOCs, VOCs, PCBs, and pesticides]. Water quality parameters for temperature, pH, conductivity, dissolved oxygen, and turbidity were collected using calibrated water quality meters (Hanna Instrument Models 9828 and 98703). A surface water and sediment sample collection sheet was completed for each sample location and is included in Appendix A.

The sediment samples were collected in accordance with Section 4.2 of the PBA08 SAP. The samples consisted of a multi-aliquot composite with 10 aliquots selected randomly within a 5 ft radius of the identified sample location. Each aliquot was collected by a push probe to a maximum depth of 0.5 ft bgs. The aliquots were homogenized in a stainless steel bowl, transferred to the appropriate, labeled sample container, and analyzed for the RVAAP full-suite analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and nitroguanidine), SVOCs, VOCs, PCBs, and pesticides]. For VOC analysis, one discrete sample collected from 0-0.5 ft bgs was collected within the 5 ft sampling radius and placed directly in the appropriate, labeled sample container.

4.2.2 Load Line 10 Surface Water and Sediment Sampling Rationale

During previous investigations, no surface water or sediment samples were collected for characterization purposes at Load Line 10. One co-located surface water and sediment sample was collected during the PBA08 RI from the drainage ditch exiting the AOC at the south end. The sample was collected in accordance with the following decision rules approved in the PBA08 SAP:

- At AOCs where overland flow of contaminants could occur to nearby perennial streams, those streams will be sampled. The sample locations may be outside of the AOC boundaries but the samples represent the areas potentially impacted by the AOCs (Load Lines 5, 6, 7, 9, 10, and Wet Storage Area).
- At points where contamination may migrate out of the AOC area, such as a ditch or a stream near the AOC boundary, samples will be collected to characterize current conditions and determine whether contaminant migration may occur at surface water runoff exit points.

Table 4-4 presents the specific rationale for the surface water and sediment samples collected for the PBA08 RI.

Table 4-4. PBA08 RI Surface Water and Sediment Samples and Rationales

Sample Type	Depth (ft bgs)	Station	Sample	Date Sampled	Comments/Rationale
Composite Sediment	0-1	L10sd-094	L10SD-094-5531-SD	2/18/2010	Assessment of potential exit pathway of ditch draining to the southwest
Grab Surface Water	NA	L10sw-094	L10SW-094-5535-SW	3/9/2010	

bgs = Below ground surface.
NA = Not Applicable.

4.2.3 Facility-wide Surface Water and Sediment Sampling Rationale

One facility-wide, co-located surface water and sediment sample was collected during the PBA08 RI from a stream that drains the Fuze and Booster Hill area. Table 4-5 presents the specific rationale for the facility-wide surface water and sediment samples collected for the PBA08 RI.

Table 4-5. Facility-wide Surface Water and Sediment Samples and Rationales

Sample Type	Depth (ft bgs)	Station	Sample	Date Sampled	Comments/Rationale
Grab Surface Water	NA	FWSsw-102	FWSsw-102-5010-SW	2/17/2010	Characterize current conditions and potential exit pathways from the Fuze and Booster Hill area, and provide data for the Nature and Extent
Composite Sediment	0 to 0.5	FWSsd-102	FWSsd-102-5011-SD	2/17/2010	

bgs = Below ground surface.
NA = Not Applicable.

4.3 CHANGES FROM THE WORK PLAN

Changes to the PBA08 SAP are documented in the field change requests (FCRs) provided in Appendix B. Changes made in the field based on AOC-specific conditions are not documented on FCRs but on the field sampling logs (Appendix A). These changes are presented in Table 4-6 and in the field sampling logs. Revised coordinates for all locations can be found on the field sampling logs.

4.4 ANALYTICAL PROGRAM OVERVIEW

The following sections describe the analytical program followed during the PBA08 RI.

Table 4-6. Changes from the PBA08 Sampling and Analysis Plan

Station	Affected Sample	Date Sampled	Change/Rationale
L10sb-067	L10SB-067-5497-SO	3/17/2010	Original station location was on a hill; location was relocated to the bottom of the adjacent ditch
	L10SB-067-5498-SO	3/17/2010	
	L10SB-067-5499-SO	3/17/2010	
	L10SB-067-5500-SO	3/17/2010	
L10sb-068	L10SB-068-5502-SO	NA	No recovery for 16 to 18 foot interval; only one geotechnical sample collected
L10sb-074	L10SB-074-5523-SO	3/16/2010	Location was relocated to the bottom of a nearby ditch
	L10SB-074-5524-SO	3/16/2010	
	L10SB-074-5525-SO	3/16/2010	
L10sb-075	L10SB-075-5527-SO	3/16/2010	Location was relocated to the bottom of a nearby ditch (former ISM area)
	L10SB-075-5528-SO	3/16/2010	
	L10SB-075-5529-SO	3/16/2010	
	L10SB-075-5530-SO	3/16/2010	
L10sw-094	L10SW-094-5535-SW	3/9/2010	No water present when sediment sample was collected; water sample was collected on a later date after snowmelt and rain.

ISM = Incremental Sampling Method.
NA = Not Applicable.

4.4.1 Data Quality Objectives

Samples were collected and analyzed according to the FWSAP and the PBA08 SAP that were prepared in accordance with USACE and USEPA guidance. The FWSAP and PBA08 SAP outline the organization, objectives, intended data uses, and QA/QC activities to perform in order to achieve the desired DQOs for maintaining the defensibility of the data. Project DQOs were established in accordance with USEPA Region 5 guidance. Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data verification criteria for the RI are consistent with USEPA and U.S. Department of Defense (DoD) requirements. DQOs for this project include analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix C presents an assessment of the analytical program objectives.

4.4.2 Quality Assurance and Quality Control

Samples were properly packaged for shipment and transferred by courier to the laboratory for analysis. A signed chain-of-custody record (included in Appendix D) with sample numbers and locations was enclosed with each shipment. When transferring the possession of samples, the individuals relinquishing and receiving 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.

QA/QC samples for this project included field blanks, trip blanks, QC field duplicates, QA split samples, laboratory method blanks, laboratory control samples, laboratory duplicates, and matrix spike/matrix spike duplicate samples. Table 4-7 presents a summary of QA/QC samples utilized during the PBA08 RI and how each sample type was used to support the quality of the analytical data. Evaluation of QA/QC samples and their contribution to documenting project data quality is provided in Appendix C.

Table 4-7. Summary of PBA08 RI QA/QC Samples

Sample Type	Rationale
Field Blank	Analyzed to determine contamination in source material that may contribute to sample contamination
Trip Blank	Analyzed to assess the potential for cross 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 non-dedicated sampling equipment
Laboratory Method Blanks	Analyzed to assess the contamination level in the laboratory preparation and analysis process
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	
Laboratory Control Sample	Analyzed to determine the accuracy and precision of the analytical method implemented by the laboratory and to monitor the laboratory’s analytical process control
QA Split	Analyzed to provide independent verification of the accuracy and precision of the principal analytical laboratory

QA = Quality Assurance.
QC = Quality Control.

4.4.3 Field Analyses

No field laboratory analyses (i.e., field explosives testing or ISM processing) were conducted for the PBA08 RI. However, water quality parameters were recorded using water quality meters (Hanna Instrument Models 9828 and 98703) that were calibrated daily. Additionally, field screening for organic vapors was not used to guide sampling or analytical efforts. Organic vapors were monitored in the breathing zone during drilling for health and safety purposes at each subsurface soil boring location.

4.4.4 Laboratory Analyses

Samples collected during the PBA08 RI were analyzed by TestAmerica Laboratories, Inc. (herein referred to as TestAmerica) of North Canton, Ohio and West Sacramento, California, as a subcontractor to White Water Associates, Inc., of Amasa, Michigan. Collected QA split samples were analyzed by USACE’s contracted QA laboratory, RTI Laboratories, Inc., of Livonia, Michigan. TestAmerica and RTI Laboratories, Inc. are accredited by the DoD Environmental Laboratory Accreditation Program (ELAP).

All analytical procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, DoD Quality Systems Manual Version 3, USACE Louisville District analytical QA guidelines, and specific project goals and requirements. In addition to these standards, the analytical laboratories were required to strictly adhere to the requirements set forth in the FWSAP and PBA08 SAP so that conditions adverse to data quality would not arise. Preparation and analyses for chemical parameters were performed according to the methods listed in Table 4-8. Additionally, soil geotechnical analysis for porosity, bulk density, moisture content, grain size fraction, and permeability were performed in compliance with American Society for Testing and Materials (ASTM) test methods.

Table 4-8. Summary of PBA08 RI Sample Preparation and Analytical Procedures

Parameter	Soil and Sediment		Surface Water	
	Preparation	**Analysis**	**Preparation**	**Analysis**
Inorganic chemicals	SW-846 3050B	SW-846 6020	SW-846 3005A	SW-846 6020
Mercury	--	SW-846 7471A	--	SW-846 7470A
Explosives	--	SW-846 8330B	--	SW-846 8330B
SVOCs and PAHs	SW-846 3540C	SW-846 8270C	SW-846 3520C	SW-846 8270C
Propellants:				
Nitrocellulose	--	353.2 Modified	--	353.2 Modified
Nitroguanidine	SW-846 3550A	SW-846 8330M	SW-846 3535	SW-846 8330M
VOCs	SW-846 5030B	SW-846 8260B	SW-846 5030B	SW-846 8260B
Pesticides	SW-846 3540C	SW-846 8081A	SW-846 3520C	SW-846 8081A
PCBs	SW-846 3540C	SW-846 8082	SW-846 3520C	SW-846 8082
Hexavalent Chromium	SW-846 3060A	SW-846 7196A	--	SW-846 7196A

PAH = Polycyclic Aromatic Hydrocarbon.
PCB = Polychlorinated Biphenyl.
SVOC = Semi-volatile Organic Compound.
VOC = Volatile Organic Compound.
-- = Preparation steps included in analytical method.

Leidos is the custodian of the project files and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, photographs, subcontractor reports, correspondence, and sample custody forms. These files will remain in a secure area under the custody of the Leidos project manager until they are transferred to USACE, Louisville District and the U.S. Army at the end of the PBA08 project.

Analytical data reports from the project laboratory were forwarded to the USACE Louisville District laboratory data validation contractor for validation, review, and QA comparison. White Water Associates, Inc. and TestAmerica will retain all original raw data (both hard copy and electronic copy) in a secure area under the custody of the laboratory project manager for a minimum of seven years.

4.4.5 Data Review, Verification, and Quality Assessment

Data were produced, reviewed, and reported by the laboratory in accordance with specifications in the PBA08 SAP, the Louisville District analytical QA guidelines, and the laboratory's QA manual.

TestAmerica 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 Leidos and USACE of any data considered "unacceptable" or requiring caution by the data user in terms of its reliability.

Final reports were generated by the laboratory project manager. Data were then delivered to Leidos for verification. TestAmerica prepared and retained full analytical and QC documentation for the project in paper copy and electronic storage media (e.g., compact disk), as directed by the analytical methodologies employed. Laboratory reports included documentation verifying analytical holding time compliance.

Leidos performed a systematic process utilizing automated data review (ADR) software for data verification to ensure the precision and accuracy of the analytical data were adequate for their intended use. The ADR outlier reports are included as Attachment 1 to Appendix C. 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 chemicals). This approach was consistent with the DQOs for the project and with the analytical methods used for determining COCs and calculating risk. "Definitive Data" were reported consistent with the deliverables identified in the project sampling and analysis plan (SAP). These definitive data were then verified through the review process outlined in the project SAP and presented in Appendix C. A few inorganic chemical, SVOC, PAH, PCB, and pesticide samples required dilution due to elevated analyte concentrations or difficult matrices. All reporting limits and/or method detection limits (MDLs) for undetected analytes remained below FWCUGs, with the exception of n-nitrosodi-n-propylamine for soil sample L10SS-080M-5537-SO. Data that have been rejected were relegated to the non-detected antimony result in soil sample L10SB-070-5510-SO. Rejected data constituted 0.02% of the Load Line 10 data. Other results were qualified as estimated, indicating accuracy, precision, or sensitivity was less than desired but adequate for their intended use. The completeness goal for analytical data is 90%, as defined in Table 3-1 and 3-2 of the Facility-wide Quality Assurance Project Plan. The project achieved this goal by collecting all samples presented in the PBA08 SAP and producing usable results for 99.98% of all samples performed. In addition to the Leidos data review, USACE performed a 10% validation of all data to evaluate data usability. Results of USACE's validation are presented in Appendix C.

THIS PAGE INTENTIONALLY LEFT BLANK

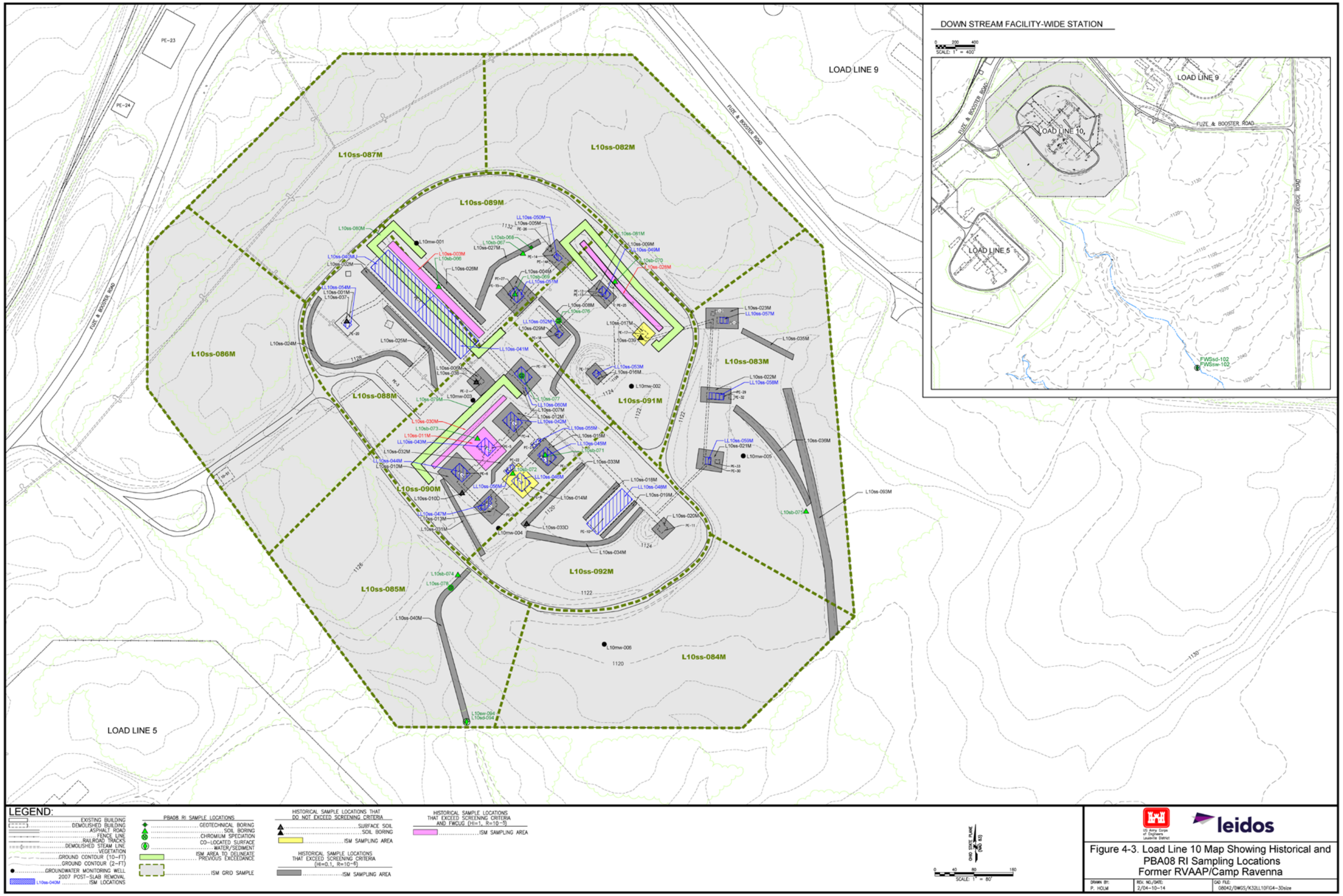


Figure 4-3. Load Line 10 Map Showing Historical and PBA08 RI Sampling Locations - Former RVAAP/Camp Ravenna

THIS PAGE INTENTIONALLY LEFT BLANK.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section presents analytical data results obtained during the PBA08 RI, Characterization of 14 AOCs and Investigation of Under Slab Surface Soils; the data screening process to identify SRCs; and the evaluation of nature and extent of SRCs in environmental media at Load Line 10.

Section 5.1 presents the statistical methods and screening processes used to distinguish constituents present at ambient concentrations (background concentrations) from those present at concentrations that indicate potential impacts related to historical operations within Load Line 10. Section 5.1.1 presents data aggregates based on environmental media, AOC characteristics, and spatial distribution of samples. The nature and extent of contamination in all sampled environmental media (surface soil, subsurface soil, sediment, and surface water) are presented in Sections 5.2.2 through 5.2.6. Each section contains data tables that present results of the PBA08 RI and identified SRCs (utilizing historical and current datasets) and summarizes the nature and extent of SRCs within each environmental medium and spatial data aggregate. Summary analytical results are presented in graphical or tabular formats at the end of this section. All validated Load Line 10 data from historical investigations and the PBA08 RI are included in Appendix D. Complete laboratory analytical data packages from the PBA08 RI are also included in Appendix D.

5.1 DATA EVALUATION METHOD

Data evaluation methods for Load Line 10 are consistent with those established in the FWCUG Report and specified in the PBA08 SAP. The process used to evaluate the analytical data involved three general steps: (1) defining data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

5.1.1 Definition of Aggregates

Load Line 10 data were grouped (aggregated) in three ways to evaluate contaminant nature and extent, HHRA, and ERA. The initial basic aggregation of data was by environmental medium: surface soil, subsurface soil, sediment, and surface water. For each medium-specific aggregate, an evaluation was conducted to determine if further aggregation was warranted with respect to AOC characteristics, historical operations, ecological habitat, and potential future remedial strategy and land use (e.g., spatial aggregates). Data for soil were further aggregated based on depth and sample type for consistency with RVAAP human health risk guidance established in the FWHHRAM and FWCUG Report. Data aggregates for evaluating the nature and extent of contamination at Load Line 10 are as follows:

- Surface Soil (0-1 ft bgs): This medium is evaluated as an AOC-wide aggregate. Further subdivision into spatial aggregates was not warranted due to the small size of the AOC and consistent physical characteristics.
- Subsurface Soil (> 1 ft bgs): This medium is evaluated as an AOC-wide aggregate on the same basis as surface soil.

- Sediment: A discrete sediment sample was collected from the main ditch draining to southwest of the AOC. Due to the limited size of the dataset, this medium is evaluated as an AOC-wide aggregate.
- Surface Water: This medium is evaluated as an AOC-wide aggregate on the same basis as sediment.

The soil data aggregates are further subdivided for the HHRA and ERAs as discussed in Section 7.1.1.

5.1.2 Data Verification, Reduction, and Screening

5.1.2.1 Data Verification

Data verification was performed on 56 surface soil, subsurface soil, sediment, and surface water samples (including QC duplicates) collected during the PBA08 RI. Historical data were verified and completed as presented in the historical reports. Analytical results were reported by the laboratory in electronic format and loaded into the Ravenna Environmental Information Management System (REIMS) database. As discussed in Section 4.4.5, data verification was performed to ensure all requested data were received and complete. Data qualifiers were assigned to each result based on the laboratory QA review and verification criteria. Results were qualified as follows:

- “U” not detected
- “UJ” not detected, reporting limit estimated
- “J” indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample
- “R” result not usable

In addition to assigning qualifiers, the verification process also selected the appropriate result to use when performing re-analyses or dilutions. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the verification chemist determined whether laboratory re-analysis should be used in place of an original reported result. If the laboratory reported results for diluted and undiluted samples, diluted sample results were used for analytes that exceeded the calibration range of the undiluted sample. A complete discussion of verification process results is contained in the data quality summary report (Appendix C). The data quality summary report also includes a summary table of the assigned data qualifiers and the accompanying rationale. Independent, third-party validation of 10% of the RI data and 100% of the USACE QA laboratory data was performed by a subcontractor to the USACE, Louisville District.

5.1.2.2 Data Reduction

Calculating data summary statistics was the initial step in the data reduction process to identify SRCs. Eligible historical and current AOC data were extracted from the database. Results from QC splits and field duplicates, as well as rejected results, were excluded from the data screening process. All analytes having at least one detected value were included in the data reduction process.

Summary statistics calculated for each data aggregate included the minimum, maximum, and average (mean) values and the proportion of detected results to the total number of samples collected. For calculating mean values, non-detected results were addressed by using one-half of the reported detection limit as a surrogate value during calculation of the mean result for each compound (USEPA 1989).

Non-detected results with elevated detection limits (more than five times the contract-required detection limit) were excluded from the summary statistics in order to avoid skewing the mean value calculations.

5.1.2.3 Data Screening

After reduction, the data were screened to identify SRCs using the processes outlined below. Additional screening of identified SRCs was conducted: (1) in the fate and transport evaluation (Section 6.0) to identify CMCOPCs; (2) in the HHRA to identify human health COPCs and COCs (Section 7.2); and (3) in the ERA to evaluate COPECs (Section 7.3). Figure 5-1 illustrates the screening process to identify SRCs and COPCs at Load Line 10 in accordance with the FWCUG Report. The steps involved in the SRC screening process are summarized below. All chemicals that were not eliminated during the screening steps were retained as SRCs.

- Data quality assessment: Discussed previously in Section 4.4.5.
- Background screening: The maximum detected concentration (MDC) of inorganic chemicals were compared to the RVAAP BSVs. If background concentrations were exceeded, the respective inorganic chemicals were retained as SRCs. No BSVs were established for organic chemicals. As such, all detected organic chemicals were retained as SRCs.
- Screening of essential human nutrients: Chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. USEPA recommends these chemicals not be evaluated unless they are grossly elevated relative to background concentrations or would exhibit toxicity at the observed concentrations at an AOC (USEPA 1989). Recommended dietary allowance (RDA) and recommended daily intake (RDI) values are available for all of these chemicals (Table 5-1). Screening values were calculated for receptors ingesting 100 mg of soil per day or 1 L of groundwater per day to meet their RDA/RDI. In the case of calcium, magnesium, phosphorous, potassium, and sodium, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI value, even if the soil consisted of the pure mineral (i.e., soil concentrations at 1,000,000 mg/kg). Essential nutrients detected at or below their RDA/RDI-based screening levels were eliminated as SRCs.
- Frequency of detection/WOE screening: Chemicals that were never detected in a given medium were eliminated as SRCs. For chemicals with at least 20 discrete samples and a

frequency of detection of less than 5%, a WOE approach was used to determine if the chemical is AOC-related. This screening was applied to all organic and inorganic chemicals with the exception of explosives and propellants; all detected explosives and propellants were considered as SRCs regardless of frequency of detection. At Load Line 10, 20 discrete subsurface soil samples were available for frequency of detection screening; however, no SRCs were screened out on this basis. The frequency of detection/WOE screening was not applied to ISM samples.

Table 5-1. Recommended Dietary Allowances/Reference Daily Intake Values

Essential Human Nutrient	USDA RDA/RDI[a] Value
Calcium	1000 mg/d
Chloride[b]	3400 mg/d
Iodine	150 µg/d
Iron	8 mg/d
Magnesium	400 mg/d
Potassium[b]	4700 mg/d
Phosphorous	700 mg/d
Sodium[b]	2300 mg/d

[a] Dietary reference intakes vary by gender and age, values present are for life stage group: Males 19-30 years.

[b] Adequate Intake Value.

mg/d = Milligram per day.

RDA= Recommended Dietary Allowance.

RDI= Reference Daily Intake.

µg/d = Micrograms per day.

USDA = U.S. Department of Agriculture.

Source= Values were obtained from http://fnic.nal.usda.gov charts.

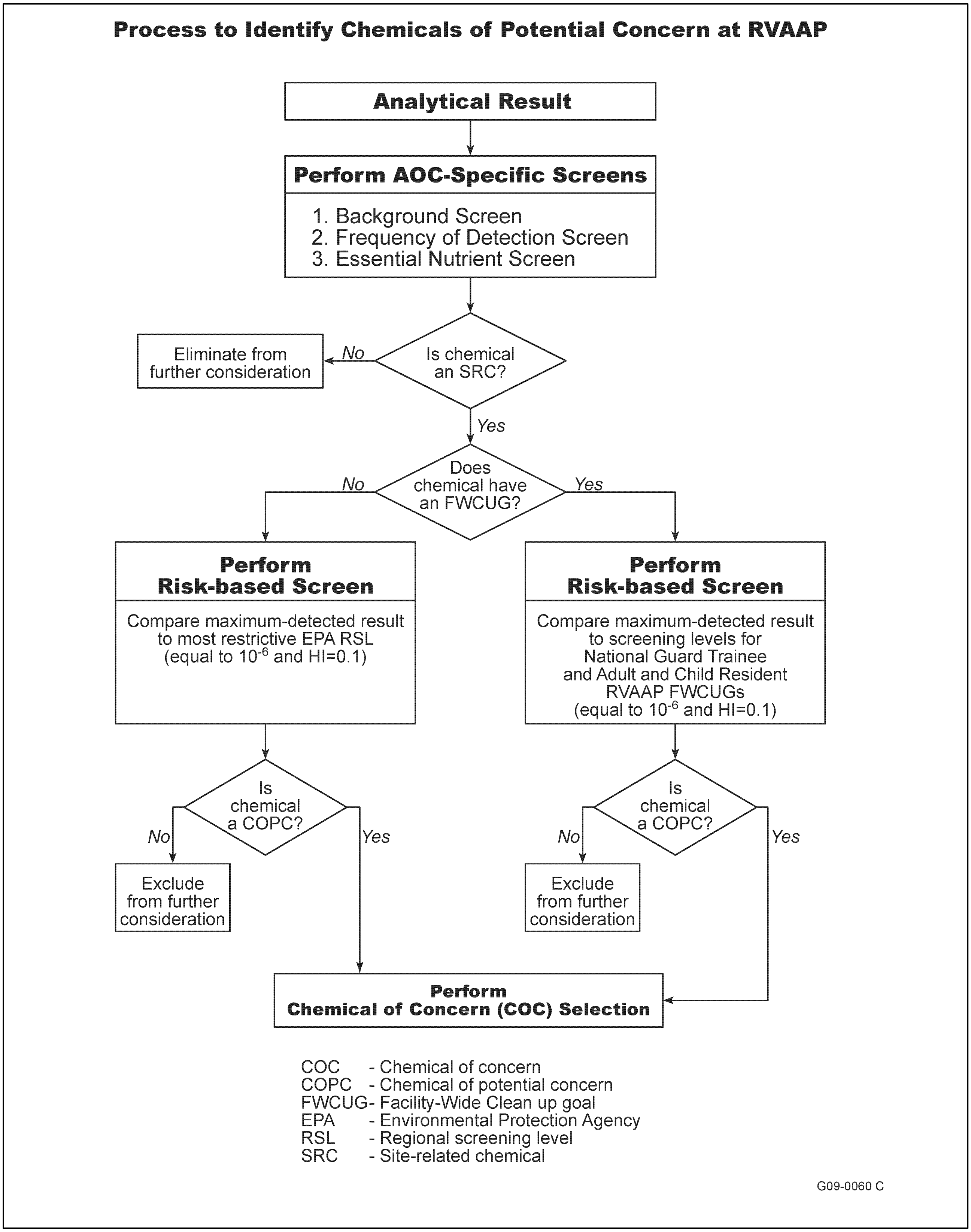


Figure 5-1. Process to Identify RVAAP COPCs in the Human Health Risk Assessment (USACE 2010a)

5.1.3 Data Presentation

Data summary statistics and screening results for SRCs in surface and subsurface soil, sediment, and surface water at Load Line 10 are presented for each medium and spatial aggregate. Analytical results for SRCs are presented by sample location on Figures 5-2 through 5-8. Analytical results for SRCs are also presented in data summary tables whenever a sufficient number of detected values occurred.

The complete laboratory analytical data packages are included in Appendix D. In order to maximize efficiency for laboratory reporting and data management activities, all of the samples received at the laboratory on a given day were reported in a single data package. Therefore, results may be present in data packages associated with different AOCs. All samples for Load Line 10 have sample IDs beginning with “L10.”

The tables in Appendix D present the analytical results for samples collected during the PBA08 RI, Characterization of 14 AOCs (MKM 2007), and Investigation of Under Slab Surface Soils (USACE 2009a). Analytical results are grouped by media (e.g., surface soil, surface water) and class of analyte (e.g., explosives, inorganic chemicals) for ease of reference.

5.1.4 Data Evaluation

All available sample data were evaluated to determine suitability for use in the RI under two primary considerations: (1) representativeness with respect to current AOC conditions; and (2) sample collection methods (e.g., discrete vs. ISM). Table 5-2 presents the designated use for all available Load Line 10 samples as well as their aggregate assignments.

Samples from the 2004 Characterization of 14 AOCs and 2007 Investigation of Under Slab Surface Soils datasets were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the PBA08 RI activities. The samples collected in 2004 were collected (1) within ditchlines peripheral to the former buildings and (2) in large areas encompassing but also extending substantially beyond the footprint of the now-demolished buildings. The 2007 sampling was conducted within the footprints of the demolished buildings following slab removal. Therefore, both datasets were considered representative of current conditions at Load Line 10.

All historical surface soil samples were collected using ISM sample methods. Under the PBA08 RI, surface soil was sampled using ISM and discrete methods. All historical and PBA08 RI ISM surface soil samples were used in the SRC screening process and carried forward into the risk assessment. Discrete surface samples were retained for nature and extent evaluation only. Discrete subsurface soil, sediment, and surface water samples were collected under the PBA08 RI activities and screened for SRCs; none of these media were sampled under previous historical investigations at the AOC.

Table 5-2. Data Summary and Designated Use for Remedial Investigation

Sample ID	Date	Sample Type	Use Type	Comments
Surface Soil (0-1 ft bgs)				
L10sb-066-5493-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-067-5497-SO	3/17/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-069-5503-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-070-5507-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-071-5511-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-072-5515-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-072-6173-FD	3/16/2010	D	FD	Quality control sample limits use to nature and extent
L10sb-073-5519-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-073-6172-FD	3/16/2010	D	FD	Quality control sample limits use to nature and extent
L10sb-074-5523-SO	3/16/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10sb-075-5527-SO	3/17/2010	D	N	Soil boring sample for 0-1 ft bgs interval used for nature and extent evaluation only, as ISM samples are used for the surface soil screening
L10ss-001M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-002M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-003M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-004M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-005M-DUP	11/17/2004	ISM	FD	Quality control sample limits use to nature and extent
L10ss-005M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-006M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-007M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening

Table 5-2. Data Summary and Designated Use for Remedial Investigation (continued)

Sample ID	Date	Sample Type	Use Type	Comments
Surface Soil (0-1 ft bgs), continued				
L10ss-008M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-009M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-010D-SO	11/16/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-010M. Sample used for nature and extent evaluation and surface soil screening
L10ss-010M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-011M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-012M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-013M-QA	11/16/2004	ISM	FD	Quality control sample limits use to nature and extent
L10ss-013M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-014M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-015M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-016M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-017M-DUP	11/17/2004	ISM	FD	Quality control sample limits use to nature and extent
L10ss-017M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-018M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-019M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-020M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-021D-SO	11/18/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-021M. Sample used for nature and extent evaluation and surface soil screening
L10ss-021M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-022M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-023M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-024M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-025M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-026M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening

Table 5-2. Data Summary and Designated Use for Remedial Investigation (continued)

Sample ID	Date	Sample Type	Use Type	Comments
Surface Soil (0-1 ft bgs), continued				
L10ss-027D-SO	11/19/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-027M. Sample used for nature and extent evaluation and surface soil screening
L10ss-027M-DUP	11/19/2004	ISM	FD	Quality control sample limits use to nature and extent
L10ss-027M-SO	11/19/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-028M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-029M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-030M-QA	11/16/2004	ISM	FD	Quality control sample limits use to nature and extent
L10ss-030M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-031M-SO	11/16/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-032M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-033D-SO	11/18/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-033M. Sample used for nature and extent evaluation and surface soil screening
L10ss-033M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-034M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-035M-SO	11/18/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-036M-SO	11/17/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-037-DUP	11/19/2004	ISM*	FD	Quality control sample limits use to nature and extent. Discrete sample collected for VOCs in association with L10ss-001M
L10ss-037-SO	11/19/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-001M. Sample used for nature and extent evaluation and surface soil screening
L10ss-038-SO	11/19/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-006M. Sample used for nature and extent evaluation and surface soil screening
L10ss-039-SO	11/19/2004	ISM*	S	Discrete sample collected for VOCs in association with L10ss-017M. Sample used for nature and extent evaluation and surface soil screening
L10ss-040M-SO	11/19/2004	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-040MU-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-041M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-042M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening

Table 5-2. Data Summary and Designated Use for Remedial Investigation (continued)

Sample ID	Date	Sample Type	Use Type	Comments
Surface Soil (0-1 ft bgs), continued				
L10ss-043M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-044M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-045M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-046M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-047M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-063M-SO	8/8/2007	ISM	FD	Quality control sample limits use to nature and extent
L10ss-065M-SO	8/14/2007	ISM	FD	Quality control sample limits use to nature and extent
L10ss-048M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-049M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-050M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-051M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-062M-SO	8/9/2007	ISM	FD	Quality control sample limits use to nature and extent
L10ss-064M-SO	8/9/2007	ISM	FD	Quality control sample limits use to nature and extent
L10ss-052M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-053M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-054M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-055M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-061D-SO	8/9/2007	ISM*	D	Discrete sample collected for VOCs in association with L10ss-056M. Sample used for nature and extent evaluation and surface soil screening
L10ss-056M-SO	8/9/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-057M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-058M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-059M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-060D-SO	8/9/2007	ISM*	D	Discrete sample collected for VOCs in association with L10ss-060M. Sample used for nature and extent evaluation and surface soil screening

Table 5-2. Data Summary and Designated Use for Remedial Investigation (continued)

Sample ID	Date	Sample Type	Use Type	Comments
Surface Soil (0-1ft), continued				
L10ss-066D-SO	8/9/2007	ISM*	FD	Quality control sample limits use to nature and extent. Discrete sample collected for VOCs in association with L10ss-060M
L10ss-060M-SO	8/8/2007	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-076-5532-SO	4/12/2010	D	C	Sample used for chromium speciation, and nature and extent evaluation
L10ss-077-5533-SO	4/12/2010	D	C	Sample used for chromium speciation, and nature and extent evaluation
L10ss-078-5534-SO	4/12/2010	D	C	Sample used for chromium speciation, and nature and extent evaluation
L10ss-079M-5536-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-080M-5537-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-081M-5538-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-082M-5539-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-083M-5540-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-084M-5541-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-085M-5542-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-085M-6169-FD	4/13/2010	ISM	FD	Quality control sample limits use to nature and extent
L10ss-086M-5543-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-087M-5544-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-088M-5545-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-089M-5546-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-089M-6171-FD	4/13/2010	ISM	FD	Quality control sample limits use to nature and extent
L10ss-090M-5547-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-091M-5548-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-092M-5549-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
L10ss-093M-5550-SO	4/13/2010	ISM	S	Sample used for nature and extent evaluation and surface soil screening
Subsurface Soil (>1 ft bgs)				
L10sb-066-5494-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-067-5498-SO	3/17/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-069-5504-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-070-5508-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening

Table 5-2. Data Summary and Designated Use for Remedial Investigation (continued)

Sample ID	Date	Sample Type	Use Type	Comments
Subsurface Soil (>1 ft), continued				
L10sb-071-5512-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-072-5516-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-073-5520-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-074-5524-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-075-5528-SO	3/17/2010	D	S	Sample used for nature and extent evaluation (1-4 ft interval) and subsurface soil screening
L10sb-066-5495-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-067-5499-SO	3/17/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-069-5505-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-070-5509-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-070-6174-FD	3/16/2010	D	FD	Quality control sample limits use to nature and extent
L10sb-071-5513-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-072-5517-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-073-5521-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-074-5525-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-075-5529-SO	3/17/2010	D	S	Sample used for nature and extent evaluation (4-7 ft interval) and subsurface soil screening
L10sb-066-5496-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (7-13 ft interval) and subsurface soil screening
L10sb-070-5510-SO	3/16/2010	D	S	Sample used for nature and extent evaluation (7-13 ft interval) and subsurface soil screening
Sediment				
L10sd-094-5531-SD	2/18/2010	D	S	Sample used for nature and extent evaluation and sediment screening
FWSsd-102-5011-SD	2/17/2010	D	N	Sample represents drainage off AOC used for nature and extent evaluation
Surface Water				
L10sw-094-5535-SW	3/9/2010	D	S	Sample used for nature and extent evaluation and surface water screening
FWSsw-102-5010-SW	2/17/2010	D	N	Sample represents drainage off AOC used for nature and extent evaluation

bgs = Below ground surface.
C = Chromium Speciation Sample.
S = Nature and extent, SRC and COPC screen, and sample point by sample point risk assessment.
D = Discrete.
FD = Field Duplicate.
ISM = Incremental Sampling Methodology.
N = Nature and extent use only.
VOC = Volatile Organic Compound.
* = Discrete sample collected for VOCs in association with an ISM sample.

5.2 CONTAMINANT NATURE AND EXTENT

This section evaluates the analytical results of previous and current investigations at Load Line 10 and identifies SRCs associated with surface soil, subsurface soil, sediment, and surface water. SRC screening tables for each media are presented at the end of Section 5 (Tables 5-6 through 5-9). The detected results of the subsequently collected PBA08 RI samples are also included at the end of Section 5 (Tables 5-10 through 5-14). Contaminant nature and extent is present below for each media and class of analytes.

5.2.1 Surface Soil Discrete Sample Results for Chromium Speciation

During the PBA08 RI, surface soil samples were collected from three discrete sample locations and analyzed for hexavalent chromium and total chromium. Samples were collected from the three sampling areas having the highest, mid-point, and lowest total historical chromium results. This sampling was accomplished to determine the contribution of hexavalent chromium to total chromium in soil at Load Line 10 for use in the HHRA (Section 7.2). Chromium speciation results are shown in Table 5-3. All three samples had a total chromium concentration below the background screening value (BSV) of 17.4 mg/kg.

Table 5-3. Chromium Speciation Results

Sample Location	Hexavalent Chromium Concentration (mg/kg)	Total Chromium Concentration[a] (mg/kg)	Percent Hexavalent Chromium (%)
L10ss-076	0.69 J	14.7	4.7 %
L10ss-077	<0.86 U	10.8	NA
L10ss-078	1.2	14.9	8.1 %

[a] Background screening value (BSV) for total chromium = 17.4 mg/kg. No BSV is available for hexavalent chromium.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NA = Not applicable; hexavalent chromium not detected in sample.
U= Non-detectable concentration.

5.2.2 Contaminant Nature and Extent in Surface Soil

Data from all eligible historical and PBA08 RI surface soil ISM samples were combined and screened, as discussed in Section 5.1.2, to identify SRCs representing current conditions at Load Line 10. Table 5-6 presents the results of the SRC screening for surface soil at Load Line 10. The surface soil aggregate SRC screening dataset included 37 ISM samples collected in 2004 under the Characterization of 14 AOCs, 21 ISM samples collected in 2007 under the Investigation of Under Slab Surface Soils, and 15 ISM samples collected in 2010 during the PBA08 RI. A total of 11 ISM samples were collected from multi-acre areas ranging from 1.8-4.1 acres in extent, encompassing the entirety of the AOC as defined by the Load Line 10 fence line. A total of 62 samples were collected near the former production area, buildings, and ditchlines.

All PBA08 RI samples were analyzed for TAL metals, explosives, and PAHs; three samples were analyzed for RVAAP full-suite analytes (TAL metals, explosives, propellants, SVOCs, VOCs, PCBs, and pesticides). Tables 5-10 and 5-11 present the results for all detected analytes in the surface soil samples collected during the PBA08 RI using ISM and discrete methods, respectively.

The results for all the surface soil samples used in this RI, including the 2004 and 2007 data, are presented in Appendix D along with complete copies of all laboratory analytical data packages for the PBA08 RI samples.

Figures 5-2 through 5-5 illustrate the distribution and concentrations of inorganic and organic SRCs that occur at each surface soil sample location, which include discrete and ISM samples. Due to the number of samples and SRCs near the former production area, only chromium was selected as the inorganic SRC to present in Figure 5-2. Chromium was selected based on AOC operational history and historical sampling data screening presented in Table L-1 of the PBA08 RI SAP. Also, for clarity of data presentation, the 11 multi-acre PBA08 RI ISM samples are presented on their own figures separate from the remainder of the ISM and discrete samples (Figures 5-4 and 5-5 for inorganic and organic SRCs, respectively). To show the extent and magnitude of contaminants on Figures 5-3 through 5-5, those SRCs that exceeded the most restrictive FWCUGs at a TR of 10^{-5} and a hazard index (HI) =1.0 (or background concentrations) are highlighted yellow.

5.2.2.1 Explosives and Propellants

All detected concentrations of explosives and propellants in surface soil were below laboratory reporting limits. As shown in Table 5-6, three explosives [2,6-dinitrotoluene (DNT); 3-nitrotoluene; and tetryl] and two propellants (nitrocellulose and nitroglycerin) were identified as SRCs, as there are no associated background concentrations for these chemicals. 2,6-DNT; 3-nitrotoluene; and nitroglycerin were detected at one sample location each, and nitrocellulose was detected at two sample locations near former Buildings PE-27, PE-15, and PE-18. The only sample location with detections of more than one explosive or propellant was PBA08 RI location L10ss-080M, at which 3-nitrotoluene and tetryl were detected.

5.2.2.2 Inorganic Chemicals

As shown on Table 5-6, 17 inorganic chemicals (16 metals and cyanide) were identified as SRCs in surface soil at Load Line 10. The distribution of inorganic SRCs is presented in Figures 5-2 (chromium) and 5-4 (multi-acre ISM areas for select SRCs). Inorganic chemical concentrations detected above background concentrations were observed in surface soil throughout Load Line 10, and all 73 samples within the SRC surface soil screening dataset exhibited multiple inorganic chemicals above background concentrations. Due to the ubiquity of detections above background concentrations, no apparent spatial trend in the distribution of inorganic chemicals throughout the AOC is evident. A total of 9 of the 16 inorganic chemicals identified as SRCs were detected in all 73 surface soil samples in the SRC dataset (aluminum, arsenic, barium, chromium, cobalt, copper, lead, nickel, and zinc). Observations regarding select individual inorganic SRCs in Load Line 10 surface soil are presented below:

- Aluminum was detected above its background concentration of 17,700 mg/kg in only 1 of 73 samples: historical sample L10ss-002M (22,000 mg/kg).
- Antimony was detected above its background concentration of 0.96 mg/kg in only 4 of the 73 samples in the surface soil screening dataset, with a maximum detection of 2.5 mg/kg (L10ss-009M).
- Arsenic was detected above its background concentration of 15.4 mg/kg at only 3 of the 73 screening sample locations, with a maximum detection of 20 mg/kg (L10ss-053M). Arsenic was not detected above its background concentration in any of the 11 PBA08 RI multi-acre ISM samples.
- Chromium was detected above its background concentration of 17.4 mg/kg in 64 of 73 samples ranging in concentration from 17.4-33 mg/kg (Figure 5-2). The maximum detection of chromium was observed at 2004 historical sample location L10ss-007M. The PBA08 RI multi-acre ISM sample L10ss-090M, which encompassed sample location L10ss-007M, also exhibited chromium concentrations above the background concentration, although at a lower concentration (21.6 mg/kg).
- Cobalt was detected above its background concentration of 10.4 mg/kg in only 7 of the 73 screening dataset surface soil samples, with a maximum detection of 14.4 mg/kg at PBA08 sample location L10ss-083M.
- Lead was detected above its background concentration of 26.1 mg/kg at 46 of the 73 SRC screening dataset sample locations, ranging in concentration from 27.2J mg/kg to 430 mg/kg. The maximum detection was observed at 2004 historical sample location L10ss-003M, located in the vicinity of former Building PE-1, and was barely above the Regional Screening Level (RSL) of 400 mg/kg. Only 2 of the 11 multi-acre ISM samples exhibited lead detections above background concentrations.
- Mercury was detected above its background concentration of 0.036 mg/kg at 41 of 73 of the screening dataset samples, ranging in concentration from 0.037J-0.1J mg/kg. The maximum detection of mercury was observed in 2007 historical sample L10ss-059M.

5.2.2.3 Semi-volatile Organic Compounds

A total of 23 SVOCs were identified as SRCs in surface soil at Load Line 10, 17 of which were PAHs (Table 5-6). All detected concentrations were retained as SRCs since no site-specific background values exist for SVOCs. Since there are no background values for screening SVOCs, those SRCs that exceeded the most restrictive FWCUGs at a TR of 10^{-5} and HI=1.0 are highlighted yellow in Figures 5-3 and 5-5 to illustrate the distribution of SVOCs. PAH detections were observed in all 22 surface soil locations in the SRC screening dataset, as well as all nine PBA08 RI discrete soil boring samples from the 0-1 ft bgs interval evaluated only for nature and extent. A total of 10 of the 22 locations exhibited detections of either 15 or 16 of the individual PAH SRCs in each sample. The PAH SRCs benzo(b)fluoranthene, fluoranthene, and pyrene were detected in all 22 samples in the surface soil screening dataset. A detection frequency of 50% or greater (i.e., 11 or more of 22 samples) was observed for 16 of the 17 PAH SRCs.

Concentrations of PAHs detected across the entire AOC are generally higher in samples taken from areas of Load Line 10 where buildings, roads, and parking areas were present than in more remote areas of the AOC. The highest occurrence of SRCs with MDCs was observed at PBA08 RI sample location L10ss-080M. L10ss-080M is an ISM sample that surrounds the vicinity of the former Building PE-1, which includes a portion of its footprint and a gravel access road. L10ss-088M is a multi-acre ISM that encompasses 1.8 acres and the majority of the L10ss-080M sample footprint.

The PAHs detected at the highest concentrations at L10ss-080M were fluoranthene (12 mg/kg), phenanthrene (11 mg/kg), and pyrene (8 mg/kg). PAH concentrations were higher in the small ISM sample L10ss-080M than the multi-acre sample L10ss-088M.

Petroleum staining was noted in a soil boring during installation of nearby and downgradient monitoring well L10mw-001 under the 2004 historical investigation. However, no PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

5.2.2.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

All detected concentrations of VOCs, pesticides, and PCBs were below laboratory reporting limits. Three pesticides (heptachlor epoxide, alpha-chlordane, and gamma-chlordane), three VOCs (acetone, carbon disulfide, and methylene chloride), and one PCB (PCB-1254) were identified as SRCs, as there are no associated background concentrations for these chemicals. The pesticide and VOC SRCs were detected only once in the screening dataset of 10 samples for these analytical suites. The three pesticide SRCs were detected at location L10ss-092M, which is a multi-acre ISM area encompassing former Buildings PE-10 and PE-11 and the neighboring vicinity of these former structures. PCB-1254 was detected only at L10ss-080M, which is associated with the former Building PE-1. Acetone and carbon disulfide were detected in only 1 of 12 VOC samples in the SRC dataset. Methylene chloride was detected in 4 of 12 samples in the SRC dataset. Acetone and methylene chloride are common laboratory contaminants.

5.2.3 Contaminant Nature and Extent in Subsurface Soil

Data from subsurface soil samples were screened, as discussed in Section 5.1.2, to identify SRCs representing subsurface conditions at Load Line 10. Since subsurface soil samples were not collected during the historical investigations at the AOC, the SRC screening dataset was comprised of 20 discrete samples collected during the PBA08 RI activities. A total of 16 of the samples were analyzed for TAL metals, explosives, and PAHs; four samples were analyzed for RVAAP full-suite analytes (TAL metals, explosives, propellants, SVOCs, VOCs, PCBs, pesticides). Table 5-7 presents the results of the SRC screening for subsurface soil samples at Load Line 10.

Table 5-12 summarizes the analytical results for all detected analytes in the PBA08 RI subsurface soil samples at Load Line 10. Complete copies of all the laboratory analytical data packages are presented in Appendix D. Figures 5-6 and 5-7 illustrate the distribution of identified inorganic and organic SRCs in subsurface soil, respectively.

5.2.3.1 Explosives and Propellants

Four explosives [1,3,5-trinitrobenzene (TNB), 2-amino-4,6-DNT, 4-amino-2,6-DNT, and PETN] were identified as SRCs in subsurface soil samples at Load Line 10 (Figure 5-7). All detected concentrations of these explosive SRCs in subsurface soil samples, except L10sb-071 4.0-6.5ft, were less than the laboratory reporting limit. Soil boring L10sb-071 had a PETN concentration of 0.75 mg/kg at 4.0-6.5 ft, only slightly above the laboratory reporting limit of 0.5 mg/kg.

No propellants were detected in subsurface soil at Load Line 10. None of the explosives detected in the surface soil were detected in the subsurface soil, and none of the subsurface SRCs were detected in the surface soil.

5.2.3.2 Inorganic Chemicals

Eight inorganic chemicals (metals) were identified as SRCs in subsurface soil samples at Load Line 10, as shown in Table 5-7 and Figure 5-6. Those SRCs that exceeded the most restrictive FWCUGs at a TR of 10^{-5} and HI=1.0 (or background concentrations) are highlighted yellow on Figure 5-6. Elevated inorganic chemicals occurred predominantly at two soil boring locations, L10sb-066 and L10sb-071. L10sb-066 is associated with the former Building PE-1. Construction debris, including brick and gravel, were observed in boring L10sb-071 that was terminated at 6.5 ft bgs due to concrete refusal.

Cadmium was detected in 18 of the 20 subsurface soil samples, ranging in concentration from 0.032J-0.37 mg/kg. Silver was detected in 9 of the 20 samples at concentrations ranging from 0.006J-0.02J mg/kg. Antimony was detected above its background concentration of 0.96 mg/kg in only one sample: the 4.0-7.0 ft bgs interval at L10sb-066 at a concentration of 27.1 mg/kg.

Lead was detected above its background concentration of 19.1 mg/kg in four samples collected from two soil borings: L10sb-066 and L10sb-071. At L10sb-066, located in a drainage ditch adjacent to former Building PE-1, lead was detected at concentrations of 79.4 mg/kg at 1.0-4.0 ft bgs and 35.6 mg/kg at 4.0-7.0 ft bgs. Lead concentrations at L10sb-071 (located adjacent to former Building PE-7) were 70 mg/kg at 1.0-4.0 ft bgs and 70.1 mg/kg at 4.0-6.5 ft bgs.

All inorganic SRCs identified for subsurface soil were also identified as SRCs for surface soil. No real trends of increasing or decreasing concentrations with depth were observed with the inorganic SRCs.

5.2.3.3 Semi-volatile Organic Compounds

A total of 19 SVOCs, 15 of which were PAHs, were detected and identified as SRCs in subsurface soil at Load Line 10 (Figure 5-7). The majority of SVOCs were detected at four of the nine soil boring locations: L10sb-066, L10sb-069 (1.0-4.0 ft bgs interval only), L10sb-071, and L10sb-073. The maximum detections for all 15 PAHs were observed at L10sb-071 in the 1.0-4.0 ft bgs interval; all 15 PAHs were also detected in the 4.0-7.0 ft bgs interval at this soil boring location at lower concentrations. Soil boring L10sb-071 was located in the footprint of former Building PE-7. L10sb-066 was the only soil boring where PAHs were detected at a higher concentration in the deeper interval (4.0-7.0 ft bgs) than in the corresponding shallow subsurface soil interval (1.0-4.0 ft bgs).

All SVOC SRCs were identified for subsurface soil, except one [bis(2-ethylhexyk)phthalate] that was also identified as SRCs for the surface soil. No real trends of increasing or decreasing concentrations with depth were observed with the organic SRCs. Additionally, no CERCLA-release related sources of PAHs were identified for this AOC.

5.2.3.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

There were no detections of pesticides or PCBs in subsurface soil at Load Line 10. Only two VOCs were detected at concentrations below laboratory reporting limits. The two VOCs (2-butanone and bromomethane) were identified as SRCs, as they were detected but had no associated background concentration. Neither of the VOCs were identified as SRCs in surface soil. Similarly, none of the SRCs identified for surface soil were detected in the subsurface soil samples. Bromomethane was detected at soil boring location L10sb-073 in the 1.0-4.0 ft bgs interval at a concentration of 0.0013J mg/kg but was not detected in the underlying 4.0-7.0 ft bgs interval. 2-Butanone was detected at soil boring location L10sb-073 in the 4.0-7.0 ft bgs interval at 0.0028J mg/kg but was not detected in the overlying 1.0-4.0 mg/kg interval.

5.2.4 Geotechnical Subsurface Soil Samples

One soil boring was completed at Load Line 10 for the purpose of obtaining geotechnical parameters to support vadose zone soil leaching and groundwater transport modeling. A sample was collected from the 4.0-4.8 ft bgs interval in this boring. Soil boring L10sb-068 was advanced to a depth of 20.0 ft bgs, with groundwater encountered at 18.9 ft bgs. Although weathered sandstone was encountered at a depth of 18.9 ft bgs, competent bedrock was not encountered at this boring location. Table 5-4 summarizes the results of the geotechnical characteristics of Load Line 10 soil. Laboratory analytical data package results are presented in Appendix D.

Table 5-4. Summary of Geotechnical Parameters

Sample ID: Parameters	L10SB-068-5501-SO
Depth	4.0 to 4.8 ft bgs
Porosity	38.9 %
Density	1.70 g/cm^3
Moisture content	15.4 %
Total organic carbon	760J mg/kg
Size fraction analysis	10.7 % gravel, 26.8 % sand, 43.7 % silt, 18.8 % clay
Permeability (K)	1.2E-07 cm/sec

bgs= Below ground surface.
cm/sec = Centimeters per second.
g/cm^3 = Grams per cubic centimeter.
mg/kg = Milligrams per kilogram.

5.2.5 Contaminant Nature and Extent in Sediment

One discrete sediment sample (0.0-0.5 ft bgs) was collected at Load Line 10 from the main ditch draining to the southwest of the AOC during the PBA08 RI and was analyzed for RVAAP full-suite analytes. No historical sediment samples were collected at Load Line 10. Table 5-8 presents the results of the SRC screening for sediment at Load Line 10, and the results of the detected analytes for the PBA08 RI sediment samples are summarized in Table 5-13. Complete copies of the laboratory analytical packages are presented in Appendix D.

One sediment sample was also collected under the PBA08 RI off thick and downstream of Load Line 10 to assess conditions downstream of the entirety of Fuze and Booster Hill. The data from this sample (FWSsd-102) were reviewed to assess any off-site and downstream impacts from the Fuze and Booster Hill vicinity, including Load Line 10. The data tables for this sample are included in Appendix D. Figure 5-8 presents the locations and concentrations of SRCs identified in sediment at Load Line 10 and the off-AOC sediment location.

5.2.5.1 Explosives and Propellants

Nitroguanidine was the only SRC detected in sediment at Load Line 10. Nitroguanidine was detected at location L10sd-094 at a concentration of 0.32 mg/kg, well below the RSL of 610 mg/kg, and was not detected in off-AOC station FWSsd-102 or any of the other media. No explosives were detected in sediment at Load Line 10 or at the downstream facility-wide location.

5.2.5.2 Inorganic Chemicals

Three inorganic chemicals (antimony, beryllium, and cadmium) were identified as SRCs in sediment at Load Line 10. Concentrations of antimony and beryllium detected at L10sd-094 were below laboratory reporting limits, as shown in Figure 5-8, and were similar to those detected in the off-AOC sample. Cadmium was detected at L10sd-094 at 0.52 mg/kg, well below the RSL of 16 mg/kg, and was not detected in the off-AOC sediment sample.

5.2.5.3 Semi-volatile Organic Compounds

All detected concentrations of SVOCs in sediment at Load Line 10 were below laboratory reporting limits. Seven SVOCs were identified as SRCs, as there are no associated background concentrations for these chemicals. All the SVOC SRCs were PAHs, with the exception of 3+4-methylphenol. All of the SRCs in sediment at L10sd-094, with the exception of 3+4-methylphenol, were also identified as SRCs in surface soil. No SVOCs were detected in sediment at downstream off-AOC sample location FWSsd-102.

5.2.5.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

All detected concentrations of VOCs, pesticides, and PCBs were below laboratory reporting limits. No pesticides or PCBs were detected in sediment at Load Line 10, and none were detected at off-AOC station FWSsd-102. One VOC (toluene) was detected at a concentration below the laboratory reporting limit and was identified as an SRC. Toluene was detected at PBA08 RI sediment location L10sd-094 at a concentration of 0.00042J mg/kg but was not detected at off-AOC sediment location FWSsd-102 or in any other media.

5.2.6 Contaminant Nature and Extent in Surface Water

Surface water at Load Line 10 is only present intermittently (i.e., following a snowmelt or rain). No historical surface water samples were collected at Load Line 10 because surface water was not present during previous investigations. During the PBA08 RI activities, one discrete surface water sample was collected at Load Line 10 from the main ditch draining to the southwest of the AOC and was analyzed for the RVAAP full suite of analytes.

Table 5-9 presents the results of the SRC screening for surface water at Load Line 10, and the results of the detected analytes for the PBA08 RI surface water sample are summarized in Table 5-14. Complete copies of the laboratory analytical packages are presented in Appendix D. Surface water field measurements for L10sw-094 are reported in Table 5-5.

One surface water sample was also collected under the PBA08 RI off the AOC and downstream of Load Line 10 to assess conditions downstream of the Fuze and Booster Hill as a whole. The data from this sample (FWSsw-102) were reviewed to assess off-site and downstream impacts from the Fuze and Booster Hill vicinity, including Load Line 10. Figure 5-8 presents the location and concentrations of SRCs identified in surface water at Load Line 10 and the off-AOC surface water location. The data tables for this sample are included in Appendix D.

5.2.6.1 Explosives and Propellants

No propellants or explosives were identified as SRCs in surface water at Load Line 10, and none were detected at off-AOC location FWSsw-102.

5.2.6.2 Inorganic Chemicals

As shown in Table 5-9, six inorganic chemicals (antimony, chromium, cobalt, lead, nickel, and vanadium) were identified as SRCs in surface water at Load Line 10. All had concentrations below laboratory reporting limits; however, these chemicals were identified as SRCs, and since they do not have an established background concentration, the background concentration is listed as 0 mg/kg. All the inorganic SRCs for Load Line 10 surface water were detected at higher concentrations in the downstream off-AOC sample location, as shown in Figure 5-8. All six SRCs, except vandanium, were also identified as surface soil SRCs.

5.2.6.3 Semi-volatile Organic Compounds

No SVOCs were identified as SRCs in surface water at Load Line 10, and none were detected at off-AOC location FWSsw-102.

5.2.6.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs or PCBs were detected in surface water at Load Line 10 or in the downstream off-AOC location FWSsw-102. One pesticide [beta-benzene hexachloride (BHC)] was detected at a concentration below the laboratory reporting limit and identified as an SRC. Beta-BHC had a concentration at L10sw-094 of 0.0000095J mg/L but was not detected at the downstream off-AOC location FWSsw-102 or in any other media.

Table 5-5. Surface Water Field Measurements

Station	Temperature (°C)	pH (S.U.)	Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
L10sw-094	4.03	6.55	0.137	6.71	11.5

°C = Degrees Celsius.
mg/L = Milligrams per liter.
mS/cm = Milli-siemens per centimeter.
NTU = Nephelometric turbidity units.
S.U. = Standard unit.

5.3 SUMMARY OF CONTAMINANT NATURE AND EXTENT

The 2004 (Characterization of 14 AOCs), 2007 (Investigation of Under Slab Surface Soils), and 2010 (PBA08 RI) data provide effective characterization of the nature and extent of the contamination at the AOC, and no further sampling is required.

The predominant SRCs in surface and subsurface soil at Load Line 10 were PAHs, which were observed in all surface soil samples analyzed across the entire AOC. Inorganic chemicals were also observed in soil at concentrations above their respective background concentrations throughout the AOC. A limited number of SRCs were observed in sediment and surface water, relative to soil at Load Line 10. Detections of explosives, propellants, VOCs, pesticides, and PCBs were limited in frequency. A summary of observations for each medium is presented below.

5.3.1 Surface Soil

The predominant SRCs for surface soil at Load Line 10 were inorganic chemicals and SVOCs, the majority of which were PAHs. Of 52 SRCs identified in surface soil, 17 were inorganic chemicals and 23 were SVOCs. Five inorganic chemicals were detected at their maximum concentrations at historical sample location L10ss-002M, adjacent to the former Building PE-1. Due to the ubiquity of detections above background concentrations, no other apparent spatial trend is evident in the distribution of inorganic chemicals throughout the AOC.

The highest occurrence of PAH SRCs with MDCs is observed at PBA08 RI sample location L10ss-080M in the vicinity of former Building PE-1. Concentrations of PAHs detected across the entire AOC are generally higher in samples taken from areas of Load Line 10 where buildings, roads, and parking areas were present than in more remote areas of the AOC. No PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

All detected concentrations of explosives, propellants, pesticides, VOCs, and PCBs were below laboratory reporting limits.

5.3.2 Subsurface Soil

A total of 33 SRCs were identified in subsurface soil at Load Line 10, the majority of which were SVOCs. There were 19 SVOCs (15 of which were PAHs) detected and identified. The maximum detections for all 15 PAHs were observed at L10sb-071 in the 1.0-4.0 ft bgs interval (Figure 5-7); all 15 PAHs were also detected in the 4.0-7.0 ft bgs interval at this soil boring location at lower concentrations. Soil boring L10sb-071 was located in the footprint of former Building PE-7.

All SVOC SRCs were identified for subsurface soil, except one [bis(2-ethylhexyk)phthalate] that was also identified as an SRC for surface soil. No real trends of increasing or decreasing concentrations with depth were observed with the organic SRCs. No CERCLA-release related sources of PAHs were identified for this AOC.

Eight inorganic chemicals were identified as SRCs. No propellants, PCBs, or pesticides were detected in subsurface soil at Load Line 10. All detected concentrations of explosives and VOCs were below the laboratory reporting limit. All inorganic SRCs identified for subsurface soil were also identified as SRCs for surface soil. No real trends of increasing or decreasing concentrations with depth were observed with the inorganic SRCs.

The PBA08 RI investigation adequately characterized the vertical extent of contamination at Load Line 10. No contaminants exceeded the most stringent risk-based screening criteria (e.g., FWCUGs or RSLs) below a depth of 7 ft bgs.

5.3.3 Sediment

A total of 12 SRCs were identified in sediment at Load Line 10, the majority of which were PAHs that were all below laboratory reporting limits. All SVOC SRCs, with the exception of 3+4-methylphenol, were also identified as SRCs in surface soil. Three inorganic chemicals (antimony, beryllium, and cadmium) were identified as SRCs in sediment and were also identified as SRCs for other media. One VOC (toluene) and one propellant (nitroguanidine) were identified as SRCs, but not identified in any other media. No explosives, pesticides, or PBCs were identified as SRCs.

Only two SRCs (antimony and beryllium) were identified in sediment at the off-AOC sediment sample location (FWSsd-102). Both were detected at the upstream location at similar concentrations; there appears to be no migration of sediment SRCs from Load Line 10 to the off-AOC location. Additionally, any PAH contamination within the AOC has not migrated off site as sediment.

5.3.4 Surface Water

Six of the seven SRCs identified in surface water at Load Line 10 were inorganic chemicals. All had concentrations below laboratory reporting limits; however, these chemicals were identified as SRCs, and since they do not have an established background concentration, the background concentration is listed as 0 mg/kg. All of the inorganic SRCs for Load Line 10 surface water were detected at higher concentrations in the downstream off-AOC sample location. One pesticide (beta- BHC) identified as an SRC was detected at a concentration below the laboratory reporting limit but was not detected at the downstream off-AOC location. No explosives, propellants, SVOCs, VOCs, or PCBs were identified as SRCs in surface water at Load Line 10, and none were detected at the off-AOC location FWSsw-102.

Table 5-6. SRC Screening Summary for Surface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria^a (mg/kg)	SRC? (yes/no)	SRC Justification
Inorganic chemicals								
Aluminum	**7429-90-5**	**73/ 73**	**7000**	**22000**	**10600**	**17700**	**Yes**	**Exceeds background**
Antimony	**7440-36-0**	**25/ 68**	**0.11**	**2.5**	**1.98**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**73/ 73**	**4.9**	**20**	**11.8**	**15.4**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**73/ 73**	**44.7**	**190**	**68.3**	**88.4**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**52/ 73**	**0.54**	**5.3**	**0.742**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**37/ 73**	**0.06**	**0.89**	**0.306**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	73/ 73	290	100000	7560	15800	No	Essential Nutrient
Chromium	**7440-47-3**	**73/ 73**	**12**	**33**	**20.2**	**17.4**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**73/ 73**	**2.9**	**14.7**	**8.47**	**10.4**	**Yes**	**Exceeds background**
Copper	**7440-50-8**	**73/ 73**	**9.1**	**42**	**19.5**	**17.7**	**Yes**	**Exceeds background**
Cyanide	**57-12-5**	**13/ 37**	**0.19**	**1.3**	**0.31**	**0**	**Yes**	**Exceeds background**
Iron	7439-89-6	73/ 73	14000	28000	20700	23100	No	Essential Nutrient
Lead	**7439-92-1**	**73/ 73**	**15**	**430**	**50.6**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	73/ 73	1700	23000	3230	3030	No	Essential Nutrient
Manganese	7439-96-5	73/ 73	250	1400	583	1450	No	Below background
Mercury	**7439-97-6**	**58/ 73**	**0.014**	**0.1**	**0.0388**	**0.036**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**73/ 73**	**10**	**37.4**	**21.9**	**21.1**	**Yes**	**Exceeds background**
Potassium	7440-09-7	59/ 73	680	1900	930	927	No	Essential Nutrient
Selenium	**7782-49-2**	**47/ 73**	**0.45**	**1.8**	**0.702**	**1.4**	**Yes**	**Exceeds background**
Silver	**7440-22-4**	**4/ 73**	**0.032**	**0.038**	**0.546**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	52/ 73	32	960	182	123	No	Essential Nutrient
Thallium	**7440-28-0**	**19/ 73**	**0.15**	**0.23**	**0.47**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	73/ 73	9	24.4	18.2	31.1	No	Below background
Zinc	**7440-66-6**	**73/ 73**	**53**	**220**	**87.6**	**61.8**	**Yes**	**Exceeds background**
Explosives/Propellants								
2,6-Dinitrotoluene	**606-20-2**	**1/ 73**	**0.14**	**0.14**	**0.111**	**None**	**Yes**	**Detected organic**
3-Nitrotoluene	**99-08-1**	**1/ 73**	**0.025**	**0.025**	**0.109**	**None**	**Yes**	**Detected organic**
Nitrocellulose	**9004-70-0**	**2/ 9**	**2.2**	**4**	**1.4**	**None**	**Yes**	**Detected organic**
Nitroglycerin	**55-63-0**	**1/ 40**	**0.6**	**0.6**	**0.254**	**None**	**Yes**	**Detected organic**
Tetryl	**479-45-8**	**4/ 73**	**0.023**	**0.035**	**0.155**	**None**	**Yes**	**Detected organic**
Semi-volatile Organic Compounds								
2-Methylnaphthalene	**91-57-6**	**5/ 10**	**0.011**	**0.41**	**0.326**	**None**	**Yes**	**Detected organic**
Acenaphthene	**83-32-9**	**11/ 22**	**0.0072**	**1.6**	**0.235**	**None**	**Yes**	**Detected organic**
Acenaphthylene	**208-96-8**	**3/ 22**	**0.0076**	**0.064**	**0.148**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**15/ 22**	**0.0073**	**2.4**	**0.303**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**20/ 22**	**0.0084**	**3.5**	**0.555**	**None**	**Yes**	**Detected organic**

Table 5-6. SRC Screening Summary for Surface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Benzenemethanol	100-51-6	1/ 7	2.1	2.1	0.814	None	Yes	Detected organic
Benzo(a)pyrene	50-32-8	20/ 22	0.0094	3.3	0.48	None	Yes	Detected organic
Benzo(b)fluoranthene	205-99-2	22/ 22	0.018	4.5	0.733	None	Yes	Detected organic
Benzo(ghi)perylene	191-24-2	18/ 22	0.0083	2	0.315	None	Yes	Detected organic
Benzo(k)fluoranthene	207-08-9	17/ 22	0.0076	1.5	0.281	None	Yes	Detected organic
Carbazole	86-74-8	2/ 10	0.29	1.4	0.477	None	Yes	Detected organic
Chrysene	218-01-9	21/ 22	0.011	3.4	0.549	None	Yes	Detected organic
Di-n-butyl phthalate	84-74-2	1/ 10	0.03	0.03	0.543	None	Yes	Detected organic
Dibenz(a,h)anthracene	53-70-3	11/ 22	0.01	0.5	0.174	None	Yes	Detected organic
Dibenzofuran	132-64-9	3/ 10	0.018	0.97	0.413	None	Yes	Detected organic
Diethyl phthalate	84-66-2	1/ 10	0.025	0.025	0.522	None	Yes	Detected organic
Fluoranthene	206-44-0	22/ 22	0.021	12	1.74	None	Yes	Detected organic
Fluorene	86-73-7	15/ 22	0.0083	1.7	0.239	None	Yes	Detected organic
Indeno(1,2,3-cd)pyrene	193-39-5	18/ 22	0.0073	1.8	0.3	None	Yes	Detected organic
Naphthalene	91-20-3	17/ 22	0.0092	1.2	0.21	None	Yes	Detected organic
Phenanthrene	85-01-8	21/ 22	0.016	11	1.38	None	Yes	Detected organic
Phenol	108-95-2	1/ 10	0.18	0.18	0.567	None	Yes	Detected organic
Pyrene	129-00-0	22/ 22	0.014	8	1.2	None	Yes	Detected organic
Pesticides/PCBs								
Heptachlor epoxide	1024-57-3	1/ 10	0.025	0.025	0.00926	None	Yes	Detected organic
PCB-1254	11097-69-1	1/ 10	0.024	0.024	0.0271	None	Yes	Detected organic
alpha-Chlordane	5103-71-9	1/ 10	0.3	0.3	0.0375	None	Yes	Detected organic
gamma-Chlordane	5103-74-2	1/ 10	0.23	0.23	0.0285	None	Yes	Detected organic
Volatile Organic Compounds								
Acetone	67-64-1	1/ 12	0.016	0.016	0.0107	None	Yes	Detected organic
Carbon disulfide	75-15-0	1/ 12	0.00061	0.00061	0.00283	None	Yes	Detected organic
Methylene chloride	75-09-2	4/ 12	0.00096	0.0013	0.00413	None	Yes	Detected organic

[a] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).
SRC screening tables include all available and appropriate data as presented in Section 5.1.4.
bgs = Below ground surface.
CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
PCB = Polychlorinated Biphenyl.
SRC = Site-related Contaminant.
Bold indicates analyte identified as an SRC.

Table 5-7. SRC Screening Summary for Subsurface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC? (yes/no)	SRC Justification
Inorganic chemicals (mg/kg)								
Aluminum	7429-90-5	20/ 20	3340	12900	8600	19500	No	Below background
Antimony	**7440-36-0**	**16/ 19**	**0.082**	**27.1**	**1.6**	**0.96**	**Yes**	**Exceeds background**
Arsenic	7440-38-2	20/ 20	6.2	19	13.7	19.8	No	Below background
Barium	**7440-39-3**	**20/ 20**	**16.5**	**151**	**46**	**124**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**20/ 20**	**0.25**	**1.2**	**0.471**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**18/ 20**	**0.032**	**0.37**	**0.0919**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	20/ 20	541	63300	8770	35500	No	Essential Nutrient
Chromium	7440-47-3	20/ 20	6.4	15.5	12.1	27.2	No	Below background
Cobalt	7440-48-4	20/ 20	3.8	15.8	8.61	23.2	No	Below background
Copper	7440-50-8	20/ 20	9.5	24.9	18.2	32.3	No	Below background
Iron	7439-89-6	20/ 20	14500	30000	22900	35200	No	Essential Nutrient
Lead	**7439-92-1**	**20/ 20**	**8.4**	**79.4**	**22.5**	**19.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	20/ 20	1770	7770	3560	8790	No	Essential Nutrient
Manganese	7439-96-5	20/ 20	221	1020	441	3030	No	Below background
Mercury	7439-97-6	4/ 20	0.017	0.031	0.0509	0.044	No	Below background
Nickel	7440-02-0	20/ 20	11.3	26	19.2	60.7	No	Below background
Potassium	7440-09-7	20/ 20	652	1580	1030	3350	No	Essential Nutrient
Selenium	**7782-49-2**	**20/ 20**	**0.58**	**5.7**	**1.25**	**1.5**	**Yes**	**Exceeds background**
Silver	**7440-22-4**	**9/ 20**	**0.006**	**0.02**	**0.0243**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	20/ 20	28.6	231	54.5	145	No	Essential Nutrient
Thallium	7440-28-0	19/ 20	0.08	0.18	0.124	0.91	No	Below background
Vanadium	7440-62-2	20/ 20	6.8	23	14.2	37.6	No	Below background
Zinc	**7440-66-6**	**20/ 20**	**49.6**	**322**	**74.3**	**93.3**	**Yes**	**Exceeds background**

Table 5-7. SRC Screening Summary for Subsurface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC? (yes/no)	SRC Justification
Explosives and Propellants (mg/kg)								
1,3,5-Trinitrobenzene	**99-35-4**	**1/ 20**	**0.037**	**0.037**	**0.119**	**None**	**Yes**	**Detected organic**
2-Amino-4,6-Dinitrotoluene	**35572-78-2**	**1/ 20**	**0.04**	**0.04**	**0.119**	**None**	**Yes**	**Detected organic**
4-Amino-2,6-Dinitrotoluene	**19406-51-0**	**3/ 20**	**0.022**	**0.16**	**0.116**	**None**	**Yes**	**Detected organic**
PETN	**78-11-5**	**3/ 20**	**0.029**	**0.75**	**0.263**	**None**	**Yes**	**Detected organic**
Semi-volatile Organic Compounds (mg/kg)								
Acenaphthene	**99-35-4**	**1/ 20**	**0.037**	**0.037**	**0.119**	**None**	**Yes**	**Detected organic**
Anthracene	**35572-78-2**	**1/ 20**	**0.04**	**0.04**	**0.119**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**19406-51-0**	**3/ 20**	**0.022**	**0.16**	**0.116**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**78-11-5**	**3/ 20**	**0.029**	**0.75**	**0.263**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**83-32-9**	**5/ 20**	**0.014**	**2.6**	**0.161**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**120-12-7**	**5/ 20**	**0.025**	**3.1**	**0.189**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**56-55-3**	**8/ 20**	**0.0077**	**5.5**	**0.353**	**None**	**Yes**	**Detected organic**
Bis(2-ethylhexyl)phthalate	**50-32-8**	**7/ 20**	**0.0098**	**4.9**	**0.313**	**None**	**Yes**	**Detected organic**
Carbazole	**205-99-2**	**7/ 20**	**0.012**	**6.2**	**0.41**	**None**	**Yes**	**Detected organic**
Chrysene	**191-24-2**	**8/ 20**	**0.0087**	**3.2**	**0.206**	**None**	**Yes**	**Detected organic**
Di-n-butyl phthalate	**207-08-9**	**6/ 20**	**0.017**	**3**	**0.188**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**117-81-7**	**4/ 4**	**0.024**	**0.033**	**0.0278**	**None**	**Yes**	**Detected organic**
Dibenzofuran	**86-74-8**	**1/ 4**	**0.063**	**0.063**	**0.0381**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**9/ 20**	**0.009**	**16**	**1.02**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**5/ 20**	**0.0094**	**2.1**	**0.13**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**8/ 20**	**0.011**	**2.8**	**0.185**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**3/ 20**	**0.012**	**0.69**	**0.0565**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**7/ 20**	**0.014**	**13**	**0.801**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**8/ 20**	**0.016**	**11**	**0.698**	**None**	**Yes**	**Detected organic**
Volatile Organic Compounds (mg/kg)								
2-Butanone	**78-93-3**	**1/ 4**	**0.0028**	**0.0028**	**0.0097**	**None**	**Yes**	**Detected organic**
Bromomethane	**74-83-9**	**1/ 4**	**0.0013**	**0.0013**	**0.00256**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
SRC screening tables include all available and appropriate data as presented in Section 5.1.4.
CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
PETN = Pentaerythritol tetranitrate.
SRC = Site-related Contaminant.
Bold indicates analyte identified as an SRC.

Table 5-8. SRC Screening for Sediment

Analyte	CAS Number	Freq of Detect	Minimum Detect	Max. Detect	Average Result	Background Criteria[a]	SRC? (yes/no)	SRC Justification
				Inorganic chemicals (mg/kg)				
Aluminum	7429-90-5	1/ 1	8600	8600	8600	13900	No	Below background
Antimony	**7440-36-0**	**1/ 1**	**0.12**	**0.12**	**0.12**	**0**	**Yes**	**Exceeds background**
Arsenic	7440-38-2	1/ 1	8	8	8	19.5	No	Below background
Barium	7440-39-3	1/ 1	65.9	65.9	65.9	123	No	Below background
Beryllium	**7440-41-7**	**1/ 1**	**0.66**	**0.66**	**0.66**	**0.38**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**1/ 1**	**0.52**	**0.52**	**0.52**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	1/ 1	1860	1860	1860	5510	No	Essential Nutrient
Chromium	7440-47-3	1/ 1	11.6	11.6	11.6	18.1	No	Below background
Cobalt	7440-48-4	1/ 1	6.5	6.5	6.5	9.1	No	Below background
Copper	7440-50-8	1/ 1	12.4	12.4	12.4	27.6	No	Below background
Iron	7439-89-6	1/ 1	16200	16200	16200	28200	No	Essential Nutrient
Lead	7439-92-1	1/ 1	21.7	21.7	21.7	27.4	No	Below background
Magnesium	7439-95-4	1/ 1	1550	1550	1550	2760	No	Essential Nutrient
Manganese	7439-96-5	1/ 1	351	351	351	1950	No	Below background
Mercury	7439-97-6	1/ 1	0.049	0.049	0.049	0.059	No	Below background
Nickel	7440-02-0	1/ 1	13.3	13.3	13.3	17.7	No	Below background
Potassium	7440-09-7	1/ 1	519	519	519	1950	No	Essential Nutrient
Selenium	7782-49-2	1/ 1	1	1	1	1.7	No	Below background
Sodium	7440-23-5	1/ 1	29.8	29.8	29.8	112	No	Essential Nutrient
Thallium	7440-28-0	1/ 1	0.17	0.17	0.17	0.89	No	Below background
Vanadium	7440-62-2	1/ 1	18.2	18.2	18.2	26.1	No	Below background
Zinc	7440-66-6	1/ 1	94.1	94.1	94.1	532	No	Below background
				Explosives and Propellants (mg/kg)				
Nitroguanidine	**556-88-7**	**1/ 1**	**0.32**	**0.32**	**0.32**	**None**	**Yes**	**Detected organic**
				Semi-volatile Organic Compounds (mg/kg)				
3+4-Methylphenol	**15831-10-4**	**1/ 1**	**0.032**	**0.032**	**0.032**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**1/ 1**	**0.01**	**0.01**	**0.01**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**1/ 1**	**0.012**	**0.012**	**0.012**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**1/ 1**	**0.021**	**0.021**	**0.021**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**1/ 1**	**0.015**	**0.015**	**0.015**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**1/ 1**	**0.02**	**0.02**	**0.02**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**1/ 1**	**0.013**	**0.013**	**0.013**	**None**	**Yes**	**Detected organic**
				Volatile Organic Compounds (mg/kg)				
Toluene	**108-88-3**	**1/ 1**	**0.00042**	**0.00042**	**0.00042**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

SRC screening tables include all available and appropriate data as presented in Section 5.1.4.

CAS = Chemical Abstract Service.

mg/kg = Milligrams per kilogram.

SRC = Site-related Contaminant.

Bold indicates analyte identified as an SRC.

Table 5-9. SRC Screening for Surface Water

Analyte	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC? (yes/no)	SRC Justification
				Inorganic chemicals (mg/L)				
Aluminum	7429-90-5	1/ 1	1.35	1.35	1.35	3.37	No	Below background
Antimony	**7440-36-0**	**1/ 1**	**0.00026**	**0.00026**	**0.00026**	**0**	**Yes**	**Exceeds background**
Arsenic	7440-38-2	1/ 1	0.00087	0.00087	0.00087	0.0032	No	Below background
Barium	7440-39-3	1/ 1	0.017	0.017	0.017	0.0475	No	Below background
Calcium	7440-70-2	1/ 1	17.8	17.8	17.8	41.4	No	Essential Nutrient
Chromium	**7440-47-3**	**1/ 1**	**0.0016**	**0.0016**	**0.0016**	**0**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**1/ 1**	**0.00027**	**0.00027**	**0.00027**	**0**	**Yes**	**Exceeds background**
Copper	7440-50-8	1/ 1	0.003	0.003	0.003	0.0079	No	Below background
Iron	7439-89-6	1/ 1	1.32	1.32	1.32	2.56	No	Essential Nutrient
Lead	**7439-92-1**	**1/ 1**	**0.0012**	**0.0012**	**0.0012**	**0**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	1/ 1	2.68	2.68	2.68	10.8	No	Essential Nutrient
Manganese	7439-96-5	1/ 1	0.0183	0.0183	0.0183	0.391	No	Below background
Nickel	**7440-02-0**	**1/ 1**	**0.0015**	**0.0015**	**0.0015**	**0**	**Yes**	**Exceeds background**
Potassium	7440-09-7	1/ 1	1.61	1.61	1.61	3.17	No	Essential Nutrient
Sodium	7440-23-5	1/ 1	0.742	0.742	0.742	21.3	No	Essential Nutrient
Vanadium	**7440-62-2**	**1/ 1**	**0.0023**	**0.0023**	**0.0023**	**0**	**Yes**	**Exceeds background**
				Pesticides and Polychlorinated Biphenyls (mg/L)				
beta-BHC	**319-85-7**	**1/ 1**	**0.0000095**	**0.0000095**	**0.0000095**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
SRC screening tables include all available and appropriate data as presented in Section 5.1.4.
BHC = Benzene hexachloride.
CAS = Chemical Abstract Service.
mg/L = Milligrams per liter.
SRC = Site-related Contaminant.
Bold indicates analyte identified as an SRC.

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples

Sample location	**Background Criteria[b]**	**L10ss-079M**	**L10ss-080M**	**L10ss-081M**	**L10ss-082M**
Sample ID		**L10ss-079M-5536-SO**	**L10ss-080M-5537-SO**	**L10ss-081M-5538-SO**	**L10ss-082M-5539-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Inorganic chemicals (mg/kg)					
Aluminum	17700	11400	13800	11800	12300
Antimony	0.96	0.18 J	0.39 J	0.37 J	0.11 J
Arsenic	15.4	10.6	12.9	11.8	10.1
Barium	88.4	68	83.2	56.7	65.2
Beryllium	0.88	0.71	0.86	0.63	0.65
Cadmium	0	**0.24 ***	**0.19 J***	**0.21 ***	**0.15 J***
Chromium	17.4	**18.7 ***	**22.6 ***	**18.8 ***	**17.8 ***
Cobalt	10.4	8.4	**12.7 ***	9.6	9.2
Copper	17.7	13.9	**20.8 ***	16.4	10.7
Cyanide	0	NR	NR	NR	NR
Lead	26.1	**29.4 J***	25.6 J	**31.5 J***	15.9 J
Mercury	0.036	**0.046 J***	0.027 J	**0.037 J***	**0.043 J***
Nickel	21.1	17.6	**29.2 ***	19.3	15.7
Selenium	1.4	0.91 J	1.1 J	0.89 J	0.89 J
Silver	0	**0.038 J***	**0.032 J***	<0.03 UJ	**0.036 J***
Thallium	0	**0.16 J***	**0.17 J***	**0.16 J***	**0.17 J***
Zinc	61.8	**71 ***	**74.6 ***	**70.8 ***	60.9
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.24 U	<0.24 U	<0.24 U	<0.25 U
3-Nitrotoluene	None	<0.24 U	**0.025 J***	<0.24 U	<0.25 U
Nitrocellulose	None	NR	<2.5 UJ	NR	NR
Nitroglycerin	None	<0.48 U	<0.48 U	<0.49 U	<0.5 U
Tetryl	None	**0.023 J***	**0.035 J***	<0.24 U	<0.25 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	**0.41 J***	NR	NR
Acenaphthene	None	<0.0068 U	**1.6 ***	**0.071 ***	**0.0072 ***
Acenaphthylene	None	<0.0068 U	<0.51 U	<0.0068 U	<0.0068 U
Anthracene	None	**0.015 ***	**2.4 ***	**0.12 ***	**0.013 ***
Benz(a)anthracene	None	**0.065 ***	**3.5 ***	**0.26 ***	**0.034 ***
Benzenemethanol	None	NR	<3.4 U	NR	NR
Benzo(a)pyrene	None	**0.064 ***	**3.3 ***	**0.22 ***	**0.034 ***
Benzo(b)fluoranthene	None	**0.1 ***	**4.5 ***	**0.33 ***	**0.048 ***
Benzo(ghi)perylene	None	**0.046 ***	**2 ***	**0.15 ***	**0.023 ***
Benzo(k)fluoranthene	None	**0.039 ***	**1.5 ***	**0.13 ***	**0.02 ***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location	**Background Criteria**[b]	**L10ss-079M**	**L10ss-080M**	**L10ss-081M**	**L10ss-082M**
Sample ID		**L10ss-079M-5536-SO**	**L10ss-080M-5537-SO**	**L10ss-081M-5538-SO**	**L10ss-082M-5539-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	**1.4 ***	NR	NR
Chrysene	None	**0.068 ***	**3.4 ***	**0.27 ***	**0.039 ***
Di-n-butyl phthalate	None	NR	<3.4 U	NR	NR
Dibenz(a,h)anthracene	None	**0.012 ***	**0.5 J***	**0.037 ***	<0.0068 U
Dibenzofuran	None	NR	**0.97 J***	NR	NR
Diethyl phthalate	None	NR	<3.4 U	NR	NR
Fluoranthene	None	**0.14 ***	**12 ***	**0.81 ***	**0.11 ***
Fluorene	None	**0.01 ***	**1.7 ***	**0.063 ***	**0.0083 ***
Indeno(1,2,3-cd)pyrene	None	**0.042 ***	**1.8 ***	**0.14 ***	**0.021 ***
Naphthalene	None	**0.021 ***	**1.2 ***	**0.022 ***	**0.014 ***
Phenanthrene	None	**0.07 ***	**11 ***	**0.57 ***	**0.06 ***
Phenol	None	NR	<3.4 U	NR	NR
Pyrene	None	**0.11 ***	**8 ***	**0.54 ***	**0.069 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	<0.051 UJ	NR	NR
PCB-1254	None	NR	**0.024 J***	NR	NR
alpha-Chlordane	None	NR	<0.061 UJ	NR	NR
gamma-Chlordane	None	NR	<0.035 UJ	NR	NR
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	<0.025 U	NR	NR
Carbon disulfide	None	NR	<0.0062 U	NR	NR
Methylene chloride	None	NR	**0.00096 J***	NR	NR

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location	**Background Criteria[b]**	**L10ss-083M**	**L10ss-084M**	**L10ss-085M**	**L10ss-085M**
Sample ID		**L10ss-083M-5540-SO**	**L10ss-084M-5541-SO**	**L10ss-085M-6169-FD**	**L10ss-085M-5542-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Inorganic chemicals (mg/kg)					
Aluminum	17700	10300	12900	11300	11500
Antimony	0.96	0.14 J	0.12 J	0.12 J	0.11 J
Arsenic	15.4	11.8	10.4	10.6	11.1
Barium	88.4	63.9	64.2	65.9	62.2
Beryllium	0.88	0.63	0.65	0.62	0.64
Cadmium	0	**0.16 J***	**0.13 J***	**0.21 ***	**0.23 ***
Chromium	17.4	**17.9 ***	**19.8 ***	**20.7 ***	**19.2 ***
Cobalt	10.4	**14.7 ***	10.1	9.1	9
Copper	17.7	17.4	11.4	14.2	16.5
Cyanide	0	NR	NR	NR	NR
Lead	26.1	20 J	15.5 J	17.7 J	17.1 J
Mercury	0.036	0.036 J	0.036 J	**0.041 J***	**0.04 J***
Nickel	21.1	20.7	17.3	18.6	17.6
Selenium	1.4	0.87 J	0.89 J	0.88 J	0.85 J
Silver	0	<0.032 UJ	**0.037 J***	**0.036 J***	<0.033 UJ
Thallium	0	**0.15 J***	**0.17 J***	**0.15 J***	**0.15 J***
Zinc	61.8	**63.4 ***	56.5	**64.7 ***	**81.6 ***
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.25 U	<0.24 U
3-Nitrotoluene	None	<0.24 U	<0.25 U	<0.25 U	<0.24 U
Nitrocellulose	None	NR	NR	NR	NR
Nitroglycerin	None	<0.49 U	<0.5 U	<0.5 U	<0.49 U
Tetryl	None	<0.24 U	<0.25 U	<0.25 U	<0.24 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	NR
Acenaphthene	None	**0.047 ***	<0.0068 U	<0.0068 U	<0.0068 U
Acenaphthylene	None	<0.0068 U	<0.0068 U	<0.0068 U	<0.0068 U
Anthracene	None	**0.076 ***	<0.0068 U	<0.0068 U	**0.0073 ***
Benz(a)anthracene	None	**0.15 ***	**0.0084 ***	**0.022 ***	**0.025 ***
Benzenemethanol	None	NR	NR	NR	NR
Benzo(a)pyrene	None	**0.13 ***	**0.0094 ***	**0.024 ***	**0.026 ***
Benzo(b)fluoranthene	None	**0.21 ***	**0.018 ***	**0.044 ***	**0.043 ***
Benzo(ghi)perylene	None	**0.094 ***	**0.0083 ***	**0.018 ***	**0.018 ***
Benzo(k)fluoranthene	None	**0.077 ***	**0.0076 ***	**0.017 ***	**0.017 ***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location		**L10ss-083M**	**L10ss-084M**	**L10ss-085M**	**L10ss-085M**
Sample ID		**L10ss-083M-5540-SO**	**L10ss-084M-5541-SO**	**L10ss-085M-6169-FD**	**L10ss-085M-5542-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]	**Background Criteria**[b]	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	NR	NR	NR
Chrysene	None	**0.16 ***	**0.011 ***	**0.03 ***	**0.028 ***
Di-n-butyl phthalate	None	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	**0.023 ***	<0.0068 U	<0.0068 U	<0.0068 U
Dibenzofuran	None	NR	NR	NR	NR
Diethyl phthalate	None	NR	NR	NR	NR
Fluoranthene	None	**0.48 ***	**0.021 ***	**0.06 ***	**0.065 ***
Fluorene	None	**0.037 ***	<0.0068 U	<0.0068 U	**0.0089 ***
Indeno(1,2,3-cd)pyrene	None	**0.082 ***	**0.0073 ***	**0.016 ***	**0.017 ***
Naphthalene	None	**0.021 ***	**0.012 ***	**0.015 ***	**0.019 ***
Phenanthrene	None	**0.34 ***	**0.016 ***	**0.035 ***	**0.044 ***
Phenol	None	NR	NR	NR	NR
Pyrene	None	**0.31 ***	**0.014 ***	**0.041 ***	**0.043 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	NR	NR	NR
PCB-1254	None	NR	NR	NR	NR
alpha-Chlordane	None	NR	NR	NR	NR
gamma-Chlordane	None	NR	NR	NR	NR
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	NR	NR	NR
Carbon disulfide	None	NR	NR	NR	NR
Methylene chloride	None	NR	NR	NR	NR

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location		**L10ss-086M**	**L10ss-087M**	**L10ss-088M**	**L10ss-089M**
Sample ID		**L10ss-086M-5543-SO**	**L10ss-087M-5544-SO**	**L10ss-088M-5545-SO**	**L10ss-089M-6171-FD**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]	**Background Criteria**[b]	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**
Analyte					
Inorganic chemicals (mg/kg)					
Aluminum	17700	12400	11700	13200	13800
Antimony	0.96	0.11 J	0.16 J	0.22 J	0.24 J
Arsenic	15.4	11.1	10.3	11.7	11.6
Barium	88.4	61.4	77.4	74.5	66.5
Beryllium	0.88	0.67	0.7	0.78	0.71
Cadmium	0	**0.15 J***	**0.17 J***	**0.18 J***	**0.17 J***
Chromium	17.4	**20.2 ***	**17.9 ***	**21.8 ***	**21.4 ***
Cobalt	10.4	9.2	10.4	8.9	**10.8 ***
Copper	17.7	13.7	13.8	**18.7 ***	16.1
Cyanide	0	NR	NR	NR	NR
Lead	26.1	16.8 J	18.9 J	**27.2 J***	**26.4 J***
Mercury	0.036	**0.039 J***	**0.046 J***	**0.034 J**	**0.044 J***
Nickel	21.1	18.5	18.2	**22.1 ***	**21.8 ***
Selenium	1.4	0.9 J	0.92 J	0.97 J	1 J
Silver	0	<0.033 UJ	<0.038 UJ	<0.029 UJ	<0.034 UJ
Thallium	0	**0.15 J***	**0.17 J***	**0.16 J***	**0.17 J***
Zinc	61.8	58.7	54.6	**65.1 ***	**68.8 ***
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 U	<0.25 U
3-Nitrotoluene	None	<0.24 U	<0.25 U	<0.24 U	<0.25 U
Nitrocellulose	None	NR	NR	<2.8 UJ	NR
Nitroglycerin	None	<0.49 U	<0.5 U	<0.49 U	<0.5 U
Tetryl	None	<0.24 U	<0.25 U	**0.028 J***	<0.25 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	NR	**0.063 J***	NR
Acenaphthene	None	<0.0068 U	**0.014 ***	**0.32 ***	**0.12 ***
Acenaphthylene	None	<0.0068 U	<0.0068 U	<0.2 U	<0.0068 U
Anthracene	None	**0.0082 ***	**0.029 ***	**0.52 ***	**0.3 ***
Benz(a)anthracene	None	**0.027 ***	**0.072 ***	**1.1 ***	**0.55 ***
Benzenemethanol	None	NR	NR	<1.3 U	NR
Benzo(a)pyrene	None	**0.029 ***	**0.07 ***	**0.92 ***	**0.49 ***
Benzo(b)fluoranthene	None	**0.045 ***	**0.11 ***	**1.2 ***	**0.68 ***
Benzo(ghi)perylene	None	**0.02 ***	**0.044 ***	**0.59 ***	**0.33 ***
Benzo(k)fluoranthene	None	**0.021 ***	**0.037 ***	**0.53 ***	**0.27 ***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location	**Background Criteria[b]**	**L10ss-086M**	**L10ss-087M**	**L10ss-088M**	**L10ss-089M**
Sample ID		**L10ss-086M-5543-SO**	**L10ss-087M-5544-SO**	**L10ss-088M-5545-SO**	**L10ss-089M-6171-FD**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**
Analyte					
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	NR	**0.29 ***	NR
Chrysene	None	**0.032 ***	**0.078 ***	**1 ***	**0.53 ***
Di-n-butyl phthalate	None	NR	NR	<1.3 U	NR
Dibenz(a,h)anthracene	None	<0.0068 U	**0.01 ***	**0.15 J***	**0.08 ***
Dibenzofuran	None	NR	NR	**0.16 J***	NR
Diethyl phthalate	None	NR	NR	<1.3 U	NR
Fluoranthene	None	**0.074 ***	**0.23 ***	**3.1 ***	**1.7 ***
Fluorene	None	**0.0097 ***	**0.014 ***	**0.3 ***	**0.1 ***
Indeno(1,2,3-cd)pyrene	None	**0.018 ***	**0.04 ***	**0.55 ***	**0.3 ***
Naphthalene	None	**0.019 ***	**0.019 ***	**0.12 J***	**0.026 ***
Phenanthrene	None	**0.046 ***	**0.12 ***	**2.4 ***	**1.1 ***
Phenol	None	NR	NR	<1.3 U	NR
Pyrene	None	**0.047 ***	**0.15 ***	**2.2 ***	**1.1 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	NR	<0.026 UJ	NR
PCB-1254	None	NR	NR	<0.034 U	NR
alpha-Chlordane	None	NR	NR	<0.031 UJ	NR
gamma-Chlordane	None	NR	NR	<0.017 UJ	NR
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	NR	<0.026 U	NR
Carbon disulfide	None	NR	NR	<0.0065 U	NR
Methylene chloride	None	NR	NR	**0.0013 J***	NR

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location	**Background Criteria**[b]	**L10ss-089M**	**L10ss-090M**	**L10ss-091M**	**L10ss-092M**
Sample ID		**L10ss-089M-5546-SO**	**L10ss-090M-5547-SO**	**L10ss-091M-5548-SO**	**L10ss-092M-5549-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**
Analyte					
Inorganic chemicals (mg/kg)					
Aluminum	17700	13400	12900	12400	11200
Antimony	0.96	0.22 J	0.19 J	0.34 J	0.18 J
Arsenic	15.4	11.8	12	12.1	10.2
Barium	88.4	69.6	74.4	60.9	60.2
Beryllium	0.88	0.68	0.77	0.65	0.6
Cadmium	0	**0.14 J***	**0.48 ***	**0.18 J***	**0.17 J***
Chromium	17.4	**20.1 ***	**21.6 ***	**20.8 ***	**20.3 ***
Cobalt	10.4	9.9	9.1	8.5	7.8
Copper	17.7	15.8	17.6	**27.5 ***	**18.9 ***
Cyanide	0	NR	NR	NR	NR
Lead	26.1	23 J	**35.3 J***	23.3 J	21.3 J
Mercury	0.036	**0.042 J***	**0.037 J***	0.033 J	**0.041 J***
Nickel	21.1	20.2	19.9	20.3	17.9
Selenium	1.4	0.92 J	0.98 J	0.86 J	0.81 J
Silver	0	<0.035 UJ	<0.033 UJ	<0.028 UJ	<0.039 UJ
Thallium	0	**0.17 J***	**0.16 J***	**0.15 J***	**0.16 J***
Zinc	61.8	54.9	**202 ***	**78.1 ***	56.9
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.25 U	<0.24 U
3-Nitrotoluene	None	<0.25 U	<0.25 U	<0.25 U	<0.24 U
Nitrocellulose	None	NR	NR	NR	<1.9 UJ
Nitroglycerin	None	<0.5 U	<0.5 U	<0.5 U	<0.49 U
Tetryl	None	<0.25 U	**0.024 J***	<0.25 U	<0.24 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	**0.024 J***
Acenaphthene	None	**0.032 ***	**0.084 ***	**0.059 ***	**0.014 J***
Acenaphthylene	None	<0.0068 U	**0.0076 ***	**0.064 ***	<0.051 U
Anthracene	None	**0.082 ***	**0.15 ***	**0.21 ***	**0.03 J***
Benz(a)anthracene	None	**0.22 ***	**0.37 ***	**0.51 ***	**0.11 ***
Benzenemethanol	None	NR	NR	NR	<0.34 U
Benzo(a)pyrene	None	**0.21 ***	**0.33 ***	**0.46 ***	**0.19 ***
Benzo(b)fluoranthene	None	**0.29 ***	**0.51 ***	**0.66 ***	**0.34 ***
Benzo(ghi)perylene	None	**0.14 ***	**0.21 ***	**0.28 ***	**0.17 ***
Benzo(k)fluoranthene	None	**0.12 ***	**0.18 ***	**0.24 ***	**0.16 ***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location	**Background Criteria[b]**	**L10ss-089M**	**L10ss-090M**	**L10ss-091M**	**L10ss-092M**
Sample ID		**L10ss-089M-5546-SO**	**L10ss-090M-5547-SO**	**L10ss-091M-5548-SO**	**L10ss-092M-5549-SO**
Date		**04/13/10**	**04/13/10**	**04/13/10**	**04/13/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**
Analyte					
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	NR	NR	<0.051 U
Chrysene	None	**0.24 ***	**0.34 ***	**0.52 ***	**0.1 ***
Di-n-butyl phthalate	None	NR	NR	NR	**0.03 J***
Dibenz(a,h)anthracene	None	**0.032 ***	**0.054 ***	**0.079 ***	**0.058 ***
Dibenzofuran	None	NR	NR	NR	<0.34 U
Diethyl phthalate	None	NR	NR	NR	**0.025 J***
Fluoranthene	None	**0.66 ***	**0.95 ***	**1.4 ***	**0.24 ***
Fluorene	None	**0.024 ***	**0.084 ***	**0.068 ***	**0.017 J***
Indeno(1,2,3-cd)pyrene	None	**0.12 ***	**0.2 ***	**0.25 ***	**0.18 ***
Naphthalene	None	**0.014 ***	**0.075 ***	**0.016 ***	**0.021 J***
Phenanthrene	None	**0.3 ***	**0.62 ***	**0.76 ***	**0.13 ***
Phenol	None	NR	NR	NR	<0.34 U
Pyrene	None	**0.45 ***	**0.65 ***	**0.95 ***	**0.17 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	NR	NR	**0.025 J***
PCB-1254	None	NR	NR	NR	<0.17 U
alpha-Chlordane	None	NR	NR	NR	**0.3 J***
gamma-Chlordane	None	NR	NR	NR	**0.23 J***
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	NR	NR	**0.016 J***
Carbon disulfide	None	NR	NR	NR	<0.0061 U
Methylene chloride	None	NR	NR	NR	**0.0013 J***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location		**L10ss-093M**
Sample ID		**L10ss-093M-5550-SO**
Date		**04/13/10**
Depth (ft)		**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**
Analyte	**Background Criteria**[b]	
Inorganic chemicals (mg/kg)		
Aluminum	17700	10600
Antimony	0.96	0.14 J
Arsenic	15.4	10.7
Barium	88.4	57.5
Beryllium	0.88	0.56
Cadmium	0	**0.24 ***
Chromium	17.4	**19.2 ***
Cobalt	10.4	9.3
Copper	17.7	17.1
Cyanide	0	NR
Lead	26.1	20.9 J
Mercury	0.036	**0.045 J***
Nickel	21.1	**21.5 ***
Selenium	1.4	0.88 J
Silver	0	<0.033 UJ
Thallium	0	**0.16 J***
Zinc	61.8	**101 ***
Explosives/Propellants (mg/kg)		
2,6-Dinitrotoluene	None	<0.24 U
3-Nitrotoluene	None	<0.24 U
Nitrocellulose	None	NR
Nitroglycerin	None	<0.49 U
Tetryl	None	<0.24 U
Semi-volatile Organic Compounds (mg/kg)		
2-Methylnaphthalene	None	NR
Acenaphthene	None	**0.15 ***
Acenaphthylene	None	**0.01 ***
Anthracene	None	**0.23 ***
Benz(a)anthracene	None	**0.54 ***
Benzenemethanol	None	NR
Benzo(a)pyrene	None	**0.55 ***
Benzo(b)fluoranthene	None	**0.85 ***
Benzo(ghi)perylene	None	**0.35 ***
Benzo(k)fluoranthene	None	**0.31 ***

Table 5-10. Analytes Detected in PBA08 RI ISM Surface Soil Samples (continued)

Sample location		**L10ss-093M**
Sample ID		**L10ss-093M-5550-SO**
Date		**04/13/10**
Depth (ft)		**0.0 - 1.0**
Parameters Analyzed[a]		
Analyte	**Background Criteria**[b]	**TAL Metals Explosives SVOCs**
Semi-volatile Organic Compounds (mg/kg), continued		
Carbazole	None	NR
Chrysene	None	**0.56 ***
Di-n-butyl phthalate	None	NR
Dibenz(a,h)anthracene	None	**0.1 ***
Dibenzofuran	None	NR
Diethyl phthalate	None	NR
Fluoranthene	None	**1.5 ***
Fluorene	None	**0.15 ***
Indeno(1,2,3-cd)pyrene	None	**0.35 ***
Naphthalene	None	**0.27 ***
Phenanthrene	None	**1 ***
Phenol	None	NR
Pyrene	None	**1 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)		
Heptachlor epoxide	None	NR
PCB-1254	None	NR
alpha-Chlordane	None	NR
gamma-Chlordane	None	NR
Volatile Organic Compounds (mg/kg)		
Acetone	None	NR
Carbon disulfide	None	NR
Methylene chloride	None	NR

[a] Only detected analytes are presented in the table.
[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).
ID = Identification.
ISM = Incremental Sampling Method.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NR = Not Reported/Not Analyzed.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile Organic Compound.
TAL = Target Analyte List.
U = Not detected.
UJ = Not detected, reporting limit estimated.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples

Sample location	**Background Criteria**[b]	**L10sb-066**	**L10sb-067**	**L10sb-069**	**L10sb-070**
Sample ID		**L10sb-066-5493-SO**	**L10sb-067-5497-SO**	**L10sb-069-5503-SO**	**L10sb-070-5507-SO**
Date		**03/16/10**	**03/17/10**	**03/16/10**	**03/16/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Inorganic chemicals (mg/kg)					
Aluminum	17700	8980	12000	8330	7530
Antimony	0.96	0.87 J	0.12 J	0.62 J	**4.5 J***
Arsenic	15.4	14.8	13	9.5	**19.6 ***
Barium	88.4	68.3 J	87.3 J	54.7 J	45.6 J
Beryllium	0.88	0.6	0.68	0.43	0.44
Cadmium	0	**0.25 ***	**0.078 J***	**0.28 ***	**0.24 ***
Chromium	17.4	13	**19.2 ***	11.2	11.3
Cobalt	10.4	9.6	**12.5 ***	7.1	6.8
Copper	17.7	**19.5 ***	**19.7 ***	17.7	**18.6 ***
Lead	26.1	**44.1 ***	14.2	**45.7 ***	**138 ***
Mercury	0.036	<0.12 U	<0.12 U	0.028 J	0.029 J
Nickel	21.1	**22.5 J***	**29.7 J***	15.8 J	18.2 J
Selenium	1.4	**1.5 J***	**1.5 J***	1.2 J	1 J
Silver	0	<0.021 UJ	<0.018 UJ	<0.018 UJ	0.03 J*
Thallium	0	**0.14 J***	**0.17 J***	**0.13 J***	**0.11 J***
Zinc	61.8	**75.2 ***	60.4	**79.7 ***	**92.9 ***
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	<0.25 U
3-Nitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	<0.25 U
Nitrocellulose	None	NR	NR	NR	NR
Nitroglycerin	None	<0.5 U	<0.5 U	<0.48 U	<0.5 U
Tetryl	None	<0.25 U	<0.25 U	<0.24 U	<0.25 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	NR
Acenaphthene	None	**0.055 ***	<0.0082 U	**0.24 ***	<0.0079 U
Acenaphthylene	None	**0.0093 ***	<0.0082 U	**0.012 ***	**0.018 ***
Anthracene	None	**0.1 ***	<0.0082 U	**0.34 ***	**0.023 ***
Benz(a)anthracene	None	**0.35 ***	<0.0082 U	**0.57 ***	**0.081 ***
Benzenemethanol	None	NR	NR	NR	NR
Benzo(a)pyrene	None	**0.31 ***	<0.0082 U	**0.52 ***	**0.083 ***
Benzo(b)fluoranthene	None	**0.41 ***	**0.0094 ***	**0.67 ***	**0.11 ***
Benzo(ghi)perylene	None	**0.24 ***	<0.0082 U	**0.35 ***	**0.057 ***
Benzo(k)fluoranthene	None	**0.19 ***	<0.0082 U	**0.29 ***	**0.047 ***

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Sample location		**L10sb-066**	**L10sb-067**	**L10sb-069**	**L10sb-070**
Sample ID		**L10sb-066-5493-SO**	**L10sb-067-5497-SO**	**L10sb-069-5503-SO**	**L10sb-070-5507-SO**
Date		**03/16/10**	**03/17/10**	**03/16/10**	**03/16/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]	**Background Criteria[b]**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte					
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	NR	NR	NR
Chrysene	None	**0.35 ***	<0.0082 U	**0.59 ***	**0.09 ***
Di-n-butyl phthalate	None	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	**0.047 ***	<0.0082 U	**0.079 ***	**0.014 ***
Dibenzofuran	None	NR	NR	NR	NR
Diethyl phthalate	None	NR	NR	NR	NR
Fluoranthene	None	**0.93 ***	**0.015 ***	**1.8 ***	**0.18 ***
Fluorene	None	**0.039 ***	<0.0082 U	**0.21 ***	<0.0079 U
Indeno(1,2,3-cd)pyrene	None	**0.2 ***	**0.022 ***	**0.3 ***	**0.048 ***
Naphthalene	None	**0.0079 ***	<0.0082 U	**0.083 ***	<0.0079 U
Phenanthrene	None	**0.43 ***	<0.0082 U	**1.4 ***	**0.054 ***
Phenol	None	NR	NR	NR	NR
Pyrene	None	**0.7 ***	**0.011 ***	**1.3 ***	**0.14 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	NR	NR	NR
PCB-1254	None	NR	NR	NR	NR
alpha-Chlordane	None	NR	NR	NR	NR
gamma-Chlordane	None	NR	NR	NR	NR
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	NR	NR	NR
Carbon disulfide	None	NR	NR	NR	NR
Methylene chloride	None	NR	NR	NR	NR

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Sample location		**L10sb-071**	**L10sb-072**	**L10sb-072**	**L10sb-073**
Sample ID		**L10sb-071-5511-SO**	**L10sb-072-6173-FD**	**L10sb-072-5515-SO**	**L10sb-073-6172-FD**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**
Analyte	**Background Criteria[b]**				
Inorganic chemicals (mg/kg)					
Aluminum	17700	10200	11800	7710	11100
Antimony	0.96	0.18 J	0.083 J	0.27 J	0.14 J
Arsenic	15.4	12.8	8.6	11.4 J	12.6
Barium	88.4	68.7 J	**89.2 J***	49.1	60.3 J
Beryllium	0.88	0.58	0.73	0.45	0.61
Cadmium	0	**0.45 ***	**0.13 J***	**0.25 ***	**0.21 J***
Chromium	17.4	14.1	14	10.5	14.4
Cobalt	10.4	8.9	**12.3 ***	7.5 J	8.8
Copper	17.7	**22.1 ***	9.6	13.9	14.3
Lead	26.1	**77.7 ***	**26.9 ***	**38.7 J***	25.2
Mercury	0.036	0.032 J	**0.038 J***	0.019 J	**0.04 J***
Nickel	21.1	19.2 J	14.7 J	13.1	16.9 J
Selenium	1.4	**1.4 J***	**1.4 J***	0.86 J	1.3 J
Silver	0	<0.028 UJ	<0.043 UJ	**0.024 J***	<0.035 UJ
Thallium	0	**0.15 J***	**0.18 J***	**0.12 J***	**0.17 J***
Zinc	61.8	**110 ***	56.6	**64.5 ***	**68.9 ***
Explosives/Propellants (mg/kg)					
2,6-Dinitrotoluene	None	<0.26 U	<0.26 U	<0.25 U	<0.25 U
3-Nitrotoluene	None	<0.26 U	<0.26 U	<0.25 U	<0.25 U
Nitrocellulose	None	NR	NR	NR	**1.1 J***
Nitroglycerin	None	<0.51 U	<0.52 U	<0.5 U	<0.5 U
Tetryl	None	<0.26 U	<0.26 U	<0.25 U	<0.25 U
Semi-volatile Organic Compounds (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	<0.41 U
Acenaphthene	None	**0.088 ***	**0.046 ***	**0.054 ***	<0.062 U
Acenaphthylene	None	<0.0084 U	<0.0081 U	<0.0083 U	<0.062 U
Anthracene	None	**0.17 ***	**0.088 ***	**0.099 ***	<0.062 U
Benz(a)anthracene	None	**0.3 ***	**0.2 J***	**0.26 ***	**0.021 J***
Benzenemethanol	None	NR	NR	NR	<0.41 U
Benzo(a)pyrene	None	**0.28 ***	**0.18 J***	**0.24 ***	**0.017 J***
Benzo(b)fluoranthene	None	**0.37 ***	**0.27 J***	**0.32 ***	**0.025 J***
Benzo(ghi)perylene	None	**0.19 ***	**0.12 ***	**0.17 ***	**0.011 J***
Benzo(k)fluoranthene	None	**0.16 ***	**0.089 ***	**0.13 ***	**0.015 J***

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Sample location		**L10sb-071**	**L10sb-072**	**L10sb-072**	**L10sb-073**
Sample ID		**L10sb-071-5511-SO**	**L10sb-072-6173-FD**	**L10sb-072-5515-SO**	**L10sb-073-6172-FD**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**RVAAP Full-suite analytes**
Analyte	**Background Criteria[b]**				
Semi-volatile Organic Compounds (mg/kg), continued					
Carbazole	None	NR	NR	NR	<0.062 U
Chrysene	None	**0.32 ***	**0.19 J***	**0.26 ***	**0.022 J***
Di-n-butyl phthalate	None	NR	NR	NR	<0.41 U
Dibenz(a,h)anthracene	None	**0.046 ***	**0.046 ***	**0.045 ***	<0.062 U
Dibenzofuran	None	NR	NR	NR	<0.41 U
Diethyl phthalate	None	NR	NR	NR	<0.41 U
Fluoranthene	None	**0.88 ***	**0.48 J***	**0.67 ***	**0.048 J***
Fluorene	None	**0.085 ***	**0.047 ***	**0.05 ***	<0.062 U
Indeno(1,2,3-cd)pyrene	None	**0.17 ***	**0.12 ***	**0.14 ***	**0.0097 J***
Naphthalene	None	**0.035 ***	**0.038 ***	**0.02 ***	<0.062 U
Phenanthrene	None	**0.64 ***	**0.34 J***	**0.4 ***	**0.021 J***
Phenol	None	NR	NR	NR	<0.41 U
Pyrene	None	**0.65 ***	**0.35 J***	**0.48 ***	**0.035 J***
Pesticides and Polychlorinated Biphenyls (mg/kg)					
Heptachlor epoxide	None	NR	NR	NR	<0.015 U
PCB-1254	None	NR	NR	NR	<0.041 U
alpha-Chlordane	None	NR	NR	NR	<0.018 U
gamma-Chlordane	None	NR	NR	NR	<0.01 U
Volatile Organic Compounds (mg/kg)					
Acetone	None	NR	NR	NR	<0.025 U
Carbon disulfide	None	NR	NR	NR	<0.0062 U
Methylene chloride	None	NR	NR	NR	<0.0062 U

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Sample location	**Background Criteria[b]**	**L10sb-073**	**L10sb-074**	**L10sb-075**
Sample ID		**L10sb-073-5519-SO**	**L10sb-074-5523-SO**	**L10sb-075-5527-SO**
Date		**03/16/10**	**03/16/10**	**03/17/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]		**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals** **Explosives** **SVOCs**
Analyte				
Inorganic chemicals (mg/kg)				
Aluminum	17700	10800	11300	13200
Antimony	0.96	0.14 J	0.087 J	0.2 J
Arsenic	15.4	12.8 J	11.7	14.5
Barium	88.4	55.6 J	66.5 J	72.8 J
Beryllium	0.88	0.53	0.56	0.72
Cadmium	0	**0.14 J***	**0.068 J***	**0.69 ***
Chromium	17.4	13.4	13.2	**18.6 ***
Cobalt	10.4	9.5	5.5	**13.1 ***
Copper	17.7	14.1	9.3	**22.7 ***
Lead	26.1	22 J	13	26
Mercury	0.036	**0.041 J***	0.019 J	<0.14 U
Nickel	21.1	16.3 J	12.7 J	**29.7 J***
Selenium	1.4	0.94 J	1.1 J	**1.6 J***
Silver	0	**0.024 J***	<0.03 UJ	<0.034 UJ
Thallium	0	**0.16 J***	**0.12 J***	**0.19 J***
Zinc	61.8	54.2	47.2	**208 ***
Explosives/Propellants (mg/kg)				
2,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 U
3-Nitrotoluene	None	<0.24 U	<0.25 U	<0.24 U
Nitrocellulose	None	**1.1 J***	<6.4 U	NR
Nitroglycerin	None	<0.48 U	<0.5 U	<0.49 U
Tetryl	None	<0.24 U	<0.25 U	<0.24 U
Semi-volatile Organic Compounds (mg/kg)				
2-Methylnaphthalene	None	<0.42 U	<0.42 U	NR
Acenaphthene	None	<0.063 U	<0.064 U	<0.0094 U
Acenaphthylene	None	<0.063 U	<0.064 U	<0.0094 U
Anthracene	None	<0.063 U	<0.064 U	<0.0094 U
Benz(a)anthracene	None	**0.026 J***	<0.064 U	**0.032 ***
Benzenemethanol	None	<0.42 U	**0.13 J***	NR
Benzo(a)pyrene	None	**0.027 J***	<0.064 U	**0.04 ***
Benzo(b)fluoranthene	None	**0.046 J***	**0.012 J***	**0.072 ***
Benzo(ghi)perylene	None	**0.019 J***	<0.064 U	**0.034 ***
Benzo(k)fluoranthene	None	**0.018 J***	<0.064 U	**0.029 ***

Table 5-11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Sample location		**L10sb-073**	**L10sb-074**	**L10sb-075**
Sample ID		**L10sb-073-5519-SO**	**L10sb-074-5523-SO**	**L10sb-075-5527-SO**
Date		**03/16/10**	**03/16/10**	**03/17/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed[a]				**TAL Metals Explosives SVOCs**
Analyte	**Background Criteria**[b]	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	
Semi-volatile Organic Compounds (mg/kg), continued				
Carbazole	None	<0.063 UJ	<0.064 UJ	NR
Chrysene	None	**0.028 J***	<0.064 U	**0.047 ***
Di-n-butyl phthalate	None	<0.42 U	<0.42 U	NR
Dibenz(a,h)anthracene	None	<0.063 U	<0.064 U	<0.0094 U
Dibenzofuran	None	<0.42 U	<0.42 U	NR
Diethyl phthalate	None	<0.42 U	<0.42 U	NR
Fluoranthene	None	**0.064 ***	**0.016 J***	**0.087 ***
Fluorene	None	<0.063 U	<0.064 U	<0.0094 U
Indeno(1,2,3-cd)pyrene	None	**0.017 J***	<0.064 U	**0.028 ***
Naphthalene	None	<0.063 U	<0.064 U	<0.0094 U
Phenanthrene	None	**0.019 J***	<0.064 U	**0.033 ***
Phenol	None	<0.42 U	<0.42 U	NR
Pyrene	None	**0.047 J***	**0.012 J***	**0.069 ***
Pesticides and Polychlorinated Biphenyls (mg/kg)				
Heptachlor epoxide	None	<0.016 U	<0.0064 U	NR
PCB-1254	None	<0.042 U	<0.042 U	NR
alpha-Chlordane	None	<0.019 U	<0.0077 U	NR
gamma-Chlordane	None	<0.011 U	<0.0044 U	NR
Volatile Organic Compounds (mg/kg)				
Acetone	None	<0.025 U	<0.026 U	NR
Carbon disulfide	None	<0.0063 U	<0.0064 U	NR
Methylene chloride	None	<0.0063 U	<0.0064 U	NR

[a] Only detected analytes are presented in the table.
[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).
ID = Identification.
J = Estimated value less than reporting limits.
mg/kg =Milligrams per kilogram.
NR = Not Reported/Not Analyzed.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile Organic Compound.
TAL = Target Analyte List.
U = Not detected.
UJ = Not detected, reporting limit estimated.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples

Station	**Background Criteria**[b]	**L10sb-066**	**L10sb-066**	**L10sb-066**	**L10sb-067**	**L10sb-067**
Sample Id		**L10sb-066-5494-SO**	**L10sb-066-5495-SO**	**L10sb-066-5496-SO**	**L10sb-067-5498-SO**	**L10sb-067-5499-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/17/10**	**03/17/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**7.0 - 12.0**	**1.0 - 4.0**	**4.0 - 7.0**
Parameters Analyzed[a]		**TAL Metals** **Explosives** **SVOCs**	**TAL Metals** **Explosives** **SVOCs**	**TAL Metals** **Explosives** **SVOCs**	**TAL Metals** **Explosives** **SVOCs**	**TAL Metals** **Explosives** **SVOCs**
Analyte						
Inorganic chemicals (mg/kg)						
Aluminum	19500	7600	8960	3340 J	8700	9800
Antimony	0.96	0.7 J	**27.1 ***	0.12 J	0.11 J	0.15 J
Arsenic	19.8	12.6	12.3	6.2	19	17.4
Barium	124	41.2 J	46.4	16.5 J	55.2 J	32.8
Beryllium	0.88	0.41	0.46	0.25	0.5	0.46
Cadmium	0	**0.087 J***	**0.13 J***	**0.073 J***	**0.097 J***	**0.042 J***
Calcium	35500	11800	11300	2430	19100	5000
Chromium	27.2	12	13	6.4	14.5	13.6
Cobalt	23.2	9.7	8.3	5.7	15.8	10
Copper	32.3	19.6	20	9.5 J	19	18.3
Iron	35200	25200	21400	14500	30000	25600
Lead	19.1	**79.4 ***	**35.6 ***	8.4	11.7	10.1
Magnesium	8790	4700 J	4380	1770 J	7770 J	4740
Manganese	3030	557	361	316	440	396
Mercury	0.044	<0.12 U	<0.12 U	<0.11 U	<0.12 U	<0.12 U
Nickel	60.7	21.8	20.5	12.3 J	26 J	23.6
Potassium	3350	1150 J	1350	652 J	1380	1580
Selenium	1.5	1.3 J	0.73	0.58 J	1.3 J	0.85
Silver	0	<0.018 UJ	**0.02 J***	**0.016 J***	<0.015 UJ	**0.01 J***
Sodium	145	52.8 J	61.9 J	29.5 J	66.8 J	59.8 J
Thallium	0.91	0.12 J	0.14 J	0.08 J	0.18 J	0.14 J
Vanadium	37.6	13.7	14.2	6.8	16.8	15.3
Zinc	93.3	58.7	83.5	54.9	79.1	55.4
Explosives and Propellants (mg/kg)						
1,3,5-Trinitrobenzene	None	<0.26 U	<0.24 U	<0.24 U	<0.25 U	<0.24 U
2,4-Dinitrotoluene	None	<0.26 U	<0.24 U	<0.24 U	<0.25 U	<0.24 U
2-Amino-4,6-Dinitrotoluene	None	<0.26 U	<0.24 U	<0.24 U	<0.25 U	<0.24 U
4-Amino-2,6-Dinitrotoluene	None	<0.26 U	<0.24 U	<0.24 U	<0.25 U	<0.24 U
PETN	None	<0.51 U	<0.48 U	<0.48 U	<0.5 U	<0.49 U
Semi-volatile Organic Compounds (mg/kg)						
Acenaphthene	None	<0.0079 U	**0.014 ***	<0.0074 U	<0.0078 U	<0.0079 U
Anthracene	None	<0.0079 U	**0.025 ***	<0.0074 U	<0.0078 U	<0.0079 U
Benz(a)anthracene	None	**0.027 ***	**0.069 ***	<0.0074 U	<0.0078 U	<0.0079 U

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-066**	**L10sb-066**	**L10sb-066**	**L10sb-067**	**L10sb-067**
Sample Id		**L10sb-066-5494-SO**	**L10sb-066-5495-SO**	**L10sb-066-5496-SO**	**L10sb-067-5498-SO**	**L10sb-067-5499-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/17/10**	**03/17/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**7.0 - 12.0**	**1.0 - 4.0**	**4.0 - 7.0**
Parameters Analyzed [a]	**Background Criteria**[b]	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte						
Semi-volatile Organic Compounds (mg/kg), continued						
Benzo(a)pyrene	None	**0.027 ***	**0.058 ***	<0.0074 U	<0.0078 U	<0.0079 U
Benzo(b)fluoranthene	None	**0.038 ***	**0.089 ***	<0.0074 U	<0.0078 U	<0.0079 U
Benzo(ghi)perylene	None	**0.024 ***	**0.042 ***	<0.0074 U	<0.0078 U	<0.0079 U
Benzo(k)fluoranthene	None	**0.017 ***	**0.029 ***	<0.0074 U	<0.0078 U	<0.0079 U
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR
Carbazole	None	NR	NR	NR	NR	NR
Chrysene	None	**0.029 ***	**0.067 ***	<0.0074 U	<0.0078 U	<0.0079 U
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	**0.024 ***	**0.01 ***	<0.0074 U	<0.0078 U	<0.0079 U
Dibenzofuran	None	NR	NR	NR	NR	NR
Fluoranthene	None	**0.067 ***	**0.18 ***	<0.0074 U	<0.0078 U	<0.0079 U
Fluorene	None	<0.0079 U	**0.0094 ***	<0.0074 U	<0.0078 U	<0.0079 U
Indeno(1,2,3-cd)pyrene	None	**0.034 ***	**0.037 ***	<0.0074 U	<0.0078 U	<0.0079 U
Naphthalene	None	<0.0079 U	<0.0077 U	<0.0074 U	<0.0078 U	<0.0079 U
Phenanthrene	None	**0.03 ***	**0.096 ***	<0.0074 U	<0.0078 U	<0.0079 U
Pyrene	None	**0.054 ***	**0.13 ***	<0.0074 U	<0.0078 U	<0.0079 U
Volatile Organic Compounds (mg/kg)						
2-Butanone	None	NR	NR	NR	NR	NR
Bromomethane	None	NR	NR	NR	NR	NR

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station	Background Criteria[b]	L10sb-069	L10sb-069	L10sb-070	L10sb-070	L10sb-070
Sample Id		L10sb-069-5504-SO	L10sb-069-5505-SO	L10sb-070-5508-SO	L10sb-070-6174-FD	L10sb-070-5509-SO
Date		03/16/10	03/16/10	03/16/10	03/16/10	03/16/10
Depth (ft)		1.0 - 4.0	4.0 - 7.0	1.0 - 4.0	4.0 - 7.0	4.0 - 7.0
Parameters Analyzed[a]		TAL Metals Explosives SVOCs	TAL Metals Explosives SVOCs	TAL Metals Explosives SVOCs	TAL Metals Explosives SVOCs	TAL Metals Explosives SVOCs
Analyte						
Inorganic chemicals (mg/kg)						
Aluminum	19500	7120	8770	6980	6320	8910
Antimony	0.96	0.099 J	0.091 J	0.34 J	0.4 J	0.15 J
Arsenic	19.8	13.1	17	7.7	9.3	12.8
Barium	124	36.4 J	33.2	31.1 J	27.2 J	29.4
Beryllium	0.88	0.37	0.41	0.4	0.32	0.43
Cadmium	0	**0.088 J***	**0.038 J***	**0.12 J***	**0.057 J***	**0.048 J***
Calcium	35500	4900	4850	1010	1110	2090
Chromium	27.2	10.2	12.7	10.3	10	12.7
Cobalt	23.2	7.7	10.2	4.6	6.9	9.1
Copper	32.3	20	19.3	13.8	14	17.2
Iron	35200	22100	25900	20200	18100	22700
Lead	19.1	13.7	10	12	8.9	10
Magnesium	8790	2510 J	3890	1890 J	2240 J	3010
Manganese	3030	402	382	468	306	352
Mercury	0.044	<0.11 U	<0.12 U	<0.11 U	<0.12 U	<0.12 U
Nickel	60.7	18 J	23.8	13.5 J	16.3 J	20.9
Potassium	3350	745	1100	784	875	1180
Selenium	1.5	1.2 J	0.78	0.83 J	0.74 J	0.82
Silver	0	**0.01 J***	**0.0099 J***	<0.022 UJ	<0.016 UJ	**0.013 J***
Sodium	145	44 J	46 J	45.4 J	46.4 J	40.2 J
Thallium	0.91	0.12 J	0.13 J	0.093 J	0.095 J	0.12 J
Vanadium	37.6	12.4	13.9	13.3	10.7	13.8
Zinc	93.3	59.4	54.1	50.1	42.8	58.5
Explosives and Propellants (mg/kg)						
1,3,5-Trinitrobenzene	None	<0.25 U	<0.25 U	<0.24 U	<0.26 U	<0.24 U
2,4-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	**0.0058 J***	<0.24 U
2-Amino-4,6-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	**0.035 J***	**0.04 J***
4-Amino-2,6-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	**0.039 J***	**0.039 J***
PETN	None	**0.029 J***	<0.5 U	<0.48 U	<0.51 U	<0.48 U
Semi-volatile Organic Compounds (mg/kg)						
Acenaphthene	None	**0.024 ***	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Anthracene	None	**0.043 ***	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Benz(a)anthracene	None	**0.073 ***	<0.0079 U	**0.0089 ***	<0.0077 U	<0.0078 U
Benzo(a)pyrene	None	**0.068 ***	<0.0079 U	**0.0098 ***	<0.0077 U	<0.0078 U

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-069**	**L10sb-069**	**L10sb-070**	**L10sb-070**	**L10sb-070**
Sample Id		**L10sb-069-5504-SO**	**L10sb-069-5505-SO**	**L10sb-070-5508-SO**	**L10sb-070-6174-FD**	**L10sb-070-5509-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 7.0**	**4.0 - 7.0**
Parameters Analyzed [a]	**Background Criteria**[b]	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte						
Semi-volatile Organic Compounds (mg/kg), continued						
Benzo(b)fluoranthene	None	**0.097 ***	<0.0079 U	**0.012 ***	<0.0077 U	<0.0078 U
Benzo(ghi)perylene	None	**0.047 ***	<0.0079 U	**0.0087 ***	<0.0077 U	<0.0078 U
Benzo(k)fluoranthene	None	**0.031 ***	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR
Carbazole	None	NR	NR	NR	NR	NR
Chrysene	None	**0.073 ***	<0.0079 U	**0.013 ***	<0.0077 U	<0.0078 U
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	<0.0076 U	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Dibenzofuran	None	NR	NR	NR	NR	NR
Fluoranthene	None	**0.22 ***	<0.0079 U	**0.019 ***	<0.0077 U	<0.0078 U
Fluorene	None	**0.022 ***	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Indeno(1,2,3-cd)pyrene	None	**0.055 ***	<0.0079 U	**0.022 ***	<0.0077 U	<0.0078 U
Naphthalene	None	**0.012 ***	<0.0079 U	<0.0075 U	<0.0077 U	<0.0078 U
Phenanthrene	None	**0.17 ***	<0.0079 U	**0.014 ***	<0.0077 U	<0.0078 U
Pyrene	None	**0.15 ***	<0.0079 U	**0.021 ***	<0.0077 U	<0.0078 U
Volatile Organic Compounds (mg/kg)						
2-Butanone	None	NR	NR	NR	NR	NR
Bromomethane	None	NR	NR	NR	NR	NR

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-070**	**L10sb-071**	**L10sb-071**	**L10sb-072**	**L10sb-072**
Sample Id		**L10sb-070-5510-SO**	**L10sb-071-5512-SO**	**L10sb-071-5513-SO**	**L10sb-072-5516-SO**	**L10sb-072-5517-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**
Depth (ft)		**7.0 - 13.0**	**1.0 - 4.0**	**4.0 - 6.5**	**1.0 - 4.0**	**4.0 - 7.0**
Parameters Analyzed [a]	**Background Criteria[b]**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte						
Inorganic chemicals (mg/kg)						
Aluminum	19500	7260	11100	11800	12200	7340
Antimony	0.96	<0.58 R	0.16 J	0.082 J	0.12 J	0.095 J
Arsenic	19.8	14.4	12.8	8.2	14.6 J	15.3
Barium	124	27.6	77.8 J	**151 J***	50.4	34
Beryllium	0.88	0.4	0.69	**1.2 ***	0.5	0.38
Cadmium	0	**0.039 J***	**0.32 ***	**0.37 ***	<0.023 UJ	**0.032 J***
Calcium	35500	3950 J	19600	**63300 ***	796	774
Chromium	27.2	11.7	14.6	13	15.5	10.4
Cobalt	23.2	8.7	7.1	3.8	14.9 J	8.1
Copper	32.3	16.2	24.5	24.9	17.7	19.3
Iron	35200	24400	21900	16300	25400	21600
Lead	19.1	10.1	**70 ***	**70.1 ***	13.6 J	12.1
Magnesium	8790	3450	3660 J	6200 J	2920	2370
Manganese	3030	323	779	1020	364	308
Mercury	0.044	<0.12 U	0.021 J	0.017 J	<0.12 U	<0.11 U
Nickel	60.7	20.7	16 J	11.3 J	19.9	19.4
Potassium	3350	1120	1230	802	1020	836
Selenium	1.5	1.2 J	1.2 J	1.3 J	0.94 J	0.86
Silver	0	**0.015 J***	<0.022 UJ	<0.016 UJ	<0.0078 UJ	<0.57 U
Sodium	145	36.1 J	83.5 J	**231 ***	28.6 J	29.3 J
Thallium	0.91	0.12 J	0.14 J	<0.24 U	0.16 J	0.11 J
Vanadium	37.6	12.5 J	17.5	12.2	21.9	12.2
Zinc	93.3	52.1	**101 ***	**322 ***	50.5	55.5
Explosives and Propellants (mg/kg)						
1,3,5-Trinitrobenzene	None	<0.25 U	<0.25 U	<0.24 U	<0.26 U	<0.23 U
2,4-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	<0.26 U	<0.23 U
2-Amino-4,6-Dinitrotoluene	None	<0.25 U	<0.25 U	<0.24 U	<0.26 U	<0.23 U
4-Amino-2,6-Dinitrotoluene	None	**0.022 J***	**0.16 J***	<0.24 U	<0.26 UJ	<0.23 U
PETN	None	<0.5 U	**0.3 J***	**0.75 ***	<0.51 U	<0.46 U
Semi-volatile Organic Compounds (mg/kg)						
Acenaphthene	None	<0.0077 U	**2.6 ***	**0.4 ***	<0.0078 U	<0.0076 U
Anthracene	None	<0.0077 U	**3.1 ***	**0.38 ***	<0.0078 U	<0.0076 U
Benz(a)anthracene	None	<0.0077 U	**5.5 ***	**1.1 ***	<0.0078 U	<0.0076 U
Benzo(a)pyrene	None	<0.0077 U	**4.9 ***	**0.91 ***	<0.0078 U	<0.0076 U

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-070**	**L10sb-071**	**L10sb-071**	**L10sb-072**	**L10sb-072**
Sample Id		**L10sb-070-5510-SO**	**L10sb-071-5512-SO**	**L10sb-071-5513-SO**	**L10sb-072-5516-SO**	**L10sb-072-5517-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**
Depth (ft)		**7.0 - 13.0**	**1.0 - 4.0**	**4.0 - 6.5**	**1.0 - 4.0**	**4.0 - 7.0**
Parameters Analyzed [a]		**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**	**TAL Metals Explosives SVOCs**
Analyte	**Background Criteria[b]**					
Semi-volatile Organic Compounds (mg/kg), continued						
Benzo(b)fluoranthene	None	<0.0077 U	**6.2 ***	**1.4 ***	<0.0078 U	<0.0076 U
Benzo(ghi)perylene	None	<0.0077 U	**3.2 ***	**0.6 ***	<0.0078 U	<0.0076 U
Benzo(k)fluoranthene	None	<0.0077 U	**3 ***	**0.46 ***	<0.0078 U	<0.0076 U
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR
Carbazole	None	NR	NR	NR	NR	NR
Chrysene	None	<0.0077 U	**5.5 ***	**0.98 ***	<0.0078 U	<0.0076 U
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	<0.0077 U	**0.77 ***	**0.22 ***	<0.0078 U	<0.0076 U
Dibenzofuran	None	NR	NR	NR	NR	NR
Fluoranthene	None	**0.009 ***	**16 ***	**3 ***	<0.0078 U	<0.0076 U
Fluorene	None	<0.0077 U	**2.1 ***	**0.29 ***	<0.0078 U	<0.0076 U
Indeno(1,2,3-cd)pyrene	None	<0.0077 U	**2.8 ***	**0.56 ***	<0.0078 U	<0.0076 U
Naphthalene	None	<0.0077 U	**0.69 ***	**0.26 ***	<0.0078 U	<0.0076 U
Phenanthrene	None	<0.0077 U	**13 ***	**2.1 ***	<0.0078 U	<0.0076 U
Pyrene	None	<0.0077 U	**11 ***	**2 ***	<0.0078 U	<0.0076 U
Volatile Organic Compounds (mg/kg)						
2-Butanone	None	NR	NR	NR	NR	NR
Bromomethane	None	NR	NR	NR	NR	NR

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-073**	**L10sb-073**	**L10sb-074**	**L10sb-074**	**L10sb-075**
Sample Id		**L10sb-073-5520-SO**	**L10sb-073-5521-SO**	**L10sb-074-5524-SO**	**L10sb-074-5525-SO**	**L10sb-075-5528-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**	**03/17/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**
Parameters Analyzed [a]		**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**
Analyte	**Background Criteria**[b]					
Inorganic chemicals (mg/kg)						
Aluminum	19500	9700	9580	12900	5500	7350
Antimony	0.96	0.094 J	0.084 J	0.1 J	<0.59 UJ	<0.57 UJ
Arsenic	19.8	17.8	13.4	15.1	13.4	15.4
Barium	124	44.1 J	49.4	67.7 J	32.4 J	35.9 J
Beryllium	0.88	0.48	0.43	0.61	0.34	0.36
Cadmium	0	**0.14 J***	**0.032 J***	<0.034 UJ	**0.053 J***	**0.059 J***
Calcium	35500	1980	808	5370	541	7560
Chromium	27.2	14	13	13.7	9	11
Cobalt	23.2	10	6.6	7.1	8.1	8.6 J
Copper	32.3	21.9	16.9	10.7	17.2	19.9
Iron	35200	29900	21800	24800	20300	23400
Lead	19.1	18.7	10.1	18.3	11.6	12.2
Magnesium	8790	3220 J	2900	2010 J	1920 J	4290 J
Manganese	3030	562	221	505	425	371
Mercury	0.044	0.031 J	<0.12 U	0.019 J	<0.12 U	<0.11 U
Nickel	60.7	23.9 J	20.8	14.6 J	18.5 J	20 J
Potassium	3350	1030	816	808	741	1160
Selenium	1.5	1.5 J	0.89	**5.7 J***	1.2 J	1.2 J
Silver	0	<0.023 UJ	**0.006 J***	<0.035 UJ	<0.0047 UJ	<0.018 UJ
Sodium	145	40.4 J	32.6 J	49 J	36 J	41 J
Thallium	0.91	0.13 J	0.13 J	0.13 J	0.093 J	0.12 J
Vanadium	37.6	15.6	13.6	23	10.3	12.8
Zinc	93.3	75.8	52.3	49.6	54.8	58
Explosives and Propellants (mg/kg)						
1,3,5-Trinitrobenzene	None	<0.24 U	<0.25 U	**0.037 J***	<0.25 U	<0.25 U
2,4-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 UJ	<0.25 U	<0.25 U
2-Amino-4,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 UJ	<0.25 U	<0.25 U
4-Amino-2,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 UJ	<0.25 U	<0.25 U
PETN	None	<0.48 U	<0.5 U	<0.49 UJ	<0.5 U	<0.5 U
Semi-volatile Organic Compounds (mg/kg)						
Acenaphthene	None	**0.056 J***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Anthracene	None	**0.098 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Benz(a)anthracene	None	**0.17 ***	**0.0077 J***	<0.062 U	<0.059 U	<0.0076 U
Benzo(a)pyrene	None	**0.15 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-073**	**L10sb-073**	**L10sb-074**	**L10sb-074**	**L10sb-075**
Sample Id		**L10sb-073-5520-SO**	**L10sb-073-5521-SO**	**L10sb-074-5524-SO**	**L10sb-074-5525-SO**	**L10sb-075-5528-SO**
Date		**03/16/10**	**03/16/10**	**03/16/10**	**03/16/10**	**03/17/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**
Parameters Analyzed [a]	**Background Criteria**[b]	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals Explosives SVOCs**
Analyte						
		Semi-volatile Organic Compounds (mg/kg), continued				
Benzo(b)fluoranthene	None	**0.24 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Benzo(ghi)perylene	None	**0.098 ***	**0.0099 J***	<0.062 U	<0.059 U	<0.0076 U
Benzo(k)fluoranthene	None	**0.089 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Bis(2-ethylhexyl)phthalate	None	**0.024 J***	**0.033 J***	**0.027 J***	**0.027 J***	NR
Carbazole	None	**0.063 J***	<0.058 UJ	<0.062 UJ	<0.059 UJ	NR
Chrysene	None	**0.2 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Di-n-butyl phthalate	None	<0.38 U	**0.027 J***	<0.41 U	<0.39 U	NR
Dibenz(a,h)anthracene	None	**0.02 J***	0.0098 J*	<0.062 U	<0.059 U	<0.0076 U
Dibenzofuran	None	**0.023 J***	<0.38 U	<0.41 U	<0.39 U	NR
Fluoranthene	None	0.78 *	**0.021 J***	<0.062 U	<0.059 U	<0.0076 U
Fluorene	None	0.045 J*	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Indeno(1,2,3-cd)pyrene	None	**0.087 ***	**0.011 J***	<0.062 U	<0.059 U	<0.0076 U
Naphthalene	None	<0.057 U	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Phenanthrene	None	**0.49 ***	<0.058 U	<0.062 U	<0.059 U	<0.0076 U
Pyrene	None	**0.49 ***	**0.016 J***	<0.062 U	<0.059 U	<0.0076 U
		Volatile Organic Compounds (mg/kg)				
2-Butanone	None	<0.023 U	**0.0028 J***	<0.025 U	<0.024 U	NR
Bromomethane	None	**0.0013 J***	<0.0058 U	<0.0062 U	<0.0059 U	NR

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station		**L10sb-075**
Sample Id		**L10sb-075-5529-SO**
Date		**03/17/10**
Depth (ft)		**4.0 - 7.0**
Parameters Analyzed [a]		**TAL Metals** **Explosives** **SVOCs**
Analyte	**Background Criteria**[b]	
Inorganic chemicals (mg/kg)		
Aluminum	19500	7030
Antimony	0.96	<0.57 U
Arsenic	19.8	15.4
Barium	124	26.7
Beryllium	0.88	0.33
Cadmium	0	**0.041 J***
Calcium	35500	8280
Chromium	27.2	10.2
Cobalt	23.2	8
Copper	32.3	18.6
Iron	35200	21400
Lead	19.1	12.3
Magnesium	8790	3600
Manganese	3030	259
Mercury	0.044	<0.11 U
Nickel	60.7	18.2
Potassium	3350	1020
Selenium	1.5	0.59
Silver	0	**0.01 J***
Sodium	145	36 J
Thallium	0.91	0.1 J
Vanadium	37.6	11.4
Zinc	93.3	59.9
Explosives and Propellants (mg/kg)		
1,3,5-Trinitrobenzene	None	<0.25 U
2,4-Dinitrotoluene	None	<0.25 U
2-Amino-4,6-Dinitrotoluene	None	<0.25 U
4-Amino-2,6-Dinitrotoluene	None	<0.25 U
PETN	None	<0.5 U
Semi-volatile Organic Compounds (mg/kg)		
Acenaphthene	None	<0.0076 U
Anthracene	None	<0.0076 U
Benz(a)anthracene	None	<0.0076 U
Benzo(a)pyrene	None	<0.0076 U

Table 5-12. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station	**Background Criteria**[b]	**L10sb-075**
Sample Id		**L10sb-075-5529-SO**
Date		**03/17/10**
Depth (ft)		**4.0 - 7.0**
Parameters Analyzed [a]		**TAL Metals** **Explosives** **SVOCs**
Analyte		
Semi-volatile Organic Compounds (mg/kg), continued		
Benzo(b)fluoranthene	None	<0.0076 U
Benzo(ghi)perylene	None	<0.0076 U
Benzo(k)fluoranthene	None	<0.0076 U
Bis(2-ethylhexyl)phthalate	None	NR
Carbazole	None	NR
Chrysene	None	<0.0076 U
Di-n-butyl phthalate	None	NR
Dibenz(a,h)anthracene	None	<0.0076 U
Dibenzofuran	None	NR
Fluoranthene	None	<0.0076 U
Fluorene	None	<0.0076 U
Indeno(1,2,3-cd)pyrene	None	<0.0076 U
Naphthalene	None	<0.0076 U
Phenanthrene	None	<0.0076 U
Pyrene	None	<0.0076 U
Volatile Organic Compounds (mg/kg)		
2-Butanone	None	NR
Bromomethane	None	NR

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NR = Not Reported/Not Analyzed.
PETN = Pentaerythritol Tetranitrate.
SVOC = Semi-volatile Organic Compound.
TAL = Target Analyte List.
U= Not detected.
UJ = Not detected, reporting limit estimated.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 5-13. Results for Analytes Detected in PBA08 RI Sediment Samples

Sample location		**L10sd-094**	**FWSsd-102**
Sample ID		**L10sd-094-5531-SD**	**FWSsd-102-5011-SD**
Date		**02/18/10**	**02/17/10**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed[a]			
Analyte	**Background Criteria**[b]	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Inorganic chemicals (mg/kg)			
Aluminum	13900.00	8600	7010
Antimony	0.00	**0.12 J***	**0.15 J***
Arsenic	19.50	8	3.3
Barium	123.00	65.9	79.3
Beryllium	0.38	**0.66 J***	**0.73 ***
Cadmium	0.00	**0.52 ***	<0.13 UJ
Calcium	5510.00	1860 J	980
Chromium	18.10	11.6	14.9
Cobalt	9.10	6.5 J	**10.8 ***
Copper	27.60	12.4	**29.1 ***
Iron	28200.00	16200	**33500 ***
Lead	27.40	21.7 J	15.1
Magnesium	2760.00	1550	2570
Manganese	1950.00	351	478
Mercury	0.06	0.049 J	0.038 J
Nickel	17.70	13.3	**25.7 ***
Potassium	1950.00	519	1670
Selenium	1.70	1	1.2
Sodium	112.00	29.8 J	72.5 J
Thallium	0.89	0.17 J	<0.31 U
Vanadium	26.10	18.2	14.8
Zinc	532.00	94.1	54.6
Explosives and Propellants (mg/kg)			
Nitroguanidine	None	**0.32 ***	<0.25 U
Semi-volatile Organic Compounds (mg/kg)			
3+4-Methylphenol	None	**0.032 J***	<0.51 U
Benz(a)anthracene	None	**0.01 J***	<0.077 U
Benzo(a)pyrene	None	**0.012 J***	<0.077 U
Benzo(b)fluoranthene	None	**0.021 J***	<0.077 U
Chrysene	None	**0.015 J***	<0.077 U
Fluoranthene	None	**0.02 J***	<0.077 U
Pyrene	None	**0.013 J***	<0.077 U

Table 5-13. Results for Analytes Detected in PBA08 RI Sediment Samples (continued)

Sample location		L10sd-094	FWSsd-102
Sample ID		L10sd-094-5531-SD	FWSsd-102-5011-SD
Date		02/18/10	02/17/10
Depth (ft)		0.0 - 0.5	0.0 - 0.5
Parameters Analyzed[a]		RVAAP Full-suite analytes	RVAAP Full-suite analytes
Analyte	Background Criteria[b]		
Volatile Organic Compounds (mg/kg)			
Toluene	None	**0.00042 J***	<0.0077 U

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
TAL = Target Analyte List.
RVAAP = Ravenna Army Ammunition Plant.
U= Not detected.
UJ = Not detected, reporting limit estimated.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 5-14. Results for Analytes Detected in PBA08 RI Surface Water Samples

Sample location		**L10sw-094**	**FWSsw-102**
Sample ID		**L10sw-094-5535-SW**	**FWSsw-102-5010-SW**
Date		**03/09/10**	**02/17/10**
Parameters Analyzed[a]			
Analyte	**Background Criteria**[b]	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Inorganic chemicals (mg/L)			
Aluminum	3.37	1.35	**15.8 ***
Antimony	0	**0.00026 J***	**0.00042 J***
Arsenic	0.0032	0.00087 J	**0.0096 ***
Barium	0.0475	0.017	**0.264 ***
Beryllium	0	<0.001 U	**0.0011 ***
Cadmium	0	<0.00004 UJ	**0.00065 J***
Calcium	41.4	17.8	24
Chromium	0	**0.0016 J***	**0.0191 ***
Cobalt	0	**0.00027 J***	**0.0148 ***
Copper	0.0079	0.003 J	**0.0211 ***
Iron	2.56	1.32	**43.5 ***
Lead	0	**0.0012 J***	**0.0194 ***
Magnesium	10.8	2.68	9.44
Manganese	0.391	0.0183	**5.07 ***
Nickel	0	**0.0015 J***	**0.0327 ***
Potassium	3.17	1.61	**3.64 ***
Selenium	0	<0.005 U	**0.0017 J***
Sodium	21.3	0.742 J	3.14
Vanadium	0	**0.0023 J***	**0.0281 ***
Zinc	0.042	<0.0231 UJ	**0.132 ***
Nitrates (mg/L)			
Nitrate	None	NR	**0.1***
Pesticides and Polychlorinated Biphenyls (mg/L)			
beta-BHC	None	**0.0000095 J***	<0.00005 U

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

BHC = Benzene hexachloride.
ID = Identification.
J = Estimated value less than reporting limits.
mg/L = Milligrams per Liter.
NR = Not Reported/Not Analyzed.
PBA08 RI = Performance Based Acquisition 2008 Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
*** = Result exceeds background criteria or no background criteria was available.**

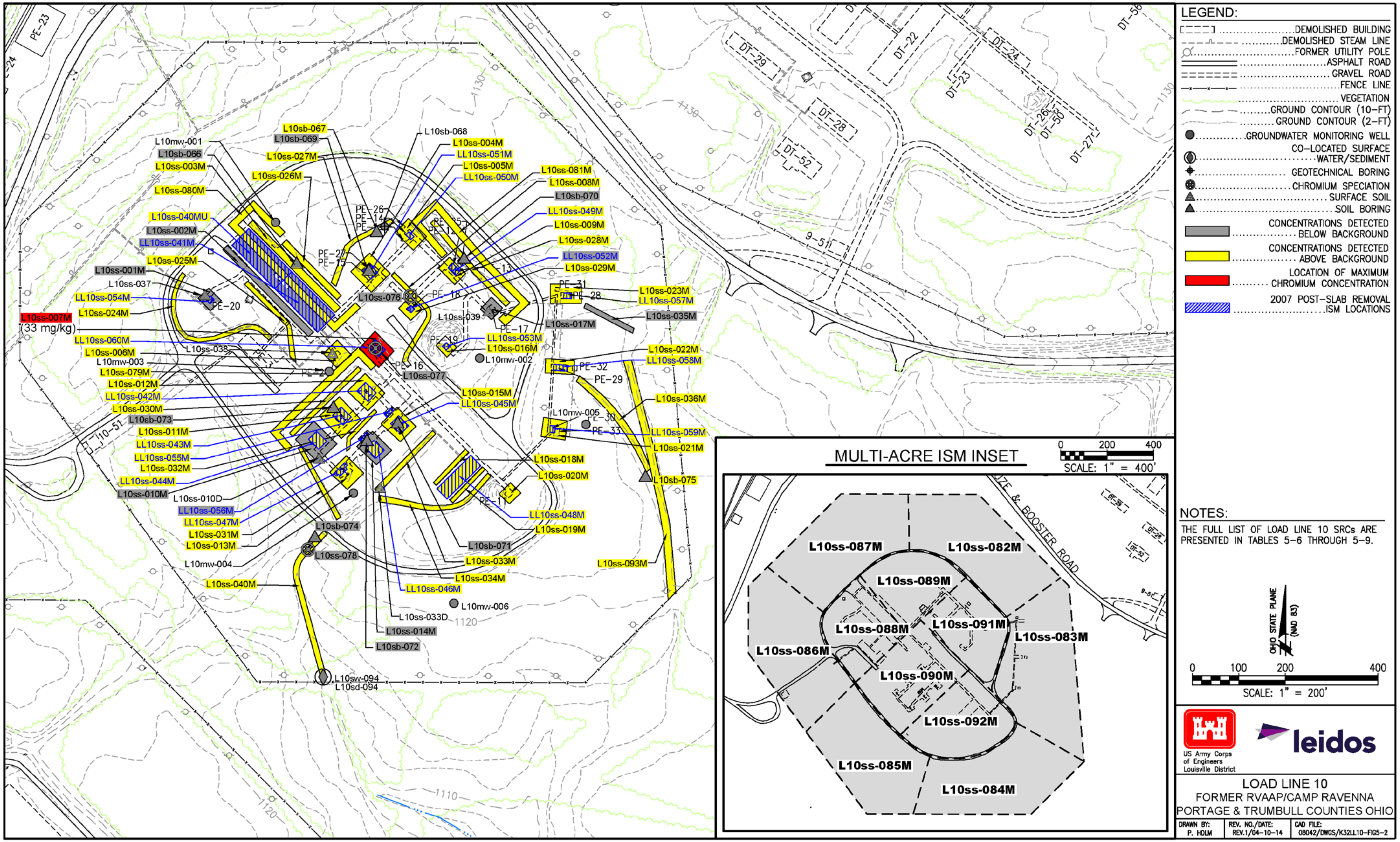
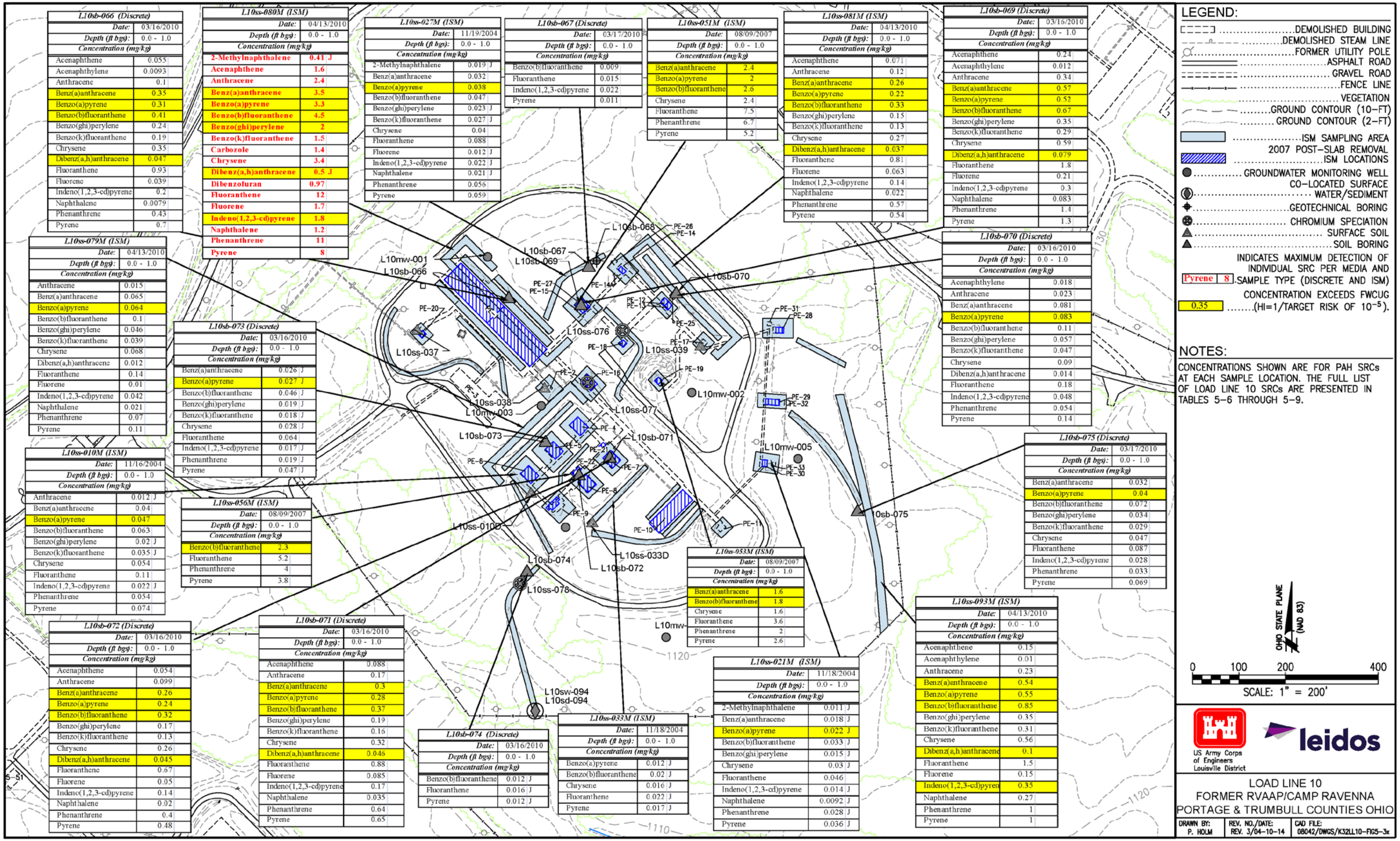


Figure 5-2. Concentration Ranges of Chromium in Surface Soil Samples

THIS PAGE INTENTIONALLY LEFT BLANK.



NOTES:

CONCENTRATIONS SHOWN ARE FOR PAH SRCs AT EACH SAMPLE LOCATION. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5-6 THROUGH 5-9.

L10sb-066 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.055
Acenaphthylene	0.0093
Anthracene	0.1
Benz(a)anthracene	0.35
Benzo(a)pyrene	0.31
Benzo(b)fluoranthene	0.41
Benzo(ghi)perylene	0.24
Benzo(k)fluoranthene	0.19
Chrysene	0.35
Dibenz(a,h)anthracene	0.047
Fluoranthene	0.93
Fluorene	0.039
Indeno(1,2,3-cd)pyrene	0.2
Naphthalene	0.0079
Phenanthrene	0.43
Pyrene	0.7

L10ss-080M (ISM)	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
2-Methylnaphthalene	**0.41 J**
Acenaphthene	**1.6**
Anthracene	**2.4**
Benz(a)anthracene	**3.5**
Benzo(a)pyrene	**3.3**
Benzo(b)fluoranthene	**4.5**
Benzo(ghi)perylene	**2**
Benzo(k)fluoranthene	**1.5**
Carbozole	**1.4**
Chrysene	**3.4**
Dibenz(a,h)anthracene	**0.5 J**
Dibenzofuran	**0.97**
Fluoranthene	**12**
Fluorene	**1.7**
Indeno(1,2,3-cd)pyrene	**1.8**
Naphthalene	**1.2**
Phenanthrene	**11**
Pyrene	**8**

L10ss-027M (ISM)	
Date:	11/19/2004
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
2-Methylnaphthalene	0.019 J
Benz(a)anthracene	0.032
Benzo(a)pyrene	0.038
Benzo(b)fluoranthene	0.047
Benzo(ghi)perylene	0.023 J
Benzo(k)fluoranthene	0.027 J
Chrysene	0.04
Fluoranthene	0.088
Fluorene	0.012 J
Indeno(1,2,3-cd)pyrene	0.022 J
Naphthalene	0.021 J
Phenanthrene	0.056
Pyrene	0.059

L10sb-067 (Discrete)	
Date:	03/17/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benzo(b)fluoranthene	0.009
Fluoranthene	0.015
Indeno(1,2,3-cd)pyrene	0.022
Pyrene	0.011

L10ss-051M (ISM)	
Date:	08/09/2007
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benz(a)anthracene	2.4
Benzo(a)pyrene	2
Benzo(b)fluoranthene	2.6
Chrysene	2.4
Fluoranthene	7.5
Phenanthrene	6.7
Pyrene	5.2

L10ss-081M (ISM)	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.071
Anthracene	0.12
Benz(a)anthracene	0.26
Benzo(a)pyrene	0.22
Benzo(b)fluoranthene	0.33
Benzo(ghi)perylene	0.15
Benzo(k)fluoranthene	0.13
Chrysene	0.27
Dibenz(a,h)anthracene	0.037
Fluoranthene	0.81
Fluorene	0.063
Indeno(1,2,3-cd)pyrene	0.14
Naphthalene	0.022
Phenanthrene	0.57
Pyrene	0.54

L10sb-069 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.24
Acenaphthylene	0.012
Anthracene	0.34
Benz(a)anthracene	0.57
Benzo(a)pyrene	0.52
Benzo(b)fluoranthene	0.67
Benzo(ghi)perylene	0.35
Benzo(k)fluoranthene	0.29
Chrysene	0.59
Dibenz(a,h)anthracene	0.079
Fluoranthene	1.8
Fluorene	0.21
Indeno(1,2,3-cd)pyrene	0.3
Naphthalene	0.083
Phenanthrene	1.4
Pyrene	1.3

L10ss-079M (ISM)	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Anthracene	0.015
Benz(a)anthracene	0.065
Benzo(a)pyrene	0.064
Benzo(b)fluoranthene	0.1
Benzo(ghi)perylene	0.046
Benzo(k)fluoranthene	0.039
Chrysene	0.068
Dibenz(a,h)anthracene	0.012
Fluoranthene	0.14
Fluorene	0.01
Indeno(1,2,3-cd)pyrene	0.042
Naphthalene	0.021
Phenanthrene	0.07
Pyrene	0.11

L10sb-070 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthylene	0.018
Anthracene	0.023
Benz(a)anthracene	0.081
Benzo(a)pyrene	0.083
Benzo(b)fluoranthene	0.11
Benzo(ghi)perylene	0.057
Benzo(k)fluoranthene	0.047
Chrysene	0.09
Dibenz(a,h)anthracene	0.014
Fluoranthene	0.18
Indeno(1,2,3-cd)pyrene	0.048
Phenanthrene	0.054
Pyrene	0.14

L10sb-073 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benz(a)anthracene	0.026 J
Benzo(a)pyrene	0.027 J
Benzo(b)fluoranthene	0.046 J
Benzo(ghi)perylene	0.019 J
Benzo(k)fluoranthene	0.018 J
Chrysene	0.028 J
Fluoranthene	0.064
Indeno(1,2,3-cd)pyrene	0.017 J
Phenanthrene	0.019 J
Pyrene	0.047 J

L10ss-010M (ISM)	
Date:	11/16/2004
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Anthracene	0.012 J
Benz(a)anthracene	0.04
Benzo(a)pyrene	0.047
Benzo(b)fluoranthene	0.063
Benzo(ghi)perylene	0.02 J
Benzo(k)fluoranthene	0.035 J
Chrysene	0.054
Fluoranthene	0.11
Indeno(1,2,3-cd)pyrene	0.022 J
Phenanthrene	0.054
Pyrene	0.074

L10ss-056M (ISM)	
Date:	08/09/2007
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benzo(b)fluoranthene	2.3
Fluoranthene	5.2
Phenanthrene	4
Pyrene	3.8

L10sb-075 (Discrete)	
Date:	03/17/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benz(a)anthracene	0.032
Benzo(a)pyrene	0.04
Benzo(b)fluoranthene	0.072
Benzo(ghi)perylene	0.034
Benzo(k)fluoranthene	0.029
Chrysene	0.047
Fluoranthene	0.087
Indeno(1,2,3-cd)pyrene	0.028
Phenanthrene	0.033
Pyrene	0.069

L10ss-053M (ISM)	
Date:	08/09/2007
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benz(a)anthracene	1.6
Benzo(b)fluoranthene	1.8
Chrysene	1.6
Fluoranthene	3.6
Phenanthrene	2
Pyrene	2.6

L10sb-072 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.054
Anthracene	0.099
Benz(a)anthracene	0.26
Benzo(a)pyrene	0.24
Benzo(b)fluoranthene	0.32
Benzo(ghi)perylene	0.17
Benzo(k)fluoranthene	0.13
Chrysene	0.26
Dibenz(a,h)anthracene	0.045
Fluoranthene	0.67
Fluorene	0.05
Indeno(1,2,3-cd)pyrene	0.14
Naphthalene	0.02
Phenanthrene	0.4
Pyrene	0.48

L10sb-071 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.088
Anthracene	0.17
Benz(a)anthracene	0.3
Benzo(a)pyrene	0.28
Benzo(b)fluoranthene	0.37
Benzo(ghi)perylene	0.19
Benzo(k)fluoranthene	0.16
Chrysene	0.32
Dibenz(a,h)anthracene	0.046
Fluoranthene	0.88
Fluorene	0.085
Indeno(1,2,3-cd)pyrene	0.17
Naphthalene	0.035
Phenanthrene	0.64
Pyrene	0.65

L10sb-074 (Discrete)	
Date:	03/16/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benzo(b)fluoranthene	0.012 J
Fluoranthene	0.016 J
Pyrene	0.012 J

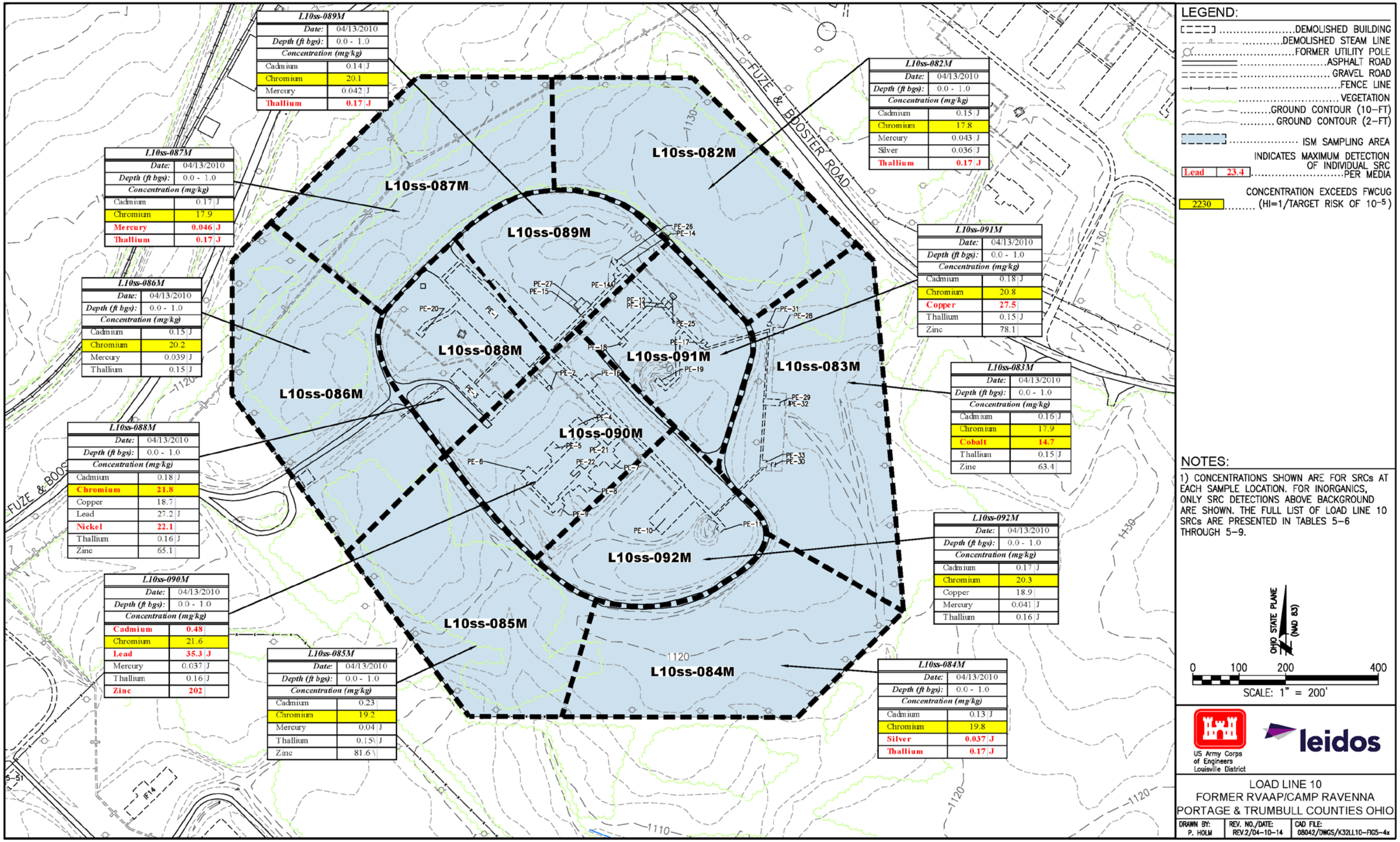
L10ss-033M (ISM)	
Date:	11/18/2004
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benzo(a)pyrene	0.012 J
Benzo(b)fluoranthene	0.02 J
Chrysene	0.016 J
Fluoranthene	0.022 J
Pyrene	0.017 J

L10ss-021M (ISM)	
Date:	11/18/2004
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
2-Methylnaphthalene	0.011 J
Benz(a)anthracene	0.018 J
Benzo(a)pyrene	0.022 J
Benzo(b)fluoranthene	0.033 J
Benzo(ghi)perylene	0.015 J
Chrysene	0.03 J
Fluoranthene	0.046
Indeno(1,2,3-cd)pyrene	0.014 J
Naphthalene	0.0092 J
Phenanthrene	0.028 J
Pyrene	0.036 J

L10ss-093M (ISM)	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.15
Acenaphthylene	0.01
Anthracene	0.23
Benz(a)anthracene	0.54
Benzo(a)pyrene	0.55
Benzo(b)fluoranthene	0.85
Benzo(ghi)perylene	0.35
Benzo(k)fluoranthene	0.31
Chrysene	0.56
Dibenz(a,h)anthracene	0.1
Fluoranthene	1.5
Fluorene	0.15
Indeno(1,2,3-cd)pyrene	0.35
Naphthalene	0.27
Phenanthrene	1
Pyrene	1

Figure 5-3. Concentrations of PAH SRCs in Surface Soil Samples

THIS PAGE INTENTIONALLY LEFT BLANK.



L10ss-089M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.14 J
Chromium	20.1
Mercury	0.042 J
Thallium	**0.17 J**

L10ss-087M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.17 J
Chromium	17.9
Mercury	**0.046 J**
Thallium	**0.17 J**

L10ss-086M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.15 J
Chromium	20.2
Mercury	0.039 J
Thallium	0.15 J

L10ss-088M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.18 J
Chromium	**21.8**
Copper	18.7
Lead	27.2 J
Nickel	**22.1**
Thallium	0.16 J
Zinc	65.1

L10ss-090M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	**0.48**
Chromium	21.6
Lead	**35.3 J**
Mercury	0.037 J
Thallium	0.16 J
Zinc	**202**

L10ss-085M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.23
Chromium	19.2
Mercury	0.04 J
Thallium	0.15\ J
Zinc	81.6 \

L10ss-082M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.15 J
Chromium	17.8
Mercury	0.043 J
Silver	0.036 J
Thallium	**0.17 J**

L10ss-091M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.18 J
Chromium	20.8
Copper	**27.5**
Thallium	0.15 J
Zinc	78.1

L10ss-083M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.16 J
Chromium	17.9
Cobalt	**14.7**
Thallium	0.15 J
Zinc	63.4

L10ss-092M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.17 J
Chromium	20.3
Copper	18.9
Mercury	0.041 J
Thallium	0.16 J

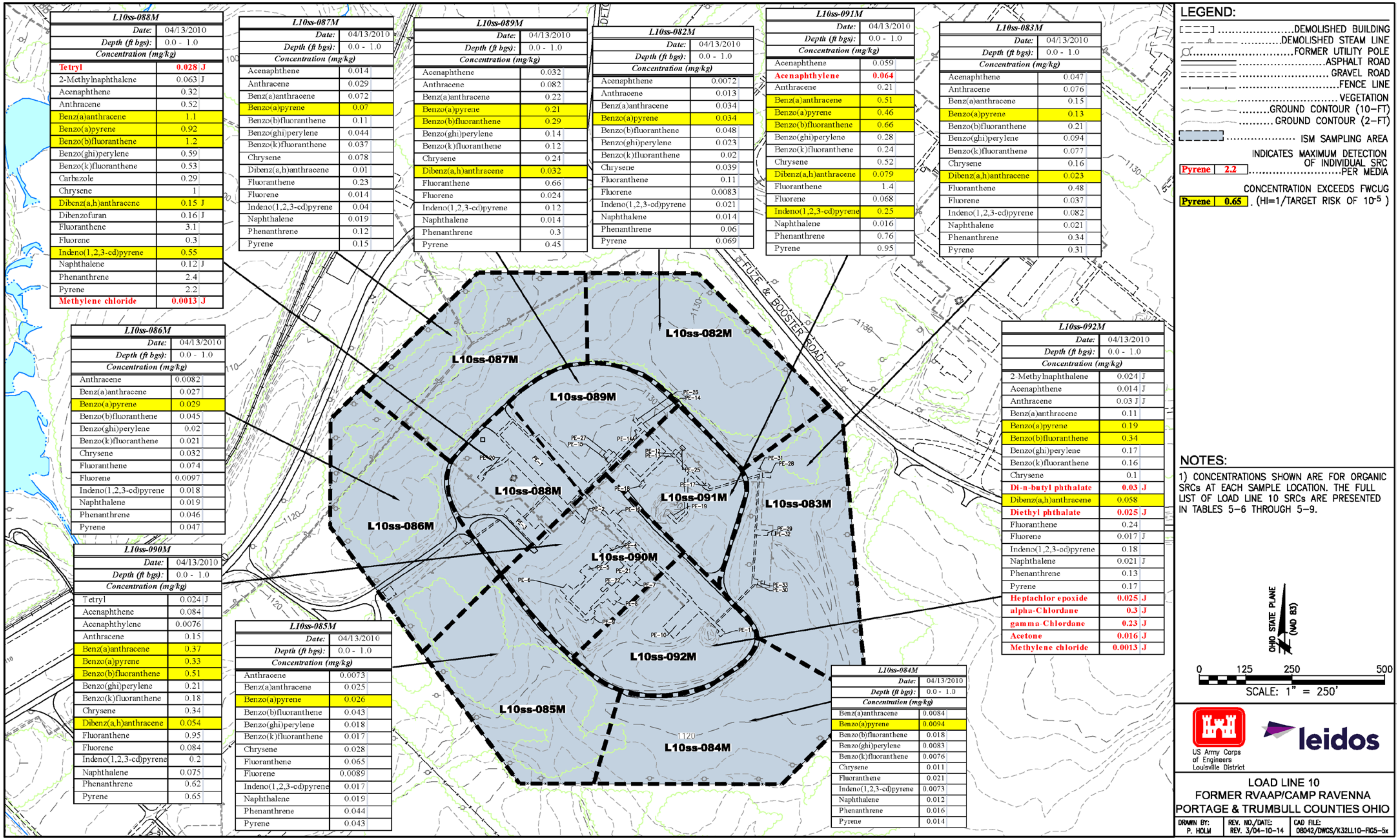
L10ss-084M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Cadmium	0.13 J
Chromium	19.8
Silver	**0.037 J**
Thallium	**0.17 J**

NOTES:

1) CONCENTRATIONS SHOWN ARE FOR SRCs AT EACH SAMPLE LOCATION. FOR INORGANICS, ONLY SRC DETECTIONS ABOVE BACKGROUND ARE SHOWN. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5–6 THROUGH 5–9.

Figure 5-4. Concentrations of Inorganic SRCs in Surface Soil ISM Grid Samples

THIS PAGE INTENTIONALLY LEFT BLANK.



L10ss-088M		
Date:	04/13/2010	
Depth (ft bgs):	0.0 - 1.0	
Concentration (mg/kg)		
Tetryl	**0.028**	**J**
2-Methylnaphthalene	0.063	J
Acenaphthene	0.32	
Anthracene	0.52	
Benz(a)anthracene	1.1	
Benzo(a)pyrene	0.92	
Benzo(b)fluoranthene	1.2	
Benzo(ghi)perylene	0.59	
Benzo(k)fluoranthene	0.53	
Carbazole	0.29	
Chrysene	1	
Dibenz(a,h)anthracene	0.15	J
Dibenzofuran	0.16	J
Fluoranthene	3.1	
Fluorene	0.3	
Indeno(1,2,3-cd)pyrene	0.55	
Naphthalene	0.12	J
Phenanthrene	2.4	
Pyrene	2.2	
Methylene chloride	**0.0013**	**J**

L10ss-087M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.014
Anthracene	0.029
Benz(a)anthracene	0.072
Benzo(a)pyrene	0.07
Benzo(b)fluoranthene	0.11
Benzo(ghi)perylene	0.044
Benzo(k)fluoranthene	0.037
Chrysene	0.078
Dibenz(a,h)anthracene	0.01
Fluoranthene	0.23
Fluorene	0.014
Indeno(1,2,3-cd)pyrene	0.04
Naphthalene	0.019
Phenanthrene	0.12
Pyrene	0.15

L10ss-089M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.032
Anthracene	0.082
Benz(a)anthracene	0.22
Benzo(a)pyrene	0.21
Benzo(b)fluoranthene	0.29
Benzo(ghi)perylene	0.14
Benzo(k)fluoranthene	0.12
Chrysene	0.24
Dibenz(a,h)anthracene	0.032
Fluoranthene	0.66
Fluorene	0.024
Indeno(1,2,3-cd)pyrene	0.12
Naphthalene	0.014
Phenanthrene	0.3
Pyrene	0.45

L10ss-082M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.0072
Anthracene	0.013
Benz(a)anthracene	0.034
Benzo(a)pyrene	0.034
Benzo(b)fluoranthene	0.048
Benzo(ghi)perylene	0.023
Benzo(k)fluoranthene	0.02
Chrysene	0.039
Fluoranthene	0.11
Fluorene	0.0083
Indeno(1,2,3-cd)pyrene	0.021
Naphthalene	0.014
Phenanthrene	0.06
Pyrene	0.069

L10ss-091M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.059
Acenaphthylene	**0.064**
Anthracene	0.21
Benz(a)anthracene	0.51
Benzo(a)pyrene	0.46
Benzo(b)fluoranthene	0.66
Benzo(ghi)perylene	0.28
Benzo(k)fluoranthene	0.24
Chrysene	0.52
Dibenz(a,h)anthracene	0.079
Fluoranthene	1.4
Fluorene	0.068
Indeno(1,2,3-cd)pyrene	0.25
Naphthalene	0.016
Phenanthrene	0.76
Pyrene	0.95

L10ss-083M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Acenaphthene	0.047
Anthracene	0.076
Benz(a)anthracene	0.15
Benzo(a)pyrene	0.13
Benzo(b)fluoranthene	0.21
Benzo(ghi)perylene	0.094
Benzo(k)fluoranthene	0.077
Chrysene	0.16
Dibenz(a,h)anthracene	0.023
Fluoranthene	0.48
Fluorene	0.037
Indeno(1,2,3-cd)pyrene	0.082
Naphthalene	0.021
Phenanthrene	0.34
Pyrene	0.31

L10ss-086M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Anthracene	0.0082
Benz(a)anthracene	0.027
Benzo(a)pyrene	0.029
Benzo(b)fluoranthene	0.045
Benzo(ghi)perylene	0.02
Benzo(k)fluoranthene	0.021
Chrysene	0.032
Fluoranthene	0.074
Fluorene	0.0097
Indeno(1,2,3-cd)pyrene	0.018
Naphthalene	0.019
Phenanthrene	0.046
Pyrene	0.047

L10ss-092M		
Date:	04/13/2010	
Depth (ft bgs):	0.0 - 1.0	
Concentration (mg/kg)		
2-Methylnaphthalene	0.024	J
Acenaphthene	0.014	J
Anthracene	0.03 J	J
Benz(a)anthracene	0.11	
Benzo(a)pyrene	0.19	
Benzo(b)fluoranthene	0.34	
Benzo(ghi)perylene	0.17	
Benzo(k)fluoranthene	0.16	
Chrysene	0.1	
Di-n-butyl phthalate	**0.03**	**J**
Dibenz(a,h)anthracene	0.058	
Diethyl phthalate	**0.025**	**J**
Fluoranthene	0.24	
Fluorene	0.017	J
Indeno(1,2,3-cd)pyrene	0.18	
Naphthalene	0.021	J
Phenanthrene	0.13	
Pyrene	0.17	
Heptachlor epoxide	**0.025**	**J**
alpha-Chlordane	**0.3**	**J**
gamma-Chlordane	**0.23**	**J**
Acetone	**0.016**	**J**
Methylene chloride	**0.0013**	**J**

L10ss-090M		
Date:	04/13/2010	
Depth (ft bgs):	0.0 - 1.0	
Concentration (mg/kg)		
Tetryl	0.024	J
Acenaphthene	0.084	
Acenaphthylene	0.0076	
Anthracene	0.15	
Benz(a)anthracene	0.37	
Benzo(a)pyrene	0.33	
Benzo(b)fluoranthene	0.51	
Benzo(ghi)perylene	0.21	
Benzo(k)fluoranthene	0.18	
Chrysene	0.34	
Dibenz(a,h)anthracene	0.054	
Fluoranthene	0.95	
Fluorene	0.084	
Indeno(1,2,3-cd)pyrene	0.2	
Naphthalene	0.075	
Phenanthrene	0.62	
Pyrene	0.65	

L10ss-085M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Anthracene	0.0073
Benz(a)anthracene	0.025
Benzo(a)pyrene	0.026
Benzo(b)fluoranthene	0.043
Benzo(ghi)perylene	0.018
Benzo(k)fluoranthene	0.017
Chrysene	0.028
Fluoranthene	0.065
Fluorene	0.0089
Indeno(1,2,3-cd)pyrene	0.017
Naphthalene	0.019
Phenanthrene	0.044
Pyrene	0.043

L10ss-084M	
Date:	04/13/2010
Depth (ft bgs):	0.0 - 1.0
Concentration (mg/kg)	
Benz(a)anthracene	0.0084
Benzo(a)pyrene	0.0094
Benzo(b)fluoranthene	0.018
Benzo(ghi)perylene	0.0083
Benzo(k)fluoranthene	0.0076
Chrysene	0.011
Fluoranthene	0.021
Indeno(1,2,3-cd)pyrene	0.0073
Naphthalene	0.012
Phenanthrene	0.016
Pyrene	0.014

NOTES:

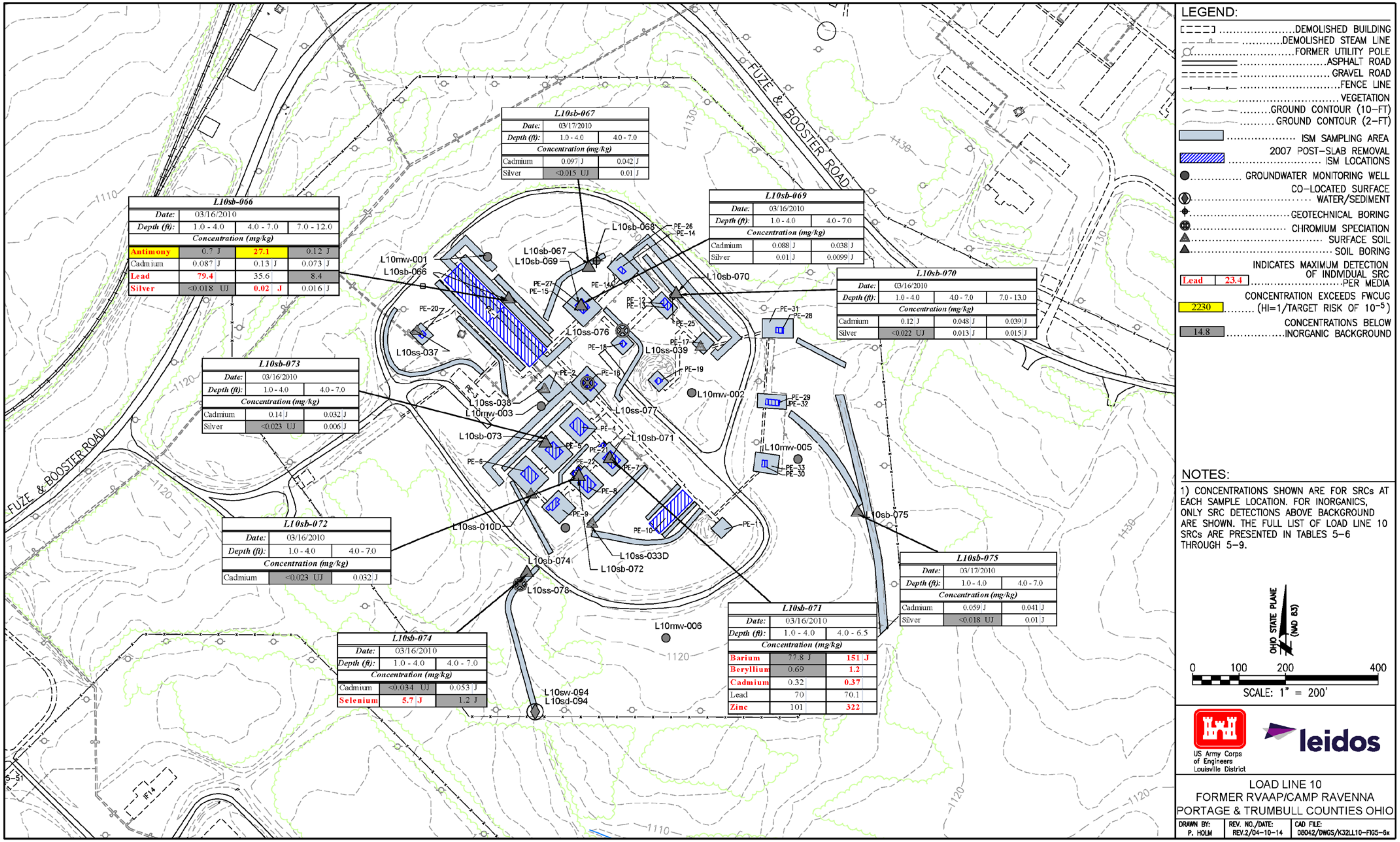
1) CONCENTRATIONS SHOWN ARE FOR ORGANIC SRCs AT EACH SAMPLE LOCATION. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5–6 THROUGH 5–9.

LOAD LINE 10
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 3/04–10–14	08042/DWGS/K32LL10–FIG5–5x

Figure 5-5. Concentrations of Organic SRCs in Surface Soil ISM Grid Samples

THIS PAGE INTENTIONALLY LEFT BLANK.



L10sb-066

Date:	03/16/2010		
Depth (ft):	1.0 - 4.0	4.0 - 7.0	7.0 - 12.0
Concentration (mg/kg)			
Antimony	0.7 J	**27.1**	0.12 J
Cadmium	0.087 J	0.13 J	0.073 J
Lead	**79.4**	35.6	8.4
Silver	<0.018 UJ	**0.02 J**	0.016 J

L10sb-067

Date:	03/17/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	0.097 J	0.042 J
Silver	<0.015 UJ	0.01 J

L10sb-069

Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	0.088 J	0.038 J
Silver	0.01 J	0.0099 J

L10sb-070

Date:	03/16/2010		
Depth (ft):	1.0 - 4.0	4.0 - 7.0	7.0 - 13.0
Concentration (mg/kg)			
Cadmium	0.12 J	0.048 J	0.039 J
Silver	<0.022 UJ	0.013 J	0.015 J

L10sb-073

Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	0.14 J	0.032 J
Silver	<0.023 UJ	0.006 J

L10sb-072

Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	<0.023 UJ	0.032 J

L10sb-074

Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	<0.034 UJ	0.053 J
Selenium	**5.7 J**	1.2 J

L10sb-071

Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 6.5
Concentration (mg/kg)		
Barium	77.8 J	**151 J**
Beryllium	0.69	**1.2**
Cadmium	0.32	**0.37**
Lead	70	70.1
Zinc	101	**322**

L10sb-075

Date:	03/17/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Cadmium	0.059 J	0.041 J
Silver	<0.018 UJ	0.01 J

LEGEND:

	DEMOLISHED BUILDING
	DEMOLISHED STEAM LINE
	FORMER UTILITY POLE
	ASPHALT ROAD
	GRAVEL ROAD
	FENCE LINE
	VEGETATION
	GROUND CONTOUR (10–FT)
	GROUND CONTOUR (2–FT)
	ISM SAMPLING AREA
▨	2007 POST–SLAB REMOVAL ISM LOCATIONS
●	GROUNDWATER MONITORING WELL
	CO–LOCATED SURFACE WATER/SEDIMENT
	GEOTECHNICAL BORING
	CHROMIUM SPECIATION
▲	SURFACE SOIL
▲	SOIL BORING
Lead **23.4**	INDICATES MAXIMUM DETECTION OF INDIVIDUAL SRC PER MEDIA
2230	CONCENTRATION EXCEEDS FWCUG (HI=1/TARGET RISK OF 10^{-5})
14.8	CONCENTRATIONS BELOW INORGANIC BACKGROUND

NOTES:

1) CONCENTRATIONS SHOWN ARE FOR SRCs AT EACH SAMPLE LOCATION. FOR INORGANICS, ONLY SRC DETECTIONS ABOVE BACKGROUND ARE SHOWN. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5–6 THROUGH 5–9.

US Army Corps of Engineers
Louisville District

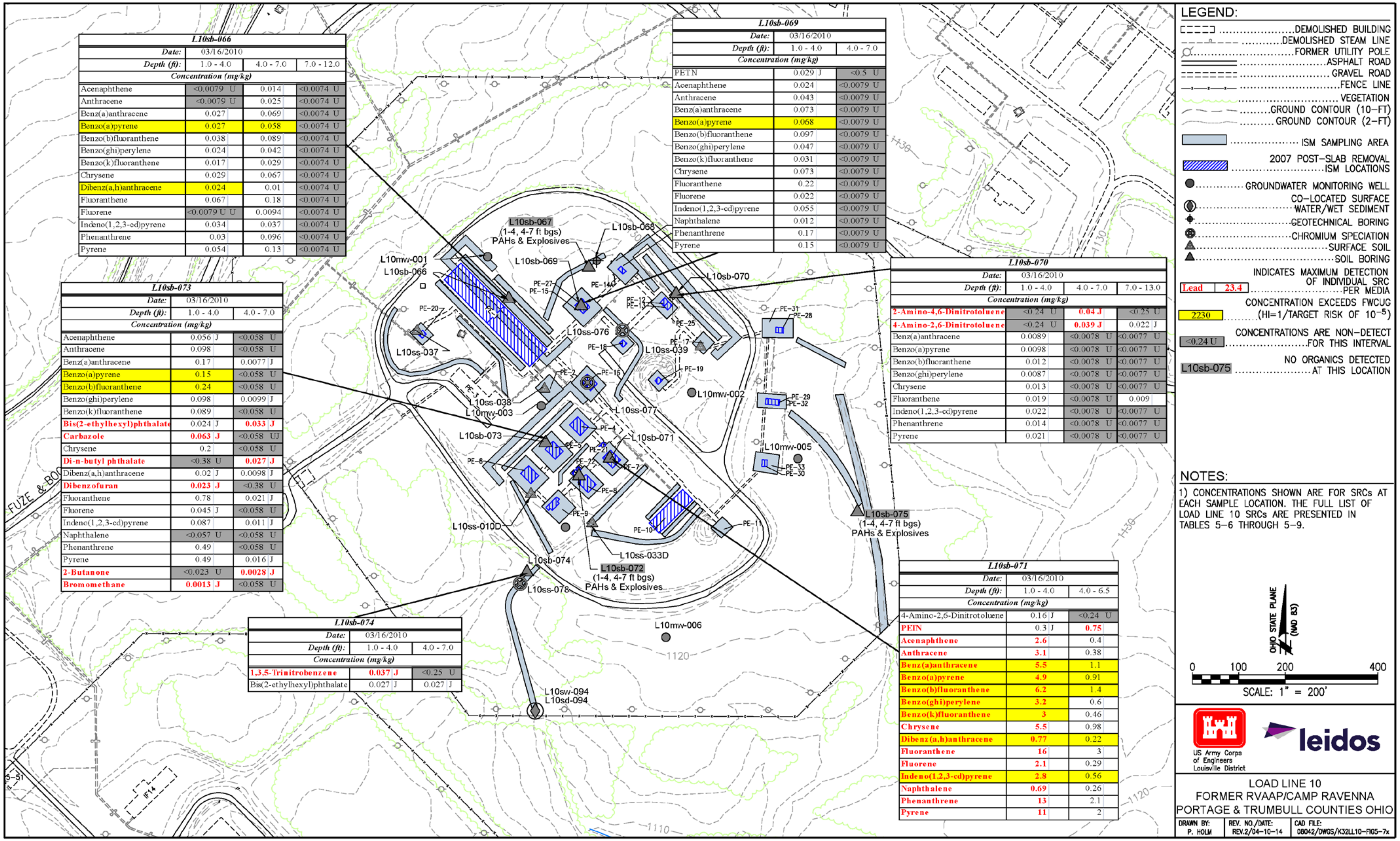
leidos

LOAD LINE 10
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV.2/04–10–14	08042/DWGS/K32LL10–FIG5–6x

Figure 5-6. Concentrations of Inorganic SRCs in Subsurface Soil

THIS PAGE INTENTIONALLY LEFT BLANK.



L10sb-066			
Date:	03/16/2010		
Depth (ft):	1.0 - 4.0	4.0 - 7.0	7.0 - 12.0
Concentration (mg/kg)			
Acenaphthene	<0.0079 U	0.014	<0.0074 U
Anthracene	<0.0079 U	0.025	<0.0074 U
Benz(a)anthracene	0.027	0.069	<0.0074 U
Benzo(a)pyrene	0.027	0.058	<0.0074 U
Benzo(b)fluoranthene	0.038	0.089	<0.0074 U
Benzo(ghi)perylene	0.024	0.042	<0.0074 U
Benzo(k)fluoranthene	0.017	0.029	<0.0074 U
Chrysene	0.029	0.067	<0.0074 U
Dibenz(a,h)anthracene	0.024	0.01	<0.0074 U
Fluoranthene	0.067	0.18	<0.0074 U
Fluorene	<0.0079 U U	0.0094	<0.0074 U
Indeno(1,2,3-cd)pyrene	0.034	0.037	<0.0074 U
Phenanthrene	0.03	0.096	<0.0074 U
Pyrene	0.054	0.13	<0.0074 U

L10sb-069		
Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
PETN	0.029 J	<0.5 U
Acenaphthene	0.024	<0.0079 U
Anthracene	0.043	<0.0079 U
Benz(a)anthracene	0.073	<0.0079 U
Benzo(a)pyrene	0.068	<0.0079 U
Benzo(b)fluoranthene	0.097	<0.0079 U
Benzo(ghi)perylene	0.047	<0.0079 U
Benzo(k)fluoranthene	0.031	<0.0079 U
Chrysene	0.073	<0.0079 U
Fluoranthene	0.22	<0.0079 U
Fluorene	0.022	<0.0079 U
Indeno(1,2,3-cd)pyrene	0.055	<0.0079 U
Naphthalene	0.012	<0.0079 U
Phenanthrene	0.17	<0.0079 U
Pyrene	0.15	<0.0079 U

L10sb-073		
Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
Acenaphthene	0.056 J	<0.058 U
Anthracene	0.098	<0.058 U
Benz(a)anthracene	0.17	0.0077 J
Benzo(a)pyrene	0.15	<0.058 U
Benzo(b)fluoranthene	0.24	<0.058 U
Benzo(ghi)perylene	0.098	0.0099 J
Benzo(k)fluoranthene	0.089	<0.058 U
Bis(2-ethylhexyl)phthalate	0.024 J	**0.033 J**
Carbazole	**0.063 J**	<0.058 UJ
Chrysene	0.2	<0.058 U
Di-n-butyl phthalate	<0.38 U	**0.027 J**
Dibenz(a,h)anthracene	0.02 J	0.0098 J
Dibenzofuran	**0.023 J**	<0.38 U
Fluoranthene	0.78	0.021 J
Fluorene	0.045 J	<0.058 U
Indeno(1,2,3-cd)pyrene	0.087	0.011 J
Naphthalene	<0.057 U	<0.058 U
Phenanthrene	0.49	<0.058 U
Pyrene	0.49	0.016 J
2-Butanone	<0.023 U	**0.0028 J**
Bromomethane	**0.0013 J**	<0.058 U

L10sb-070			
Date:	03/16/2010		
Depth (ft):	1.0 - 4.0	4.0 - 7.0	7.0 - 13.0
Concentration (mg/kg)			
2-Amino-4,6-Dinitrotoluene	<0.24 U	**0.04 J**	<0.25 U
4-Amino-2,6-Dinitrotoluene	<0.24 U	**0.039 J**	0.022 J
Benz(a)anthracene	0.0089	<0.0078 U	<0.0077 U
Benzo(a)pyrene	0.0098	<0.0078 U	<0.0077 U
Benzo(b)fluoranthene	0.012	<0.0078 U	<0.0077 U
Benzo(ghi)perylene	0.0087	<0.0078 U	<0.0077 U
Chrysene	0.013	<0.0078 U	<0.0077 U
Fluoranthene	0.019	<0.0078 U	0.009
Indeno(1,2,3-cd)pyrene	0.022	<0.0078 U	<0.0077 U
Phenanthrene	0.014	<0.0078 U	<0.0077 U
Pyrene	0.021	<0.0078 U	<0.0077 U

L10sb-074		
Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 7.0
Concentration (mg/kg)		
1,3,5-Trinitrobenzene	**0.037 J**	<0.25 U
Bis(2-ethylhexyl)phthalate	0.027 J	0.027 J

L10sb-071		
Date:	03/16/2010	
Depth (ft):	1.0 - 4.0	4.0 - 6.5
Concentration (mg/kg)		
4-Amino-2,6-Dinitrotoluene	0.16 J	<0.24 U
PETN	0.3 J	**0.75**
Acenaphthene	**2.6**	0.4
Anthracene	**3.1**	0.38
Benz(a)anthracene	**5.5**	1.1
Benzo(a)pyrene	**4.9**	0.91
Benzo(b)fluoranthene	**6.2**	1.4
Benzo(ghi)perylene	**3.2**	0.6
Benzo(k)fluoranthene	**3**	0.46
Chrysene	**5.5**	0.98
Dibenz(a,h)anthracene	**0.77**	0.22
Fluoranthene	**16**	3
Fluorene	**2.1**	0.29
Indeno(1,2,3-cd)pyrene	**2.8**	0.56
Naphthalene	**0.69**	0.26
Phenanthrene	**13**	2.1
Pyrene	**11**	2

LEGEND:

NOTES:

1) CONCENTRATIONS SHOWN ARE FOR SRCs AT EACH SAMPLE LOCATION. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5–6 THROUGH 5–9.

US Army Corps
of Engineers
Louisville District

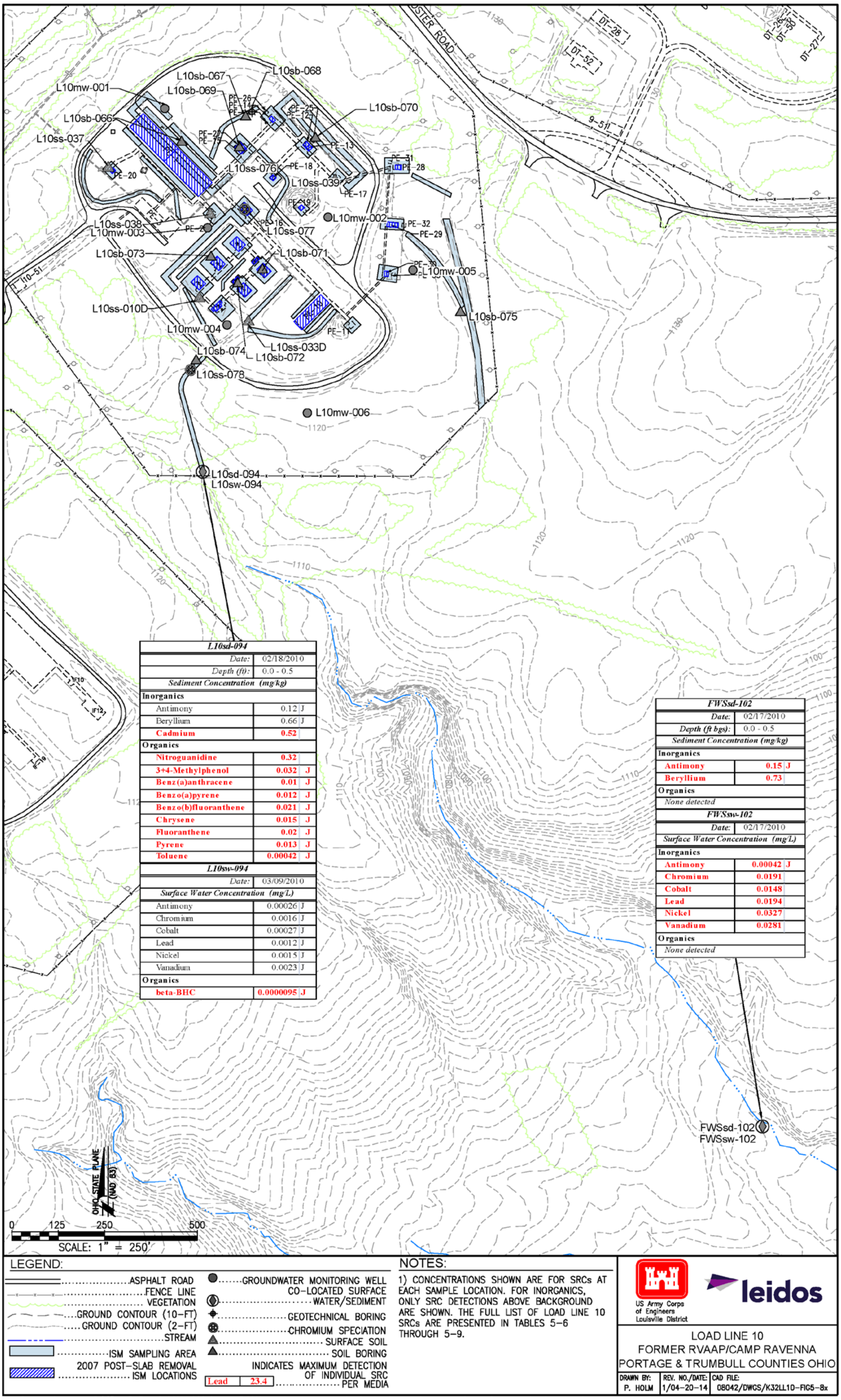
leidos

LOAD LINE 10
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV.2/04–10–14	08042/DWGS/K32LL10–FIG5–7x

Figure 5-7. Concentrations of Organic SRCs in Subsurface Soil

THIS PAGE INTENTIONALLY LEFT BLANK.



L10sd-094		
Date:	02/18/2010	
Depth (ft):	0.0 - 0.5	
Sediment Concentration (mg/kg)		
Inorganics		
Antimony	0.12	J
Beryllium	0.66	J
Cadmium	**0.52**	
Organics		
Nitroguanidine	**0.32**	
3+4-Methylphenol	**0.032**	**J**
Benz(a)anthracene	**0.01**	**J**
Benzo(a)pyrene	**0.012**	**J**
Benzo(b)fluoranthene	**0.021**	**J**
Chrysene	**0.015**	**J**
Fluoranthene	**0.02**	**J**
Pyrene	**0.013**	**J**
Toluene	**0.00042**	**J**

L10sw-094		
Date:	03/09/2010	
Surface Water Concentration (mg/L)		
Antimony	0.00026	J
Chromium	0.0016	J
Cobalt	0.00027	J
Lead	0.0012	J
Nickel	0.0015	J
Vanadium	0.0023	J
Organics		
beta-BHC	**0.0000095**	**J**

FWSsd-102		
Date:	02/17/2010	
Depth (ft bgs):	0.0 - 0.5	
Sediment Concentration (mg/kg)		
Inorganics		
Antimony	**0.15**	**J**
Beryllium	**0.73**	
Organics		
None detected		

FWSsw-102		
Date:	02/17/2010	
Surface Water Concentration (mg/L)		
Inorganics		
Antimony	**0.00042**	**J**
Chromium	**0.0191**	
Cobalt	**0.0148**	
Lead	**0.0194**	
Nickel	**0.0327**	
Vanadium	**0.0281**	
Organics		
None detected		

NOTES:

1) CONCENTRATIONS SHOWN ARE FOR SRCs AT EACH SAMPLE LOCATION. FOR INORGANICS, ONLY SRC DETECTIONS ABOVE BACKGROUND ARE SHOWN. THE FULL LIST OF LOAD LINE 10 SRCs ARE PRESENTED IN TABLES 5-6 THROUGH 5-9.

LOAD LINE 10
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	1/04-20-14	08042/DWGS/K32LL10-FIG5-8x

Figure 5-8. Concentrations of SRCs in Sediment and Surface Water at Load Line 10 and Downstream Facility-wide Sample Locations

THIS PAGE INTENTIONALLY LEFT BLANK.

6.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport modeling assesses the potential for SRCs to leach from surface soil, subsurface soil, and sediment sources at Load Line 10 and impact groundwater beneath the sources and downgradient receptor locations. Modeling results were included in the decision-making process to determine whether remedial actions of sources may be necessary to protect groundwater resources. Surface water transport pathways are evaluated in the HHRA and ERA presented in Sections 7.2 and 7.3, respectively. A summary of the principles of contaminant fate and transport are presented in this section along with the results of the modeling.

Section 6.1 describes physical and chemical properties of SRCs found in soil and sediment at the AOC. Section 6.2 presents a conceptual model for contaminant fate and transport that considers AOC topography, hydrogeology, contaminant sources, and release mechanisms. Section 6.3 presents a soil screening analysis, and Section 6.4 presents a sediment screening analysis to identify SRCs with the potential to migrate from soil and sediment to groundwater as initial CMCOPCs. Section 6.5 describes fate and transport modeling of final CMCOPCs and presents CMCOCs. Section 6.6 presents a summary and conclusions of the fate and transport analysis.

6.1 PHYSICAL AND CHEMICAL PROPERTIES OF SITE-RELATED CONTAMINANTS

Surface and subsurface soil SRCs (including 17 inorganic chemicals and 42 organic chemicals) and sediment SRCs (including three inorganic chemicals and nine organic chemicals) were detailed in Section 5.0 and are summarized below:

- Inorganic SRCs in surface and subsurface soil: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, mercury, nickel, selenium, silver, thallium, and zinc.
- Inorganic SRCs in sediment: antimony, beryllium, and cadmium.
- Organic SRCs in surface and subsurface soil: 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzenemethanol, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, carbazole, chrysene, di-n-butyl phthalate, dibenz(a,h)anthracene, dibenzofuran, diethyl phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, phenol, pyrene, 2-butanone, acetone, bromomethane, carbon disulfide, methylene chloride, heptachlor epoxide, PCB-1254, alpha-chlordane, gamma-chlordane, 1,3,5-TNB, 2,6-DNT, 2-amino-4,6-DNT, 3-nitrotoluene, 4-amino-2,6-DNT, nitrocellulose, nitroglycerin, PETN, and tetryl.
- Organic SRCs in sediment: 3+4-methylphenol, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, pyrene, toluene, and nitroguanidine.

Chemicals released into the environment are susceptible to several degradation pathways, including hydrolysis, oxidation, reduction, isomerization, photolysis, photo-oxidation, biotransformation, and biodegradation. Transformed products resulting from these processes may behave differently than their parent chemical in the environment.

The migration of chemicals is governed by the physical and chemical properties and the surface and subsurface media through which chemicals are transferred. In general, chemicals and structures with similar physical and chemical characteristics will show similar patterns of transformation, transport, or attenuation in the environment. Solubility, vapor pressure data, chemical partitioning coefficients, degradation rates, and Henry's Law Constant (HLC) provide information that can be used to evaluate contaminant mobility in the environment. Partitioning coefficients are used to assess relative affinities of chemicals for solution or solid phase adsorption. However, the synergistic effects of multiple migrating chemicals and complexity of soil/water interactions, including pH and oxidation-reduction potential (Eh), grain size, and clay mineral variability, are typically unknown.

The physical properties of the chemicals defined as SRCs in surface and subsurface soil are summarized in Tables E-1 and E-2 in Appendix E. These properties are used to assess the anticipated behavior of each chemical under environmental conditions. The physical properties of the chemicals defined as SRCs detected in soil and sediment are summarized in Section 6.1.1 through Section 6.1.5.

6.1.1 Chemical Factors Affecting Fate and Transport

The water solubility of a chemical is a measure of the saturated concentration of the chemical in water at a given temperature and pressure. The tendency for a chemical to be transported by groundwater is directly related to its solubility and inversely related to its tendencies to adsorb to soil and volatilize from water (OGE 1988). Chemicals with high water solubilities tend to desorb from soil, are less likely to volatilize from water, and are susceptible to biodegradation. The water solubility of a chemical varies with temperature, pH, and the presence of other dissolved chemicals (including organic carbon and humic acids).

The octanol-water partition coefficient (K_{ow}) can be used to estimate the tendency for a chemical to partition between environmental phases of different polarity. The K_{ow} is a laboratory-determined ratio of the concentration of a chemical in the n-octanol phase of a two-phase system to the concentration in the water phase. Chemicals with log K_{ow} values less than one are highly hydrophilic, while chemicals with log K_{ow} values greater than four will partition to soil particles (Lyman et al. 1990).

The water/organic carbon partition coefficient (K_{oc}) is a measure of the tendency of an organic chemical to partition between water and organic carbon in soil. The K_{oc} is defined as the ratio of the absorbed chemical per unit weight of organic carbon to the aqueous solute concentration.

This coefficient can be used to estimate the degree to which an organic chemical will adsorb to soil and thus not migrate with groundwater. The higher the K_{oc} value, the greater is the tendency of the chemical to partition into soil (OGE 1988). The soil/water partitioning coefficient (K_d) is calculated by multiplying the K_{oc} value by the fraction of organic carbon in the soil.

Vapor pressure is a measure of the pressure at which a chemical and its vapor are in equilibrium. The value can be used to determine the extent to which a chemical would travel in air, as well as the rate of volatilization from soil and solution (OGE 1988). In general, chemicals with vapor pressures lower than 10^{-7} mm mercury will not be present in the atmosphere or air spaces in soil in significant amounts, while chemicals with vapor pressures higher than 10^{-2} mm mercury will exist primarily in the air (Dragun 1988).

The HLC value for a chemical is a measure of the ratio of the chemical's vapor pressure to its aqueous solubility. The HLC value can be used to make general predictions about a chemical's tendency to volatilize from water. Chemicals with HLC values less than 10^{-7} atm-m^3/mol will generally volatilize slowly, while chemicals with a HLC greater than 10^{-3} atm-m^3/mol will volatilize rapidly (Lyman et al. 1990).

6.1.2 Biodegradation

Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical. Complete biodegradation is the biologically mediated degradation of an organic chemical into carbon dioxide, water, oxygen, and other metabolic inorganic products (Dragun 1988). The first order biodegradation rate of an organic chemical is proportional to the concentration:

$$-dC/dt = kC \qquad \text{(Equation 6-1)}$$

Where:

C = concentration
t = time
k = biodegradation rate constant = $\ln 2 / t_{1/2}$
$t_{1/2}$ = biodegradation half-life

The biodegradation half-life is the time necessary for half of the chemical to degrade. The biodegradation rate of an organic chemical generally depends on the presence and population size of soil microorganisms that are capable of degrading the chemical.

6.1.3 Inorganic Chemicals

Inorganic chemicals detected in soil and sediment samples are associated with the aqueous phase and leachable metal ions on soil particles. The transport of this material from unsaturated soil to the underlying water table is controlled by the physical processes of precipitation percolation, chemical interaction with the soil, and downward transport of metal ions by continued percolation. The chemistry of inorganic chemical interactions with percolating precipitation and varying soil conditions is complex and includes numerous chemical transformations that may result in altered oxidation states, including ion exchange, adsorption, precipitation, or complexation. The chemical reactions, which are affected by environmental conditions (pH, oxidation/reduction conditions, type and amount of organic matter, clay content, and the presence of hydrous oxides), may act to enhance or reduce the mobility and toxicity of metal ions. In general, these reactions are reversible and add to the variability commonly observed in distributions of inorganic chemicals in soil.

The chemical form of an inorganic chemical determines its solubility and mobility in the environment; however, chemical speciation is complex and difficult to delineate in routine laboratory analysis. Inorganic chemicals in soil are commonly found in several forms, including dissolved concentrations in soil pore water, metal ions occupying exchange sites on inorganic soil constituents (adsorbed to inorganic soil constituents), metal ions associated with insoluble organic matter, precipitated inorganic chemicals as pure or mixed solids, and metal ions present in the structure of primary or secondary minerals.

The dissolved (aqueous) fraction and its equilibrium sorbed fraction are important when considering the migration potential of inorganic chemicals through soil. Of the inorganic chemicals that are likely to form, chlorides, nitrates, and nitrites are commonly the most soluble. Sulfate, carbonate, and hydroxides generally have low to moderate solubility. Soluble chemicals are transported in aqueous forms subject to attenuation, whereas less soluble chemicals remain as a precipitate and limit the overall dissolution of metal ions. The solubility of the metal ions is also regulated by ambient chemical conditions, including pH and oxidation/reduction.

The attenuation of metal ions in the environment can be estimated numerically using the retardation factor (R), dispersion in higher flow systems (high conductivity environments), and diffusion in low conductivity environments. R defines the extent to which the velocity of the contaminant is slowed, which is largely derived from the soil/water K_d. R is calculated using the following equation:

$$R = 1 + (K_d \rho_b)/\theta_w \qquad \text{(Equation 6-2)}$$

Where:

ρ_b = the soil bulk dry density (g/cm^3)
θ_w = soil moisture content (dimensionless)

Metal ion concentrations in the environment do not attenuate by natural or biological degradation because of low volatility and solubility of the ions. Inorganic chemicals may be biotransformed or bioconcentrated through microbial activity.

6.1.4 Organic Chemicals

Organic chemicals, such as SVOCs or VOCs, may be transformed or degraded in the environment by processes including hydrolysis, oxidation/reduction, photolysis, volatilization, biodegradation, or biotransformation. The half-life of organic chemicals in transport media can vary from minutes to years, depending on environmental conditions and chemical structures. Some types of organic chemicals are very stable, and degradation rates can be very slow. Organic degradation may either enhance (by producing more toxic byproducts) or reduce (reducing concentrations) the toxicity of a chemical in the environment.

6.1.5 Explosives – Related Chemicals

Several explosive compounds were detected in soil and sediment at Load Line 10. Microbiological and photochemical transformation may affect the fate and transport of explosive compounds in the environment. For example, based on the results of culture studies involving the removal of TNT by activated sludge microorganisms, it has been concluded that TNT undergoes biotransformation but not biodegradation (USABRDL 1989). Biotransformation of TNT occurs with the reduction of the nitro groups by microbial reduction, typically under anaerobic conditions. Beneficial bacteria in these reactions include Pseudomonas, Escherichia, Bacillus, Citrobacter, Enterobacter, Klebseilla, Veillonella, and Clostridium (USACHPPM 2000). It has been found that anaerobic metabolism occurs in two stages (Funk et al. 1993). The first stage is the reductive stage in which TNT is reduced to its amino derivatives. In the second stage, degradation to non-aromatic products begins after the reduction of the third nitro group.

The biotransformation rate of TNT has been found to be rapid at most sites (ERDC 2007) and may be increased with the presence of carbon (USACHPPM 2000). Fungi and photolysis can also biotransform TNT. 1,3,5-TNB, 4,6-dinitroanthranil, 2,4,6-trinitrobezadehyde, and 2,4,6-trinitrobenzonitrite are the predominant transformation products due to photolysis of TNT (USACHPPM 2000). The biotransformation pathway for TNT is shown in Figure E-1 in Appendix E (Kaplan and Kaplan 1982).

Biotransformation of 2,4-DNT has been systematically studied in laboratory cell cultures. The biotransformation pathway is shown in Figure E-2 in Appendix E (McCormick et al. 1978). The reduction products include the amino and azoxy derivatives as observed with TNT biotransformation. As with TNT and DNT, the principal mode of microbial transformation of the nitroaromatic chemicals TNB and 1,3-dinitrobenzene is reduction of nitro groups to form amino groups. TNB is a photolytic product of TNT but will not undergo further photolysis. TNB will also resist hydrolysis. TNB primarily breaks down through microbial degradation (USACHPPM 2001b).

Limited information exists regarding biotransformation or biodegradation of RDX and HMX. RDX has a natural degradation rate, typically in the range of months, but may take years in more arid environments (ERDC 2007). One pilot study evaluated the treatment of pink water waste using an anaerobic fluidized-bed granular activated carbon bioreactor (USACE 2004). The study indicated RDX biodegrades in the presence of ethanol. Such data may be useful for evaluating potential use of enhanced bioremediation as a remedial option. Figure E-3 in Appendix E shows the biotransformation pathway for RDX (McCormick et al. 1981). A conservative biodegradation rate of 5.00E-04 per day was used for RDX (ANRCP 1999). Biotransformation of HMX, primarily by anaerobic degradation (ERDC 2007), occurs at a slow rate in the environment (USACHPPM 2001a). HMX degrades at a slower rate than RDX (ERDC 2007). HMX is primarily broken down by photolysis and has a photolytic rate constant of 0.15 days (USEPA 1988). Breakdown products of HMX include nitrate, nitrite, and formaldehyde (USACHPPM 2001a). Figure E-4 in Appendix E shows the biotransformation pathway for HMX (ATSDR 1997).

6.2 CONCEPTUAL MODEL FOR FATE AND TRANSPORT

The CSM, which defines the framework for fate and transport modeling, describes conditions at Load Line 10, including the contaminant sources, surficial and subsurface hydrogeologic conditions, contaminant migration and pathways, and contaminant release mechanisms.

AOC conditions described in Sections 2.0 through 5.0 include contaminant source information, the surrounding geologic and hydrologic conditions, and the magnitude of SRCs and their current spatial distribution. Information from the preliminary CSM presented in Section 3.7 and the nature and extent evaluation in Section 5.0 was used to develop the CSM for fate and transport modeling by identifying SRCs and migration pathways. The CSM is based on information and data collected for historical investigations, this RI Report, and informed assumptions about the AOC. Assumptions contained in the CSM are reiterated throughout this section. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the AOC, and therefore, the more reliable the fate and transport modeling predictions can be. A summary of the salient elements of the CSM that apply to fate and transport modeling are summarized in the following sections.

6.2.1 Contaminant Sources

No primary contaminant sources are located on the AOC. Secondary sources (contaminated media) identified in previous investigations are further evaluated in this report. Another potential secondary source of contamination at the AOC is contaminated sediment, which if deposited adjacent to a stream/ditch during a storm event, has potential to leach contaminants to the groundwater.

6.2.2 Hydrogeology

A description of regional and AOC-specific geology and hydrology are provided in Sections 3.3.3 and 3.4.2, respectively, and are summarized below.

- The topography at Load Line 10 ranges from approximately 1,114-1,133 ft amsl and is relatively flat. Surface water drainage associated with heavy rainfall events would follow the topography and drain from the northwest to the southeast (Figure 3-1).
- Soil beneath the AOC consists of clay to sand-rich silt tills with interbedded sands scattered throughout, as observed in subsurface borings installed during the PBA08 RI (Appendix A). Bedrock was encountered at 12.5-23.0 ft bgs during monitoring well installation under the Characterization of 14 AOCs (MKM 2007).
- Six groundwater monitoring wells were installed at the AOC to an average depth of 26.8 ft bgs. All Load Line 10 monitoring wells were installed to monitor shallow bedrock. However, monitoring well L10mw-006 is installed in the unconsolidated zone because it is located in an area where the depth to bedrock is approximately 9 ft deeper than at any other wells at the AOC.
- The potentiometric surface is a subdued replica of the topographic surface and shows a flow divide through the central portion of the AOC. Groundwater flow from this divide is to the

north-northwest at a gradient of 0.0065 ft/ft and to the south at a gradient of 0.0015 ft/ft with an average hydraulic gradient of 0.003 ft/ft (Figure 3-1).

- Water level elevations at the AOC ranged from 1,107.14-1,111.05 ft amsl (10.15-22.86 ft bgs) with the highest elevation at the unconsolidated well L10mw-006 (Figure 3-1). Potentiometric data indicate the groundwater table occurs within bedrock throughout most of the AOC (wells L10mw-001 through L10mw-005), with the exception of well LL10mw-006.

6.2.3 Contaminant Release Mechanisms and Migration Pathways

Based on the information presented above, the following contaminant release mechanisms and migration pathways have been identified at the AOC:

- Contaminant leaching from soil to the water table (vertical migration) and lateral transport to downgradient receptors (i.e., tributary to Sand Creek north of the local groundwater divide and tributary to the small stream south of Load Line 10);
- Contaminated sediment transported to potential downstream receptors;
- Contaminated surface water migrating to potential downstream receptors; and
- Contaminated sediment within wet ditches and deposited on ditch banks as a secondary source of leaching to the water table (vertical migration) and lateral transport to potential downgradient receptors.

The first of these pathways, which considers a primary groundwater transport pathway, is treated explicitly in this fate and transport section. Sediment and surface water transport pathways are evaluated in the HHRA and ERA presented in Sections 7.2 and 7.3, respectively. The fourth pathway listed above, which considers a secondary groundwater transport pathway, is evaluated using the sediment screening analysis presented in Section 6.4.

One of the principal migration pathways at the AOC is percolation through the unsaturated soil to the water table (i.e., vertical leaching of contaminants from soil into groundwater). However, because of the very heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns within the unconsolidated soil are difficult to predict. Precipitation that does not leave the AOC as surface runoff percolates into the subsurface. Some of the percolating water leaves this environment via evapotranspiration after little or no vertical migration.

The remainder of the water percolates into the water table. As discussed in Section 6.2.4, the rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions. Figure 6-1 illustrates the contaminant migration conceptual model.

Once the contaminant leachate percolates through the soil and reaches the water table, it migrates with the local groundwater and discharges at the downgradient receptors. Groundwater flow likely occurs along preferential pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities. For inorganic chemicals, lateral migration through groundwater will be very limited due to their high retardation by the bedrock material (USACE 2003a).

Additional factors that affect the leaching rate include a chemical's solubility, sorption capacity (expressed by the K_d), and the amount of percolation. Insoluble chemicals will precipitate out of the solution in the subsurface or remain in insoluble forms with little leaching.

Another factor that affects whether a chemical will reach the water table through percolation of precipitation is the chemical’s rate of decay. Most organic compounds decay at characteristic rates proportional to the chemical’s half-life. For a given percolation rate, those chemicals with long half-lives have a greater potential for contaminating groundwater than those with shorter half-lives. For this analysis, the rate of decay/half-life was not considered.

Contaminant releases through gaseous emissions and airborne particulates are not significant at Load Line 10. The AOC is vegetated, located in a humid temperate climate, and soil moisture is typically high, which prevents dust borne contaminant migration. Therefore, there is likely little to no gaseous emission, and contaminant levels in the air pathway are minor to nonexistent.

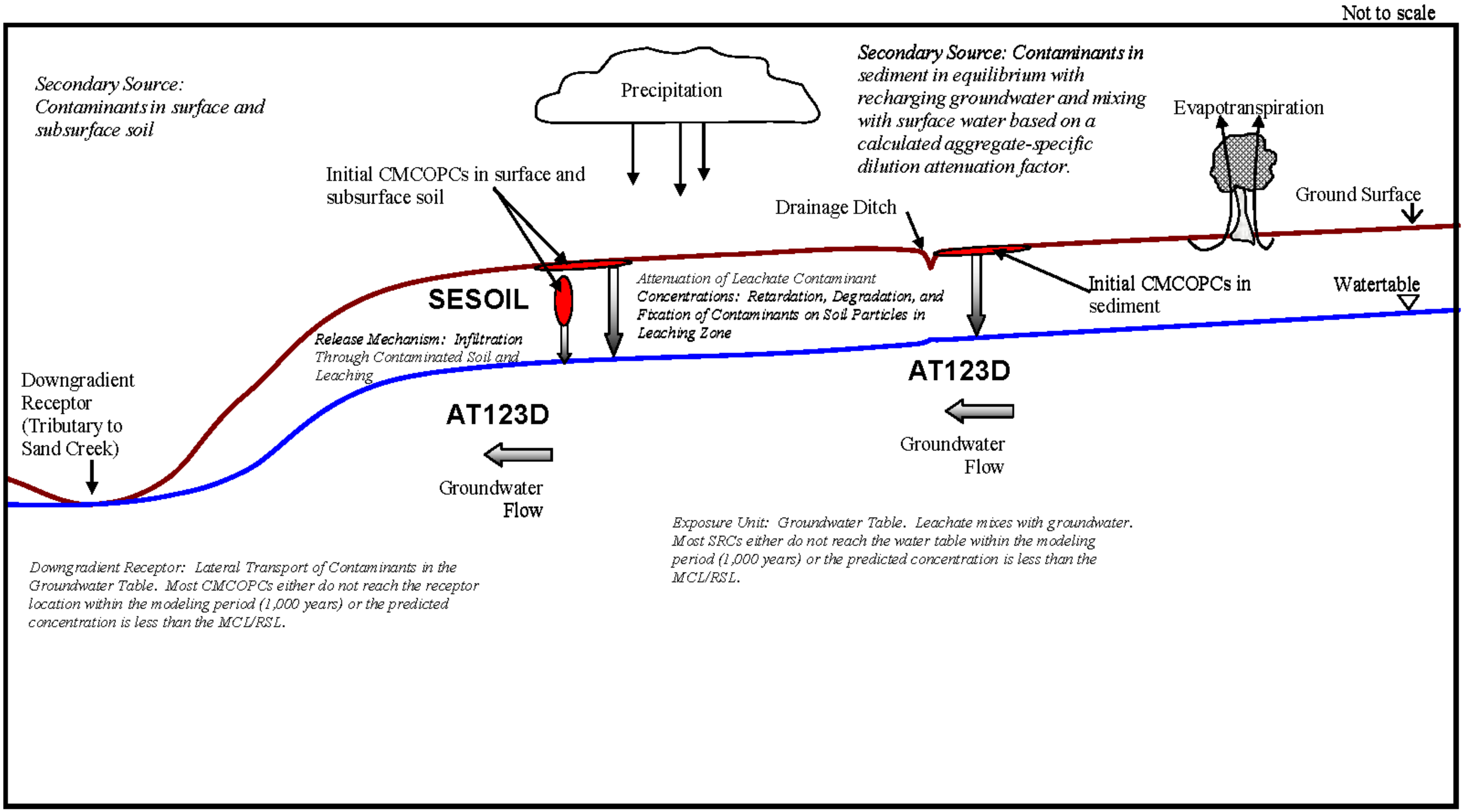


Figure 6-1. Contaminant Migration Conceptual Model

6.2.4 Water Budget

The potential for contaminant transport begins with precipitation. Percolation is the driving mechanism for leaching of soil contaminants to groundwater. The actual amount of rainwater available for flow and percolation to groundwater is highly variable and depends upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all components of the hydrologic cycle. The quantified elements of the water balance are used for inputs to the soil leaching and groundwater transport models discussed later. The components of a simple steady-state water balance model include precipitation, evapotranspiration, surface runoff, and groundwater recharge or percolation. These terms are defined as follows:

$$P = ET + Sr + q \qquad \text{(Equation 6-3)}$$

or

$$\text{Rainwater available for flow} = Sr + q = P - ET \qquad \text{(Equation 6-4)}$$

Where:

P = precipitation

Sr = surface runoff

ET = evaportranspiration

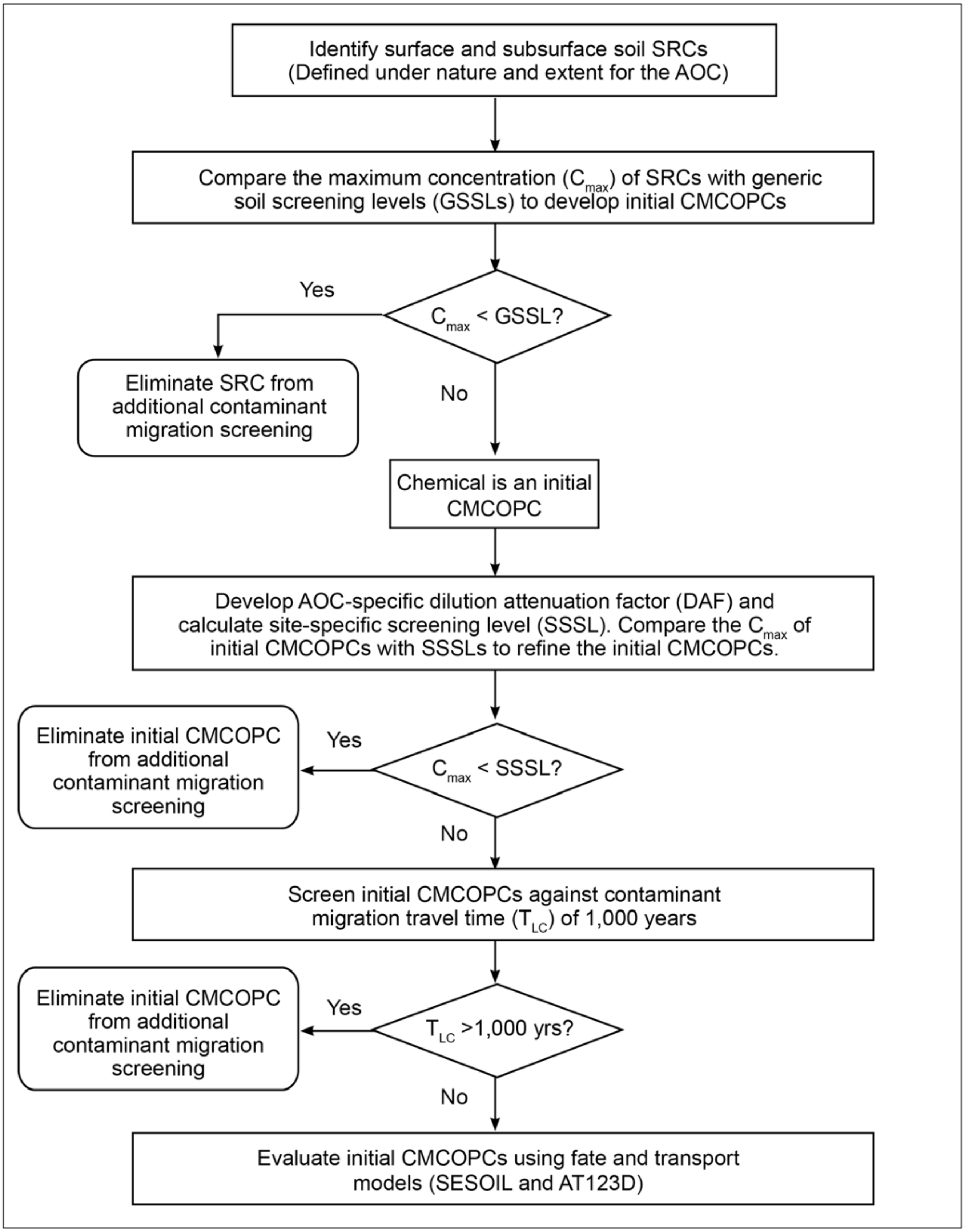
q = groundwater recharge or percolation

It is expected that loss of runoff also occurs in the form of evaporation. The remaining water, after runoff and evaporation, is available for percolation which includes loss to the atmosphere by evapotranspiration. The water balance estimations were developed using the Hydrologic Evaluation of Landfill Performance (HELP) model (USEPA 1994). See Table E-3 in Appendix E for parameters used in the HELP model to develop the water budget estimates used in the evaluation. Calculations using precipitation and temperature data for a 100-year period were generated synthetically using coefficients for Cleveland, Ohio (e.g., the nearest weather station to Camp Ravenna with HELP model coefficients).

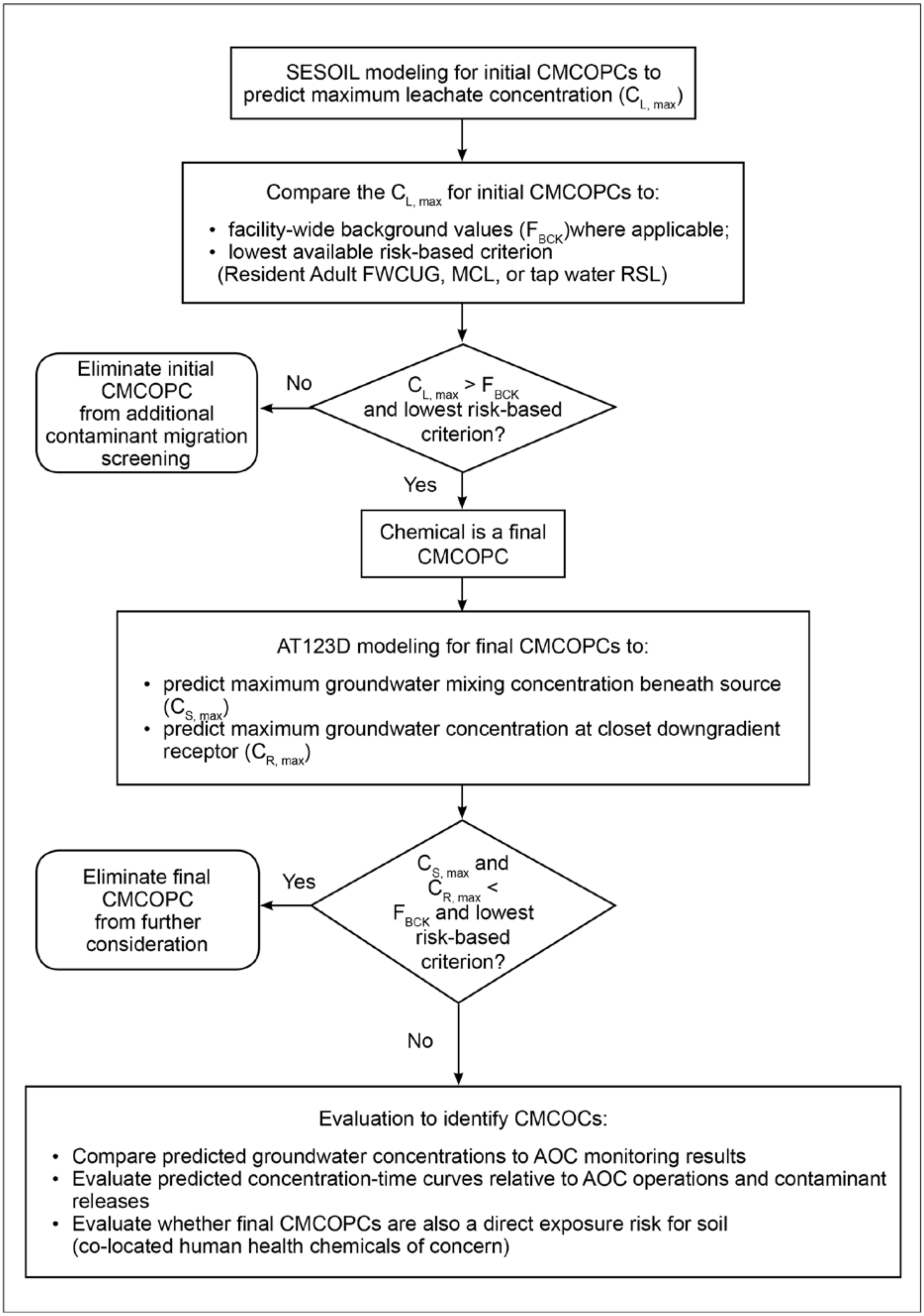
The annual average water balance estimates indicate an evapotranspiration of 28% (10.3 inches) of total precipitation (37 inches). The remaining 72% (27 inches) of rainwater is available for surface water runoff and percolation to groundwater. Of the 72% (27 inches) of water available for runoff or percolation, groundwater recharge (percolation) accounts for 13% (3.6 inches), and surface runoff (along downgradient topography to nearest surface water bodies) accounts for the remaining 87% (23 inches).

6.3 SOIL SCREENING ANALYSIS

Soil screening analyses are screening evaluations performed to identify SRCs with the potential to leach to groundwater as CMCOPCs. The five steps for the soil leachability analysis are illustrated in Figure 6-2.



1 **Figure 6-2. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation**



1 **Figure 6-2. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation (Continued)**

6.3.1 Soil Screening Analysis

The first step of the soil screening analysis is the development of SRCs, as presented Section 5.0. A summary of SRCs identified for soil and sediment is presented in Section 6.1.

The second step of the soil screening process (Figure 6-2) involves comparing the maximum concentrations of the SRCs with maximum contaminant levels (MCL)-based Generic Soil Screening Levels (GSSLs). GSSLs were developed for Superfund sites for contaminant migration to groundwater (USEPA 1996b, USEPA 2012). The GSSL is defined as the concentration of a chemical in soil that represents a level of contamination below which there is no concern for impacts to groundwater under CERCLA, provided conditions associated with USEPA risk-based Soil Screening Level (SSLs) are met. Generally, if chemical concentrations in soil fall below the GSSL, and there are no groundwater receptors of concern or anticipated exposures, then no further study or action is warranted for that chemical. If the GSSL for a chemical is not available, the USEPA risk-based SSL for groundwater migration, dated November 2012 (USEPA 2012), will be obtained from the USEPA RSL website and used. If neither the GSSL nor the USEPA risk-based SSL for a chemical is available, then no further evaluation of the chemical is performed and it is eliminated from the list of the initial CMCOPCs. However, some chemicals have been assigned surrogates by risk assessors if the chemical without an SSL is similar to another chemical with an SSL. Surrogates used for this analysis include acenaphthene for acenaphthylene and pyrene for benzo(ghi)perylene and phenanthrene.

One soil SRC, carbazole, was eliminated as an initial CMCOPC because it does not have an associated GSSL or USEPA risk-based SSL. Because this constituent does not have an associated USEPA RSL or MCL, an AOC-specific SSL could not be calculated. Carbazole was detected in 3 of 14 soil samples at a maximum concentration of 1.4 mg/kg. Carbazole is an SVOC with a relatively high K_{oc} value (9.16E+03 L/kg); therefore, this compound has the tendency to partition into soil and is not likely to pose a risk to groundwater. Carbazole was not detected in groundwater samples collected at Load Line 10 under the 2009 FWGWMP (EQM 2010).

The initial CMCOPC screen, as presented in Table E-4 in Appendix E, eliminates six inorganic and 19 organic SRCs from further consideration. There were 11 inorganic and 23 organic SRCs carried forward to the third step of the soil CMCOPC screening process.

The third step of the soil screening process (Figure 6-2) involves comparing the maximum chemical concentrations with the Site-specific Soil Screening Levels (SSSLs). The SSSL is defined as the GSSL (or the USEPA risk-based SSL for groundwater protection if a GSSL is not available) multiplied by the AOC-specific Dilution Attenuation Factor (DAF). Direct partitioning is used to derive the GSSLs, assuming groundwater is in contact with the chemicals in soil and the groundwater concentration is equal to the leachate concentration. However, as leachate moves through soil, chemical concentrations are attenuated by adsorption and degradation. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations. This concentration reduction can be expressed by a DAF. DAFs can vary based on AOC-specific characteristics (e.g., hydrogeologic properties, contaminated source area, depth to contamination). As described in the *Soil Screening Guidance: Technical Background Document* (USEPA 1996b), chemical dilution in groundwater is estimated at each AOC from an AOC-specific DAF. The DAF, which is defined as the ratio of soil leachate concentration to receptor point concentration, is minimally equal to one. Dilution in groundwater is derived from a simple mixing zone equation (Equation 6-5) and relies upon estimation of the mixing zone depth (Equation 6-6).

$$\mathrm{DAF} = 1 + \frac{(\mathrm{K} \times i \times \mathrm{d})}{(\mathrm{q} \times \mathrm{L})} \qquad \text{(Equation 6-5)}$$

Where:

DAF = dilution attenuation factor
K = aquifer hydraulic conductivity (m/yr)
i = horizontal hydraulic gradient (m/m)
q = percolation rate (m/yr)
L = source length parallel to groundwater flow (m)
d = mixing zone depth (m) (which is defined below)

$$\mathrm{d} = \sqrt{0.0112 \times \mathrm{L}^2} + \mathrm{d_a} \times \left[1 - \exp\left(\frac{-\mathrm{L} \times \mathrm{I}}{\mathrm{K} \times i \times \mathrm{d_a}}\right)\right] \qquad \text{(Equation 6-6)}$$

Where:

d_a = aquifer thickness (m)
$d \leq d_a$

As stated above, if the aquifer thickness is less than the calculated mixing zone depth, then the aquifer thickness is used for “d” in the DAF calculation. The DAF calculation for the AOC is presented in Table E-5 in Appendix E. It should be noted that the purpose of this screen is not to identify the chemicals that may pose risk at downgradient locations, but to target those chemicals that pose the greatest problem if they migrate from the AOC.

Based on this screening and an AOC-specific DAF of 1.28, zinc and pyrene were eliminated from further consideration. All the remaining SRCs exceeded their published or calculated GSSL multiplied by the respective DAF and were identified as the initial CMCOPCs, based on leaching to groundwater. The SRCs identified as initial CMCOPCs are presented in Table E-6 in Appendix E.

The fourth step of the soil screening process (Figure 6-2) involves eliminating initial CMCOPCs identified in the SSSL evaluation which require more than 1,000 years to leach through the unsaturated zone before reaching the water table from further consideration. A period of 1,000 years was conservatively selected to evaluate eventual migration of the contaminant front to the water table despite uncertainties in vadose zone hydraulic parameters and groundwater recharge over time. Additionally, USACE suggests a screening value of 1,000 years be used due to the high uncertainty associated with predicting conditions beyond that time frame (USACE 2003a). Therefore, the initial CMCOPCs at the selected sources were screened against a travel time of greater than 1,000 years.

The travel time in this screen is the time required for a CMCOPC to migrate vertically from the base of the soil interval detected above the background concentration to the water table. This distance is the leaching zone, which is evaluated in Table E-7 of Appendix E, which may vary across the AOC based on the varying depths of soil sample concentrations above the facility-wide background concentrations and the elevation of the water table. The estimated travel time for each initial CMCOPC to reach the water table is determined using the following equations:

$$T = \frac{Lz \times R}{V_p} \qquad \text{(Equation 6-7)}$$

Where:

T = leachate travel time (year)
Lz = thickness of attenuation zone (ft)
R = retardation factor (dimensionless) (Equation 6-2)
V_p = porewater velocity (ft/year)

and

$$V_p = \frac{q}{\theta_w} \qquad \text{(Equation 6-8)}$$

Where:

q = percolation rate (ft/year)
θ_w = fraction of total porosity that is filled by water

If the travel time for a chemical from a source area exceeded 1,000 years, then the chemical was eliminated from the list of initial CMCOPCs. Eight inorganic and organic SRCs were eliminated from further consideration based on their travel times exceeding 1,000 years. Initial CMCOPCs with travel times less than 1,000 years were retained for further evaluation (Appendix E, Table E-7). The constituents selected for further evaluation with Seasonal Soil Compartment Model (SESOIL) modeling are listed in Table 6-1.

In the fifth step (Figure 6-2), the initial CMCOPCs were further evaluated using fate and transport models provided in Section 6.5.

Table 6-1. Initial CMCOPCs Evaluated with SESOIL Modeling

SRCs	Maximum Concentrations (mg/kg)	ISM Area or Discrete Sample Location	Sample Depth (ft bgs)	Leachate Modeling? (Yes/No)
Inorganic chemicals				
Barium	1.90E+02	L10ss-002M	0.0-1.0	Yes
Selenium	5.70E+00	L10sb-074[a]	1.0-4.0	Yes
Semi-volatile organic compounds				
2-Methylnaphthalene	4.10E-01	L10ss-080M	0.0-1.0	Yes
Benzenemethanol	2.10E+00	L10ss-027Mzswe	0.0-1.0	Yes
Dibenzofuran	9.70E-01	L10ss-080M	0.0-1.0	Yes
Naphthalene	1.20E+00	L10ss-080M	0.0-1.0	Yes
Phenantherene	1.30E+01	L10sb-071[b]	1.0-4.0	Yes
Explosives				
2,6-Dinitrotoluene	1.40E-01	L10ss-008M	0.0-1.0	Yes
2-Amino-4,6-Dinitrotoluene	4.00E-02	L10sb-070[c]	4.0-7.0	Yes
3-Nitrotoluene	2.50E-02	L10ss-080M	0.0-1.0	Yes
4-Amino-2,6-Dinitrotoluene	1.60E-01	L10sb-071[b]	1.0-4.0	Yes
Nitroglycerin	6.00E-01	L10ss-057M-SO	0.0-1.0	Yes
PETN	7.50E-01	L10sb-071[b]	4.0-6.5	Yes
Pesticide/PCB				
Heptachlor epoxide	2.50E-02	L10ss-092M-SO	0.0-1.0	Yes
alpha-Chlordane	3.00E-01	L10ss-092M-SO	0.0-1.0	Yes
gamma-Chlordane	2.30E-01	L10ss-092M-SO	0.0-1.0	Yes

[a] The discrete sample location of L10sb-074-5524-SO is within the L10ss-040M area. Therefore, the area of L10ss-040M was used for modeling purposes.

[b] The discrete sample location of L10sb-071-5512-SO is within the L10ss-045M area. Therefore, the area of L10ss-045M was used for modeling purposes.

[c] The discrete sample location of L10sb-070-5509-SO is within the L10ss-080M area. Therefore, the area of L10ss-080M was used for modeling purposes.

bgs = Below ground surface.
ISM = Incremental Sampling Method.
mg/kg = Milligram per kilogram.
PCB = Polychlorinated Biphenyl.
PETN = Pentaerythritol tetranitrate.
SRC = Site-related contaminant.

6.3.2 Limitations and Assumptions of Soil Screening Analysis

It is important to recognize that acceptable soil concentrations for individual chemicals are highly AOC-specific. The GSSLs used in this screening are based on a number of default assumptions chosen to be protective of human health for most AOC conditions (USEPA 1996b). These GSSLs are expected to be more conservative than SSSLs based on AOC conditions. The conservative assumptions included in this analysis are: (1) no adsorption in the unsaturated zone or in the aquifer; (2) no biological or chemical degradation in the soil or aquifer; and (3) contamination is uniformly distributed throughout the source. However, the GSSL does not incorporate the existence of contamination already present within the aquifer.

6.4 SEDIMENT SCREENING ANALYSIS

Sediment SRCs were developed in Section 5.0 and are presented in Section 6.1. The purpose of this screening analysis is to identify the CMCOPCs based on contaminant migration from the sediment to the groundwater. Any identified CMCOPCs are modeled with Analytical Transient 1-, 2-, 3-Dimensional (AT123D) to a downgradient receptor if present. The four steps for the sediment screening analysis are illustrated in Figure 6-3.

Sediment SRCs were screened by developing leachate concentrations assuming equilibrium between sediment and groundwater. The predicted leachate concentrations were diluted based on a sample-specific DAF calculated by dividing the calculated leachate concentrations by the co-located surface water concentrations. The DAF was calculated for each chemical that was detected in the sediment and surface water at the same sample location. The calculated DAF was then used to calculate the maximum groundwater concentration, considering dilution for sediment SRCs. The lowest DAF calculated for the sample area was used for sediment SRCs that did not have a sample-specific DAF. The DAFs calculated for each chemical are shown in Table 6-2.

This sediment screening analysis assumed that the sediment concentration and the recharging groundwater concentration were in equilibrium and a sample-specific DAF for each chemical was used for dilution in the aquifer. Based on this screening analysis, two inorganic SRCs (antimony and beryllium) and six organic SRCs [3+4-methylphenol, benzo(a)pyrene, chrysene, fluoranthene, pyrene, and toluene] did not exceed the risk-based screening criteria and were eliminated from further evaluation. The remaining SRCs [cadmium, benz(a)anthracene, benzo(b)fluoranthene, and nitroguanidine] were evaluated with AT123D models, described in Section 6.5. See Table E-8 in Appendix E for the results of the sediment screening analysis.

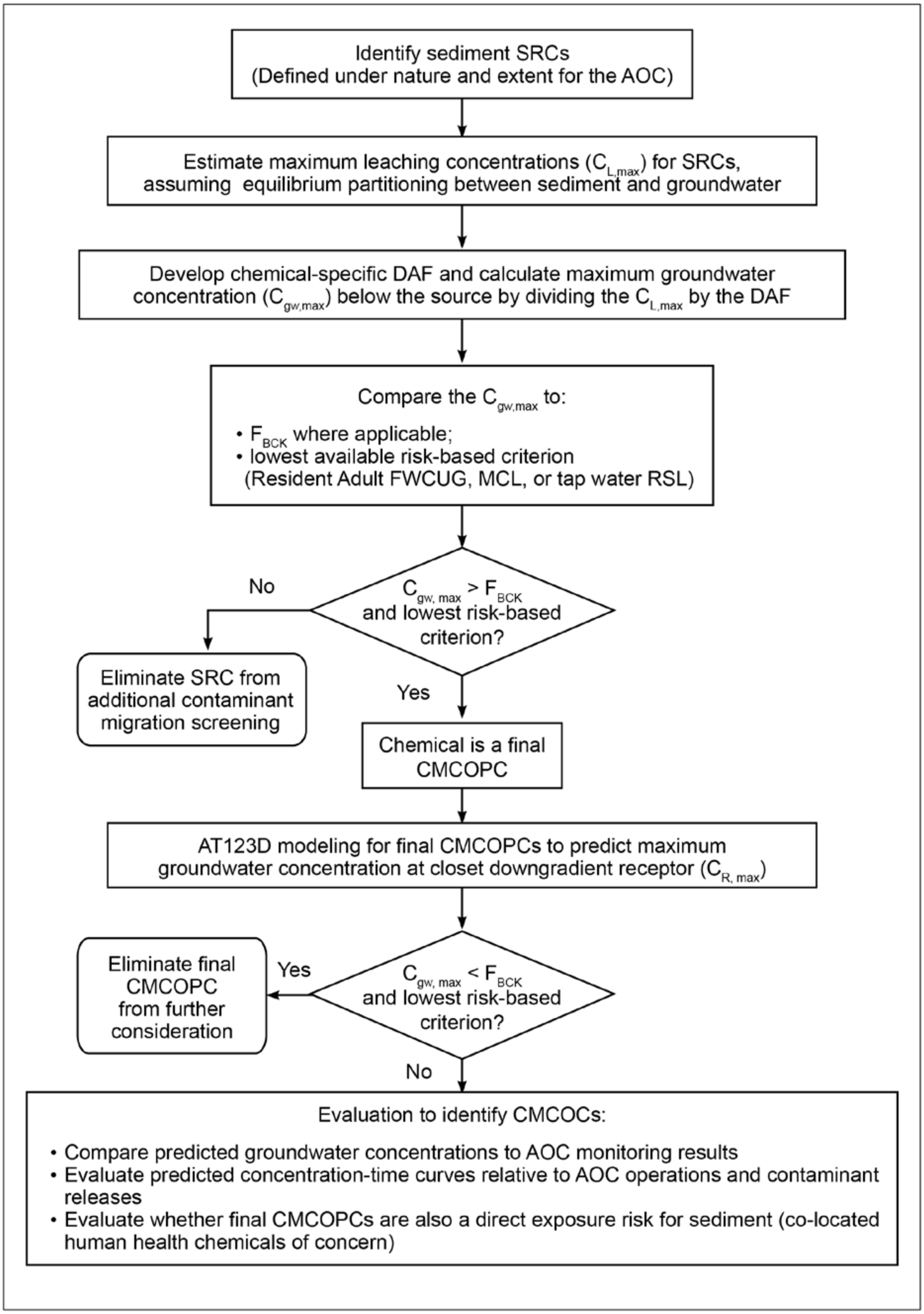


Figure 6-3. AOC Fate and Transport Modeling Approach - Sediment

Table 6-2. Calculated Sample-specific DAFs for Load Line 10

Analyte	Sediment Concentration (mg/kg)	Sediment and Surface Water Sample Location	K_d (L/kg)	Reference	Maximum Groundwater Concentration (mg/L)[a]	Co-located Surface Water Concentration (mg/L)	DAF[b]
Inorganic chemicals							
Aluminum	7010	FWSsd-102/FWSsw-102	1.50E+03	c	4.67E+00	15.8	1
Antimony	0.15	FWSsd-102/FWSsw-102	4.50E+01	d	3.33E-03	0.00042	8
Arsenic	3.3	FWSsd-102/FWSsw-102	2.90E+01	d	1.14E-01	0.0096	12
Barium	79.3	FWSsd-102/FWSsw-102	4.10E+01	d	1.93E+00	0.264	7
Beryllium	0.73	FWSsd-102/FWSsw-102	7.90E+02	d	9.24E-04	0.0011	1
Calcium	980	FWSsd-102/FWSsw-102	3.00E+01	e	3.27E+01	24	1
Chromium	14.9	FWSsd-102/FWSsw-102	1.90E+01	d	7.84E-01	0.0191	41
Cobalt	10.8	FWSsd-102/FWSsw-102	5.50E+02	e	1.96E-02	0.0148	1
Copper	29.1	FWSsd-102/FWSsw-102	2.20E+01	c	1.32E+00	0.0211	63
Iron	33500	FWSsd-102/FWSsw-102	8.00E+02	e	4.19E+01	43.5	1
Lead	15.1	FWSsd-102/FWSsw-102	5.50E+02	e	2.75E-02	0.0194	1
Magnesium	2570	FWSsd-102/FWSsw-102	1.80E+02	c	1.43E+01	9.44	2
Manganese	478	FWSsd-102/FWSsw-102	5.20E+01	e	9.19E+00	5.07	2
Nickel	25.7	FWSsd-102/FWSsw-102	6.50E+01	d	3.95E-01	0.0327	12
Potassium	519	L10sd-094/L10sw-094	5.50E+01	e	9.44E+00	1.61	6
Selenium	1.2	FWSsd-102/FWSsw-102	5.00E+00	d	2.40E-01	0.0017	141
Sodium	72.5	FWSsd-102/FWSsw-102	1.00E+02	e	7.25E-01	3.14	1
Vanadium	14.8	FWSsd-102/FWSsw-102	1.00E+03	d	1.48E-02	0.0281	1
Zinc	54.6	FWSsd-102/FWSsw-102	6.20E+01	d	8.81E-01	0.132	7

Sediment samples were taken from a depth of 0.0-0.5 ft bgs.

[a] Maximum groundwater concentration = maximum sediment concentration divided by the distribution coefficient.

[b] DAFs were calculated by dividing the calculated groundwater concentration by the co-located surface water concentration.

[c] Baes and Sharp 1983. *A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models*. Journal of Environmental Quality, Volume 12, Issue I. March 1983.

[d] USEPA 1996b. *Soil Screening Guidance: Technical Background Document*. Office of Solid Waste and Emergency Response, Washington, D.C. May 1996.

[e] Sheppard and Thibault 1990. *Default soil/liquid partition coefficients, KdS, for four major soil types: a compendium*. Health Physics, Volume 59, Issue 4. October 1990.

DAF = Dilution Attenuation Factor.
Kd = Distribution Coefficient.
L/kg = Liters per kilogram.
mg/kg = Milligrams per kilogram.
mg/L =Milligrams per liter.

6.5 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling represents the fifth step in the fate and transport screening and evaluation process (Figure 6-2). SESOIL modeling was performed for chemicals identified as initial CMCOPCs from the soil screening analysis presented in Section 6.3 and summarized in Table 6-1. SESOIL modeling was performed to predict chemical concentrations in the leachate immediately beneath the selected source areas and just above the water table. If the predicted maximum leachate concentration of an initial CMCOPC was higher than the facility-wide background concentration and the lowest risk-based screening value (Resident Adult FWCUG, MCL, or RSL), the CMCOPC was further evaluated using the AT123D model to predict future maximum concentrations in groundwater beneath the source, as well as at downgradient receptor locations, if applicable. The downgradient receptor location (if required) is the closest surface water body feature downgradient of the source areas that is connected to the groundwater. The predicted concentrations of CMCOPCs in groundwater beneath the source were compared to available groundwater monitoring results for the AOC to validate modeling results and provide WOE for identification or elimination of CMCOCs.

6.5.1 Modeling Approach

Contaminant transport includes the movement of water and dissolved material from the source areas to groundwater. This occurs as rainwater infiltrates from the surface and percolates through the area of contamination, its surrounding soil, and into the saturated zone. The downward movement of water, driven by gravitational potential, capillary pressure, and other components of total fluid potential mobilizes the contaminants and carries them through the soil into the mixing zone with the water table. Lateral transport within the shallow bedrock is controlled by the groundwater gradient. Vertical transport (evaluated with the SESOIL model) through the overburden to the water table and horizontal transport (evaluated with the AT123D model) through the shallow bedrock to downgradient receptor locations are illustrated in Figure 6-1.

The output of the contaminant fate and transport modeling is presented as the expected maximum concentration of modeled contaminants at the selected receptor locations. For SESOIL, the receptor location is the groundwater table beneath the source area. For this analysis, eight sampling locations (two discrete samples and six ISM areas) were considered as sources of contamination based on the results of the soil screening analysis. A separate SESOIL analysis was performed for each initial CMCOPC listed in Table 6-1 and is presented in Figure 6-4.

The predicted maximum leachate concentration just above the water table, observed in the SESOIL results, was compared against its applicable RVAAP facility-wide background concentration, as well as RVAAP FWCUGs for the Resident Adult, MCL, and RSL. If the predicted maximum leachate concentration of an initial CMCOPC was higher than the facility-wide background concentration, and the lowest risk-based screening value (Resident Adult FWCUG, MCL, or RSL), the CMCOPC was further evaluated using the AT123D model to predict future maximum concentrations in groundwater beneath the source, as well as at downgradient receptor locations, if applicable.

If a predicted maximum leachate concentration was lower than the screening criteria, the chemical was no longer considered a CMCOPC.

For chemicals identified as CMCOPCs, maximum concentrations predicted by AT123D in groundwater directly below the source areas and at the downgradient receptor locations were compared to the applicable RVAAP facility-wide background concentrations, as well as RVAAP FWCUGs for the Resident Adult, MCL, and RSL. If the predicted maximum concentration of a CMCOPC was higher than its facility-wide background concentration, and the lowest risk-based screening value (Resident Adult FWCUG, MCL, or RSL), the chemical was retained as a CMCOC. If the predicted maximum concentration of a CMCOPC in groundwater directly below the source areas and at the downgradient receptor location was lower than the screening criteria, the chemical would not be considered a CMCOC.

CMCOCs identified by modeling results were evaluated with respect to WOE for retaining or eliminating CMCOCs from further consideration as a basis for potential soil or sediment remedial actions. Lines of evidence include validation of modeling results using available AOC-specific groundwater monitoring data. Modeled timelines for potential leaching and lateral transport were evaluated with respect to estimated times for contaminant releases during RVAAP operations to determine if peak leaching concentrations would likely have occurred in the past. Some CMCOCs present at or below RVAAP soil or sediment background concentrations may have predicted leachate or groundwater concentrations exceeding risk-based criteria due to conservative model assumptions; therefore, these were also identified and considered in the evaluation. Additionally, identified CMCOCs were compared to COCs identified in the HHRA to determine if they had an associated risk related to direct exposure to soil or sediment or if CMCOCs and COCs were co-located and may be addressed simultaneously under a potential remedial action.

6.5.2 Model Applications

The SESOIL model (GSC 1998) used for leachate modeling, when applicable, estimates pollutant concentrations in the soil profile following introduction via direct application and/or interaction with transport media. The AT123D model (DOE 1992) is an analytical groundwater pollutant fate and transport model. It computes the spatial-temporal concentration distribution of waste in the aquifer system and predicts the transient spread of a contaminant plume through a groundwater aquifer. The application of both of these models is discussed in the following subsections.

6.5.2.1 SESOIL Modeling

The SESOIL model defines the soil column as compartments extending from the ground surface through the unsaturated zone and to the upper level of the saturated soil zone or top of bedrock. Processes simulated in SESOIL are categorized in three cycles: the hydrologic cycle, sedimentation cycle, and pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, percolation, soil-water content, evapotranspiration, and groundwater recharge. The sediment washload cycle includes erosion and sediment transport.

The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A chemical in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure). Data requirements for SESOIL are not extensive and utilize a minimum of AOC-specific soil and chemical parameters and monthly or seasonal meteorological values as input.

The SESOIL model output includes pollutant concentrations at various soil depths and pollutant loss from the unsaturated soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. The mathematical representations in SESOIL generally consider the rate at which the modeled processes occur, the interaction of different processes with each other, and the initial conditions of the waste area and the surrounding subsurface matrix material.

The input data for SESOIL can be grouped into four types: climatic data, chemical data, soil data, and application data. There are a total of 61 separate parameters contained in these four data groups. Wherever possible, AOC-specific parameter values were used for modeling. However, certain parameters were not available for the source areas and were estimated based on pertinent scientific literature, geochemical investigations, and checks for consistency between model results and historical data. Conservative estimates were used when a range of values existed or parameter values were not available.

6.5.2.2 Climate Data

The climatic data file of SESOIL consists of an array of mean monthly temperature, mean monthly cloud cover fraction, average monthly relative humidity, average monthly reflectivity of the earth’s surface (i.e., shortwave albedo), average daily evapotranspiration, monthly precipitation, mean number of storm events per month, mean duration of rainfall, and mean length of rainy season. The climatic data are presented in Table E-9 of Appendix E. The data set was taken from the Youngstown National Weather Service Office weather station at the Youngstown–Warren Regional Airport in Vienna, Ohio, as it was determined to be most appropriate in corresponding to the latitude and the longitude at Camp Ravenna.

Climate data from the Youngstown weather station did not have all of the necessary climatic parameters for the HELP model simulation. Accordingly, the water balance evaluation presented in Section 6.2.4 was based on the nearest available weather station data with all necessary coefficients stored within the HELP model (Cleveland, Ohio). Inputs for the SESOIL model (Youngstown station) and HELP model (Cleveland station) produced virtually the same recharge rate (9.40 cm/yr for Cleveland and 9.42 cm/yr for Youngstown) for each location. Therefore, the use of the two different weather station data sets did not impact modeling results.

6.5.2.3 Chemical Data

The pollutant fate cycle of SESOIL focuses on various chemical transport and transformation processes that may occur in the soil zone. These processes include volatilization/diffusion, adsorption/desorption, cation exchange, biodegradation and hydrolysis, and metal complexation. The chemical-specific parameters used for SESOIL are presented in Appendix E (Table E-10). The distribution coefficients (K_ds) for inorganic chemicals were obtained from the *Soil Screening Guidance: Technical Background Document*, assuming a neutral pH of 7, unless otherwise stated (USEPA 1996b). The K_ds for organic chemicals were estimated from organic, carbon-based K_{oc} using the relationship $K_d = (f_{oc})(K_{oc})$, where f_{oc} = mass fraction of the organic carbon soil content obtained from AOC-specific measurements. K_{oc} values were obtained from *Soil Screening Guidance: Technical Background Document* (USEPA 1996b), unless otherwise stated. In general, biodegradation rates are not applicable for inorganic CMCOPCs and biodegradation was not considered for the organic chemicals in this evaluation.

6.5.2.4 Soil Data

The soil data file of SESOIL contains input parameters describing the physical characteristics of the subsurface soil and is presented in Table 6-3. These parameters include soil bulk density, intrinsic permeability, soil disconnectedness index, soil porosity, organic carbon content, and cation exchange capacity. AOC-specific data were used from geotechnical samples collected at the AOC during the PBA08 RI (Table 5-4). There is, however, no measurement method for the soil disconnectedness index or a measured value of the Freundlich exponent. Soil disconnectedness index is a parameter that relates the soil permeability to the moisture content. Thus, SESOIL default values were used for these two parameters.

An average intrinsic permeability for the vadose zone, representing the unconsolidated zone above the water table, was calibrated using the percolation rate of 9.42 cm/yr (3.6 inches/year) as the calibration target. The model was calibrated against the percolation rate by varying the intrinsic permeability and keeping all other AOC-specific geotechnical parameters fixed. The final hydrogeologic parameter values used in this modeling are shown in Table 6-3. The soil porosity was set to the AOC-specific value. The intrinsic permeability, calibrated in SESOIL to the percolation rate (determined from a water balance estimated in HELP), was found to match the AOC-specific measurements from geotechnical samples.

The soil disconnectedness index replaces the moisture retention curves (or characteristic curves) used by other unsaturated zone leaching models. SESOIL's User Guide defines this parameter to be the exponent relating the "wetting" and "drying" time-dependent permeability of soil to its saturated permeability (Hetrick and Scott 1993). This "one variable" approach of using soil disconnectedness index in SESOIL simplifies the data estimation process and reduces computational time. In addition, this parameter was calibrated for four different soil types ranging from sandy loam to clay (Hetrick et al. 1986), and calibrated values fell within the default range specified in the SESOIL's User Guide.

6.5.2.5 Source Terms

Analytical data from surface and subsurface soil collected at the AOC were used as source terms for SESOIL modeling. All the samples collected at different depth intervals were compiled to provide a detailed loading option for the SESOIL model. The maximum soil concentrations for each CMCOPC, listed in Table 6-1, were used as source term concentrations for the SESOIL model.

6.5.2.6 Application Data

Seven different layering schemes were developed for sample locations within the AOC due to varying thicknesses of the loading and leaching zones that are based on varying soil sample and groundwater depths throughout the AOC. Details of the model layers utilized in this modeling are presented in Table E-11 in Appendix E.

Each model was arranged in four layers. The top layer (Layer 1) for each model consisted of the loading zone, with the exception of the selenium, PETN, phenanthrene, 2-amino-2,6-DNT, and 4-amino-2,6-DNT models.

The thicknesses of Layers 2 and 3 varied between the models for each chemical but served as a leaching zone in each. The fourth layer (Layer 4) was 0.5 ft thick and did not contain sublayers. Layer 4 was included just above the water table to read output results at the water table/vadose zone interface (i.e., leachate concentration entering groundwater).

For the selenium model, Layers 1 and 2 served as a loading zone in the 8-ft thick vadose zone. Layers 3 and 4 served as the leaching zone of 1 ft. For the PETN model, Layers 2 and 3 served as a loading zone in the 6.5-ft thick vadose zone. Layer 4 served as the leaching zone of 0.5 ft. For the phenanthrene model, Layers 1, 2, and 3 served as a loading zone in the 6.5-ft thick vadose zone. Layer 4 served as the leaching zone of 0.5 ft. For the 2-amino-2,6-DNT model, Layer 2 served as the loading zone in the 13-ft thick vadose zone and the bottom two layers served as the leaching zone. For the 4-amino-2,6-DNT model, Layer 2 served as the loading zone in the 6-ft thick vadose zone and the bottom two layers served as the leaching zone. In each of these models, Layer 4 was included just above the water table to read output results at the water table/vadose zone interface (i.e., leachate concentration entering groundwater).

Table 6-3. Unit-Specific Parameters Used in SESOIL and AT123D Modeling

Parameters	Symbol	Units	Value	Source for Value
				SESOIL
Percolation Rate (Recharge Rate)	q	m/yr	9.42E-02	0.1 SESOIL Precipitation for Youngstown, Ohio
Horizontal Area of Aggregate	A_p	cm^2	Varies	Sample specific
Intrinsic Permeability - clayey sand	p	cm^2	1.05E-10	Calibrated from SESOIL model
Disconnectedness Index	c	unitless	11	Calibrated from SESOIL model
Freundlich Equation Exponent	n	unitless	1	SESOIL default
Fraction Organic Carbon	f_{oc}	unitless	7.60E-04	From the PBA08 RI geotechnical sample L10SB-068-5501-SO
Bulk Density	ρ_b	kg/L	1.7	
Moisture Content	w	wt %	15.4	
Water-filled Soil Porosity	Tw	unitless	0.262	
Air-filled Soil Porosity	Ta	unitless	0.127	
Porosity – total	n_T	unitless	0.389	
Vadose Zone Thickness	Vz	m	3.66	Average depth to water table from potentiometric surface map (Figure 6-4)
Leaching Zone Thickness	Th	m	0.30 - 4.88	Based on distance from deepest detection of a CMCOC to the water table from potentiometric surface maps (Figure 6-4)
				AT123D
Aquifer Thickness	h	m	6	Conservative assumption for sallow bedrock aquifer. Facility-wide assumption for the unconsolidated aquifer presented the Load Line 1 investigation was 6 meters (USACE 2003a)
Hydraulic Conductivity in Saturated Zone	K_S	cm/s	2.55E-04	Average of slug test results (MKM 2007)
Hydraulic Gradient	i	unitless	3.00E-03	Documented value from (MKM 2007) and within range (0.0065 - 0.0015) reported in January 2010 FWGWMP report used to generate potentiometric surface maps (Figure 6-4).

Table 6-3. Unit-Specific Parameters Used in SESOIL and AT123D Modeling (continued)

Parameters	Symbol	Units	Value	Source for Value
Effective porosity	n_e	unitless	0.2	Assumed for sandstone (USEPA 1985)
Dispersivity, longitudinal	α_L	m	30	Assumed
Dispersivity, transverse	α_T	m	3	0.1 α_L
Dispersivity, vertical	α_V	m	0.3	0.01 α_L
Retardation factor	R_d	unitless	chemical-specific	Presented in Table E-7 in Appendix E

MKM 2007. Characterization of 14 AOCs at Ravenna Army Ammunition Plant (March 2007).

USACE 2003a. Phase II Remedial Investigation Report for the Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio. June 2003.

USEPA (U.S. Environmental Protection Agency) 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water, Revised 1985 Parts 1 and 2, EPA/600/6-85/002. Office of Research and Development, Environmental Research Laboratory, Athens, Georgia. September 1985.

AT123D = Analytical Transient 1-,2-,3-Dimensional model.
cm^2 = Square centimeters.
CMCOC = Contaminant Migration Chemical of Concern.
cm/s = Centimeters per second.
FWGWMP = Facility-wide Groundwater Monitoring Program.
kg/L = Kilograms per liter.
m = Meter.
m/yr = Meters per year.
PBA08 RI = Performance Based Acquisition 2008 Remedial Investigation.
SESOIL = Seasonal Soil Compartment Model.
wt % = Weight bb percent.

6.5.3 SESOIL Modeling Results

SESOIL modeling was performed for initial CMCOPCs (barium, selenium, 2-methylnaphtalene, benzenemethanol, dibenzofuran, naphthalene, phenantherene, heptachlor epoxide, alpha-chlordane, gamma-chlordane, 2,6-DNT, 2-amino-4,6-DNT, 3-nitrotoluene, 4-amino-2,6-DNT, nitroglycerin, and PETN) that have the potential to reach the water table within 1,000 years based on the soil screening analysis results (Table 6-1). Table 6-4 presents the predicted peak leachate concentrations beneath the source areas relative to the discrete sample locations and ISM areas corresponding to the time of peak leachate concentrations. The Resident Adult FWCUGs, RVAAP facility-wide background concentrations, and MCL/RSL values for the CMCOPCs, if available, are also shown in this table for comparison purposes. Barium was eliminated as a final CMCOPC based on the results of the SESOIL modeling, as the leachate below the source and just above the water table was below its screening criterion. The remaining SRCs were selected as final CMCOPCs. Figures E-5 through E-19 in Appendix E show the leachate mass flux versus time plots generated by SESOIL.

Selenium, 2-methylnaphthalene, benzenemethanol, dibenzofuran, naphthalene, phenantherene, 2,6-DNT, 2-amino-4,6-DNT, 3-nitrotoluene, 4-amino-2,6-DNT, nitroglycerin, PETN, heptachlor epoxide, alpha-chlordane, and gamma-chlordane were identified as the final soil CMCOPCs based on SESOIL results for each sample location within the AOC where the leachate concentration exceeded its screening criteria.

6.5.4 AT123D Modeling in the Saturated Zone

The fate and transport processes accounted for in the AT123D model include advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater, resulting from a mass release over a source area (point, line, area, or volume source). The model can handle instantaneous, as well as continuous, source loadings of CMCOPC concentrations. AT123D is frequently used by the scientific and technical community to perform quick and conservative estimates of groundwater plume movements in space and time. SESOIL and AT123D are linked in a software package (RISKPRO) so that mass loading to the groundwater predicted by SESOIL can be transferred directly to AT123D. Therefore, AT123D was chosen to predict the maximum concentration of contaminants in groundwater after mixing with the leachate and the future concentrations for the contaminants in groundwater at the receptor locations.

The hydrogeologic parameter values used in this modeling are shown in Table 6-3. Most of the parameters presented in this table are AOC-specific values, unless otherwise indicated. The chemical-specific parameters used for AT123D are presented in Appendix E (Table E-12). A discussion of model assumptions and limitations is presented in Section 6.5.6.

Selenium, 2-methylnaphthalene, benzenemethanol, dibenzofuran, naphthalene, phenantherene, 2,6-DNT, 2-amino-4,6-DNT, 3-nitrotoluene, 4-amino-2,6-DNT, nitroglycerin, PETN, heptachlor epoxide, alpha-chlordane, and gamma-chlordane were identified as the final soil CMCOPCs based on

SESOIL results for each sample location within the AOC where the leachate concentration exceeded its screening criteria.

Cadmium, nitroguanidine, benz(a)anthracene, and benzo(f)fluoranthene were identified as final CMCOPCs based on the sediment screening analysis. Figure 6-5 presents the locations of the soil and sediment samples where the final CMCOPCs exist. Figures E-20 through E-36 show the predicted concentration versus time curves based on AT123D modeling.

6.5.5 AT123D Modeling Results

Results of AT123D modeling for final soil and sediment CMCOPCs are shown in Table 6-5. The results show predicted groundwater concentrations for CMCOPCs beneath the source area and at the selected downgradient receptor locations (i.e., tributary to Sand Creek and small stream south of Load Line 10). Observed groundwater concentrations from AOC monitoring wells are included in Table 6-5; however, it should be noted that these wells may not exist near the sample location with the maximum concentration and should not be considered in direct correlation. The observed groundwater concentrations were added for comparison, not for screening criteria. The distances to the downgradient receptors were based on the distance along the groundwater flow direction to the closest surface water body.

For final soil CMCOPCs, the maximum predicted concentrations of benzenemethanol, 2-amino-4,6-DNT, nitroglycerin, and heptachlor epoxide in the groundwater were not predicted to exceed the screening criteria beneath the source area and were eliminated as CMCOCs. The maximum predicted concentrations of alpha-chlordane, gamma-chlordane, PETN, 3-nitrotoluene, 4-amino-2,6-DNT, 2,6-DNT, phenantherene, naphthalene, dibenzofuran, 2-methylnaphthalene, and selenium were predicted to exceed the screening criteria in groundwater beneath the source area and were; therefore, modeled to the downgradient receptors (i.e., tributary to Sand Creek and small stream south of Load Line 10). The identified sediment CMCOPCs [cadmium, benz(a)anthracene, benzo(b)fluoranthene, and nitroguanidine] were also predicted by analytical solutions to exceed screening criteria in groundwater beneath their source and were retained for lateral transport modeling.

Lateral transport modeling showed the maximum predicted concentrations of final soil CMCOPCs did not exceed the screening criteria at their downgradient receptor location (tributary to Sand Creek north of the AOC). Likewise, maximum predicted concentrations of final sediment CMCOPCs did not exceed screening criteria at their downgradient receptor (unnamed tributary south of the AOC). However, the nine final soil CMCOPCs (alpha-chlordane, gamma-chlordane, PETN, 3-nitrotoluene, 4-amino-2,6-DNT, 2,6-DNT, phenantherene, naphthalene, dibenzofuran, 2-methylnaphthalene, and selenium) and the four final sediment CMCOPCs [cadmium, benz(a)anthracene, benzo(b)fluoranthene, and nitroguanidine] exceeded screening criteria in groundwater beneath their respective source areas and were retained for further evaluation.

Table 6-4. Summary of SESOIL Modeling Results

Initial CMCOPC	Maximum Soil Concentration (mg/kg)	ISM Area or Discrete Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted $C_{leachate, max}$ Beneath Source (mg/L)	Time Required to Reach $C_{leachate, max}$ (years)	MCL/RSL (mg/L)	Resident Adult FWCUG[a] (mg/L)	Facility-wide Background Bedrock Groundwater (mg/L)	Final CMCOPC?[b] (yes/no)
Inorganic Chemicals										
Barium	1.90E+02	L10ss-002M	1.0	16.0	0.00E+00	NA	2.00E+00	0.706	2.41E-01	No
Selenium	**5.70E+00**	**L10sb-074-5524-SO[c]**	**7.0**	**8.0**	**1.13E+00**	**90**	**5.00E-02**	**None**	**0.00**	**Yes**
Semi-volatile Organic Compounds										
2-Methylnaphthalene	**4.10E-01**	**L10ss-080M**	**1.0**	**16.0**	**3.11E-02**	**100**	**2.70E-02**	**None**	**None**	**Yes**
Benzenemethanol	**2.10E+00**	**L10ss-027M**	**1.0**	**17.0**	**2.61E+00**	**8**	**1.50E+00**	**None**	**None**	**Yes**
Dibenzofuran	**9.70E-01**	**L10ss-080M**	**1.0**	**16.0**	**2.24E-02**	**356**	**5.80E-03**	**None**	**None**	**Yes**
Naphthalene	**1.20E+00**	**L10ss-080M**	**1.0**	**16.0**	**1.42E-01**	**65**	**1.40E-04**	**None**	**None**	**Yes**
Phenantherene	**1.30E+01**	**L10sb-071-5512-SO[d]**	**6.5**	**7.0**	**8.16E-01**	**168**	**8.70E-02**	**None**	**None**	**Yes**
Explosives										
2,6-Dinitrotoluene	**1.40E-01**	**L10ss-008M**	**1.0**	**15.0**	**4.77E-02**	**27**	**1.50E-02**	**1.22E-04**	**None**	**Yes**
2-Amino-4,6-Dinitrotoluene	**4.00E-02**	**L10sb-070-6174-FD**	**7.0**	**14**	**1.13E-01**	**11**	**3.00E-02**	**None**	**None**	**Yes**
3-Nitrotoluene	**2.50E-02**	**L10ss-080M**	**1.0**	**16.0**	**1.13E-02**	**20**	**1.30E-03**	**None**	**None**	**Yes**
4-Amino-2,6-Dinitrotoluene	**1.60E-01**	**L10sb-071-5512-SO[d]**	**4.0**	**7.0**	**7.57E-01**	**4**	**3.00E-02**	**None**	**None**	**Yes**
Nitroglycerin	**6.00E-01**	**L10ss-057M-SO**	**1.0**	**11.0**	**7.74E-01**	**8**	**1.50E-03**	**5.01E-03**	**None**	**Yes**
PETN	**7.50E-01**	**L10sb-71-5513-SO[e]**	**6.5**	**7.0**	**1.83E+00**	**4**	**1.60E-02**	**None**	**None**	**Yes**

Table 6-4. Summary of SESOIL Modeling Results (continued)

Initial CMCOPC	Maximum Soil Concentration (mg/kg)	ISM Area or Discrete Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted $C_{leachate, max}$ Beneath Source (mg/L)	Time Required to Reach Leachate C_{max} (years)	MCL/RSL (mg/L)	Resident Adult FWCUG[a] (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)	Final CMCOPC?[b] (yes/no)
Organic Chemicals - Pesticide/PCBs										
Heptachlor epoxide	**2.50E-02**	**L10ss-092M-SO**	**1.0**	**8.0**	**1.24E-03**	**187**	**2.00E-04**	**9.00E-06**	**None**	**Yes**
alpha-Chlordane	**3.00E-01**	**L10ss-092M-SO**	**1.0**	**8.0**	**4.38E-03**	**620**	**2.00E-03**	**None**	**None**	**Yes**
gamma-Chlordane	**2.30E-01**	**L10ss-092M-SO**	**1.0**	**8.0**	**3.33E-03**	**620**	**2.00E-03**	**None**	**None**	**Yes**

[a] The Resident Adult FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

[b] The Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, Resident Adult FWCUGs, and facility-wide background concentrations. A constituent is a CMCOPC if its predicted leachate concentration exceeds its MCL/RSL within 1,000 years.

[c] The discrete sample location of L10sb-074-5524-SO was within the L10ss-040M area. Therefore, the area of L10ss-040M was used for modeling purposes.

[d] The discrete sample location of L10sb-071-5512-SO was within the L10ss-045M area. Therefore, the area of L10ss-045M was used for modeling purposes.

bgs = Below ground surface.
CMCOPC = Contaminant migration chemical of potential concern.
FWCUG = Facility-wide cleanup goal.
ISM = Incremental sampling method.
MCL = Maximum contaminant level.
mg/kg = Milligram per kilogram.
mg/L = Milligram per liter.
NA = Not available.
PCB = Polychlorinated biphenyl.
PETN = Pentaerythritol tetranitrate.
RSL = Regional Screening Level.
SESOIL = Seasonal soil compartment model.
Bold = CMCOPCs exceeding MCL/RSL, Resident Adult FWCUGs, and facility-wide background concentrations.

Table 6-5. Summary of AT123D Modeling Results

Final CMCOPC	Maximum Leachate Concentration[a] (mg/L)	Predicted Groundwater[b] (C_{MAX}) Beneath Source (mg/L)	Predicted Groundwater[b] (C_{MAX}) Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	Observed Maximum Groundwater Concentrations[c] (mg/L)	MCL/RSL (mg/L)	Resident Adult FWCUG[d] (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)	Identified CMCOC for Further Evaluation?[e] (yes/no)
Final CMCOPCs in Soil									
Inorganic chemicals									
Selenium	1.13E+00	9.37E-01	0.00E+00	1875	ND	5.00E-02	None	0.00	Yes
Semi-volatile Organic Compounds									
2-Methylnaphthalene	3.11E-02	3.19E-02	0.00E+00	1875	ND	2.70E-02	None	None	Yes
Benzenemethanol	2.61E+00	3.25E-01	2.65E-03	1875	ND	1.50E+00	None	None	No
Dibenzofuran	2.24E-02	1.34E-02	0.00E+00	1875	ND	5.80E-03	None	None	Yes
Naphthalene	1.42E-01	1.35E-01	0.00E+00	1875	ND	1.40E-04	None	None	Yes
Phenantherene	8.16E-01	4.91E-01	0.00E+00	1875	ND	8.70E-02	None	None	Yes
Explosives									
2,6-Dinitrotoluene	4.77E-02	1.13E-02	1.13E-06	1875	8.9E-05J	1.50E-02	1.22E-04	None	Yes
2-Amino-4,6-Dinitrotoluene	1.13E-01	2.17E-02	2.63E-05	1875	ND	3.00E-02	None	None	No
3-Nitrotoluene	1.13E-02	1.03E-02	2.00E-05	1875	ND	1.30E-03	None	None	Yes
4-Amino-2,6-Dinitrotoluene	7.57E-01	1.98E-01	1.06E-04	1875	ND	3.00E-02	None	None	Yes
Nitroglycerin	7.74E-01	6.03E-02	3.48E-05	1875	ND	1.50E-03	5.01E-03	None	No
PETN	1.83E+00	5.92E-01	1.40E-05	1875	ND	1.60E-02	None	None	Yes
Pesticide/PCBs									
Heptachlor epoxide	1.24E-03	1.68E-06	0.00E+00	1875	ND	2.00E-04	9.00E-06	None	No
alpha-Chlordane	4.38E-03	3.05E-03	0.00E+00	1875	ND	2.00E-03	None	None	Yes
gamma-Chlordane	3.33E-03	2.31E-03	0.00E+00	1875	ND	2.00E-03	None	None	Yes

Table 6-5. Summary of AT123D Modeling Results (continued)

Final CMCOPC	Maximum Leachate Concentration[a] (mg/L)	Predicted Groundwater[b] (C_{MAX}) Beneath Source (mg/L)	Predicted Groundwater[b] (C_{MAX}) Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	Observed Maximum Groundwater Concentrations[c] (mg/L)	MCL/RSL (mg/L)	Resident Adult FWCUG[d] (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)	Identified CMCOC for Further Evaluation?[e] (yes/no)
Final CMCOPCs in Sediment[f]									
Inorganic chemicals									
Cadmium	6.93E-03	6.94E-03	0.00E+00	1000	ND	5.00E-03	1.47E-03	None	Yes
Semi-volatile Organic Compounds									
Benz(a)anthracene	7.44E-05	7.40-05	0.00E+00	1000	ND	2.90E-05	4.00E-06	None	Yes
Benzo(b)fluoranthene	4.61E-05	4.58EE-05	0.00E+00	1000	ND	2.90E-05	2.00E-06	None	Yes
Explosives									
Nitroguanidine	2.04E+01	2.02E+01	5.01E-05	1000	ND	1.60E+00	None	None	Yes

[a] Represents SESOIL predicted maximum leachate concentration just above the water table.

[b] The predicted concentration was estimated using the results from SESOIL and applying AT123D model.

[c] Observed groundwater concentrations were reported in the *RVAAP Facility-wide Groundwater Monitoring Program 2009 Annual Report* (EQM 2010) and sampling events through 2012.

[d] The Resident Adult FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

[e] The CMCOC was identified comparing predicted concentration in groundwater to MCL/RSL, Resident Adult FWCUGs, and facility-wide background concentrations. A constituent is a CMCOC if its predicted concentration in groundwater exceeds all its screening criteria within 1,000 years.

[f] Maximum groundwater concentration = maximum sediment concentration divided by the distribution coefficient.

CMCOC = Contaminant migration chemical of concern.
CMCOPC = Contaminant migration chemical of potential concern.
FWCUG = Facility-wide cleanup goal.
MCL = Maximum contaminant level.
Mg/L = Milligrams per liter.
ND = Not detected.
PCB = Polychlorinated biphenyl.
PETN = Pentaerythritol tetranitrate.
RSL = Regional Screening Level.
SESOIL = Seasonal soil compartment model.

6.5.6 Limitations/Assumptions

In general, a conservative modeling approach was used, which may overestimate the contaminant concentration in the leachate for migration from observed soil concentrations. Listed below are important assumptions used in this analysis:

- Chemical and biological degradation rates for organic CMCOPCs were not considered in the SESOIL and AT123D models.
- The use of K_d and R to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid-phase and solution-phase concentrations and that the relationship is linear and reversible.
- Since AOC-specific data are not available, the K_d and K_{oc} values used in this analysis for all CMCOPCs represent literature or calculated values and may not represent conditions at the AOC.
- The K_d for inorganic chemicals used here assumed a pH of 6.8 [i.e., the middle value in the USEPA's evaluation presented in the soil screening guidance document (USEPA 1996b)]. The K_d for inorganic chemicals varies with pH (generally decreasing with decreasing pH, although there are few exceptions); therefore, if AOC-specific pH measurements are greater or less than 6.8, the K_d and calculated screening parameters (such as R) will deviate from those presented here.
- Flow and transport in the vadose zone is one-dimensional (i.e., only in the vertical direction).
- This modeling used the current soil concentrations that were collected approximately 65 years after historical operations were terminated at the AOC. Therefore, it does not account for constituents that have already leached to groundwater.
- Flow and transport are not affected by density variations.
- A realistic distribution of soil contamination was not considered. The maximum concentration value was used as the source term concentrations for SESOIL model layers; this is a highly conservative assumption that is expected to produce higher leachate concentrations for the CMCOPCs than the average condition. The horizontal distribution of soil contamination was assumed based on concentration levels from nearby sample locations as opposed to taking into account the entire area.
- The water balance represents an overall average rainwater recharge and assumes an even distribution of infiltration in the modeled area. An average water balance assumes some areas will have higher or lower recharge based on the heterogeneity of the soil and varying topography.

The inherent uncertainties associated with using these assumptions must be recognized. K_d values are highly sensitive to changes in the major chemistry of the solution phase. Therefore, it is important that the values be measured or estimated under conditions that will closely represent those of the contaminant plume. Deviations from actual AOC-specific parameter values from assumed literature values may significantly affect contaminant fate predictions. It is also important to note that the contaminant plume will change over time and will be affected by multiple solutes present at the AOC. The effects of heterogeneity and anisotropy are not addressed in these simulations.

The discrepancy between the contaminant concentrations measured in the field and the values predicted by the model could be investigated by performing sensitivity analyses on the model input parameters that have the most influence on the model predictions.

These parameters are: (1) biodegradation rate constants for organic chemicals; (2) saturated hydraulic conductivity; (3) soil porosity; (4) fraction of soil organic carbon-content (f_{oc}) for organic chemicals; (5) K_d for inorganic chemicals; and (6) longitudinal, transverse, and vertical dispersivity values. Generally, higher biodegradation rates will produce lower concentrations, and lower rates will produce higher concentrations for organic chemicals without impacting the results of the inorganic chemicals. Higher hydraulic conductivity and dispersivity causes higher advection and dispersion, thereby producing lower peaks near the source area, but increasing the migration distance. The reverse will be true with lower hydraulic conductivity and dispersivity values. Higher f_{oc} values have a similar effect on organic chemicals as higher K_d has on inorganic chemicals; they decrease the mobility of the chemicals as well as produce lower concentrations in groundwater.

AOC-specific groundwater data indicate the AT123D modeling results are conservative with respect to predicted concentrations of chemicals in groundwater beneath the sources. None of the final CMCOPCs in soil and sediment were detected in recent AOC groundwater samples collected from 2009-2012 (EQM 2010), except 2,6-DNT (Table 6-5). A single estimated detection of 2,6-DNT (0.000089J mg/L) occurred in one monitoring well (LL10mw-002) in 2009; this compound has not been subsequently detected in any Load Line 10 groundwater samples. These data indicate soil and sediment sources are not currently impacting groundwater quality.

Predictive modeling for 11 final soil CMCOPCs (alpha-chlordane, gamma-chlordane, PETN, 3-nitrotoluene, 4-amino-2,6-DNT, 2,6-DNT, phenantherene, naphthalene, dibenzofuran, 2-methylnaphthalene, and selenium) indicated they may exceed the screening criteria in groundwater beneath their respective source areas. Alpha- and gamma-chlordane modeling results did not indicate breakthrough in groundwater beneath the source at concentrations above MCLs or RSLs until over 600 years in the future even under conservative model assumptions that assume no chemical degradation. These results indicate very high retardation in the soil matrices and it is likely these chemicals would degrade prior to mixing with groundwater.

The explosive compounds 2,6-DNT, 3-nitrotoluene, 4-amino-2,6-DNT, and PETN modeling results indicate concentrations in groundwater beneath the source areas would exceed MCLs or RSLs at about 15 years or less with peak concentrations occurring at approximate 25 years or less. Therefore, these chemicals should have already been detected in the existing groundwater. However, none of these explosive compounds have been detected in the AOC groundwater samples except 2,6-DNT which was detected only once, and at concentration much below its screening criterion. Therefore, it may be concluded that the model predicted concentrations are highly conservative and would potentially be below their screening levels had site-specific biodegradation rates been determined and used by the groundwater models (SESOIL and AT123D).

Naphthalene, 2-methylnaphthalene, dibenzofuran, phenantherene, and selenium modeling results indicate concentrations in groundwater beneath the source areas would exceed MCLs or RSLs at about 50 years or less with peak concentrations occurring at approximately 150 years or less.

Considering activities at Load Line 10 spanned 1941-1971, detectable concentrations of both chemicals near or above MCLs or RSLs are predicted by the models. However, the predicted concentrations are conservative based on current groundwater monitoring data for the AOC, in which none of these chemicals were detected. These data indicate retardation and degradation are higher than accounted for by the modeling results and potential impacts to groundwater are mitigated by these factors. Predictive modeling for final sediment CMCOPCs show peak concentrations in groundwater beneath the source would occur very quickly (< 20 years). Considering the timeline of Load Line 10 activities, peak concentrations likely occurred in the past and modeling results do not indicate potential future impacts.

None of the final soil CMCOPCs predicted to exceed screening criteria in groundwater beneath the sources were identified as COCs for soil in the HHRA (Section 7.0). Likewise, none of the sediment CMCOPCs modeled using AT123D were identified as COCs for sediment in the HHRA.

Based on review of the screening and modeling results, along with WOE factors noted above, none of the identified CMCOCs are impacting groundwater at Load Line 10 and do not warrant further evaluation of source removal in an FS.

6.6 SUMMARY AND CONCLUSIONS

Inorganic and organic SRCs exist in surface soil, subsurface soil, and sediment at Load Line 10. These SRCs were further evaluated to determine if residual concentrations in soil and sediment may potentially impact groundwater quality and warrant evaluation in an FS.

Evaluation of modeling results with respect to current AOC groundwater data and model limitations indicate identified soil SRCs are not currently impacting groundwater beneath the source areas and that predicted future impacts would be mitigated by factors such as chemical and biological degradation and lateral dispersivity. All SRCs identified in the surface soil and subsurface soil at Load Line 10 and evaluated through the stepwise fate and transport evaluation are eliminated as posing future impacts to groundwater.

A sediment screening analysis was performed for sediment samples at the AOC. An AOC-specific DAF was calculated using a co-located surface water and sediment concentrations for identified sediment SRCs. These DAFs were used in the sediment screening analysis to identify CMCOPCs for predictive modeling and further evaluation. Results for the sediment screening analysis and modeling eliminated all SRCs as posing future impacts to groundwater at Load Line 10.

Based on review of the screening and modeling results, along with WOE factors, none of the identified CMCOCs for soil or sediment are impacting groundwater at Load Line 10 and do not warrant further evaluation of source removal in a FS.

THIS PAGE INTENTIONALLY LEFT BLANK.

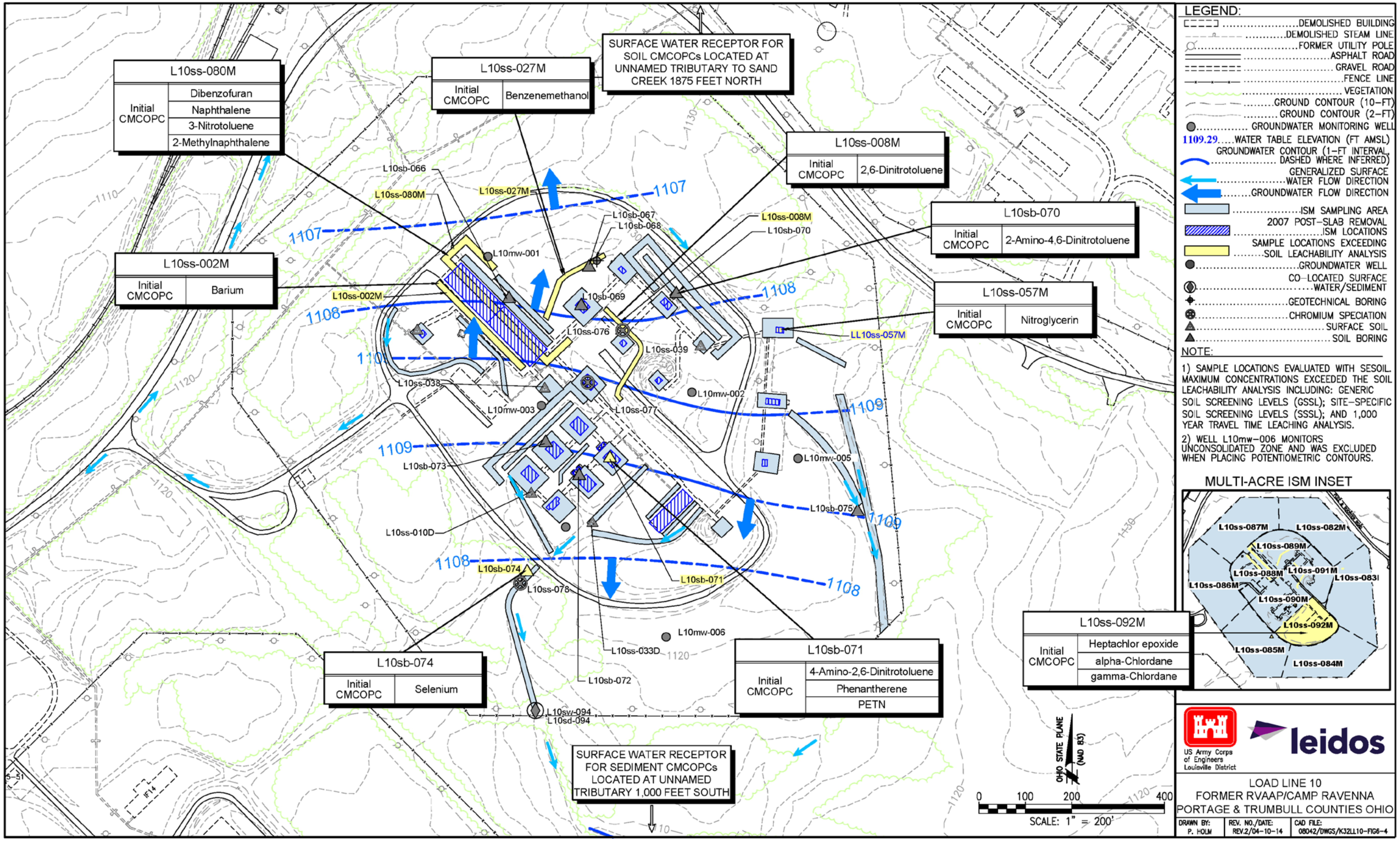
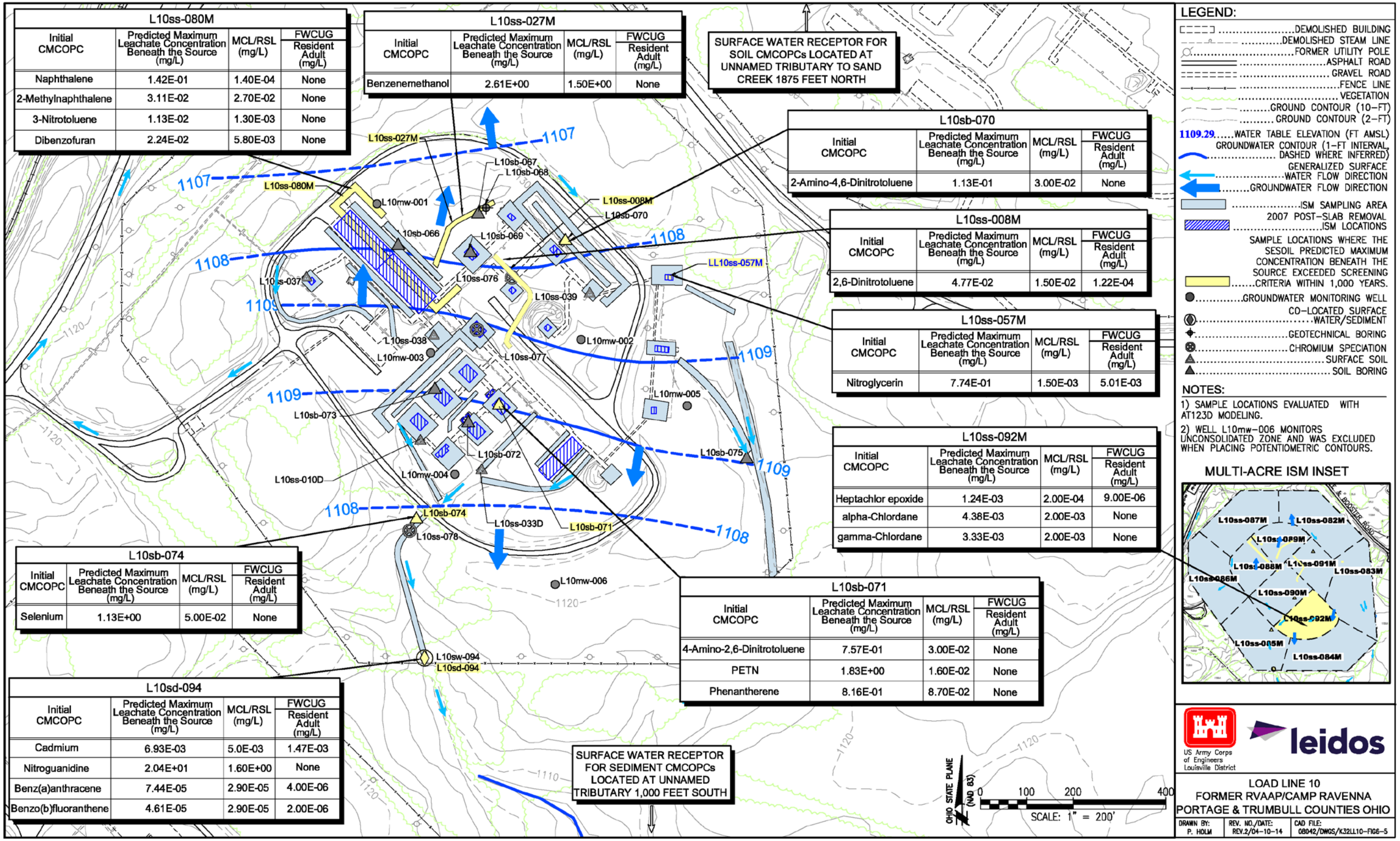


Figure 6-4. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation

THIS PAGE INTENTIONALLY LEFT BLANK



L10ss-080M

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Naphthalene	1.42E-01	1.40E-04	None
2-Methylnaphthalene	3.11E-02	2.70E-02	None
3-Nitrotoluene	1.13E-02	1.30E-03	None
Dibenzofuran	2.24E-02	5.80E-03	None

L10ss-027M

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Benzenemethanol	2.61E+00	1.50E+00	None

L10sb-070

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
2-Amino-4,6-Dinitrotoluene	1.13E-01	3.00E-02	None

L10ss-008M

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
2,6-Dinitrotoluene	4.77E-02	1.50E-02	1.22E-04

L10ss-057M

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Nitroglycerin	7.74E-01	1.50E-03	5.01E-03

L10ss-092M

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Heptachlor epoxide	1.24E-03	2.00E-04	9.00E-06
alpha-Chlordane	4.38E-03	2.00E-03	None
gamma-Chlordane	3.33E-03	2.00E-03	None

L10sb-074

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Selenium	1.13E+00	5.00E-02	None

L10sb-071

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
4-Amino-2,6-Dinitrotoluene	7.57E-01	3.00E-02	None
PETN	1.83E+00	1.60E-02	None
Phenantherene	8.16E-01	8.70E-02	None

L10sd-094

Initial CMCOPC	Predicted Maximum Leachate Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG
			Resident Adult (mg/L)
Cadmium	6.93E-03	5.0E-03	1.47E-03
Nitroguanidine	2.04E+01	1.60E+00	None
Benz(a)anthracene	7.44E-05	2.90E-05	4.00E-06
Benzo(b)fluoranthene	4.61E-05	2.90E-05	2.00E-06

NOTES:

1) SAMPLE LOCATIONS EVALUATED WITH AT123D MODELING.

2) WELL L10mw–006 MONITORS UNCONSOLIDATED ZONE AND WAS EXCLUDED WHEN PLACING POTENTIOMETRIC CONTOURS.

LOAD LINE 10
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV.2/04–10–14	08042/DWGS/K32LL10–FIG6–5

Figure 6-5. CMCOPCs Identified in SESOIL and Sediment Screening Analysis for AT123D Evaluation

THIS PAGE INTENTIONALLY LEFT BLANK.

7.0 RISK ASSESSMENT

7.1 DATA EVALUATION FOR HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The purpose of this data evaluation is to develop a set of chemical data suitable to use in the HHRA and ERA. Load Line 10 data are evaluated to establish data aggregates and identify a list of SRCs.

7.1.1 Data Aggregates

Section 5.1 provides a summary of available data. Soil data collected at Load Line 10 were grouped (aggregated) by exposure depth (e.g., surface soil), exposure unit (EU), and sample type (i.e., discrete or ISM). Samples included in the risk assessment data sets for soil are listed in Tables 7-1 and 7-2. Samples included in the risk assessment data sets for sediment and surface water are listed in Table 7-3. A description of the data aggregates for the media for which human and ecological receptors are potentially exposed is provided in Section 7.1.1, followed by a summary of SRCs in Section 7.1.2.

7.1.1.1 Soil Data

EUs were established at Load Line 10 as part of the data aggregation prior to the risk assessment evaluations. An EU is an area where receptors could come into contact with contaminants in soil on a regular basis. The EUs take into account the potential current and future exposures at Load Line 10. In the establishment of EUs at Load Line 10, the area within the perimeter road is assumed to have the maximum exposure for future receptors; therefore, that area was identified as a separate EU [Former production area (FPA)] from the rest of the AOC. In addition, the potential source of contamination was considered when establishing the EUs.

Soil at Load Line 10 is evaluated in the following two EUs, as shown in Figure 7-1.

- FPA EU: the area inside the perimeter road and all former buildings and operational areas.
- Non-production area (NPA) EU: the area outside the production area to the fence line.

Soil data in each of these EUs were further aggregated by the following depth intervals:

- Surface soil with an exposure depth of 0-1 ft bgs was evaluated for the Resident Receptor (Adult and Child) and potential risk to ecological receptors, as this layer is the most active biological zone (USACE 2003c). Table 7-1 presents the risk assessment data for surface soil (0-1 ft bgs) data. For this risk assessment, 73 surface soil (0-1 ft bgs) ISM samples were used to characterize surface soil. The evaluation of VOCs and hexavalent chromium speciation were done using results from discrete soil samples. All other discrete surface soil samples collected in 2010 were used to characterize the nature and extent of contamination but were not used for screening purposes since ISM and discrete data should not be combined into a single statistical analysis.

- Subsurface soil with an exposure depth of 1-13 ft bgs was evaluated for the Resident Receptor (Adult and Child). Discrete soil data were used to evaluate this exposure depth. Table 7-2 presents the risk assessment date for subsurface soil (1-13 ft bgs).

Table 7-1. Risk Assessment Data Set for Surface Soil

Station	Sample ID	Date	Depth (ft bgs)	Size of ISM Area (acres)
NPA Grid Samples				
L10ss-082M	L10ss-082M-5539-SO	4/13/2010	0 - 1	4.2
L10ss-083M	L10ss-083M-5540-SO	4/13/2010	0 - 1	4.3
L10ss-084M	L10ss-084M-5541-SO	4/13/2010	0 - 1	4.0
L10ss-085M	L10ss-085M-5542-SO	4/13/2010	0 - 1	3.8
L10ss-086M	L10ss-086M-5543-SO	4/13/2010	0 - 1	4.1
L10ss-087M	L10ss-087M-5544-SO	4/13/2010	0 - 1	4.0
FPA Grid Samples				
L10ss-088M	L10ss-088M-5545-SO	4/13/2010	0 - 1	1.9
L10ss-089M	L10ss-089M-5546-SO	4/13/2010	0 - 1	2.1
L10ss-090M	L10ss-090M-5547-SO	4/13/2010	0 - 1	2.6
L10ss-091M	L10ss-091M-5548-SO	4/13/2010	0 - 1	2.1
L10ss-092M	L10ss-092M-5549-SO	4/13/2010	0 - 1	2.6
NPA Source Area Samples				
L10ss-021D[a]	L10ss-021D-SO	11/18/2004	0 – 1	NA
L10ss-021M	L10ss-021M-SO	11/18/2004	0 – 1	0.05
L10ss-022M	L10ss-022M-SO	11/18/2004	0 – 1	0.04
L10ss-023M	L10ss-023M-SO	11/18/2004	0 – 1	0.06
L10ss-035M	L10ss-035M-SO	11/18/2004	0 - 1	0.03
L10ss-036M	L10ss-036M-SO	11/17/2004	0 - 1	0.08
L10ss-040M	L10ss-040M-SO	11/19/2004	0 - 1	0.04
L10ss-078[b]	L10ss-078-5534-SO	4/12/2010	0 - 1	NA
FPA Source Area Samples				
L10ss-001M	L10ss-001M-SO	11/16/2004	0 – 1	0.03
L10ss-002M	L10ss-002M-SO	11/16/2004	0 – 1	0.08
L10ss-003M	L10ss-003M-SO	11/16/2004	0 – 1	0.1
L10ss-004M	L10ss-004M-SO	11/17/2004	0 – 1	0.08
L10ss-005M	L10ss-005M-SO	11/17/2004	0 – 1	0.05
L10ss-006M	L10ss-006M-SO	11/17/2004	0 – 1	0.04
L10ss-007M	L10ss-007M-SO	11/17/2004	0 – 1	0.07
L10ss-008M	L10ss-008M-SO	11/17/2004	0 – 1	0.06
L10ss-009M	L10ss-009M-SO	11/17/2004	0 – 1	0.04
L10ss-010D[a]	L10ss-010D-SO	11/16/2004	0 – 1	NA
L10ss-010M	L10ss-010M-SO	11/16/2004	0 – 1	0.09
L10ss-011M	L10ss-011M-SO	11/16/2004	0 – 1	0.09
L10ss-012M	L10ss-012M-SO	11/17/2004	0 – 1	0.07
L10ss-013M	L10ss-013M-SO	11/16/2004	0 – 1	0.06

Table 7-1. Risk Assessment Data Set for Surface Soil (continued)

Station	Sample ID	Date	Depth (ft bgs)	Size of ISM Area (acres)
L10ss-014M	L10ss-014M-SO	11/16/2004	0 – 1	0.06
L10ss-015M	L10ss-015M-SO	11/17/2004	0 – 1	0.06
L10ss-016M	L10ss-016M-SO	11/17/2004	0 – 1	0.02
L10ss-017M	L10ss-017M-SO	11/17/2004	0 – 1	0.03
L10ss-018M	L10ss-018M-SO	11/17/2004	0 – 1	0.02
L10ss-019M	L10ss-019M-SO	11/17/2004	0 – 1	0.02
L10ss-020M	L10ss-020M-SO	11/17/2004	0 – 1	0.02
L10ss-024M	L10ss-024M-SO	11/17/2004	0 – 1	0.08
L10ss-025M	L10ss-025M-SO	11/16/2004	0 – 1	0.05
L10ss-026M	L10ss-026M-SO	11/16/2004	0 – 1	0.05
L10ss-027D[a]	L10ss-027D-SO	11/19/2004	0 – 1	NA
L10ss-027M	L10ss-027M-SO	11/19/2004	0 – 1	0.05
L10ss-028M	L10ss-028M-SO	11/18/2004	0 – 1	0.06
L10ss-029M	L10ss-029M-SO	11/17/2004	0 – 1	0.03
L10ss-030M	L10ss-030M-SO	11/16/2004	0 – 1	0.05
L10ss-031M	L10ss-031M-SO	11/16/2004	0 – 1	0.04
L10ss-032M	L10ss-032M-SO	11/18/2004	0 – 1	0.02
L10ss-033D[a]	L10ss-033D-SO	11/18/2004	0 - 1	NA
L10ss-033M	L10ss-033M-SO	11/18/2004	0 - 1	0.04
L10ss-034M	L10ss-034M-SO	11/17/2004	0 - 1	0.07
L10ss-037[a]	L10ss-037-SO	11/19/2004	0 - 1	NA
L10ss-038[a]	L10ss-038-SO	11/19/2004	0 - 1	NA
L10ss-039[a]	L10ss-039-SO	11/19/2004	0 - 1	NA
L10ss-040MU	L10ss-040MU-SO	8/9/2007	0 - 1	0.2
L10ss-041M	L10ss-041M-SO	8/9/2007	0 - 1	0.2
L10ss-042M	L10ss-042M-SO	8/8/2007	0 - 1	0.02
L10ss-043M	L10ss-043M-SO	8/8/2007	0 - 1	0.02
L10ss-044M	L10ss-044M-SO	8/8/2007	0 - 1	0.02
L10ss-045M	L10ss-045M-SO	8/8/2007	0 - 1	0.02
L10ss-046M	L10ss-046M-SO	8/8/2007	0 - 1	0.02
L10ss-047M	L10ss-047M-SO	8/9/2007	0 - 1	0.009
L10ss-048M	L10ss-048M-SO	8/8/2007	0 - 1	0.07
L10ss-049M	L10ss-049M-SO	8/8/2007	0 - 1	0.004
L10ss-050M	L10ss-050M-SO	8/9/2007	0 - 1	0.003
L10ss-051M	L10ss-051M-SO	8/9/2007	0 - 1	0.01
L10ss-052M	L10ss-052M-SO	8/9/2007	0 - 1	0.003
L10ss-053M	L10ss-053M-SO	8/9/2007	0 - 1	0.003
L10ss-054M	L10ss-054M-SO	8/9/2007	0 - 1	0.003
L10ss-055M	L10ss-055M-SO	8/9/2007	0 - 1	0.004
L10ss-056D[a]	L10ss-061D-SO	8/9/2007	0 - 1	NA
L10ss-056M	L10ss-056M-SO	8/9/2007	0 - 1	0.004
L10ss-057M	L10ss-057M-SO	8/8/2007	0 - 1	0.005

Table 7-1. Risk Assessment Data Set for Surface Soil (continued)

Station	Sample ID	Date	Depth (ft bgs)	Size of ISM Area (acres)
L10ss-058M	L10ss-058M-SO	8/8/2007	0 - 1	0.009
L10ss-059M	L10ss-059M-SO	8/8/2007	0 - 1	0.004
L10ss-060D[a]	L10ss-060D-SO	8/9/2007	0 - 1	NA
L10ss-060M	L10ss-060M-SO	8/8/2007	0 - 1	0.01
L10ss-076[b]	L10ss-076-5532-SO	4/12/2010	0 - 1	NA
L10ss-077[b]	L10ss-077-5533-SO	4/12/2010	0 - 1	NA
L10ss-079M	L10ss-079M-5536-SO	4/13/2010	0 - 1	0.12
L10ss-080M	L10ss-080M-5537-SO	4/13/2010	0 - 1	0.2
L10ss-081M	L10ss-081M-5538-SO	4/13/2010	0 - 1	0.2
L10ss-093M	L10ss-093M-5550-SO	4/13/2010	0 - 1	0.2

[a] Discrete sample taken in ISM areas for the determination of volatile organic compounds.
[b] Chromium speciation samples used to evaluate the presence of hexavalent chromium. L10ss-076 collected at ISM area L10ss-008M; L10ss-077 collected at ISM area L10ss-007M; L10ss-078 collected at ISM area L10ss-040M.
bgs = Below ground surface.
FPA = Former production area.
ISM = Incremental Sampling Method.
NA = Not applicable.
NPA = Non-production area.

Table 7-2. Risk Assessment Data Sets for Subsurface Soil

Station	Sample ID	Date	Depth (ft bgs)
NPA Subsurface Soil Samples			
L10sb-074	L10sb-074-5524-SO	3/16/2010	1 - 4
L10sb-075	L10sb-075-5528-SO	3/17/2010	1 - 4
L10sb-074	L10sb-074-5525-SO	3/16/2010	4 - 7
L10sb-075	L10sb-075-5529-SO	3/17/2010	4 - 7
FPA Subsurface Soil Samples			
L10sb-066	L10sb-066-5494-SO	3/16/2010	1 - 4
L10sb-067	L10sb-067-5498-SO	3/17/2010	1 - 4
L10sb-069	L10sb-069-5504-SO	3/16/2010	1 - 4
L10sb-070	L10sb-070-5508-SO	3/16/2010	1 - 4
L10sb-071	L10sb-071-5512-SO	3/16/2010	1 - 4
L10sb-072	L10sb-072-5516-SO	3/16/2010	1 - 4
L10sb-073	L10sb-073-5520-SO	3/16/2010	1 - 4
L10sb-066	L10sb-066-5495-SO	3/16/2010	4 - 7
L10sb-067	L10sb-067-5499-SO	3/17/2010	4 - 7
L10sb-069	L10sb-069-5505-SO	3/16/2010	4 - 7
L10sb-070	L10sb-070-5509-SO	3/16/2010	4 - 7
L10sb-071	L10sb-071-5513-SO	3/16/2010	4 - 6.5
L10sb-072	L10sb-072-5517-SO	3/16/2010	4 - 7
L10sb-073	L10sb-073-5521-SO	3/16/2010	4 - 7
L10sb-066	L10sb-066-5496-SO	3/16/2010	7 - 12
L10sb-070	L10sb-070-5510-SO	3/16/2010	7 - 13

bgs = Below ground surface.
FPA = Former production area.
NPA = Non-production area.

7.1.1.2 Surface Water and Sediment Data

Per the PBA08 SAP, one surface water and one co-located sediment sample were collected in the main ditch that drains to southwest of the AOC. These samples were included to assess a potential exit pathway from the AOC. The sediment and surface water samples included in the risk assessment data set are listed in Table 7-3.

Table 7-3. Risk Assessment Data Sets for Surface Water and Sediment

Station	Sample ID	Date
Surface Water		
L10sw-094	L10sw-094-5535-SW	3/9/2010
Sediment		
L10sd-094	L10sd-094-5531-SD	02/18/2010

7.1.2 Identification of SRCs

Section 5.1 presents the statistical methods and screening criteria used to identify SRCs. The purpose of identifying SRCs is to determine the presence or absence of contamination that is above naturally occurring levels.

The SRC screen followed the three steps outlined in the FWCUG Report, as summarized below:

- Background screening: MDCs of naturally occurring inorganic chemicals were compared to the facility-wide background concentrations for RVAAP, which are summarized in the FWCUG Report. Inorganic chemicals detected above BSVs or having no BSVs were retained as SRCs. All detected organic chemicals were retained as SRCs.
- Screening of essential human nutrients: Chemicals considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. USEPA recommends these chemicals not be evaluated so long as they are: (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the AOC) (USEPA 1989). Essential nutrients detected near or below their RDA/RDI-based screening levels were eliminated as SRCs.
- Frequency of detection screening: In accordance with the FWCUG Report and as revised in the Final (Revised) United States Army Corps of Engineers RVAAP Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals (USACE 2012b) (hereafter referred to as the Position Paper for Human Health CUGs), analytes detected in less than 5% of the samples are screened out from further consideration, with the exception of explosives and propellants. At Load Line 10, 20 discrete subsurface samples (1-13 ft bgs) were available for frequency of detection screening; however, no SRCs were screened out on this basis. The frequency of detection screening was not applied to ISM samples.

Details of the SRC screening for each exposure medium are provided in Tables G-1 through G-4 of Appendix G. The SRCs identified for Load Line 10 are summarized in Table 7-4.

Table 7-4. Summary of SRCs

SRC	**Soil**		**Sediment**	**Surface Water**
	Surface Soil (0-1 ft bgs)	**Subsurface Soil (1-13 ft bgs)**		
Inorganic chemicals				
Aluminum	X	--	--	--
Antimony	X	X	X	X
Arsenic	X	--	--	--
Barium	X	X	--	--
Beryllium	X	X	X	--
Cadmium	X	X	X	--
Chromium	X	--	--	X
Cobalt	X	--	--	X
Copper	X	--	--	--
Cyanide	X	--	--	--
Lead	X	X	--	X
Mercury	X	--	--	--
Nickel	X	--	--	X
Selenium	X	X	--	--
Silver	X	X	--	--
Thallium	X	--	--	--
Vanadium	--	--	--	X
Zinc	X	X	--	--
Explosives				
2,6-Dinitrotoluene	X	--	--	--
1,3,5-Trinitrobenzene	--	X	--	--
3-Nitrotoluene	X	--	--	--
2-Amino-4,6-Dinitrotoluene	--	X	--	--
4-Amino-2,6-Dinitrotoluene	--	X	--	--
Nitrocellulose	X	--	--	--
Nitroglycerin	X	--	--	--
Nitroguanidine	--	--	X	--
PETN	--	X	--	--
Tetryl	X	--	--	--
Semi-volatile Organic Compounds				
2-Methylnaphthalene	X	--	--	--
3+4-Methylphenol	--	--	X	--
Acenaphthene	X	X	--	--
Acenaphthylene	X	--	--	--
Anthracene	X	X	--	--
Benz(a)anthracene	X	X	X	--
Benzenemethanol	X	--	--	--
Benzo(a)pyrene	X	X	X	--

Table 7-4. Summary of SRCs (continued)

SRC	Soil		Sediment	Surface Water
	Surface Soil (0-1 ft bgs)	Subsurface Soil (1-13 ft bgs)		
Benzo(b)fluoranthene	X	X	X	--
Benzo(g,h,i)perylene	X	X	--	--
Benzo(k)fluoranthene	X	X	--	--
Bis(2-ethylhexyl)phthalate	--	X	--	--
Carbazole	X	X	--	--
Chrysene	X	X	X	--
Di-n-butyl phthalate	X	X	--	--
Dibenz(a,h)anthracene	X	X	--	--
Dibenzofuran	X	X	--	--
Diethyl phthalate	X	--	--	--
Fluoranthene	X	X	X	--
Fluorene	X	X	--	--
Indeno(1,2,3-cd)pyrene	X	X	--	--
Naphthalene	X	X	--	--
Phenanthrene	X	X	--	--
Phenol	X	--	--	--
Pyrene	X	X	X	--
Pesticides/PCBs				
beta-BHC	--	--	--	X
Heptachlor epoxide	X	--	--	--
PCB-1254	X	--	--	--
alpha-Chlordane	X	--	--	--
gamma-Chlordane	X	--	--	--
Volatile Organic Compounds				
2-Butanone	--	X	--	--
Acetone	X	--	--	--
Bromomethane	--	X	--	--
Carbon disulfide	X	--	--	--
Methylene chloride	X	--	--	--
Toluene	--	--	X	--

bgs = Below ground surface.
BHC = Benzene hexachloride.
PCB = Polychlorinated Biphenyl.
PETN = Pentaerythritol Tetranitrate.
SRC = Site-related Contaminant.
X = Chemical is an SRC in this medium.
-- = Chemical is not an SRC in this medium.

7.2 HUMAN HEALTH RISK ASSESSMENT

This HHRA identifies COCs that may pose potential health risks to humans resulting from exposure to contamination at Load Line 10. This HHRA was conducted as part of the PBA08 RI and is based on methods from the following guidance documents:

- FWHHRAM (USACE 2005b),
- FWCUG Report (USACE 2010a),
- Position Paper for Human Health CUGs (USACE 2012b), and
- Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the RVAAP Installation Restoration Program (ARNG 2014) (hereafter referred to at the Technical Memorandum).

To accomplish the goal of streamlined, risk-based decision making, the FWCUG Report was developed to support risk assessments of the remaining AOCs that will undergo final transfer of the land for use and management by OHARNG. The FWCUG Report contains calculated FWCUGs and guidance for applying the FWCUGs to accelerate the risk assessment process. This approach takes advantage of the many risk assessment inputs and decisions that have previously been accepted by stakeholders through the application of the CERCLA process at the former RVAAP.

Most of the agreed upon risk assessment methodology has been documented in the FWHHRAM (USACE 2005b) and follows standard USEPA-approved risk assessment guidance. This includes the process to identify RVAAP COPCs (presented in Figure 5-1), a TR of 1E-06 and HQ of 0.1 to identify COPCs, and a TR of 1E-05 and HQ of 1.0 to identify COCs.

Other approaches, such as calculating the sum-of-ratios (SOR), were developed in the FWCUG Report (USACE 2010a) and Position Paper for Human Health CUGs (USACE 2012b). The Technical Memorandum (ARNG 2014) amends the risk assessment process to establish future Land Uses and applicable receptors to be evaluated in an RI.

The approach to risk-based decision making is as follows:

1. ***Develop FWCUGs* -** Use the risk assessment process presented in the FWHHRAM to develop FWCUGs for all COPCs identified from the facility-wide data set at RVAAP. This process has been completed in the FWCUG Report.
2. ***RI Characterization Sampling* -** Perform sampling and analysis to characterize an AOC and establish baseline chemical concentrations. A summary and the results of the RI characterization sampling for Load Line 10 are presented in Section 4.0 of this report.
3. ***Mapping and Data Analysis to Identify SRCs and COPCs* -** Follow the requirements specified in the FWHHRAM and the Position Paper for Human Health CUGs (USACE 2012b), perform data analysis and mapping to identify SRCs and COPCs, establish EUs, and calculate exposure point concentrations (EPCs) for each COPC. The results of the

mapping and data analysis for Load Line 10 to identify SRCs are presented in Section 5.0 of this report and are summarized in Section 7.1

4. ***Identification of COCs*** **-** Compare EPCs to FWCUGs to determine COCs.
5. ***Address Identified COCs*** **-** Develop FS, PP, and ROD to address any COCs requiring remedy.

Identifying COPCs and COCs follows the four steps for a streamlined risk assessment, established in the FWCUG Report and shown in Figure 1-3: identify media of concern, identify COPCs, present AOC Land Use and appropriate receptors, and compare to appropriate FWCUGs to identify COCs. These steps are discussed in the following subsections.

7.2.1 Identify Media of Concern

Media of concern at Load Line 10 are surface soil, subsurface soil, sediment, and surface water. Groundwater is present at this AOC and will be evaluated (including a risk assessment) in a separate document, as explained in Section 1.2.

7.2.2 Identify COPCs

Section 5.1 presents the statistical methods and screening criteria used to identify SRCs. COPCs are a subset of the SRCs in each exposure medium present at concentrations that indicate the potential for impacts to human receptors. The COPC screen follows the approach specified in the FWCUG Report and is summarized in this section.

To identify COPCs, the MDC of all SRCs was screened against the most stringent chemical-specific FWCUG of all RVAAP receptors at a target cancer risk level of 1E-06 and non-carcinogenic target HQ of 0.1 for the Resident Adult and Child, and National Guard Trainee. If no FWCUGs existed for an SRC, the USEPA Residential RSL (from RSL table dated November 2012) was used for this screen. No reference dose (RfD) or cancer potency factors are available for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene; therefore, the RSL for pyrene was used for these PAHs (NDEP 2006).

Hexavalent chromium was detected in two of three discrete surface soil samples collected at Load Line 10 for chromium speciation. Since hexavalent chromium was detected, as part of the conservative screening approach for identifying COPCs, the FWCUG for hexavalent chromium (the more toxic of the two chromium species evaluated) was used at this stage.

Details of the COPC screenings for each exposure medium are provided in Tables G-1 through G-4 of Appendix G. The COPCs identified for the media of concern at Load Line 10 are presented in Table 7-5 and are summarized below.

7.2.2.1 COPCs in Surface Soil

A total of 59 chemicals were detected in surface soil ISM samples, 52 of these chemicals (17 inorganic chemicals, five explosives, 23 SVOCs, four pesticides/PCBs, and three VOCs) were identified as SRCs. Risk-based screening identified five inorganic chemicals (aluminum, arsenic, chromium, cobalt, and lead) and five SVOCs [benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene] as COPCs in surface soil.

At Load Line 10, chromium was identified as an SRC in surface soil ISM samples. The MDC of total chromium in surface soil ISM samples was 33 mg/kg, which is greater than the lowest screening value for hexavalent chromium (1.64 mg/kg) and greater than the total chromium background concentrations for surface soil (17.4 mg/kg). Therefore, total chromium was retained as a COPC for surface soil.

7.2.2.2 COPCs in Subsurface Soil

A total of 48 chemicals were detected in discrete subsurface soil samples collected from the 1-13 ft bgs exposure depth. A total of 33 of these chemicals (eight inorganic chemicals, four explosives, 19 SVOCs, and two VOCs) were identified as SRCs. Risk-based screening identified one inorganic chemical (antimony) and six SVOCs [benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene] as COPCs for subsurface soil.

7.2.2.3 COPCs in Sediment

A total of 31 chemicals were detected in sediment, 12 of these chemicals (three inorganic chemicals, one explosive, seven SVOCs, and one VOC) were identified as SRCs. Risk-based screening identified no COPCs in sediment.

7.2.2.4 COPCs in Surface Water

A total of 17 chemicals were detected in the surface water sample, and seven of these chemicals (six inorganic chemicals and one pesticide/PCB) were identified as SRCs. Risk-based screening identified no COPCs in surface water.

Table 7-5. Summary of COPCs

COPC	Soil Surface soil (0-1 ft bgs)	Soil Subsurface Soil (1-13 ft bgs)	Sediment	Surface Water
Inorganic chemicals				
Aluminum	X	--	--	--
Antimony	--	X	--	--
Arsenic	X	--	--	--
Chromium	X[a]	--	--	--
Cobalt	X	--	--	--
Lead	X	--	--	--
Semi-volatile Organic Compounds				
Benz(a)anthracene	X	X	--	--
Benzo(a)pyrene	X	X	--	--
Benzo(b)fluoranthene	X	X	--	--
Benzo(k)fluoranthene	--	X	--	--
Dibenz(a,h)anthracene	X	X	--	--
Indeno(1,2,3-cd)pyrene	X	X	--	--

[a] The maximum detected concentration exceeded the screening FWCUG for hexavalent chromium but is less than the FWCUG for trivalent chromium.

bgs = Below ground surface.
COPC = Chemical of Potential Concern
X = Chemical identified as a COPC in this medium.
-- = Chemical not identified as a COPC in this medium.

7.2.3 Land Use and Representative Receptors

Camp Ravenna is a controlled access facility. Load Line 10 is located in the south-central portion of the facility and is not currently used for training.

Three Land Uses for the RVAAP restoration program are specified in the Technical Memorandum (ARNG 2014) for consideration in the RI along with the following Representative Receptors:

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child)
2. Military Training Land Use – National Guard Trainee
3. Commercial/Industrial Land Use – Industrial Receptor (USEPA's Composite Worker)

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and

Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of the Commercial/Industrial Land Use as an Alternative, if it achieves NFA for Unrestricted (Residential) Land Use.

7.2.4 Compare to Appropriate FWCUGs

Previous sections have outlined the process for identifying SRCs and COPCs. Comparing COPC exposure concentrations to FWCUGs and determining COCs follows guidance presented in the Position Paper for Human Health CUGs (USACE 2012b) and Technical Memorandum (ARNG 2014).

The COC determination process is as follows:

- Report all carcinogenic and non-carcinogenic based FWCUGs corresponding to a TR of 1E-05 and target HQ of 1.0 using the most stringent of the Resident Receptor FWCUGs Adult and Resident Receptor Child to evaluate Unrestricted (Residential) Land Use for each COPC. If no FWCUG is available for a COPC, the Residential RSL, adjusted to represent a TR of 1E-05 or target HQ of 1.0, is used.
- Report critical effect and target organ for each non-carcinogenic based FWCUG.
- Compare the selected FWCUG to the EPC, including an SOR.
    - For non-carcinogens, compare the EPC to the target HQ FWCUG. Sum the ratios of EPC/FWCUG for COPCs that affect similar target organs or do not have an identified target organ.
    - For carcinogens, compare the EPC to the TR FWCUG. Sum the ratios of EPC/FWCUG for all carcinogens.
- Identify the COPC as a COC if:
    - The EPC exceeds the most stringent of the Resident Receptor Adult and Resident Receptor Child FWCUGs for either the 1E-05 target cancer risk or the 1.0 target HQ; or
    - The SOR for all carcinogens or all non-carcinogens that may affect the same organ is greater than one. Chemicals contributing at least 10% to the SOR are also considered COCs. In accordance with the Position Paper for Human Health CUGs (USACE 2012b), chemicals contributing greater than 5% but less than 10% to the SOR must be further evaluated before being eliminated as COCs.

The process for calculating FWCUGs rearranges cancer risk or non-cancer hazard equations in order to obtain a concentration that will produce a specific risk or hazard level (USEPA 1991, USACE 2010a). For example, the FWCUG for arsenic at the cancer risk level of 1E-05 for the Resident Receptor Adult is the concentration of arsenic that produces a risk of 1E-05 when using exposure parameters specific to the Resident Receptor Adult.

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the increased chance of cancer above the normal background rate. In the United States, the background chance of contracting cancer is a little more than 3 in 10, or 3E-01 (American Cancer Society 2003). The calculated incremental lifetime cancer risks (ILCRs) are compared to the range specified in the NCP of 10^{-6} to 10^{-4}, or 1 in a million to 1 in 10,000 exposed persons developing cancer (USEPA 1990). Cancer risks below 10^{-6} are considered acceptable; cancer risks above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address risks further in this range, either through additional study or engineered control measures, should account for uncertainty in risk estimates. The Ohio EPA Division of Environmental Response and Revitalization (DERR) program has adopted a human health cumulative ILCR goal within this range of 1E-05 to be used as the level of acceptable excess cancer risk and for developing remediation goals for the site. The DERR notes that the defined risk goal should be applied as a goal, recognizing the need to retain flexibility during the evaluation and selection of remedial alternatives.

In addition to developing cancer from exposure to chemicals, an individual may experience other adverse effects. The term “adverse effects” is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects, such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e., non-carcinogenic) chemicals are evaluated by comparing an estimated exposure (i.e., intake or dose) from AOC media to an acceptable exposure expressed as an RfD. The RfD is the threshold level below which no adverse effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the HQ (USEPA 1989).

The SOR is used to account for the potential additive effects from exposure to multiple chemicals that can cause the same effect (e.g., cancer) or affect the same target organ. Cancer risk is assumed to be additive for all carcinogens. Non-cancer risk is assumed to be additive for chemicals with similar sites of toxicological action (i.e., target organ such as liver or critical effect such as adversely affecting the ability to reproduce). This approach compares the EPC of each COPC to the FWCUG to determine a ratio. The sum of these individual ratios is then compared to one. The SOR method is based on the principle that a ratio greater than one represents unacceptable cumulative exposure (i.e., above FWCUGs if adjusted for exposure to multiple COPCs), and a ratio less than or equal to one represents acceptable cumulative exposure (i.e., below FWCUGs if adjusted for exposure to multiple COPCs). The FWCUGs for some chemical/receptor combinations are less than the background concentration. In these instances, the chemical concentrations are compared to background concentrations to identify COCs. Since the background concentration is not risk-based, these chemicals are not included in the SOR calculations.

COCs identified by comparing EPCs to FWCUGs are further evaluated in an uncertainty analysis to identify COCs requiring evaluation in the FS. The selection of FWCUGs, calculation of EPCs for comparison to the FWCUGs, and the resulting risk-based COCs are detailed in the following sections.

7.2.4.1 Selection of Appropriate FWCUGs

As specified in the Technical Memorandum (ARNG 2014), EPCs for each AOC should initially be evaluated using the most stringent of the Resident Receptor Adult and Resident Receptor Child FWCUGs to determine if NFA is necessary at an AOC to attain Unrestricted (Residential) Land Use. If this assessment indicates COCs exist that prevent Unrestricted (Residential) Land Use, an FS must be completed to evaluate cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use].

Unrestricted (Residential) Land Use is evaluated using FWCUGs for the Resident Receptor (Adult and Child). The Resident Receptor (Adult and Child) FWCUGs provided in Table 7-6 are the lower of the Resident Receptor Adult or Resident Receptor Child values for each COPC and endpoint (non-cancer and cancer). The critical effects or target organs associated with the toxicity values used to calculate the non-cancer FWCUGs are also provided.

Table 7-6. FWCUGs Corresponding to an HQ of 1.0 and Target Risk of 1E-05 in Soil

COPC	Critical Effect or Target Organ	FWCUG (mg/kg)	
		Resident Receptor[a]	
		HQ=1.0	TR=1E-05
Aluminum	Neurotoxicity in offspring	73,798	--
Antimony	Blood glucose, cholesterol	28.2	--
Arsenic	Skin	20.2	4.25[b]
Chromium, hexavalent	Stomach, liver/kidney	199	1874[c]
Chromium, trivalent	NOAEL	81,473	--
Cobalt	Thyroid	1313	8030
Lead	--	400[d]	
Benz(a)anthracene	NA	--	2.21
Benzo(a)pyrene	NA	--	0.221
Benzo(b)fluoranthene	NA	--	2.21
Benzo(k)fluoranthene	NA	--	22.1
Dibenz(a,h)anthracene	NA	--	0.221
Indeno(1,2,3-cd)pyrene	NA	--	2.21

[a] Resident Receptor FWCUGs are the smaller of the Resident Receptor Adult or Resident Receptor Child values for each COPC and endpoint (non-cancer and cancer).

[b] FWCUG value is less than the background screening values for arsenic in surface soil (15.4 mg/kg) and subsurface soil (19.8 mg/kg).

[c] FWCUG for hexavalent chromium was calculated using a cancer unit risk factor developed for a chromate mixture consisting of 1/7 hexavalent chromium and 6/7 trivalent chromium.

[d] No FWCUG is available for lead; the Residential Regional Screening Level (RSL) is used. No endpoint is specified for this screening level.

COPC = Chemical of Potential Concern.
FWCUG = Facility-wide Cleanup Goal.
HQ = Hazard Quotient.
mg/kg = Milligram per kilogram.
NA = Not applicable.
NOAEL = No Observable Adverse Effect Level.
TR = Target Risk.
-- = No value available.

Chromium Speciation

FWCUGs are available for hexavalent chromium and trivalent chromium. Existing data at other AOCs, such the Building 1200 and Anchor Test Area AOCs (USACE 2012c, USACE 2012d), indicates chromium exists predominantly in the trivalent state, rather than the more toxic hexavalent state. The Implementation of the Chromium Speciation process per the PBA08 SAP is discussed below.

- **Hexavalent chromium and total chromium sample collection and results -** To determine whether the FWCUGs for trivalent or hexavalent chromium are most applicable to Load Line 10 and to support risk management decisions, three discrete surface soil samples were collected and analyzed for hexavalent chromium and total chromium per the PBA08 SAP and as described in Sections 4.1.1 and 5.1.2. Two samples were collected from areas previously identified as having elevated total chromium concentrations, and one was collected from an area identified as having chromium concentrations near background concentrations. Hexavalent chromium was detected in two of the three samples at 1.2 mg/kg and an estimated (i.e., less than the laboratory reporting limit) concentration of 0.69J mg/kg.
- **Percent hexavalent chromium in chromium speciation samples –** As documented in the PBA08 SAP, "Chromium speciation evaluates the concentration ratio of hexavalent chromium to total chromium. This ratio will be calculated by collecting and analyzing three samples per AOC for both hexavalent chromium and total chromium." Hexavalent chromium was not detected in one of the three chromium speciation samples collected at Load Line 10. The other two samples contained 4.7% and 8.1% hexavalent chromium. The FWCUG for hexavalent chromium is based on a cancer unit risk factor (URF) calculated using a chromium mixture containing 14% hexavalent chromium and 86% trivalent chromium. These sample results are below the 14% hexavalent chromium used as the basis for the cancer URF, which was used to calculate the hexavalent chromium FWCUGs.
- **Comparison of the concentration of hexavalent chromium detected in the chromium speciation samples to a FWCUG adjusted to represent only hexavalent chromium -** The most protective FWCUG for hexavalent chromium is for the National Guard Trainee (16.4 mg/kg) and was calculated from a cancer URF based on a chromium mixture containing one-seventh (14%) hexavalent chromium (USEPA 2010). Since the study used as the basis for the cancer URF included workers exposed to both trivalent and hexavalent chromium, the FWCUG must be adjusted to represent only hexavalent chromium for comparison to hexavalent chromium results in the speciation samples. The toxicological review of hexavalent chromium written in support of summary information on the USEPA's Integrated Risk Information System (IRIS) states the risk of hexavalent chromium is estimated on the basis of the total chromium obtained from all soluble and insoluble chromium to which workers were exposed. Since there are likely differences between the chromium compounds to which workers were exposed, the potency of hexavalent chromium compounds may be underestimated. However, since the maximum ratio of trivalent chromium to hexavalent chromium reported in the worker studies is six, the underestimation of the risk for hexavalent chromium is unlikely to be greater than sevenfold (USEPA 1998). Therefore, one-seventh of

the National Guard Trainee FWCUG (16.4/7=2.3 mg/kg) is appropriate for evaluating hexavalent chromium alone. The detected concentrations of hexavalent chromium in the chromium speciation samples (0.69 and 1.2 mg/kg) are less than 2.3 mg/kg, indicating hexavalent chromium is not present above the hexavalent chromium FWCUG.

- **Comparison of the concentration of total chromium to the FWCUG for trivalent chromium** – Implementing the chromium speciation process specified in the PBA08 SAP, hexavalent chromium is present at a very low concentration (i.e., below the FWCUG for hexavalent chromium), and the percent hexavalent chromium is less than 14%. Therefore, hexavalent chromium is not of concern at Load Line 10, and the reported concentrations of total chromium were compared to the FWCUGs for trivalent chromium for identifying COCs at this AOC.

7.2.4.2 Exposure Point Concentrations for Comparison to FWCUGs

Surface Soil

Surface soil at Load Line 10 was characterized using ISM sampling. The ISM analytical result can provide a more reliable estimate of the average concentration for a decision unit but cannot be combined with analytical results from discrete samples (USACE 2009c). As noted in the *Technical and Regulatory Guidance for Incremental Sampling Methodology* (ITRC 2012), different objectives require different spatial scales for ISM sample areas.

Some objectives call for characterizing contaminant concentrations over a relatively large area (e.g., multiple acres) if the primary objective is risk assessment to represent an exposure concentration within a human health exposure area. Other objectives focus on distinguishing concentration differences on a much smaller scale (e.g., within a few feet) to delineate potential remediation areas. In accordance with the PBA08 SAP, two types of ISM grid sampling were used to characterize surface soil at Load Line 10.

1. Potential source area ISM samples were collected from areas biased toward locations anticipated to have the highest level of potential contamination (i.e., around former buildings) to delineate potential sources. These ISM samples ranged from 0.003-0.2 acres and averaged 0.05 acres in size.
2. Larger ISM samples were collected to characterize potential exposure areas within the AOC, but these samples do not provide the spatial resolution needed to identify potential source areas. Characterization of the former operational area (i.e., the FPA) was achieved using ISM samples with a nominal 2-acre grid size, and the former non-operational area (i.e., the NPA) was characterized using ISM samples with a nominal 4-acre grid size.

An EPC was calculated for each of the two EUs (NPA and FPA) using all of the ISM grid samples within each EU, presented in Table 7-1. EPCs are intended to provide representative chemical concentrations that a receptor might be exposed to for a long duration of time (i.e., an exposure duration of 6-30 years). The EPC is either the 95% upper confidence level (UCL) of the mean or the

MDC, whichever value is lowest. If the 95% UCL could not be determined, the EPC is the MDC. The 95% UCL was calculated for an area weighted mean and standard error using the Chebyshev approach (ITRC 2012) shown below:

Chebyshev 95% UCL = weighted mean + (sqrt(1/0.05-1) x weighted standard error

The Interstate Technology and Regulatory Council (2012) recommends using an area weighted mean and standard error when combining ISM samples collected over different size areas to calculate an EPC. In the absence of sample-specific estimates of variance, the standard error of the mean is calculated using the variance estimated from the unweighted concentrations. If any COCs are identified for an EU, chemical concentrations in individual ISM sample locations (including all potential source area ISM samples) are compared directly to the soil FWCUGs to identify which ISM sample locations (i.e., smaller decision units) contain COCs.

Subsurface Soil

EPCs were calculated for the 1-13 ft bgs subsurface soil exposure depth using analytical results from the discrete samples presented in Table 7-2. Per the FWHHRAM, the EPC is either the 95% UCL of the mean or the MDC, whichever value is lowest. If the 95% UCL could not be determined, the EPC is the MDC.

7.2.4.3 Identification of COCs for Unrestricted (Residential) Land Use

Load Line 10 COCs for Unrestricted (Residential) Land Use, as represented by the Resident Receptor (Adult and Child), are presented below.

COCs for Surface Soil (0-1 ft bgs): COC determination for surface soil for the Resident Receptor (Adult and Child) is detailed in Tables G-5 through G-9 of Appendix G. Several PAHs were identified as COCs for the Resident Receptor (Adult and Child), as explained below.

COPCs with EPCs lower than the Resident Receptor (Adult and Child) FWCUG: The aluminum, chromium, cobalt, lead, benz(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene at the NPA and FPA are lower that the Resident Receptor (Adult and Child) FWCUG.

COPCs exceeding the Resident Receptor (Adult and Child) FWCUG: The EPCs for arsenic (11.8 and 12.1 mg/kg) at the NPA and FPA exceed the FWCUG of 4.25 mg/kg but are less than the surface soil BSV of 15.4 mg/kg. Therefore, arsenic was not identified as a COC in surface soil.

The EPC for benzo(a)pyrene at the NPA (0.13 mg/kg) is less than the FWCUG. The EPC for benzo(a)pyrene at the FPA (0.92 mg/kg) exceeds the FWCUG. Therefore, benzo(a)pyrene is identified as a COC for Unrestricted (Residential) Land Use at the FPA.

SOR Analysis: Three additional COCs were identified for the Resident Receptor (Adult and Child) exposed to surface soil at the FPA based on the SOR analysis. The SOR analysis is summarized below:

- Four COPCs (aluminum, arsenic, chromium, and cobalt) identified in surface soil have FWCUGs for non-cancer endpoints. The EPCs for three of these COPCs (aluminum, arsenic, and cobalt) at the FPA are below the BSVs; therefore, no SOR was calculated for non-cancer endpoints at the FPA. The EPCs for aluminum and arsenic are also below BSVs at the NPA. The EPCs for chromium and cobalt at the NPA exceed BSVs. The RfD for chromium is based on a NOAEL and does not have an identified target organ for toxicity; therefore, a SOR was calculated for chromium and cobalt at the NPA for potential effects to the thyroid. The SOR is less than 1; therefore no additional COCs were identified using this analysis.
- Eight COPCs [arsenic; cobalt; chromium, benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene] identified in surface soil have FWCUGs for the cancer endpoint. The EPCs for arsenic at the NPA and FPA were less than the BSV. The EPC for cobalt is less than the BSV at the FPA. These inorganic chemicals were not included in the SOR at EUs where the EPC is less than the BSV. The SOR for carcinogenic COPCs at the NPA is 1; therefore no additional COCs were identified at this EU. The SOR for carcinogenic COPCs at the FPA is greater than 1 (Table G-9), largely due to the contribution from benzo(a)pyrene. COPCs contributing at least 10% to this SOR and identified as COCs are the PAHs benzo(a)pyrene and dibenz(a,h)anthracene. Benz(a)anthracene and benzo(b)fluoranthene contribute greater than 5% to the SOR. Because other PAHs were identified as COCs, and it is common to find mixtures of PAHs, benz(a)anthracene and benzo(b)fluoranthene were also identified as COCs using this analysis.

Sample Location Analysis: Because COCs were identified at the FPA, further analysis was used to identify the ISM sample locations (i.e., smaller decision units) within this EU where the COCs exceed FWCUGs. The evaluation of COCs at individual ISM sample locations for Unrestricted (Residential) Land Use is detailed in Table G-10 of Appendix G. Six ISM sample locations within the FPA were identified as having COCs detected above FWCUGs for the Resident Receptor (Adult and Child). The reported concentrations of one or more of the PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene exceed FWCUGs for the Resident Receptor (Adult and Child) at source area ISM locations L10ss-051M, L10ss-056M, L10ss-080M, and the grid sample locations L10ss-088M, L10ss-090M, L10ss-091M overlying these source areas (Figure 7-1). Results for each of these locations are discussed below. The reported concentrations of all COCs were less than FWCUGs at all other decision units at the FPA.

- **L10ss-51M.** Sample L10ss-051M was collected in 2007 from an approximately 0.01-acre area at the former wet mix building (PE-15) following slab removal in 2006. The detected concentration of benzo(a)pyrene (2.0 mg/kg) exceeds the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. The detected concentrations of benz(a)anthracene (2.4 mg/kg) and benzo(b)fluoranthene (2.6 mg/kg) slightly exceed the FWCUG of 2.21 mg/kg for these PAHs.

- **L10ss-056M.** Sample L10ss-056M was collected in 2007 from an approximately 0.004-acre area at the former solvent storage building (PE-22) following slab removal. The detected concentration of benzo(b)fluoranthene (2.3 mg/kg) barely exceeds the FWCUG of 2.21 mg/kg for this chemical.
- **L10ss-080M.** Sample L10ss-80M was collected from an approximately 0.2 acre area as part of the PBA08 RI to delineate inorganic chemical detections near the former manufacturing building (PE-1). The detected concentrations of benz(a)anthracene (3.5 mg/kg) and benzo(b)fluoranthene (4.5 mg/kg) exceed the FWCUG of 2.21 mg/kg for these PAHs. The detected concentrations of benzo(a)pyrene (3.3 mg/kg) and dibenz(a,h)anthracene (0.5J mg/kg) exceed the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg for these PAHs.
- **L10ss-088M, L10ss-090M, and L10ss-91M.** These are large (approximately 2 acre) ISM grid samples collected, with other grid samples, to represent the concentration across the FPA. Detected concentrations of benzo(a)pyrene in these three samples range from 0.33-0.92 mg/kg and exceed the FWCUG of 0.221 mg/kg. The smaller ISM samples collected at L10ss-080M and L10ss-056M are located within the sampled areas of L10ss-088M and L10ss-090M, respectively.

COCs in Subsurface Soil (1-13 ft bgs)

The COC determination for the subsurface soil exposure depth (1-13 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Tables G-11 through G-13 of Appendix G.

<u>COPCs with EPCs lower than the Resident Receptor (Adult and Child) FWCUG</u>: The EPCs for antimony; benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene at NPA and FPA are all lower than the FWCUGs for the Resident Receptor (Adult and Child).

<u>COPCs exceeding the Resident Receptor (Adult and Child) FWCUG</u>: Benzo(a)pyrene was identified as exceeding a FWCUG for the Resident Receptor (Adult and Child) in subsurface soil (1-13 ft bgs) at the FPA because the EPC of 0.923 mg/kg exceeds the FWCUG of 0.221 mg/kg. Therefore, benzo(a)pyrene is identified as a COC for Unrestricted (Residential) Land Use at the FPA. Benzo(a)pyrene was not detected in subsurface soil at the NPA.

<u>SOR Analysis</u>: Three additional COCs were identified for the Resident Receptor (Adult and Child) exposed to subsurface soil based on the SOR analysis. The SOR analysis is summarized below:

- Antimony is the only non-cancer COPC identified in subsurface soil; therefore, a non-cancer SOR calculation was not needed.
- Six COPCs [benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(k)fluoranthene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene] identified in subsurface soil at the FPA have FWCUGs for the cancer endpoint so an SOR was calculated (Table G-13). The SOR is greater than 1 due primarily to benzo(a)pyrene, which exceeds the

FWCUG. The only other COPC contributing at least 10% to the SOR is dibenz(a,h)anthracene. Benz(a)anthracene and benzo(b)fluoranthene contribute greater than 5% to the SOR. Because other PAHs were identified as COCs and it is common to find mixtures of PAHs, benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene are also identified as COCs at the FPA. These PAHs were not detected in subsurface soil at the NPA.

The COCs identified for Unrestricted (Residential) Land Use are summarized in Table 7-7.

COCs for Sediment and Surface Water

No COPCs, and therefore no COCs, were identified for sediment or surface water at Load Line 10.

7.2.5 Uncertainty Assessment

The sources of uncertainty, as well as the potential bias they impart to the risk assessment (i.e., whether conservatism is increased or decreased) and approaches for minimizing their impact on the conclusions of the RI, are briefly discussed below.

Table 7-7. Surface Soil and Subsurface Soil COCs for Unrestricted (Residential) Land Use

COC	FWCUG (mg/kg)	BSV (mg/kg)	Exposure Point Concentration (mg/kg)			
			Surface Soil (0-1 ft bgs)		Subsurface Soil (1-13 ft bgs)	
			NPA	FPA	NPA	FPA
Benz(a)anthracene	2.21	--	0.14	1.1	ND	1.04
Benzo(a)pyrene	0.221	--	0.12	0.92	ND	0.923
Benzo(b)fluoranthene	2.21	--	0.19	1.2	ND	1.19
Dibenz(a,h)anthracene	0.221	--	0.021	0.15	ND	0.154

bgs = Below ground surface.
BSV = RVAAP Background Screening Value.
COC = Chemical of Concern.
FPA = Former production area.
FWCUG = Risk-based Facility-Wide Cleanup Goal corresponding to a target risk of 1E-05.
mg/kg = Milligram per kilogram.
ND = Not detected.
NPA = Non-production area.
-- = No value available.

7.2.5.1 Uncertainty in Estimating Potential Exposure

Sources of uncertainty in estimating potential human exposure include sampling and analysis limitations, comparison to background concentrations to identify SRCs, and estimation of EPCs.

Sampling Limitations – Uncertainties arise from limits on the media sampled, the total number of samples, specific locations that can be sampled, and the parameters chosen for analysis to characterize the AOC. In accordance with the PBA08 SAP, potential source area ISM samples (0.003-0.2 acres in size) were collected from areas biased toward areas anticipated to have the highest level of potential contamination (i.e., around former buildings) to delineate potential sources. In addition, 10 ISM grid sampling was used to characterize surface soil (0-1 ft bgs) at former operational and non-operational portions of the AOC. Characterization of the former operational area was achieved using ISM samples with a nominal 2-acre grid size and former non-operational areas were characterized using ISM samples with a nominal 4-acre grid size. These sampling areas fully characterize potential exposure areas within the AOC but do not provide the spatial resolution needed to identify potential source areas.

The results of surface soil sampling were used to select locations for discrete subsurface soil sampling that focused on areas with the highest potential for contamination.

Analytical Limitations – Uncertainty is associated with the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment was maximized and uncertainty was minimized by implementing QA/QC procedures that specify how samples are selected and handled; however, sampling errors, laboratory analysis errors, and data analysis errors can occur. Beyond the potential for errors, there is normal variability in analytical results.

Some current analytical methods are limited in their ability to achieve detection limits at or below risk-based screening levels. Under these circumstances, it is uncertain whether the true concentration is above or below the screening levels, which are protective of human health.

When analytes have a mixture of detected and non-detected concentrations, EPC calculations may be affected by these detection limits. Risks may be overestimated as the result of non-detected sample concentrations being reported at the MDL, when the actual concentration may be much smaller. Risks may be underestimated if analytes that were not detected in any sample are removed from the COPC list. If these analyte concentrations are below the MDL but above the screening level, the risk would not be included in the risk assessment results.

As reported in the Investigation of Under Slab Surface Soils (USACE 2009a), the detection limits for SVOCs were elevated at sample location L10ss-053M due to dilution of the sample necessitated by elevated PAH concentrations. Detected concentrations of benz(a)anthracene (1.6 mg/kg) and benzo(b)fluoranthene (1.8 mg/kg) are close to the Resident Receptor (Adult and Child) FWCUG (2.21 mg/kg). Generally, elevated concentrations of these two PAHs in Load Line 10 soil samples are accompanied by an elevated concentration of benzo(a)pyrene.

Benzo(a)pyrene was not detected at L10ss-053M; however, the elevated detection limit (1.6 mg/kg) was larger than the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg, leading to the potential to underestimate the PAHs present at this decision unit. Therefore, this decision unit (L10ss-053M) was identified as potentially having COCs present above FWCUGs for the Resident Receptor (Adult and Child).

Identification of SRCs – Part of the determination of SRCs is to identify chemicals detected above the established RVAAP BSVs. This screen does not account for the potential sources of chemicals, and BSVs are only available for inorganic chemicals.

Uncertainty associated with screening against background concentrations results from statistical limitations and natural variation in background concentrations. Because of these variations, inorganic chemical concentrations below the BSV are likely representative of background conditions. Inorganic chemical concentrations above the BSV may be above background concentrations or may reflect natural variation. This is especially true for measured concentrations close to the BSV.
At Load Line 10, nine inorganic SRCs (aluminum, arsenic, chromium, cobalt, iron, manganese, nickel, selenium, and vanadium) had MDCs in surface soil that were above but close to (i.e., less than 2x) the BSV. Cadmium, cyanide, silver, and vanadium had no BSV for comparison. The consequences of carrying most of these inorganic chemicals forward as SRCs, even if they actually represent background concentrations, is negligible because they are not toxic at near-background concentrations. By contrast, naturally occurring arsenic in soil exceeds risk-based FWCUGs. Therefore, the consequence of identifying arsenic as an SRC if it is, in fact, representative of background can have a significant impact on the conclusions of the risk assessment. The MDC of arsenic in surface soil at Load Line 10 was 20 mg/kg. The RVAAP BSV for arsenic in surface soil is 15.4 mg/kg and in subsurface soil is 19.8 mg/kg. Because building demolition activities disturbed the soil, including removing surface soil and exposing subsurface soil at the surface, it is appropriate to compare surface soil sample results to the subsurface BSV. The MDC of arsenic in surface soil (20 mg/kg) is essentially equal to the BSV of 19.8 mg/kg for subsurface soil.

Other studies indicate arsenic may be naturally occurring in Ohio soils at greater than 20 mg/kg. For example, an environmental study of three locations in Cuyahoga County performed for Ohio EPA (Weston 2012) showed arsenic ranged from 4.6-25.2 mg/kg (22.9 mg/kg excluding statistical outliers) in surface soil (0-2 ft bgs) and 5.3-34.8 mg/kg (22.6 mg/kg excluding statistical outliers) in subsurface soil (2-4 ft bgs). Also, Vosnakis and Perry (2009) published the results of arsenic concentration studies that included 313 samples of Ohio soil. Naturally occurring arsenic in these samples ranged from 1.6-71.3 mg/kg with 95th percentiles of 21.7 mg/kg in surface soil, 25.5 mg/kg in subsurface soil, and upper tolerance limits of 22.8 mg/kg for surface soil and 29.6 mg/kg for subsurface soil. In other studies, native soil concentrations of arsenic in Ohio have been reported as ranging from 0.5-56 mg/kg (Ohio EPA 1996), and the U.S. Geological Survey's Certificate of Analysis of the Devonian Ohio Shale estimates arsenic concentrations of 68.5 mg/kg are naturally present in bedrock shale (USGS 2004).

Organic chemicals are not screened against background concentrations, even though some organic compounds are present in the environment as a result of natural or human activities not related to CERCLA releases at the AOC. For example, PAHs are present in the environment as a result of burning fossil fuels and as a component of road dust, vehicle exhaust, tire wear particles, pavement, and slag used as railroad ballast and fill. Samples collected near roadways or parking areas may represent normal "urban" sources of PAHs. These issues represent significant sources of uncertainty at sites where low levels of PAHs are found over large areas of the AOC. At Load Line 10, PAHs were detected across the entire AOC, as one or more PAHs were detected in all 22 surface soil samples analyzed for SVOCs. Detected concentrations were generally less than or very close to Resident Receptor (Adult and Child) FWCUGs in all but the following sample locations:

- L10ss-051M and L10ss-080M have soil concentrations that were 10 times or more than Resident Receptor (Adult and Child) FWCUGs;
- L10sb-071 that contained building debris; and
- Potentially L10ss-053M, that had elevated detection limits that prevented definitive assessment of benzo(a)pyrene.

Although no BSVs for PAHs were established for RVAAP, the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b) which established the BSVs for inorganics, included a characterization of naturally occurring background metal concentrations in surface and subsurface soil at Camp Ravenna using samples from outside the process areas. Surface soil samples were collected at 15 locations on the eastern half of Camp Ravenna. These background locations were chosen using aerial photographs and site visits with the concurrence of Ohio EPA and USACE to (1) reflect areas not impacted by RVAAP activities and (2) establish background values that are unaffected by any human activity. The background locations were situated upgradient and generally upwind of known or suspected contaminant sources.

Background sampling was conducted in April and May 1998. All background samples were analyzed for TAL metals, cyanide, and SVOCs. Two of the background samples were also analyzed for VOCs and pesticides/PCBs. The background soil sampling effort established BSVs for naturally occurring metals in soil at RVAAP.

In establishing the BSVs for naturally occurring metals, data were screened to identify outliers in the inorganic chemical results. Ohio EPA guidance (Comment Resolution Meeting, December 2, 1998) called for using upper and lower cutoff limits based on quartiles to identify outliers. The upper cutoff limit is the third quartile (the 75th percentile) plus one and a half times the interquartile range. All results that exceeded the upper cutoff limit were examined to determine if the results should be used in establishing the BSVs for naturally occurring metals. Outliers were removed so that background values would most nearly represent natural conditions and exclude human disturbance whether from RVAAP or pre-RVAAP activities.

Statistical outliers were identified in five surface soil and 15 subsurface soil samples. All analytical results for four of these samples [BKGss-011(b)-0794-SO, BKGss-012(b)-0795-SO, BKGss-015(b)-0798-SO, and BKGss-005(b)-0788-SO] were removed from the surface soil background data set.

The primary reason for eliminating these four samples from the surface soil background data set was that PAHs were elevated and these sampling locations were near pre-existing homes or farms and could have been influenced by activities associated with those structures (e.g., burning wood and fossil fuels, vehicle exhaust, or building materials such as slag used as fill or tar paper and shingles). The other 11 outlier samples were not excluded from the BSV calculations primarily because no

SVOCs were detected in those samples and thus the outliers did not appear to be associated with human activities.

Concentrations of PAHs in surface soil at Camp Ravenna associated with pre-RVAAP anthropogenic sources calculated from the 15 RVAAP background surface soil samples are shown in Table 7-8. Since the purpose here is to identify PAH levels associated with anthropogenic activities unrelated to CERCLA releases from operations at RVAAP, it is appropriate to include all 15 background samples in these calculations. The following criteria were used per the method used in establishing the BSVs for naturally occurring metals (USACE 2001b):

- For analytes with a frequency of detection > 50%, a distribution (determined using the Shapiro-Wilk test) that is neither normal nor log-normal, and a sample size of 59 or less, the maximum result represents the nonparametric 95% UTL and was identified as the BSV for naturally occurring metals. These conditions apply to four of the PAHs detected in background samples [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene].
- For analytes with a frequency of detection between 0 and 50% with a sample size of 15, the maximum result represents the 99th percentile value and was identified as the BSV for naturally occurring metals. These conditions apply to the remainder of the PAHs detected in background samples.

Table 7-8. Environmental Concentrations of PAHs Measured in Background Surface Soil Samples at RVAAP

		Reported Concentration[a] (mg/kg)		
Analyte	**% Detects**	**Minimum**		**Maximum**
Acenaphthene	1/ 15	7%	0.88	0.88
Acenaphthylene	1/15	7%	0.07	0.07
Anthracene	2/15	13%	0.12	1
Benz(a)anthracene	10/15	67%	0.044	4.1
Benzo(a)pyrene	8/15	53%	0.058	3.7
Benzo(b)fluoranthene	10/15	67%	0.062	4.8
Benzo(g,h,i)perylene	6/15	40%	0.046	1.3
Benzo(k)fluoranthene	6/15	40%	0.053	2.6
Chrysene	10/15	67%	0.057	4
Dibenz(a,h)anthracene	2/15	13%	0.11	0.37
Indeno(1,2,3-cd)pyrene	5/15	33%	0.054	1.5

These results demonstrate the large variability in environmental concentrations of PAHs. For example, benzo(a)pyrene was detected in 8 of 15 background surface soil samples at concentrations ranging from 0.058-3.7 mg/kg.

Other studies of environmental concentrations of PAHs in Ohio soils show similar variability. For example, in the environmental study of three locations in Cuyahoga County performed for Ohio EPA (Weston 2012), PAHs were detected in only 1 of 36 surface soil samples with a reported concentration of benzo(a)pyrene of 1.33 mg/kg. Aerial photographs indicate this sample was collected near an old road or trail, but no other sources of PAHs are apparent.

In addition to these RVAAP and Cuyahoga County studies, numerous other environmental studies have been conducted that examine environmental levels of PAHs in rural and urban surface soil (e.g., ATSDR 1995, Bradley et al. 1994, IEPA 2005, MADEP 2002, Teaf et al. 2008). Reported minimum, maximum, and 95th percentile concentrations of benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene from numerous studies are shown in Table 7-9. These studies further demonstrate the high variability in environmental levels of PAHs within a single study area and among multiple studies.

The lack of established RVAAP-specific BSVs for identifying SRCs for PAHs is a source of uncertainty. Evaluating potential RVAAP process-related sources and other common anthropogenic (non-CERCLA) sources using available PAH environmental data minimizes the impact of this uncertainty on the conclusions of the RI (see Section 7.2.6).

Exposure Point Concentrations – Surface soil was characterized using ISM. ISM is used to determine an average concentration representative of the soil contained within an ISM sample location (i.e., the “decision unit”). For ISM samples, 30-50 aliquots of surface soil are generally collected from random locations within a decision unit and combined into a single sample. Using ISM reduces the uncertainty associated with estimating a statistical average concentration within a decision unit.

Soil data at Load Line 10 were aggregated into surface and subsurface soil for two EUs as described in Section 7.1.1. Based on AOC characteristics and the operational constraints during its use, the sample coverage to define nature and extent of operationally impacted areas of the AOC is adequate.

Potential source area ISM samples (0.003-0.2 acres, with an average 0.05 acres) were collected from areas biased toward locations anticipated to have the highest level of potential contamination (i.e., around former buildings) to delineate potential sources. Characterization of the FPA was achieved using ISM samples with a nominal 2-acre grid size and the NPA was characterized using ISM samples with a nominal 4-acre grid size. These sampling areas characterize potential exposure areas within the AOC, but do not provide the spatial resolution needed to identify potential source areas. Therefore, both types of samples were used in the analysis.

First, an EPC was calculated for each of the two EUs (NPA and FPA) using all of the ISM grid samples within each EU as listed in Table 7-1. The EPC is intended to represent the mean concentration a receptor may be exposed to over a long duration (i.e., the exposure duration of 6-30 years). The 95% UCL or MDC, whichever is lower, was used as a conservative estimate of the mean to compensate for uncertainty in the exposure estimates.

Table 7-9. Concentrations of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Various Environmental Studies

Study	Number of Samples	Geometric Mean or Median	Minimum	95th Percentile[a]	Maximum
Benz(a)anthracene					
CA/T Project[b]	872	0.33	0.045	19	250
LSPA Project[b]	490	0.563	ND	--	796
Watertown[b]	17	0.411	0.021	6.04	6.05
Worcester[b]	68	--	ND	3.8	15
New England[c]	62	0.672	ND	1.86	15
Illinois[d] Urban	--	--	--	1.8	--
Illinois[d] Rural	--	--	--	0.72	--
ATSDR[e] Urban	--	--	0.169	--	59
ATSDR[e] Rural	--	--	0.005	--	0.02
ATSDR[e] Agricultural	--	--	0.056	--	0.11
NYSDEC Rural Near Roads[f]	28	--	ND	1.2	2.9
NYSDEC Rural Distant Roads[f]	118	--	ND	0.16	2.6
Benzo(a)pyrene					
CA/T Project[b]	873	0.3	0.031	17	230
LSPA Project[b]	489	0.44	ND	--	222
Watertown[b]	17	0.95	0.6	4.77	6.08
Worcester[b]	67	--	ND	3.3	9.7
New England[c]	62	0.686	ND	1.82	13
Illinois[d] Urban	--	--	--	2.1	--
Illinois[d] Rural	--	--	--	0.98	--
ATSDR[e] Urban	--	--	0.165	--	0.22
ATSDR[e] Rural	--	--	0.002	--	1.3
ATSDR[e] Agricultural	--	--	0.0046	--	0.9
NYSDEC Rural Near Roads[f]	28	--	ND	1.1	2.4
NYSDEC Rural Distant Roads[f]	118	--	ND	0.12	3.4
Benzo(b)fluoranthene					
CA/T Project[b]	873	0.68	0.045	18	270
LSPA Project[b]	486	--	ND	--	250
Watertown[b]	17	1.4	0.6	6.79	7.08
Worcester[b]	--	--	--	--	--
New England[c]	62	0.722	ND	1.97	12
Illinois[d] Urban	--	--	--	2	--
Illinois[d] Rural	--	--	--	0.7	--
ATSDR[e] Urban	--	--	15	--	62
ATSDR[e] Rural	--	--	0.02	--	0.03
ATSDR[e] Agricultural	--	--	0.058	--	0.22
NYSDEC Rural Near Roads[f]	28	--	ND	1.2	3.3
NYSDEC Rural Distant Roads[f]	118	--	ND	0.36	4.6
Dibenz(a,h)anthracene					
CA/T Project[b]	866	0.17	0.045	2.1	39
LSPA Project[b]	--	--	--	--	--

Table 7-9. Concentrations of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Environmental Studies (continued)

Study	Number of Samples	Geometric Mean or Median	Minimum	95th Percentile[a]	Maximum
Watertown[b]	17	0.195	0.155	0.604	0.64
Worcester[b]	68	--	ND	--	1.6
New England[c]	62	0.245	ND	--	2.9
Illinois[d] Urban	--	--	--	0.42	--
Illinois[d] Rural	--	--	--	0.15	--
ATSDR[e]	--	--	--	--	--
NYSDEC Rural Near Roads[f]	28	--	--	--	--
NYSDEC Rural Distant Roads[f]	118	--	ND	--	0.23

[a] Lognormal 95th percentile value for all studies except: (1) New England value is 95% upper confidence limit and (2) NYSDEC values are distribution-free 95th percentile.

[b] Data reported by Massachusetts Department of Environmental Protection (MADEP 2002) are from the following data sets:
CA/T = Data collected by Mass Highway Department as part of the Central Artery/Tunnel (CA/T) project.
LSPA = Preliminary data compiled by the Massachusetts Licensed Site professional Association (LSPA) from data submitted by its members in 2001.
Water Town and Worcester Site-specific samples.[c] Data from three New England locations from Bradley et al. 1994.

[d] Concentrations of PAHs in Illinois metropolitan statistical areas (urban) and non-metropolitan statistical areas (rural) as reported by Illinois EPA (IEPA 2005).

[e] Data published by the Agency for Toxic Substances and Disease Registry (ATSDR) in Polycyclic Aromatic Hydrocarbons (PAHs) August 1995.

[f] Distribution-free 95th percentile values for near roads (less than 10 ft from roads and pavement) and not near roads (more than 15 ft from roads and pavement) from New York State Brownfield Cleanup program Development of Soil Cleanup Objectives Technical Support Document (September 2006), Appendix D.

ND = Not detected.
NYSDEC = New York State Department of Environmental Conservation.
-- = No value reported for this source.

Following evaluation of the EPC, for COCs identified at an EU, chemical concentrations in individual ISM sample locations (including all source area ISM samples) are compared directly to the soil FWCUGs to identify which ISM sample locations (i.e., smaller decision units) contain COCs.

EPCs were calculated for the 1-13 ft bgs subsurface soil sample interval using analytical results from the discrete samples listed in Table 7-2. Soil borings for discrete samples were located in areas of highest potential contamination based on previous sampling results, resulting in calculated EPCs that provide conservative estimates of exposure concentrations across the EU.

There is some evidence that using stainless steel grinding blades when processing ISM samples could contribute chromium and nickel to the ISM soil samples. However, neither of these metals were identified as COCs at Load Line 10; therefore, the impact of the potential contribution from grinding is minimal.

7.2.5.2 Uncertainty in Use of FWCUGs

Sources of uncertainty in the FWCUGs used to identify COCs include selecting appropriate receptors and exposure parameters, exposure models, and toxicity values used in calculating FWCUGs.

Selection of Representative Receptors - An evaluation using Resident Receptor (Adult and Child) FWCUGs is included to provide an Unrestricted (Residential) Land Use evaluation as required by CERCLA and the U.S. Army.

Exposure Parameters and Exposure Models - For each primary exposure pathway included in the FWCUGs, assumptions are made concerning the exposure parameters (e.g., amount of contaminated media a receptor can be exposed to and intake rates for different routes of exposure) and the routes of exposure. Most exposure parameters have been selected so that errors occur on the side of human health protection. When several of these upper-bound values are combined in estimating exposure for a pathway, the resulting risks can be in excess of the 99th percentile and are therefore outside of the range that may be reasonably expected. The consistent selection of upper-bound parameters generally leads to overestimation of the potential risks.

Toxicity Values – The toxicity of chemicals is under constant study and values change from time to time. The toxicity values used in calculating the FWCUGs were the most recent values available at the time (September 2008). These values are designed to be conservative and provide an upper-bound estimate of risk.

The toxicity and mobility of many inorganic chemicals in the environment depends on the chemical species present. Two important examples are arsenic and chromium. The toxicity values used in developing the FWCUGs are for inorganic arsenic, and do not distinguish between arsenite and arsenate. Chromium is generally present in the environment as either the trivalent (Cr+3) or hexavalent (Cr+6) species, with the trivalent form generally being more stable and, therefore, more common. FWCUGs are available for hexavalent chromium and trivalent chromium.

Trivalent chromium has not been shown to be carcinogenic. It is an essential micronutrient but can also be toxic at high doses (i.e., above the RfD used to calculate the FWCUG). The FWCUGs for trivalent chromium are based on non-cancerous effects. Hexavalent chromium is much more toxic than trivalent chromium. It is classified as a “known human carcinogen” and may also cause non-cancerous effects. The cancer URF for hexavalent chromium published in USEPA’s IRIS is based on epidemiological data on lung cancer in workers associated with chromate production. Workers in the chromate industry are exposed to trivalent and hexavalent compounds of chromium. The cancer mortality in the study used to establish the URF was assumed to be due to hexavalent chromium. It was further assumed that hexavalent chromium constituted no less than 1/7 of the total chromium in air that the workers were exposed to. As noted in IRIS, the assumption that the ratio of hexavalent to trivalent chromium was 1:6 in this study may lead to a sevenfold underestimation of risk when using this URF to evaluate exposure to hexavalent chromium alone.

To avoid the underestimation of risk, selection of the FWCUG for chromium includes a step that compares the maximum concentration of hexavalent chromium detected in chromium speciation samples to a FWCUG adjusted to represent only hexavalent chromium. The lowest and most conservative FWCUG for hexavalent chromium is for the National Guard Trainee (16.4 mg/kg) and is based on a cancer URF calculated using a chromate mixture containing 14% hexavalent chromium

(USEPA 2010). Since the study used as the basis for the cancer URF included workers exposed to trivalent and hexavalent chromium, the FWCUG must be adjusted to represent only hexavalent chromium. A total of 1/7, or 14%, of the National Guard Trainee FWCUG [(16.4 mg/kg)/7 = 2.3 mg/kg] is appropriate for evaluating hexavalent chromium alone. Concentrations of hexavalent chromium in chromium speciation samples that are less than or equal to 2.3 mg/kg indicate that hexavalent chromium is not present above the hexavalent chromium FWCUGs and supports using the trivalent chromium FWCUGs.

The use of speciation samples to identify the appropriate FWCUG minimizes the associated uncertainty.

FWCUGs Below Background Concentrations - One purpose of the HHRA process is to identify COCs and CUGs for evaluating remedial alternatives for remediation of residual contamination that has resulted from process operations at the AOC. The FWCUGs are risk-based values. In some cases, natural or anthropogenic background concentrations unrelated to process operations exceed the risk-based FWCUGs. For naturally occurring inorganic chemicals, this problem is addressed by using the BSV as the cleanup goal (CUG). This introduces uncertainty in the chosen CUG because there is uncertainty in assigning a specific value to background, which can be highly variable.

No BSVs are available for organic chemicals, although PAHs are often present in the environment from natural and anthropogenic sources and regulatory standards are often much lower than environmental levels of PAHs in urban and rural surface soil, especially near areas of vehicle traffic (e.g., roads and parking areas). Given their frequent presence in environmental media, and especially in areas influenced by vehicle exhaust and tire particles, it is important to compare risk-based cleanup levels with typical environmental concentrations before utilizing unrealistically low cleanup targets. Numerous studies have been conducted that examine ambient levels of PAHs in rural and urban surface soil (ATSDR 1995, Bradley et al. 1994, MADEP 2002, Teaf et al. 2008). These studies indicate that given the multitude of non-point mobile sources for PAHs, it is not uncommon for ambient concentrations to exceed health-based regulatory recommendations. Some states have begun to include consideration of ambient anthropogenic levels by establishing minimum screening levels based on environmental studies. For example, the New York State Department of Environmental Conservation has established a minimum soil cleanup objective of 1.0 mg/kg for benz(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene and 0.1 mg/kg for dibenz(a,h)anthracene, based on the 95th percentile concentrations of these PAHs in rural areas near roads (NYSDEC 2006).

7.2.5.3 Uncertainty in the Identification of COCs

All sources of uncertainty described in previous sections potentially impact the identification of COCs. The exposure and toxicity values used to calculate FWCUGs, as well as the approach for identifying SRCs, COPCs, and ultimately COCs based on the FWCUGs, were designed to ensure the overestimation rather than underestimation of potential risks. The uncertainty assessment attempts to put the identified COCs in perspective to facilitate informed risk management decisions for the AOC.

The SOR is used to account for potential additive effects from exposure to multiple chemicals that can cause the same effect or affect the same target organ. Cancer risk is assumed to be additive for all carcinogens. Non-cancer risk is assumed to be additive for chemicals with similar sites of toxicological action. In the event that any combination of COPCs results in synergistic effects, risk might be underestimated. Conversely, the assumption of additivity would overestimate risk if a combination of COPCs acted antagonistically. It is unclear whether the potential for chemical interaction has been inadvertently understated or overstated. It seems unlikely that the potential for chemical interaction contributes significant uncertainty to the conclusions of the risk assessment.

7.2.6 Identification of COCs for Potential Remediation

No COPCs, and therefore no COCs, were identified for sediment or surface water at Load Line 10. Soil COCs were identified in Section 7.2.4 as any COPC having an EPC greater than a FWCUG. For inorganic chemicals with FWCUGs below BSVs, the BSV was used as the point of comparison. The TR for the FWCUGs used to identify COCs is 1E-05 per the Ohio EPA DERR program, which has adopted a human health cumulative ILCR goal of 1E-05 to be used as the level of acceptable excess cancer risk and for developing site remediation goals.

The results of the COC screening (Section 7.2.4) are combined with the results of the uncertainty assessment (Section 7.2.5) to identify COCs to be carried forward for potential remediation. Four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs for the Resident Receptor (Adult and Child) in surface soil at the FPA. The EPC for benzo(a)pyrene (0.92 mg/kg) in surface soil at the FPA exceeds the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. Three additional PAHs [benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs in surface soil at the FPA based on their contribution to total risk using the SOR approach.

COCs are present above FWCUGs for one or more receptors at six ISM sample locations within the FPA, and one additional sample location (L10ss-053M) was identified as potentially having benzo(a)pyrene present above the Resident Receptor (Adult and Child) FWCUG based on the uncertainty analysis. These ISM sample locations are described below:

- L10ss-051M was collected in 2007 from an approximately 0.01-acre area at the former wet mix building (PE-15) following slab removal in 2006. The detected concentration of benzo(a)pyrene (2.0 mg/kg) exceeds the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. The detected concentrations of benz(a)anthracene (2.4 mg/kg) and benzo(b)fluoranthene (2.6 mg/kg) exceed their Resident Receptor (Adult and Child) FWCUG of 2.21 mg/kg. The surface interval of a soil boring advanced in 2010 near the location of L10ss-051M (L10sb-069 advanced in the footprint of former Building PE-15 as part of the PBA08 RI) did not show similar levels of benzo(a)pyrene (0.52 mg/kg in the 0-1 ft bgs interval).
- L10ss-80M was collected from an approximately 0.2-acre ISM sample area as part of the PBA08 RI to delineate inorganic chemical detections near the former manufacturing building

(PE-1). The detected concentration of benzo(a)pyrene (3.3 mg/kg) exceeds the Resident Receptor (Adult and Child) FWCUG. The detected concentrations of benz(a)anthracene (3.5 mg/kg), benzo(b)fluoranthene (4.5 mg/kg), and dibenz(a,h)anthracene (0.5J mg/kg) exceed the Resident Receptor (Adult and Child) FWCUGs for these PAHs.

- L10ss-056M was collected in 2007 from an approximately 0.005-acre (6 x 6 ft) area at the former solvent storage building (PE-22) following slab removal. The detected concentration of benzo(b)fluoranthene (2.3 mg/kg) barely exceeds the Resident Receptor (Adult and Child) FWCUG of 2.21 mg/kg for this chemical. The measured concentration in the adjacent soil boring (L10sb-072 at 0-1 ft bgs) is 0.32 mg/kg. The measured concentration of benzo(b)fluoranthene in the larger ISM sample (L10ss-090M) that encompasses L10ss-056M is below the FWCUG at 0.51 mg/kg.
- L10ss-053M was collected in 2007 from an approximately 0.02-acre (35 x 29 ft) area at the former storage magazine (Building PE-19) following slab removal. Benz(a)anthracene (1.6 mg/kg) and benzo(b)fluoranthene (1.8 mg/kg) were detected near the Resident Receptor (Adult and Child) FWCUG of 2.21 mg/kg. Benzo(a)pyrene was not detected at L10ss-053M but with an elevated detection limit (1.6 mg/kg) due to dilution of the sample. This detection limit is above the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. The sample was diluted by the laboratory due to elevated concentrations of PAHs. Therefore, benzo(a)pyrene may be present above the FWCUG. Because of the uncertainty associated with the potential concentration of benzo(a)pyrene, this sample was identified as potentially having COCs.
- L10ss-088M, L10ss-090M, and L10ss-91M are large ISM grid samples ranging from 1.8-2.7 acres collected within the FPA. Detected concentrations of benzo(a)pyrene in these three samples range from 0.33-0.92 mg/kg, exceeding the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. These three sample areas are surrounded by the asphalt perimeter road and include numerous current and former gravel roads and parking areas. Building demolition in these areas utilized heavy diesel-fueled equipment and left residual demolition debris, including brick fragments, asphalt fragments, gravel, and other fill material, including slag/ballast. The smaller ISM samples collected at L10ss-080M, L10ss-056M, and L10ss-053M are located within the sampled areas of L10ss-088M, L10ss-090M, and L10ss-91M respectively.

Organic chemicals do not have established RVAAP BSVs. However, some organic compounds are present in the environment as a result of natural or human activities not related to CERCLA releases at the AOC. For example, PAHs are present in the environment as a result of burning fossil fuels and as a component of road dust, vehicle exhaust, tire wear particles, pavement, and slag used as railroad ballast and fill. No PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC. PAHs were detected across the entire AOC (i.e., one or more PAHs were detected in all 22 surface soil samples analyzed for SVOCs). Concentrations of PAHs are generally higher in samples taken from areas of Load Line 10 where buildings, roads, and parking areas were present than in more remote areas of the AOC where airborne dust from sources such as vehicle exhaust may have migrated.

Although no BSVs for PAHs were established for RVAAP, the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b) included analytical data from RVAAP background soil samples collected outside the process areas and analyzed for SVOCs as well as TAL metals. Surface soil samples were collected at 15 locations on the eastern half of Camp Ravenna. These background locations were chosen using aerial photographs and site visits with the concurrence of Ohio EPA and USACE to (1) reflect areas not impacted by RVAAP activities and (2) establish background values that are unaffected by any human activity. The background locations were situated upgradient and generally upwind of known or suspected contaminant sources.

Some of these background locations were near pre-existing homes or farms and could have been influenced by activities associated with those structures (e.g., burning of wood and fossil fuels, vehicle exhaust, or building materials such as slag used as fill or tar paper and shingles). Concentrations of PAHs in surface soil at Camp Ravenna associated with pre-RVAAP anthropogenic sources calculated from the 15 RVAAP background surface soil samples are shown in Table 7-8.

The reported concentrations of COCs in surface soil at Load Line 10 fall within the range of the concentrations of these PAHs associated with pre-RVAAP anthropogenic sources, calculated from the 15 RVAAP background surface soil samples as shown in Table 7-10.

Table 7-10. PAH Concentrations in Load Line 10 Surface Soil Samples and RVAAP Background Surface Soil Samples

	Load Line 10 Surface Soil Samples[a]			RVAAP Background Surface Soil Samples[b]		
COC (mg/kg)	Freq. of Detect	Min Detect	Max Detect	Freq. of Detect	Min Detect	Max Detect
Benz(a)anthracene	20/22	0.0084	3.5	10/15	0.044	4.1
Benzo(a)pyrene	20/22	0.0094	3.3	8/15	0.058	3.7
Benzo(b)fluoranthene	22/22	0.018	4.5	10/15	0.062	4.8
Dibenz(a,h)anthracene	11/22	0.01	0.5	2/15	0.11	0.37

[a] Results for both ISM grid samples used to characterize the exposure units and smaller source area ISM samples are included.
[b] Data from Appendix F of the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

The Load Line 10 surface soil samples were collected using ISM and the RVAAP background surface soil samples were collected using discrete sampling methods; therefore, direct statistical comparison of these two data sets is not possible. However, a review of the range of detected concentrations in both data sets indicates the reported concentrations at Load Line 10 are very similar to the reported concentrations in the background soil samples. Both data sets show a relatively high frequency of detection of the PAHs, with most reported concentrations being less than 1 mg/kg and a few higher detections in samples likely influenced by heavy vehicle traffic and/or construction materials.

Benzo(a)pyrene was detected at a concentration of 4.9 mg/kg, exceeding the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg in one discrete subsurface soil sample (L10sb-071 at 1-4 ft bgs) within the subsurface soil exposure depth (1-13 ft bgs) for the Resident Receptor (Adult and Child). Soil boring L12sb-071 was located near the former solvent storage building (PE-22) in an area recommended for further investigation in the Investigation of Under Slab Surface Soils (USACE 2009a). This soil boring was noted as containing fill and construction debris, including brick and gravel, and was terminated at 6.5 ft bgs due to concrete refusal. The benzo(a)pyrene concentration in samples collected above and below this 1-4 ft bgs sample interval were 0.28 mg/kg in the 0-1 ft bgs sample interval and 0.91 mg/kg in the 4-7 ft bgs sample interval. The benzo(a)pyrene concentration in the 18 subsurface soil samples collected from the other soil borings ranged from non-detected concentrations to 0.15 mg/kg. Location L10sb-072 was approximately 80 ft southwest of this sample and did not have a detectable concentration of benzo(a)pyrene. Location L10sb-073 was approximately 140 ft northwest of this sample and had a benzo(a)pyrene concentration of 0.15 mg/kg in the 1-4 ft bgs interval. All of these data indicate the elevated result in the 1-4 ft bgs interval of L10sb-071 is indicative of the fill material/building debris present in this boring and does not represent a CERCLA release, nor does it represent the EPC across the EU. With this outlier removed, the EPC for the remaining subsurface soil samples at the FPA is 0.19 mg/kg.

Based on the evaluation of potential sources of PAHs at Load Line 10 and a comparison to PAH concentrations from the RVAAP background surface soil samples, PAHs are not associated with a CERCLA release at Load Line 10 and were not identified as COCs requiring remediation.

7.2.7 Summary of HHRA

This HHRA documents COCs that may pose potential health risks to human receptors resulting from exposure to contamination at Load Line 10. This HHRA was conducted as part of the RI and was based on the streamlined approach described in the FWCUG Report, Position Paper for Human Health CUGs (USACE 2012b), and Technical Memorandum (ARNG 2014). The components of the risk assessment (receptors, exposure media, EPCs, and results) are summarized below.

Receptors. Camp Ravenna is a controlled access facility. Load Line 10 is located in the south-central portion of the facility and is not currently used for training. An evaluation using Resident Receptor (Adult and Child) FWCUGs is used to provide an Unrestricted (Residential) Land Use evaluation as required by CERCLA and the U.S. Army. Unrestricted (Residential) Land Use is considered protective for all categories of Land Use on the former RVAAP/Camp Ravenna.

Exposure Media. Media of concern at Load Line 10 are surface soil, subsurface soil, sediment, and surface water. Surface soil exposure depth is defined as 0-1 ft bgs for the Resident Receptor (Adult and Child). Subsurface soil exposure depth is defined as 1-13 ft bgs for the Resident Receptor (Adult and Child) (USACE 2010a).

Estimation of EPCs. EPCs were calculated using analytical results from the ISM grid samples for surface soil in each EU listed in Table 7-1. These grid samples provide full coverage of the AOC. The COCs identified at these EUs were further evaluated by reviewing analytical results for individual source area ISM samples. EPCs were calculated using analytical results from discrete soil boring samples listed in Table 7-2. The EPC was either the 95% UCL of the mean or the MDC, whichever value is lowest. If the 95% UCL could not be determined, the EPC is the MDC.

Results of Human Health Risk Assessment. No COPCs, and therefore no COCs, were identified for sediment or surface water at Load Line 10. No COCs were identified in soil as a product of a CERCLA-related release. Consequently, no COCs in surface soil or subsurface soil require remediation. Accordingly, NFA is necessary for soil, sediment, and surface water at Load Line 10 to attain Unrestricted (Residential) Land Use.

7.3 ECOLOGICAL RISK ASSESSMENT

7.3.1 Introduction

The ERA presented in this RI Report follows a unified approach of methods integrating U.S. Army, Ohio EPA, and USEPA guidance. This ERA approach is consistent with the general approach by these agencies and primarily follows the Level I Scoping ERA, Level II Screening ERA, and Level III Baseline ERA outlined in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008), with specific application of components from the FWERWP, *Risk Assessment Handbook Volume II: Environmental Evaluation* (USACE 2010b), and *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997). The process implemented in this RI Report combines these guidance documents to meet requirements of the Ohio EPA and U.S. Army, while following previously accepted methods established for RVAAP. This unified approach resulted from coordination between USACE and Ohio EPA during the summer of 2011.

7.3.1.1 Scope and Objective

Load Line 10 contains a habitat (primarily soil) that supports ecological receptors. This habitat has known chemical contamination (MKM 2007). Habitat types and an assessment of the ecological resources found at Load Line 10 are presented in subsequent subsections. Additionally, the results of a historical ERA (an ERS performed as part of the Characterization of 14 AOCs) and the PBA08 RI are provided to determine whether a qualitative ERA (Level I) is sufficient, based on the quality of the habitat and the presence of contamination, or whether a more rigorous ERA (Level II or III) should be conducted.

7.3.2 Level I: Scoping Level Ecological Risk Assessment

The ERA method for Level I follows guidance documents listed in Section 7.3.1. Level I is intended to evaluate if the AOC had past releases or the potential for current contamination and if there are important ecological resources on or near the AOC.

The following two questions should be answered when the Level I ERA is complete:

1. **Are current or past releases suspected at the AOC?** Current or past releases are determined by evidence that chemical contaminants or COPECs are present.

2. **Are important ecological resources present at or in the locality of the AOC?** Important ecological resources are defined in the Guidance for Conducting Ecological Risk Assessments (Ohio EPA 2008) and Technical Document for Ecological Risk Assessment: Process for Developing Management Goals (BTAG 2005).

If an AOC has contaminants but lacks important ecological resources, the ERA process can stop at Level I. Contamination and important ecological resources must both be present to proceed to a Level II Screening Level ERA.

7.3.2.1 AOC Description and Land Use

Load Line 10 is approximately 36 acres in size. The habitat is mostly field and shrubland with some forest and is large enough to completely support cover and food for small birds and mammals that typically require approximately 1 acre (USEPA 1993) of habitat. The habitat area at Load Line 10 represents approximately 0.17% of the 21,683 acres at Camp Ravenna.

Load Line 10 will be used for Military Training.

7.3.2.2 Evidence of Historical Chemical Contamination

The goal of the historical ERA (MKM 2007) was to identify COPECs in soil for Load Line 10. The historical ERA also identified COPECs for sewer sediment and water. The Facility-wide Sewers (storm and sanitary sewer systems) are identified as a separate AOC, designated as RVAAP-67. The risks in the sewer sediment and surface water at Load Line 10 are evaluated in a separate report specific to the Facility-wide Sewers. Sewer samples and COPECs identified in the historical ERA are not discussed in this report.

The historical ERA followed instructions presented in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003) and consisted of the first two of six steps listed in Figure III of the FWERWP (USACE 2003c). These two steps identified the evaluation procedures, which were used to determine AOC-related COPECs. First, the MDC of each chemical was compared to its respective facility-wide background concentration. Chemicals were not considered COPECs if the MDC was below the background concentration. For all chemicals detected above background concentrations, the MDC was compared to an ESV. The hierarchy of screening values was based on the guidance included in the FWERWP and *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003). In addition to the ESV comparison, it was determined if the chemical was a persistent, bioaccumulative, and toxic (PBT) compound. Chemicals were retained as COPECs if they exceeded background concentrations and the ESV, if the chemical exceeded background concentrations and had no toxicity information, or if the chemical was considered a PBT compound.

Groundwater was not included in the historical ERA. As explained in Section 3.2.2 of the FWERWP, groundwater is not considered an exposure medium to ecological receptors because these receptors are unlikely to contact groundwater greater than 5 ft bgs. As discussed in Section 3.4.2, the water table at Load Line 10 occurs in the bedrock zone at 10.2-22.9 ft bgs. With the exception of the sewer sediment and water samples (USACE 2011), no additional sediment and surface water data were evaluated for Load Line 10 during the historical ERA.

The historical ERA table for soil is included in Appendix Table H-1 and contains the following:

- Frequency of detection,
- Average concentration,
- MDC,
- Background concentration,
- SRC determination,
- ESVs used for COPEC determinations,
- PBT compound identification,
- COPEC determination, and
- COPEC rationale.

Historical COPECs for Soil. The historical ERA conducted as part of the Characterization of 14 AOCs reported 41 chemicals in surface soil (0-1 ft) at Load Line 10 (MKM 2007). Of the 41 chemicals detected, four chemicals (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen. A total of 16S detected inorganic chemicals and 19 organic chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Nine of the inorganic chemicals (aluminum, arsenic, chromium, iron, lead, mercury, nickel, selenium, and zinc) and two organic chemicals (dibenzofuran and 2,6-DNT) were identified as COPECs because detected concentrations were above ESVs (Table 7-11).

Table 7-11. Summary of Historical COPECs per the Characterization of 14 AOCs

Group	COPEC[a]	Shallow Soil	Sediment	Surface Water
Inorganic Chemicals	Aluminum	X	--	--
	Arsenic	X	--	--
	Chromium	X	--	--
	Iron	X	--	--
	Lead	X	--	--
	Mercury	X	--	--
	Nickel	X	--	--
	Selenium	X	--	--
	Zinc	X	--	--
SVOCs	Dibenzofuran	X	--	--
Explosives	2,6-Dinitrotoluene	X	--	--

[a] Adapted from Table L10-14: Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).
COPEC = Chemical of Potential Ecological Concern.
SVOC = Semi-volatile Organic Compounds.
X = Quantitative COPEC, exceeds ESV.
-- = Chemical not identified as a COPEC in this data set.

Historical COPECs for Sediment. No historical sediment samples were collected at Load Line 10, except those from the sewer.

Historical COPECs for Surface Water. No historical surface water samples were collected at Load Line 10, except those from the sewer.

Summary of Historical ERA. As explained previously, a historical ERA was performed to determine COPECs at Load Line 10. HQs were not calculated in this evaluation. The COPECs are summarized in Table 7-11. Based on the identification of COPECs, ecological risk in surface soil was predicted in the historical investigation, and an additional investigation was recommended for Load Line 10 (MKM 2007).

Additional information regarding the evaluation of the PBA08 RI contamination is presented in Section 7.3.2.5.

7.3.2.3 Ecological Significance

Sources of data and information about the ecological resources at Load Line 10 include the *Integrated Natural Resource Management Plan* (OHARNG 2008), *Facility-Wide Biological and Water Quality Study* (USACE 2005a) (where applicable), previous characterization work (e.g., Characterization of 14 AOCs), and visits to Load Line 10 conducted for the PBA08 RI. Revisions to the INRMP (OHARNG 2008) and the Rare Species List are underway; however, documents associated with PBA08 will reference and utilize information from the 2008 INRMP.

One of the two key questions to answer in the Level I Scoping ERA is whether there are ecologically important and especially ecologically significant resources at Load Line 10. Ecological importance is defined as a place or resource that exhibits unique, special, or other attributes that makes it of great value. Ecological significance is defined as an important resource found at an AOC or in its vicinity that is subject to contaminant exposure.

The underlying basis for this distinction can be found in *Ecological Significance and Selection of Candidate Assessment Endpoints* (USEPA 1996a), and is stated as follows:

> “A critical element in the ERA process requires distinguishing important environmental responses to chemical releases from those that are inconsequential to the ecosystem in which the site resides: in other words, determining the ecological significance of past, current, or projected site-related effects.”

Important places and resources identified by the U.S. Army and Ohio EPA (Appendix Table H-2) include wetlands, terrestrial areas used for breeding by large or dense aggregations of animals, habitat known to be used by threatened or endangered species, state land designated for wildlife or game management, locally important ecological places, and state parks. Both the U.S. Army and Ohio EPA recognize 17 important places and resources. The U.S. Army recognizes an additional 16 important places (BTAG 2005), and the Ohio EPA recognizes another six important places (Ohio EPA 2008). In total, there are 39 important places. Presence or absence of an ecologically important place can be determined by comparing environmental facts and characteristics of Load Line 10 with each of the important places and resources listed in Appendix Table H-2.

Ecological significance is defined as an important resource found at an AOC or in its vicinity that is subject to contaminant exposure. Thus, any important places and resources listed in Appendix Table H-2 are elevated to ecologically significant when present on the AOC and there is exposure to contaminants. For all 39 important places and resources, it is relatively clear that the ecological place or resource is either present or absent on the AOC; therefore, the decision process is objective. If no important or significant resource is present at an AOC, the evaluation will not proceed to Level II regardless of the presence of contamination. Instead, the Level I Scoping ERA would acknowledge there are important ecological places, but that those resources are not ecologically significant and no further evaluation is required.

Management Goals for the AOC. Regardless of whether the evaluation is concluded at Level I or continues to Level II, there is another level of environmental protection for Load Line 10 through the natural resource management goals expressed in the INRMP (OHARNG 2008). The OHARNG manages the ecological and natural resources at Camp Ravenna to maintain or enhance the current integrity of the natural resources and ecosystems at the facility. Natural resource management activities in place at Camp Ravenna may also be applicable to any degradation noted from contamination.

Some Natural Resources Management Goals of OHARNG (listed in Appendix Table H-3) benefit Load Line 10. For example, Goal 1 states the natural resources need to be managed in a compatible way with the military mission, and Goal 5 requires the U.S. Army to sustain usable training lands and native natural resources by implementing a natural resource management plan which incorporates invasive species management and by utilizing native species mixes for revegetation after ground disturbance activities. These management goals help detect minor degradation (whether from training activities or historical contamination). While the applicability of the remaining nine management goals to Load Line 10 varies, all of the management goals are intended to either monitor, maintain, or enhance the facility's natural resources and ecosystem. While these goals are for managing all types of resources at and near Load Line 10, they do not affect the decisions already concluded in Section 7.3.2.3 concerning the presence or absence of important or significant ecological places or resources at Load Line 10.

Important Places and Resources. Ecological importance means a place or resource that exhibits a unique, special, or other attribute that makes it of great value. Examples of important places and resources include wetlands, terrestrial areas used for breeding by large or dense aggregations of animals, and habitat of state-listed or federally listed species. An important resource becomes significant when found on an AOC and there is contaminant exposure. There is no important/significant ecological resource at Load Line 10 (Appendix Table H-2).

Terrestrial Resources. Load Line 10 is dominated by terrestrial resources, as described below.

Habitat Descriptions and Species. The INRMP and AOC visits showed that Load Line 10 consists of three vegetation types (Figure 7-2). Load Line 10 is dominated by dry, early-successional, herbaceous field in the center of the area and dry, mid-successional, cold-deciduous shrubland between the boundary fence and the perimeter road. A small amount of *Acer rubrum* successional forest was mapped along the eastern and western sides of the area. The extent of herbaceous field and shrubland communities was approximately equal; forest and associated woodland habitat was extremely limited in extent (OHARNG 2008). This characterization was originally established by a vegetation study using aerial photography and field verification (USACE 1999) and was later used in the INRMP (OHARNG 2008).

A field survey conducted by Leidos, formerly a part of SAIC, field biologists at Load Line 10 in May 2010 identified four main habitat types: dry, early-successional, herbaceous field; dry, mid-successional, cold-deciduous, shrubland; *Acer rubrum* successional forest; and *Malus* spp.*/Fraxinus pennsylvanica* woodland. The herbaceous field and shrubland habitats have declined over the last decade while the area of forest and woodland communities has increased.

The herbaceous habitat is largely concentrated within the loop road around the old load line (Photograph 7-1). The demolition activities associated with removing buildings and other infrastructure have helped maintain this community. Dominant plants include an assortment of grasses, forbs, and seedlings of trees and shrubs. Common species include several species of goldenrod (*Solidago* spp.), clasping-leaf dogbane (*Apocynum cannabinum*), yarrow (*Achillea millefolium*), gray dogwood (*Cornus racemosa*), blackberry (*Rubus allegheniensis*), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*). Despite some apparent decrease of the area covered by this habitat type over the last decade, it is presently the dominant habitat at Load Line 10.

The decrease in the shrubland is also attributable to plant succession. In general, the shrubland habitat that has been lost has been replaced by the forest and woodland habitat described below.

The shrubland areas occur in the eastern half of Load Line 10 between the AOC boundary and the perimeter road that encircles the old load line (Photograph 7-1). Despite the cessation of continued disturbance from periodic mowing and recent demolition activities, shrubs and small trees remain at the AOC. Many of the shrub species are colonial and spread by vegetative propagation. Common species include various willows (*Salix* spp.), gray dogwood (*Cornus racemosa*), autumn olive (*Elaeagnus umbellata*), blackberry (*Rubus allegheniensis*), hawthorn (*Crataegus* spp.), and multiflora rose (*Rosa multiflora*).

The increase in forested area is attributed primarily to plant succession as young tree species in the upland shrubland habitat grow into mature trees. The dominant forest tree species include red maple (*Acer rubrum*), quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and black locust (*Robinia pseudoacacia*). The forested areas occur in the northern half of Load Line 10, primarily between the boundary and the roadway that encircles the old load line, and in a small area in the southwest corner of the AOC. Currently, the extent of forested habitat at Load Line 10 is second only to herbaceous field habitat. The forest includes small open areas and an understory that results in multi-story vegetation. This, in turn, provides layers of vegetation for various foraging height preferences of birds, mammals, insects, and other organisms.

Similarly, the changes in woodland habitat are attributable to plant succession from shrubland to a habitat consisting of widely scattered larger trees with an open, herbaceous understory (Photograph 7-2). The dominant woodland trees include apple (*Malus* spp.) and green ash (*Fraxinus pennsylvanica*). The apple trees may be remnants of an old orchard that predates RVAAP. The woodland community is present in a small area along the southwestern corner of the AOC between the boundary and perimeter road.

The habitats at Load Line 10 were assessed to be healthy and functioning, based on May 2010 (Photographs 7-1 and 7-2) observations by Leidos biologists. Functional habitat was determined by noting the absence of large bare spots and dead vegetation or other obvious visual signs of an unhealthy ecosystem. Additional habitat photographs are provided in Appendix H.

Photograph 7-1. Load Line 10 Shrubland Vegetation
(facing east from access road on May 20, 2010)

Photograph 7-2. Load Line 10 Forest Vegetation
(facing west from access road on May 20, 2010)

Threatened and Endangered and Other State-listed or Federally-listed Species. There are currently no federally listed species or critical habitats on Camp Ravenna. Load Line 10 has not been previously surveyed for federal or state-listed species; however, there have been no documented sightings of state-listed, federally listed, threatened, or endangered species at the AOC (OHARNG 2008).

Other Terrestrial Resources. While there are no other known important features, there are other resources at or near Load Line 10 (e.g., vegetation, animals) that interact in their ecosystems and support nutrient cycling and energy flow. For example, wildlife such as wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*) could use the area. The INRMP provides information about species and habitat surveys at Camp Ravenna (e.g., timber and ecological succession) (OHARNG 2008). Aside from the natural resource map in the INRMP (OHARNG 2008) as shown in Figure 7-2, there are no other reported surveys of habitats and animals at Load Line 10.

Aquatic Resources. Load Line 10 has few aquatic resources. Although there are no ponds, streams, or wetlands identified, there are drainage ditches within Load Line 10.

Habitat Descriptions and Species. As noted, there is only one type of known aquatic resource at Load Line 10. Intermittent surface water flows in small drainage ditches bordering the roads and within the former production area (Figure 3-1). During most of the year, there is no water in the drainage ditches. Precipitation data from Camp Ravenna are provided in Section 3.5. The storm frequency is 35 days per year, and precipitation occurs 154 days per year. This is not sufficient to create and maintain aquatic habitat at Load Line 10, as evidenced by the lack of such habitat.

Wetlands. A wetland survey has not been conducted at Load Line 10; however, there was no evidence of a wetland during the field survey conducted by SAIC biologists at Load Line 10 in May 2010. In addition, there are no wetlands identified for Load Line 10 in the INRMP (OHARNG 2008).

Threatened and Endangered and Other State-listed or Federally Listed Species. There are currently no federally listed species or critical habitats on Camp Ravenna. Load Line 10 has not been previously surveyed for federal or state-listed species; however, there have been no documented sightings of state-listed, federally listed, threatened, or endangered species at the AOC (OHARNG 2008).

Other Aquatic Resources. There are no other known aquatic resources at Load Line 10.

Ecosystem and Landscape Roles and Relationships. There are four spatial areas evaluated to assess the ecosystem and landscape roles and relationships at Load Line 10: the actual AOC, the vicinity of the AOC, the entire Camp Ravenna, and the northeastern or ecoregion of Ohio. Information about the first spatial area (the actual AOC) was provided in the section above on terrestrial and aquatic resources.

Vicinity of the AOC. Four vegetation communities border Load Line 10 (Figure 7-2) and include a variety of herbaceous field, shrubland, and forest communities similar to the vegetation observed at Load Line 10. There are no apparent differences in habitat quality of these plant communities inside or outside of the AOC. For example, the herbaceous field and shrubland vegetation types occur at adjacent AOCs Load Line 5 and Load Line 9, respectively. In addition, the red maple (*Acer rubrum)* forest and the mixed and cold-deciduous successional forest occur in all four directions for many hundreds of feet from the outer edge of the habitat area. The types and qualities of habitat are not unique to Load Line 10 and can be found at many other areas at Camp Ravenna.

The nearest streams are a tributary to Sand Creek approximately 1,875 ft to the north and an unnamed stream approximately 1,000 ft to the south of Load Line 10. There are no known wetlands in Load Line 10 (Figure 7-2). However, there are three small wetlands near the AOC: one small wetland is directly south of the southern boundary, another is near the southeast border, and another is 300-400 ft from the southwest boundary. By definition, a wetland is considered an important ecological resource (BTAG 2005); however, the wetlands are located far enough from the AOC that they are unlikely to be impacted by contamination present at Load Line 10. There is no known connection between Load Line 10 and any off-site wetlands.

The closest recorded federal or state-listed species [Eastern box turtle (*Terrapene carolina*)] is located approximately 400 ft west of the AOC (Table 7-12) (OHARNG 2008); it is a state species of concern.

The next closest federal or state-listed species [yellow-bellied sapsucker (*Sphrapicus varius*)] is located about 3,000 ft southeast of the AOC; it is a state endangered species.

No beaver dams, 100 year floodplains, or biological/water quality sampling stations are in or near the AOC. The nearest resources of these types are more than 400 ft away, and the existence of beaver dams may be ephemeral.

Table 7-12. Survey of Proximity to the AOC of Various Ecological Resources

Natural Resource	Inside Habitat Area	Near the AOC	Distances to Nearest Resource[a] and Comments
Wetlands (Planning Level Survey and Jurisdictional)	Not surveyed, none known	Yes – along SE border and 100 ft S	Others around 300-400 ft and greater distances, SW
Federal or state-listed species	No known sightings	None	400 ft W 3,000 ft SE See text for species names
Beaver dams	None	None	Nearest beaver dams located 1,100 ft N and 1,000 ft NW
100-year floodplain	None	None	2,500 ft NE
Stream sampling[b]	None	None	Nearest stream station located about 2,400 ft NE
Pond sampling[b]	None	None	Nearest pond station located about 4,500 ft SE

[a] Measurements of distance and direction are taken from the nearest boundary of the AOC to the resource being measured.
[b] Stream and pond sampling refers to Facility-Wide Biological and Water Quality Study 2003 (USACE 2005a).
AOC = Area of Concern.

The Entire Camp Ravenna. Load Line 10 is approximately 36 acres in size. This represents approximately 0.17% of the entire area of Camp Ravenna (21,683 acres in size). There are approximately 5,780 acres of forest types FU2 and FU4 (American beech, maple, oak forest alliance and red maple successional forest) based on the INRMP map (OHARNG 2008), representing 21.6% of the forest vegetation types at Camp Ravenna. There are approximately 1,940 acres of herbaceous field (HU1) and 3,120 acres of cold deciduous shrubland (SL1 and SU1) (OHARNG 2008), representing 8.9% and 14.4%, respectively, of the herbaceous and shrubland vegetation types. Thus, these types of resources are abundant and are not unique to Load Line 10.

Ecoregion. In the area surrounding Camp Ravenna, forests occupy a high percentage of the terrain. For example, Ohio's forests cover approximately 8,000,000 acres or 30% of the state (USDA 2009).

The Erie/Ontario Drift and Lake Plain ecoregion (USEPA 2011), located in northeastern Ohio, contains communities of forest alliance [American beech (*Fagus grandfolia*), maple (*Acer spp.*), and oak (*Quercus spp.*), red maple (*Acer rubrum*)], successional forest/herbaceous field [goldenrod (*Solidago spp.*)], and cold-deciduous shrubland [eastern cottonwood (*Populus deltoides*)]. This ecoregion is made up of rolling to level terrain and low lime drift and lacustrine deposits. Lakes, wetlands, and swampy streams occur where stream networks converge or where the land is flat and clayey (USEPA 2011). The same ecoregion and forest alliance is found throughout northeastern Ohio and also in Cuyahoga, Geauga, Mahoning, Portage, Stark, Summit, and Trumbull counties that surround Camp Ravenna. The U.S. Forest Service (USFS) has a Forest Inventory Data Online tool that was queried for the forest alliance in the surrounding counties in or near Camp Ravenna (USFS 2011). In 2009, approximately 527,200 acres of forest types FU2 and FU4 (American beech, maple, oak forest alliance, and red maple successional forest) and approximately 24,100 acres of cold deciduous shrubland SL1 and SU1 (e.g., eastern cottonwood and willow) were found throughout Ohio and also in Cuyahoga, Geauga, Mahoning, Portage, Stark, Summit, and Trumbull counties that surround Camp Ravenna. The herbaceous field HU1 (e.g., goldenrod) was not individually found in this query but is assumed to be common across the ecoregion due to favorable temperatures and terrain. Thus, the vegetation communities at Load Line 10 are also found in the ecoregion of northeastern Ohio.

In summary, the forest alliance, successional forest, herbaceous field, and cold-deciduous shrubland are found at and in the vicinity of Load Line 10. These vegetation types are in abundance at Camp Ravenna and the larger surrounding local ecoregion. Thus, there is no known unique resource at Load Line 10 that cannot be found in the immediate vicinity of the AOC, Camp Ravenna, or in a large part of the ecoregion of Northeastern Ohio.

7.3.2.4 Evaluation of Historical Chemical Contamination and Ecological Significance

There are 11 historical COPECs identified in the historical ERA as part of the Characterization of 14 AOCs: aluminum, arsenic, chromium, iron, lead, mercury, nickel, selenium, zinc, dibenzofuran, and 2,6-DNT (Section 7.3.2.2). Section 7.3.2.3 provides information about the lack of important/significant ecological resources at the AOC. There are no known wetlands, federal or state-listed species, or other important/significant ecological resources, as defined by the U.S. Army and Ohio EPA. Section 7.3.2.6 summarizes the chemicals and resources to demonstrate there is contamination but no important/significant ecological resources at Load Line 10.

7.3.2.5 Evaluation of Chemical Contamination

This section provides information about methods and results of the analysis of current and historical chemical contamination.

The screening level approach to evaluate sample results from the PBA08 RI followed a similar approach as used in the historical ERA. Section 5.1 details chemical concentration data. The PBA08 RI evaluation uses ISM soil data collected during the PBA08 RI, ISM soil data used in the historical ERA, and ISM soil data collected during the Investigation of Under Slab Surface Soils (USACE 2009a). The PBA08 RI included collecting surface soil (0-1 ft bgs) samples at locations different from the historical soil sample locations (Figure 4-3).

This ERA uses updated sediment reference values (SRVs) (Appendix Table H-4) and ESVs that follow the revised *Ecological Risk Assessment Guidance* (Ohio EPA 2008), as provided in Appendix

Tables H-5, H-6, and H-7. MDC to ESV ratios are used to determine the integrated COPECs that result from the combined current and historical data sets. A ratio greater than 1 suggests a possible environmental consequence.

Any chemicals with ratios greater than 1 are identified as integrated COPECs. Also, a PBT compound becomes an integrated COPEC.

Integrated COPECs in Surface Soil (0-1 ft bgs). Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs, as described in Section 5.1. A total of 17 inorganic chemicals and 35 organic chemicals were determined to be SRCs because the detected chemicals either exceeded background concentrations or did not have an associated background concentration for comparison. Of the 52 SRCs, 11 detected concentrations of inorganic chemicals and five organic chemicals exceeded the ESVs. These SRCs are identified as integrated COPECs (Table 7-13). In addition, seven organic chemicals were selected as COPECs because they do not have an ESV. Four of these 23 soil COPECs are also PBT compounds (mercury, PCB-1254, alpha-chlordane, and gamma-chlordane). The calculated ratio of MDC to ESV is shown in Table 7-13 for each integrated COPEC. Table H-8 in Appendix H presents the detailed ESV comparisons for surface soil.

Most COPECs reported in the historical ERA (Table 7-11) are also identified in the current ERA. The earlier work (Characterization of 14 AOCs) identified two COPECs (iron and nickel) that are not integrated COPECs. Nickel was below the new ESV (Ohio EPA 2008, Appendix Table H-5) and iron was considered an essential nutrient in the new data set. A total of 14 new COPECs [antimony, cadmium, cobalt, copper, 3-nitrotoluene, nitrocellulose, nitroglycerin, tetryl, benzo(a)pyrene, carbazole, naphthalene, PCB-1254, alpha-chlordane, and gamma-chlordane] are identified in the PBA08 RI. The addition of antimony, cadmium, cobalt, and copper is due to updated, more conservative ESVs. Benzo(a)pyrene was detected at a higher concentration during the PBA08 RI that is greater than the ESV. The remaining explosives, SVOCs, and pesticides/PCBs were not detected and/or not analyzed in the historical ERA.

Integrated COPECs in Sediment. The PBA08 RI included one sediment sample in a drainage ditch near the southern AOC boundary (Figure 4-3). Detected chemical concentrations were compared to the sediment background concentration, SRVs, and ESVs (Appendix H, Table H-9), and the results are summarized in Table 7-14. Three integrated COPECs (mercury, nitroguanidine, and 3+4-methylphenol) were identified in sediment. Nitroguanidine is an integrated COPEC because it does not have an ESV, while 3+4-methylphenol exceeded its ESV. Mercury is below its ESV, but it is included as a PBT compound per Ohio EPA (2008). No sediment samples were collected during the historical ERA; therefore, no comparison to historical results is available. Available data (Section 5.2.5) showed no concentration increase of integrated COPECs at off-site sampling station.

Table 7-13. Summary of Integrated COPECs for Surface Soil

COPEC[a]	Maximum Concentration (mg/kg)	ESV (mg/kg)	Ratio of Maximum to ESV	Comments
Aluminum	22,000	50	440	Highest ratio at 440X
Antimony	2.5	0.27	9.26	None
Arsenic	20	18	1.11	None
Cadmium	0.89	0.36	2.47	None
Chromium	33	26	1.27	None
Cobalt	14.7	13	1.13	None
Copper	42	28	1.5	None
Lead	430	11	39.09	Third highest ratio at nearly 40X
Mercury	0.1	0.00051	196.08	Second ratio at nearly 200X; PBT compound
Selenium	1.8	0.52	3.46	None
Zinc	220	46	4.78	None
2,6-Dinitrotoluene	0.14	0.0328	4.27	None
3-Nitrotoluene	0.025	No ESV	--	None
Nitrocellulose	4	No ESV	--	None
Nitroglycerin	0.6	No ESV	--	None
Tetryl	0.035	No ESV	--	None
Benzo(a)pyrene	3.3	1.52	2.17	None
Carbazole	1.4	No ESV	--	None
Dibenzofuran	0.97	No ESV	--	None
Naphthalene	1.2	0.0994	12.07	None
PCB-1254	0.024	No ESV	--	PBT compound
alpha-Chlordane	0.3	0.224	1.34	PBT compound
gamma-Chlordane	0.23	0.224	1.03	PBT compound

[a] Excludes essential nutrients.
COPEC = Chemical of Potential Ecological Concern.
ESV = Ecological Screening Value.
PBT = Persistent, Bioaccumulative, and Toxic.
mg/kg = Milligrams per kilogram.
PCB = Polychlorinated Biphenyl.
X = Multiplier.
-- = No ESV available to calculate rations.

Table 7-14. Summary of Integrated COPECs for Sediment

COPEC	Maximum Concentration (mg/kg)	ESV (mg/kg)	Ratio of Maximum to ESV	Comments
Mercury	0.049	0.18	0.27	PBT compound
Nitroguanidine	0.32	No ESV	--	None
3+4-Methylphenol	0.032	0.0202	1.58	None

COPEC = Chemical of Potential Ecological Concern. Table excludes nutrients.
ESV = Ecological Screening Value.
mg/kg = Milligrams per kilogram.
PBT = Persistent, Bioaccumulative, and Toxic.
-- = No ESV available to calculate rations.

Integrated COPECs in Surface Water. There is intermittent surface water in a drainage ditch at Load Line 10. The PBA08 RI included one surface water sample near the southern AOC boundary (Figure 4-3). Surface water ESVs are published in Appendix H, Table H-7. Detected chemical concentrations were compared to the surface water background concentration and ESVs (Appendix H, Table H-10). Beta-BHC was identified as an integrated COPEC due to its PBT status per Ohio EPA (2008), although it did not exceed its ESV (MDC to ESV ratio was 0.02). No surface water samples were collected during the historical ERA; therefore, no comparison to the historical results is available. Available data (Section 5.2.6) showed no increase in concentration of the COPECs at an off-site sampling station.

Summary of ERA Findings. There are 23 integrated COPECs identified in soil at Load Line 10: aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, selenium, zinc, 2,6-DNT, 3-nitrotoluene, nitrocellulose, nitroglycerin, tetryl, benzo(a)pyrene, carbazole, dibenzofuran, naphthalene, PCB-1254, alpha-chlordane, and gamma-chlordane. There are three integrated COPECs identified in sediment at Load Line 10: mercury, nitroguanidine, and 3+4-methylphenol. Beta-BHC was identified as an integrated COPEC in surface water as it is a PBT compound.

7.3.2.6 Summary and Conclusions of the Scoping Level Ecological Risk Assessment

Based on the results of the screening level ERA, there are 23 integrated soil COPECs at Load Line 10. These COPECs consist of inorganic chemicals, explosives, PCBs, pesticides, and SVOCs. There are three integrated COPECs (mercury, nitroguanidine, and 3+4-methylphenol) identified in sediment at Load Line 10. Beta-BHC was identified as an integrated COPEC in surface water as it is a PBT compound. Thus, there is contamination present at Load Line 10.

The information in Section 7.3.2.3 regarding ecological resources at Load Line 10 was compared to the list of important ecological places and resources (Appendix Table H-2). None of the 39 important places were present, and there is nothing ecologically significant at Load Line 10. Environmental management goals and objectives of OHARNG are applicable to Load Line 10, as presented in Appendix Table H-3. Some of the management goals benefit Load Line 10, including Goal 1, which requires management of natural resources to be compatible with military mission. Goal 5 requires the U.S. Army to sustain usable training lands and native natural resources by implementing a natural resource management plan which incorporates invasive species management and utilizes native species mixes for revegetation after ground disturbance activities.

Load Line 10 is approximately 36 acres and is vegetated with dry, early-successional, herbaceous field; dry, mid-successional, cold-deciduous, shrubland; *Acer rubrum* successional forest; and *Malus* spp./*Fraxinus pennsylvanica* woodland. These same types of habitats are found adjacent to the AOC and elsewhere at Camp Ravenna (OHARNG 2008). The habitats are also found in the larger, local ecoregion that surrounds Camp Ravenna (USFS 2011). Thus, there is no known unique resource at Load Line 10.

Although there is contamination at Load Line 10, the AOC has no known important/significant ecological places or resources. Consequently, the ERA can conclude with a Level I Scoping Level Risk Assessment that NFA is necessary to protect important ecological receptors at Load Line 10.

7.3.3 Conclusions

There is chemical contamination present at Load Line 10 based on the results presented in this RI. The screening level ERA identified 23 integrated soil COPECs, three integrated sediment COPECs, and one integrated surface water COPEC at Load Line 10. Based on the 39 criteria defining important places as identified by the U.S. Army and Ohio EPA, no important/significant ecological resources were identified at the AOC. The vegetation types present at Load Line 10 are also found elsewhere near the AOC, at Camp Ravenna, and in the ecoregion. Therefore, there is sufficient justification for a conclusion of NFA for Load Line 10 from the ecological perspective.

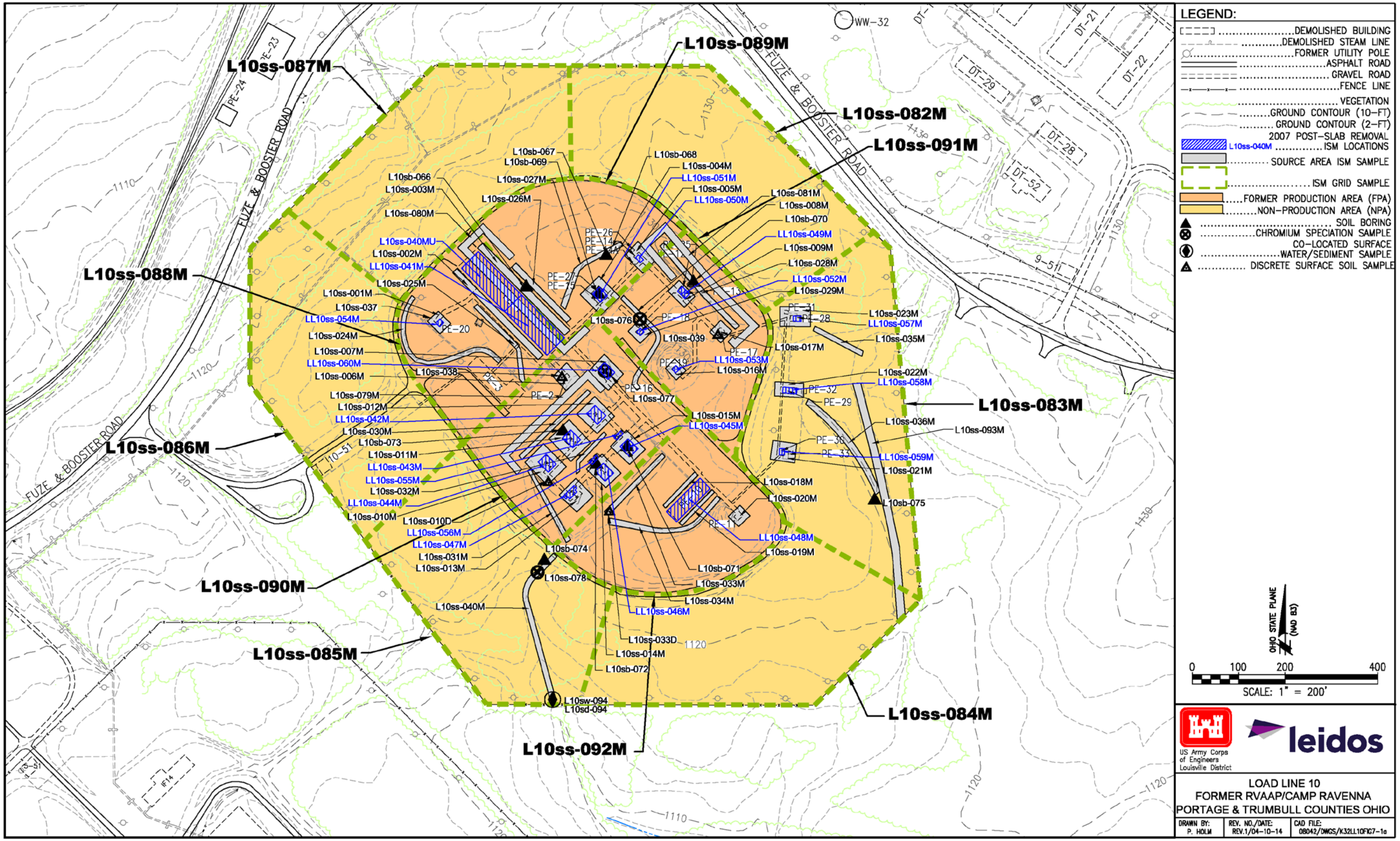


Figure 7-1. Load Line 10 Exposure Units

THIS PAGE INTENTIONALLY LEFT BLANK.

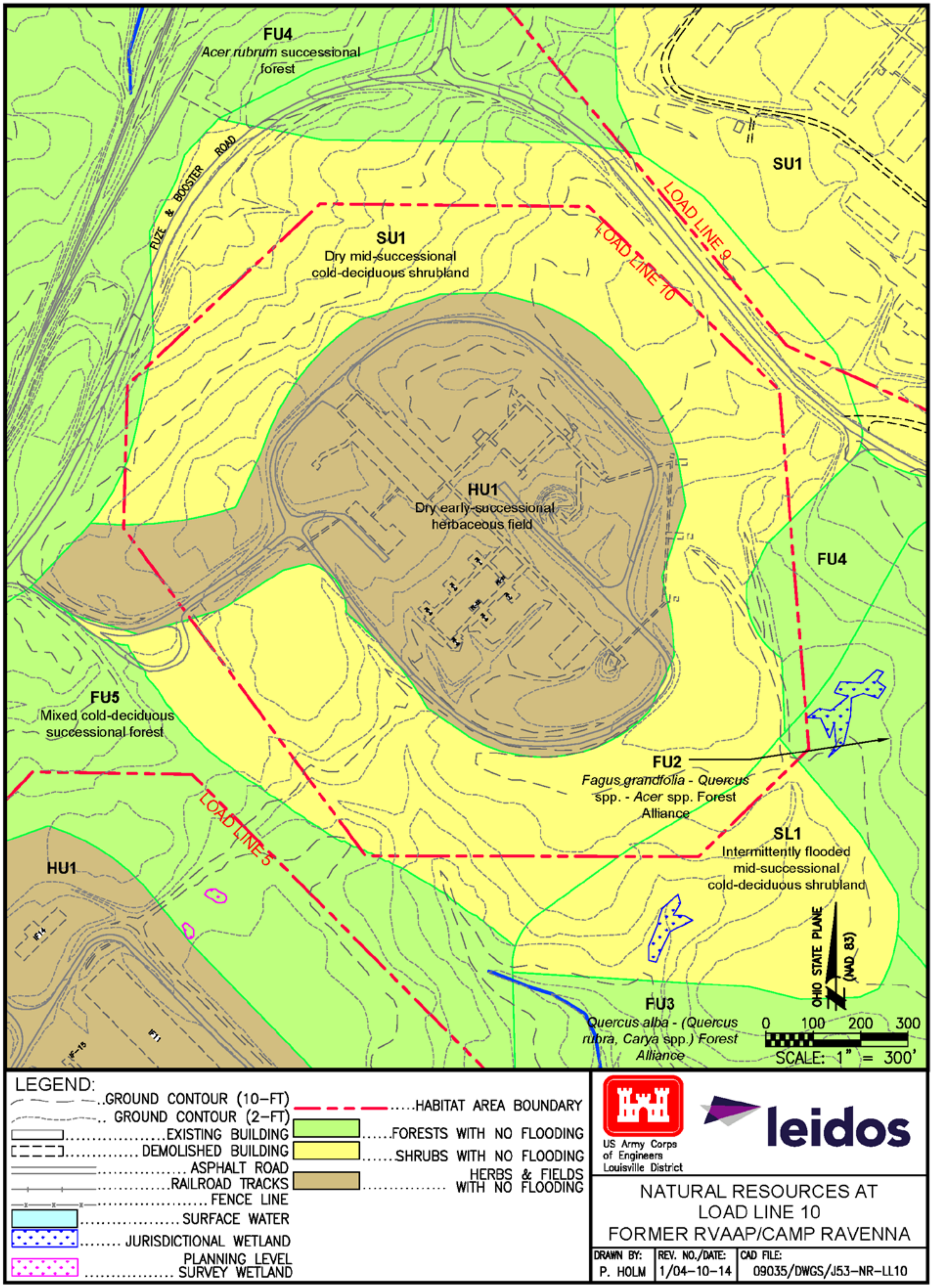


Figure 7-2. Natural Resources (OHARNG 2008) Inside and Near Habitat Area at Load Line 10

THIS PAGE INTENTIONALLY LEFT BLANK.

8.0 REMEDIAL INVESTIGATION CONCLUSIONS

8.1 INTRODUCTION

The RI Report for Load Line 10 presents a detailed analysis of historical and newly acquired environmental data. The following sections summarize the major findings of the nature and extent of contamination, modeling of contaminant fate and transport, HHRA, and ERA. An updated CSM incorporating all available information is presented to integrate results of prior investigations and the PBA08 RI. The CSM denotes, based on available data, where source areas occur, the mechanisms for contaminant migration from source areas to receptor media (e.g., surface water and groundwater), exit pathways from the AOC, and whether COCs occur that may require further evaluation in an FS. This section presents the need for any further characterization of the media evaluated under the RI phase of work and whether to proceed to the FS phase of the CERCLA RI/FS process.

8.2 SUMMARY OF DATA USED IN THE REMEDIAL INVESTIGATION

Available quality-assured data for Load Line 10 represent conditions of the AOC over a span of approximately five years and were collected using ISM and discrete sampling methods. Data were collected during the 2004 Characterization of 14 AOCs (MKM 2007), 2007 Investigation of Under Slab Surface Soils (USACE 2009a), and the 2010 PBA08 RI. Physical conditions at the AOC, particularly within the former production area, changed during the time between the 2004 Characterization of 14 AOCs and 2007 Investigation of Under Slab Surface Soils due to building demolition actions completed in 2006. PBA08 RI samples were collected using ISM (surface soil) and discrete (subsurface soil, sediment, surface water) methods to be consistent with the population of historical samples and allow evaluation of equivalent data.

A systematic process was used to evaluate data usability for the RI Report based on project DQOs, data age and representativeness with respect to current AOC conditions, and sampling methods. The data usability evaluation focused particularly on whether samples from the Characterization of 14 AOCs were representative of current conditions, due to such factors as soil disturbance or removal during building demolition and re-grading of construction areas following demolition. Section 5.1.4 presents the results of the data usability evaluation for all available Load Line 10 samples; a summary is presented below.

All data collected during the 2004 Characterization of 14 AOCs, 2007 Investigation of Under Slab Surface Soils, and 2010 PBA08 RI investigations were deemed usable for this report. For surface soil, all available ISM samples (with the exception of field duplicate samples) were included in data screening to identify SRCs, contaminant nature and extent, contaminant fate and transport, and in the risk assessments. Discrete surface soil samples associated with ISM samples, which were used for VOC analysis, were also included in all RI evaluations.

Use of certain surface soil samples was limited to only nature and extent evaluation and analysis of temporal trends. These surface soil sample types, which are not included in quantitative data screening (i.e., identification of SRCs) or risk assessment calculations, included ISM and discrete field duplicate samples from all investigations, discrete samples from PBA08 RI soil borings (0-1 ft bgs interval), and discrete samples collected for chromium speciation analyses.

For subsurface soil, only PBA08 RI discrete sample data were available and are included (with exception of field duplicate samples) for all evaluations performed in this RI Report. For sediment and surface water, only PBA08 RI discrete sample data were available and were included for all evaluations performed in this RI Report.

8.3 SUMMARY OF NATURE AND EXTENT

The Characterization of 14 AOCs, Investigation of Under Slab Surface Soils, and PBA08 RI data provide effective characterization of the nature and extent of the contamination at the AOC, and no further sampling is required.

The predominant SRCs in surface and subsurface soil at Load Line 10 were PAHs, which were observed in all surface soil samples analyzed across the entire AOC. Inorganic chemicals were also observed in soil at concentrations above their respective background concentrations throughout the AOC. A limited number of SRCs were observed in sediment and surface water, relative to soil at Load Line 10. Detections of explosives, propellants, VOCs, pesticides, and PCBs were limited in frequency. A summary of observations for each medium is presented below.

8.3.1 Surface Soil

The predominant SRCs for surface soil (52 total SRCs) at Load Line 10 were inorganic chemicals (17 SRCs) and SVOCs (23 SRCs), the majority of which were PAHs. The occurrence and distribution of inorganic SRCs above background concentrations in surface soil is generally widespread, and notable spatial patterns are not evident for most SRCs, except in the former Building PE-1 vicinity. Five inorganic chemicals were detected at their maximum concentrations at historical sample location L10ss-002M, adjacent to the former Building PE-1.

Concentrations of PAHs detected across the entire AOC are generally higher in samples taken from areas of Load Line 10 where buildings, roads, and parking areas were present than in more remote areas of the AOC. The highest concentrations of PAH SRCs are observed at PBA08 RI sample location L10ss-080M in the vicinity of former Building PE-1. Petroleum staining was noted in a soil boring during installation of nearby and downgradient monitoring well L10mw-001 under the 2004 historical investigation; however, no staining was observed in any other historical or in any PBA08 RI samples. No PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

All detected concentrations of explosives, propellants, pesticides, VOCs, and PCBs were below laboratory reporting limits.

8.3.2 Subsurface Soil

A total of 33 SRCs were identified in subsurface soil at Load Line 10, the majority of which were SVOCs (15 of 19 SVOCs were PAHs). The maximum detections for all 15 PAHs were observed at L10sb-071 in the 1.0-4.0 ft bgs interval; all 15 PAHs were also detected in the 4.0-7.0 ft bgs interval at this soil boring location at lower concentrations. Soil boring L10sb-071 was located in the footprint of former Building PE-7. The AOC has no historical operations or CERCLA-release related sources that would contribute to the PAHs detected at the AOC.

Eight inorganic chemicals were identified as SRCs. Elevated inorganic chemicals (particularly lead) occurred predominantly at two soil boring locations, L10sb-066 and L10sb-071. L10sb-066 is associated with the former Building PE-1. Construction debris including brick and gravel were observed in boring L10sb-071 that was terminated at 6.5 ft bgs due to concrete refusal. No propellants, PCBs, or pesticides were detected in subsurface soil at Load Line 10. All detected concentrations of explosives and VOCs were below the laboratory reporting limit.

8.3.3 Sediment

One discrete sediment sample was collected at Load Line 10 from the main ditch draining to the southwest of the AOC during the PBA08 RI and was compared to off-AOC facility-wide samples to assess if the AOC has impacted conditions downstream.

A total of 12 SRCs were identified in sediment at Load Line 10, the majority of which were PAHs that were all below laboratory reporting limits. All SVOC SRCs, with the exception of 3+4-methylphenol, were also identified as SRCs in surface soil. Three inorganic chemicals (antimony, beryllium, and cadmium) were identified as SRCs in sediment and are also SRCs for other media. One VOC (toluene) and one propellant (nitroguanidine) were identified as SRCs, but not identified in any other media. No explosives, pesticides, or PBCs were identified as SRCs.

Only two SRCs (antimony and beryllium) were identified in sediment at the off-AOC sediment sample location (FWSsd-102). Both were detected at the upstream location at similar concentrations; however, there appears to be no migration of sediment SRCs from Load Line 10 to the off-AOC location. Additionally, any PAH contamination within the Load Line 10 AOC has not migrated off site as sediment.

8.3.4 Surface Water

Six of the seven SRCs identified in surface water at Load Line 10 were inorganic chemicals. The concentrations of these chemicals were below laboratory reporting limits, and these chemicals were identified as SRCs because their background concentrations are 0 mg/kg. All of the inorganic SRCs for Load Line 10 surface water were detected at higher concentrations in the downstream off-AOC sample location. One pesticide (beta-BHC) identified as an SRC was detected at a concentration below the laboratory reporting limit, but was not detected at the downstream off-AOC location. No explosives, propellants, SVOCs, VOCs, or PCBs were identified as SRCs in surface water at Load Line 10, and none were detected at off-AOC location FWSsw-102.

8.4 SUMMARY OF CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport evaluation (Section 6.0) included analysis of two contaminant migration pathways: (1) leaching and migration from soil to groundwater; and (2) partitioning of contaminants from sediment to surface water within the main drainage ditch exiting the AOC, with transferal to groundwater through surface water/groundwater interaction.

Maximum concentrations of SRCs identified in surface and subsurface soil were evaluated using a series of generic screening steps to identify initial CMCOPCs. These CMCOPCs for soil were further evaluated using the SESOIL model to predict leaching concentrations and identify final CMCOPCs based on RVAAP facility-wide background criteria and the lowest risk-based screening criteria among USEPA MCLs, USEPA tap water RSLs, or RVAAP groundwater FWCUGs for the Resident Receptor Adult. Final CMCOPCs were evaluated using the AT123D model to predict groundwater mixing concentrations beneath source areas and concentrations at the nearest downgradient groundwater receptor to the AOC (e.g., stream). Maximum SRC concentrations in sediment were evaluated using an analytical solution to identify final CMCOPCs for evaluation using AT123D. The AT123D modeling results were evaluated with respect to AOC groundwater monitoring data, as well as model limitations and assumptions, to identify chemicals to be retained as CMCOCs that may warrant further evaluation in an FS.

Conclusions of the soil and sediment screening, leachate modeling, and groundwater modeling are as follows:

- The AT123D model predicted maximum future groundwater concentrations for the final soil CMCOPCs alpha-chlordane, gamma-chlordane, PETN, 3-nitrotoluene, 4-amino-2,6-DNT, 2,6-DNT, phenantherene, naphthalene, dibenzofuran, 2-methylnaphthalene, and selenium exceed groundwater screening criteria beneath soil source areas, but do not exceed groundwater screening criteria at the downgradient receptor location (unnamed tributary to Sand Creek 1,875 ft north of the AOC). Predicted groundwater concentrations of the final sediment CMCOPCs cadmium, benz(a)anthracene, benzo(b)fluoranthene, and nitroguanidine also do not exceed groundwater screening criteria at the downgradient receptor location (unnamed tributary 1,000 ft south of the AOC).
- Evaluation of modeling results with respect to current AOC groundwater data and model limitations indicate that identified CMCOPCs are not currently impacting groundwater beneath the source areas and that modeling assumptions are conservative. Evaluation of predicted breakthrough curves show peak concentrations for PAHs would have occurred in the past. Potential future impacts predicted by the model for remaining CMCOPCs would likely be mitigated by factors such as chemical and biological degradation, lateral dispersivity, and AOC-specific variations soil geochemistry.

All SRCs identified in the surface soil, subsurface soil, and sediment at Load Line 10 were evaluated through the stepwise fate and transport evaluation. All SRCs were eliminated as posing future impacts to groundwater, and NFA is necessary for surface soil, subsurface soil, and sediment to protect groundwater.

8.5 SUMMARY OF THE HUMAN HEALTH RISK ASSESSMENT

The HHRA identified COCs and conducted risk management analysis to identify COCs requiring potential remediation based on potential risks to human receptors. Camp Ravenna is a controlled access facility. Load Line 10 is located in the south central portion of the facility and is not currently used for training. The future use of the AOC is Military Training. An evaluation using Resident Receptor (Adult and Child) FWCUGs was used to evaluate the Unrestricted (Residential) Land Use. Unrestricted (Residential) Land Use is considered protective for all categories of Land Use on the former RVAAP/Camp Ravenna.

Media of concern evaluated in the HHRA are surface soil (0-1 ft bgs), subsurface soil (1-13 ft bgs), sediment, and surface water. No COPCs, and therefore no COCs, were identified for sediment or surface water at Load Line 10. The only soil (surface and subsurface) COCs identified were four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene], as concentrations of these chemicals in soil either exceeded FWCUGs or contributed to an SOR greater than one. However, no PAHs or PAH-containing materials were used operationally at Load Line 10, and no burning was conducted. Thus, there are no CERCLA-release related sources of PAHs at this AOC.

Evaluation of PAH concentrations associated with common anthropogenic (non-CERCLA) sources using available data from RVAAP background soil samples and other environmental studies of environmental concentrations of PAHs indicate the concentrations reported at Load Line 10 are indicative of releases from common anthropogenic sources such as road dust, vehicle exhaust, tire wear particles, pavement, and slag used as fill. No CERCLA-release related COCs pose an unacceptable risk to human health; therefore no COCs require remediation or evaluation in an FS.

8.6 SUMMARY OF THE ECOLOGICAL RISK ASSESSMENT

The ERA Level I presented important ecological resources on or near the AOC and evaluated the potential for current contamination to impact ecological resources. There are 23 integrated soil COPECs based on the historical and current information at the Load Line 10: aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, selenium, zinc, 2,6-DNT, 3-nitrotoluene, nitrocellulose, nitroglycerin, tetryl, benzo(a)pyrene, carbazole, dibenzofuran, naphthalene, PCB-1254, alpha-chlordane, and gamma-chlordane. There are three integrated COPECs identified in sediment at Load Line 10: mercury, nitroguanidine, and 3+4-methylphenol. Beta-BHC was identified as an integrated COPEC in surface water as it is a PBT compound. Ecological resources at Load Line 10 were compared to the list of important ecological places and resources. None of the 39 important places were present, and there is nothing ecologically significant at Load Line 10. The ERA summarizes the chemicals and resources in detail to demonstrate there is contamination but no important or significant ecological resources at Load Line 10. Consequently, the Level I Scoping Level Risk Assessment concludes that NFA is necessary to be protective of ecological resources.

8.7 UPDATED CONCEPTUAL SITE MODEL

The preliminary CSM for Load Line 10 was summarized in Section 3.7. The CSM is updated in this section to incorporate results of the PBA08 RI. Elements of the CSM include:

- Primary and secondary contaminant sources and release mechanisms;
- Contaminant migration pathways and discharge or exit points;
- Potential receptors with unacceptable risk; and
- Data gaps and uncertainties.

Due to the absence of primary contaminant sources at this AOC, lack of CMCOCs, occurrence of few COCs, and overall simplicity of fate and transport mechanisms, an illustrated summary of the CSM is not included. Previous figures are referenced to assist in visualizing the key summary points of the revised CSM.

8.7.1 Primary and Secondary Contaminant Sources and Release Mechanisms

No primary contaminant sources (e.g., operational facilities) are currently located at the AOC. All buildings were demolished in 2006. Remnant contamination in soil and sediment within the AOC is considered as a secondary source of contamination.

The occurrence and distribution of inorganic SRCs above background concentrations in surface soil is generally widespread and notable spatial patterns are not evident for most SRCs, except in the vicinity of former Building PE-1. A lower number and generally lower concentrations of inorganic SRCs occur in subsurface soil than in associated surface soil. The majority of the SVOCs and SRCs are primarily PAHs and are observed in all surface soil samples analyzed for PAHs across the entire AOC.

Within sediment, RI results indicate surface soil contaminants sourced from Load Line 10, particularly SVOCs, have accumulated within sediment in the main drainage ditch at the exit point from the AOC. However, the majority of these SRCs have not migrated or have attenuated at a distance downstream of the AOC. Inorganic SRC concentrations in sediment were similar between the AOC exit point and an off-AOC sample location about 1,800 ft downstream. No SVOCs, explosives, propellants, pesticides, or PCBs were detected at the off-AOC sediment sample location. The primary mechanisms for release of contaminants from secondary sources at the AOC are:

- Erosion of soil matrices with sorbed contaminants and mobilization in overland surface water storm runoff during heavy rainfall conditions;

- Dissolution of soluble contaminants and transport in perennial surface water conveyances and intermittent surface water runoff;
- Re-suspension of contaminated sediment during periods of high flow with downstream transport within the surface water system; and
- Contaminant leaching to groundwater.

8.7.2 Contaminant Migration Pathways and Exit Points

8.7.2.1 Surface Water Pathways

Migration of contaminants from soil sources via surface water occurs primarily by: (1) movement of particle-bound contaminants in surface water runoff, and (2) transport of dissolved constituents in surface water. In particle-bound contaminant migration, contaminants will be mobilized during periods of high flow (e.g., rain events) and upon reaching portions of surface water conveyances where flow velocities decrease, they will settle out as sediment accumulation. Sediment-bound contaminants may become re-suspended and migrate during storm events or may partition to dissolved phase in surface water. Sediment data from the main ditch indicate accumulation of SRCs within the main drainage ditch to the point where it exits the AOC. Of the SRCs identified at the AOC exit point, none were detected at a downstream location, with the exception of antimony and beryllium, which were detected at comparable concentrations at both locations. The sediment data from the main drainage ditch indicate minimal longitudinal transport and deposition of contaminants from secondary sources within the AOC via this pathway.

In the case of dissolved phase contaminant transport, migration patterns typically reflect a combination of continuous baseflow inputs with superimposed episodic cycles in association with rain events, snow melt, or seasonal precipitation patterns. Such episodic events may temporarily increase dissolved phase contaminant concentrations depending on the source and solubility of SRCs, or they may serve to dilute and decrease contaminant concentrations if a large influx of comparatively non-contaminated water associated with longitudinal concentration trends occurs As noted in Section 3.0, intermittent surface water from a majority of the AOC flows along various small drainage ditches and exits the AOC at the south boundary through the main drainage conveyance. Inorganic SRCs in surface water at the Load Line 10 main ditch exit point had concentrations below laboratory reporting limits (antimony, chromium, cobalt, lead, nickel, and vanadium). The same six inorganic SRCs were detected in the downstream sample location at consistently higher concentrations. Only antimony was identified as an SRC in co-located sediment samples; therefore, partitioning of inorganic chemicals from sediment to surface water was not indicated. Beta-BHC was identified as an SRC in surface water at Load Line 10 at a concentration below laboratory reporting limits, but was not detected at the downstream off-AOC station. Explosives, propellants, SVOCs, VOCs, and PCBs were not identified as SRCs in surface water at the Load Line 10 exit point, and none were detected at the downstream sampling location. The PBA08 RI data evaluation indicates minimal transport of contaminants off of the AOC via this pathway.

8.7.2.2 <u>Groundwater Pathways</u>

The estimated direction of groundwater flow at Load Line 10 is dependent on location with respect to a water table divide that bisects the AOC (Figure 3-1). North of the divide, flow is to the north toward a tributary to Sand Creek. South of the divide, flow is to the south toward based on RVAAP facility-wide potentiometric data. The groundwater table occurs within bedrock throughout a large portion of Load Line 10 at an approximate depth ranging from 14-23 ft bgs, except at the southernmost AOC well that monitors the unconsolidated zone where bedrock is, where the water table is about 10 ft bgs.

Contaminant leaching pathways from soil to the water table are through poorly sorted interbedded silty sand to clayey silt with overall moderate to low hydraulic conductivities ranging from 1.97E-04-1.2E-07 cm/s. Transport modeling indicates four chemicals may leach from soil and migrate to the groundwater table at concentrations exceeding MCLs/RSLs beneath their respective sources (selenium, naphthalene, alpha-chlordane, and gamma-chlordane); however, these chemicals are not predicted to migrate laterally and reach the nearest surface water receptor (Sand Creek at a distance of 1,875 ft) at concentrations exceeding MCL/RSLs. Sediment screening analysis does not indicate any CMCOCs for the sediment to groundwater transport pathway. Based on the modeling results, impacts to surface water features due to migration of contaminants in groundwater are not expected. Further evaluation of groundwater at the AOC will be performed in a separate report for groundwater.

8.7.3 Potential Receptors

As identified in the HHRA, the future use of the AOC is Military Training. An evaluation using Resident Receptor (Adult and Child) FWCUGs was used to provide an Unrestricted (Residential) Land Use evaluation. Unrestricted (Residential) Land Use is considered protective for all categories of Land Use on the Camp Ravenna. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs in soil for the Resident Receptor (Adult and Child). However, these chemicals are not considered to be CERCLA-related. No COCs were identified for sediment or surface water.

Ecological resources at Load Line 10 were compared to the list of important ecological places and resources. None of the 39 important ecological places were present, and there is nothing ecologically significant at Load Line 10.

8.7.4 Uncertainties

Uncertainties are inherent in the CSM depending on the density and availability of data. The CSM for Load Line 10 is overall well-defined using existing data and major data gaps do not remain to be resolved. However, surface water characterization on the AOC is subject to some uncertainty due to the intermittent occurrence of surface water originating within the AOC during precipitation events and exiting along the main drainage ditch to the south. However, the available data do not suggest high contaminant fluxes exiting Load Line 10. Removal of primary contaminants sources (e.g., buildings), grading, and continuing vegetation succession within those areas has likely resulted in a lower overall degree of soil erosion and contaminant migration from the former operations area.

8.8 CONCLUSIONS OF THE REMEDIAL INVESTIGATION

Historical investigations and the PBA08 RI have adequately characterized Load Line 10. Further investigation is not warranted at this AOC for the following reasons: (1) the nature and extent of impacted media has been sufficiently characterized; (2) the fate and transport modeling did not identify soil CMCOCs requiring further evaluation or remediation to protect groundwater; (3) there are no CERCLA-release related human health COCs identified in soil, sediment, or surface water requiring further evaluation in an FS or remediation; and (4) remedial actions to protect ecological resources are not warranted. Accordingly, NFA is necessary for soil, sediment, and surface water at Load Line 10 to attain Unrestricted (Residential) Land Use.

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, since Load Line 10 meets the requirements for Unrestricted (Residential) Land Use, the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation. As stated in Paragraph 6.d of the Technical Memorandum, since this RI Report was in progress at the time of the Technical Memorandum's approval on February 11, 2014 and Load Line 10 achieves NFA for Unrestricted (Residential) Land Use, this report is not required to include an evaluation of the Commercial/Industrial Land Use.

The next step in the CERCLA process is to prepare a PP to solicit public input with respect to NFA for soil, sediment, and surface water. This PP will provide a brief summary of the history, characteristics, risks, and the basis for NFA. Comments on the PP received from state and federal agencies and the public will be considered when preparing a ROD to document the final remedy. The ROD will also include a responsiveness summary addressing comments received on the PP.

THIS PAGE INTENTIONALLY LEFT BLANK.

9.0 AGENCY COORDINATION AND PUBLIC INVOLVEMENT

The U.S. Army is the lead agency responsible for executing the CERCLA process and for ultimately completing an approved ROD for soil, sediment, and surface water at Load Line 10. This section reviews actions that have been conducted and presents activities that are planned to ensure the regulatory agencies and members of the public have been provided with appropriate opportunities to stay informed of the progress of the Load Line 10 environmental investigation, restoration efforts, and final selection of a remedy.

9.1 STATE ACCEPTANCE

State acceptance considers comments received from agencies of the state of Ohio on the proposed remedial alternatives. Ohio EPA is the lead regulatory agency for supporting the remedy for soil, sediment, and surface water at Load Line 10. This RI Report has been prepared in consultation with the Ohio EPA.

Ohio EPA has provided input during the ongoing investigation and report development to ensure the remedy ultimately selected for Load Line 10 is protective of human health and the environment and fulfills the requirements of the DFFO (Ohio EPA 2004). Ohio EPA provided comments on this RI Report and will also provide comments on the subsequent PP and ROD. The U.S. Army will obtain Ohio EPA concurrence prior to selecting a final remedy for soil, sediment, and surface water at the AOC.

9.2 COMMUNITY ACCEPTANCE

Community acceptance considers comments provided by community members. CERCLA 42 U.S.C. 9617(a) emphasizes early, constant, and responsive community relations. The U.S. Army has prepared a Community Relations Plan (USACE 2003b) to facilitate communication between Camp Ravenna and the community surrounding Ravenna, Ohio during environmental investigations and potential remedial actions. The plan was developed to ensure the public has convenient access to information regarding project progress. The community relations program interacts with the public through news releases, public meetings, public workshops, and Restoration Advisory Board meetings with local officials, interest groups, and the general public.

CERCLA 42 U.S.C. 9617(a) requires an Administrative Record to be established “at or near the facility at issue.” Relevant documents have been made available to the public for review and comment. The Administrative Record for this project is available at the following location:

Camp Ravenna
Attn: Environmental Office
1438 State Route 534
Newton Falls, Ohio 44444-9297
(330)- 872-8003

Access to Camp Ravenna is controlled but can be obtained by prior notification and arrangement. In addition, an Information Repository of current information and final documents is available to any interested reader at the following libraries:

Reed Memorial Library
167 East Main Street
Ravenna, Ohio 44266

Newton Falls Public Library
204 South Canal Street
Newton Falls, Ohio 44444-1694

Additionally, the RVAAP restoration program has an online resource for restoration news and information. This website is available at: www.rvaap.org.

Comments will be received from the community upon issuance of the PP. As required by the CERCLA regulatory process and the *RVAAP Community Relations Plan* (USACE 2003b), the U.S. Army will hold a public meeting and request public comments on the PP for Load Line 10. These comments will be considered prior to the final selection of a remedy. Responses to these comments will be addressed in the responsiveness summary of the ROD.

10.0 REFERENCES

American Cancer Society 2003. *Cancer Facts & Figures 2003*. Website: www.cancer.org. 2003.

ANRCP (Amarillo National Resource Center for Plutonium) 1999. *Bioremediation of RDX in the Vadose Zone Beneath the Pantex Plant*. January 1999.

Army National Guard-ILE Cleanup, U.S. Army (ARNG). February 2014. *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program, Portage /Trumbull Counties, Ohio (Tech Memo)*. (Memorandum between ARNG-ILE Cleanup and the Ohio Environmental Protection Agency; dated 4 February 2014).

ATSDR (Agency for Toxic Substances and Disease Registry) 1995. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons*. United States Department of Health and Human Services. August 1995.

ATSDR 1997. *Toxicological Profile for HMX*. United States Department of Health and Human Services, Public Health Service. September 1997.

Baes, C.F. and R.D. Sharp 1983. *A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models*. Journal of Environmental Quality, Volume 12, Issue I. March 1983.

Bradley, L. J. N., B. H. McGee and S.L. Allen, 1994. *Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils*, Journal of Soil Contamination. 1994.

BTAG (U.S. Army Biological Technical Assistance Group) 2005. *Technical Document for Ecological Risk Assessment: Process for Developing Management Goals*. August 2005.

DOE (Department of Energy) 1992. *An Analytical Solution for Transient One-, Two-, or Three-Dimensional Transport in a Homogenous, Anisotropic Aquifer with Uniform, Stationary Regional Flow*. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 1992.

Dragun, James 1988. *The Soil Chemistry of Hazardous Materials*. Hazardous Materials Control Research Institute, Silver Spring, MD. 1988.

EQM (Environmental Quality Management, Inc.) 2010. *Facility-Wide Groundwater Monitoring Program Report on the January 2010 Sampling Event, Ravenna Army Ammunition Plant, Ravenna, Ohio*. July 2010.

ERDC (Engineer Research and Development Center) 2007. *Development of Environmental Data for Navy, Air Force, and Marine Munitions*. Cold Regions Research and Engineering Laboratory, Arlington, Virginia. June 2007.

Funk, S.B., D.J. Roberts, D.L. Crawford, and R.L. Crawford 1993. *Initial-Phase Optimization for Bioremediation of Munition Compound-Contaminated Soils*. Applied and Environmental Microbiology, Volume 59, No. 7. July 1993.

GSC (General Sciences Corporation) 1998. *SESOIL for Windows*, Version 3.0, Laurel, MD. 1998.

Hetrick, D. M., C. C. Travis, P. S. Shirley, and E. L. Etnier 1986. *Model Predictions of Watershed Hydrologic Components: Comparison and Verification*. Journal of the American Water Resources Association. October 1986.

Hetrick, D.M. and S.J. Scott 1993. *The New SESOIL User's Guide*, Wisconsin Department of Natural Resources, PUBL-SW-200, Madison, WI. 1993.

IEPA (Illinois Environmental Protection Agency) 2005. Urban area polycyclic aromatic hydrocarbons study tiered approach to corrective action objectives. 2005.

ITRC (Interstate Technology & Regulatory Council). 2012. *Incremental Sampling Methodology*. ISM-1. Washington, D.C.: Interstate Technology & Regulatory Council, Incremental Sampling Methodology Team. www.itrcweb.org.

Jacobs (Jacobs Engineering Group, Inc.) 1989. *RCRA Facility Assessment, Preliminary Review/ Visual Site Inspection Ravenna Army Ammunition Plant Ravenna, Ohio*. October 1989.

Kammer, H.W. 1982. *A Hydrologic Study of the Ravenna Arsenal, Eastern Portage and Western Trumbull Counties, Ohio*. Master Thesis, Kent State University. 1982.

Kaplan, D.L. and A.M. Kaplan 1982. *Thermophilic biotransformation of 2,4,6-trinitrotoluene under simulated composting conditions*. Applied and Environmental Microbiology. September 1982.

Lyman, Warren J., William F. Reehl, and David H. Rosenblatt 1990. *Handbook of Chemical Property Estimation Methods*. American Chemical Society. 1990.

MADEP (Massachusetts Department of Environmental Protection) 2002. Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil. May 2002.

McCormick, N.G., J.H. Cornell, and A.M. Kaplan 1978. *Identification of Biotransformation Products from 2,4-Dinitrotoluene*. Applied and Environmental Microbiology. May 1978.

McCormick, N. G., J. H. Cornell, and A. M. Kaplan 1981. *Biodegradation of Hexahydro-1,3,5-Trinitro-1,3,5-Trazine*. Applied and Environmental Microbiology. November 1981.

MKM (MKM Engineers, Inc.) 2007. *Final Characterization of 14 AOCs at Ravenna Army Ammunition Plant*. March 2007.

NDEP (Nevada Division of Environmental Protection) 2006. *Selection of Pyrene as a Noncarcinogenic Toxicological Surrogate for PAHs. Technical memorandum from T.L. Copeland DABT (consulting toxicologist) to B. Rakvica P.E. NDEP Bureau of Corrective Actions)*. February 2006.

NYSDEC (New York State Department of Environmental Conservation) 2006. *New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives Technical Support Document*. September 2006.

OGE (O'Brien and Gere Engineers, Inc.) 1988. *Hazardous Waste Site Remediation, the Engineer's Perspective*. 1988.

OHARNG (Ohio Army National Guard) 2008. *Integrated Natural Resources Management Plan and Environmental Assessment for the Ravenna Training and Logistics Site, Portage and Trumbull Counties, Ohio*. March 2008.

Ohio EPA (Ohio Environmental Protection Agency) 1996. *Draft Evaluation of Background Metal Concentrations in Ohio Soils.* June 1996.

Ohio EPA 2003. *Guidance for Conducting Ecological Risk Assessments (Ohio EPA)*. Division of Emergency and Remedial Response. February 2003.

Ohio EPA 2004. *Director's Final Findings and Orders for the Ravenna Army Ammunition Plant*. June 2004.

Ohio EPA 2008. *Guidance for Conducting Ecological Risk Assessments (Ohio EPA)*. Division of Emergency and Remedial Response. April 2008.

PIKA (PIKA International, Inc.) 2007. *Munitions Response for the Demolition of RVAAP-41 Load Line 8 and RVAAP-43 Load Line 10*. August 2007.

Sheppard, M.I. and D.H. Thibault 1990. *Default soil/liquid partition coefficients, KdS, for four major soil types: a compendium*. Health Physics, Volume 59, Issue 4. October 1990.

Teaf, Christopher M.; Covert, Douglas J.; and Kothur, Srikant R. 2008. "Urban Polycyclic Aromatic Hydrocarbons (PAHS): A Florida Perspective," *Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy*: Vol. 13, Article 23. 2008.

USABRDL (United States Army Biomedical Research and Development Laboratory) 1989. *Organic Explosives and Related Compounds: Environmental and Health Considerations*. March 1989.

USACE (United States Army Corps of Engineers) 1996. *Preliminary Assessment for the Characterization of Areas of Contamination at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. February 1996.

USACE 1998. *Phase I Remedial Investigation Report of High-Priority Areas of Concern at the Ravenna Army Ammunition Plant, Ravenna Ohio.* February 1998.

USACE 1999. *Plant Community Survey for the Ravenna Army Ammunition Plant Summary Report.* Prepared for Ohio Army National Guard, Adjutant General's Department, Columbus, Ohio. August 1999.

USACE 2001a. *Facility-wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant, Ravenna, Ohio.* March 2001.

USACE 2001b. *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio.* April 2001.

USACE 2003a. *Phase II Remedial Investigation Report for the Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. June 2003.

USACE 2003b. *Ravenna Army Ammunition Plant Ravenna, Ohio Community Relations Plan.* September 2003.

USACE 2003c. *RVAAP Facility Wide Ecological Risk Work Plan.* April 2003.

USACE 2004. *Pathways and Controlling Factors in the Biodegradation of Energetic Wastes.* Engineering and Development Center Fact Sheet. 2004

USACE 2005a. *Facility-Wide Biological and Water Quality Study 2003 Ravenna Army Ammunition Plant, Ravenna, Ohio, Part I-Streams, Part II-Ponds*. November 2005.

USACE 2005b. *RVAAP Facility-Wide Human Health Risk Assessors Manual – Amendment 1.* December 2005.

USACE 2009a. *Final Investigation of the Under Slab Surface Soils, Post Slab and Foundation Removal at RVAAP-39 Load Line 5, RVAAP-40 Load Line 7, RVAAP-41 Load Line 8, and RVAAP-43 Load Line 10, Version 1.0, Ravenna Army Ammunition Plant, Ravenna, Ohio.* January 2009.

USACE 2009b. *PBA 2008 Supplemental Investigation Sampling Analysis Plan Addendum No. 1 Ravenna Army Ammunition Plant, Ravenna, Ohio.* December 2009.

USACE 2009c. *Multi-Increment Sampling: What It Is And What It Does For Site Characterization And Risk Assessment*. Presentation by Terry L. Walker at the Joint ERAF/TSERAWG Meeting. Website: http://el.erdc.usace.army.mil/workshops/09jan-epadod/8_Walker_MISampling.pdf. January 2009.

USACE 2010a. *Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, RVAAP, Ravenna, Ohio*. March 2010.

USACE 2010b. *Risk Assessment Handbook Volume II: Environmental Evaluation*. December 2010.

USACE 2012a. *Draft Remedial Investigation/Feasibility Study Report for RVAAP-67 Facility-Wide Sewers at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. September 2012.

USACE 2012b. *Final (Revised) United States Army Corps of Engineers Ravenna Army Ammunition Plant (RVAAP) Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals.* February 2012.

USACE 2012c. *Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-13 Building 1200.* March 2012.

USACE 2012d. *Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-48 Anchor Test Area.* January 2012.

USACHPPM (United States Army Center for Health Promotion and Preventative Medicine) 1998. *Relative Risk Site Evaluation for Newly Added Sites at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. Hazardous and Medical Waste Study No. 37-EF-5360-99. October 1998.

USACHPPM 2000. *Wildlife Toxicity Assessment for 2,4,6-Trinitrotoluene*. November 2000.

USACHPPM 2001a. *Wildlife Toxicity Assessment for High Melting Explosive (HMX).* November 2001.

USACHPPM 2001b. *Wildlife Toxicity Assessment for 1,3,5-Trinitrobenzene.* November 2001.

USAEHA (U.S. Army Environmental Hygiene Agency) 1994. *Preliminary Assessment Screening No. 38-26-1329-94, Boundary Load Line Areas, Ravenna Army Ammunition Plant, Ravenna, Ohio*, 6-10 June 1994.

USATHAMA (United States Army Toxic and Hazardous Materials Agency) 1978. *Installation Assessment of Ravenna Army Ammunition Plant*, Records Evaluation Report No. 132. 1978.

USDA (United States Department of Agriculture) 1978. *Soil Survey of Portage County, Ohio*. 1978.

USDA 2009. *Forest Service. Resource Bulletin NRS-36*. http://www.nrs.fs.fed.us/. 2009.

USDA 2010. *Soil Map of Portage County, Version 4*. Website: www.websoilsurvey.nrcs.usda.gov. January 2010.

USEPA (United States Environmental Protection Agency) 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water, Revised 1985 Parts 1 and 2, EPA/600/6-85/002*. Office of Research and Development, Environmental Research Laboratory, Athens, Georgia. September 1985.

USEPA 1988. *Health Advisory for Octahydro-1,3,5,7-Tetranitro 1,3,5,7-Tetrazocine (HMX).* PB90-273525. Office of Drinking Water. November 1988.

USEPA 1989. *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A)*. December 1989.

USEPA 1990. *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule,* FR Vol. 55, No. 46, available from U.S. Government Printing Office, Washington, D.C. March 1990.

USEPA 1991. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals).* EPA/540/R-92/003, U.S. Environmental Protection Agency Office of Emergency and remedial Response, Washington, DC. December 1991.

USEPA 1993. *Wildlife Exposure Factors Handbook.* Office of Research and Development, Washington, D.C., Volume 1 of 2. December 1993.

USEPA 1994. *The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3*. EPA/600/R-94/168b, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC. September 2004.

USEPA 1996a. *Ecological Significance and Selection of Candidate Assessment Endpoints.* ECO Update. Volume 3, Number 1. EPA 540/F-95/037. January 1996.

USEPA 1996b. *Soil Screening Guidance: Technical Background Document.* Office of Solid Waste and Emergency Response, Washington, D.C. May 1996.

USEPA 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Office of Solid Waste and Emergency Response, Washington, D.C. June 1997.

USEPA 1998. *Toxicological Review of Hexavalent Chromium*. August 1998.

USEPA 2010. *Integrated Risk Information System (IRIS) Database*. Office of Research and Development, Washington, D.C. 2010.

USEPA 2011. *Ecoregions of EPA Region 3: Delaware, Maryland, Pennsylvania, Virginia, and West Virginia*. Western Ecology Division. Located at http://www.epa.gov/wed/pages/ecoregions/reg3_eco.htm. October 2011.

USEPA 2012. EPA Regional Screening Level (RSL). Website: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. November 2012.

USFS (United States Forest Service) 2011. *Forest Inventory Data Online (FIDO). Forest Inventory and Analysis National Program*. http://www.fia.fs.fed.us/tools-data/default.asp. February 2011.

USGS (United States Geological Survey) 1968. Mineral Resources of the Appalachian Region. U.S. Geological Survey Professional Paper No. 580. 1968.

USGS 2004. *U.S. Geological Survey Certificate of Analysis Devonian Ohio Shale, SDO-1*. Online: <http://minerals.cr.usgs.gov/geo_chem_stand/ohioshale.html>. December 2004.

Vosnakis, Kelly A.S., and Elizabeth Perry 2009. *Background Versus Risk-Based Screening Levels – An Examination of Arsenic Background Soil Concentrations in Seven States*. International Journal of Soil, Sediment, and Water. Volume 2, Issue 2, Article 2. August 2009.

Weston Solutions, Inc., 2012. *Background Soil Determination Summary for Three Locations in Cuyahoga County, Ohio.* USEPA Region V, Chicago, IL and Ohio EPA Division of Environmental response and Revitialization, Twinsburg, OH. July 2012.

Winslow, J.D., and G.W. White, 1966. *Geology and Ground-water Resources of Portage County, Ohio*. Geological Survey Professional Paper 511. 1966.

THIS PAGE INTENTIONALLY LEFT BLANK.