Final

Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-06 C Block Quarry

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912QR-15-C-0046

Prepared for:

U.S. Army Corps of Engineers
Louisville District

Prepared by:

Leidos
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

February 26, 2019

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None.

14. ABSTRACT

This Remedial Investigation/Feasibility Study Report for C Block Quarry presents physical characteristics, geology, and hydrogeology of C Block Quarry; 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; identifies response actions, screening of remedial technologies and process options; develops remedial alternatives to address chemicals of concern (COCs) presenting unacceptable risk; and presents a recommended alternative to meet the remedial action objective at this AOC. The recommended alternative for C Block Quarry is Alternative 2: Surficial ACM Removal and LUCs. Alternative 2 meets the threshold and primary balancing criteria and meets the RAOs by removing ACM on the ground surface and implementing LUCs to prevent Unrestricted (Residential) Land Use and prohibit digging by the Industrial Receptor.

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Cleanup goals, remedial action objective, risk assessment, weight of evidence, nature and extent, fate and transport, remedial alternative

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Ohio Environmental Protection Agency
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Jon Husted, Lt. Governor
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April 12, 2019

RE: US Army Ravenna Ammunition Plt RVAAP
Remediation Response
Project Records
Remedial Response
Portage County
ID # 267000859095

Mr. David Connolly
Army National Guard Directorate
Environmental Programs Division
ARNG-ILE-CR
111 South George Mason Drive
Arlington, VA 22204

Subject: Final Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-06 C Block Quarry

Dear Mr. Connolly:

The Ohio Environmental Protection Agency (Ohio EPA), Northeast District Office (NEDO), Division of Environmental Response and Revitalization (DERR) has received and reviewed the "Final Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-06 C Block Quarry," dated February 26, 2019, prepared by Leidos.

Personnel from Ohio EPA reviewed the "Final Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-06 C Block Quarry" and have no comments. Ohio EPA considers the document final and approved.

If you have any questions concerning this letter, please contact Megan Oravec at (330) 963-1168.

Sincerely,

Megan Oravec

Megan Oravec
Site Coordinator
Division of Environmental Response and Revitalization

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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Leidos has completed the Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-06 C Block Quarry at the Former Ravenna Army Ammunition Plant, Portage and Trumbull Counties, 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 U.S. Army Corps of Engineers (USACE) policy. In addition, an independent verification was performed to ensure all applicable changes were made per regulatory and Army comments.

Jed Thomas, P.E. Study/Design Team Leader, Main Author	February 26, 2019 Date
Selvam Arunachalam, P.E. Independent Technical Review Team Leader	February 26, 2019 Date

Significant concerns and explanation of the resolutions are documented within the project file. As noted above, all concerns resulting from independent technical review of the project have been considered.

Lisa Jones-Bateman Senior Program Manager	February 26, 2019 Date

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ARNG = Army National Guard.
I&E = Installations & Environment.
NEDO = Northeast District Office.
OHARNG = Ohio Army National Guard.
Ohio EPA = Ohio Environmental Protection Agency.
REIMS = Ravenna Environmental Information Management System.
SWDO = Southwest District Office.
USACE = U.S. Army Corps of Engineers.

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
amsl	Above Mean Sea Level
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
Army	U.S. Department of the Army
bgs	Below Ground Surface
Camp Ravenna	Camp Ravenna Joint Military Training Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
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
DERR	Division of Environmental Response and Revitalization
DFFO	Director's Final Findings and Orders
DNT	Dinitrotoluene
DQO	Data Quality Objective
EP	Extraction Procedure
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERS	Ecological Risk Screening
ESV	Ecological Screening Value
EU	Exposure Unit
f_{oc}	Mass Fraction of the Organic Carbon Soil Content
FS	Feasibility Study
FWCUG	Facility-wide Cleanup Goal
FWERWP	Facility-wide Ecological Risk Work Plan
FWGWMP	Facility-wide Groundwater Monitoring Program
FWHHRAM	Facility-wide Human Health Risk Assessor Manual
FWSAP	Facility-wide Sampling and Analysis Plan
gpm	Gallons Per Minute
GRA	General Response Action
GSSL	Generic Soil Screening Level
HEPA	High-Efficiency Particulate Air
HHRA	Human Health Risk Assessment
HHRS	Human Health Risk Screening
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risk

INRMP	Integrated Natural Resources Management Plan
IRIS	Integrated Risk Information System
ISM	Incremental Sampling Methodology
LDR	Land Disposal Restriction
LUC	Land Use Control
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
MI	Multi-increment
NCP	National Contingency Plan
O&M	Operation and Maintenance
OAC	Ohio Administrative Code
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PAH	Polycyclic Aromatic Hydrocarbon
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
PLM	Polarized Light Microscopy
PP	Proposed Plan
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDA	Recommended Daily 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
SESOIL	Seasonal Soil Compartment
SL	Screening Level
SOR	Sum-of-Ratio
SRC	Site-related Contaminant

SSSL	Site-Specific Soil Screening Level
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TNT	2,4,6-Trinitrotoluene
TR	Target Risk
UCL	Upper Confidence Limit
URF	Unit Risk Factor
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USP&FO	U.S. Property and Fiscal Officer
UTS	Universal Treatment Standard
VOC	Volatile Organic Compound
WOE	Weight-of-Evidence

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION AND SCOPE

This document has been revised by Leidos under the U.S. Army Corps of Engineers Louisville District Contract Number W912QR-15-C-0046. This Remedial Investigation (RI) Report and Feasibility Study (FS) address soil, sediment, and surface water at C Block Quarry within the former Ravenna Army Ammunition Plant (RVAAP) [now known as Camp Ravenna Joint Military Training Center (Camp Ravenna)] in Portage and Trumbull counties, Ohio.

This report has been prepared 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 the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP) to implement an RI to characterize the area of concern (AOC); develop an FS Report (if remediation is 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. The following sections present the site history, scope of this report, and an explanation of the evaluation of future use.

ES.1.1 Site History

C Block Quarry is a 0.96-acre AOC located between roads 3C and 4C of the C Block Storage Area north of Newton Falls Road in the northwestern portion of Camp Ravenna. The C Block Storage Area contains parallel roads of 99 aboveground reinforced concrete igloos that formerly stored munitions. These igloos are earth-covered. During the 1940s and 1950s, C Block Quarry was used to mine Homewood Sandstone. This sandstone was quarried for road and construction base material. C Block Quarry currently has a maximum depth of 25 ft below the surrounding grade.

In a letter dated March 24, 1950, a conference was conducted to assess waste disposal for the former RVAAP. The conference concluded that C Block Quarry was the most satisfactory location to dispose of sulfuric acid, nitric acid, mercury, chromic acid, phosphoric acid plus accelerator, and alkali compound stripper. Triton N.E. (or X-100) and Naccronal N.R (or Santomerse No.3), which are surfactants commonly used in detergents, also were listed. The summary report (U.S. Government 1950) of this conference stated:

"It was concluded the disposal site (Quarry Group C) was most satisfactory for disposal of these wastes due to:

a. Infiltration benefits through stone substrata. Combinations with elements of the stone substrata due to relative positions of elements.
b. Distance from any water supply or contributory surface water which might contaminate raw water supply.
c. Lack of recognizable traces in any water supply or surface water to date.
d. Evaporation of mixed compounds which probably leave complex molecular salts of low solubility."

During the 1950s and 1960s, C Block Quarry was used as a disposal area for annealing process waste for a short duration (USATHAMA 1982). Liquid waste was dumped on the ground surface in the bottom of the abandoned unlined borrow pit. This liquid waste reportedly included annealing process liquids (chromic acid) from Building 802 at Load Line 2 and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. The volume of liquid waste disposed of at C Block Quarry is unknown.

ES.1.2 Scope

The scope of this report to present: 1) the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface soil and subsurface soil at the AOC; 2) the results of the evaluation of remedial alternatives for meeting remedial action objectives (RAOs) for any CERCLA-related chemicals of concern (COCs) identified in the media at the AOC; and 3) a preferred alternative to present to the public in a PP. Sediment and associated surface water were not evaluated as part of this report, as these media are not present at the AOC.

The preferred alternative will achieve required risk reductions to protect human health and the environment and attain all applicable or relevant and appropriate requirements. In accordance with CERCLA, remedial alternatives are to be cost effective; use permanent solutions and alternative treatment technologies to the maximum extent practicable; and satisfy the preference for treatment that reduces volume, toxicity, or mobility to the maximum practical extent.

Potential impacts to groundwater from soil (e.g., contaminant leaching) are evaluated in this report, as protectiveness to groundwater is included in the fate and transport analysis and the evaluation of remedial alternatives for soil. Groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS Report.

ES.1.3 Evaluation of Future Use

In February 2014, the U.S. Department of the 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) (herein referred to as the Technical Memorandum) identified the three Categorical Land Uses and Representative Receptors below to be considered during the RI phase of the CERCLA process.

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 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.

ES.2 FINDINGS AND RECOMMENDATIONS OF THE REMEDIAL INVESTIGATION

This section presents the data used in the RI, contaminant nature and extent, fate and transport, human health risk assessment (HHRA), and environmental risk assessment (ERA), followed by the conclusions of the RI.

ES.2.1 Data Use and Sample Selection Process

Quality-assured sample data from the 2004 Characterization of 14 AOCs and the 2010 and 2012 Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) were used to evaluate nature and extent of contamination at C Block Quarry. These investigations used incremental sampling methodology (ISM) and discrete sampling methods.

All available sample data were evaluated to determine suitability for use in various key RI data screens and evaluations (i.e., nature and extent, fate and transport, and risk assessment). Evaluating the data's suitability for use in the PBA08 RI involved two primary considerations: whether the data represented current AOC conditions and sample collection methods (e.g., discrete vs. ISM).

Soil samples from the Characterization of 14 AOCs were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the PBA08 RI. No AOC disturbance activities occurred at C Block Quarry between the Characterization of 14 AOCs in 2004 and the PBA08 RI. The soil samples collected in 2004 were collected from ISM sample areas along the quarry bottom. Data collected in 2010 and 2012 as part of the PBA08 RI focused on delineating the extent of contaminants identified surface soil [0–1 ft below ground surface (bgs)], subsurface soil (1 ft bgs to bedrock), chromium speciation, and debris samples for asbestos fibers. Bedrock was encountered in all subsurface soil borings at depths ranging from 2–7 ft bgs. The PBA08 RI sampled locations with the greatest likelihood of contamination and analyzed for chemicals identified in historical investigations.

ES.2.2 Summary of Contaminant Nature and Extent

Nature and extent of contamination in surface soil (0–1 ft bgs) and subsurface soil (greater than 1 ft bgs) were evaluated in the RI. Data from the Characterization of 14 AOCs and 2010 and 2012 PBA08 RI effectively characterized the nature and extent of contamination at the AOC. Surface water and sediment were not evaluated, as these media are not present on the AOC. Figure ES-1 shows the sample locations used to conduct this RI. To support the evaluation of nature and extent of contamination, site-related contaminant (SRC) concentrations were compared to screening levels (SLs) corresponding to the lowest facility-wide cleanup goal (FWCUG) for the Resident Receptor (Adult and Child) and National Guard Trainee at a target hazard quotient (HQ) of 0.1 or target risk (TR) of 1E-06, as presented in the *Facility-wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2010a) (herein referred to as the FWCUG Report). It can be concluded that the vertical and horizontal extent of chemical contamination is defined, and no further sampling is needed to evaluate C Block Quarry.

ES.2.2.1 <u>Surface and Subsurface Soil</u>

Metals were identified as potential contaminants from former disposal operations (chromium, lead, and mercury) and were thoroughly evaluated across the quarry bottom as a whole. The highest inorganic chemical concentrations were observed in the southern portion of the AOC (ISM sample areas CBLss-003M, CBLss-004M, and CBLss-005M, and borings CBLsb-025, and CBLsb-026). The chromium concentration was particularly high at 920 mg/kg at CBLss-005M, but was below the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Hexavalent chromium at CBLsb-025 had a concentration of 19J mg/kg, which was above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1, but below the SL at CBLsb-026 (0–1 and 1–1.8 ft bgs) and CBLss-003M.

Explosives were thoroughly evaluated across the AOC as a whole. The maximum concentrations for 2-amino-4,6-dinitrotoluene (DNT); 4-amino-2,6-DNT; and nitrocellulose (observed in CBLss-004M in the southern portion of the AOC) were all below their respective SLs and were not considered chemicals of potential concern (COPCs). 2,4,6-Trinitrotoluene (TNT) at CBLss-004M had a surface soil concentration of 22 mg/kg, which exceeded the SL, but was below the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

Polycyclic aromatic hydrocarbon concentrations were detected at CBLss-005M and CBLsb-011, at the southern end of the AOC. All 12 semi-volatile organic compound SRCs were detected in the 1–4 ft bgs interval at CBLss-011. However, concentrations in subsurface soil at this location were less than SLs, except for benzo(a)pyrene. Benzo(a)pyrene was detected at a concentration (0.4 mg/kg) that exceeded its SL of 0.022 mg/kg; therefore, benzo(a)pyrene was identified as a COPC. The benzo(a)pyrene concentration was detected above the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg).

Volatile organic compounds, pesticides, and polychlorinated biphenyls were not detected in surface soil and subsurface soil; propellants were not detected in subsurface soil in C Block Quarry.

ES.2.2.2 Asbestos-Containing Material

A certified State of Ohio Department of Health Asbestos Hazard Evaluation Specialist collected samples and conducted an asbestos-containing material (ACM) survey. The ACM survey included visually inspecting the entire quarry, identifying suspect materials, estimating the approximate quantity of suspected ACM, and collecting six bulk samples and one soil sample for analysis by polarized light microscopy.

Four of six bulk samples contained asbestos fibers and were considered friable. The ACM survey indicated several areas of exposed transite/shingle and steel panels with block insulation and paper within C Block Quarry. The survey indicated that suspect ACM occurred in an area of approximately 2,750 ft^2, although visible debris occupied less than 10 ft^2. Polarized light microscopy analysis of suspect ACM debris samples indicated transite shingles and insulation material contained up to 35% asbestos fibers. Samples of firebrick and suspected burn residue/cinder did not contain detectable asbestos fiber.

The one soil sample collected during the ACM survey near a pile of material with suspected ACM contained less than 1% asbestos fiber. Additionally, nine soil samples collected from PBA08 RI soil borings did not contain detectable asbestos fibers.

ES.2.3 Summary and Conclusions of Contaminant Fate and Transport

Contaminant fate and transport at C Block Quarry was evaluated using 1) groundwater data collected to date at the AOC, and 2) modeling to assess the potential for SRCs to leach from surface and subsurface soil and impact groundwater beneath the sources. Groundwater samples were collected from 5 monitoring wells around C Block Quarry during 13 separate sampling events under the Characterization of 14 AOCs (MKM 2007) and the Facility-wide Groundwater Monitoring Program (FWGWMP) from January 2005 to November 2016 to assess the potential impact that historical site activities may have had on groundwater. Explosives, propellants, volatile organic compounds (VOCs), pesticides, perchlorate, and cyanide results were all below the screening level [maximum contaminant level (MCL), Resident Receptor FWCUG, or Resident Tap Water regional screening level (RSL)]. Only seven chemicals [hexavalent chromium, manganese, polychlorinated biphenyl (PCB)-1248, benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and bis(2-ethylhexyl)phthalate] exceeded the screening levels.

The fate and transport evaluation concluded that chromium and mercury were not potentially impacting groundwater through soil screening analysis [i.e., by comparing their maximum soil concentrations to the MCL-based generic soil screening levels (GSSLs)], and lead and hexavalent chromium were not expected to reach the water table from the source area within 1,000 years. The fate and transport evaluation identified TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT as final contaminant migration chemicals of potential concern (CMCOPCs). None of these final CMCOPCs were detected in AOC groundwater samples collected from 2009–2013. A qualitative assessment concluded that CMCOPCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts. The contaminant fate and transport evaluation concludes that no further action is required for soil to be protective of groundwater.

ES.2.4 Summary and Conclusions of the Human Health Risk Assessment

The HHRA identified COCs and conducted risk management analysis to determine if COCs pose unacceptable risk to the Resident Receptor. If there is no unacceptable risk to the Resident Receptor, it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor. However, if unacceptable risk is identified for the Resident Receptor, the risk to the National Guard Trainee and Industrial Receptor is evaluated.

Media of concern at C Block Quarry are surface soil and subsurface soil. Surface water and sediment were not present within the C Block Quarry. Hexavalent chromium was identified as a COC to be carried forward for potential remediation in surface soil and subsurface soil for Unrestricted (Residential) and Military Training Land Uses. No COCs were identified for Commercial/Industrial Land Use.

ES.2.5 Summary and Conclusions of the Ecological Risk Assessment

The Level I ERA presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. There is chemical contamination present in surface soil at C Block Quarry; there is no permanent sediment or surface water at the AOC. This contamination was identified using discrete soil data collected for the PBA08 RI. There are eight integrated chemicals of potential ecological concern identified in surface soil. Ecological resources at C Block Quarry were compared to the list of important ecological places and resources. None of the 39 important places and resources were present, and there is nothing ecologically significant at C Block Quarry. The ERA summarizes the chemicals and resources in detail to demonstrate that there is contamination at C Block Quarry, but no important or significant ecological resources are present. Consequently, the ERA for C Block Quarry concludes with a Level I Scoping Level Risk Assessment and a recommendation that no further action is required to be protective of ecological resources.

ES.2.6 Recommendation of the Remedial Investigation

Based on the investigation results, C Block Quarry has been adequately characterized and nature and extent has been defined. The fate and transport assessment concluded that chemicals in soil and sediment are not adversely impacting groundwater quality and are not predicted to have future impacts. The ERA concluded that there are no important or ecologically significant resources at the AOC; consequently, no further action is recommended from the ecological risk perspective.

No COCs requiring remediation were identified for the Industrial Receptor; however, the HHRA identified hexavalent chromium as a surface and subsurface soil COC for the Resident Receptor and the National Guard Trainee Receptors in C Block Quarry. Additionally, asbestos debris was identified in soil samples. Analyses of remedial alternatives are not warranted for sediment or surface water based on the absence of these media. The recommended path forward is to evaluate remedial alternatives for C Block Quarry in an FS.

ES.3 SUMMARY AND RECOMMENDATION OF THE FEASIBILITY STUDY

Because Military Training Land Use requires monitoring personnel exposure and documenting site usage for training purposes, the Army has elected to evaluate only alternatives associated with Commercial/Industrial Land Use and Unrestricted (Residential) Land Use in this FS.

The FS developed RAOs, identified appropriate cleanup goals for remedial actions, identified applicable or relevant and appropriate requirements, screened potential remedial technologies and process options, and developed and evaluated remedial alternatives to achieve adequate protection for the Commercial/Industrial and Unrestricted (Residential) land uses.

ES.3.1 Remedial Action Objectives

The RI for C Block Quarry concluded that concentrations of hexavalent chromium in soil at and near sample locations CBLss-003M and CBLss-005M exceeded the residential regional screening level of 3 mg/kg. Additionally, friable ACM (e.g., transite and black tar paper) was intermixed with the soil. These locations are presented in Figure ES-2. Accordingly, the RAOs for C Block Quarry are as follows:

- Prevent Resident Receptor exposure to hexavalent chromium in soil with concentrations above 3 mg/kg at sample locations CBLss-003M and CBLss-005M and prevent Resident Receptor and Industrial Receptor exposure to friable ACM.

Table ES-1 summarizes the recommended cleanup goals.

ES.3.2 Remedial Alternatives

Remedial technologies and process options were screened, and the following viable remedial alternatives were developed:

1. Alternative 1: No Action.
2. Alternative 2: Surficial ACM Removal and Land Use Controls (LUCs).
3. Alternative 3: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.

The No Action alternative, required for evaluation under the NCP, provides the baseline against which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) are discontinued and assumes no future actions take place to protect human receptors or the environment. Removal or treatment of COCs at the AOC is not implemented.

Alternative 2 consists of 1) removing surficial ACM through non-intrusive, no-digging methods to prevent Industrial Receptor exposure to ACM in surface soil; 2) implementing LUCs to prevent the Industrial Receptor from digging and possibly encountering subsurface ACM; 3) implementing LUCs to prevent Resident Receptor use of the site; and 4) performing five-year reviews to assess the effectiveness of LUCs and whether there is a need to modify them. Implementing Alternative 2 does not result in Unrestricted (Residential) Land Use of the site.

Alternative 3 includes conducting a subsurface evaluation to determine if and where ACM is present in subsurface soil, performing pre-excavation and waste characterization sampling, excavating and disposing surface and subsurface soil to remove COC-contaminated soil and ACM, and performing site restoration. This alternative will meet the RAOs by removing soil with hexavalent chromium concentrations exceeding the residential regional screening level of 3 mg/kg and removing surface and any potential subsurface friable ACM. An estimated 1,517 yd^3 (ex situ) of soil and debris would require removal and disposal under this alternative. ACM would be handled, packaged, transported, and disposed of in accordance with applicable federal and state regulations. Excavations would be backfilled with clean, approved soil from a local commercial supplier. Disturbed areas would be restored to surrounding grade, re-vegetated using an Ohio Army National Guard-approved seed mixture, and mulched. No LUCs or five-year reviews pursuant to CERCLA would be required because this alternative attains a level of protection for Unrestricted (Residential) Land Use of the AOC.

The alternatives were compared to CERCLA threshold and balancing criteria, and a comparative analysis was completed to justify the selection of a recommended alternative for soil at C Block Quarry. Table ES-2 summarizes the comparative analysis of the alternatives.

ES.3.3 Recommended Alternative

The recommended alternative for C Block Quarry is Alternative 2: Surficial ACM Removal and LUCs. Alternative 2 meets the threshold and primary balancing criteria and meets the RAOs by removing ACM on the ground surface and implementing LUCs to prevent Unrestricted (Residential) Land Use and prohibit digging by the Industrial Receptor. The cost of Alternative 2 is $108,534, which includes operation and maintenance costs.

Table ES–1. Cleanup Goals for C Block Quarry

Soil Contaminant	Cleanup Goal
Hexavalent Chromium	3 mg/kg
Asbestos	Non-detectable

mg/kg = Milligrams per kilogram.
Non-detectable concentration of asbestos will be determined by using test methods with an analytical sensitivity of at least 0.25% by weight.

Table ES–2. Summary of Comparative Analysis of Remedial Alternatives

NCP Evaluation Criteria	Alternative 1: No Action	Alternative 2: Surficial ACM Removal and LUCs	Alternative 3: Excavation and Off-Site Disposal – Attain Unrestricted (Residential) Land Use
Threshold Criteria	***Result***	***Result***	***Result***
1. Overall Protection of Human Health and the Environment	Not protective	Protective	Protective
2. Compliance with ARARs	Not compliant	Compliant	Compliant
Balancing Criteria	***Score***	***Score***	***Score***
3. Long-term Effectiveness and Permanence	Not applicable	1	2
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Not applicable	1	2
5. Short-term Effectiveness	Not applicable	2	1
6. Implementability	Not applicable	2	1
7. Cost	Not applicable ($0)	2 ($108,534)	1 ($390,224)
Balancing Criteria Score	*Not applicable*	*8*	*7*

Any alternative considered "not protective" for overall protection of human health and the environment or "not compliant" for compliance with ARARs is not eligible for selection as the recommended alternative. Therefore, that alternative is not scored as part of the balancing criteria evaluation.

Scoring for the balancing criteria is as follows for applicable alternatives: most favorable = 2, least favorable = 1. The alternative with the highest total balancing criteria score is considered the most feasible.

ACM = Asbestos-containing material.

ARAR = Applicable or relevant and appropriate requirement.

NCP = National Oil and Hazardous Substances Pollution Contingency Plan.

LUC = Land use control.

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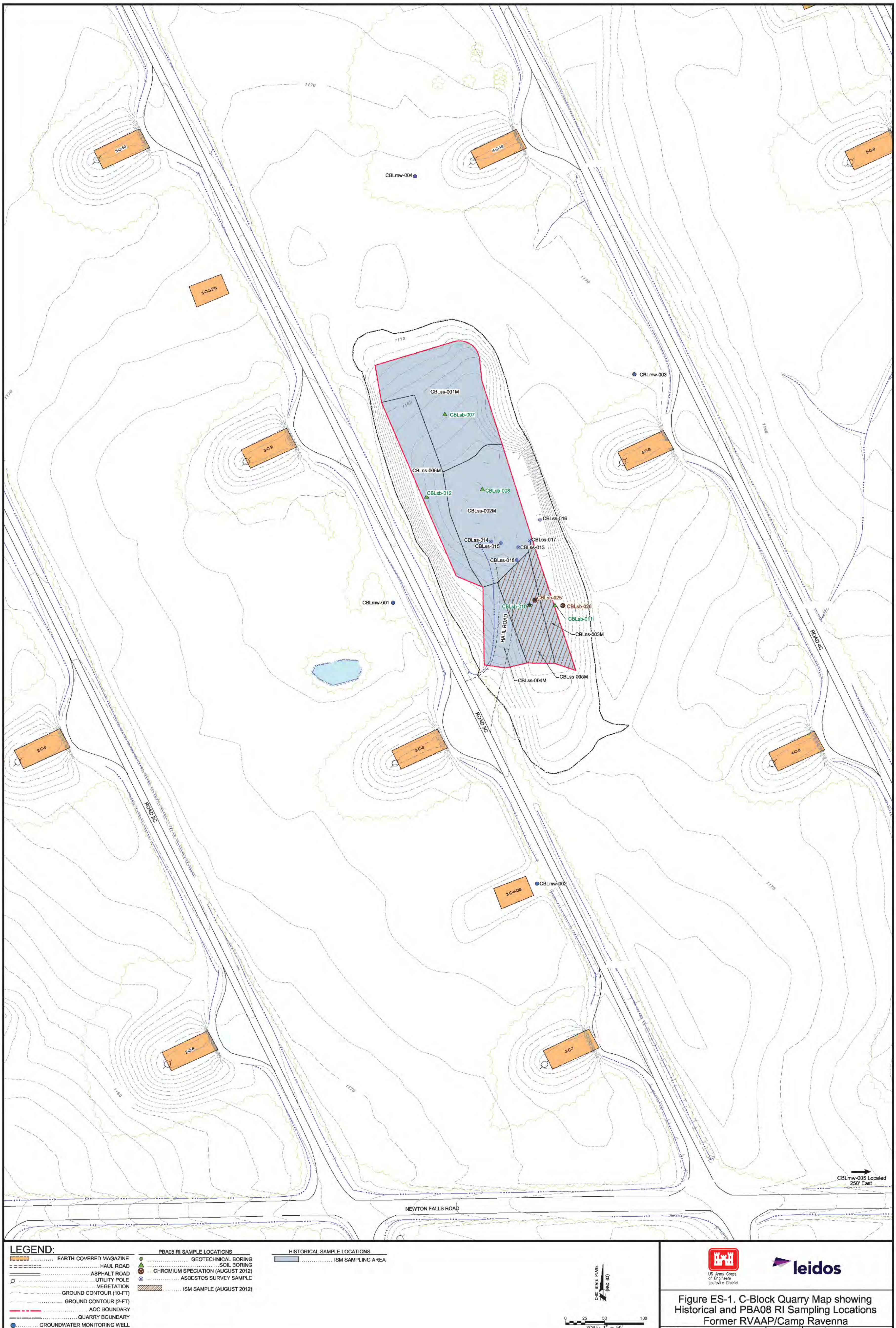

Figure ES–1. C Block Quarry Sampling Locations

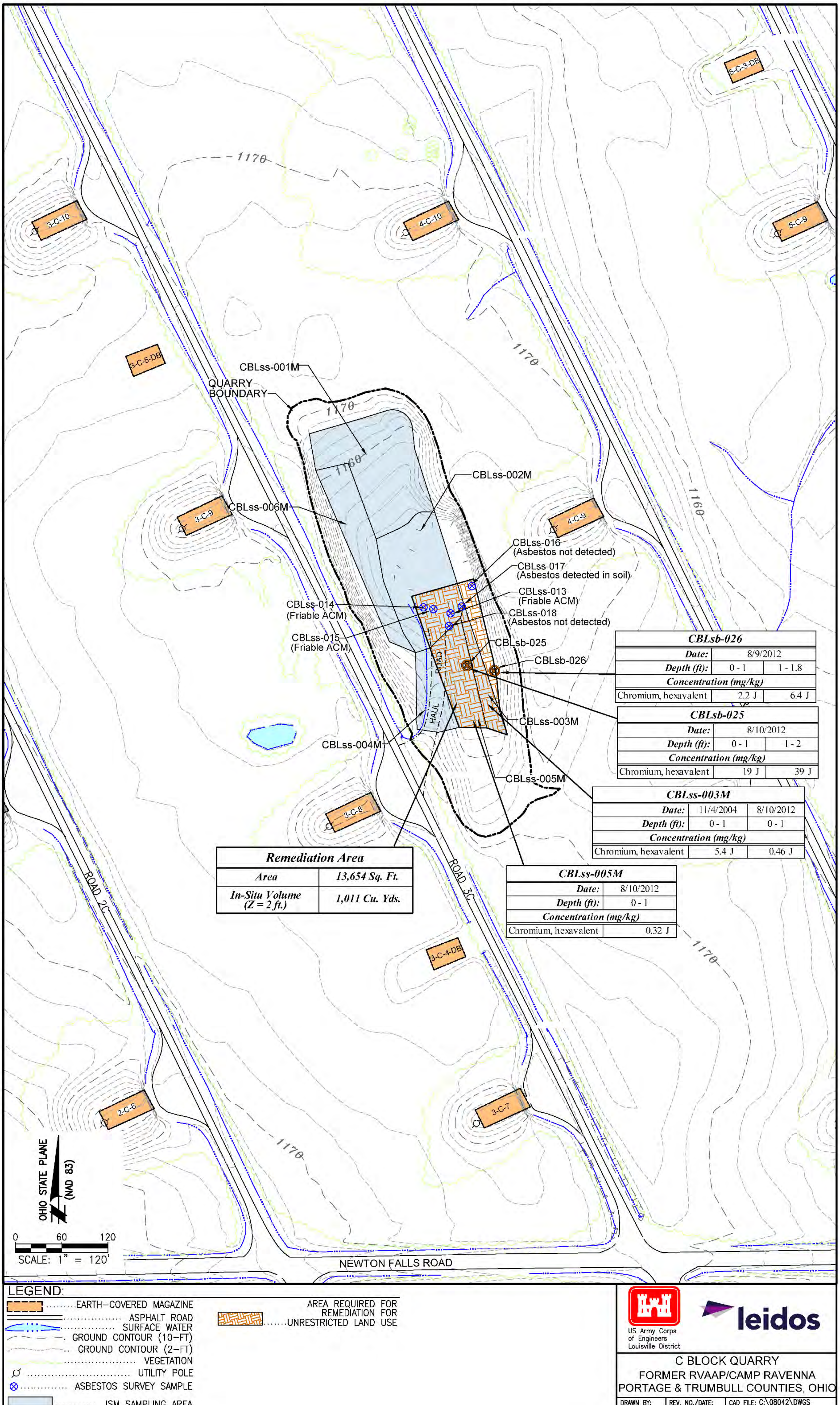

Figure ES–2. Estimated Extent of Soil Requiring Remediation

1.0 INTRODUCTION

This document was revised by Leidos under the U.S. Army Corps of Engineers (USACE) Louisville District Contract Number W912QR-15-C-0046. This Remedial Investigation (RI) and Feasibility Study (FS) Report address soil, sediment, and surface water at the C Block Quarry area of concern (AOC) within the former Ravenna Army Ammunition Plant (RVAAP) [now known as Camp Ravenna Joint Military Training Center (Camp Ravenna)] in Portage and Trumbull counties, Ohio (Figures 1-1 and 1-2). The C Block Quarry AOC is designated as RVAAP-06.

This report has been prepared 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 the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP) to implement an RI to characterize the AOC, develop an FS (if remediation is necessary) to evaluate remedial alternatives to address contamination presenting unacceptable risk to human health and the environment, present a preferred remedial alternative in a proposed plan (PP), and document stakeholder selection and acceptance of the preferred final remedy in a record of decision (ROD).

This document includes the following:

- A description of the operational history and environmental setting for the AOC.
- A summary of all historical assessments and investigations at C Block Quarry.
- A description of the nature and extent of contamination, including the identification of site-related contaminants (SRCs) by screening applicable data against background, 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.
- Conclusions of the RI Report, including the identification and extent of COCs, which form the basis for conducting the FS.
- Identification of remedial action objectives (RAOs) for contaminated media at the AOC.
- Identification of applicable or relevant and appropriate requirements (ARARs).
- Identification of general response actions (GRAs) and screening of a range of remedial technologies to reduce risk to human health and the environment at the AOC from COCs identified in the RI Report.
- Development of remedial alternatives from appropriate GRAs and remedial technologies and evaluation of alternatives against criteria specified by CERCLA.
- Conclusions of the FS and a preferred alternative.

1.1 PURPOSE

The purpose of this report is to use available RI data to evaluate the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface and subsurface soil at C Block Quarry. Sediment and associated surface water are not present at the AOC.

This report summarizes the Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) that was performed at C Block Quarry to supplement data from previous sampling events. All PBA08 RI sampling activities at the AOC occurred within the 0.96-acre former quarry boundary located between roads 3C and 4C of the C Block Storage Area. This RI/FS Report evaluates soil to bedrock within the quarry bottom.

Depending on the results of the evaluations contained in this report, a conclusion of no further action is provided or a recommendation to complete an FS to evaluate potential remedies and future actions will be made. The purpose of the FS is to identify RAOs and appropriate cleanup goals (CUGs), screen remedial technologies, develop remedial alternatives to meet RAOs and attain CUGs, and perform a detailed evaluation of remedial alternatives to identify a preferred remedy.

1.2 SCOPE

The scope of this report to present: 1) the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface soil and subsurface soil at the AOC; 2) the results of the evaluation of remedial alternatives for meeting RAOs for any CERCLA-related COCs identified in the media at the AOC; and 3) a preferred alternative to present to the public in a PP. Sediment and associated surface water were not evaluated as part of this report, as these media are not present at the AOC.

The preferred alternative will achieve required risk reductions to protect human health and the environment and attain all ARARs. In accordance with CERCLA, remedial alternatives are to be cost effective; use permanent solutions and alternative treatment technologies to the maximum extent practicable; and satisfy the preference for treatment that reduces volume, toxicity, or mobility to the maximum practical extent.

Potential impacts to groundwater from soil (e.g., contaminant leaching) are evaluated in this report, as protectiveness to groundwater is included in the fate and transport analysis and the evaluation of remedial alternatives for soil. Groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS Report.

1.3 REPORT ORGANIZATION

This report is organized in accordance with Ohio EPA and U.S. Environmental Protection Agency (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 a description and history of the former RVAAP and the AOC, presents potential sources of contamination, presents potential receptors, and summarizes co-located or proximate sites.
- Section 3.0 describes the environmental setting at Camp Ravenna and C Block Quarry, including the geology, hydrogeology, climate, and receptor population.
- Section 4.0 summarizes previous assessments and investigations at C Block Quarry, as well as the data used to support this RI.
- Section 5.0 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 the methods and results of the HHRA and ERA.
- Section 8.0 provides the conclusions and recommendations of the RI.
- Section 9.0 outlines the development of RAOs for the chemicals and media of concern.
- Section 10.0 summarizes potential federal and state chemical-, location-, and action-specific ARARs for potential remedial actions.
- Section 11.0 presents GRAs and the identification and screening of technology types and process options considered for possible use in remediation.
- Section 12.0 develops remedial alternatives from technologies and process options that passed initial screening and presents an initial evaluation against effectiveness, implementability, and cost.
- Section 13.0 presents the detailed and comparative analyses of viable remedial action alternatives developed to address chemicals and media of concern using the seven criteria specified by CERCLA guidance.
- Section 14.0 presents the conclusions of the FS and the preferred remedial alternative.
- Section 15.0 summarizes the framework for conducting the necessary agency and public involvement activities.
- Section 16.0 provides a list of references used to develop this report.
- 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: Contaminant Fate and Transport Modeling Results,
  Appendix F: Investigation-derived Waste Management Reports,
  Appendix G: Human Health Risk Assessment Tables,
  Appendix H: Ecological Risk Assessment Information and Data,
  Appendix I: PBA08 Remedial Investigation Summary,
  Appendix J: Asbestos Results Report,
  Appendix K: Detailed Cost Estimates, and
  Appendix L: Ohio EPA Comments.

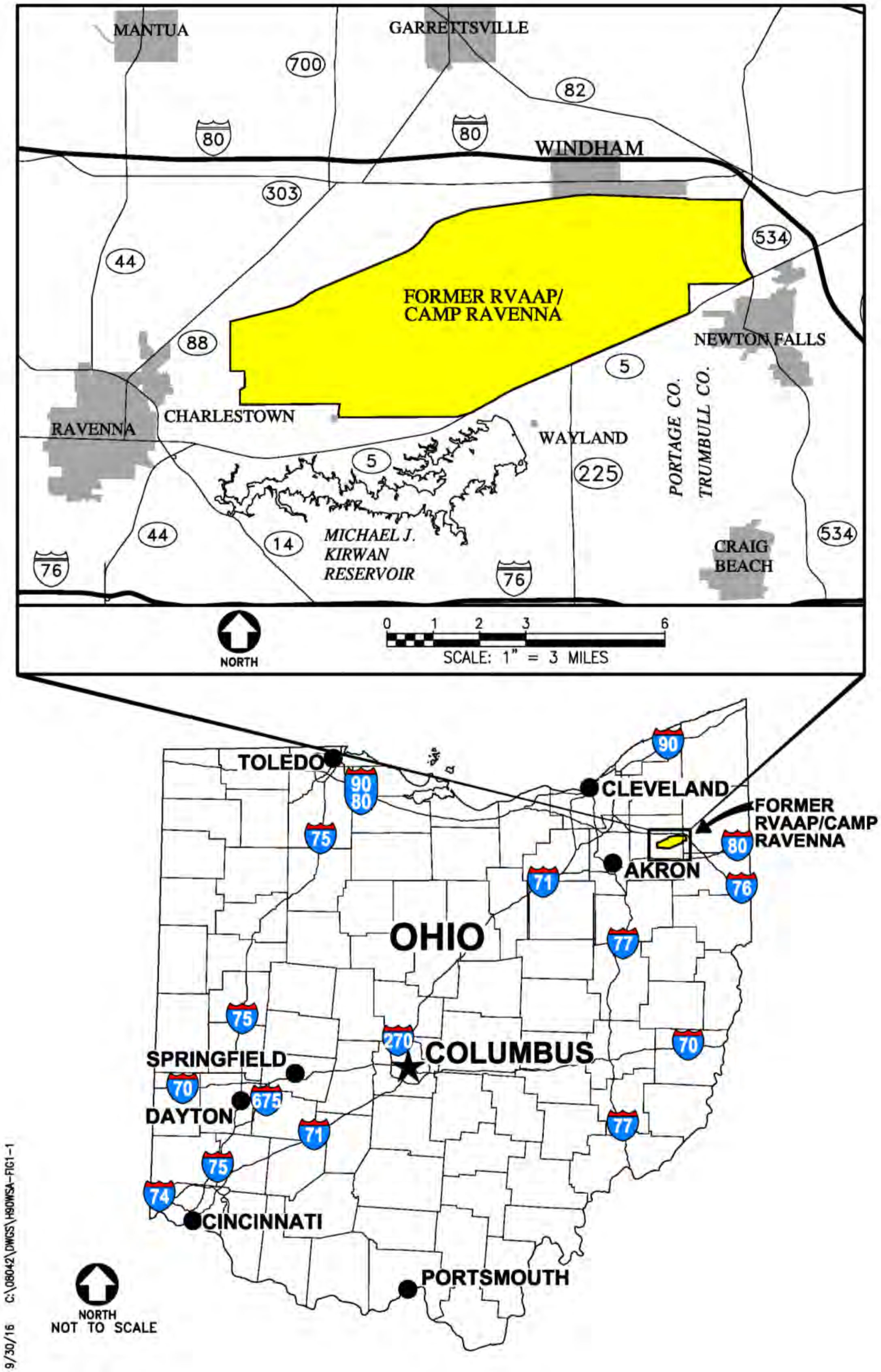

Figure 1–1. General Location and Orientation of Camp Ravenna

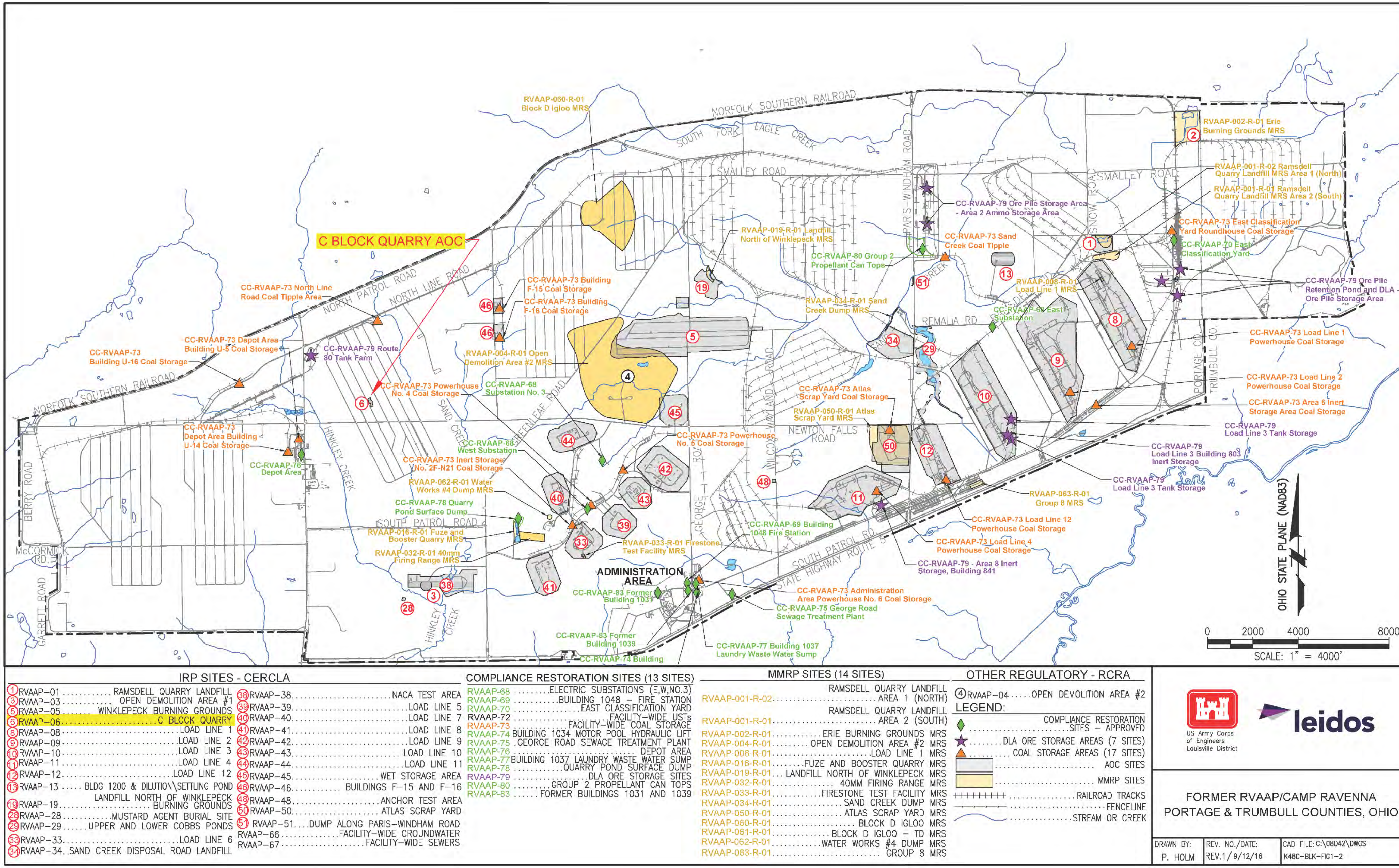

Figure 1–2. Location of AOCs and Munitions Response Sites at Camp Ravenna

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2.0 BACKGROUND

This section provides a description of the facility. In addition, it summarizes C Block Quarry's operational history, potential sources, potential human health and ecological receptors, co-located or proximate sites, and potential site-related releases.

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 (Figure 1-1). 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 indicated the populations of Portage and Trumbull counties are 161,419 and 210,312, respectively. Population centers closest to Camp Ravenna are Ravenna, with a population of 11,724, and Newton Falls, with a 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, in which 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 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, range firing activities, convoy training and maintaining equipment, C-130 aircraft drop zone operations, helicopter operations, and storing heavy equipment.

2.2 C BLOCK QUARRY BACKGROUND INFORMATION

2.2.1 Site Description and Operational History

C Block Quarry is a 0.96-acre AOC located between roads 3C and 4C of the C Block Storage Area north of Newton Falls Road in the northwestern portion of Camp Ravenna. Figure 2-1 presents site features of C Block Quarry, and Figure 2-2 presents a 1959 aerial photograph of the entire C Block Storage Area.

The C Block Storage Area contains parallel roads of 99 aboveground reinforced concrete igloos that formerly stored munitions. These igloos are earth-covered. During the 1940s and 1950s, C Block Quarry was used to mine Homewood Sandstone. This sandstone was quarried for road and construction base material. C Block Quarry currently has a maximum depth of 25 ft below the surrounding grade.

In a letter dated March 24, 1950, a conference was conducted to assess waste disposal for the former RVAAP. The conference concluded that C Block Quarry was the most satisfactory location to dispose of sulfuric acid, nitric acid, mercury, chromic acid, phosphoric acid plus accelerator, and alkali compound stripper. Triton N.E. (or X-100) and Naccronal N.R (or Santomerse No.3), which are surfactants commonly used in detergents, also were listed. The summary report (U.S. Government 1950) of this conference stated:

"It was concluded the disposal site (Quarry Group C) was most satisfactory for disposal of these wastes due to:

a. Infiltration benefits through stone substrata. Combinations with elements of the stone substrata due to relative positions of elements.
b. Distance from any water supply or contributory surface water which might contaminate raw water supply.
c. Lack of recognizable traces in any water supply or surface water to date.
d. Evaporation of mixed compounds which probably leave complex molecular salts of low solubility."

During the 1950s and 1960s, C Block Quarry was used as a disposal area for annealing process waste for a short duration (USATHAMA 1982). Liquid waste was dumped on the ground surface in the bottom of the abandoned unlined borrow pit. This liquid waste reportedly included annealing process liquids (chromic acid) from Building 802 at Load Line 2 and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. The volume of liquid waste disposed of at C Block Quarry is unknown.

Currently, the AOC is heavily forested with brush and trees at least 1 ft in diameter. The 1989 Resource Conservation and Recovery Act (RCRA) Facility Assessment observed two empty 55-gal drums, glass fragments, cinder blocks, and several empty 5-gal buckets at the AOC (Jacobs 1989). PBA08 RI activities confirmed the presence of these items as well as roofing shingle material, asbestos-containing material (ACM), wooden doors, metal hinges and doorknobs, corrugated sheet metal, glass bottles, bricks, and insulation-like foam. As no buildings were constructed within C Block Quarry, these materials are assumed to be the result of dumping during an unknown timeframe.

2.2.2 Potential Sources

Primary sources exist at C Block Quarry, such as debris and ACM discussed in the previous section. Secondary sources also exist at C Block Quarry, such as contaminated soil. The exposure risk associated with this media is evaluated in this RI Report. The site was used for disposing annealing process liquids (chromic acid) and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. This material was reportedly dumped on the ground surface. The volume of liquid waste disposed of at C Block Quarry is unknown. Many other chemicals and ACM were analyzed during the site investigations and are discussed in this report.

2.2.3 AOC Boundary

C Block Quarry is located in the northwestern portion of Camp Ravenna. The AOC is located between roads 3C and 4C of the C Block Storage Area north of Newton Falls Road (Figures 1-2, 2-1, and 2-2). No fences exist at the AOC; however, the eastern and western sides of the AOC are defined by the quarry walls. As presented in Figure 2-1, the AOC boundary includes the quarry bottom and is 0.96 acres.

2.2.4 Current Land Use

C Block Quarry is currently inactive. The site is believed to be inactive since the 1960s.

2.3 POTENTIAL HUMAN RECEPTORS AND ECOLOGICAL RESOURCES AT C BLOCK QUARRY

The following sections discuss potential human receptors and ecological resources at C Block Quarry.

2.3.1 Human Receptors

In February 2014, the U.S. Department of the Army (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) (herein referred to as the Technical Memorandum) identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process. This RI Report evaluates the Resident Receptor (Adult and Child) (formerly called the Resident Farmer) to assess Unrestricted (Residential) Land Use, National Guard Trainee to assess Military Training Land Use, and Industrial Receptor to assess Commercial/Industrial Land Use.

2.3.2 Ecological Resources

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 (OHARNG 2014).

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. The northern long-eared bat (*Myotis septentrionalis*; federally threatened) exists at Camp Ravenna. There are no other federally listed species and no critical habitat occurs (OHARNG 2014). 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 2-1.

C Block Quarry is vegetated primarily with *Acer rubrum* successional forest, with a small area of herbaceous growth. These same types of habitats are adjacent to the AOC and elsewhere at Camp Ravenna (OHARNG 2014). The habitats are also found in the larger, local ecoregion that surrounds Camp Ravenna (USFS 2011). There is no known unique resource at C Block Quarry (OHARNG 2014). Additional information specific to ecological resources at C Block Quarry is included in Section 7.3.

2.4 CO-LOCATED OR PROXIMATE SITES

The following subsections summarize sites that are co-located or proximate to C Block Quarry, but are addressed separately.

2.4.1 Facility-wide Sewers

There are no facility-wide sewers within or adjacent to the AOC boundary.

2.4.2 Facility-wide Groundwater

As part of the Installation Restoration Program, the Army implements the Facility-wide Groundwater Monitoring Program (FWGWMP) in accordance with previous agreements made with Ohio EPA. The FWGWMP was initiated in 2005 and involves quarterly and semi-annual sampling of selected wells within the former RVAAP.

From 2008–2009, groundwater samples were collected from each of the four wells (CBLmw-001 through CBLmw-004) associated with C Block Quarry. In April 2011, additional groundwater data from CBLmw-004 were collected. In January 2012 through January 2013, additional semi-annual groundwater data from CBLmw-002 were collected. All chemical concentrations in groundwater were below the maximum contaminant level (MCL) or regional screening level (RSL) [target risk (TR) of 1E-05, hazard quotient (HQ) of 1] (EQM 2015).

An additional monitoring well (CBLmw-005) was installed near C Block Quarry in 2012 and sampled for four quarters from April 2012 to June 2013. The only chemical to exceed the RSL of 1E-05 (6 µg/L) and MCL was cobalt in the April 2012 sample with a concentration of 6.9 µg/L. There was no MCL associated with cobalt, and the RSL was 6 µg/L. The samples collected in the following three quarters had cobalt concentrations below the RSL of 1E-05.

Additional groundwater level monitoring was performed in May 2014 and July 2015 at the five monitoring wells around C Block Quarry; however, no samples were collected (EQM 2015, TEC-Weston 2016). Facility-wide groundwater is currently at the RI phase of the CERCLA process. Any future decisions or actions respective to groundwater at C Block Quarry will be addressed as part of that facility-wide AOC.

2.4.3 Munitions Response Sites

There is no munitions response site within or adjacent to the AOC boundary identified as part of the Military Munitions Response Program.

2.4.4 Compliance Restoration Sites

There are no compliance restoration sites, such as former or existing underground storage tanks, within or adjacent to the AOC boundary.

2.5 POTENTIAL SITE-RELATED RELEASES

As discussed previously, the site was used for disposing annealing process liquids (chromic acid) and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. This material was reportedly dumped on the ground surface during the 1950s and 1960s (USATHAMA 1982). The volume of liquid waste disposed of at C Block Quarry is unknown. The 1989 RCRA Facility Assessment (Jacobs 1989) evaluated potential releases of contamination to the environment from the site. This assessment determined that any releases are unknown, there is a low potential of releases to the soil and groundwater, there is a low potential of releases to surface water from this unit, and a low potential of releases to the air.

Table 2–1. Federal- and State-listed Species List

CAMP RAVENNA JOINT MILITARY TRAINING CENTER RARE SPECIES LIST	
December 2014	
I. Species confirmed to be on Camp Ravenna property by biological inventories and confirmed sightings.	
A. Federal Threatened	
1. Northern long-eared bat, *Myotis septentrionalis*	
B. State Endangered	
1. American bittern, *Botaurus lentiginosus* (migrant) 2. Northern harrier, *Circus cyaneus* 3. Sandhill Crane, *Grus Canadensis* (probable nester) 4. Black bear, *Ursus americanus* 5. Mountain Brook Lamprey, *Ichthyomyzon greeleyi* 6. Brush-tipped emerald, *Somatochlora walshii* 7. Graceful Underwing, *Catocala gracilis*	8. Tufted Moisture-loving Moss, *Philonotis Fontana var. caespitosa* 9. Appalachian quillwort, *Isoetes engelmannii* 10. Handsome sedge, *Carex formosa* 11. Narrow-necked Pohl's Moss, *Pohlia elongata var. elongate* 12. Philadelphia panic-grass, *Panicum philadelphicum* 13. Variegated scouring-rush, *Equisetum variegatum*
C. State Threatened	
1. Barn owl, *Tyto alba* *2.* Least bittern, *Ixobrychus exilis* 3. Trumpeter swan, *Cygnus buccinators* (migrant) 4. Bobcat, *Felis rufus* 5. Caddis fly, *Psilotreta indecisa*	6. Northern long-eared bat, *Myotis septentrionalis* 7. Hobblebush, *Viburnum alnifolium* 8. Simple willow-herb, *Epilobium strictum* 9. Lurking leskea, *Plagiothecium latebricola* 10. Strict blue-eyed grass, *Sisyrinchium montanum*
D. State Potentially Threatened Plants	
1. Arborvitae, *Thuja occidentalis* 2. False hop sedge, *Carex lupiliformis* 3. Greenwhite sedge, *Carex albolutescens* 4. Long Beech Fern, *Phegopteris connectilis* (*Thelypteris phegopteris*) 5. Pale sedge, *Carex pallescens*	6. Sharp-glumed manna-grass, *Glyceria acutifolia* 7. Straw sedge, *Carex straminea* 8. Water avens, *Geum rivale* 9. Woodland Horsetail, *Equisetum sylvaticum* 10. Shining ladies'-tresses, *Spiranthes lucida*
E. State Species of Concern	
1. Big brown bat, *Eptesicus fuscus* 2. Deer mouse, *Peromyscus maniculatus* 3. Eastern red bat, *Lasiurus borealis* 4. Hoary bat, *Lasiurus cinereus* 5. Little brown bat, *Myotis lucifugus* 6. Pygmy shrew, *Sorex hovi* 7. Southern bog lemming, *Svnaptomys cooperi* 8. Star-nosed mole, *Condylura cristata* 9. Tri-colored bat, *Perimyotis subflavus* 10. Woodland jumping mouse, *Napaeozapus insignis* 11. Sharp-shinned hawk, *Accipiter striatus* 12. Marsh wren, *Cistothorus palustris* 13. Henslow's sparrow, *Ammodramus henslowii* 14. Cerulean warbler, *Dendroica cerulean* 15. Prothonotary warbler, *Protonotaria citrea* 16. Bobolink, *Dolichonyx oryzivorus*	17. Northern bobwhite, *Colinus virginianus* 18. Common moorhen, *Gallinula chloropus* 19. Great egret, *Ardea alba* (migrant) 20. Sora, *Porzana carolina* 21. Virginia Rail, *Rallus limicola* 22. Yellow-bellied Sapsucker, *Sphyrapicus varius* 23. Creek heelsplitter, *Lasmigona compressa* 24. Eastern box turtle, *Terrapene carolina* 25. Four-toed Salamander, *Hemidacrylium scutatum* 26. Eastern garter snake, *Thamnophis sirtalis* 27. Smooth green snake, *Opheodrys vernalis* 28. Eastern sand darter, *Ammocrypta pellucida* 29. Mayfly, *Stenonema ithica* 30. Moth, *Apamea mixta* 31. Moth, *Brachylomia algens* 32. Scurfy quaker, *Homorthodes furfurata* 33. Sedge wren, *Cistothorus platensis*

Table 2–1. Federal- and State-listed Species List (continued)

CAMP RAVENNA JOINT MILITARY TRAINING CENTER RARE SPECIES LIST	
December 2014	
F. State Special Interest	
1. American black duck, *Anas rubripes* 2. Canada warbler, *Wilsonia Canadensis* 3. Dark-eyed junco, *Junco hyemalis* (migrant) 4. Hermit thrush, *Catharus guttatus* (migrant) 5. Least flycatcher, *Empidonax minimus* 6. Magnolia warbler, *Dendroica magnolia* 7. Northern waterthrush, *Seiurus noveboracensis* 8. Winter wren, *Troglodytes troglodytes* 9. Back-throated blue warbler, *Dendroica caerulescens* 10. Brown creeper, *Certhia Americana* 11. Mourning warbler, *Oporornis Philadelphia* 12. Pine siskit, *Carduelis pinus*	13. Purple finch, *Carpodacus purpureus* 14. Red-breasted nuthatch, *Sitta Canadensis* 15. Golden-crowned kinglet, *Regulus satrapa* 16. Blackburnian warbler, *Dendroica fusca* 17. Gadwall, *Anas strepera* 18. Green-winged teal, *Anas crecca* 19. Northern shoveler, *Anas clypeata* 20. Redhead duck, *Aytya Americana* *21.* Ruddy duck, *Oxyura jamaicensis* 22. Wilson's snipe, *Gallinago delicata* 23. Subflava sedge borer, *Capsula subflava*

Note: The Integrated Natural Resources Plan (OHARNG 2014) indicated that no federally listed species are known to reside at Camp Ravenna, and no critical habitat occurs. However, Table 2-1 reflects that the northern long-eared bat exists at Camp Ravenna and is federally threatened (USFWS 2016) and state threatened (ODNR 2016).

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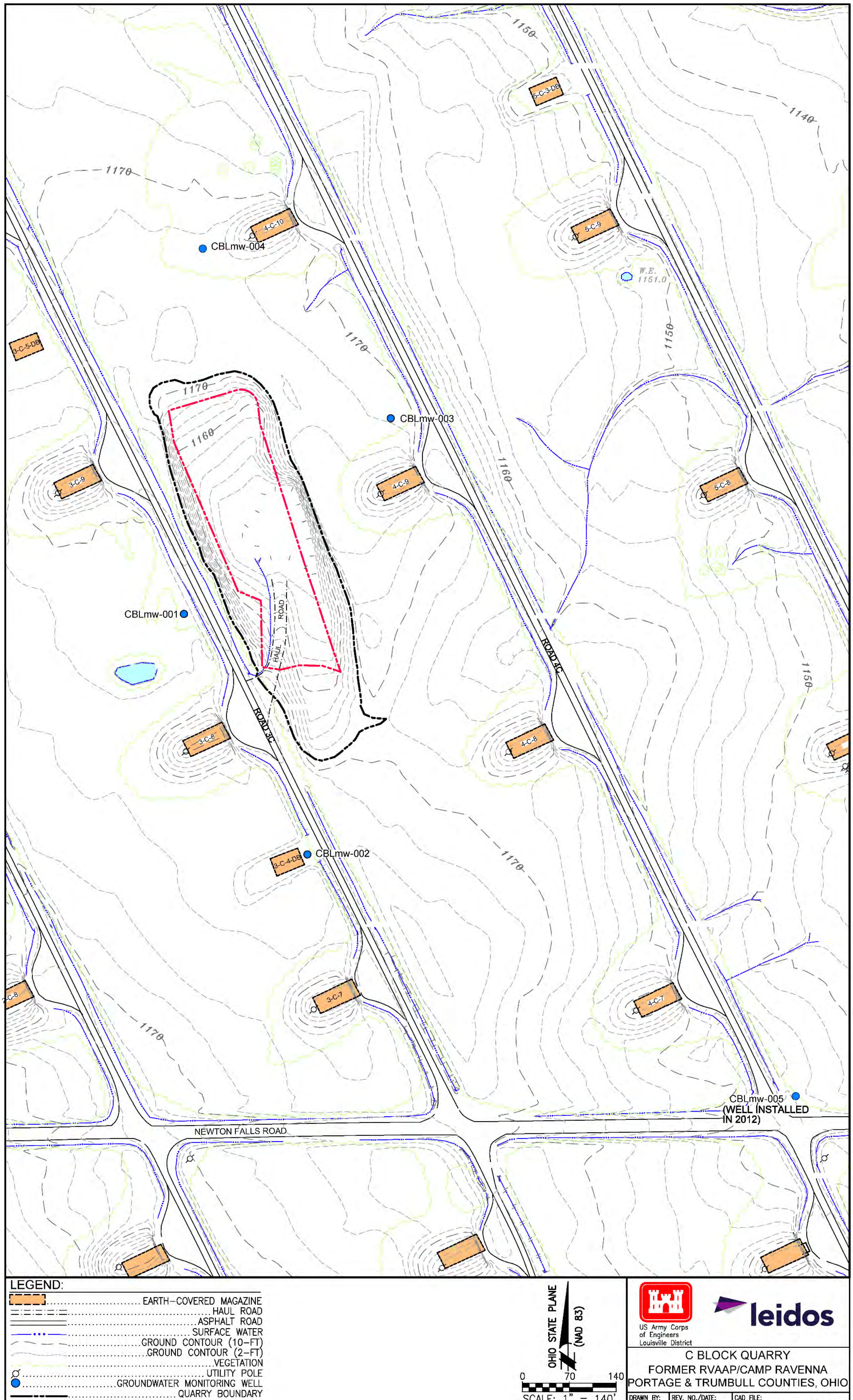

Figure 2–1. C Block Quarry Site Features

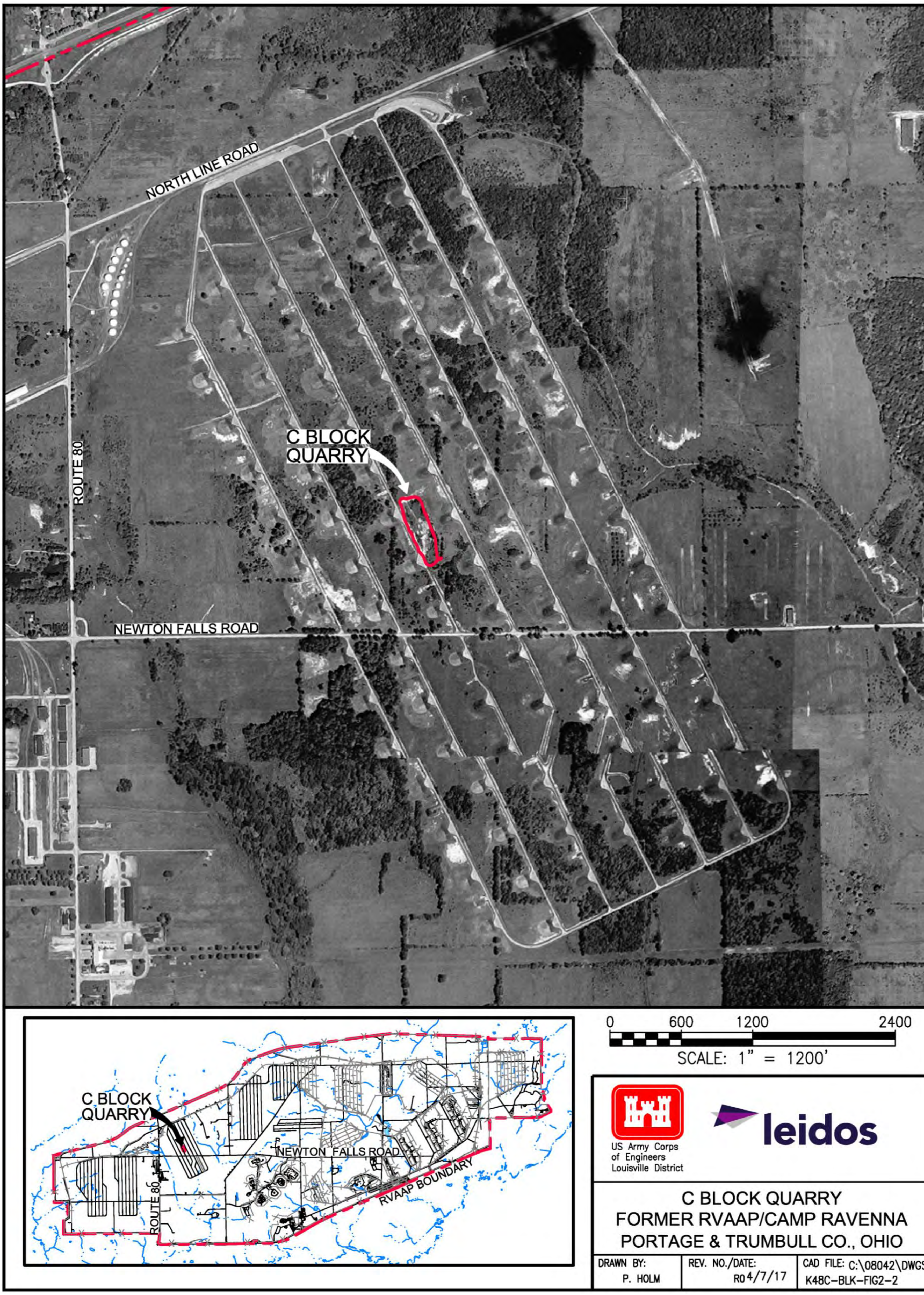

Figure 2–2. C Block Storage Area (Aerial Photo dated 1959)

3.0 ENVIRONMENTAL SETTING

This section describes the physical features, topography, geology, hydrogeology, and environmental characteristics of Camp Ravenna at C Block Quarry that are factors in identifying the potential contaminant transport pathways, receptor populations, and exposure scenarios to evaluate human health and ecological risk.

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 rounded ridges, filled major valleys, and blanketed many areas with glacially-derived unconsolidated deposits (e.g., sand, gravel, and finer-grained outwash deposits). As a result of glacial activity in this section, old stream drainage patterns were disrupted in many locales, and extensive wetland areas developed.

3.2 SURFACE FEATURES AND AOC 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 contour interval with an accuracy of 0.02 ft. 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 included in this report.

C Block Quarry is in the northwest portion of Camp Ravenna, between roads 3C and 4C of the C Block Storage Area, north of Newton Falls Road (Figures 1-2 and 2-1). The quarry is characterized by a large plateau which slopes radially in all directions (MKM 2007). The quarry bottom has a maximum depth of 25 ft below the surrounding grade (Figure 3-1). Hinkley Creek is approximately 2,400 ft to the west, and Sand Creek is approximately 2,000 ft to the east (Figure 1-2).

Access to the quarry bottom is limited to two gradually sloped areas near the northwest and southwest corners of the AOC. No fences exist; however, the eastern and western sides of the AOC are defined by the quarry walls. Ground elevations within C Block Quarry range from 1,174 ft amsl at the quarry rim to 1,150 ft amsl at the center of the quarry bottom (Figure 3-1). Bedrock is typically encountered at 1,149 ft amsl across the AOC. No perennial surface water features are present within the AOC or in the immediate vicinity. Intermittent surface water flows into the quarry and accumulates in low-lying areas.

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 the geology specific to C Block Quarry are presented in the following subsections.

3.3.2 Soil and Glacial Deposits

Bedrock at Camp Ravenna is overlain by deposits of the Wisconsin-age Lavery Till in the western portion of the facility and the younger Hiram Till and associated outwash deposits in the eastern two-thirds of the facility (Figure 3-2). 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 in the south-central portion.

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 locations such as Load Line 1 and the Erie Burning Grounds (USACE 2001a). Where this glacial material is still present, its distribution and character indicate its origin as 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*, which describes soil as nearly level to gently sloping and poor to moderately well drained (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 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 C Block Quarry

C Block Quarry is located on a local bedrock high. The bedrock formation observed at C Block Quarry is the Pennsylvanian age Pottsville Formation, Homewood Sandstone Member (Figure 3-3). 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. Boring logs describing bedrock lithologies as well as bedrock core photographs to a maximum installation depth of 50 ft below ground surface (bgs) are included in the Characterization of 14 AOCs. Cross-sections of the C Block Quarry subsurface were created from monitoring well lithology records to illustrate lateral distribution and variation of the discontinuous glacial sediment atop bedrock (MKM 2007).

During the PBA08 RI, bedrock was encountered at depths ranging from 0.75 ft bgs in the center of the quarry bottom to 7 ft bgs along the northern edge of the AOC boundary. Bedrock was typically encountered in the southern and western extents of the AOC around 4 ft bgs. Historical investigations report encountering bedrock at C Block Quarry at 2–6 ft bgs.

The primary soil type found at C Block Quarry is the Mitiwanga silt loam (MvB) (2-6% slopes) (USDA 2010). Mitiwanga silt loam is a gently sloping, moderately well drained soil formed from glacial till over weathered sandstone. As observed in PBA08 RI soil borings, the composition of unconsolidated deposits at C Block Quarry generally consist of yellowish-brown to brown medium dense sand-rich silt tills with trace to little weathered sandstone throughout.

Geologic descriptions and geotechnical analyses of subsurface soil samples collected during the PBA08 RI are generally consistent with the conclusions from the Characterization of 14 AOCs. Overall, the PBA08 RI observed sandy silts and silty sands, with trace, discontinuous gravel above sandstone. Groundwater was not observed in unconsolidated borings. PBA08 RI boring logs containing geologic descriptions of unconsolidated deposits at C Block Quarry are included in Appendix A.

Geotechnical analyses conducted during the Characterization of 14 AOCs indicated a grain size distribution of 49% silt and clay fractions, 39–47% sand fractions, and 2–12% aggregate. The geotechnical sample collected from 0–2 ft bgs was clayey sand with little gravel, and the 2–4 ft bgs sample was characterized as silty sand with trace gravel (MKM 2007). One geotechnical sample was collected as part of the PBA08 RI from 1.5–3.5 ft bgs. Analyses of undisturbed geotechnical samples (Shelby tube) collected from 2.5–4.5 ft bgs during the PBA08 RI indicate 34% aggregate, 56% sand, and 10% silt and clay fractions. Geotechnical analysis further indicated a porosity of 35% and a permeability of 5.6E-07 cm/sec for this sample. A summary of the PBA08 RI geotechnical analysis is presented in Section 5.3.5.

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, 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 permeabilities than surrounding clay or silt-rich material. Figure 3-4 illustrates facility-wide potentiometric surface data in the unconsolidated interval from the recent October 2018 contemporaneous measurement event (Leidos 2019).

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 Massillon Sandstone. Wells completed in the Massillon Sandstone in Portage County have yields ranging from 5–100 gpm but are typically less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow et al. 1966).

Figure 3-5 shows the potentiometric surface within bedrock strata at the facility in from the recent October 2018 contemporaneous measurement event (Leidos 2019). 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 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 hydraulic communication between the two aquifers is occurring.

3.4.2 C Block Quarry Hydrologic/Hydrogeologic Setting

Four groundwater monitoring wells were installed around C Block Quarry during the Characterization of 14 AOCs. In 2012, an additional monitoring well (CBLmw-005) was installed near the northeastern corner of the intersection of Road 4C and Newton Falls Road, approximately

850 ft southeast of the AOC (Figure 3-1). This monitoring well was completed to 31 ft bgs (1,124 ft amsl) and screened in the Homewood Sandstone to monitor groundwater in the bedrock (EQM 2015).

All monitoring wells (CBLmw-001 through CBLmw-005) are screened in bedrock, and the groundwater elevations were collected under the FWGWMP. The potentiometric surface of the AOC from the April 2017 monitoring event is shown in Figure 3-1. Groundwater elevations were from 1,132–1,138 amsl in the wells (TEC-Weston 2018) and at an estimated 1,137 ft amsl within the quarry.

The estimated groundwater flow directions reflect the April 2017 facility-wide potentiometric data presented in the *Facility-wide Groundwater Monitoring Program Annual Report for 2017* (TEC-Weston 2018). The potentiometric surface shows the groundwater flow pattern to the southeast. The horizontal hydraulic gradient from the 2012 water levels was 0.0028 ft/ft (EQM 2010a), which is lower than the hydraulic gradient (0.005 ft/ft) based on the 2017 water levels.

Results of slug tests performed at the four monitoring wells during the Characterization of 14 AOCs indicate an average hydraulic conductivity of 3.80E-04 cm/s (MKM 2007). Table 3-1 presents the hydraulic conductivity result for each well.

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. The west branch 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 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):

- South Fork Eagle Creek,
- Sand Creek, and
- Hinkley Creek.

These watercourses have many associated tributaries. Sand Creek, with a drainage area of 13.9 square miles (36 km^2), 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 to its confluence with Eagle Creek. The drainage area of South Fork Eagle Creek is 26.2 square miles, including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Routes 88 and 303 to the north of the facility. Hinkley Creek, with a drainage area of 11 square miles, flows in a southerly direction through the facility and converges with the west branch of the Mahoning River (USACE 2001a).

Previous jurisdictional wetland delineations have surveyed approximately 5,680 acres (or 26% of the Camp Ravenna land). Approximately 715 acres of jurisdictional wetlands have been delineated within the 5,680 acres surveyed, which comprises approximately 13% of the total surveyed area. 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 30 ponds are scattered throughout the facility. Many were constructed within natural drainageways 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 2.3.2. 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 C Block Quarry Surface Water

No perennial surface water features are present within the AOC or in the immediate vicinity. Intermittent surface water flows into the quarry and accumulates in low-lying areas (Figure 3-1). Surface water drainage generally follows the topography at the AOC radially inward toward the quarry bottom. Low-lying areas contain surface water for short periods of time only during precipitation events or periods of snow melt. The bedrock sidewall of the quarry does not contribute to surface water within the AOC because the water table is below the quarry bottom. No migration pathways for surface water runoff to exit the AOC are identified within C Block Quarry. During the PBA08 RI, surface water was observed only as stagnant puddles in low-lying areas.

3.5 CLIMATE

The general climate of the Camp Ravenna area is continental and is 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 the Camp Ravenna area were obtained from available National Weather Service records for the 30-year period of record from 1981–2010 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 (http://www1.ncdc.noaa.gov/pub/data/ccd-data/wndspd14.txt) for the available 30-year period of record from 1984–2014.

Average annual rainfall at Camp Ravenna area 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 the Camp Ravenna area is 49.3ºF, with an average daily high temperature of 70.9ºF and an average daily low temperature of 26.1ºF. The record high 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 (10.3 miles per hour) and the lowest average wind speed occurring in August (6.5 miles per hour). Thunderstorms occur on 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.

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)
CBLmw-001	39–49	Sandstone	1.75E-04
CBLmw-002	34.5–44.5	Sandstone	4.14E-04
CBLmw-003	33–43	Sandstone	3.69E-04
CBLmw-004	34–44	Sandstone	5.62E-04

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

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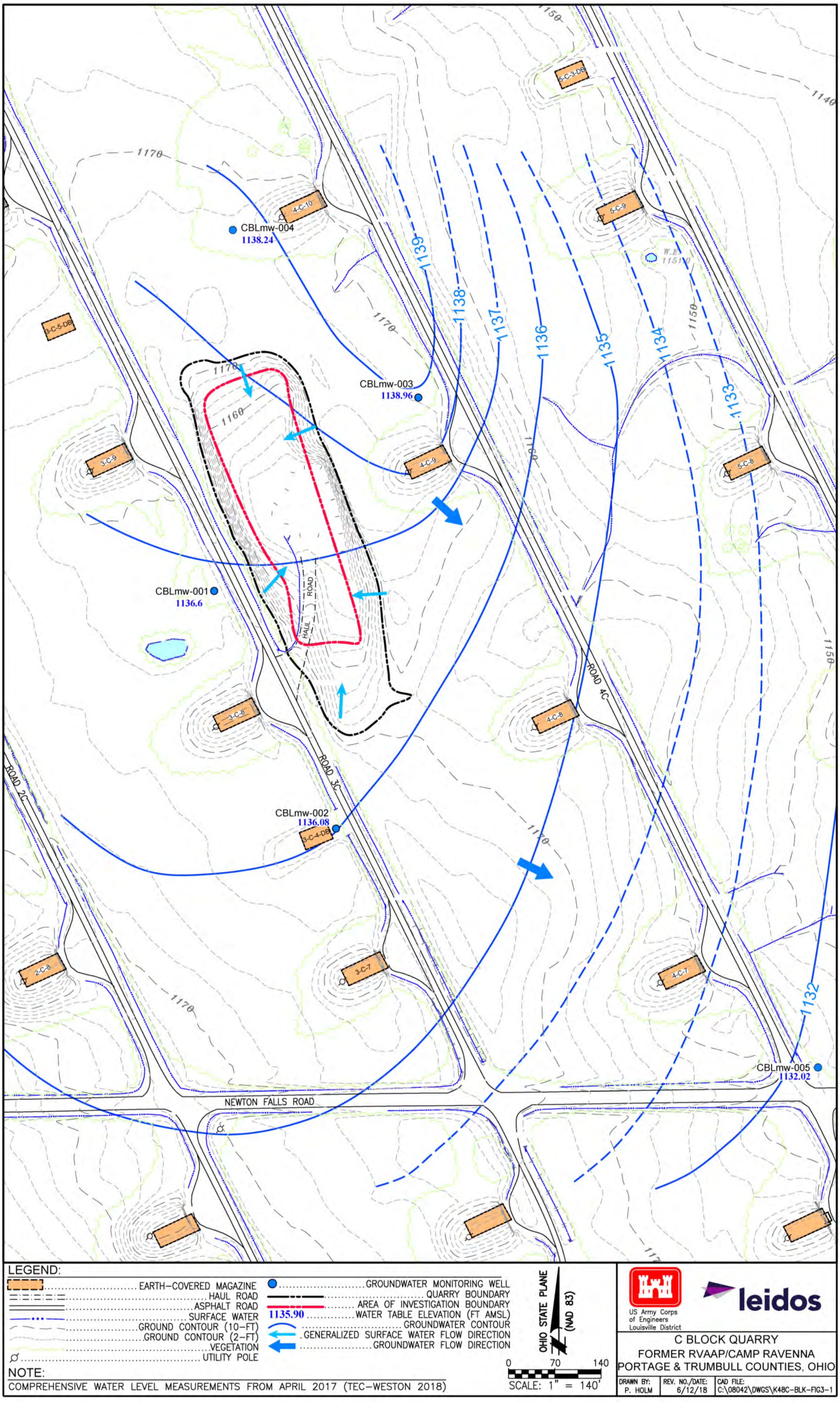

Figure 3–1. Topography, Groundwater Flow, and Surface Water Flow at C Block Quarry

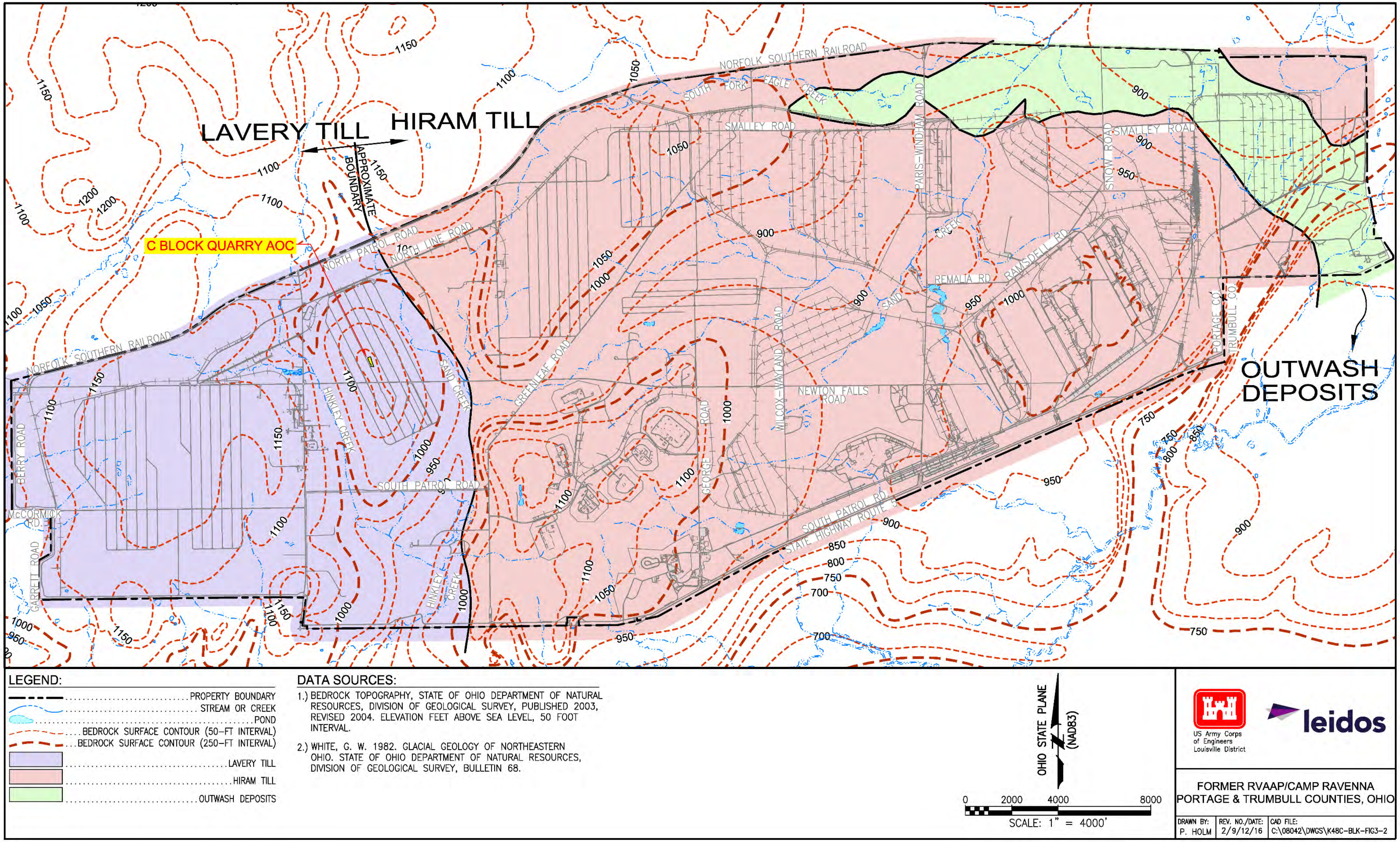

Figure 3–2. Geologic Map of Unconsolidated Deposits on Camp Ravenna

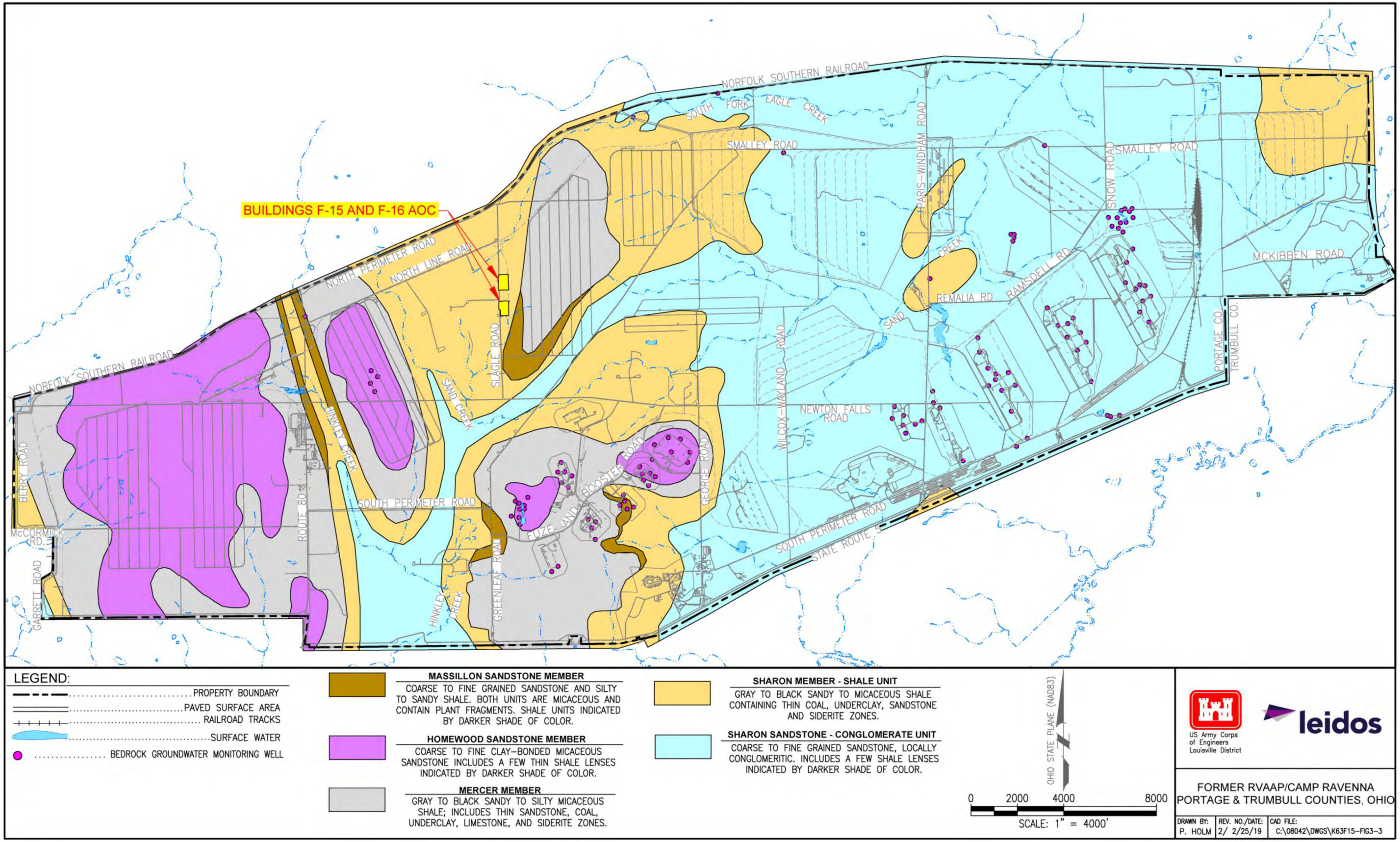

Figure 3–3. Geologic Bedrock Map and Stratigraphic Description of Units on Camp Ravenna

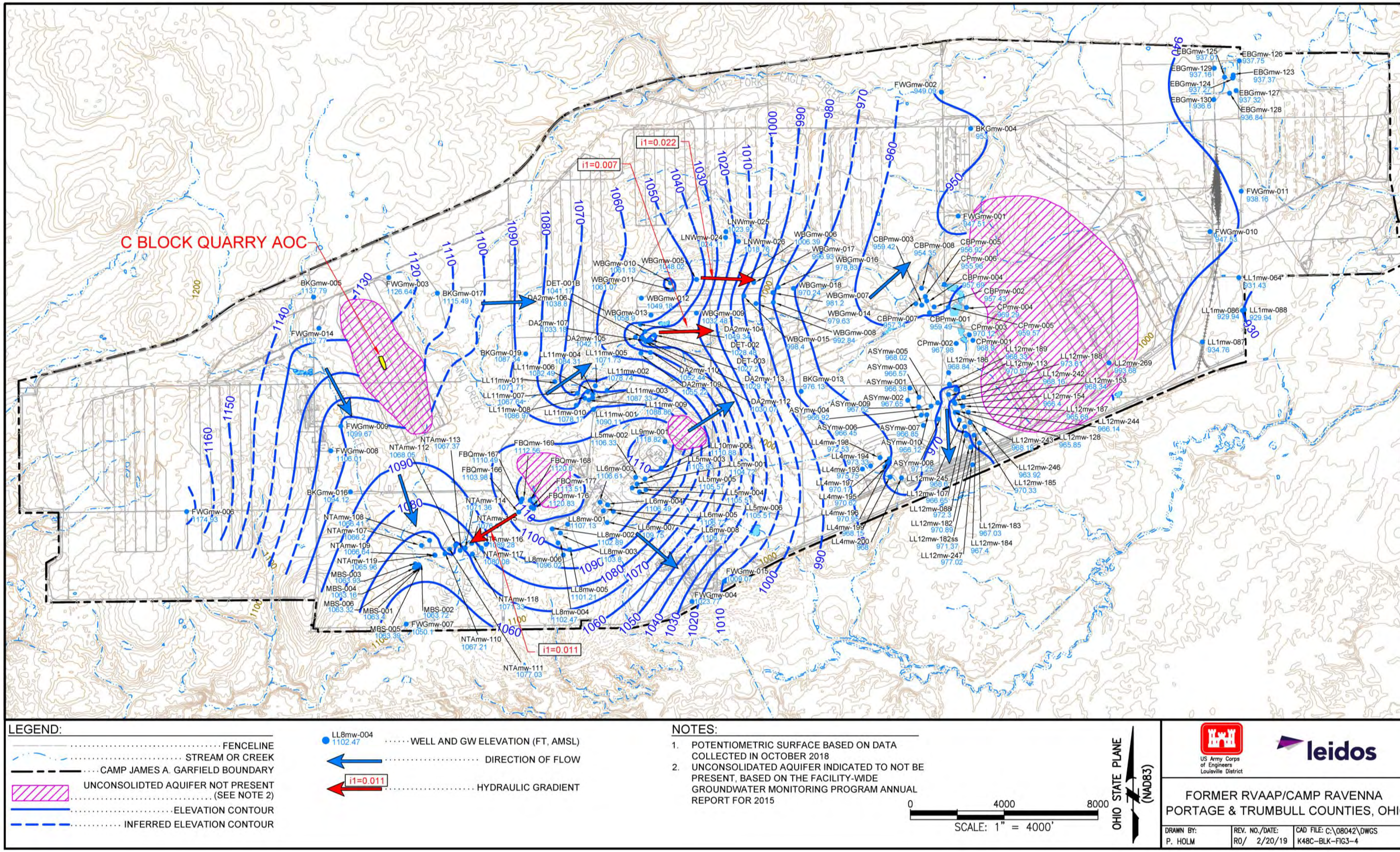

Figure 3–4. Potentiometric Surface of Unconsolidated Aquifer at Camp Ravenna

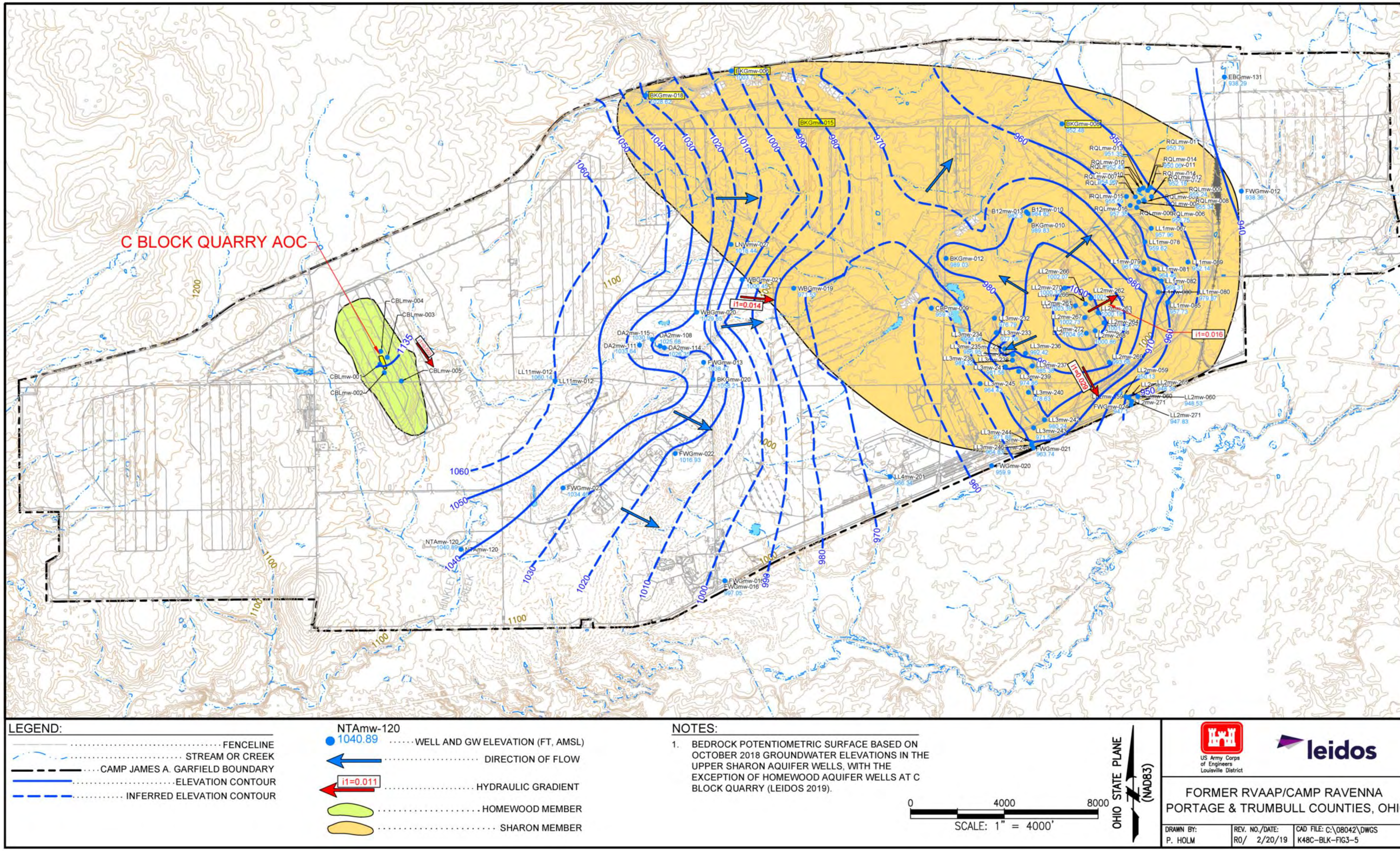

Figure 3–5. Potentiometric Surface of Bedrock Aquifers at Camp Ravenna

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4.0 SITE ASSESSMENTS, INVESTIGATIONS, AND DATA ASSEMBLY

This section summarizes all previous site assessments and investigations conducted at C Block Quarry. These previous activities included assessments to prioritize the AOC and investigations that collected data used in support of the RI.

4.1 C BLOCK QUARRY PREVIOUS ASSESSMENTS AND EVALUATIONS

This section summarizes previous assessments and evaluations conducted at C Block Quarry. These activities were generally performed as an initial evaluation and/or prioritization assessment of the AOC. The data collected as part of these prioritization assessments and evaluations are not used in the nature and extent, fate and transport, HHRA, or ERA due to their age and lack of data quality documentation.

4.1.1 1982 Soil and Sediment Analysis

The Mogul Corporation performed surface soil and sediment analysis at selected RVAAP ponds, streams, and quarries for the explosives 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in May 1982. This analysis included collecting three surface soil samples from C Block Quarry.

A description of field activities and data summary are provided in the *Soil and Sediment Analysis Performed for Ravenna Arsenal* (Mogul 1982). Table 4-1 summarizes the results of the 1982 soil investigation at C Block Quarry. Results relevant to C Block Quarry are as follows:

- TNT and RDX were not detected in the three surface soil samples collected from C Block Quarry.
- One surface soil sample had a chromium concentration of 290 mg/kg, a lead concentration of 150 mg/kg, and a mercury concentration of 1.24 mg/kg.
- Two samples had chromium concentrations of 13 and 16 mg/kg, respectively.

4.1.2 1982 Installation Reassessment of Ravenna Army Ammunition Plant

In 1978, 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. C Block Quarry was not included in this assessment. The 1982 *Installation Reassessment of the Ravenna Army Ammunition Plant* (USATHAMA 1982) reassessed RVAAP to review areas with potential for contaminant releases not documented in the 1978 Installation Assessment. The 1982 Installation Reassessment also 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 C Block Quarry as part of the reassessment. The report recommended that RVAAP coordinate with U.S. Army Environmental Hygiene Agency for future water quality monitoring and site closure (USATHAMA 1982). The reassessment identified the following conditions at RVAAP, applicable to C Block Quarry (USATHAMA 1982):

- Spent rinse solutions and sludge from acid dip tanks were discarded by transporting to and dumping at the stone quarry in the early 1950s and 1960s. Reportedly, this quarry was located in the Block C magazine area and was observed from aerial photographs as a dump site in the 1950s.
- Off-post contaminant migration was not evident, but the quarry bottom dump may be a source of contamination that should be evaluated.

4.1.3 1986 Soil Contamination Survey

The 1986 soil investigation was performed to assess the quarry for metal contamination in soil as a result of waste disposal activities related to annealing process wastes from Load Line 2 (renovation of fired 90 mm shells) (Mogul 1986). Soil samples were collected and analyzed for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver to assess if soil at the site exhibits the characteristic of extraction procedure (EP) toxicity.

The quarry bottom was divided into 12 quadrants, and discrete soil samples were collected from the middle of the quadrants. Each location was sampled from three intervals: top 3 inches, at 1 ft, and 2 ft bgs. A total of 36 soil samples were collected for this EP toxicity study in November 1986.

Table 4-2 presents the EP toxicity concentrations of the soil samples. While some soil samples had concentrations in the EP toxicity analysis, all concentrations were below the maximum concentration of contaminants for the toxicity characteristic, as specified in Table 1 of 40 Code of Federal Regulations (CFR) 261.24.

4.1.4 1989 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). Solid waste management units were evaluated to determine the potential need for corrective action if releases of contamination to the environment were identified. The assessment provided the following conclusions pertaining to C Block Quarry:

- Waste types and constituents were primarily chromium, lead, mercury, and sulfuric acid with unknown volume or capacity.
- Releases (if any) are unknown.
- Low potential of releases to the soil and groundwater from this unit.
- Low potential of releases to surface water from this unit.
- Low potential of releases to the air.
- No potential for subsurface gas release.

- Visual site inspection findings included deteriorated barrels, glass fragments, bricks, and several 5 gallon pails.
- The unit was heavily overgrown with vegetation, and no damage to flora or fauna was observed.
- There was no potential soil contamination observed.

This assessment indicated that no further action was needed at the time of the assessment and recommended closure of the unit according to a USEPA-approved closure plan.

4.1.5 1996 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). This document also summarized available historic information associated with C Block Quarry. No additional historical records were found to supplement information from the 1989 RCRA Facility Assessment of C Block Quarry. The report provided preliminary assessment scoring, subsequent prioritization of AOCs through evaluation of exposure pathways, and a relative risk site evaluation (RRSE) model. C Block Quarry was ranked as a low priority AOC primarily due to inactive status and limited exposure pathways.

4.1.6 1996 Relative Risk Site Evaluation

In 1996, the U.S. Army Center for Health Promotion and Preventive Medicine conducted an RRSE at C Block Quarry. This evaluation was completed to prioritize future remedial or corrective activities at RVAAP. The RRSE does not provide any risk assessment for human health or ecology.

The RRSE also included collecting surface soil samples at C Block Quarry. The data collected at the site "…are minimal Level III data, as defined by U.S. EPA, and are not intended to be used as definitive evidence of contamination presence or absence or to support health risk assessment." This section summarizes the samples collected as part of the RRSE data, the chemicals detected, and the associated prioritization recommendations, but the analytical results are not presented and are not used in subsequent evaluations in this RI Report. However, as stated in Appendix A, Section 1.2 of the *Final Sampling and Analysis Plan Addendum for the Characterization of 14 RVAAP AOCs* (MKM 2004), "Information from these assessments, evaluations and investigations plus institutional knowledge about the disposal that occurred at the quarry was used to determine the sampling locations, media and numbers of samples for this characterization activity."

The RRSE evaluated the soil pathway (human receptor endpoint) using data from three surface soil samples (RVAP-061 to RVAP-063) collected at the AOC and analyzed the soil for metals and cyanide. Subsurface soil, sediment, and groundwater were not evaluated as part of the RRSE. No explosives were detected in the surface soil samples, but several inorganic chemicals were detected in surface soil. Detected analyte concentrations are presented in Appendix C of the RRSE (USACHPPM 1996).

The surface soil pathways were evaluated as follows:

1. Surface soil
   a. Contaminant Hazard Factor: Minimal.
   b. Migration Pathway Factor: Potential. There is no evidence that site contaminants are migrating. However, there are no physical barriers in place to prevent migration.
   c. Receptor Pathway Factor: Potential. This area is not used for production and is not populated with workers. However, access to the site is not restricted in any manner.
2. Sediment – Not evaluated, as sediment is not present at the site.
3. Surface water – Not evaluated, as surface water is not present at the site.
2. Groundwater – Not evaluated.

Human receptor endpoints were evaluated based on the available surface soil data. The RRSE scored C Block Quarry as a "low-priority" AOC due to potentially contaminated surface soil potentially migrating and affecting human and ecological receptors (USACHPPM 1996).

4.2 REMEDIAL INVESTIGATIONS

This section summarizes previous investigations conducted at C Block Quarry. These investigations collected data of sufficient provenance and quality to be used to support the evaluations in this RI, including the nature and extent, fate and transport, HHRA, and/or ERA.

The previous *Characterization of 14 AOCs at the Ravenna Army Ammunition Plant* (MKM 2007) (herein referred to as the Characterization of 14 AOCs report) presented SRCs and/or COPCs based on data evaluation protocols in use at the time the investigations were completed. The data and information are used in this report; however, an updated screening process and the addition of new data and information may result in a different list of SRCs and/or COPCs.

References to "RVAAP full-suite analytes" generally include analyses of target analyte list (TAL) metals, explosives, propellants (nitrocellulose and nitroguanidine), semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and pesticides. If an incremental sampling methodology (ISM) sample was analyzed for RVAAP full-suite analytes, all parameters except VOCs were collected and analyzed as part of the ISM sample process, and the VOCs were analyzed from a discrete soil sample collected from within the ISM sample area.

4.2.1 Characterization of 14 Areas of Concern

The Characterization of 14 AOCs data quality objectives (DQOs) were developed to collect and provide sufficient, high-quality data for all applicable media such that future actions (i.e., HHRAs and ERAs) can be efficiently planned and accomplished at each AOC. Data generated by the characterization activities were used to determine if residual contaminants remain at the AOCs; if contaminants impact soil, sediment, surface water, or groundwater; if there is a need for more extensive risk assessments; and if remedial actions are appropriate.

From 2004–2005, sampling was conducted at C Block Quarry in accordance with the *Final Sampling and Analysis Plan Addendum for the Characterization of 14 RVAAP AOCs* (MKM 2004) (herein referred to as the Characterization of 14 AOCs SAP).

The Characterization of 14 AOCs investigation 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 (MKM 2007) and are summarized below.

4.2.1.1 Field Activities

The following investigation field activities were conducted from October 2004 to May 2005 to assess potential impacts from former operations at C Block Quarry (MKM 2007):

- Collected six multi-increment (MI) surface soil (0–1 ft bgs) samples,
- Collected one discrete surface soil (0–1 ft bgs) sample for VOCs, and
- Completed sampling location survey.

In addition, during the development of the Characterization of 14 AOCs SAP (MKM 2004), four springs/ponded areas were identified northeast of C Block Quarry. These locations were along lane C-5. Sediment and surface water samples from locations CBLsd/sw-001, CBLsd/sw-002, CBLsd/sw-003, and CBLsd/sw-004 (each representing a spring/ponded area) were collected and analyzed during the Characterization of 14 AOCs field effort to assess potential impacts from C Block Quarry. The nearest location (CBLsd/sw-004) was approximately 910 ft northeast of the AOC, and the farthest location (CBLsd/sw-004) was approximately 1,500 ft north-northeast of the AOC. Since the development of the Characterization of 14 AOCs SAP (MKM 2004) and field activities, it has been concluded that the groundwater flow direction at C Block Quarry is southeast. Therefore, these sample locations are upgradient of C Block Quarry and not potentially impacted by C Block Quarry contamination. These sample locations are not included in this RI.

The Characterization of 14 AOCs utilized MI samples. This sampling technique is currently referred to as ISM. The C Block Quarry bottom was divided into six ISM sample areas. All surface soil samples were analyzed for TAL metals and explosives, except one sample was analyzed for RVAAP full-suite analytes. In addition, one discrete surface soil sample was collected from one ISM sample area for VOC analyses to fulfill requirements to conduct a full-suite analysis for 10% of the MI sample population. Figure 4-1 presents the locations sampled under the Characterization of 14 AOCs.

Analytical laboratory procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, and specific project goals and requirements. Samples were analyzed as specified by the Facility-wide Sampling and Analysis Plan (FWSAP) current at the time of the investigation, the Characterization of 14 AOCs SAP (MKM 2004), and USACE Louisville Chemistry Guideline (USACE 2002). DQOs were established for the Characterization of 14 AOCs and complied with USEPA Region 5 guidance. The requisite number of quality assurance (QA)/quality control (QC) samples was obtained during the investigation. The data validation determined that the data met the completeness requirements for the project (90% complete), was usable, and that it satisfied the DQOs for the project.

Table 4-3 presents the ISM sample locations, associated operations, and suite of chemicals analyzed as part of the Characterization of 14 AOCs. Table 4-4 presents the results of the analytes detected from samples collected during the Characterization of 14 AOCs.

4.2.1.2 Nature and Extent of Contamination

The nature of contamination for C Block Quarry was characterized in surface soil (0–1 ft bgs) media only. Two of the contaminants were inorganic chemicals (arsenic and chromium) that were detected above RVAAP background concentrations and/or Region 9 residential preliminary remediation goal (PRG) screening values at that time, and two SVOCs [benzo(ghi)perylene and phenanthrene], three explosives [TNT; 2-amino-4,6-dinitrotoluene (DNT); and 4-amino-2,6-DNT], and one propellant (nitrocellulose) were also detected above screening criteria. Figure 4-4 presents locations that exceed current screening criteria.

4.2.1.3 Human Health Risk Screening

The HHRS compared chemical concentrations detected in the AOC surface soil samples to RVAAP screening criteria in effect at that time, which included facility-wide background concentrations for inorganic constituents and USEPA Region 9 residential PRGs. Constituents were retained if they did not have screening values. The results of the HHRS identified contaminants above screening criteria in surface soil, as summarized in Table 4-5.

4.2.1.4 Ecological Risk Screening

The ERS compared chemical concentrations detected in C Block Quarry surface soil 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 2003) (herein referred to as the FWERWP) and *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003). Chemicals were retained if they did not have screening values. Table 4-6 presents the chemicals identified in the ERS as exceeding screening values for C Block Quarry surface soil.

4.2.1.5 <u>Results and Conclusions</u>

Two metals (arsenic and chromium), two SVOCs [benzo(ghi)perylene and phenanthrene], three explosives (TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT), and one propellant (nitrocellulose) were identified as COPCs in surface soil. All VOCs and PCBs were below Region 9 residential PRGs and/or laboratory detection limits. The Characterization of 14 AOCs report recommended that the full range of human health and ecological risks should be considered to assist in the overall risk management decisions for C Block Quarry.

4.2.2 PBA08 Remedial Investigation – March 2010

In November 2008, Science Applications International Corporation (SAIC) scientists performed a site walk of C Block Quarry. The site walk was conducted to develop the *Performance-based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1* (USACE 2009a) (herein referred to as the PBA08 SAP), which supplemented the Characterization of 14 AOCs and completed the RI phase of the CERCLA process. No physical changes occurred at C Block Quarry between the 2004 Characterization of 14 AOCs sampling and the development of the PBA08 SAP. The PBA08 SAP considered prior investigations and changes in AOC conditions during development of the DQOs and sampling scheme for completing the C Block Quarry RI. Section 4.4.4 discusses the suitability and use of samples collected to support the RI, with respect to changes in AOC conditions. The PBA08 SAP was reviewed and approved by representatives of the Army and Ohio EPA in January 2010.

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). Decision flowcharts for PBA08 RI surface and subsurface sampling are presented in Figures 4-2 and 4-3, respectively. The screening approach presented in the PBA08 SAP compared sample results from previous investigations at C Block Quarry to chemical-specific facility-wide cleanup goals (FWCUGs) at the 1E-06 cancer risk level and non-carcinogenic risk HQ of 0.1, as presented in the Facility-wide Human Health Risk Assessor Manual (FWHHRAM) (USACE 2005a). The most protective FWCUGs for the three potential receptors are referred to as “screening criteria.” Previous results were also compared to FWCUGs at the higher TR of 1E-05, HQ of 1 to facilitate identifying potential source areas that may require additional sampling to refine the extent of contamination. Table 4-7 lists the chemicals with detected concentrations that exceeded screening criteria at the time of the PBA08 SAP in historical soil samples.

In March 2010, the PBA08 RI was implemented by collecting surface and subsurface soil using ISM and discrete sampling techniques. The results of the PBA08 RI sampling, combined with the results of the Characterization of 14 AOCs, were used 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.

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.

A sample log for each sample and lithologic soil description for each soil boring collected during the PBA08 RI is included in Appendix A. The DQOs, field activities, sampling methodologies, QA/QC, and management of analytical data for the PBA08 RI are examined further in Appendix I.

4.2.2.1 Subsurface Soil Sampling Rationale and Methods

The PBA08 RI used discrete samples from soil borings to characterize subsurface soil. Subsurface soil sampling was conducted according to the decision rules approved in the PBA08 SAP.

Subsurface soil was characterized by placing five borings in ISM areas with previous surface soil results greater than the screening criteria. In all cases, soil samples were collected from the subsurface borings to further define the vertical extent of contamination in subsurface soil at the AOC (Figure 4-4). Table 4-8 presents the specific rationale for each soil sample collected for the PBA08 RI. Results of detected analytes in discrete surface soil and subsurface soil are presented in Tables 4-9 and 4-10, respectively.

To assess the depths of exposure of the Resident Receptor, each soil boring was sampled at 0–1, 1–4, and 4–7 ft bgs (or refusal) using a hand auger. Depth of borehole completion was limited by the depth to bedrock at the quarry pit bottom.

Each interval was composited and homogenized in a stainless steel bowl, except the VOC samples. All samples were analyzed for TAL metals and explosives; three samples were analyzed for RVAAP full-suite analytes to satisfy the PBA08 SAP sample requirements of a minimum of 15% frequency for full-suite analysis.

Two QC field duplicates and two QA split sample were collected to satisfy the QA/QC sample requirements of 10% frequency for subsurface soil samples.

One geotechnical sample was collected from one boring location (1.5–3.5 ft bgs) to provide soil data for fate and transport modeling. The geotechnical sample location was offset 2 ft south of soil boring CBLsb-010 and was installed by manually pushing the tubes into the soil to the top of bedrock. The Shelby tube was collected from 1.5–3.5 ft bgs. The 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 Section 5.3.5 and Appendix D.

4.2.2.2 Surface Water and Sediment Characterization

No surface water or sediment samples were collected because these media are not present at the AOC.

4.2.2.3 <u>Asbestos Characterization and Sampling</u>

Suspected ACM, consisting predominantly of loose transite tiles, was observed at C Block Quarry during reconnaissance activities in 2008. An Asbestos Hazard Evaluation Specialist, certified by the State of Ohio Department of Health, conducted the asbestos survey and sampling at C Block Quarry. The sample results from the ACM survey are summarized in Table 4-11, and the complete survey report is presented in Appendix J.

A visual survey was conducted for the entire AOC. Six building material samples and one soil sample (CBLss-017-5798-BD) were collected at locations presented in Figure 4-4. The asbestos sampling included identifying suspect material, estimating approximate quantity of suspected ACM, and collecting and analyzing samples from each material identified. Bulk samples were placed into clean, sealable bags and were analyzed by Polarized Light Microscopy (PLM) using USEPA Method 600/R-93/116.

In addition to an asbestos survey and sample collection by a certified Asbestos Hazard Evaluation Specialist, ACM sampling during the PBA08 RI consisted of analyzing soil boring samples for ACM. Nine soil samples were submitted for ACM analysis from four of the soil borings advanced during the PBA08 RI (CBLsb-007, CBLsb-008, CBLsb-010, and CBLsb-012). Results are presented in Tables 4-9 and 4-10. None of the nine soil samples exhibited detectable asbestos content.

4.2.2.4 <u>Changes from the Work Plan</u>

Significant changes to the work plan are documented in field change requests (Appendix B). Changes made in the field based on site conditions are not documented on field change requests but on the field sampling logs (Appendix A); none of these changes were necessary at C Block Quarry. New coordinates for all station locations can be found on the field sampling logs.

4.2.3 August 2012 Chromium Speciation Sampling

In August 2012, two ISM chromium speciation samples (and one QC field duplicate and one QA split) were recollected from historically sampled ISM areas (CBLss-003M and CBLss-005M) identified as having elevated total chromium concentrations 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 FWSAP (USACE 2001a). The rationale for the chromium speciation samples collected as part of the PBA08 RI is summarized in Table 4-12. The locations of these samples are presented in Figure 4-4, and chromium and hexavalent chromium results for the 2012 samples at CBLss-003M and CBLss-005M are presented in Table 4-13.

In addition, four discrete surface and subsurface soil samples and one QC field duplicate were collected from two soil borings located within ISM area with elevated chromium concentration (CBLss-003M) or near CBLsb-010. Samples from 0–1 and 1-2 ft bgs were collected in accordance with the bucket hand auger method described in Section 4.5.2.1.1 of the FWSAP (USACE 2001a).

Tables 4-9 and 4-10 present the analytes detected from the additional surface and subsurface soil samples collected in August 2012. These results are included as part of the SRC screens and in the HHRA and ERA.

4.3 FACILITY-WIDE BACKGROUND EVALUATION

Facility-wide background values for inorganic constituents in soil, sediment, surface water, and groundwater were developed in 1998, as documented in the *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds* (USACE 2001b). These background values are currently being reassessed, but the background values developed in 1998 are used throughout this report.

These facility-wide background values developed in 1998 were employed in the data reduction and screening process described in Section 4.4.2 and the remainder of the evaluations in this RI (e.g., nature and extent and fate and transport). Background locations were selected using aerial photographs and site visits from areas believed to be unaffected by RVAAP activities. Soil, sediment, surface water, and groundwater samples were collected from those locations to determine the range of background concentrations that could be expected in these media. Results from the site-specific background data collection were used to determine if detected metals and potential anthropogenic compounds [such as polycyclic aromatic hydrocarbons (PAHs)] are site-related, naturally occurring, or from non-RVAAP-related anthropogenic sources.

A total of 14 wells were installed in established background locations to collect filtered and unfiltered samples from the bedrock and unconsolidated zones. These samples were analyzed for TAL metals and cyanide for determining background concentrations.

Soil samples were collected from each of the background monitoring well locations from three intervals: 0–1, 1–3, and greater than 3 ft bgs. Because boring locations were changed during sampling based on the lithological requirements for well screen intervals, all depth intervals for soil were not sampled for each boring. Background surface soil samples were analyzed for TAL metals, cyanide, SVOCs, pesticides, PCBs, and VOCs. Surface water samples were analyzed for TAL metals and cyanide.

Seven stream locations upstream of RVAAP activities along Hinkley, Sand, and Eagle Creeks were sampled for sediment and surface water to characterize background conditions. Background sediment samples were analyzed for TAL metals, cyanide, SVOCs, pesticides, PCBs, and VOCs. Surface water samples were analyzed for TAL metals and cyanide.

Using the sampling results, an evaluation of outliers, data assessment, and statistical analyses were performed to determine background concentrations for each medium. For surface soil samples, PAHs, in addition to metals, were elevated in four samples. PAHs are related to combustion products and could indicate human disturbance at the locations where they were detected. Visits to the sampling locations and a review of aerial photography showing the area prior to the establishment of RVAAP indicated that these sampling locations were near homes or farms and could have been influenced by activities associated with those structures.

During the finalization of background concentrations at the former RVAAP, the Army and Ohio EPA agreed that formal background concentrations would only be applicable for inorganics. All organic analytes (e.g., PAHs, VOCs, and explosives) were classified as anthropogenic and potentially related to RVAAP operations; therefore, no background values were established for these classes of compounds. The final, approved facility-wide background concentrations for inorganics are presented in Table 4-14.

4.4 DATA EVALUATION METHOD

Data evaluation methods for C Block Quarry are consistent with those established in the *Facility-wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2010a), herein referred to as the FWCUG Report. These methods were specified in the PBA08 SAP (USACE 2009a). The processes used to evaluate the analytical data involved three general steps: 1) defining data aggregates; 2) conducting data verification, reduction, and screening; and 3) presenting data.

4.4.1 Definition of Aggregates

C Block Quarry data were aggregated in three ways for evaluating contaminant nature and extent and completing the HHRA and ERA. The initial basic aggregation of data was by environmental medium: surface soil and subsurface soil. 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 exposure units (EUs) and guidance established in the FWHHRAM and FWCUG Report.

Data aggregates for evaluating the nature and extent of contamination at C Block Quarry are as follows:

- **Surface Soil (0–1 ft bgs).** This medium was classified 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 (greater than 1 ft bgs).** This medium was classified as an AOC-wide spatial aggregate on the same basis as surface soil.

The soil data aggregates are further subdivided to define human health and ecological risk EUs in the risk assessments as discussed in Section 7.1 (e.g., shallow surface soil, deep surface soil, and subsurface soil).

Sediment and surface water are not present at this AOC. During the development of the Characterization of 14 AOCs SAP (MKM 2004), four springs/ponded areas were identified northeast of C Block Quarry and groundwater direction was unknown. These locations were along lane C-5. Sediment and surface water samples from locations CBLsd/sw-001, CBLsd/sw-002, CBLsd/sw-003, and CBLsd/sw-004 (each representing a spring/ponded area) were collected and analyzed during the Characterization of 14 AOCs field effort to assess potential impacts from C Block Quarry. The nearest location sampled (CBLsd/sw-004) was approximately 910 ft northeast of the AOC, and the farthest location (CBLsd/sw-004) was approximately 1,500 ft north-northeast of the AOC. Since the development of the Characterization of 14 AOCs SAP (MKM 2004) and field activities, it has been concluded that the groundwater flow direction at C Block Quarry is southeast. Therefore, these sample locations are upgradient of C Block Quarry and not potentially impacted by C Block Quarry contamination. These sample locations are not included in this RI.

4.4.2 Data Verification, Reduction, and Screening

4.4.2.1 <u>Data Verification</u>

Data verification was performed on 14 surface and subsurface soil samples (including QC duplicates) collected during the PBA08 RI in March 2010 and 8 surface and subsurface soil samples (including QC duplicates) in August 2012. 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. 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; and
- "R" result not usable.

In addition to assigning qualifiers, the verification process also selected the appropriate result to use when re-analyses or dilutions were performed. 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 both diluted and undiluted samples, diluted sample results were used for those analytes that exceeded the calibration range of the undiluted sample. A complete discussion of verification process results is contained in the data QC summary report (Appendix C). The data QC summary report also includes a summary table of the assigned data qualifiers and an 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.

4.4.2.2 <u>Data Reduction</u>

Calculating data summary statistics was the initial step in the data reduction process to identify SRCs. Eligible historic 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. As stated in Section 5.4.7 of the FWSAP, “The duplicate is submitted as ‘blind’ to the laboratory and is used to determine whether the field sampling technique is reproducible and to check the accuracy of reported laboratory results.” Therefore, duplicates are not used in 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 when calculating the mean result for each compound (USEPA 1989). Non-detected results with elevated detection limits (i.e., more than five times the contract-required detection limit) were excluded from the summary statistics in order to avoid skewing the mean value calculations.

4.4.2.3 Data Screening

After reduction, the data were screened to identify SRCs using the processes outlined below. Additional screening of identified SRCs against applicable criteria (e.g., USEPA RSLs, FWCUGs, and ESVs) 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). All chemicals that were not eliminated during the screening steps were retained as SRCs. The steps involved in the SRC screening are summarized below:

- **Data quality assessment** – Review the usability of the RI data set with respect to established DQOs as discussed in Section I.4.5 of Appendix I.
- **Background screening –** Compare the maximum detected concentrations (MDCs) of inorganic chemicals to background concentrations. If background concentrations are exceeded, the respective inorganic chemicals are retained as SRCs. No background concentrations were established for organic chemicals at C Block Quarry. As such, all detected organic chemicals were retained as SRCs.
- **Screening of essential human nutrients** – Evaluate chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) that 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 daily allowance (RDA) and recommended daily intake (RDI) values are available for all of these chemicals (Table 4-15). Screening values are 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 (SLs) are eliminated as SRCs.

- **Frequency of detection/WOE screening –** The FWCUG Report and the *Final (Revised) USACE RVAAP Position Paper for the Application and Use of Facility-wide Human Health Cleanup Goals* (USACE 2012a) (hereafter referred to as the FWCUG Position Paper) establish the protocol for frequency of detection and WOE screening. These guidance documents denote that analytes (except for explosives and propellants) detected in less than 5% of the discrete samples are screened out from further consideration if the sample population is 20 or more samples and evidence exists that the analyte is not AOC-related. Chemicals that were never detected in a given medium are eliminated as SRCs. For chemicals with at least 20 samples and a frequency of detection of less than 5%, a WOE approach is used to determine if the chemical is AOC-related. The WOE evaluates magnitude and location (clustering) of detected results and if the distribution of detected results indicates a potential source of the chemical. If the detected results for a chemical show 1) no clustering, 2) concentrations were not substantially elevated relative to detection limit, and 3) the chemical did not have an evident source, the results are considered spurious, and the chemical is eliminated from further consideration. This screen is applied to all organic chemicals and inorganic chemicals (except for explosives and propellants); all detected explosives and propellants are considered SRCs regardless of frequency of detection. Frequency of detection/WOE screening were not applied to C Block Quarry data sets as none were comprised of 20 or more samples.

4.4.3 Data Presentation

Data summary statistics and screening results for SRCs in surface and subsurface soil at C Block Quarry are presented below for each media and spatial aggregate. Analytical results for SRCs are presented in Table 4-16 for surface soil and Table 4-17 for subsurface soil.

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 the data packages in Appendix D that are associated with different AOCs. All samples for C Block Quarry have sample identifications beginning with "CBL." Each table in Appendix D presents the results for each sampling location for a specific medium aggregate (i.e., surface soil and subsurface soil), and class of analyte (e.g., explosives, inorganic chemicals, SVOCs, and VOCs).

The tables in Appendix D present the analytical results for samples collected during the 2004 Characterization of 14 AOCs and PBA08 RI. Sample locations from these investigations are presented in Figure 4-5. Analytical results are grouped by media (e.g., surface soil and subsurface soil) and class of analyte (e.g., explosives and inorganic chemicals) for ease of reference.

4.4.4 Data Evaluation

All quality-assured sample data were further evaluated to determine suitability for use in the various key RI data screens and evaluations (i.e., nature and extent, fate and transport, and risk assessment). Evaluating data suitability for use in the PBA08 RI involved considering representativeness with respect to current AOC conditions. Table 4-18 presents the designated use for all available C Block Quarry samples.

Surface and subsurface soil samples at C Block Quarry were collected using ISM and discrete sample methods during the 2004 Characterization of 14 AOCs and the PBA08 RI. Samples from 2004 (Characterization of 14 AOCs) were evaluated to determine if conditions had changed substantively between earlier characterization efforts and PBA08 RI activities. No AOC disturbance activities occurred at C Block Quarry between the Characterization of 14 AOCs in 2004 and the PBA08 RI sampling in 2010 and 2012. The full Characterization of 14 AOCs and PBA08 RI data sets were incorporated into the SRC screening process, and were carried forward into the risk assessment.

Table 4–1. Soil Sample Results for 1982 Soil and Sediment Analysis

Area		**AOI**	**AOI**	**AOI**
Station		**Block C Sample #1**	**Block C Sample #2**	**Block C Sample #3**
Sample ID		**43**	**8**	**41**
Date		**5/4/1982**	**5/4/1982**	**5/4/1982**
Depth (ft)		**0.0 – 2.0**	**0.0 – 2.0**	**0.0 – 2.0**
Parameters Analyzed / **Analyte**	**Background Criteria (Surface/Subsurface)**	**TNT/RDX, Chromium**	**TNT/RDX, Chromium, Lead, Mercury**	**TNT/RDX, Chromium**
Metals (mg/kg)				
Chromium	17.4/27.2	16	**290 ***	13
Lead	26.1/19.1	NR	**150 ***	NR
Mercury	0.04/0.04	NR	**1.24 ***	NR
Explosives (µg/mL)				
RDX	None	ND	ND	ND
TNT	None	ND	ND	ND

AOI = Area of interest.
ft = Feet.
ID = Identification.
mg/kg = Milligrams per kilogram.
ND = Not detected.
NR = Not reported/not analyzed.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
TNT = 2,4,6-Trinitrotoluene
µg/mL = Micrograms per milliliter
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 4–2. EP Toxicity Soil Sample Results from 1986 Soil Investigation

Area	Maximum Concentration for Toxicity Characteristic[1]	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI
Station		**1**	**1**	**1**	**2**	**2**	**2**	**3**	**3**	**3**	**4**
Sample ID		**1RAM11863**	**1RAM118612**	**1RAM118624**	**2RAM11863**	**2RAM118612**	**2RAM118624**	**3RAM11863**	**3RAM118612**	**3RAM118624**	**4RAM11863**
Date		**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**
Depth (ft)		**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**
Parameters Analyzed											
Analyte		**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**
Metals (mg/L)											
Arsenic	5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Barium	100	0.8	0.4	0.4	0.6	0.4	0.3	0.3	0.4	0.3	0.5
Cadmium	1	0.007	0.006	0.006	0.003	0.002	0.005	0.005	0.004	0.002	0.005
Chromium	5	0.08	0.03	0.1	0.03	0.02	0.02	0.01	0.02	0.01	0.95
Lead	5	0.13	0.05	0.02	0.07	0.04	0.03	<0.01	<0.01	<0.01	0.12
Mercury	0.2	0.0003	<0.0002	0.0003	<0.0002	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	0.0005
Selenium	1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4–2. EP Toxicity Soil Sample Results from 1986 Soil Investigation (continued)

Area	Maximum Concentration for Toxicity Characteristic[1]	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI
Station		**4**	**4**	**5**	**5**	**5**	**6**	**6**	**6**	**7**	**7**
Sample ID		**4RAM118612**	**4RAM118624**	**5RAM11863**	**5RAM118612**	**5RAM118624**	**6RAM11863**	**6RAM118612**	**6RAM118624**	**7RAM11863**	**7RAM118612**
Date		**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**
Depth (ft)		**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**
Parameters Analyzed											
Analyte		**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**
Metals (mg/L)											
Arsenic	5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Barium	100	0.8	0.7	0.1	0.1	0.1	0.3	0.2	0.2	0.4	0.2
Cadmium	1	0.002	0.003	0.002	0.002	0.002	0.002	0.004	0.002	0.006	0.002
Chromium	5	1.19	0.21	0.13	0.28	0.38	0.19	0.06	0.05	0.03	<0.01
Lead	5	0.33	0.03	<0.01	<0.01	<0.01	0.21	0.03	0.03	0.12	0.02
Mercury	0.2	0.0002	0.0004	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	0.0002	<0.0002
Selenium	1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4–2. EP Toxicity Soil Sample Results from 1986 Soil Investigation (continued)

Area	**Maximum Concentration for Toxicity Characteristic**[1]	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**
Station		**7**	**8**	**8**	**8**	**9**	**9**	**9**	**10**	**10**	**10**
Sample ID		**7RAM118624**	**8RAM11863**	**8RAM118612**	**8RAM118624**	**9RAM11863**	**9RAM118612**	**9RAM118624**	**10RAM11863**	**10RAM118612**	**10RAM118624**
Date		**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**
Depth (ft)		**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**
Parameters Analyzed											
Analyte		**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**
Metals (mg/L)											
Arsenic	5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Barium	100	0.2	0.1	0.1	0.1	0.4	0.3	0.1	0.3	0.1	0.1
Cadmium	1	0.007	0.004	0.003	0.02	0.004	0.008	0.002	0.004	0.005	0.004
Chromium	5	<0.01	<0.01	<0.01	<0.01	0.03	0.01	0.01	0.02	<0.01	<0.01
Lead	5	<0.01	<0.01	<0.01	<0.01	0.15	0.07	0.03	0.09	<0.01	<0.01
Mercury	0.2	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Selenium	1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4–2. EP Toxicity Soil Sample Results from 1986 Soil Investigation (continued)

Area	**Maximum Concentration for Toxicity Characteristic**[1]	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**
Station		**11**	**11**	**11**	**12**	**12**	**12**
Sample ID		**11RAM11863**	**11RAM118612**	**11RAM118624**	**12RAM11863**	**12RAM118612**	**12RAM118624**
Date		**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**	**11/19/1986**
Depth (ft)		**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**	**0.0 - 0.25**	**1.0 - 1.0**	**2.0 - 2.0**
Parameters Analyzed							
Analyte		**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**	**EP Metals**
Metals (mg/L)							
Arsenic	5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Barium	100	0.8	0.7	0.1	0.1	0.1	0.3
Cadmium	1	0.002	0.003	0.002	0.002	0.002	0.002
Chromium	5	1.19	0.21	0.13	0.28	0.38	0.19
Lead	5	0.33	0.03	<0.01	<0.01	<0.01	0.21
Mercury	0.2	0.0002	0.0004	<0.0002	<0.0002	<0.0002	0.0003
Selenium	1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

[1]Maximum concentration of contaminants for the toxicity characteristic, as specified in Table 1 of 40 Code of Federal Regulations 261.24.
AOI = Area of interest.
EP = Extract procedure.
ft = Feet.
ID = Identification.
mg/L = Milligrams per liter.
TCLP = Toxicity characteristic leaching procedure.
< = Less than.

Table 4–3. Characterization of 14 AOCs Sampling Locations

Characterization of 14 AOCs Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
CBLss-001M	0–1	Metals, Explosives	C Block Quarry, northern portion	1940–1950: C Block Quarry was used to mine Homewood Sandstone for road and construction base material 1950s: The AOC was used as a disposal area for annealing process waste and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations	Unknown quantity of liquid wastes	Arsenic, chromium, lead, mercury, sulfuric acid, asbestos
CBLss-002M	0–1	Metals, Explosives	C Block Quarry, central portion			
CBLss-003M	0–1	Metals, Explosives	C Block Quarry, southeastern portion.			
CBLss-003M	0–1	Metals, Explosives (QC)				
CBLss-004M	0-0.5	Metals, Explosives	C Block Quarry, southwestern portion			
CBLss-005D	0–1	VOCs	C Block Quarry, south-central portion			
CBLss-005M	0–1	Metals, Explosives, Pesticides/PCBs, SVOCs				
CBLss-006M	0–1	Metals, Explosives	C Block Quarry, western portion			

AOC = Area of concern.
bgs = Below ground surface.
ft = Feet.
QC = Quality control.
PCB = Polychlorinated biphenyl.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.

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Table 4–4. Analytes Detected in Characterization of 14 AOCs Surface Soil Samples

Area		AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI
Station		**CBLss-001M**	**CBLss-002M**	**CBLss-003M**	**CBLss-003M**	**CBLss-004M**	**CBLss-005D**	**CBLss-005M**	**CBLss-006M**
Sample ID		**CBLss-001M-SO**	**CBLss-002M-SO**	**CBLss-003M-DUP**	**CBLss-003M-SO**	**CBLss-004M-SO**	**CBLss-005D-SO**	**CBLss-005M-SO**	**CBLss-006M-SO**
Date		**11/04/04**	**11/04/04**	**11/04/04**	**11/04/04**	**11/04/04**	**11/04/04**	**11/04/04**	**11/04/04**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed									
Analyte	**Background Criteria**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**VOCs**	**TAL Metals, Explosives, Pesticides/PCBs, SVOCs**	**TAL Metals, Explosives**
Metals (mg/kg)									
Aluminum	17700	11000	8200	9600	12000	1800	NR	11000	7100
Arsenic	15.4	**19***	14	13	13	6.7	NR	14	12
Barium	88.4	74	63	79	79	23	NR	84	50
Beryllium	0.88	0.69	0.49	0.65	0.71	0.22	NR	0.7	0.55
Calcium	15800	1300	620	370	350	960	NR	830	890
Chromium	17.4	17	**430***	**250***	**240***	**150***	NR	**920***	**19***
Chromium, hexavalent	None	<2.2U	<2.2U	<2.1U	**5.4J***	<2U	NR	NR	<2U
Cobalt	10.4	9.6	5.6	8.4	8.6	1.7	NR	8.3	6.8
Copper	17.7	16	**35***	**31***	**31***	17	NR	**78***	15
Iron	23100	21000	20000	20000	20000	9900	NR	22000	18000
Lead	26.1	21	**43***	22	21	17	NR	24	21
Magnesium	3030	2100	1500	1700	1800	270	NR	1900	1300
Manganese	1450	950	370	730	760	140	NR	820	540
Mercury	0.036	<0.05U	<0.05U	**0.07***	**0.06***	**0.05***	NR	<0.05U	**0.07***
Nickel	21.1	16	13	15	15	13	NR	16	15
Potassium	927	870	**960***	640	910	360	NR	890	650
Selenium	1.4	0.84	0.64	<1.5U	0.85	0.48	NR	0.79	<1.6U
Sodium	123	**280***	**290***	**260***	**310***	**130***	NR	**290***	**230***
Thallium	0	<0.6U	**0.36***	<0.61U	**0.19***	<0.61U	NR	<0.63U	<0.61U
Vanadium	31.1	21	19	19	23	5.3	NR	24	16
Zinc	61.8	57	47	54	56	34	NR	59	52
Explosives (mg/kg)									
2,4,6-Trinitrotoluene	None	<0.1U	<0.1U	**0.09J***	**0.09J***	**22***	NR	**0.15***	<0.1U
2-Amino-4,6-Dinitrotoluene	None	<0.2U	<0.2U	<0.2U	<0.2U	**0.54***	NR	**0.19J***	<0.2U
4-Amino-2,6-Dinitrotoluene	None	<0.29U	<0.29U	<0.3U	<0.3U	**0.64***	NR	**0.12J***	<0.3U
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	**1.3***	NR
SVOCs (mg/kg)									
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	**0.017J***	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.036J***	NR
Benzo(ghi)perylene	None	NR	NR	NR	NR	NR	NR	**0.019J***	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.019J***	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	**0.054J***	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	**0.028J***	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.036J***	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	**0.017J***	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	**0.027J***	NR

AOC = Area of concern.
AOI = Area of interest.
ft = Feet.
ID = Identification.
J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample.

mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
PCB = Polychlorinated biphenyl.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
TAL = Target analyte list.

U = Not detected.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

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Table 4–5. Human Health COPCs per the Characterization of 14 AOCs Report

Surface Soil	Sediment*	Surface Water*	Groundwater
Arsenic	Aluminum	Arsenic	2-methylnaphthalene
Chromium	Vanadium	Iron	Benz(a)anthracene
Benzo(ghi)perylene		Manganese	Benzo(a)pyrene
Phenanthrene		Methylene	Benzo(2-ethylhexyl)phthalate
TNT		Chloride	Bis(2-ethylhexyl) phthalate
2-amino-4,6-dinitrotoluene		Bis(2-ethylhexyl)	Indeno(1,2,3-cd)pyrene
4-amino-2,6-dinitrotoluene		phthalate	Phenanthrene
Nitrocellulose			

Adapted from Table CBL-18, Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).
*Sediment and Surface water does not exist within the AOC boundary. Samples were collected outside of the AOC.
AOC = Area of concern.
COPC = Chemical of potential concern.
TNT = 2,4,6-Trinitrotoluene.

Table 4–6. Chemicals Exceeding ESVs per the Characterization of 14 AOCs Report

Surface Soil	Sediment*	Surface Water*	Groundwater
Arsenic	Beryllium	Iron	Not evaluated
Chromium	Acetone	Manganese	
Copper		Hexavalent Chromium	
Lead		Mercury	
Mercury		Acetone	
TNT		Benzoic Acid	
2-amino-4,6-dinitrotoluene		Benzenemethanol	
4-amino-2,6-dinitrotoluene			
Nitrocellulose			
Aroclor-1254			
Lead			
Chromium			
Zinc			

Adapted from Table CBL-19, Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).
*Sediment and Surface water does not exist within the AOC boundary. Samples were collected outside of the AOC.
AOC = Area of concern.
ESV = Ecological screening value.
TNT = 2,4,6-Trinitrotoluene.

Table 4–7. Chemicals Detected at Concentrations above Screening Criteria in Previous Investigations

Surface Soil	Subsurface Soil	Sediment	Surface Water
Arsenic	Media not previously sampled	Media not previously sampled	Media not previously sampled
Chromium			
Chromium, hexavalent			
TNT			

Source: Preliminary Assessment for the Characterization of Areas of Contamination (USACE 1996) and the Characterization of 14 AOCs (MKM 2007).
[a]Screening criteria are the smaller of the facility-wide cleanup goals for the Resident Receptor (Adult and Child) and National Guard Trainee based on hazard quotient of 0.1 or target risk of 1E-06.
TNT = 2,4,6-Trinitrotoluene.

Table 4–8. PBA08 RI Soil Sample Rationale and Analyses

PBA08 RI Location	Comments/Rationale	Sample Type	Depth (ft bgs)	Analyses Performed Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC	Asbestos
CBLsb-007	Delineate vertical extent of previously identified contamination; bedrock encountered at 7 ft	Discrete	0-1	Y	Y	N	N	N	Y
		Discrete	1-4	Y	Y	N	N	N	Y
		Discrete	4-7	Y	Y	N	N	N	Y
		NS	7-13	N	N	N	N	N	N
CBLsb-008	Delineate vertical extent of previously identified contamination; bedrock encountered at 2 ft	Discrete	0-1	Y	Y	N	N	N	Y
		Discrete	1-2	Y	Y	N	N	N	Y
		NS	4-7	N	N	N	N	N	N
		NS	7-13	N	N	N	N	N	N
	QA/QC	Discrete	0-1	Y	Y	N	N	N	Y
		Discrete	0-1	Y	Y	N	N	N	Y
CBLsb-010	Delineate vertical extent of previously identified contamination; bedrock encountered at 4 ft	Discrete	0-1	Y	Y	N	N	N	Y
		Discrete	1-4	Y	Y	N	N	N	Y
		NS	4-7	N	N	N	N	N	N
		NS	7-13	N	N	N	N	N	N
	Geotechnical	Discrete	1.5-3.5	N	N	N	N	N	N
CBLsb-011	Delineate vertical extent of previously identified contamination; bedrock encountered at 4.5 ft. Analyzed for RVAAP full-suite analytes	Discrete	0-1	Y	Y	Y	Y	Y	N
		Discrete	1-4	Y	Y	Y	Y	Y	N
		Discrete	4-4.5	Y	Y	Y	Y	Y	N
		NS	7-13	N	N	N	N	N	N
	QA/QC, Analyzed for RVAAP full-suite analytes	Discrete	1-4	Y	Y	Y	Y	Y	N
		Discrete	1-4	Y	Y	Y	Y	Y	N
CBLsb-012	Delineate vertical extent of previously identified contamination; bedrock encountered at 3 ft	Discrete	0-1	Y	Y	N	N	N	Y
		Discrete	1-4	Y	Y	N	N	N	Y
		NS	4-7	Y	Y	N	N	N	N
		NS	7-13	N	N	N	N	N	N
CBLsb-025	Discrete sample recollected to assess chromium speciation (August 2012). Previous chromium result represents elevated chromium concentration (CBLsb-010 at 2,100 mg/kg)	Discrete	0-1	Y	N	N	N	N	N
		Discrete	1-2	Y	N	N	N	N	N

Table 4–8. PBA08 RI Subsurface Soil Rationale and Analyses (continued)

PBA08 RI Location	Comments/Rationale	Sample Type	Depth (ft bgs)	Analyses Performed					
				Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC	Asbestos
CBLsb-026	Discrete sample recollected to assess chromium speciation (August 2012). Previous chromium result represents elevated chromium concentration (CBLss-003M at 240 mg/kg). Bedrock encountered at 1.8 ft	Discrete	0-1	Y	N	N	N	N	N
		Discrete	1-1.8	Y	N	N	N	N	N
	QC sample collected	Discrete	0-1	Y	N	N	N	N	N

bgs = Below ground surface.
ft = Feet.
mg/kg = Milligrams per kilogram.
NS = Not sampled due to refusal.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
PCB = Polychlorinated biphenyl.
QA = Quality assurance.
QC = Quality control.
RVAAP = Ravenna Army and Ammunition Plant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.

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Table 4–9. Analytes Detected in PBA08 RI Discrete Surface Soil Samples

Area		AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI
Station		CBLsb-007	CBLsb-008	CBLsb-008	CBLsb-010	CBLsb-011	CBLsb-012	CBLsb-025	CBLsb-026	CBLsb-026
Sample ID		CBLsb-007-5249-SO	CBLsb-008-6126-FD	CBLsb-008-5253-SO	CBLsb-010-5257-SO	CBLsb-011-5261-SO	CBLsb-012-5265-SO	CBLsb-025-5878-SO	CBLsb-026-6248-FD	CBLsb-026-5881-SO
Date		03/22/10	03/22/10	03/22/10	03/22/10	03/23/10	03/22/10	08/10/12	08/09/12	08/09/12
Depth (ft)		0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Parameters Analyzed / Analyte	Background Criteria	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	RVAAP Full-suite analytes	TAL Metals, Explosives, Asbestos	Chromium speciation	Chromium speciation	Chromium speciation
Metals (mg/kg)										
Aluminum	17700	10900	9320	8210	8790	4990	9000	NR	NR	NR
Antimony	0.96	0.099J	0.11J	0.087J	0.17J	0.069J	0.11J	NR	NR	NR
Arsenic	15.4	13.4	13	12.4	12.6	7	13.9	NR	NR	NR
Barium	88.4	76.2J	66.8J	53J	76.9J	39.3J	63.3J	NR	NR	NR
Beryllium	0.88	0.54	0.4	0.38	0.32	0.35	0.49	NR	NR	NR
Cadmium	0	**0.1J***	**0.052J***	**0.069J***	**0.11J***	**0.15J***	**0.22J***	NR	NR	NR
Calcium	15800	277J	394J	425J	1570J	3040J	1710J	NR	NR	NR
Chromium	17.4	14	**52.3***	**25.7***	**2100***	8.6	12.9	**1700J***	**310J***	**390J***
Chromium, hexavalent	None	NR	NR	NR	NR	NR	NR	**19J***	**0.83J***	**2.2J***
Cobalt	10.4	10.2	9	7.9	7	5.9	10.3	NR	NR	NR
Copper	17.7	15.9	**23.2***	16.7	**126***	10.6	14.6	NR	NR	NR
Iron	23100	23000	22500	21700	22900	14200	23000	NR	NR	NR
Lead	26.1	17.8	20.4	18.4	**27.7***	10.8	21.5	NR	NR	NR
Magnesium	3030	2110	1920	1600	2090	1020	1730	NR	NR	NR
Manganese	1450	851	502	590	462	302	903	NR	NR	NR
Mercury	0.036	0.024J	0.026J	**0.046J***	**0.067J***	**0.037J***	**0.052J***	NR	NR	NR
Nickel	21.1	16.5	14.6	12.4	16.8	12.1	14.7	NR	NR	NR
Potassium	927	662	667	588	615	481	565	NR	NR	NR
Selenium	1.4	1.2	1.1	1	0.8	0.79	1.3	NR	NR	NR
Silver	0	<0.029UJ	**0.047J***	**0.048J***	**0.066J***	<0.016UJ	<0.026UJ	NR	NR	NR
Sodium	123	30.3J	26.9J	24.2J	28.9J	24.9J	25.2J	NR	NR	NR
Thallium	0	**0.17J***	0.14J*	0.12J*	**0.13J***	**0.087J***	**0.15J***	NR	NR	NR
Vanadium	31.1	21.1	16.4	16.3	<1.4U	10.4	18.9	NR	NR	NR
Zinc	61.8	51.8	47.6	43	55.9	46.2	50	NR	NR	NR
Explosives (mg/kg)										
2,4-Dinitrotoluene	None	<0.25U	<0.24U	<0.25U	**0.025J***	<0.25U	<0.26U	NR	NR	NR
2-Amino-4,6-Dinitrotoluene	None	<0.25U	<0.24U	<0.25U	**0.16J***	<0.25U	<0.26U	NR	NR	NR
3-Nitrotoluene	None	<0.25U	<0.24U	<0.25U	<0.24U	**0.018J***	<0.26U	NR	NR	NR
4-Amino-2,6-Dinitrotoluene	None	<0.25U	<0.24U	<0.25U	**0.13J***	<0.25U	<0.26U	NR	NR	NR

Table 4–9. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Area		AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI	AOI
Station		CBLsb-007	CBLsb-008	CBLsb-008	CBLsb-010	CBLsb-011	CBLsb-012	CBLsb-025	CBLsb-026	CBLsb-026
Sample ID		CBLsb-007-5249-SO	CBLsb-008-6126-FD	CBLsb-008-5253-SO	CBLsb-010-5257-SO	CBLsb-011-5261-SO	CBLsb-012-5265-SO	CBLsb-025-5878-SO	CBLsb-026-6248-FD	CBLsb-026-5881-SO
Date		03/22/10	03/22/10	03/22/10	03/22/10	03/23/10	03/22/10	08/10/12	08/09/12	08/09/12
Depth (ft)		0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Parameters Analyzed Analyte	Background Criteria	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	TAL Metals, Explosives, Asbestos	RVAAP Full-suite analytes	TAL Metals, Explosives, Asbestos	Chromium speciation	Chromium speciation	Chromium speciation
						SVOCs (mg/kg)				
Acenaphthene	None	NR	NR	NR	NR	**0.025J***	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	**0.043J***	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	**0.21***	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	**0.4***	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	**0.51***	NR	NR	NR	NR
Benzo(ghi)perylene	None	NR	NR	NR	NR	**0.35***	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	**0.21***	NR	NR	NR	NR
Carbazole	None	NR	NR	NR	NR	**0.029J***	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	**0.26***	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	**0.49***	NR	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	**0.019J***	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	**0.3***	NR	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	**0.27***	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	**0.41***	NR	NR	NR	NR
						Asbestos (%)				
Asbestos	None	ND	ND	ND	ND	**NR**	ND	NR	NR	NR

AOI = Area of interest.
ft = Feet.
ID = Identification.
J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample.
mg/kg = Milligrams per kilogram.
ND = No fibers were detected.
NR = Not reported/not analyzed.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Not detected.
UJ = Non-detectable concentration and reporting limit estimated.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–10. Analytes Detected in PBA08 RI Subsurface Soil Samples

Area		**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**
Station		**CBLsb-007**	**CBLsb-007**	**CBLsb-008**	**CBLsb-010**	**CBLsb-011**	**CBLsb-011**	**CBLsb-011**	**CBLsb-012**	**CBLsb-025**	**CBLsb-026**
Sample ID		**CBLsb-007-5250-SO**	**CBLsb-007-5251-SO**	**CBLsb-008-5254-SO**	**CBLsb-010-5258-SO**	**CBLsb-011-6127-FD**	**CBLsb-011-5262-SO**	**CBLsb-011-5263-SO**	**CBLsb-012-5266-SO**	**CBLsb-025-5879-SO**	**CBLsb-026-5882-SO**
Date		**03/22/10**	**03/22/10**	**03/22/10**	**03/22/10**	**03/23/10**	**03/23/10**	**03/23/10**	**03/22/10**	**08/10/12**	**08/09/12**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 2.0**	**1.0 - 4.0**	**1.0 - 4.0**	**1.0 - 4.0**	**4.0 - 4.5**	**1.0 - 3.0**	**1.0 - 2.0**	**1.0 - 1.8**
Parameters Analyzed / **Analyte**	**Background Criteria**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, Asbestos**	**TAL Metals**	**TAL Metals**
Metals (mg/kg)											
Aluminum	19500	11600	11800	11100	8470	10200	9660	8590	10300	NR	NR
Antimony	0.96	<0.61UJ	0.08J	0.082J	0.15J	0.12J	0.089J	0.14J	0.085J	NR	NR
Arsenic	19.8	13	14.7	13.9	11.9	14	12.8	13.6	14.4	NR	NR
Barium	124	70.6J	61.5J	67.4J	72.4J	67.4J	74.7J	74.3J	56.6J	NR	NR
Beryllium	0.88	0.53	0.5	0.51	0.45	0.52	0.49	0.47	0.47	NR	NR
Cadmium	0	**0.07J***	**0.048J***	**0.044J***	**0.079J***	**0.069J***	**0.086J***	**0.11J***	**0.058J***	NR	NR
Calcium	35500	376J	463J	260J	809J	1690J	1760J	597J	706J	NR	NR
Chromium	27.2	14	14.6	18.5	**698***	14.2	12.1	12.6	13.8	**930J***	**920J***
Chromium, hexavalent	None	NR	NR	NR	NR	NR	NR	NR	NR	**39J***	**6.4J***
Cobalt	23.2	9.2	8.3	9.5	8.2	8.6	9.9	9.3	9.6	NR	NR
Copper	32.3	20.4	16.9	18.9	**218***	15.9	14.9	14	15.8	NR	NR
Iron	35200	22700	26400	24200	23400	25500	20500	22500	24800	NR	NR
Lead	19.1	13	12.6	12.5	17.4	13.9	14.4	**25.6***	13.6	NR	NR
Magnesium	8790	2270	2480	2110	1800	2040	1820	1660	2190	NR	NR
Manganese	3030	691	513	485	476	554	797	896	487	NR	NR
Mercury	0.044	0.022J	0.032J	**0.049J***	**0.058J***	0.033J	0.041J	**0.047J***	**0.067J***	NR	NR
Nickel	60.7	17.4	17.2	15.8	17.1	16.1	15.6	15.7	16.9	NR	NR
Potassium	3350	795	729	774	539	661	573	546	720	NR	NR
Selenium	1.5	1.2	1.1	1.2	1	1.2	1.3	1.2	1.2	NR	NR
Sodium	145	31.7J	31.5J	27.7J	28.7J	28.9J	29.4J	27.5J	27.6J	NR	NR
Thallium	0.91	0.16J	0.15J	0.14J	0.13J	0.14J	0.14J	0.16J	0.14J	NR	NR
Vanadium	37.6	20.6	21.4	20.4	<1.3U	19.4	18.2	16	19.2	NR	NR
Zinc	93.3	51.9	48.7	47.3	57.6	48	45	51.8	47.2	NR	NR
Explosives (mg/kg)											
2-Amino-4,6-Dinitrotoluene	None	<0.26U	<0.24U	<0.25U	**0.073J***	<0.24U	<0.24UJ	<0.25U	<0.24U	NR	NR
4-Amino-2,6-Dinitrotoluene	None	<0.26U	<0.24U	<0.25U	**0.051J***	<0.24U	<0.24U	<0.25U	<0.24U	NR	NR
SVOCs (mg/kg)											
Anthracene	None	NR	NR	NR	NR	<0.061U	**0.021J***	<0.062U	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	**0.0088J***	**0.048J***	<0.062U	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	**0.011J***	**0.049J***	<0.062U	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	**0.013J***	**0.062***	**0.01J***	NR	NR	NR
Benzo(ghi)perylene	None	NR	NR	NR	NR	<0.061U	**0.037J***	<0.062U	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	<0.061U	**0.028J***	<0.062U	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	**0.0095J***	**0.05J***	<0.062U	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	**0.02J***	**0.13***	**0.012J***	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	<0.061U	**0.0094J***	<0.062U	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	<0.061U	**0.03J***	<0.062U	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	**0.0095J***	**0.087***	<0.062U	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	**0.015J***	**0.097***	**0.01J***	NR	NR	NR

Table 4–10. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Area		**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**	**AOI**
Station		**CBLsb-007**	**CBLsb-007**	**CBLsb-008**	**CBLsb-010**	**CBLsb-011**	**CBLsb-011**	**CBLsb-011**	**CBLsb-012**	**CBLsb-025**	**CBLsb-026**
Sample ID		**CBLsb-007-5250-SO**	**CBLsb-007-5251-SO**	**CBLsb-008-5254-SO**	**CBLsb-010-5258-SO**	**CBLsb-011-6127-FD**	**CBLsb-011-5262-SO**	**CBLsb-011-5263-SO**	**CBLsb-012-5266-SO**	**CBLsb-025-5879-SO**	**CBLsb-026-5882-SO**
Date		**03/22/10**	**03/22/10**	**03/22/10**	**03/22/10**	**03/23/10**	**03/23/10**	**03/23/10**	**03/22/10**	**08/10/12**	**08/09/12**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 2.0**	**1.0 - 4.0**	**1.0 - 4.0**	**1.0 - 4.0**	**4.0 - 4.5**	**1.0 - 3.0**	**1.0 - 2.0**	**1.0 - 1.8**
Parameters Analyzed / **Analyte**	**Background Criteria**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**TAL Metals, Explosives, Asbestos**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, Asbestos**	**TAL Metals**	**TAL Metals**
Asbestos (%)											
Asbestos	None	ND	ND	ND	ND	NR	NR	NR	ND	NR	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).
AOI = Area of interest.
ft = Feet.
ID = Identification.
J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample.
mg/kg = Milligrams per kilogram.
ND = No fibers were detected.
NR = Not reported/not analyzed.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Non-detectable concentration.
UJ = Non-detectable concentration and reporting limit estimated.
*** = Result exceeds background concentration.**
< = Less than.

Table 4–11. Summary of Asbestos-Containing Material Survey Samples

Sample ID:	Material Description	Approximate % of Asbestos	Friability[1]
CBLSS-013-5793-BD	Grey Transite (cement shingle)	16% chrysotile	F
CBLSS-014-5794-BD	Beige Transite (cement shingle)	20% chrysotile	F
CBLSS-014-5795-BD	Black Tar (from black building insulation)	10% chrysotile	F
CBLSS-015-5796-BD	Black Tar Paper (from black building insulation)	35% chrysotile	F
CBLSS-016-5797-BD	Beige Firebrick (orange cement block)	ND	NF-II
CBLSS-017-5798-BD	Surface soil, 0-1 ft bgs (brown soil)	<1% chrysotile	NA
CBLSS-018-5799-BD	Black Cinder (black rock-like material)	ND	NF-II

[1]Although the Asbestos Results Report in Appendix J indicates the soil sample in CBLss-017-5798-BD is friable, the friability determination of the soil sample is not applicable.
F = Friable.
NA = Not applicable.
ND = Not detected.
NF-II = Non-friable category II.
< = Less than.

Table 4–12. PBA08 RI (2012) Chromium Speciation Sample Rationale for ISM Surface Soil Samples

PBA08 RI Location	Rationale for Sample Selection
CBLss-003M	ISM sample recollected to assess chromium speciation. Previous chromium result represents elevated chromium concentration (CBLss-003M at 240 mg/kg). QC sample collected.
CBLss-005M	ISM sample recollected to assess chromium speciation. Previous chromium result represents elevated chromium concentration (CBLss-005M at 920 mg/kg)

ISM = Incremental sampling methodology.
mg/kg = Milligrams per kilogram.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
QC = Quality control.

Table 4–13. 2012 Chromium Speciation Sampling Results for ISM Surface Soil Samples

Area		**AOI**	**AOI**	**AOI**
Station		**CBLss-003M**	**CBLss-003M**	**CBLss-005M**
Sample ID		**CBLss-003M-6247-FD**	**CBLss-003M-5876-SO**	**CBLss-005M-5877-SO**
Date		**08/10/12**	**08/10/12**	**08/10/12**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed	**Background Criteria**	**Chromium speciation**	**Chromium speciation**	**Chromium speciation**
Analyte				
Metals (mg/kg)				
Chromium	17.4	**480J***	**520J***	**1000J***
Chromium, hexavalent	None	**0.61J***	**0.46J***	**0.32J***

AOI = Area of interest.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.
J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample.
mg/kg = Milligrams per kilogram.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
*** = Result exceeds background criteria or no background criteria was available.**

Table 4–14. RVAAP Background Concentrations

Chemical	Surface Soil (mg/kg)	Subsurface soil (mg/kg)	Sediment (mg/kg)	Surface Water (mg/L)	Groundwater-Unconsolidated (mg/L)		Groundwater-Bedrock (mg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered
Aluminum	17700	19500	13900	3.37	NA	48	NA	9.41
Antimony	0.96	0.96	0	0	0	0.0043	0	0
Arsenic	15.4	19.8	19.5	0.0032	0.0117	0.215	0	0.0191
Barium	88.4	124	123	0.0475	0.0821	0.327	0.256	0.241
Beryllium	0.88	0.88	0.38	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0
Calcium	15800	35500	5510	41.4	115	194	53.1	48.2
Chromium	17.4	27.2	18.1	0	0.0073	0.0852	0	0.0195
Cobalt	10.4	23.2	9.1	0	0	0.0463	0	0
Copper	17.7	32.3	27.6	0.0079	0	0.289	0	0.017
Cyanide	0	0	0	0	0	0	0	0
Iron	23100	35200	28200	2.56	0.279	195	1.43	21.5
Lead	26.1	19.1	27.4	0	0	0.183	0	0.023
Magnesium	3030	8790	2760	10.8	43.3	58.4	15	13.7
Manganese	1450	3030	1950	0.391	1.02	2.86	1.34	1.26
Mercury	0.036	0.044	0.059	0	0	0.00025	0	0
Nickel	21.1	60.7	17.7	0	0	0.117	0.0834	0.0853
Potassium	927	3350	1950	3.17	2.89	7.48	5.77	6.06
Selenium	1.4	1.5	1.7	0	0	0.0057	0	0
Silver	0	0	0	0	0	0	0	0
Sodium	123	145	112	21.3	45.7	44.7	51.4	49.7
Thallium	0	0.91	0.89	0	0	0.0024	0	0
Vanadium	31.1	37.6	26.1	0	0	0.0981	0	0.0155
Zinc	61.8	93.3	532	0.042	0.0609	0.888	0.0523	0.193

Background concentrations were developed in 1998 are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b). These background values are currently being reassessed, but the background valued developed in 1998 are used throughout this report.
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not available. Aluminum results were rejected in validation.
RVAAP = Ravenna Army Ammunition Plant.

Table 4–15. 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

Source = Values were obtained from http://fnic.nal.usda.gov charts.
[a] Dietary reference intakes vary by gender and age, values present are for life stage group: Males 19-30 years.
[b] Adequate intake value.
µg/d = Micrograms per day.
mg/d = Milligram per day.
RDA = Recommended dietary allowance.
RDI = Reference daily intake.
USDA = U.S. Department of Agriculture.

Table 4–16. SRC Screening for ISM Surface Soil (0-1 ft bgs) Samples at C Block Quarry

Analyte (mg/kg)	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC?	SRC Justification
Metals								
Aluminum	7429-90-5	6/ 6	1800	12000	8520	17700	No	Below background
Arsenic	**7440-38-2**	**6/ 6**	**6.7**	**19**	**13.1**	**15.4**	**Yes**	**Exceeds background**
Barium	7440-39-3	6/ 6	23	84	62.2	88.4	No	Below background
Beryllium	7440-41-7	6/ 6	0.22	0.71	0.56	0.88	No	Below background
Calcium	7440-70-2	6/ 6	350	1300	825	15800	No	Essential nutrient
Chromium	**7440-47-3**	**8/ 8**	**17**	**1000**	**412**	**17.4**	**Yes**	**Exceeds background**
Chromium, hexavalent	**18540-29-9**	**3/ 7**	**0.32**	**5.4**	**1.48**	**None**	**Yes**	**Exceeds background**
Cobalt	7440-48-4	6/ 6	1.7	9.6	6.77	10.4	No	Below background
Copper	**7440-50-8**	**6/ 6**	**15**	**78**	**32**	**17.7**	**Yes**	**Exceeds background**
Iron	7439-89-6	6/ 6	9900	22000	18500	23100	No	Essential nutrient
Lead	**7439-92-1**	**6/ 6**	**17**	**43**	**24.5**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	6/ 6	270	2100	1480	3030	No	Essential nutrient
Manganese	7439-96-5	6/ 6	140	950	597	1450	No	Below background
Mercury	**7439-97-6**	**3/ 6**	**0.05**	**0.07**	**0.0425**	**0.036**	**Yes**	**Exceeds background**
Nickel	7440-02-0	6/ 6	13	16	14.7	21.1	No	Below background
Potassium	7440-09-7	6/ 6	360	960	773	927	No	Essential nutrient
Selenium	7782-49-2	5/ 6	0.48	0.85	0.733	1.4	No	Below background
Sodium	7440-23-5	6/ 6	130	310	255	123	No	Essential nutrient
Thallium	**7440-28-0**	**2/ 6**	**0.19**	**0.36**	**0.296**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	6/ 6	5.3	24	18.1	31.1	No	Below background
Zinc	7440-66-6	6/ 6	34	59	50.8	61.8	No	Below background
Explosives								
2,4,6-Trinitrotoluene	**118-96-7**	**3/ 6**	**0.09**	**22**	**3.73**	**None**	**Yes**	**Detected organic**
2-Amino-4,6-Dinitrotoluene	**35572-78-2**	**2/ 6**	**0.19**	**0.54**	**0.188**	**None**	**Yes**	**Detected organic**
4-Amino-2,6-Dinitrotoluene	**19406-51-0**	**2/ 6**	**0.12**	**0.64**	**0.225**	**None**	**Yes**	**Detected organic**
Nitrocellulose	**9004-70-0**	**1/ 1**	**1.3**	**1.3**	**1.3**	**None**	**Yes**	**Detected organic**

Table 4–16. SRC Screening for ISM Surface Soil (0-1 ft bgs) Samples at C Block Quarry (continued)

Analyte (mg/kg)	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC?	SRC Justification
				SVOCs				
Benz(a)anthracene	**56-55-3**	**1/ 1**	**0.017**	**0.017**	**0.017**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**1/ 1**	**0.036**	**0.036**	**0.036**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**191-24-2**	**1/ 1**	**0.019**	**0.019**	**0.019**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**1/ 1**	**0.019**	**0.019**	**0.019**	**None**	**Yes**	**Detected organic**
Bis(2-ethylhexyl)phthalate	**117-81-7**	**1/ 1**	**0.054**	**0.054**	**0.054**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**1/ 1**	**0.028**	**0.028**	**0.028**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**1/ 1**	**0.036**	**0.036**	**0.036**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**1/ 1**	**0.017**	**0.017**	**0.017**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**1/ 1**	**0.027**	**0.027**	**0.027**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b). Site-related contaminant screening tables include all available and appropriate data as presented in Section 4.4.4.

[d] Facility-wide cleanup goal (FWCUG) is the most conservative (smallest) of the FWCUGs for hexavalent and trivalent chromium.

bgs = Below ground surface.
CAS = Chemical Abstract Service.
ft = Feet.
Freq = Frequency.
ISM = Incremental sampling methodology.
mg/kg = Milligrams per kilogram.
SRC = Site-related contaminant.
SVOC= Semi-volatile organic compound
Bold indicates analyte identified as an SRC.

Table 4–17. SRC Screening for Discrete Subsurface Soil (1-13 ft bgs) Samples at C Block Quarry

Analyte (mg/kg)	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC?	SRC Justification
Metals								
Aluminum	7429-90-5	7/ 7	8470	11800	10200	19500	No	Below background
Antimony	7440-36-0	6/ 7	0.08	0.15	0.133	0.96	No	Below background
Arsenic	7440-38-2	7/ 7	11.9	14.7	13.5	19.8	No	Below background
Barium	7440-39-3	7/ 7	56.6	74.7	68.2	124	No	Below background
Beryllium	7440-41-7	7/ 7	0.45	0.53	0.489	0.88	No	Below background
Cadmium	**7440-43-9**	**7/ 7**	**0.044**	**0.11**	**0.0707**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	7/ 7	260	1760	710	35500	No	Essential Nutrient
Chromium	**7440-47-3**	**9/ 9**	**12.1**	**930**	**293**	**27.2**	**Yes**	**Exceeds background**
Chromium, hexavalent	**18540-29-9**	**2/ 2**	**6.4**	**39**	**22.7**	**None**	**Yes**	**Exceeds background**
Cobalt	7440-48-4	7/ 7	8.2	9.9	9.14	23.2	No	Below background
Copper	**7440-50-8**	**7/ 7**	**14**	**218**	**45.6**	**32.3**	**Yes**	**Exceeds background**
Iron	7439-89-6	7/ 7	20500	26400	23500	35200	No	Essential Nutrient
Lead	**7439-92-1**	**7/ 7**	**12.5**	**25.6**	**15.6**	**19.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	7/ 7	1660	2480	2050	8790	No	Essential Nutrient
Manganese	7439-96-5	7/ 7	476	896	621	3030	No	Below background
Mercury	**7439-97-6**	**7/ 7**	**0.022**	**0.067**	**0.0451**	**0.044**	**Yes**	**Exceeds background**
Nickel	7440-02-0	7/ 7	15.6	17.4	16.5	60.7	No	Below background
Potassium	7440-09-7	7/ 7	539	795	668	3350	No	Essential Nutrient
Selenium	7782-49-2	7/ 7	1	1.3	1.17	1.5	No	Below background
Sodium	7440-23-5	7/ 7	27.5	31.7	29.2	145	No	Essential Nutrient
Thallium	7440-28-0	7/ 7	0.13	0.16	0.146	0.91	No	Below background
Vanadium	7440-62-2	6/ 7	16	21.4	16.6	37.6	No	Below background
Zinc	7440-66-6	7/ 7	45	57.6	49.9	93.3	No	Below background
Explosives/Propellants								
2-Amino-4,6-Dinitrotoluene	**35572-78-2**	**1/ 7**	**0.073**	**0.073**	**0.116**	**None**	**Yes**	**Detected organic**
4-Amino-2,6-Dinitrotoluene	**19406-51-0**	**1/ 7**	**0.051**	**0.051**	**0.113**	**None**	**Yes**	**Detected organic**

Table 4–17. SRC Screening for Discrete Subsurface Soil (1-13 ft bgs) Samples at C Block Quarry (continued)

Analyte (mg/kg)	CAS Number	Freq of Detect	Minimum Detect	Maximum Detect	Average Result	Background Criteria[a]	SRC?	SRC Justification
SVOCs								
Anthracene	**120-12-7**	**1/ 2**	**0.021**	**0.021**	**0.026**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**1/ 2**	**0.048**	**0.048**	**0.0395**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**1/ 2**	**0.049**	**0.049**	**0.04**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**2/ 2**	**0.01**	**0.062**	**0.036**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**191-24-2**	**1/ 2**	**0.037**	**0.037**	**0.034**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**1/ 2**	**0.028**	**0.028**	**0.0295**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**1/ 2**	**0.05**	**0.05**	**0.0405**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**2/ 2**	**0.012**	**0.13**	**0.071**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**1/ 2**	**0.0094**	**0.0094**	**0.0202**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**1/ 2**	**0.03**	**0.03**	**0.0305**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**1/ 2**	**0.087**	**0.087**	**0.059**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**2/ 2**	**0.01**	**0.097**	**0.0535**	**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 4.4.4.
bgs = Below ground surface.
CAS = Chemical Abstract Service.
ft = Feet.
Freq = Frequency.
mg/kg = Milligrams per kilogram.
SRC = Site-related contaminant.
SVOC = Semi-volatile organic compound.
Bold indicates analyte identified as an SRC.

Table 4–18. Data Summary and Designated Use for RI

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
Surface (0-1 ft) and Subsurface (>1 ft) Soil										
CBLsb-007-5249-SO	D	03/22/10	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-007-5250-SO	D	03/22/10	1–4	PBA08 RI	--	X	X	X	--	
CBLsb-007-5251-SO	D	03/22/10	4–7	PBA08 RI	--	X	X	X	--	
CBLsb-008-5253-SO	D	03/22/10	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-008-5254-SO	D	03/22/10	1–2	PBA08 RI	--	X	X	X	--	
CBLsb-008-6126-FD	D	03/22/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
CBLsb-010-5257-SO	D	03/22/10	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-010-5258-SO	D	03/22/10	1–4	PBA08 RI	--	X	X	X	--	
CBLsb-011-5261-SO	D	03/23/10	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-011-5262-SO	D	03/23/10	1–4	PBA08 RI	--	X	X	X	--	
CBLsb-011-5263-SO	D	03/23/10	4–4.5	PBA08 RI	--	X	X	X	--	
CBLsb-011-6127-FD	D	03/23/10	1–4	PBA08 RI	X	--	--	--	--	Field duplicate.
CBLsb-012-5265-SO	D	03/22/10	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-012-5266-SO	D	03/22/10	1–3	PBA08 RI	--	X	X	X	--	
CBLsb-025-5878-SO	D	08/10/12	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-025-5879-SO	D	08/10/12	1–2	PBA08 RI	--	X	X	X	--	
CBLsb-026-5881-SO	D	08/09/12	0–1	PBA08 RI	--	X	--	X	--	
CBLsb-026-5882-SO	D	08/09/12	1–1.8	PBA08 RI	--	X	X	X	--	
CBLsb-026-6248-FD	D	08/09/12	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
CBLss-001M-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	
CBLss-002M-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	
CBLss-003M-5876-SO	ISM	08/10/12	0–1	PBA08 RI	--	X	X	X	X	
CBLss-003M-6247-FD	ISM	08/10/12	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
CBLss-003M-DUP	ISM	11/04/04	0–1	14 AOCs	X	--	--	--	--	Field duplicate.
CBLss-003M-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	
CBLss-004M-SO	ISM	11/04/04	0–0.5	14 AOCs	--	X	X	X	X	
CBLss-005D-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	Discrete sample taken to characterize volatile organics in ISM area.
CBLss-005M-5877-SO	ISM	08/10/12	0–1	PBA08 RI	--	X	X	X	X	
CBLss-005M-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	
CBLss-006M-SO	ISM	11/04/04	0–1	14 AOCs	--	X	X	X	X	

Table 4–18. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
RVAP-061	D	10/28/96	0–0.5	RRSE	--	--	--	--	--	Used for initial evaluation of site.
RVAP-062	D	10/28/96	0–0.5	RRSE	--	--	--	--	--	Used for initial evaluation of site.
RVAP-063	D	10/28/96	0–0.5	RRSE	--	--	--	--	--	Used for initial evaluation of site.
8	D	5/4/1982	0–2	1982 Soil and Sediment Analysis	--	--	--	--	--	Used for initial evaluation of site.
41	D	5/4/1982	0–2	1982 Soil and Sediment Analysis	--	--	--	--	--	Used for initial evaluation of site.
43	D	5/4/1982	0–2	1982 Soil and Sediment Analysis	--	--	--	--	--	Used for initial evaluation of site.
1RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
1RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
1RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
2RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
2RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
2RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
3RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
3RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
3RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
4RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
4RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.

Table 4–18. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
4RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
5RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
5RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
5RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
6RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
6RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
6RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
7RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
7RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
7RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
8RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
8RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
8RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
9RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
9RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
9RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
10RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.

Table 4–18. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
10RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
10RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
11RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
11RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
11RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
12RAM11863	D	11/19/1986	0–0.25	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
12RAM118612	D	11/19/1986	1–1	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.
12RAM118624	D	11/19/1986	2–2	1986 Soil Investigation	--	--	--	--	--	Used for initial evaluation of site.

AOC = Area of concern.
D = Discrete.
ERA = Ecological risk assessment.
ft = Feet.
F&T = Fate and transport.
HHRA = Human health risk assessment.
ID = Identification.
ISM = Incremental sampling methodology.
N&E = Nature and extent.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
QC = Quality control.
RI = Remedial investigation.
-- = No data available.
X = Included in screening.

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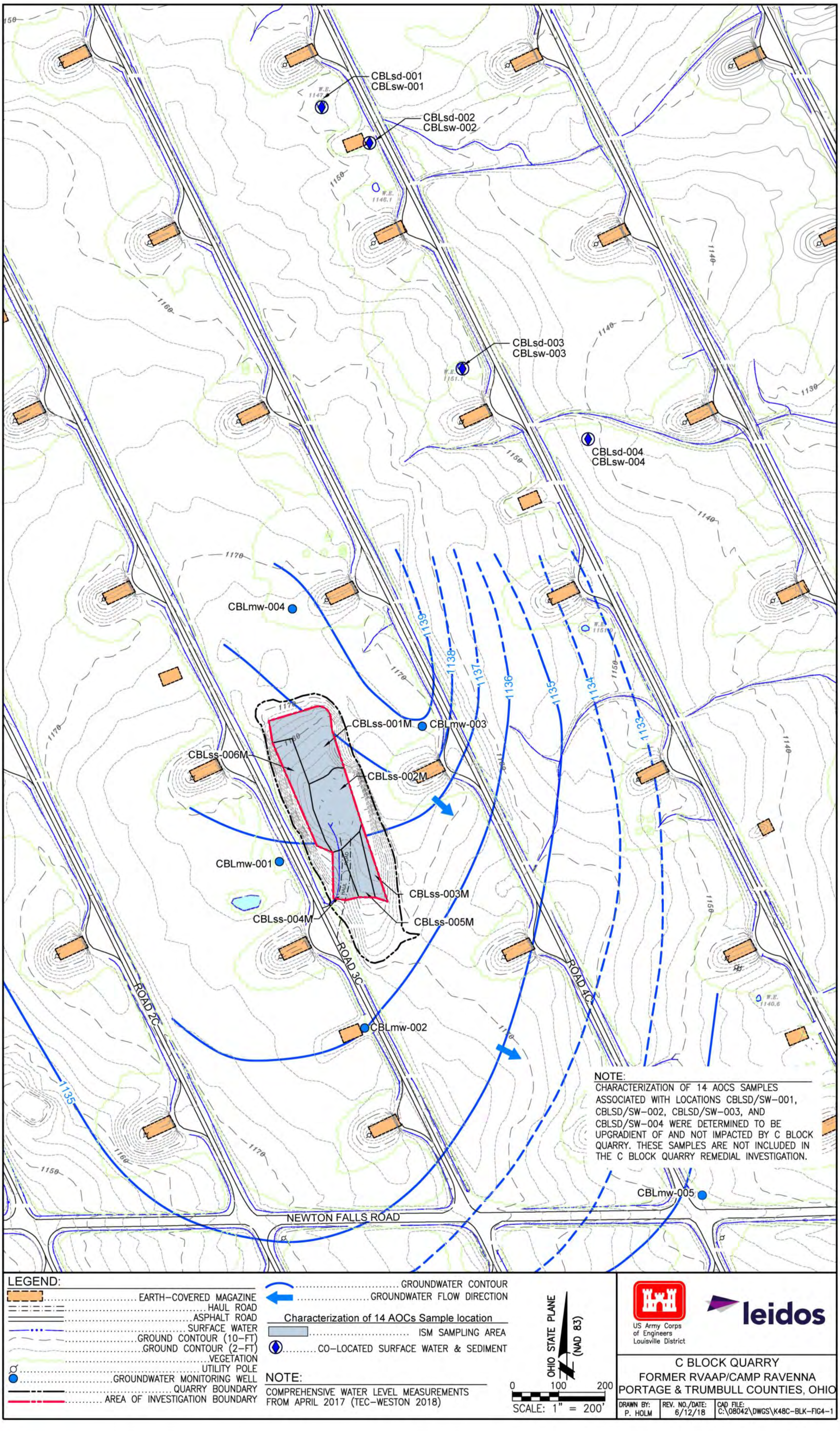

Figure 4–1. Characterization of 14 AOCs Sample Locations at C Block Quarry

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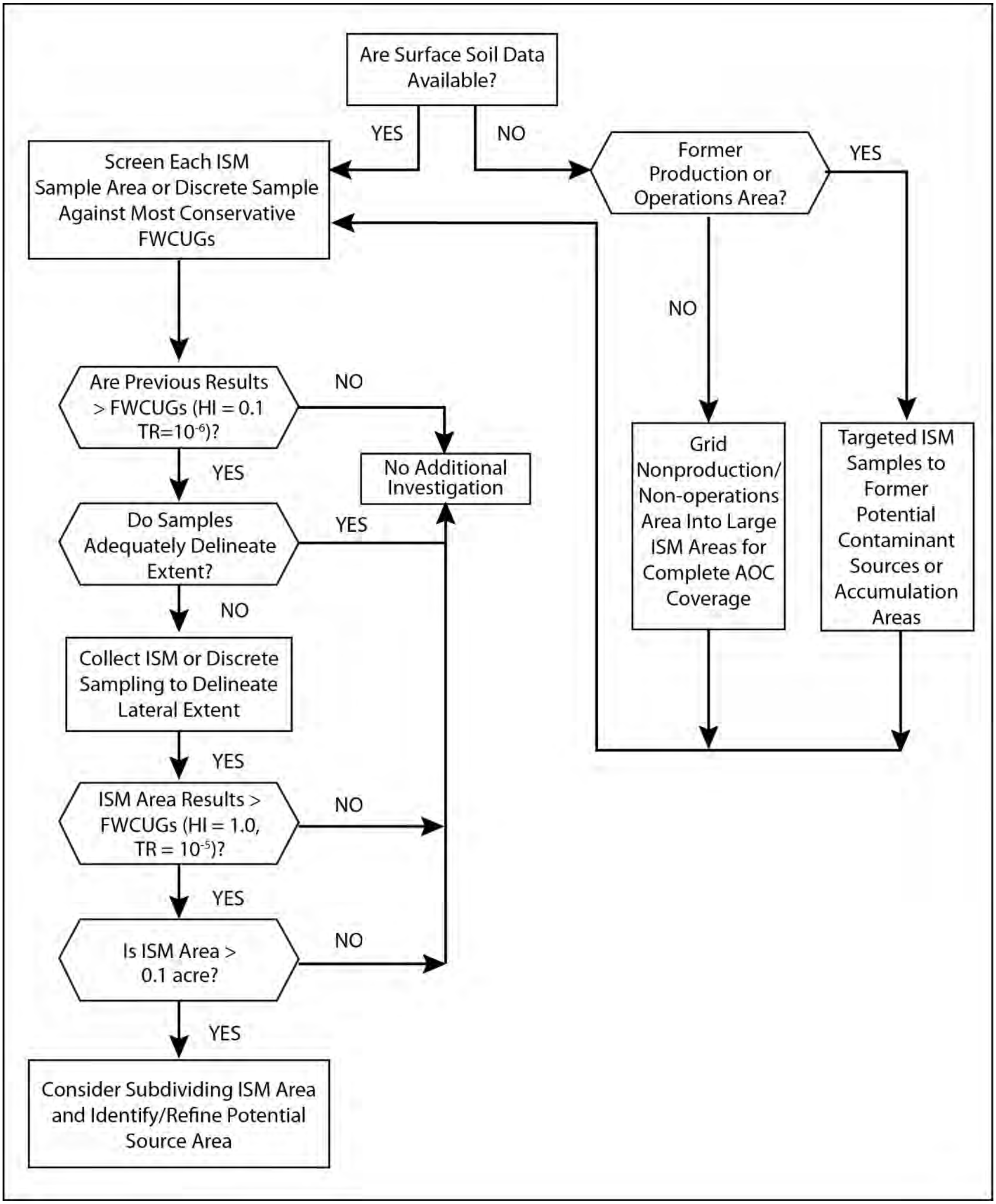

Figure 4–2. PBA08 RI Surface Soil Sampling

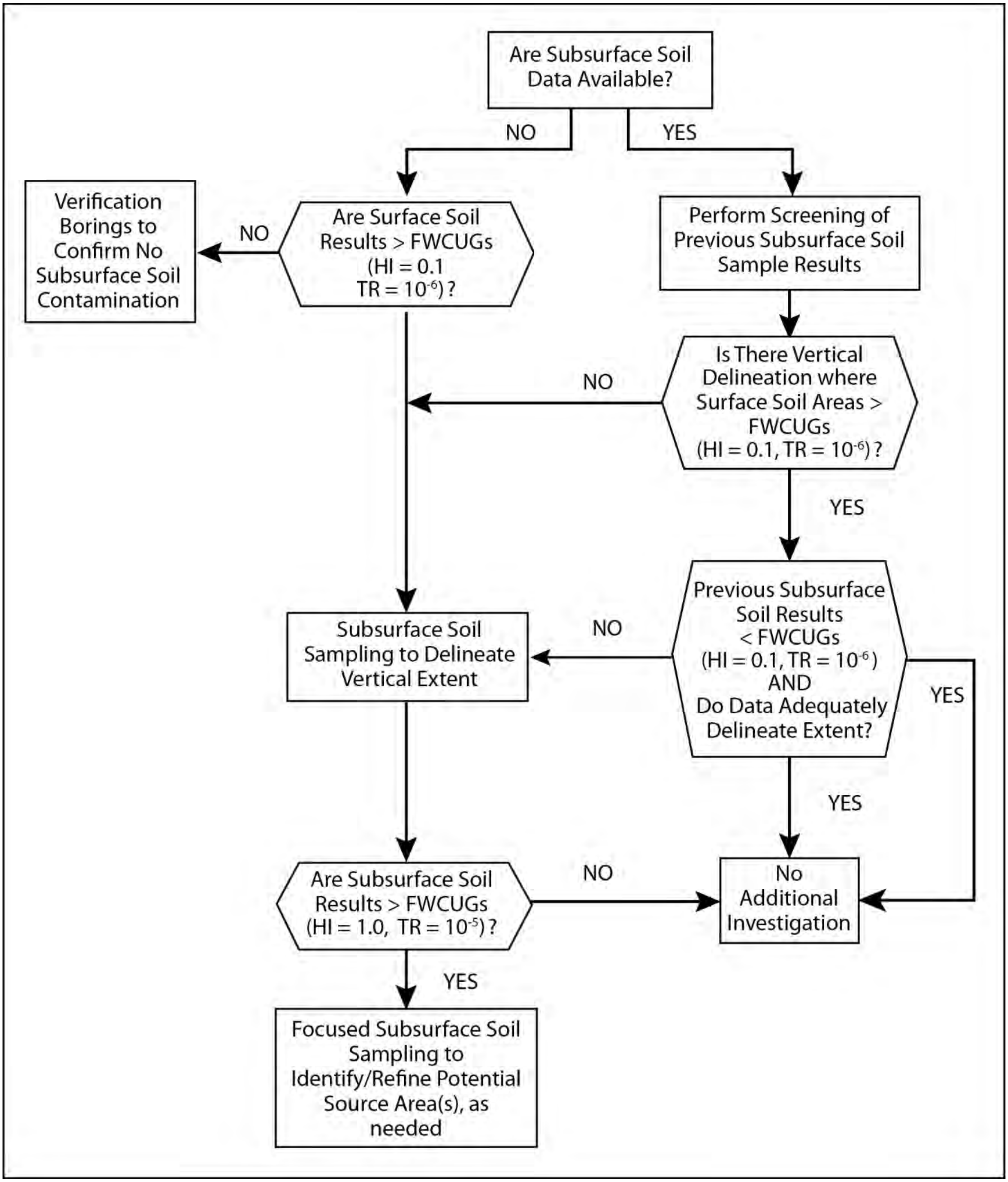

Figure 4–3. PBA08 RI Subsurface Soil Sampling

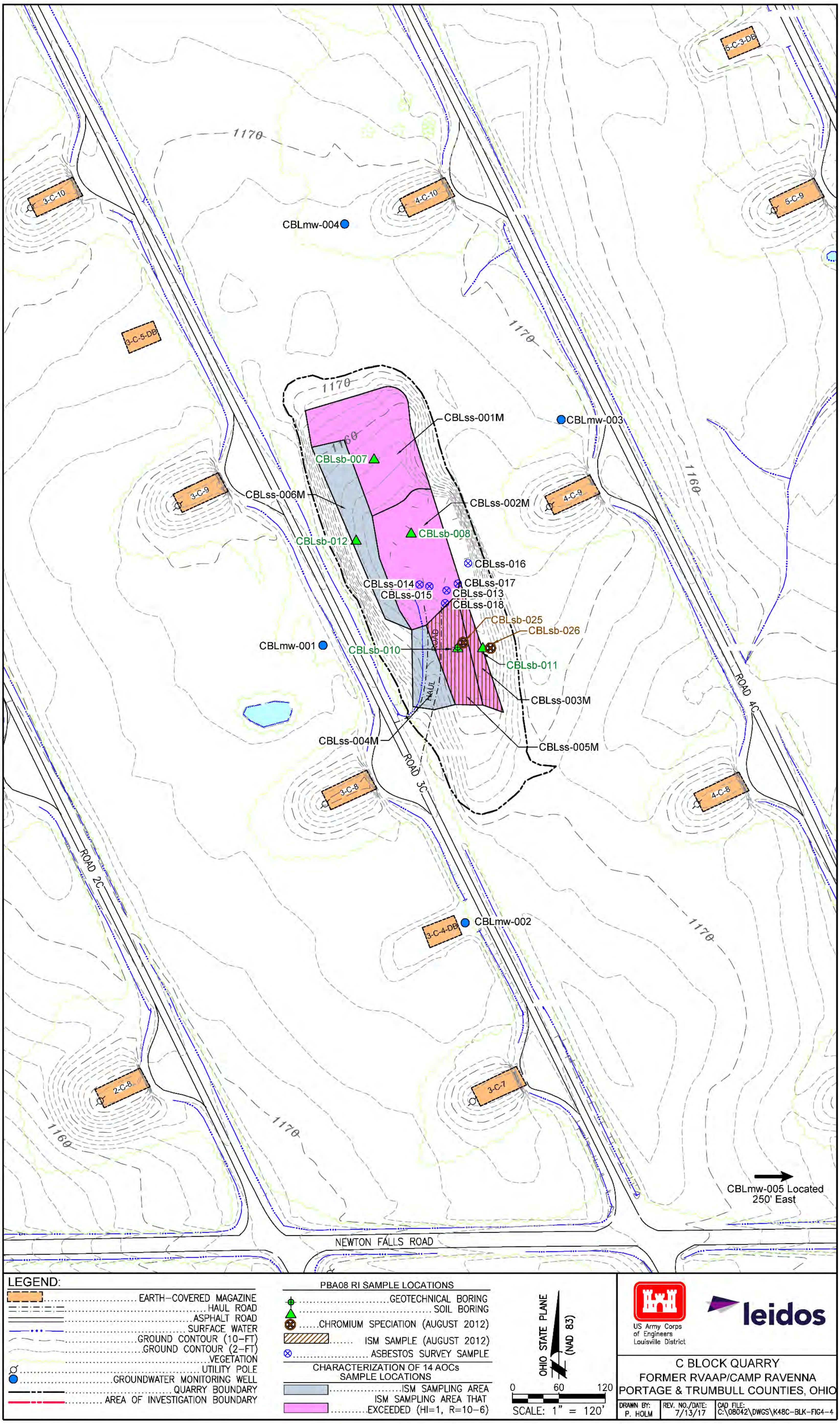

Figure 4–4. PBA08 RI Sample Locations at C Block Quarry

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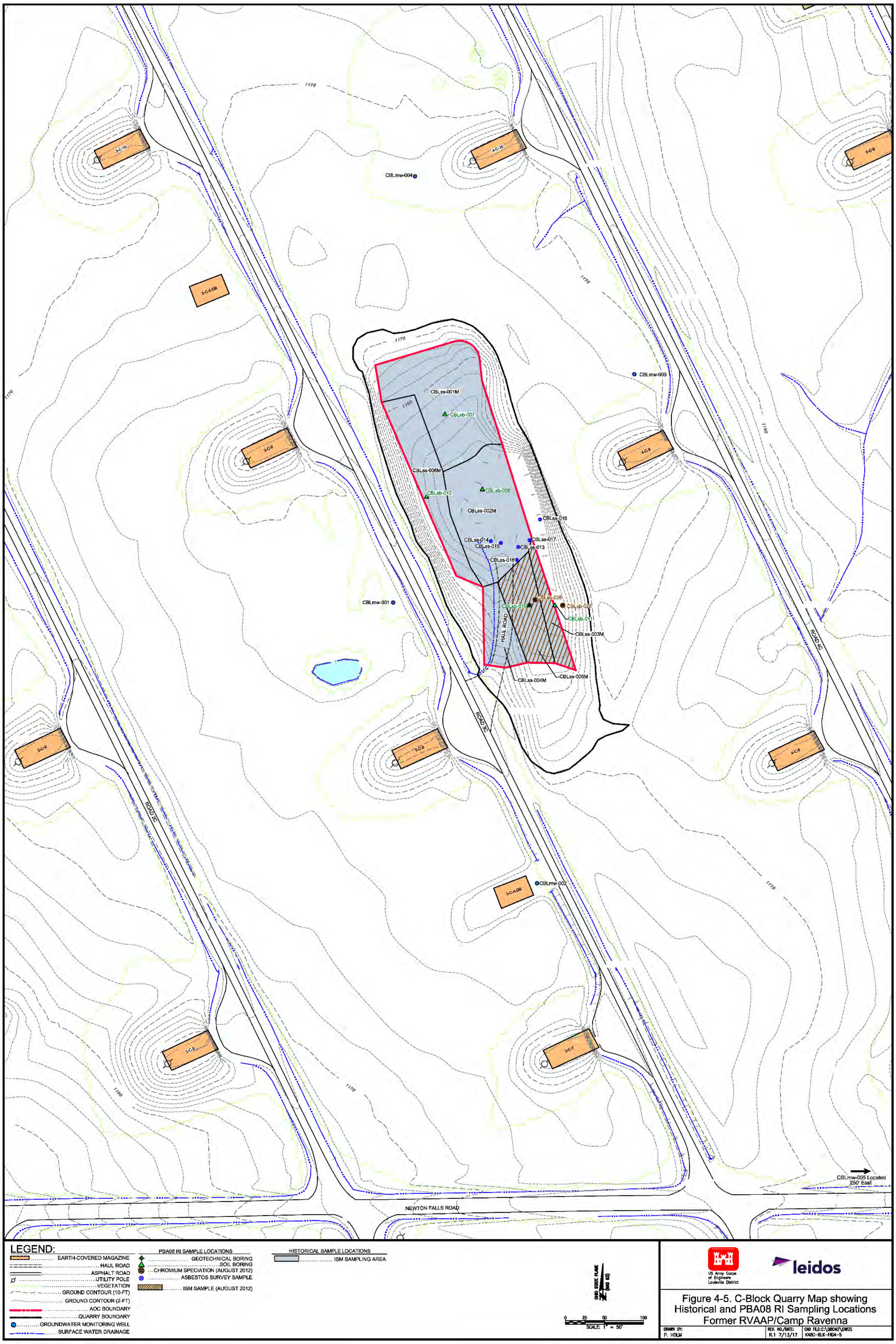

Figure 4–5. All C Block Quarry RI Sample Locations

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5.0 NATURE AND EXTENT OF CONTAMINATION

This section evaluates the nature and extent of contamination at C Block Quarry. This evaluation includes two types of chemicals: SRCs identified as being previously dumped during disposal activities or that potentially were associated with C Block operations, and SRCs that do not appear to have been used/disposed of during historical operations but were analyzed during investigations. The evaluation discusses the nature and extent of SRCs in environmental media at C Block Quarry, with a focus on chemicals previously dumped during disposal activities, using analytical data results obtained from the 2004 Characterization of 14 AOCs and 2010 and 2012 PBA08 RI.

To support the evaluation of nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report. The following figures in Section 5.0 illustrate the concentrations and distribution of SRCs that exceed SLs.

- Figure 5-1 – Detected Concentrations of Explosives and Propellants in Soil.
- Figure 5-2 – Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) for Arsenic and Hexavalent Chromium in Soil.
- Figure 5-3 – PAH Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) in Soil.
- Figure 5-4 – Total Chromium and Hexavalent Chromium Results in Soil Samples.
- Figure 5-5 – Asbestos-Containing Material Survey and Sampling Results.

As discussed in Section 4.0, data from all eligible samples were combined and screened to identify SRCs representing current conditions at C Block Quarry. All validated C Block Quarry data from previous studies (2004 Characterization of 14 AOCs and 2010/2012 PBA08 RI) are included in Appendix D. Complete laboratory analytical data packages from the PBA08 RI are also included in Appendix D.

Contaminant nature and extent is presented below for each medium and class of analytes.

5.1 DATA EVALUATION

As discussed in Section 4.2.1, surface soil samples were collected during the Characterization of 14 AOCs. Surface soil and subsurface soil samples were also collected during the PBA08 RI. All available sample data were evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, and risk assessment). Evaluation of data suitability for use in the PBA08 RI involved two primary considerations: representativeness with respect to current AOC conditions and sample collection methods (e.g., discrete vs. ISM).

Soil samples from the 2004 Characterization of 14 AOCs were evaluated to determine if conditions had changed substantively between earlier characterization efforts and PBA08 RI activities. No disturbances occurred within C Block Quarry between the Characterization of 14 AOCs and PBA08

RI. Therefore, both data sets were considered representative of current conditions at C Block Quarry. No soil samples were eliminated from the SRC screening process or nature and extent evaluation on the basis of changed conditions. Only PBA08 RI data are available for subsurface soil, as the 2004 investigation did not include soil borings.

All previous surface soil samples from 2004 Characterization of 14 AOCs were collected using ISM sample methods. Surface soil samples were collected at the bottom of C Block Quarry during the 2004 sampling activities and consisted of 10 aliquots per ISM sample due to the limited size of the sampling area. No subsurface samples were collected for analysis during the Characterization of 14 AOCs. Subsurface soil samples were collected during the PBA08 RI, and the discrete samples from the 0–1 ft bgs interval from each soil boring were submitted for analysis. The surface soil SRC screening data set consisted only of ISM samples collected during the Characterization of 14 AOCs and two PBA08 ISM samples taken for chromium speciation. Discrete surface soil samples sourced from the 0–1 ft bgs interval from soil borings installed in 2010 were utilized for nature and extent evaluation only, as only the ISM samples were utilized for surface soil SRC screening. For subsurface soil, only discrete sample data from the PBA08 RI were available; therefore, they were screened for SRCs and COPCs and carried forward into the risk assessment.

5.2 CONTAMINANT NATURE AND EXTENT IN SURFACE SOIL

Table 4-16 presents the results of the SRC screening for ISM surface soil samples at C Block Quarry. The PBA08 RI samples were not used in the SRC screening, as only discrete surface soil samples were collected from the 0–1 ft bgs interval of each subsurface soil boring. However, the two chromium speciation ISM samples (CBLss-003M and CBLss-005M) were included in the screening. The following subsections discuss the concentration and distribution of ISM surface soil results.

5.2.1 Explosives and Propellants

Figure 5-1 presents the locations that had detectable concentrations of explosives and propellants. Three explosives (TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT) and one propellant (nitrocellulose) were identified as SRCs in surface soil at C Block Quarry. The ISM soil samples collected from within the quarry bottom during the 2004 Characterization of 14 AOCs and discrete surface soil samples collected from soil borings during the 2010 PBA08 RI were analyzed for explosives and propellants.

All three explosive compounds (TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT) were detected at their maximum concentrations at CBLss-004M. TNT was detected at three locations, with a maximum concentration of 22 mg/kg at CBLss-004M. The maximum concentrations of 2-amino-4,6-DNT; 4-amino-2,6-DNT; and nitrocellulose were all below their respective SLs and were not considered COPCs.

The only PBA08 RI discrete surface soil samples to exhibit explosives detections were CBLsb-010 and CBLsb-011. 2,4-DNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT were detected in discrete sample CBLsb-010 at low, estimated concentrations of 0.025J, 0.16J and 0.13J mg/kg, respectively. Soil boring CBLsb-010 was located at the center of ISM sample CBLss-005M and exhibits similar explosives concentrations of 2-amino-4,6-DNT and 4-amino-2,6-DNT to those observed in the ISM sample CBLss-005M. 3-Nitrotoluene was detected in discrete sample CBLsb-011 at a low, estimated concentration of 0.018J mg/kg.

5.2.2 Inorganic Chemicals

Chromium, hexavalent chromium, lead, and mercury were identified as potential inorganic SRCs and as potentially related to previous site use. These inorganic chemicals had a maximum detection above the background concentration, as summarized in the list below.

- Chromium was detected above the background concentration (17.4 mg/kg) in seven of eight ISM samples, with a maximum concentration of 1,000 mg/kg observed at 2012 sample location CBLss-005M that evaluated surface soil in the south-central portion of C Block Quarry. Chromium was detected above its background concentration in four of the seven PBA08 RI discrete surface soil samples: CBLsb-008 (25.7 mg/kg) and CBLsb-010 (2,100 mg/kg) in 2010 and CBLsb-025 (1,700J mg/kg) and CBLsb-026 (390J mg/kg) in 2012. PBA08 RI sample CBLsb-010, where the overall maximum detection occurred, is located central to ISM sample area CBLss-005M, where the highest chromium detection in the SRC screening data set was observed. CBLss-005M is located in the south-central portion of C Block Quarry.
- Hexavalent chromium
  - In 2004, hexavalent chromium was detected in one of five SRC screening samples (CBLss-003M at a concentration of 5.4J mg/kg)
  - In 2012, hexavalent chromium was detected in both ISM samples (CBLss-003M and CBLss-005M at concentrations of 0.46J and 0.32J mg/kg, respectively).
  - In 2012, two discrete surface soil samples were collected from two soil borings (CBLsb-025 and CBLsb-026) located within ISM areas with elevated chromium concentrations (CBLss-003M and CBLss-005M). Hexavalent chromium concentrations were 19J and 2.2J mg/kg, respectively.
- Lead was detected above the background concentration of 26.1 mg/kg in one of six ISM samples, with a maximum concentration of 43 mg/kg observed at 2004 sample location CBLss-002M that evaluated surface soil in eastern-central portion of C Block Quarry. Lead was detected above its background concentration at only one PBA08 RI discrete surface soil station: CBLsb-010 at a concentration of 27.7 mg/kg.
- Mercury was detected above the background concentration of 0.036 mg/kg in three of six ISM samples, with a maximum concentration of 0.07 mg/kg at 2004 sample location CBLss-006M. Mercury was also detected above its background concentration in four of five PBA08 RI discrete soil samples, ranging in concentration from 0.037J mg/kg (CBLsb-011) to 0.067 mg/kg (CBLsb-010). No trend in the distribution of mercury concentrations is apparent as detections occur above the background concentration, and within the same magnitude of concentration, at multiple locations throughout the AOC.

Although not identified as previously used during historical operations, arsenic, copper, and thallium were identified as SRCs from the RVAAP screening process, as presented in Table 4-16.

- Arsenic was detected above the background concentration (15.4 mg/kg) in only one of six ISM samples, with a maximum concentration of 19 mg/kg at 2004 sample location CBLss-001M that evaluated surface soil in northern portion of the quarry bottom. Arsenic was not detected above its background concentration in any of the five PBA08 RI discrete surface soil samples.
- Copper was detected above its background concentration of 17.7 mg/kg in three of six ISM samples, with a maximum concentration of 78 mg/kg at 2004 sample location CBLss-005M. Copper was detected above its background concentration in only one of the PBA08 RI discrete surface soil samples (CBLsb-010) at a concentration of 126 mg/kg. CBLsb-010 was collected at the center of ISM sample area CBLss-005M and exhibited the highest overall copper concentration at C Block Quarry.
- Thallium was detected at two of six ISM samples, with a maximum of 0.36 mg/kg at 2004 sample location CBLss-002M. Thallium was detected in all five PBA08 RI discrete surface soil samples, with a maximum concentration of 0.17J mg/kg (CBLsb-007).

Figure 5-2 presents the locations with inorganic chemical concentrations that exceeded SLs and background concentrations. Of the seven chemicals discussed above, copper, lead, mercury, and thallium had no detections above the SLs, and were therefore not considered COPCs and are not presented in Figure 5-2. Chromium exceeded the SL for hexavalent chromium (1.64 mg/kg), but did not exceed the SL for trivalent chromium (8,147 mg/kg) and therefore is not presented in Figure 5-2. The SL exceedances of arsenic and hexavalent chromium do not appear to be concentrated in any particular area of the AOC.

5.2.3 Semi-volatile Organic Compounds

SVOCs do not have background concentrations for comparison purposes with chemical results; consequently, a large number of SVOCs were identified as SRCs. Nine SVOC SRCs were identified by data screening for ISM sample location CBLss-005M, including eight PAHs [benz(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene]. Detections of all of SVOCs at CBLss-005M occurred at low, estimated concentrations below laboratory reporting limits and SLs. The highest SVOC concentration detected was bis(2-ethylhexyl)phthalate at 0.054J mg/kg.

Fourteen PAHs (eight of the nine ISM SRCs) were detected in PBA08 RI discrete soil sample CBLsb-011, located in the southeast corner of C Block Quarry and within 2004 ISM sample CBLss-003M (Figure 5-3). All of the SRCs for surface soil SVOCs were detected in CBLsb-011, with the exception of the non-PAH bis(2-ethylhexyl)phthalate. The PAH SRC concentrations detected at CBLsb-011 ranged from 0.025J mg/kg (acenaphthene) to 0.51 mg/kg [benzo(b)fluoranthene].

Benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene were detected above their respective Resident Receptor (Adult and Child) FWCUGs at a TR of 1E-06, HQ of 0.1 in the 2010 PBA08 RI discrete surface soil sample CBLsb-011. Benzo(a)pyrene also exceeded the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1.

5.2.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs, pesticides, or PCBs were identified as SRCs in surface soil at C Block Quarry, nor were these chemicals detected in the PBA08 RI discrete surface soil samples.

5.3 CONTAMINANT NATURE AND EXTENT IN SUBSURFACE SOIL

As discussed in Section 4.0, data from subsurface soil samples were screened to identify SRCs representing subsurface conditions at C Block Quarry. Subsurface soil samples were not collected during the Characterization of 14 AOCs; therefore, the SRC screening data set was comprised of seven discrete samples collected during the 2010 PBA08 RI, and two additional discrete samples from two borings collected for subsurface chromium speciation in 2012. Five soil borings were completed at C Block Quarry to define the vertical extent of contamination in subsurface soil. Due to the shallowness of the soil layer at the quarry bottom, the deepest subsurface soil sample was collected at 4–7 ft bgs. Four subsurface borings were analyzed for TAL metals and explosives; three samples from one boring were analyzed for RVAAP full-suite analytes. Table 4-17 presents the results of the SRC screening for subsurface soil samples. Figures 5-1 through 5-3 illustrate the distribution of identified subsurface soil SRCs in all samples collected at C Block Quarry.

5.3.1 Explosives and Propellants

Two explosives (2-amino-4,6-DNT and 4-amino-2,6-DNT) were identified as SRCs in the 1–4 ft bgs interval of subsurface soil at C Block Quarry. Both 2-amino-4,6-DNT and 4-amino-2,6-DNT were detected at CBLsb-010 at concentrations of 0.073J and 0.051J mg/kg, respectively. Explosives were not detected in any of the other six subsurface soil samples. Both subsurface soil SRCs were also detected in the 0–1 ft bgs surface soil interval at CBLsb-010 at higher concentrations than those observed in the subsurface soil interval.

No propellants were identified as SRCs in subsurface soil at C Block Quarry.

5.3.2 Inorganic Chemicals

Chromium, hexavalent chromium, lead, and mercury were identified as potential inorganic SRCs and as potentially related to previous site use (i.e., disposal area).

The subsurface soil sampling results are discussed below.

- Chromium was detected in the 1–4 ft bgs interval at CBLsb-010 at a concentration of 698 mg/kg. The subsurface soil chromium concentration at CBLsb-010 was lower than that observed in the overlying 0–1 ft bgs interval (2,100 mg/kg). The maximum detection of chromium in the ISM sample data set occurred in CBLss-005M (1,000J mg/kg), which encompasses soil boring CBLsb-010.
- Hexavalent chromium concentrations detected at CBLsb-025 (adjacent to CBLsb-010, 1–2 ft bgs interval) and CBLsb-026 (adjacent to CBLsb-011, 1–1.8 ft bgs interval) were 39J and 6.4J mg/kg, respectively. These concentrations were above the SL, and hexavalent chromium is considered to be a COPC.
- Lead was detected above its background concentration of 19.1 mg/kg only in the 4–4.5 ft bgs interval at CBLsb-011, with a concentration of 25.6 mg/kg. Lead was not detected above its background concentration in the 1–4 ft bgs interval at CBLsb-011 or in the overlying 0–1 ft bgs surface soil sample interval.
- Mercury was detected in four of seven subsurface soil samples above its background concentration of 0.044 mg/kg, within a narrow range of concentrations from 0.047J–0.067J mg/kg.

Two additional inorganic chemicals were identified as SRCs from the RVAAP screening process, as presented in Table 4-17 and as summarized below:

- Cadmium does not have a background concentration. The inorganic chemical was detected in all seven subsurface samples, with a maximum concentration of 0.11 mg/kg observed at 2010 PBA08 RI sample location CBLsb-011in the 4–4.5 ft bgs interval.
- Copper was detected above the background concentration of 32.3 mg/kg in one sample, with a concentration of 218 mg/kg observed at 2010 PBA08 RI sample location CBLsb-010 in the 1–4 ft bgs interval. The copper concentration in the 1–4 ft bgs interval at CBLsb-010 was higher than that detected in the overlying surface soil discrete sample (126 mg/kg). The maximum detection of copper in the ISM sample data set occurred in CBLss-005M, which encompasses soil boring CBLsb-010. Copper was below its respective SL (311 mg/kg).

Figure 5-2 presents the locations with inorganic chemical concentrations that exceeded SLs and background concentrations. Of the six chemicals discussed above, the only chemical in subsurface soil that exceeded the SL was hexavalent chromium, as shown in Figure 5-2.

5.3.3 Semi-volatile Organic Compounds

Twelve SVOCs, all PAHs, were detected and identified as SRCs in subsurface soil at C Block Quarry. All 12 SVOCs were detected in the 1–4 ft bgs interval at CBLsb-011, ranging in concentration from 0.0094J mg/kg (fluorene) to 0.13 mg/kg (fluoranthene). Three SVOCs [benzo(b)fluoranthene, fluoranthene, and pyrene] were detected in the 4–4.5 ft bgs interval at CBLsb-011 at lower concentrations than those observed in the overlying 1–4 ft bgs interval. Benzo(a)pyrene was detected from the 1–4 ft bgs interval at PBA08 RI sample location CBLsb-011 at a concentration that exceeded its SL of 0.022 mg/kg; thus, benzo(a)pyrene was identified as a COPC (Figure 5-3). However, the benzo(a)pyrene concentration was detected below the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1.

5.3.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs, pesticides, or PCBs were detected in subsurface soil at C Block Quarry.

5.3.5 Geotechnical Subsurface Soil Sample

One soil boring was completed at C Block Quarry to obtain geotechnical parameters to perform vadose zone soil leaching and groundwater transport modeling. One sample was collected from this soil boring from the 1.5–3.5 ft bgs interval. The geotechnical sample location was offset 2 ft south of soil boring CBLsb-010 and was installed by manually pushing the tubes into the soil to the top of bedrock. Sandstone was encountered at a depth of 4 ft bgs, and the boring was terminated. Groundwater was not encountered in this boring. Table 5-2 summarizes the results of the geotechnical characteristics of C Block Quarry soil. Laboratory analytical data package results are presented in Appendix D.

5.4 CHROMIUM SPECIATION OF SOIL

The total chromium and hexavalent chromium results are presented in Figure 5-4. During the PBA08 RI in 2012, surface soil samples were collected from two ISM sample locations and analyzed for total chromium and hexavalent chromium from areas previously identified during the 2004 Characterization of 14 AOCs as having elevated total chromium concentrations (CBLss-003M and CBLss-005M).

In August 2012, surface soil at ISM sample locations CBLss-003M and CBLss-005M was re-collected and analyzed for total chromium and hexavalent chromium. In addition, two soil borings (CBLsb-025 and CBLsb-026) were collected from 0–1 ft bgs and below 1 ft bgs and analyzed for total chromium and hexavalent chromium. These samples were collected to further assess contributions of hexavalent chromium to total chromium and to refine potential remedial options. This sampling determined the contribution of hexavalent chromium to total chromium over a range of concentrations in soil at C Block Quarry for use in the HHRA (Section 7.2).

Chromium speciation results from August 2012 are shown in Table 5-1. All six samples had a total chromium concentration above the facility-wide background concentration of 17.4 and 27.2 mg/kg, for surface and subsurface soil, respectively. The range of hexavalent chromium concentrations was 0.32J–39J mg/kg and did not appear to be correlated to total chromium values. A detailed assessment of the speciation results respective to the HHRA is presented in Section 7.2.5.1.

5.5 ASBESTOS SAMPLE RESULTS

Suspected ACM, consisting predominantly of loose transite tiles, was observed at C Block Quarry during reconnaissance activities in 2008. Accordingly, the investigation conducted in 2010 by a certified Asbestos Hazard Evaluation Specialist consisted of a visual inspection, sampling of suspect ACM material, and analysis of asbestos in soil.

Several areas of exposed transite/shingle and steel panels with block insulation and paper were observed within C Block Quarry, as shown in Figure 5-5. The survey indicated the ACM occurred in an area of approximately 2,750 ft^2, although the visible debris occupied less than 10 ft^2. Six bulk material samples were collected adjacent to the debris pile containing the suspect ACM. Four of the six bulk material samples were confirmed to contain asbestos fibers.

One soil sample (CBLss-017-5798-BD) was collected approximately 1 ft away from a pile of exposed ACM that was partially covered in soil. This soil sample had less than 1% chrysotile. Nine soil samples were collected and submitted for ACM analysis from four of the soil borings advanced during the PBA08 RI (CBLsb-007, CBLsb-008, CBLsb-010, and CBLsb-012) due to suspect ACM construction debris observed in previous investigations. None of the nine soil samples exhibited detectable asbestos content.

The sample results from the ACM survey are summarized in Table 4-11, and the complete survey report is presented in Appendix J.

5.6 SUMMARY OF CONTAMINANT NATURE AND EXTENT

Data from the 2004 Characterization of 14 AOCs and 2010/2012 PBA08 RI sampling were used to identify SRCs at C Block Quarry. This data effectively characterizes the nature and extent of contamination at the AOC. To support the evaluation of the nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and the National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report. If there was no FWCUG for a chemical, the USEPA RSL was used as the SL. Based on the information provided earlier in this section and as summarized below, it can be concluded that the vertical and horizontal extent of chemical contamination is defined, and no further sampling is needed to evaluate C Block Quarry.

The PBA08 RI data effectively characterized the nature and extent of the chemical contamination at the AOC, and no further sampling is recommended. In both surface and subsurface soil at C Block Quarry, the predominant SRCs observed were inorganic chemicals, explosives, and PAHs. For both media, the highest SRC concentrations occurred in the southern portion of the AOC. Detections of VOCs, pesticides, and PCBs were not observed at the AOC. A summary of observations for each medium is presented below.

5.6.1 Surface Soil

The predominant SRCs in surface soil at C Block Quarry were inorganic chemicals, explosives, and SVOCs, the majority of which were PAHs. Twenty SRCs were identified in surface soil at C Block Quarry. Three explosives (TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT) and one propellant (nitrocellulose) were identified as SRCs in surface soil at C Block Quarry. Explosives were detected in three of six SRC screening data set samples. All three explosive compounds were detected at their maximum concentrations at CBLss-004M, located in the southwest portion of the AOC. Seven inorganic chemicals were identified as SRCs in surface soil at C Block Quarry. The highest inorganic chemical concentrations were observed in the southern portion of the AOC. The concentration of chromium was particularly high at 920 mg/kg at CBLss-005M. Nine SVOCs, eight of which are PAHs, were identified as SRCs in ISM surface soil, and an additional six PAHs were identified in a discrete surface soil sample at C Block Quarry. The SVOC detections occurred at CBLss-005M and CBLsb-011, at the southern end of the AOC. Arsenic, hexavalent chromium, and benzo(a)pyrene also exceeded the Resident Receptor (Adult and Child) FWCUGs at a TR of 1E-05, HQ of 1, and identified as a COPCs for further evaluation.

No VOCs, pesticides, or PCBs were identified as SRCs in C Block Quarry surface soil. Elevated SRC contamination in surface soil was localized to the southern portion of the AOC and is likely associated with former disposal operations. Migration of sediment material into the AOC from off-AOC sources is neither evident nor expected, as the quarry area is located on a local bedrock high.

5.6.2 Subsurface Soil

Twenty SRCs were identified in subsurface soil at C Block Quarry. Six of seven subsurface soil borings were terminated prior to a depth of 7 ft bgs due to the shallowness of the overlying soil layer at the bottom of the quarry. Two explosives (2-amino-4,6-DNT and 4-amino-2,6-DNT) were identified as SRCs in the 1–4 ft bgs interval of subsurface soil at CBLsb-010, located in the south-central portion of the AOC. Six inorganic chemicals were identified as SRCs in subsurface soil samples at C Block Quarry. Within the 1–4 ft bgs interval, high concentrations of inorganic chemicals (e.g., chromium at 698 mg/kg) were observed at CBLsb-010, in the vicinity of surface soil ISM location CBLss-005M. The hexavalent chromium concentrations detected at CBLsb-025 (adjacent to CBLsb-010, 1–2 ft bgs interval) and CBLsb-026 (adjacent to CBLsb-011, 1–1.8 ft bgs interval) were above the SL. Therefore, hexavalent chromium is considered to be a COPC for further evaluation. Twelve SVOCs, all PAHs, were detected and identified as SRCs in subsurface soil at the AOC. All twelve SVOCs were detected in the 1–4 ft bgs interval at CBLsb-011, located in the southeast corner of the AOC. Three SVOCs [benzo(b)fluoranthene, fluoranthene, and pyrene] were detected in the 4–4.5 ft bgs interval at CBLsb-011; the concentrations were below SLs. No propellants, VOCs, PCBs, or pesticides were identified as SRCs in subsurface soil at C Block Quarry.

The number and distribution of SRCs in subsurface soil were comparable to those observed in surface soil, although concentrations of SRCs in subsurface soil were typically observed at levels lower than those observed in the corresponding surface soil interval.

Table 5-1. Chromium Speciation Results (August 2012)

Sample Location	Hexavalent Chromium Concentration (mg/kg)	Total Chromium Concentration[a] (mg/kg)	Percent Hexavalent Chromium (%)
CBLss-003M	**0.46J***	**520J***	0.09
CBLss-005M	**0.32J***	**1000J***	0.032
CBLsb-025 (0–1 ft bgs)	**19J ***	**1700J***	1.1
CBLsb-025 (1–2 ft bgs)	**39J***	**930J***	4.2
CBLsb-026 (0–1 ft bgs)	**2.2J***	**390J***	0.6
CBLsb-026 (1–1.8 ft bgs)	**6.4J***	**920J***	0.7

[a] Background concentration for total chromium = 17.4 mg/kg. No background concentration is available for hexavalent chromium.

J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample.

mg/kg = Milligrams per kilogram.

* = Result exceeds background criteria or no background criteria was available.

Table 5-2. Summary of Geotechnical Parameters

Sample ID: Parameters	CBLsb-010-5269-SO
Depth	1.5–3.5 ft bgs
Porosity	35.1%
Density	1.74 g/cm^3
Moisture content	13.6%
Total organic carbon	670J mg/kg
Size fraction analysis	33.6% gravel, 56.3% sand, 4.8% silt, 5.2% clay
Permeability (K)	5.6E-07 cm/sec

bgs = Below ground surface.

cm/sec = Centimeters per second.

ft = Feet.

g/cm^3 = Grams per cubic centimeter.

ID = Identification.

J = Indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample

mg/kg = Milligrams per kilogram.

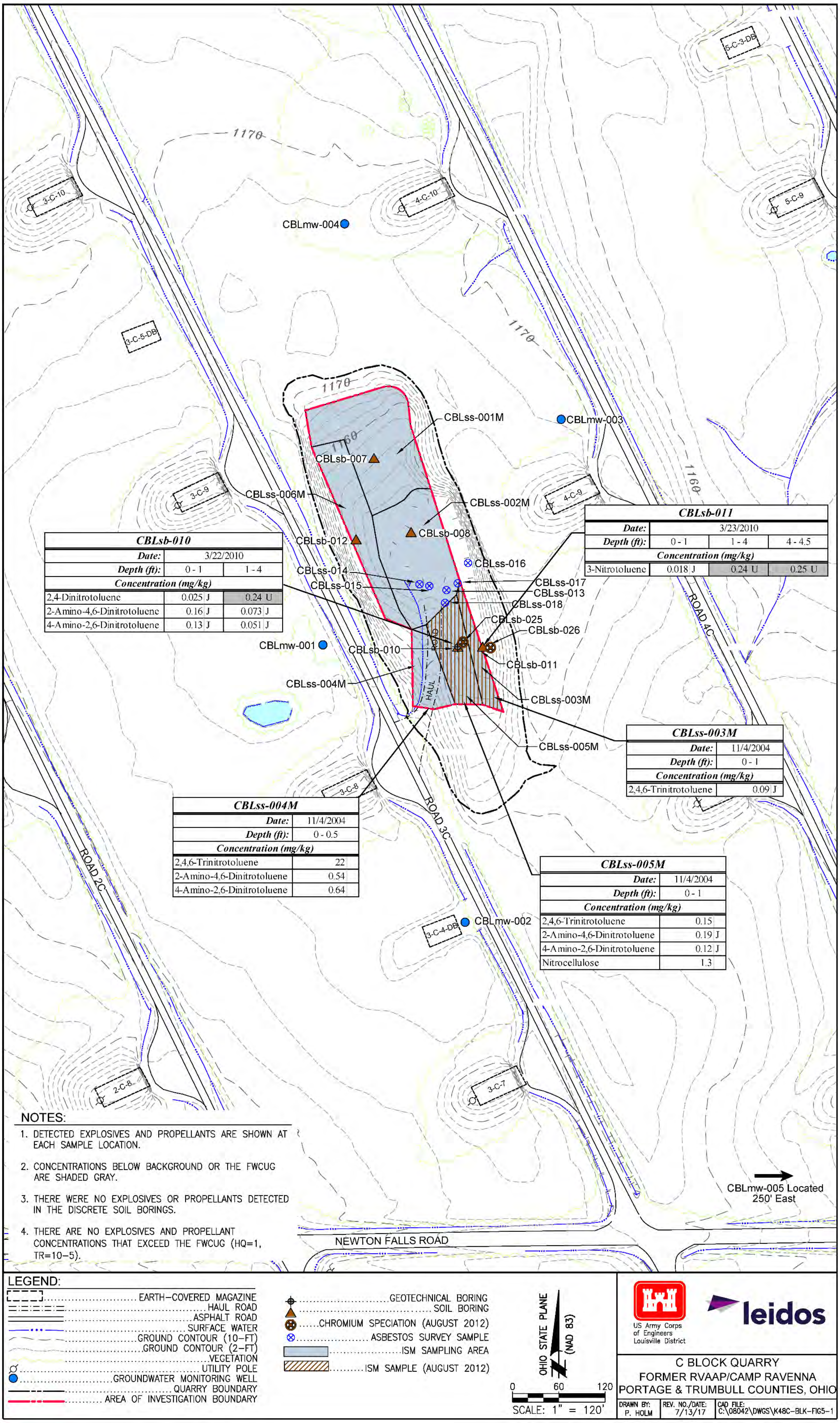

Figure 5–1. Detected Concentrations of Explosives and Propellants in Soil

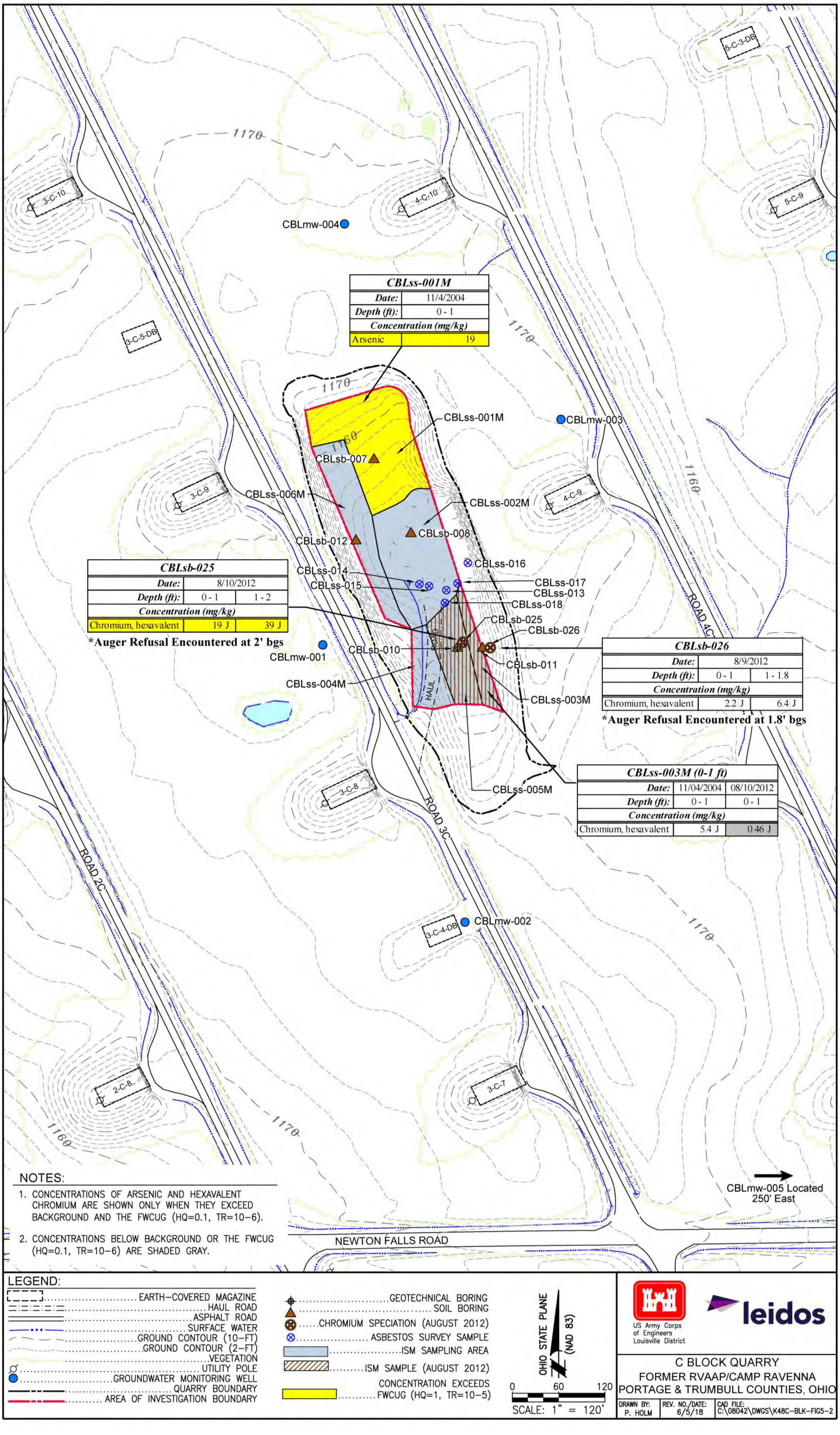

Figure 5–2. Exceedances of FWCUG (HQ=0.1, TR=1E-06) for Arsenic and Hexavalent Chromium in Soil

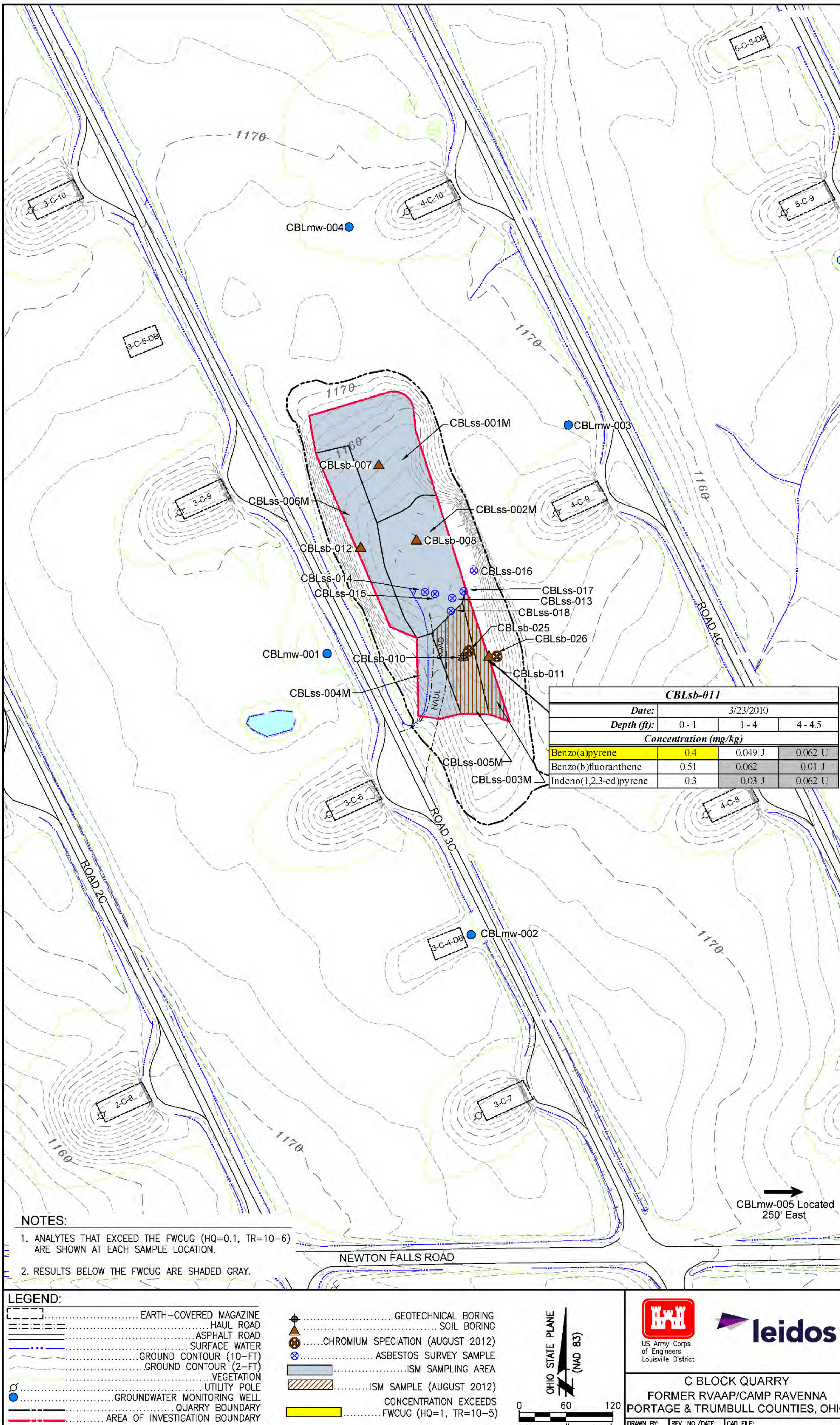

Figure 5–3. PAH Exceedances of FWCUG (HQ=0.1, TR=1E-06) in Soil

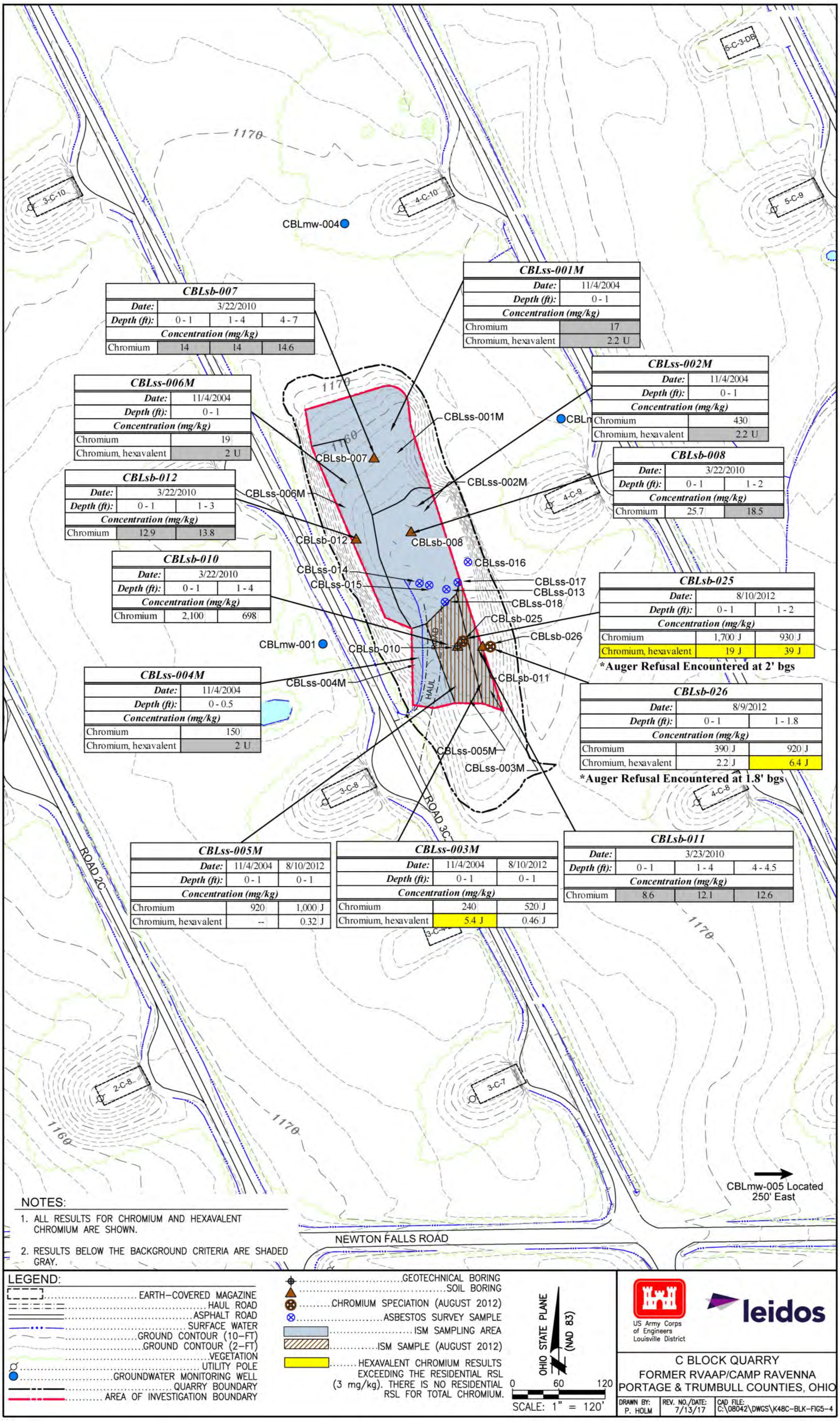

Figure 5–4. Total Chromium and Hexavalent Chromium Results in Soil Samples

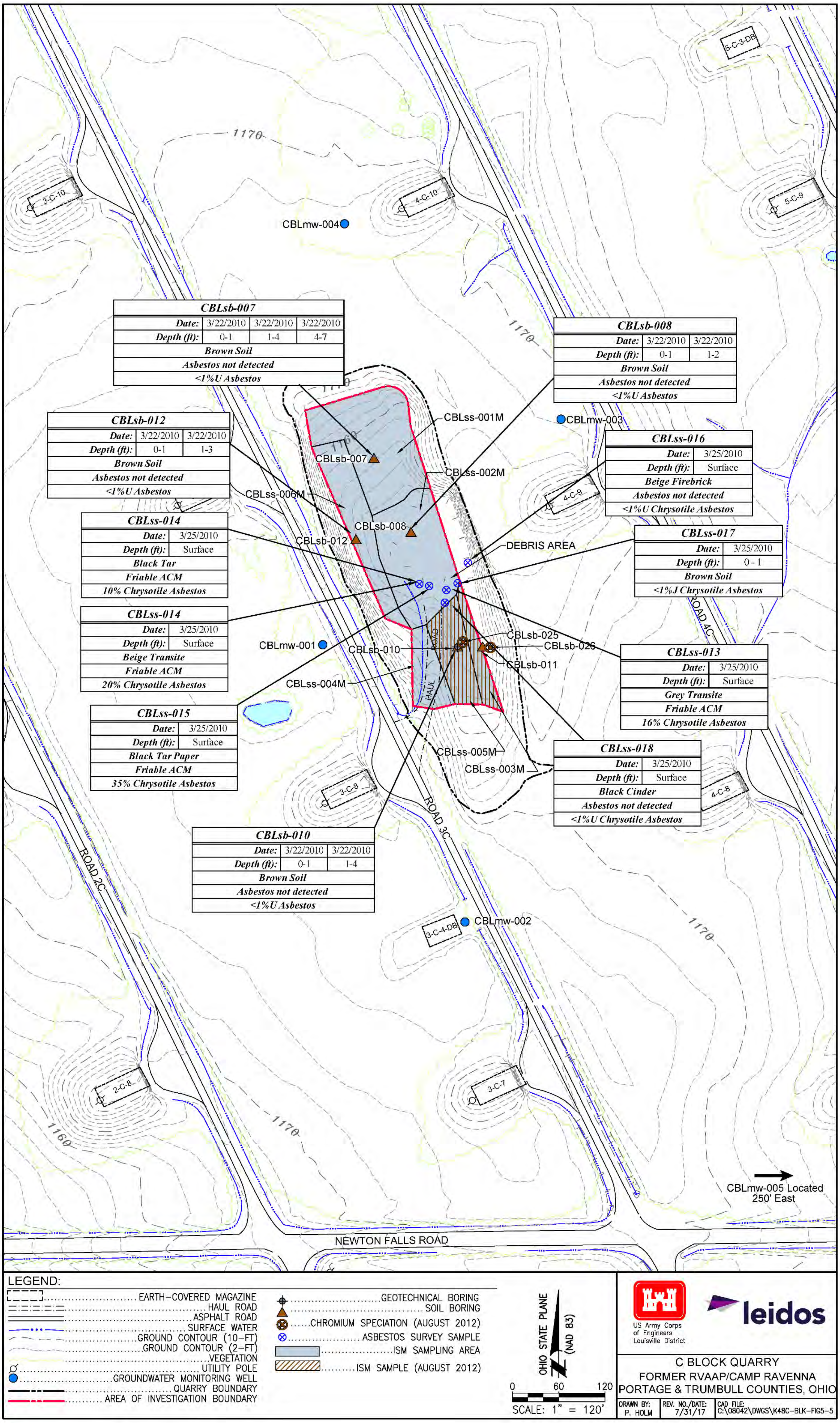

Figure 5–5. Asbestos-Containing Material Survey and Sampling Results

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6.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport at C Block Quarry is evaluated using 1) groundwater data collected to date at the AOC and 2) modeling to assess the potential for SRCs to leach from surface and subsurface soil sources and impact groundwater beneath the sources. This evaluation is included in the decision-making process to determine whether remedial actions may be necessary to protect groundwater resources.

6.1 GROUNDWATER CHEMICAL CONCENTRATIONS

6.1.1 Groundwater Sampling Summary

Groundwater samples were collected from 5 monitoring wells around C Block Quarry during 13 separate sampling events under the Characterization of 14 AOCs (MKM 2007) and the FWGWMP from January 2005 to November 2016 to assess the potential impact that historical site activities may have had on groundwater. Table 6-1 summarizes the C Block Quarry monitoring well sampling and the laboratory analyses that were performed during those sampling events.

From December 2004 through January 2005, monitoring wells CBLmw-001 to CBLmw-004 were installed during the Characterization of 14 AOCs. After the well installation, these wells were sampled and analyzed for the RVAAP full-suite analytes in January 2005. Additional analyses were performed for RVAAP full-suite analytes as part of the FWGWMP for four quarters from April 2008 to January 2009. The monitoring wells have been periodically sampled since January 2009 and analyzed for the select parameters presented in Table 6-1.

Under the FWGWMP, an additional monitoring well (CBLmw-005) was installed near C Block Quarry in 2012. CBLmw-005 was sampled for four quarters from April 2012 to June 2013 and analyzed for RVAAP full-suite parameters.

6.1.2 Groundwater Sample Results

Groundwater samples have been analyzed for metals, explosives, propellants, SVOCs, VOCs, PCBs, pesticides, perchlorate, and cyanide. Monitoring wells CBLmw-001 to CBLmw-004 had five sample events in which groundwater samples were analyzed for the RVAAP full-suite analytes. Monitoring well CBLmw-005 had four sample events in which groundwater samples were analyzed for RVAAP full-suite analytes.

Table 6-2 summarizes the chemicals detected within the C Block Quarry monitoring wells from January 2005 to January 2013. This table includes duplicate sample results and only includes results from metal analyses that were filtered at the time of sample collection. Table 6-2 does not include data from the November 2016 sample event, as the data were not available at the time for inclusion in the data summary. However, none of the November 2016 samples had detectable concentrations of PCBs or SVOCs, and the maximum concentration of cyanide was an estimated 0.003J mg/L, well below the MCL of 0.2 mg/L.

Table 6-2 also presents screening criteria at a risk level of HQ of 0.1, TR of 1E-06 for comparison purposes. The initial screening criterion used was the USEPA MCL. If a chemical did not have a USEPA MCL, the Resident Receptor FWCUG at a risk level of HQ of 0.1, TR of 1E-06 was used. If a chemical did not have an MCL or Resident Receptor FWCUG, the Resident Tap Water RSL at a risk level of HQ of 0.1, TR of 1E-06 was used.

Explosives, propellants, VOCs, pesticides, perchlorate, and cyanide results were all below the screening levels provided. Seven chemicals had at least one exceedance of the screening level, and a discussion of these chemicals is presented below.

- **Hexavalent chromium** – Hexavalent chromium was detected in four of five samples collected in 2005 at concentrations ranging from 0.0052B–0.0077B mg/L. Hexavalent chromium does not have an MCL or Resident Receptor FWCUG; consequently, the Resident Tap Water RSL (0.000035 mg/L) was used for the screening criteria. The results of these 2005 samples were "B qualified," indicating the result was above the instrument detection limit but below the contract required detection limit. In July 2012, groundwater samples were collected from CBLmw-002 and CBLmw-005 (downgradient from the AOC). These samples did not have detectable concentrations of hexavalent chromium.
- **Manganese** – Only 4 of 32 samples exceeded the Resident Receptor FWCUG at HQ of 0.1, TR of TR of 1E-06 (0.0463 mg/L). Three of these samples were collected in January 2005, including the maximum concentration of 0.19 mg/L at CBLmw-001. All four samples that exceeded this screening level had a subsequent groundwater sample collected at that well that was below the screening level.
- **PCB-1248** – Of the 30 groundwater samples analyzed for PCBs, only 1 sample had a detectable concentration. This detectable concentration was PCB-1248 at CBLmw-004 with an estimated concentration of 0.00011J mg/L in October 2008, which is below the MCL (0.0005 mg/L). The samples collected from CBLmw-004 in January 2009 and April 2011 did not have detectable concentrations of any PCBs.
- **Benz(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene** – These chemicals each had one exceedance of the Resident Receptor FWCUG in the January 2005 sample at CBLmw-001. All other C Block Quarry groundwater samples, including subsequent samples from monitoring well CBLmw-001, did not have detectable concentrations of these three chemicals.
- **Bis(2-ethylhexyl)phthalate** – Of the 30 groundwater samples analyzed for bis(2-ethylhexyl)phthalate, only 8 samples had a detectable concentration, and only 2 samples exceeded the MCL of 0.006 mg/L. The maximum concentration was 0.4 mg/L at CBLmw-002 in January 2005; however, all subsequent samples from CBLmw-002 were well below the MCL.

6.2 FATE AND TRANSPORT EVALUATION

Contaminant fate and transport modeling to assess the potential for SRCs to leach from surface and subsurface soil sources at C Block Quarry and impact groundwater beneath the sources was performed as part of this RI Report. The detailed evaluation is provided in Appendix E.

6.2.1 Approach

The fate and transport evaluation assesses the potential for SRCs to leach from surface and subsurface soil sources at C Block Quarry and impact groundwater beneath the sources. The surface and subsurface soil SRCs include chemicals that were identified as potential contaminants from previous site usage and chemicals that were identified from the SRC screening process using available data. All SRCs were evaluated to determine if residual concentrations in soil may potentially impact groundwater quality and warrant evaluation in an FS.

The principal migration pathway at C Block Quarry 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 five steps for the soil leachability analysis are described below and are discussed in further detail in Appendix E:

- Step 1. Identify SRCs for evaluation.
- Step 2. Compare maximum concentrations of SRCs with MCL-based generic soil screening levels (GSSLs).
- Step 3. Compare the maximum chemical concentrations with the site-specific soil screening level (SSSLs). SRCs that are not eliminated at this step are considered initial CMCOPCs.
- Step 4. Eliminate initial CMCOPCs identified in the SSSL evaluation from further consideration that require more than 1,000 years to leach through the unsaturated zone before reaching the water table.
- Step 5. Perform contaminant fate and transport modeling [Seasonal Soil Compartment (SESOIL) modeling] for remaining initial CMCOPCs to predict chemical concentrations in the leachate immediately beneath the selected source areas and just above the water table and identify final CMCOPCs.
- Step 6. Perform dilution attenuation modeling for the final CMCOPCs to predict chemical concentrations in groundwater just beneath the selected source areas and identify the initial CMCOCs.

6.2.2 Results

Among the potential contaminants from previous use, chromium and mercury were eliminated from potentially impacting groundwater through soil screening analysis (i.e., by comparing their maximum soil concentrations to the MCL-based GSSLs). Lead and hexavalent chromium were eliminated, since their travel times to reach the water table from the source area exceeds 1,000 years.

Evaluation of modeling results identified TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT as final CMCOPCs. These final CMCOPCs were predicted to exceed the screening criteria in groundwater beneath the source area and were identified as initial CMCOCs; however, none of these initial CMCOCs were detected in AOC groundwater samples collected from 2009–2013.

A qualitative assessment of the sample results was performed and the limitations and assumptions of the models were considered to identify if any CMCOCs are present in soil at C Block Quarry that may potentially impact groundwater at C Block Quarry. Modeling results indicated that the predicted concentrations in groundwater beneath the source area could potentially exceed the RSLs and the Resident Receptor Adult FWCUGs within 10–15 years. Based on the AOC period of operations, these constituents should have already been detected in groundwater. However, none of these constituents were detected in groundwater, likely due to biodegradation, which is not accounted for in the conservative modeling. This qualitative assessment concluded that CMCOPCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts.

6.3 CONCLUSIONS

Contaminant fate and transport at C Block Quarry is evaluated using 1) groundwater data collected to date at the AOC and 2) modeling to assess the potential for SRCs to leach from surface and subsurface soil and impact groundwater beneath the sources.

Groundwater samples were collected from 5 monitoring wells around C Block Quarry during 13 separate sampling events under the Characterization of 14 AOCs (MKM 2007) and the FWGWMP from January 2005 to November 2016 to assess the potential impact that historical site activities may have had on groundwater. Explosives, propellants, VOCs, pesticides, perchlorate, and cyanide results were all below the screening level (MCL, Resident Receptor FWCUG, or Resident Tap Water RSL). Only seven chemicals [hexavalent chromium, manganese, PCB-1248, benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and bis(2-ethylhexyl)phthalate] exceeded the screening levels. Further evaluation in Section 6.1.2 indicates that the chemicals in groundwater do not warrant additional action.

The fate and transport evaluation concluded that chromium and mercury were not potentially impacting groundwater through soil screening analysis (i.e., by comparing their maximum soil concentrations to the MCL-based GSSLs), and lead and hexavalent chromium were not expected to reach the water table from the source area within 1,000 years. The fate and transport evaluation identified TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT as final CMCOPCs. Based on soil concentrations, these final CMCOPCs were predicted to exceed the screening criteria in groundwater beneath the source area. However, none of these final CMCOPCs were detected in AOC groundwater samples collected from 2009–2013. A qualitative assessment of the groundwater sample results was performed and the limitations and assumptions of the models were considered to identify if any CMCOCs are present in soil at C Block Quarry that may potentially impact groundwater. This qualitative assessment concluded that CMCOPCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts.

The contaminant fate and transport evaluation concludes that no further action is required for soil to be protective of groundwater. In a letter from the Army to Ohio EPA dated June 1, 2018, the Army agreed to further assess this conclusion and concentrations in groundwater by analyzing groundwater samples from CBLmw-001, CBLmw-002, CBLmw-003, and CBLmw-004 for SVOCs, metals (including hexavalent chromium), PCBs, explosives, nitrate/nitrite, sulfate/sulfide, and pH as part of the FWGWMP in 2018.

Table 6–1. Historical Monitoring Well Sampling Summary at C Block Quarry

Sample Event	Well	Explosives/ Propellants	Metals	SVOCs	VOCs	PCBs	Pesticides	Hexavalent Chromium	Perchlorate	Cyanide
January 2005	CBLmw-001	x	x	x	x	x	x	x	--	--
	CBLmw-002	x	x	x	x	x	x	x	--	--
	CBLmw-003	x	x	x	x	x	x	x	--	--
	CBLmw-004	x	x	x	x	x	x	x	--	--
April 2008	CBLmw-001	x	x	x	x	x	x	--	--	x
	CBLmw-002	x	x	x	x	x	x	--	--	x
	CBLmw-003	x	x	x	x	x	x	--	--	x
	CBLmw-004	x	x	x	x	x	x	--	--	x
July 2008	CBLmw-001	x	x	x	x	x	x	--	x	x
	CBLmw-002	x	x	x	x	x	x	--	x	x
	CBLmw-003	x	x	x	x	x	x	--	x	x
	CBLmw-004	x	x	x	x	x	x	--	x	x
October 2008	CBLmw-001	x	x	x	x	x	x	--	--	x
	CBLmw-002	x	x	x	x	x	x	--	--	x
	CBLmw-003	x	x	x	x	x	x	--	--	x
	CBLmw-004	x	x	x	x	x	x	--	--	x
January 2009	CBLmw-001	x	x	x	x	x	x	--	--	x
	CBLmw-002	x	x	x	x	x	x	--	--	x
	CBLmw-003	x	x	x	x	x	x	--	--	x
	CBLmw-004	x	x	x	x	x	x	--	--	x
October 2009	CBLmw-001	--	x	--	--	--	--	--	--	--
	CBLmw-002	--	x	--	--	--	--	--	--	--
	CBLmw-003	--	x	--	--	--	--	--	--	--
	CBLmw-004	--	x	--	--	--	--	--	--	--
April 2011	CBLmw-004	x	x	x	x	x	x	--	--	x
February 2012	CBLmw-002	--	--	x	--	x	--	--	--	--
May 2012	CBLmw-005	x	x	x	x	x	x	--	--	x
July 2012	CBLmw-002	--	--	x	--	x	--	--	--	--
	CBLmw-005	x	x	x	x	x	x	x	--	x
October 2012	CBLmw-005	x	x	x	x	x	x	--	--	x
January 2013	CBLmw-002	--	--	x	--	x	--	--	--	--
	CBLmw-005	x	x	x	x	x	x	--	x	x

Table 6–1. Historical Monitoring Well Sampling Summary at C Block Quarry (continued)

Sample Event	Well	Explosives/ Propellants	Metals	SVOCs	VOCs	PCBs	Pesticides	Hexavalent Chromium	Perchlorate	Cyanide
November 2016	CBLmw-001	--	--	x	--	x	--	--	--	x
	CBLmw-002	--	--	x	--	x	--	--	--	x
	CBLmw-003	--	--	x	--	x	--	--	--	x
	CBLmw-004	--	--	x	--	x	--	--	--	x

PCB = Polychlorinated biphenyl.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
x = Parameter was included in sampling event.
-- = Parameter was not included in sampling event.

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Table 6–2. Screening of Groundwater Sample Results at C Block Quarry

Chemical (mg/L)	CAS Number	Results >Detection Limit	Minimum Detect	Maximum Detect	Average Result	Screening Level	Screening Level Source[1]	Number of Samples Exceeding Screening Level	Station at Max Detect	Date Collected at Max Detect	Most Recent Result	Most Recent Sample Date
Cyanide	57-12-5	1/ 22	0.007	0.007	0.00509	0.2	MCL	0	CBLmw-001	10/10/2008	<0.01U	1/20/2009
1,3,5-Trinitrobenzene	99-35-4	1/ 27	0.000048	0.000048	0.0000612	0.059	Tap RSL	0	CBLmw-004	1/21/2009	<0.00011U	4/7/2011
Nitrobenzene	98-95-3	1/ 27	0.000056	0.000056	0.0000604	0.000521	RES CUG	0	CBLmw-004	10/9/2008	<0.00011U	4/7/2011
Nitrocellulose	9004-70-0	2/ 27	0.14	0.15	0.3	6000	Tap RSL	0	CBLmw-003	7/10/2008	<0.5UJ	1/20/2009
Chromium, hexavalent	**18540-29-9**	**4/ 7**	**0.01**	**0.01**	**0.00643**	**0.000035**	**Tap RSL**	**4**	**CBLmw-001**	**1/20/2005**	**0.01**	**1/20/2005**
Aluminum	7429-90-5	18/ 32	0.0192	0.469	0.047	1.028	RES CUG	0	CBLmw-004	4/10/2008	<0.05U	4/7/2011
Barium	7440-39-3	32/ 32	0.0117	0.0668	0.0431	2	MCL	0	CBLmw-002	10/21/2009	0.0668	10/21/2009
Beryllium	7440-41-7	2/ 32	0.000069	0.00012	0.000524	0.004	MCL	0	CBLmw-005	7/24/2012	<0.00009U	1/24/2013
Cadmium	7440-43-9	5/ 32	0.00013	0.0002	0.000327	0.005	MCL	0	CBLmw-002	1/20/2009	0.00016J	10/21/2009
Calcium	7440-70-2	32/ 32	2.84	14.3	7.35	---	---	0	CBLmw-003	7/10/2008	7.12	10/22/2009
Cobalt	7440-48-4	4/ 32	0.0013	0.0069	0.0025	0.0208	RES CUG	0	CBLmw-005	5/2/2012	<0.0025U	1/24/2013
Copper	7440-50-8	4/ 32	0.0022	0.011	0.00334	1.3	MCL	0	CBLmw-001	1/20/2005	<0.005U	10/21/2009
Iron	7439-89-6	8/ 32	0.0281	0.178	0.0393	0.31	RES CUG	0	CBLmw-004	10/22/2009	<0.05U	4/7/2011
Magnesium	7439-95-4	32/ 32	1.5	5.5	3.37	---	---	0	CBLmw-005	7/24/2012	4.1	1/24/2013
Manganese	**7439-96-5**	**27/ 32**	**0.0027**	**0.19**	**0.0292**	**0.0463**	**RES CUG**	**4**	**CBLmw-001**	**1/20/2005**	**0.0094J**	**10/21/2009**
Mercury	7439-97-6	2/ 32	0.00013	0.00018	0.000101	0.002	MCL	0	CBLmw-003	10/9/2008	<0.0002U	10/22/2009
Nickel	7440-02-0	27/ 32	0.0033	0.02	0.00708	0.0208	RES CUG	0	CBLmw-005	5/2/2012	0.0099	1/24/2013
Potassium	7440-09-7	30/ 32	0.739	1.91	1.14	---	---	0	CBLmw-004	7/11/2008	1.12	4/7/2011
Silver	7440-22-4	1/ 32	0.0032	0.0032	0.00285	0.0094	Tap RSL	0	CBLmw-001	4/10/2008	<0.005U	10/21/2009
Sodium	7440-23-5	28/ 32	0.633	3.7	1.6	---	---	0	CBLmw-005	7/24/2012	2.7	1/24/2013
Vanadium	7440-62-2	1/ 32	0.0018	0.0018	0.00454	0.00638	RES CUG	0	CBLmw-001	4/10/2008	<0.01U	10/21/2009
Zinc	7440-66-6	18/ 32	0.0059	0.0372	0.0135	0.312	RES CUG	0	CBLmw-002	4/10/2008	<0.0356B	10/21/2009
PCB-1248	**12672-29-6**	**1/ 30**	**0.00011**	**0.00011**	**0.000294**	**0.0000078**	**Tap RSL**	**1**	**CBLmw-004**	**10/9/2008**	**<0.0005UJ**	**4/7/2011**
Perchlorate	14797-73-0	5/ 5	0.000045	0.000088	0.0000662	0.0014	Tap RSL	0	CBLmw-002	7/10/2008	0.00009	7/10/2008
beta-BHC	319-85-7	2/ 27	0.0000088	0.00001	0.0000195	0.000047	RES CUG	0	CBLmw-004	10/9/2008	<0.00003UJ	4/7/2011
2-Methylnaphthalene	91-57-6	1/ 27	0.00025	0.00025	0.000122	0.0036	Tap RSL	0	CBLmw-002	1/12/2005	<0.0002U	1/20/2009
Benz(a)anthracene	**56-55-3**	**1/ 30**	**0.00016**	**0.00016**	**0.0000914**	**0.000004**	**RES CUG**	**1**	**CBLmw-001**	**1/20/2005**	**<0.0002U**	**1/20/2009**
Benzo(a)pyrene	50-32-8	1/ 30	0.00017	0.00017	0.000105	0.0002	MCL	0	CBLmw-001	1/20/2005	<0.0002U	1/20/2009
Benzo(b)fluoranthene	**205-99-2**	**1/ 30**	**0.00013**	**0.00013**	**0.000104**	**0.000002**	**RES CUG**	**1**	**CBLmw-001**	**1/20/2005**	**<0.0002U**	**1/20/2009**
Benzo(k)fluoranthene	207-08-9	1/ 30	0.00022	0.00022	0.000107	0.0025	Tap RSL	0	CBLmw-001	1/20/2005	<0.0002U	1/20/2009
Chrysene	218-01-9	2/ 30	0.00012	0.00014	0.000107	0.025	Tap RSL	0	CBLmw-001	1/20/2005	<0.0002U	1/20/2009
Fluoranthene	206-44-0	1/ 30	0.00032	0.00032	0.000149	0.08	Tap RSL	0	CBLmw-002	1/12/2005	<0.0001U	1/23/2013
Indeno(1,2,3-cd)pyrene	**193-39-5**	**1/ 30**	**0.00014**	**0.00014**	**0.000104**	**0.000002**	**RES CUG**	**1**	**CBLmw-001**	**1/20/2005**	**<0.0002U**	**1/20/2009**
Phenanthrene	85-01-8	1/ 30	0.00024	0.00024	0.000147	0.012	Tap RSL	0	CBLmw-002	1/12/2005	<0.0001U	1/23/2013
Pyrene	129-00-0	1/ 30	0.0004	0.0004	0.000152	0.012	Tap RSL	0	CBLmw-002	1/12/2005	<0.0001U	1/23/2013
Bis(2-ethylhexyl)phthalate	**117-81-7**	**8/ 30**	**0.00092**	**0.4**	**0.017**	**0.006**	**MCL**	**2**	**CBLmw-002**	**1/12/2005**	**<0.0011B**	**1/23/2013**
Acetone	67-64-1	2/ 27	0.0012	0.0015	0.00337	1.4	Tap RSL	0	CBLmw-004	4/10/2008	<0.01U	4/7/2011

Summary of chemicals detected within the C Block Quarry monitoring wells from January 2005 to January 2013.

Table includes duplicate sample results and only includes results from metal analyses that were filtered at the time of sample collection.

Bold = Chemical had at least one exceedance of screening level.

[1]For the screening level source, the U.S. Environmental Protection Agency MCL is used. If the chemical does not have an MCL, the Resident Receptor facility-wide cleanup goal (FWCUG) at a risk level of hazard quotient (HQ) of 0.1, target risk (TR) of 1E-06 is used. If a chemical does not have an MCL or Resident Receptor FWCUG, the Resident Tap Water RSL at a risk level of HQ of 0.1, TR of 1E-06 is used.

B = Blank contamination: The chemical was detected above one-half the reporting limit in an associated blank.
CAS = Chemical Abstract Service.
CUG = Cleanup goal.
J = Indicates the chemical was positively identified, but the associated numerical value is an approximate concentration of the chemical in the sample.
MCL = Maximum contaminant level.
mg/L = Milligrams per liter.
RES = Resident
RSL = Regional screening level.
U = Non-detectable concentration.
UJ = Non-detectable concentration and reporting limit estimated.
< = Less than.
> = Greater than.
--- = There is no applicable screening criteria for chemical.

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7.0 RISK ASSESSMENT

C Block Quarry is an approximately 0.96-acre abandoned quarry located in the northwestern portion of the former RVAAP. The quarry bottom has a measured maximum depth of 25 ft below the surrounding grade, and the fill material ranges from 0.75–7 ft in thickness. The quarry was excavated from the sandstone bedrock, which remains exposed along the quarry walls and portions of the quarry ground surface. C Block Quarry is currently inactive. However, it may receive occasional foot traffic from security, maintenance, and natural resource management staff (OHARNG 2009).

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., Commercial/Industrial and Military Training), and those other Land Uses do not require evaluation. However, as presented in Section 7.2.1, a remedial action is required to attain Unrestricted (Residential) Land Use. Therefore, Military Training Land Use and Commercial/Industrial Land Use are evaluated in this HHRA.

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 for use in the HHRA and ERA. C Block Quarry data were evaluated to establish data aggregates and identify a list of SRCs.

7.1.1 Data Aggregates

This section describes the data aggregates for the media for which human and ecological receptors are potentially exposed, followed by a summary of SRCs in Section 7.1.2. Section 4.0 provides a summary of available data.

Soil at C Block Quarry was 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), Industrial Receptor, and for potential risk to ecological receptors because this layer is the most active biological zone (USACE 2003). Table 7-1 presents the risk assessment data set for surface soil (0–1 ft bgs). For this risk assessment, six surface soil ISM samples collected in November 2004 (MKM 2007) and two surface soil ISM samples collected in August 2012 from two previous ISM locations during the PBA08 RI on the ground surface of C Block Quarry were used to characterize surface soil. Since the horizontal extent of soil contamination within C Block Quarry soil is constrained by the AOC's physical characteristics (e.g., quarry high wall), the horizontal extent of soil contamination is defined by these ISM samples. PBA08 RI sampling included surface soil analysis for ACM and six soil boring samples to further define the vertical extent of contamination in C Block Quarry soil. Discrete surface soil samples collected in March 2010 and August 2012 were not used for risk assessment screening purposes because 1) the entire AOC was sampled using ISM, and 2) ISM and discrete data should not be combined into a single statistical analysis. For surface soil ISM samples, each sample result was evaluated as an individual decision unit. Discrete data were used to supplement the evaluation of ISM results and are included in the uncertainty discussion.

- Deep surface soil with an exposure depth of 0–4 ft bgs was evaluated for the National Guard Trainee. Because the upper (0–1 ft bgs) portion of this interval was characterized using ISM sampling and the deeper (1–4 ft bgs) portion of this interval was characterized using discrete samples from soil borings, these two intervals were evaluated separately. It is inappropriate to combine the ISM and discrete sample data due to different levels of variability in these two data types. The surface soil (0–1 ft bgs) ISM data described above and discrete data from samples collected in March 2010 and August 2012 (during the PBA08 RI) with a starting depth between 1–4 ft bgs were used to separately evaluate deep surface soil for this receptor. Table 7-2 presents the risk assessment data sets for deep surface soil.
- Subsurface soil is defined as an exposure depth of 4–7 ft bgs for the National Guard Trainee and 1–13 ft bgs for the Resident Receptor (Adult and Child) and Industrial Receptor; however, bedrock is as shallow as 0.75 ft bgs in portions of C Block Quarry and can be as deep as 7 ft bgs. Therefore, there is no soil exposure below 7 ft bgs. Subsurface soil with an exposure depth of 1–7 ft bgs was evaluated for the Resident Receptor (Adult and Child) and Industrial Receptor. Subsurface soil with an exposure depth of 4–7 ft bgs was evaluated for the National Guard Trainee. Discrete samples collected in March 2010 and August 2012 during the PBA08 RI with a starting depth within these intervals were used to characterize subsurface soil. Table 7-3 presents the risk assessment data sets for subsurface soil.

Surface water and sediment were not evaluated in the risk assessments because these media are not currently present at the AOC.

7.1.2 Identification of SRCs

Section 4.4 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.

C Block Quarry is an abandoned quarry approximately 0.96 acres, located in the northwestern portion of RVAAP. The material mined at C Block Quarry consisted of Homewood Sandstone which was quarried for use as road and construction base material. During the 1950s, C Block Quarry was used as a disposal area for annealing process waste (chromic acid), spent pickle liquors from brass finishing, fill dirt, and miscellaneous construction and demolition material.

The SRC screen was not limited to only contaminants that may have been products of previous site use. Rather, the SRC screen followed the three steps outlined in the FWCUG Report, as summarized below, using all chemical data available:

- **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 constituents detected above facility-wide background concentrations or having no background concentrations 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 provided they are present at low concentrations (i.e., only slightly above naturally occurring levels) and toxic at only 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 SLs were eliminated as SRCs.
- **Frequency of detection screening** – In accordance with the FWCUG Report and as revised in the FWCUG Position Paper (USACE 2012a), analytes detected in less than 5% of the samples are screened out from further consideration except for explosives and propellants. At C Block Quarry, there were no data sets with 20 or more samples; therefore, no SRCs were screened out on the basis of frequency of detection. Frequency of detection screening was not applied to ISM samples.

Details of the SRC screening for each exposure medium are provided in Appendix G, Tables G-1 through G-7. The SRCs identified for C Block Quarry are summarized in Table 7-4.

7.2 HUMAN HEALTH RISK ASSESSMENT

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

- FWHHRAM (USACE 2005a),
- FWCUG Report (USACE 2010a),
- FWCUG Position Paper (USACE 2012a), and
- Technical Memorandum (ARNG 2014).

To accomplish the goal of streamlined decision making, the FWCUG Report was developed to support risk assessments of the remaining AOCs within the former RVAAP. The FWCUG Report contains calculated FWCUGs and guidance for applying 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 applying the CERCLA process at the former RVAAP.

The agreed upon risk assessment methods have been documented in the FWHHRAM (USACE 2005a) and follow standard USEPA-approved risk assessment guidance. Other approaches, such as calculating the sum-of-ratios (SOR), were developed in the FWCUG Report (USACE 2010a) and FWCUG Position Paper (USACE 2012a). The Technical Memorandum (ARNG 2014) identifies future Land Uses and prescribes the applicable receptors for these Land Uses to be evaluated in an RI.

Using the FWCUGs and information from the RI sampling, the approach to the HHRA is as follows:

1. **Specify Land Use(s) and Representative Receptor(s).**
2. **Identify Media of Concern.**
3. **Synthesize and Analyze Data to Identify SRCs**. Follow the requirements specified in the FWHHRAM (USACE 2005a) and the FWCUG Position Paper (USACE 2012a), perform data analysis and mapping to identify SRCs, establish EUs, and calculate exposure point concentrations (EPCs) for each COPC. The results of the mapping and data analysis for C Block Quarry to identify SRCs are presented in Sections 4.0 and 5.0 and are summarized in Section 7.1.
4. **Identify COPCs**. To identify COPCs, the MDC of all SRCs are screened against the most stringent chemical-specific FWCUG or RSL at a target cancer risk level of 1E-06 and non-carcinogenic target HQ of 0.1 for the Representative Receptors: Unrestricted (Residential) Land Use [Resident Receptor (Adult and Child)], Military Training Land Use (National Guard Trainee), and Commercial/Industrial Land Use [Industrial Receptor (USEPA's Composite Worker)]. If no FWCUGs exist for an SRC, the residential and industrial RSLs are used for the Resident Receptor and National Guard Trainee, respectively. The USEPA RSLs (from RSL table dated June 2015) are used for this screen.
5. **Compare to Appropriate FWCUGs or RSLs and Identify COCs**. Compare COPC exposure concentrations to FWCUGs and determine COCs following guidance presented in the FWCUG Position Paper (USACE 2012a) and Technical Memorandum (ARNG 2014). The COC determination process is as follows:

- Report all carcinogenic- and non-carcinogenic-based SLs for the Representative Receptors: Unrestricted (Residential) Land Use [Resident Receptor (Adult and Child)], Military Training Land Use (National Guard Trainee), and Commercial/Industrial Land Use [Industrial Receptor (USEPA's Composite Worker)].
  - SLs for the Resident Receptor (Adult and Child) and National Guard Trainee are the FWCUGs corresponding to a TR of 1E-05 and target HQ of 1. If no FWCUG is available for a COPC, the residential and industrial RSLs, adjusted to represent a TR of 1E-05 or target HQ of 1, are used for the Resident Receptor and National Guard Trainee, respectively.
  - SLs for the Industrial Receptor are the industrial RSLs adjusted to represent a TR of 1E-05 or target HQ of 1.

- Report critical effect and target organ for each non-carcinogenic-based FWCUG and RSL.
- Compare the selected FWCUG or RSL to the EPC, including an SOR.
    - For non-carcinogens, compare the EPC to the target HQ SL. Sum the ratios of EPC/SL for COPCs that affect similar target organs or do not have an identified target organ.
    - For carcinogens, compare the EPC to the TR SL. Sum the ratios of EPC/SL for all carcinogens.
- Identify the COPC as a COC for a given receptor if:
    - The EPC exceeds the appropriate FWCUG or RSL for either the 1E-05 target cancer risk or the target HQ of 1; or
    - The SOR for all carcinogens or non-carcinogens that may affect the same organ is greater than one. Chemicals contributing at least 10% to an SOR greater than one are also considered COCs. In accordance with the FWCUG Position Paper (USACE 2012a), 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 and RSLs rearranges the cancer risk or non-cancer hazard equations 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 the 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 for women and a little less than 5 in 10 for men, or 3E-01 to 5E-01 (American Cancer Society 2015). The calculated incremental lifetime cancer risk (ILCR) is 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 above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address risk further in this range, either through additional study or engineered control measures, should account for uncertainty in the 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 risk associated with non-carcinogenic chemicals is evaluated by comparing an estimated exposure (i.e., intake or dose) from AOC media to an acceptable exposure expressed as a reference dose (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 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 or RSL to determine a ratio. The sum of these individual ratios is then compared to one (using one significant figure). The SOR method is based on the principle that a ratio greater than one represents unacceptable cumulative exposure (i.e., above FWCUGs or RSLs if adjusted for exposure to multiple COPCs), and a ratio less than or equal to one represents acceptable cumulative exposure (i.e., below FWCUGs or RSLs if adjusted for exposure to multiple COPCs). The FWCUGs and RSLs 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 an FS.

6. **Uncertainty Assessment** – Assess 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.
7. **Identify COCs for Potential Remediation** – Make a final determination of COCs requiring evaluation in an FS and potential remediation.

These steps are executed in the following subsections.

7.2.1 Land Use and Representative Receptors

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, the AOC is also considered to have met the requirements of the other Land Uses (i.e., Commercial/Industrial and Military Training), and those other Land Uses do not require evaluation. However, a remedial action is required to attain Unrestricted (Residential) Land Use. Therefore, Military Training Land Use and Commercial/Industrial Land Use are evaluated in this HHRA.

7.2.2 Identify Media of Concern

Media of concern at C Block Quarry are surface soil and subsurface soil. No sediment or surface water was identified within the quarry. Groundwater is present at this AOC but will be evaluated (including risk assessment) in a separate document, as described in Section 1.2.

7.2.3 Data Synthesis and Analysis to Identify SRCs

The results of the mapping and data analysis for C Block Quarry to identify SRCs are presented in Sections 4.0 and 5.0 and are summarized in Section 7.1.

7.2.4 Identify COPCs

Details of the COPC screening for each exposure medium are provided in Appendix G, Tables G-1 through G-7. The COPCs identified for the media of concern at C Block Quarry are presented in Table 7-5 and are summarized below.

No RfD or cancer potency factors are available for benzo(*ghi*)perylene and phenanthrene; therefore, the RSL for pyrene was used for these PAHs (NDEP 2006).

Hexavalent chromium was detected in three of seven ISM surface soil samples and two of two discrete subsurface soil samples analyzed for hexavalent and total chromium at C Block Quarry. 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 for evaluating both total chromium and hexavalent chromium results.

7.2.4.1 <u>COPCs in Surface Soil</u>

Surface soil (0–1 ft bgs)

Of the 33 chemicals (counting total chromium and hexavalent chromium as one chemical) detected in the ISM surface soil (0–1 ft bgs) samples at C Block Quarry, 19 (6 inorganic chemicals, 4 explosives, and 9 SVOCs) were identified as SRCs. Risk-based screening identified arsenic, total chromium, and TNT as COPCs for the Resident Receptor (Adult and Child) (Appendix G, Table G-1). Risk-based screening identified arsenic and total chromium as COPCs for the Industrial Receptor (Appendix G, Table G-3).

Deep surface soil (0–4 ft bgs)

Deep surface soil with an exposure depth of 0–4 ft bgs was evaluated for the National Guard Trainee. Because the upper (0–1 ft bgs) portion of this interval was characterized using ISM sampling and the deeper (1–4 ft bgs) portion of this interval was characterized using discrete samples from soil borings, these two intervals were evaluated separately.

Of the 33 chemicals (counting total chromium and hexavalent chromium as one chemical) detected in the ISM surface soil samples (0–1 ft bgs) at C Block Quarry, 19 (6 inorganic chemicals, 4 explosives, and 9 SVOCs) were identified as SRCs. Risk-based screening identified arsenic, total chromium, and hexavalent chromium as COPCs in this interval for the National Guard Trainee (Appendix G, Table G-5). Of the 36 chemicals detected in the discrete deep surface soil (1–4 ft bgs) samples, 18 (4 inorganic chemicals, 12 SVOCs, and 2 explosives) were identified as SRCs. Risk-based screening identified total chromium and hexavalent chromium as COPCs in this interval (Appendix G, Table G-6).

7.2.4.2 COPCs in Subsurface Soil

Subsurface soil (1–7 ft bgs)

Of the 36 chemicals detected in discrete subsurface soil (1–7 ft bgs) samples, 19 (5 inorganic chemicals, 12 SVOCs, and 2 explosives) were identified as SRCs. Risk-based screening identified total chromium, hexavalent chromium, and benzo(a)pyrene as COPCs for the Resident Receptor (Adult and Child) (Appendix G, Table G-2). Risk-based screening also identified total chromium and hexavalent chromium as COPCs for the Industrial Receptor (Appendix G, Table G-4).

Subsurface soil (4-7 ft bgs)

Of the 25 chemicals detected in subsurface soil (4–7 ft bgs) samples, 6 (3 inorganic chemicals and 3 SVOCs) were identified as SRCs. Risk-based screening did not identify any COPCs in subsurface soil (4-7 ft bgs) (Appendix G, Table G-7).

7.2.5 Compare to Appropriate FWCUGs

7.2.5.1 Selection of Appropriate FWCUGs

As specified in the Technical Memorandum (ARNG 2014), EPCs for each AOC should initially be evaluated to determine if no further action is necessary at an AOC to attain Unrestricted (Residential) 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 and Child) values for each COPC and endpoint (non-cancer and cancer) corresponding to a TR of 1E-05 and target HQ of 1. The critical effect or target organ associated with the toxicity values used to calculate the non-cancer FWCUGs are also provided.

Chromium Speciation

FWCUGs and RSLs are available for hexavalent chromium and trivalent chromium. Existing data at other AOCs, such as the Building 1200 and Anchor Test Area AOCs (USACE 2012b, USACE 2012c), indicate chromium naturally exists predominantly in the trivalent state rather than the more toxic hexavalent state. C Block Quarry is a suspected disposal area for annealing process waste (chromic acid) and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations which were dumped on the ground surface. Because of this history, many of the soil samples were analyzed for both hexavalent and total chromium.

RVAAP background concentrations for total chromium range from 17.4 mg/kg in surface soil to 27.2 mg/kg in subsurface soil. Earth moving activities, including mining and filling the quarry, make the distinction between surface and subsurface soil inappropriate. Background concentrations are not available for hexavalent chromium. Chromium concentrations are elevated in soil at C Block Quarry with reported total chromium concentrations exceeding background in six ISM and six discrete soil samples ranging from 150–2,100 mg/kg. Total chromium concentrations in the other 2 ISM and 10 discrete samples range from 8.6–25.7 mg/kg. Most (7 of 8) ISM surface samples were analyzed for both hexavalent and total chromium. In addition, two of seven discrete surface soil samples and two of nine discrete subsurface soil samples were analyzed for both hexavalent and total chromium. The results indicate most of the chromium present is not in the hexavalent form (i.e., hexavalent chromium contributed 0.03–4.2% in the speciation samples); however, hexavalent chromium concentrations exceed the residential RSL of 3 mg/kg in several samples, with a maximum detected hexavalent chromium concentration of 39J mg/kg in one discrete subsurface sample. Because adequate hexavalent chromium data are available to characterize the soil, total chromium results are evaluated using the trivalent chromium FWCUGs and RSLs because the hexavalent portion of the total chromium result is evaluated separately. Uncertainties associated with this approach are discussed in Section 7.2.6.2.

The FWCUGs for hexavalent chromium were calculated from a cancer unit risk factor (URF) based on a chromium mixture containing one-seventh (14%) hexavalent chromium (USEPA 2010). Because the study used as the basis for the cancer URF included workers exposed to both trivalent and hexavalent chromium, these FWCUGs must be adjusted to represent only hexavalent chromium for comparison to hexavalent chromium specific results available at C Block Quarry. Therefore, one-seventh of the Resident Receptor (Adult and Child) and National Guard Trainee FWCUGs are appropriate for evaluating hexavalent chromium alone. The hexavalent chromium FWCUGs listed in Table 7-6 are adjusted to account for the toxicity of hexavalent chromium alone. The hexavalent chromium RSL for the Industrial Receptor (63 mg/kg at a TR of 1E-05) includes this adjustment as published.

7.2.5.2 <u>Exposure Point Concentrations for Comparison to FWCUGs</u>

Surface Soil EPCs

Surface soil (0–1 ft bgs) at C Block Quarry 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 2009b). Small, targeted ISM samples were used to characterize surface soil at C Block Quarry. These small, targeted ISM samples were anticipated to have the highest levels of potential contamination (i.e., at the bottom of the quarry) to delineate potential sources. The ISM samples ranged from 0.06–0.3 acres and averaged 0.16 acres.

EPCs are intended to provide representative concentrations that a receptor might contact during the period of exposure. Exposure to surface soil was based on ISM samples. The ISM was used to determine an average concentration representative of the soil contained within a defined area (i.e., the "decision unit"). Therefore, individual ISM results were compared directly to the surface soil FWCUGs for the C Block Quarry receptors.

EPCs were calculated for the 1–4 ft bgs component of the deep surface soil exposure depth using analytical results from the discrete samples presented in Table 7-2. Per the FWHHRAM, the EPC is either the 95% upper confidence limit (UCL) of the mean or the MDC, whichever value is lowest. If the 95% UCL cannot be determined, the EPC is the MDC.

Subsurface Soil

EPCs were calculated for the subsurface soil (4–7 and 1–7 ft bgs) exposure depths using analytical results from the discrete samples presented in Table 7-3. As indicated in Section 7.1.1, the subsurface soil depth intervals for the National Guard Trainee are 4–7 and 1–7 ft bgs for the Resident Receptor (Adult and Child) and Industrial Receptor. Per the FWHHRAM, the EPC is either the 95% UCL of the mean or the MDC, whichever value is lowest. If the 95% UCL cannot be determined, the EPC is the MDC.

7.2.5.3 Identification of COCs for Unrestricted (Residential) Land Use

C Block Quarry 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 screening for surface soil (0–1 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Appendix G, Tables G-8 and G-9. No COCs were identified in surface soil (0–1 ft bgs) for the Resident Receptor (Adult and Child), as explained below:

COPCs with Concentrations Lower than the Resident Receptor (Adult and Child) FWCUG

All total chromium and TNT concentrations are lower than the Resident Receptor (Adult and Child) FWCUG.

COPCs with Concentrations Exceeding the Resident Receptor (Adult and Child) FWCUG

The MDC of arsenic (19 mg/kg at CBLss-001M) exceeds the FWCUG of 4.25 mg/kg and the surface soil facility-wide background concentration of 15.4 mg/kg. This concentration is less than the subsurface background concentration of 19.8 mg/kg. The quarry operations conducted at this AOC resulted in significant soil disturbance. Therefore, it is appropriate to compare surface soil results to the subsurface soil background concentration. Because the MDC for arsenic in surface soil is essentially equal to the subsurface background concentration for arsenic, it was not identified as a surface soil COC for the Resident Receptor (Adult and Child) at C Block Quarry.

SOR Analysis

No COCs were identified based on the SOR analysis as summarized below:

- Three COPCs (arsenic, total chromium, and TNT) identified in surface soil have FWCUGs for non-cancer endpoints. All detected concentrations of arsenic are less than the subsurface background concentration; therefore, arsenic was not included in any SOR calculations. Total chromium was detected below the facility-wide background concentration at two ISM sample locations and was not included in the SOR for samples where the detected concentration is less than the facility-wide background concentration. SOR calculations are presented in Appendix G, Table G-9. The total SORs, regardless of endpoint, were less than one; therefore, no COCs were identified by the SOR analysis.
- Two COPCs (arsenic and TNT) identified in surface soil have FWCUGs for the cancer endpoint. All detected concentrations of arsenic are less than the subsurface background concentration; therefore, arsenic was not included in any SOR calculations. Only one COPC (TNT) with a cancer endpoint is present above background concentrations; therefore, no SOR was calculated.

COCs for Subsurface Soil (1–7 ft bgs)

COC screening for subsurface soil (1-7 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Appendix G, Tables G-10 through G-12. No COCs were identified in subsurface soil (1–7 ft bgs) for the Resident Receptor (Adult and Child), as explained below:

COPCs with EPCs lower than the Resident Receptor (Adult and Child) FWCUG

The EPCs for total chromium, hexavalent chromium, and benzo(a)pyrene are all lower than the FWCUGs for the Resident Receptor (Adult and Child).

COPCs with EPCs exceeding the Resident Receptor (Adult and Child) FWCUG

None of the EPCs exceeded the FWCUGs for the Resident Receptor (Adult and Child).

SOR Analysis

No COCs were identified for the Resident Receptor (Adult and Child) exposed to subsurface soil based on the SOR analysis as summarized below:

- Two COPCs (total chromium and hexavalent chromium) identified in subsurface soil have FWCUGs for non-cancer endpoints. The SOR calculation is presented in Appendix G,

Table G-11. The SOR for subsurface soil is less than one; thus, no additional COCs are identified based on the SOR analysis.

- Benzo(a)pyrene and hexavalent chromium were identified as subsurface soil COPCs with FWCUGs for the cancer endpoint. The SOR calculation is presented in Appendix G, Table G-12. The SOR for subsurface soil is less than one; thus, no additional COCs are identified based on the SOR analysis.

7.2.5.4 Identification of COCs for Commercial/Industrial Land Use

C Block Quarry COCs for Commercial/Industrial Land Use, as represented by the Industrial Receptor, are presented below.

COCs for Surface Soil (0–1 ft bgs)

COC screening for surface soil (0-1 ft bgs) for the Industrial Receptor is detailed in Appendix G, Table G-13. No COCs were identified in surface soil (0–1 ft bgs), as explained below.

COPCs with Concentrations Lower than the Industrial Receptor RSL

All arsenic and total chromium concentrations are lower than the Industrial Receptor RSLs.

COPCs with Concentrations Exceeding Industrial Receptor RSLs

None of the COPC concentrations exceeded the Industrial Receptor RSLs.

SOR Analysis

No COCs were identified based on the SOR analysis as summarized below.

- Arsenic and chromium have RSLs for non-cancer endpoints. Concentrations of arsenic are less than the facility-wide background concentrations for subsurface soil; therefore, this metal is not included in the SOR leaving only chromium. Thus, no SOR was calculated.
- Only arsenic has an RSL for the cancer endpoint; therefore, no SOR was calculated.

COCs for Subsurface Soil (1–7 ft bgs)

COC screening for subsurface soil (1–7 ft bgs) for the Industrial Receptor is detailed in Appendix G, Tables G-14 and G-15. No COCs were identified in subsurface soil (1–7 ft bgs) as explained below:

COPCs with EPCs Lower than the Industrial Receptor RSL

All total chromium and hexavalent chromium EPCs are lower than the Industrial Receptor RSLs.

COPCs with EPCs Exceeding Industrial Receptor RSLs

No EPCs exceed the Industrial Receptor RSLs.

SOR Analysis

No COCs were identified for the Industrial Receptor exposed to subsurface soil based on the SOR analysis.

- Two COPCs (total chromium and hexavalent chromium) identified in subsurface soil have RSLs for non-cancer endpoints. The SOR calculation is presented in Appendix G, Table G-15. The total SOR for these COPCs is less than or equal to one; therefore, no COCs were identified.
- Only hexavalent chromium has an RSL for the cancer endpoint; therefore, no SOR was calculated.

7.2.5.5 Identification of COCs for Military Training Land Use

C Block Quarry COCs for Military Training Land Use, as represented by the National Guard Trainee, are presented below.

COCs for Deep Surface Soil (0–4 ft bgs)

The FWCUG Report (USACE 2010a) defines the exposure depths for the National Guard Trainee as deep surface soil (0–4 ft bgs) and subsurface soil (4–7 ft bgs). At C Block Quarry, the 0–1 ft bgs portion of the deep surface soil interval was characterized using ISM sampling and the deeper portion (1–4 ft bgs) was characterized using discrete samples from soil borings. Due to different levels of variability in the two data types, these two intervals were evaluated separately. The evaluation of the 0–1 ft bgs ISM deep surface soil samples is detailed in Appendix G, Table G-16. The evaluation of the 1–4 ft bgs discrete deeper portion of soil samples is detailed in Appendix G, Tables G-17 and G-18. Hexavalent chromium was identified as a COC for the National Guard Trainee exposed to the 0–4 ft bgs interval of deep surface soil at C Block Quarry, as summarized below.

Surface Soil (0–1 ft bgs) ISM Samples:

COPCs with Concentrations Lower than the National Guard Trainee FWCUG

All arsenic and total chromium concentrations are lower than the National Guard Trainee FWCUGs.

COPCs with Concentrations Exceeding the National Guard Trainee FWCUG

The reported concentration of hexavalent chromium exceeded the FWCUG at CBLss-003M and hexavalent chromium is identified as a COC at this location.

SOR Analysis

No additional COCs were identified for the National Guard Trainee exposed to surface soil (0–1 ft bgs) based on the SOR analysis as summarized below:

- Arsenic and chromium have RSLs for non-cancer endpoints. Concentrations of arsenic are less than the facility-wide background concentrations for subsurface soil; therefore, this metal is not included in the SOR leaving only chromium. Thus, no SOR was calculated.
- Two COPCs (arsenic and hexavalent chromium) identified in surface soil have FWCUGs for the cancer endpoint. All detected concentrations of arsenic are less than the subsurface background concentration; therefore, arsenic was not included in any SOR calculations and no SOR was calculated.

Deep Surface Soil (1–4 ft bgs) Discrete Samples:

COPCs with EPCs lower than the National Guard Trainee FWCUG

The total chromium EPCs are lower than the National Guard Trainee FWCUGs.

COPCs with EPCs higher than the National Guard Trainee FWCUG:

The hexavalent chromium EPC is higher than the National Guard Trainee FWCUG and hexavalent chromium is identified as a COC.

SOR Analysis

No additional COCs were identified based on the SOR analysis as summarized below.

- Two COPCs (total chromium and hexavalent chromium) identified in deep surface soil have FWCUGs for non-cancer endpoints. The SOR calculation is presented in Appendix G, Table G-18. The total SORs for these COPCs are less than or equal to one; therefore, no COCs were identified.
- Only hexavalent chromium has an RSL for the cancer endpoint; therefore, no SOR was calculated.

COCs for Subsurface Soil (4–7 ft bgs)

No COPCs were identified in subsurface soil (4–7 ft bgs); therefore, no COC screening was performed.

7.2.6 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.

7.2.6.1 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 and specific locations that can be sampled, and the parameters chosen for analysis to characterize the AOC. At C Block Quarry, surface soil was characterized using ISM samples collected on the quarry ground surface where the highest level of potential contamination is expected but is also well below the level of natural surface soil. Although surface soil samples were collected using ISM, the results are based on only 10 soil aliquots rather than the preferred 30–50 aliquots in the 6 samples collected in 2004. The two ISM samples collected in 2012 each included at least 30 aliquots. The low number of soil aliquots in surface soil ISM samples results in a low degree of statistical confidence for these samples.

In addition to the ISM samples, discrete samples are available from the 0–1 ft bgs interval of the soil borings used to evaluate subsurface soil. The results of these discrete samples were considered in the context of the ISM samples in which they were located to identify the potential for “hot spots” not identified by the ISM samples.

The results of the ISM and discrete sample evaluation are included in Table 7-7. The discrete sample results parallel the conclusions of the ISM samples as summarized below:

- Eleven chemicals [antimony; cadmium; silver; 2,4-DNT; 3-nitrotoluene; acenaphthene; anthracene; benzo(a)pyrene; carbazole; fluorene; and indeno(1,2,3-cd)pyrene] were detected in the discrete surface soil samples and were not detected in the ISM samples. With the exception of benzo(a)pyrene, concentrations of these chemicals were below facility-wide background criteria and/or FWCUGs in both ISM and discrete samples. Benzo(a)pyrene was detected (0.4 mg/kg) above the Resident Receptor FWCUG (0.221 mg/kg) in one discrete surface soil sample. This low benzo(a)pyrene concentration is not confirmed by the ISM sample and all other PAHs were less than their respective FWCUGs. Therefore; conclusions drawn from the ISM samples regarding these 11 analytes would not be changed by the discrete samples.
- MDCs of calcium, total chromium, hexavalent chromium, cobalt, copper, iron, magnesium, nickel, selenium, benz(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene in the discrete samples were higher than the MDCs in ISM samples. With the exception of hexavalent chromium, the MDCs of these chemicals were below facility-wide background criteria and/or

FWCUGs in both ISM and discrete samples. Therefore, conclusions drawn from the ISM samples regarding these analytes would not be changed by the discrete samples. Hexavalent chromium results are discussed in more detail below.

Evaluation of total chromium and hexavalent chromium results indicated adequate hexavalent chromium data were available to characterize the site; thus, the total chromium results were screened against FWCUGs/RSLs for trivalent chromium as described in Section 7.2.5.1. This introduces uncertainty into the evaluation because some samples were analyzed for total chromium only (i.e., they were not analyzed for hexavalent chromium). Evaluation of the data supports the conclusion that adequate hexavalent chromium data are available. All chromium sample results are shown in Table 7-8. A total of 24 soil samples were analyzed for chromium (8 surface soil ISM samples, 7 surface soil discrete samples, and 9 subsurface soil discrete samples). Of these, 11 samples were analyzed for both total chromium and hexavalent chromium. The remaining 13 samples (1 surface soil ISM sample, 5 surface soil discrete samples, and 7 subsurface soil discrete samples) were analyzed for total chromium only and are discussed below:

- The total chromium concentrations in 10 of 13 soil samples not analyzed for hexavalent chromium range from 8.6–25.7 mg/kg and are less than the background concentrations of 17.4 mg/kg (surface soil) and 27.2 mg/kg (subsurface soil).
- The surface soil ISM sample collected at CBLss-005M in 2004 was analyzed for total chromium (920 mg/kg) but not hexavalent chromium. The same ISM area was sampled again in 2012 and analyzed for total chromium (1,000J mg/kg) and hexavalent chromium (0.32J mg/kg). Thus, adequate hexavalent chromium data are available to characterize this location.
- The surface soil (0–1 ft bgs) and subsurface soil (1–4 ft bgs) discrete samples collected in 2010 from boring CBLsb-010 have elevated total chromium concentrations of 2,100 and 698 mg/kg. These samples were not analyzed for hexavalent chromium. Given the very high total chromium results, it is possible hexavalent chromium is also elevated at this location. Soil boring CBLsb-025 was sampled adjacent to CBLsb-010 in 2012. Total chromium (1,700 and 930J mg/kg) and hexavalent chromium (19 and 39J mg/kg) concentrations were elevated in surface (0–1 ft bgs) and subsurface (1–2 ft bgs) soil samples from this boring. Thus, the uncertainty associated with not having hexavalent chromium results for CBLsb-010 is mitigated by the chromium speciation results at CBLsb-025.

Analytical Limitations – Uncertainty is associated with the chemical 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 SLs. Under these circumstances, it is uncertain whether the true concentration is above or below the SLs that 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 a result of some sample concentrations being reported as non-detected at the method detection limit (MDL), when the actual concentration may be much smaller than the MDL. Risks may also be underestimated if some analytes that were not detected in any sample were removed from the COPC list. If the concentrations of these analytes are below the MDL but are above the SL, the risk from these analytes would not be included in the risk assessment results.

Identifying SRCs – Part of determining SRCs is to identify chemicals detected above the established RVAAP facility-wide background concentrations. This screen does not account for the potential sources of chemicals, and background values are only available for inorganic chemicals.

Uncertainty associated with screening against background results from statistical limitations and natural variation in background concentrations. Because of this variation, inorganic chemical concentrations below the background concentration are likely representative of background conditions. Inorganic chemical concentrations above the background concentration may be above background concentrations or may reflect natural variation. This is especially true for measured concentrations close to the background concentration.

At C Block Quarry, three of six inorganic chemicals identified as SRCs (arsenic, lead, and mercury) had MDCs in surface soil that were less than two times their background concentrations. The consequences of carrying most 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 (background) arsenic in soil exceeds risk-based FWCUGs. Therefore, the consequence of identifying arsenic as an SRC if it is representative of the background concentration can have a significant impact on the conclusions of the risk assessment. The MDC of arsenic in surface soil at C Block Quarry was 19 mg/kg. Although arsenic appears to be elevated at CBLss-001M relative to the surface soil background concentration, it is not elevated relative to subsurface background concentration. Given the significant soil disturbance that occurred during quarry operations, it is likely the concentration of arsenic measured at C Block Quarry reflects the naturally-occurring background concentration rather than contamination.

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 the AOC. For example, PAHs are present in the environment as a result of burning fossil fuels and as a component of asphalt. Samples collected near roadways or parking areas may represent normal "urban" sources of PAHs. These background issues represent significant sources of uncertainty.

Exposure Point Concentrations – Surface soil was characterized using ISM sampling techniques. ISM samples provide a physical average concentration across an exposure area. Using ISM sampling reduces the uncertainty associated with estimating a statistical average exposure. There is some evidence that supports that using stainless steel grinding blades in the processing of ISM samples could contribute chromium and nickel to the ISM soil samples.

EPCs were calculated for the 1–4, 4–7, and 1–7 ft bgs sample intervals using analytical results from the discrete samples listed in Tables 7-2 and 7-3. Soil borings for discrete samples were located in areas of highest potential contamination based on site history and the site geography, resulting in calculated EPCs that provide conservative estimates of exposure concentrations across the EU. Generally, the 95% UCL on the arithmetic mean was adopted as the EPC for discrete sample results and is considered to represent a conservative estimate of the average concentration. This imparts a small but intentional conservative bias to the risk assessment, provided the sampling captured the most highly contaminated areas. Thus, representative EPCs for the EUs were calculated from discrete data based on the assumption that the samples collected from the EUs were truly random samples. This assumption is not true for C Block Quarry where sample locations were biased to identify areas of highest contaminant concentrations. Therefore, EPCs generated from these data are likely to represent an upper bound of potential exposure concentrations.

7.2.6.2 Uncertainty in Use of FWCUGs and RSLs

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 and RSLs.

Selection of Representative Receptors – C Block Quarry is located in the northwestern portion of RVAAP. C Block Quarry is currently inactive. C Block Quarry may receive occasional foot traffic from security, maintenance, and natural resource management staff (OHARNG 2009).

While Residential Land Use is unlikely, an evaluation using Resident Receptor (Adult and Child) FWCUGs is included to provide an Unrestricted (Residential) Land Use evaluation. As stated in Paragraph 6.d of the Technical Memorandum (ARNG 2014), if an AOC fails to meet the Unrestricted (Residential) Land Use, then all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use] will be evaluated.

Exposure Parameters and Exposure Models – For each primary exposure pathway included in the FWCUGs and RSLs, 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 any one pathway, the resulting risks can be in excess of the 99th percentile and outside of the range that may be reasonably expected. Therefore, consistently selecting upper-bound parameters generally leads to overestimation of the potential risk.

Toxicity Values – 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 FWCUGs are for inorganic arsenic; however, these values 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 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). 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 Integrated Risk Information System (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 one seventh 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 minimize the impact of this assumption, the cancer risk-based FWCUGs were adjusted by dividing by seven when they were used for comparison to hexavalent chromium-specific data.

The toxicity of chemicals is under constant study and values change from time to time. The toxicity values used in calculating FWCUGs were the most recent values available at the time of those calculations (September 2008). These values are designed to be conservative and provide an upper-bound estimate of risk. USEPA issued a review draft Toxicological Review of Hexavalent Chromium (75 FR 60454) in September 2010. This review included an oral slope factor for ingesting hexavalent chromium. This oral slope factor has not yet been approved for publication on IRIS; however, it has been accepted as a provisional value for use in calculating a residential RSL (USEPA 2016). In response to this review, the U.S. Department of Defense recognized hexavalent chromium as an emerging contaminant and issued a Chemical & Material Emerging Risk Alert Hexavalent Chromium (DoD MERIT 2011) recommending the review of any sites with detected releases of chromium or hexavalent chromium to determine how tightened standards may affect activities. Therefore, in addition to evaluating the chromium results by comparing it to the FWCUGs, the results are evaluated in comparison to the current (May 2016) residential RSLs. Soil sample results exceeding the residential RSL are identified in Table 7-8 and summarized below:

- All total chromium results are less than the residential RSL for trivalent chromium of 120,000 mg/kg.
- ISM area CBLss-003M:
    - The hexavalent chromium result for the surface soil ISM sample collected in 2004 (5.4 mg/kg) exceeds the residential RSL of 3 mg/kg. The hexavalent chromium result in a second sample collected from the same area in 2012 (0.46J mg/kg) is less than the RSL.
    - A soil boring (CBLsb-026) was installed adjacent to ISM area CBLss-003M in 2012. The hexavalent chromium result for the discrete surface soil (2.2J mg/kg at 0–1 ft bgs) was less than the RSL but the result for the discrete subsurface soil sample (6.4J mg/kg at 1–1.8 ft bgs) exceeded the RSL.

- ISM area CBLss-005M:
  - The surface soil ISM sample collected in 2004 was not analyzed for hexavalent chromium. The hexavalent chromium result in a second sample collected from the same area in 2012 (0.32J mg/kg) is less than the residential RSL of 3 mg/kg.
  - A soil boring (CBLsb-025) was installed within this ISM area in 2012. The hexavalent chromium results for the discrete surface soil (19 mg/kg at 0–1 ft bgs) and subsurface soil (39J mg/kg at 1–2 ft bgs) samples exceed the RSL.
- All other hexavalent chromium results are less than the residential RSL of 3 mg/kg.

As a result of the comparison to the current (May 2016) residential RSLs to site concentrations, hexavalent chromium is recommended as a COC for potential remediation in surface and subsurface soil at CBLss-003M and CBLss-005M for Unrestricted (Residential) Land Use.

FWCUGs and RSLs below Background Concentrations – One purpose of the HHRA process is to identify COCs and CUGs for evaluating remedial alternatives for remediating residual contamination that has resulted from process operations at the AOC. FWCUGs and RSLs are risk-based values. In some cases, natural or anthropogenic background concentrations, unrelated to process operations, exceed the risk-based FWCUGs and RSLs. For naturally occurring inorganic chemicals, this problem is addressed by using the background concentration as the 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 background concentrations 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 (e.g., ATSDR 1995, Bradley et al. 1994, MADEP 2002, and 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 consider ambient anthropogenic levels by establishing minimum SLs based on environmental studies. For example, the New York State Department of Environmental Conservation has established a minimum soil cleanup objective of 1 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).

7.2.6.3 <u>Uncertainty in the Identification of COCs</u>

All of the sources of uncertainty described in the previous sections potentially impact the identification of COCs. The exposure and toxicity values used to calculate FWCUGs and RSLs as well as the approach for identifying SRCs, COPCs, and ultimately COCs based on the FWCUGs and RSLs were designed to ensure overestimation, rather than underestimation, of potential risk. 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 the 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.

7.2.7 Identification of COCs for Potential Remediation

COCs were identified in Section 7.2.5 as any COPC having an EPC greater than an applicable FWCUG or RSL or contributing more than 5–10% to an SOR greater than one. For inorganic chemicals with FWCUGs or RSLs below background concentrations, the background concentration was used as the point of comparison. The TR for the FWCUGs and RSLs 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 7.2.5) are combined with the results of the uncertainty assessment (Section 7.2.6) to identify COCs to be carried forward for potential remediation. Hexavalent chromium was identified as a COC to be carried forward for potential remediation.

Hexavalent chromium was identified as a COC for potential remediation in surface soil (0–1 ft bgs) and subsurface soil (1–7 ft bgs) for Unrestricted (Residential) Land Use and as a COC for potential remediation in deep surface soil (0–4 ft bgs) for Military Training Land Use. Hexavalent chromium concentrations were less than Resident Receptor (Adult and Child) FWCUGs calculated based on inhalation toxicity. However, newer toxicity studies indicate hexavalent chromium may also be carcinogenic by the oral route. In response to this new toxicity information, the U.S. Department of Defense has recognized hexavalent chromium as an emerging contaminant and recommends review of sites using this new information. Hexavalent chromium concentrations exceed the current (May 2016) residential RSL adjusted for a 1E-05 risk level of 3 mg/kg. The National Guard Trainee FWCUG of 2.3 mg/kg is very similar to this residential RSL. Hexavalent chromium is recommended for potential remediation for these receptors in two areas as described below:

- ISM area CBLss-003M:
    - A soil boring (CBLsb-026) was installed adjacent to ISM area CBLss-003M in 2012. The hexavalent chromium result for the discrete surface soil (2.2J mg/kg at 0–1 ft bgs) was less than the residential RSL and National Guard Trainee FWCUG but the result for the discrete subsurface soil sample (6.4J mg/kg at 1–1.8 ft bgs) exceeds these values.

    - The hexavalent chromium result for the surface soil ISM sample collected in 2004 (5.4 mg/kg) exceeds the residential RSL and National Guard Trainee FWCUG. The hexavalent chromium result in a second sample collected from the same area in 2012 (0.46J mg/kg) is less than the RSL and FWCUG. While the newer sample indicates the hexavalent chromium concentration may be below the RSL and FWCUG in this area, discrete surface and subsurface results at both CBLss-003M and CBLss-005M indicate hexavalent chromium concentrations are highly variable and hotspots may be present within this area. Therefore, hexavalent chromium is recommended as a COC for potential remediation in surface and subsurface soil at CBLss-003M.
- ISM area CBLss-005M:
    - A soil boring (CBLsb-025) was installed within this ISM area in 2012. The hexavalent chromium results for the discrete surface soil (19 mg/kg at 0–1 ft bgs) and subsurface soil (39J mg/kg at 1–2 ft bgs) samples exceed the RSL and FWCUG.
    - The surface soil ISM sample collected in 2004 was not analyzed for hexavalent chromium. The hexavalent chromium result in a second sample collected from the same area in 2012 (0.32J mg/kg) is less than the residential RSL and National Guard FWCUG. While the 2012 sample indicates the hexavalent chromium concentration is below the RSL and FWCUG in this area, as noted previously discrete surface and subsurface results indicate hexavalent chromium concentrations are highly variable and hotspots may be present within this area. Therefore, hexavalent chromium is recommended as a COC for potential remediation in surface and subsurface soil at CBLss-005M.
- All other hexavalent chromium results are less than the residential RSL of 3 mg/kg and National Guard FWCUG of 2.3 mg/kg.

All hexavalent chromium concentrations are less than the Industrial RSL of 63 mg/kg at a TR of 1E-05; thus, no COCs are identified for Commercial/Industrial Land Use.

7.2.8 Summary of HHRA

This HHRA documents COCs that may pose potential health risk to human receptors resulting from exposure to contamination at C Block Quarry. This HHRA was conducted as part of the RI and was based on the streamlined approach described in the FWCUG Report (USACE 2010a), FWCUG Position Paper (USACE 2012a), and Technical Memorandum (ARNG 2014). The components of the risk assessment (i.e., receptors, exposure media, EPCs, and results) are summarized below.

Receptors – C Block Quarry is located in the northwestern portion of RVAAP, north of Newton Falls Road within the central portion of the C Block Storage Area. C Block Quarry is currently inactive. Due to the former operations at this AOC and because the site is still under investigation, the AOC is currently managed as Restricted Access. However, C Block Quarry may receive occasional foot traffic from security, maintenance, and natural resource management staff (OHARNG 2009).

Three Land Uses for the RVAAP restoration program are specified in the Technical Memorandum (ARNG 2014) for consideration in the RI along with their Representative Receptors. Unrestricted

(Residential) Land Use [Resident Receptor (Adult and Child)] 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., Commercial/Industrial and Military Training). Commercial/Industrial Land Use (Industrial Receptor) is considered protective of all uses other than Residential. Military Training Land Use is represented by the National Guard Trainee. All three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use] are evaluated in this HHRA.

Exposure Media – Media of concern at C Block Quarry are surface and subsurface soil.

Estimation of EPCs – For surface soil (0–1 ft bgs), the EPC is the detected concentration in each ISM sample collected at C Block Quarry. The results of soil ISM data were evaluated separately with each ISM sample representing a decision unit. For deep surface (1–4 ft bgs) and subsurface soil (4–7 and 1–7 ft bgs), the EPCs were calculated from the results of all of the discrete samples collected from a given depth interval. 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 – Hexavalent chromium was identified as a COC to be carried forward for potential remediation at C Block Quarry for Unrestricted (Residential) Land Use in surface and subsurface soil and Military Training Land Use in deep surface soil. No COCs were identified for Commercial/Industrial Land Use.

7.3 ECOLOGICAL RISK ASSESSMENT

7.3.1 Introduction

The ERA presented in this RI/FS Report follows a unified approach of methods integrating 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/FS Report combines these guidance documents to meet requirements of the Ohio EPA and 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

C Block Quarry contains habitat that supports ecological receptors. This habitat has known chemical contamination (MKM 2007). Habitat types and an assessment of the ecological resources found at C Block Quarry 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

C Block Quarry is approximately 0.96 acres and is currently inactive. The habitat is mostly forest and is large enough to completely support cover and food for small birds and mammals that typically require approximately 1 acre of habitat (USEPA 1993). The habitat area at C Block Quarry represents 0.004% of the 21,683 acres at Camp Ravenna.

7.3.2.2 Evidence of Historical Chemical Contamination

C Block Quarry was used for disposing annealing process liquids (chromic acid) and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. This material was reportedly dumped on the ground surface during the 1950s and 1960s (USATHAMA 1982). The volume of liquid waste disposed of at C Block Quarry is unknown. The 1989 RCRA Facility Assessment (Jacobs 1989) evaluated potential releases of contamination to the environment from the site. This assessment determined that any releases are unknown, there is a low potential of releases to the soil and groundwater, there is a low potential of releases to surface water from this unit, and a low potential of releases to the air.

The goal of the historical ERA (MKM 2007) was to identify COPECs in soil for C Block Quarry. 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 2003). 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. In addition, sediment and surface water do not exist at C Block Quarry.

The historical ERA table for soil is included in Appendix H, Table H-1 and contains the following:

- Frequency of detection,
- Average concentration,
- MDC,
- Background concentration,
- Comparison of MDC to background concentration (SRC determination),
- Screening values (ESVs),
- Comparison of MDC to ESVs,
- 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 34 chemicals in surface soil (0–1 ft bgs) at C Block Quarry (MKM 2007). Of these, 4 chemicals (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen. A total of 6 inorganic chemicals and 13 organic chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Five of the inorganic chemicals (arsenic, chromium, copper, lead, and mercury) were identified as COPECs because their concentrations were above ESVs (Table 7-9). Four chemicals (TNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; and nitrocellulose) were identified as COPECs due to a lack of ESVs. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Appendix H, Table H-1 presents the Characterization of 14 AOCs ecological screening for surface soil at C Block Quarry.

Historical COPECs for Sediment – No historical sediment samples were collected within the AOC, as sediment is not present at the AOC.

Historical COPECs for Surface Water – No historical surface water samples were collected within the AOC, as surface water is not present at the AOC.

Summary of Historical ERA – As explained previously, a historical ERA was performed to determine COPECs at C Block Quarry in surface soil. These COPECs are summarized in Table 7-9. Based on the identified COPECs, ecological risk in surface soil was predicted in the historical investigation, and an additional investigation was recommended for C Block Quarry (MKM 2007).

7.3.2.3 Ecological Significance

Sources of data and information about the ecological resources at C Block Quarry include the *Integrated Natural Resource Management Plan* (INRMP) (OHARNG 2014), previous characterization work (e.g., Characterization of 14 AOCs), and visits to C Block Quarry conducted for the PBA08 RI.

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 C Block Quarry. 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 1996), 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 Army and Ohio EPA (Appendix H, 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. The Army and Ohio EPA recognize 17 important places and resources. The Army recognizes an additional 16 important places (BTAG 2005), and the Ohio EPA recognizes another 6 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 C Block Quarry with each of the important places and resources listed in Appendix H, Table H-2.

Presence of an important ecological resource or place and proximity to contamination at an AOC make a resource ecologically significant. Thus, any important places and resources listed in Appendix H, 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 that 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 C Block Quarry through the natural resource management goals expressed in the INRMP (OHARNG 2014). 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 resource management goals of OHARNG (listed in Appendix H, Table H-3) benefit C Block Quarry. For example, Goal 1 states natural resources need to be managed in a compatible way with the military mission, and Goal 5 requires the 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 degradation (whether from training activities or historical contamination). While the applicability of the remaining 10 management goals to C Block Quarry varies, all of the management goals are intended to monitor, maintain, or enhance the Camp Ravenna and RVAAP natural resources and ecosystem. While these goals are for managing all types of resources at and near C Block Quarry, they do not affect the decisions concerning the presence or absence of important or significant ecological places or resources at C Block Quarry.

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 rare species. An important resource becomes significant when found on an AOC and there is contaminant exposure. There is no important/significant ecological resource at C Block Quarry (Appendix H, Table H-2).

Terrestrial Resources – C Block Quarry is dominated by terrestrial resources, as described below.

Habitat Descriptions and Species**.** The INRMP and AOC visits by SAIC scientists indicate C Block Quarry consists of one dominant vegetation type (Figure 7-1). The habitat area is dominated by red maple (*Acer rubrum)* successional forest (OHARNG 2014). A very small amount of herbaceous field is found in the southwestern portion of the AOC. 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 2014).

A field survey conducted by SAIC field biologists at C Block Quarry in November 2008 confirmed the main habitat type: red maple successional forest. Although red maple successional forest dominates the AOC, the herbaceous field habitat tends to be intermingled (Photograph 7-1) in the southwestern edge of the AOC along old access routes into the quarry and other similarly disturbed areas.

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 throughout C Block Quarry. The forest includes small open areas and 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.

The herbaceous habitat occurs in the southwestern portion of the habitat area along the main transportation corridors and access routes to the quarry and near the earth-covered magazines. 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*).

Photograph 7–1. Young Forest Vegetation and Herbaceous Growth in the Habitat Area (August 12, 2008)

Based on November 2008 observations (Photograph 7-1), SAIC scientists assessed the habitat at C Block Quarry to be healthy and functioning. 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.

Threatened and Endangered and Other Rare Species. The northern long-eared bat (*Myotis septentrionalis*; federally threatened) exists at Camp Ravenna. There are no other federally listed species and no critical habitat on Camp Ravenna. C Block Quarry has not been previously surveyed for rare, threatened, or endangered species; however, there have been no documented sightings of rare, threatened, or endangered species at the AOC (OHARNG 2014).

Other Terrestrial Resources. While there are no other known important terrestrial places and resources (Appendix H, Table H-2), there are other resources at or near C Block Quarry (e.g., vegetation and 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 2014). There are no other reported surveys of habitats and animals at C Block Quarry beyond those summarized in the INRMP (OHARNG 2014).

Aquatic Resources – Wetlands are important habitats with water-saturated soil or sediment whose plant life can survive saturation. Wetlands are home to many different species and are chemical sinks that can serve as detoxifiers and natural water purifiers. However, there are no known wetlands at C Block Quarry to perform this and related functions. A planning level survey for wetlands was completed for the facility. No wetlands were identified at this AOC during the planning level survey (Figure 7-1). Several wetlands were identified offsite during the planning level survey. These wetlands are located about 1,300 ft southwest (in a tributary of Hinkley Creek) and about 1,600 ft east (near Sand Creek). There is no known connection between C Block Quarry and these wetlands. There are no ditches, streams, and ponds at C Block Quarry. Lack of aquatic habitat lowers the diversity of resources at C Block Quarry.

Ecosystem and Landscape Roles and Relationships – There were four spatial areas evaluated to assess the ecosystem and landscape roles and relationships at C Block Quarry: the actual AOC, the vicinity of the AOC, the entire Camp Ravenna, and the ecoregion of northeastern Ohio. Information about the first spatial area (the AOC) was provided in the subsections above on terrestrial and aquatic resources.

Vicinity of the AOC. Two vegetation communities border C Block Quarry (Figure 7-1): red maple successional forest and herbaceous field. These communities are similar to the vegetation observed at C Block Quarry. There are no apparent differences in habitat quality of the plant communities inside or in close proximity of the AOC. The types and qualities of habitat are not unique to C Block Quarry and can be found at many other areas at Camp Ravenna.

No perennial surface water features are present within the AOC or in the immediate vicinity. The nearest streams are Sand Creek (approximately 2,000 ft to the east) and Hinkley Creek (approximately 2,500 ft to the west). There are no known wetlands in C Block Quarry (Figure 7-1). The closest wetlands are located approximately 1,300 ft southwest and 1,600 ft east of the AOC. By definition, a wetland is considered an important ecological resource (BTAG 2005); however, they are located far enough from the AOC that they are unlikely to be impacted by contamination present at C Block Quarry. There is no known connection between C Block Quarry and any offsite wetlands.

The closest recorded rare species [caddisfly (*Psilotreta indecisa*)] is located approximately 2,400 ft west-southwest of the AOC (Table 7-10) (OHARNG 2014). It is a state threatened species. The next closest rare species [woodland jumping mouse (*Napaeozapus insignis*)] is located about 3,300 ft west of the AOC. It is a state species of concern.

As shown in Table 7-10, no beaver dams, 100-year floodplains, or biological/water quality (stream and pond) sampling stations are in or near the AOC. The nearest resources of these types are more than 1,800 ft away.

The Entire Camp Ravenna. C Block Quarry is considered a small (approximately 0.96 acres) AOC, which represents 0.004% of the total area of Camp Ravenna (21,683 acres). There are approximately 3,510 acres of forest type FU4 (red maple successional forest) at Camp Ravenna; based on the INRMP map (OHARNG 2014), this represents 16.2% of the habitat at Camp Ravenna. There are 2,050 acres of forest type HU1 [dry, early-successional herbaceous field (e.g., goldenrod and blackberry)] (OHARNG 2014), representing 9.5% of the habitat at Camp Ravenna. These types of resources are abundant and are not unique to C Block Quarry at Camp Ravenna.

Ecoregion. In the area surrounding Camp Ravenna, forests occupy a high percentage of the terrain. Ohio's forests cover approximately 8,000,000 acres or 30% of the state (USDA 2009). The Erie/Ontario Drift and Lake Plain ecoregion (USGS 1998) is located in the northeastern part of Ohio and both contain the communities of red maple successional forest and dry, early-successional, herbaceous field (e.g., goldenrod and blackberry). The Erie/Ontario Drift and Lake Plain ecoregion exhibits rolling to level terrain formed by lacustrine and low lime drift deposits. Lakes, wetlands, and swampy streams occur where stream networks converge or where the land is flat and clayey (USGS 1998). The U.S. Forest Service has a Forest Inventory Data Online tool that was queried for the forest types in the surrounding counties in or near Camp Ravenna (USFS 2011). In 2009, approximately 138,840 acres of forest type FU4 were found throughout northwestern Ohio in Cuyahoga, Geauga, Mahoning, Portage, Stark, Summit, and Trumbull counties that surround Camp Ravenna (USFS 2011). The herbaceous field was not individually found in this query because it is not classified as a main group of trees in the forest inventory data tool. However, herbaceous field (HU1) is common across the ecoregion (USDA 2011). The vegetation communities at C Block Quarry are also found in the surrounding counties in the ecoregion of northeastern Ohio.

In summary, the current vegetation types of red maple successional forest and dry, early-successional, herbaceous field (e.g., goldenrod and blackberry) are found in the vicinity of C Block Quarry. The forest type and herbaceous field are abundant at Camp Ravenna and the larger surrounding local ecoregion. There is no known unique resource at C Block Quarry that cannot be found in the immediate vicinity of the AOC, Camp Ravenna, and in the large part of the ecoregion of northeastern Ohio.

7.3.2.4 <u>Evaluation of Historical Chemical Contamination and Ecological Significance</u>

There were nine COPECs identified in the historical ERA as part of the Characterization of 14 AOCs: arsenic; chromium; copper; lead; mercury; TNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; and nitrocellulose (Section 7.3.2.2). Section 7.3.2.3 provides information about the lack of important/significant ecological resources at the AOC. There is no known wetland, no rare species, and no other important/significant ecological resources, as defined by the 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 C Block Quarry.

7.3.2.5 Evaluation of Current Chemical Contamination

This section provides information about methods and results of the analysis of current and historical chemical contamination.

The SL approach to evaluate sample results from the PBA08 RI followed a similar approach to that used in the historical ERA. Section 5.0 details chemical concentration data. The PBA08 RI evaluation uses discrete soil data collected during the PBA08 RI. The PBA08 RI included collecting discrete surface soil (0–1 ft bgs) samples at locations within the historical ISM soil sample locations (Figure 4-1). This ERA uses updated ESVs that follow the revised *Ecological Risk Assessment Guidance* (Ohio EPA 2008), as provided in Appendix H, Table H-4.

The MDC of each chemical is compared to its respective facility-wide background concentration. Chemicals are not considered site-related if the MDC is below the background concentration. For all chemicals detected above background concentrations, the MDC is compared to the chemical-specific ESV. The hierarchy of ESVs is based on the information found in the Ohio EPA risk assessment guidance (Ohio EPA 2008) and FWERWP (USACE 2003). In addition to the ESV comparison, it was determined if the chemical is a PBT compound. A chemical is retained as a COPEC if it exceeds its background concentration and the ESV, if the chemical exceeds its background concentration and had no toxicity information, or if the chemical is considered a PBT compound. MDC to ESV ratios are used to determine the integrated COPECs; the MDCs used are those from the current discrete data set. A ratio greater than one suggests a possible environmental consequence. Any chemicals with ratios greater than one are identified as integrated COPECs.

Integrated COPECs in Surface Soil (0–1 ft bgs) – During the PBA08 RI, 41 chemicals were detected in soil at C Block Quarry. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. A total of 7 inorganic chemicals and 18 organic chemicals were determined to be SRCs because they either exceeded their background concentrations or did not have an associated background concentration for comparison. Of these 25 SRCs, four inorganic chemicals (chromium, copper, lead, and mercury) exceeded their ESVs and are identified as integrated COPECs (Table 7-11). In addition, four organic chemicals (2-amino-4,6-DNT; 3-nitrotoluene; 4-amino-2,6-DNT; and carbazole) were selected as integrated COPECs because they do not have an ESV. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Table 7-11 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix H, Table H-5 presents the details of the ESV comparisons for surface soil at C Block Quarry.

Six of the COPECs (chromium; copper; lead; mercury; 2-amino-4,6-DNT; and 4-amino-2,6-DNT) reported in the historical ERA (Table 7-9) for soil are also identified in the PBA08 RI ERA for

C Block Quarry. The historical ERA (MKM 2007) identified one inorganic COPEC (arsenic) and two organic COPECs (TNT and nitrocellulose) based on ISM samples. However, in the discrete PBA08 RI samples, arsenic was detected below its background concentration, and TNT and nitrocellulose were not detected (Table H-5). Organic chemicals 3-nitrotoluene and carbazole were detected in discrete samples collected during the PBA08 RI. Based on the presence of integrated COPECs, this ERA predicts the potential for ecological risk in soil at C Block Quarry.

Integrated COPECs in Sediment – No sediment was available for collection at C Block Quarry.

Integrated COPECs in Surface Water – No surface water was available at C Block Quarry.

Summary of ERA Findings – There are eight integrated COPECs identified in soil at C Block Quarry: chromium; copper; lead; mercury; 2-amino-4,6-DNT; 3-nitrotoluene; 4-amino-2,6-DNT; and carbazole. Sediment and surface water do not exist at the AOC; therefore, no COPECs were identified for these media.

7.3.2.6 Summary and Recommendations of Scoping Level Ecological Risk Assessment

Based on information from the Characterization of 14 AOCs and the PBA08 RI, there are eight integrated soil COPECs at C Block Quarry. These COPECs consist of inorganic chemicals, explosives, and SVOCs. There is no sediment or surface water at C Block Quarry.

The information in Section 7.3.2.3 regarding ecological resources at C Block Quarry was compared to the list of important ecological places and resources (Appendix H, Table H-2). None of the 39 important places were present, and there is nothing ecologically significant at C Block Quarry. Environmental management goals and objectives of OHARNG are applicable to C Block Quarry, as presented in Appendix H, Table H-3. Some of the management goals benefit C Block Quarry, including Goal 1 that requires management of natural resources to be compatible with military mission, and Goal 5 that requires the Army to sustain usable training lands and natural resources.

C Block Quarry is approximately 0.96 acres and is vegetated primarily with *Acer rubrum* successional forest, with a small area of herbaceous growth. These same types of habitats are found adjacent to the AOC and elsewhere at Camp Ravenna (OHARNG 2014). The habitats are also found in the larger, local ecoregion that surrounds Camp Ravenna (USFS 2011). There is no known unique resource at C Block Quarry (OHARNG 2014).

Although there is contamination at C Block Quarry, the AOC has no known important/significant ecological places or resources. Consequently, the ERA for C Block Quarry can conclude with a Level I Scoping Level Risk Assessment, with the recommendation that no further action is required to be protective of important ecological resources.

7.3.3 Conclusions

There is chemical contamination present at C Block Quarry. There are eight integrated soil COPECs at C Block Quarry. There are no important/significant ecological resources at C Block Quarry habitat according to the Army and Ohio EPA list of important places and resources. Further, the vegetation types are found elsewhere near the AOC, at Camp Ravenna, and in the ecoregion. Per guidance from the Ohio EPA, there is sufficient justification to recommend that no further action is required to be protective of important ecological resources at C Block Quarry.

Table 7–1. Risk Assessment Data Set for Surface Soil (0–1 ft bgs): ISM Samples

Station	Sample ID	Date	Depth (ft bgs)
CBLss-001M	CBLss-001M-SO	11/4/2004	0–1
CBLss-002M	CBLss-002M-SO	11/4/2004	0–1
CBLss-003M	CBLss-003M-SO	11/4/2004	0–1
CBLss-004M	CBLss-004M-SO	11/4/2004	0–0.5
CBLss-005M	CBLss-005M-SO	11/4/2004	0–1
CBLss-005D[a]	CBLss-005M	11/4/2004	0–1
CBLss-006M	CBLss-006M-SO	11/4/2004	0–1
CBLss-003M	CBLss-003M-5876-SO	08/10/2012	0–1
CBLss-005M	CBLss-005M-5877-SO	08/10/2012	0–1
CBLsb-025[b]	CBLsb-025-5878-SO	08/10/2012	0–1
CBLsb-026[b]	CBLsb-026-5881-SO	08/10/2012	0–1

[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. CBLsb-025 collected at ISM area CBLss-005M and CBLsb-026 collected just east of ISM area CBLss-003M.
bgs = Below ground surface.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.

Table 7–2. Risk Assessment Data Set for Deep Surface Soil (1–4 ft bgs): Discrete Samples

Station	Sample ID	Date	Depth[a] (ft bgs)
CBLsb-007	CBLsb-007-5250-SO	3/22/2010	1–4
CBLsb-008	CBLsb-008-5254-SO	3/22/2010	1–2
CBLsb-010	CBLsb-010-5258-SO	3/22/2010	1–4
CBLsb-011	CBLsb-011-5262-SO	3/23/2010	1–4
CBLsb-012	CBLsb-012-5266-SO	3/22/2010	1–4

[a]Deep surface soil is defined as 0–4 ft bgs for the National Guard Trainee. Because 0–1 ft bgs samples were collected using ISM and discrete sampling was used for the 1–4 ft bgs interval, these intervals were evaluated separately.
bgs = Below ground surface.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.

Table 7–3. Risk Assessment Data Set for Subsurface Soil Discrete Samples

Station	Sample ID	Date	Depth (ft bgs)
National Guard Trainee[a]			
CBLsb-007	CBLsb-007-5251-SO	3/22/2010	4–7
CBLsb-011	CBLsb-011-5263-SO	3/23/2010	4–4.5
Resident Receptor (Adult and Child)[b]			
CBLsb-007	CBLsb-007-5250-SO	3/22/2010	1–4
CBLsb-008	CBLsb-008-5254-SO	3/22/2010	1–2
CBLsb-010	CBLsb-010-5258-SO	3/22/2010	1–4
CBLsb-011	CBLsb-011-5262-SO	3/23/2010	1–4
CBLsb-011	CBLsb-011-6127-FD	3/23/2010	1–4
CBLsb-012	CBLsb-012-5266-SO	3/22/2010	1–4
CBLsb-007	CBLsb-007-5251-SO	3/22/2010	4–7
CBLsb-011	CBLsb-011-5263-SO	3/23/2010	4–4.5
CBLsb-025	CBLsb-025-5879-SO	8/10/2012	1–2
CBLsb-026	CBLsb-026-5882-SO	8/09/2012	1–1.8

[a]Subsurface soil is defined as 4–7 ft bgs for National Guard Trainee

[b]Subsurface soil is defined as 1–13 ft bgs for Resident Receptor (Adult and Child); however, at C Block Quarry bedrock is present at 7 ft bgs. Therefore, discrete soil data from 1–7 ft bgs were used to evaluate subsurface soil for the Resident Receptor (Adult and Child).

bgs = Below ground surface.

ft = Feet.

ID = Identification.

Table 7–4. Summary of SRCs

COPC	Surface Soil[a] (0–1 ft bgs)	Deep Surface Soil[b] (1–4 ft bgs)	Subsurface Soil[b] (4–7 ft bgs)	Subsurface Soil[b,c] (1–7 ft bgs)
Inorganic Chemicals				
Arsenic	X	--	--	--
Cadmium	--	X	X	X
Chromium (total)[d]	X	X	--	X
Chromium (hexavalent)	X	X	NR	X
Copper	X	X	--	X
Lead	X	--	X	X
Mercury	X	X	X	X
Thallium	X	--	--	--
Explosives				
2,4,6-Trinitrotoluene	X	--	--	--
2-Amino-4,6-Dinitrotoluene	X	X	--	X
4-Amino-2,6-Dinitrotoluene	X	X	--	X
Nitrocellulose	X	--	--	--

Table 7-4. Summary of SRCs (continued)

COPC	Surface Soil[a] (0–1 ft bgs)	Deep Surface Soil[b] (1–4 ft bgs)	Subsurface Soil[b] (4–7 ft bgs)	Subsurface Soil[b,c] (1–7 ft bgs)
Semi-volatile Organic Compounds				
Anthracene		X	--	X
Benz(a)anthracene	X	X	--	X
Benzo(a)pyrene	--	X	--	X
Benzo(b)fluoranthene	X	X	X	X
Benzo(ghi)perylene	X	X	--	X
Benzo(k)fluoranthene	X	X	--	X
Bis(2-ethylhexyl)phthalate	X	--	--	--
Chrysene	X	X	--	X
Fluoranthene	X	X	X	X
Fluorene	--	X	--	X
Indeno(1,2,3-cd)pyrene	--	X	--	X
Phenanthrene	X	X	--	X
Pyrene	X	X	X	X

[a]Surface soil characterized using incremental sampling methodology (ISM) sampling
[b]Deep surface and subsurface soil characterized using discrete sampling.
[c]Subsurface soil is defined as 1–13 ft bgs for Resident Receptor (Adult and Child); however, bedrock is present at 7 ft bgs at C Block Quarry. Therefore, discrete soil data from 1–7 ft bgs were used to evaluate subsurface soil for the Resident Receptor.
[d]Surface soil ISM samples analyzed for both total chromium and hexavalent chromium.
bgs = Below ground surface.
COPC = Chemical of potential concern.
ft = Feet.
NR = Not reported. This aggregate was not analyzed for hexavalent chromium.
SRC = Site-related contaminant.
X = Chemical is an SRC in this medium.
-- = Chemical not identified as an SRC in this medium.

Table 7–5. Summary of COPCs

Unrestricted Land Use: Resident Receptor (Adult and Child)			
SRC	**Surface Soil (0-1 ft bgs)[a]**		**Subsurface Soil (1-7 ft bgs)[bc]**
Arsenic	X		--
Chromium (total)	X		X
Chromium (hexavalent)	--		X
2,4,6-Trinitrotoluene	X		--
Benzo(a)pyrene	--		X
Commercial/Industrial Land Use: Industrial Receptor			
SRC	**Surface Soil (0-1 ft bgs)[a]**		**Subsurface Soil (1-7 ft bgs)[b]**
Arsenic	X		--
Chromium (total)	X		X
Chromium (hexavalent)	--		X
Military Training Land Use: National Guard Trainee			
	Deep Surface Soil		**Subsurface Soil**
SRC	**(0-1 ft bgs)[a]**	**(1-4ft bgs)[b]**	**(4-7 ft bgs)[b]**
Arsenic	X	--	--
Chromium (total)	X	X	--
Chromium (hexavalent)	X	X	NR

[a]Surface soil (0-1 ft bgs) characterized using incremental sampling methodology (ISM) sampling.
[b]Soil below 1 ft bgs characterized using discrete sampling.
[c]Subsurface soil is defined as 1–13 ft bgs for Resident Receptor (Adult and Child); however, bedrock is present at 7 ft bgs at C Block Quarry. Therefore, discrete soil data from 1–7 ft bgs were used to evaluate subsurface soil for the Resident (Adult and Child).
bgs = Below ground surface.
COPC = Chemical of potential concern.
ft = Feet.
NR = Not reported. This aggregate was not analyzed for hexavalent chromium.
SRC = Site-related contaminant.
X = Chemical is a COPC in this medium.
-- = Chemical not identified as a COPC in this medium.

Table 7–6. FWCUGs Corresponding to an HQ of 1, TR of 1E-05 for COPCs in Soil

COPC	Critical Effect or Target Organ	FWCUG (mg/kg)					
		Resident Receptor (Adult and Child)[a]		National Guard Trainee		Industrial Receptor	
		HQ=1	TR=1E-05	HQ=1	TR=1E-05	HQ=1	TR=1E-05
Arsenic	Skin	20.2	4.25[c]	1,140	27.8	480	30
Chromium, hexavalent	Stomach ulcer, liver/kidney damage	199	268[b]	56.1	2.3[b]	3,500	63
Chromium, trivalent	NOAEL	81,473	--	1,000,000	--	1,800,000	--
2,4,6-Trinitrotoluene	Liver effects	36.5	248	2,488	4,643	510	960
Benzo(a)pyrene	NA	--	0.221	--	4.77	--	2.9

[a] Resident Receptor FWCUGs are the smaller of the Adult or Child values for each COPC and endpoint (non-cancer and cancer).
[b]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. FWCUG for comparison to hexavalent chromium results is 1/7th the FWCUG calculated for this mixture.
[c]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).
COPC = Chemical of potential concern.
FWCUG = Facility-wide cleanup goal.
HQ = Hazard quotient.
mg/L = Milligrams per liter.
NA = Not applicable.
NOAEL = No observable adverse effect level.
TR = Target risk.
-- = No value available.

Table 7–7. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at C Block Quarry

Analyte (mg/kg)	CAS Number	ISM Sample Results		Discrete Sample Results		Maximum Detected Concentration in ISM or Discrete Sample
		Freq of Detect	Maximum Detect	Freq of Detect	Maximum Detect	
Metals and Anions						
Aluminum	7429-90-5	6/ 6	12000	5/ 5	10900	ISM
Antimony	7440-36-0	ND	ND	5/ 5	0.17	Discrete
Arsenic	7440-38-2	**6/ 6**	**19**	5/ 5	13.9	ISM
Barium	7440-39-3	6/ 6	84	5/ 5	76.9	ISM
Beryllium	7440-41-7	6/ 6	0.71	5/ 5	0.54	ISM
Cadmium	7440-43-9	ND	ND	5/ 5	0.22	Discrete
Calcium	7440-70-2	6/ 6	1300	5/ 5	3040	Discrete
Chromium	**7440-47-3**	**8/ 8**	**1000**	**7/ 7**	**2100**	**Discrete**
Chromium, hexavalent	18540-29-9	3/ 7	5.4	2/ 2	19	Discrete
Cobalt	7440-48-4	6/ 6	9.6	5/ 5	10.3	Discrete
Copper	7440-50-8	6/ 6	78	5/ 5	126	Discrete
Iron	7439-89-6	6/ 6	22000	5/ 5	23000	Discrete
Lead	7439-92-1	6/ 6	43	5/ 5	27.7	ISM
Magnesium	7439-95-4	6/ 6	2100	5/ 5	2110	Discrete
Manganese	7439-96-5	6/ 6	950	5/ 5	903	ISM
Mercury	7439-97-6	3/ 6	0.07	5/ 5	0.067	ISM
Nickel	7440-02-0	6/ 6	16	5/ 5	16.8	Discrete
Potassium	7440-09-7	6/ 6	960	5/ 5	662	ISM
Selenium	7782-49-2	5/ 6	0.85	5/ 5	1.3	Discrete
Silver	7440-22-4	ND	ND	2/ 5	0.066	Discrete

Table 7-7. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at C Block Quarry (continued)

Analyte (mg/kg)	CAS Number	ISM Sample Results		Discrete Sample Results		Maximum Detected Concentration in ISM or Discrete Sample
		Freq of Detect	Maximum Detect	Freq of Detect	Maximum Detect	
Sodium	7440-23-5	6/ 6	310	5/ 5	30.3	ISM
Thallium	7440-28-0	2/ 6	0.36	5/ 5	0.17	ISM
Vanadium	7440-62-2	6/ 6	24	4/ 5	21.1	ISM
Zinc	7440-66-6	6/ 6	59	5/ 5	55.9	ISM
2,4,6-Trinitrotoluene	**118-96-7**	**3/ 6**	**22**	**ND**	**ND**	**ISM**
2,4-Dinitrotoluene	121-14-2	ND	ND	1/ 5	0.025	Discrete
2-Amino-4,6-Dinitrotoluene	35572-78-2	2/ 6	0.54	1/ 5	0.16	ISM
3-Nitrotoluene	99-08-1	ND	ND	1/ 5	0.018	Discrete
4-Amino-2,6-Dinitrotoluene	19406-51-0	2/ 6	0.64	1/ 5	0.13	ISM
Nitrocellulose	9004-70-0	1/ 1	1.3	ND	ND	ISM
Acenaphthene	83-32-9	ND	ND	1/ 1	0.025	Discrete
Anthracene	120-12-7	ND	ND	1/ 1	0.043	Discrete
Benz(a)anthracene	56-55-3	1/ 1	0.017	1/ 1	0.21	Discrete
Benzo(a)pyrene	**50-32-8**	**ND**	**ND**	**1/ 1**	**0.4**	**Discrete**
Benzo(b)fluoranthene	**205-99-2**	**1/ 1**	**0.036**	**1/ 1**	**0.51**	**Discrete**
Benzo(ghi)perylene	191-24-2	1/ 1	0.019	1/ 1	0.35	Discrete
Benzo(k)fluoranthene	207-08-9	1/ 1	0.019	1/ 1	0.21	Discrete
Bis(2-ethylhexyl)phthalate	117-81-7	1/ 1	0.054	ND	ND	ISM
Carbazole	86-74-8	ND	ND	1/ 1	0.029	Discrete
Chrysene	218-01-9	1/ 1	0.028	1/ 1	0.26	Discrete
Fluoranthene	206-44-0	1/ 1	0.036	1/ 1	0.49	Discrete
Fluorene	86-73-7	ND	ND	1/ 1	0.019	Discrete
Indeno(1,2,3-cd)pyrene	**193-39-5**	**ND**	**ND**	**1/ 1**	**0.3**	**Discrete**
Phenanthrene	85-01-8	1/ 1	0.017	1/ 1	0.27	Discrete
Pyrene	129-00-0	1/ 1	0.027	1/ 1	0.41	Discrete

bgs = Below ground surface.
CAS = Chemical Abstract Service.
ft = Feet.
Freq = Frequency.
ISM = Incremental sampling methodology.
mg/kg = Milligrams per kilogram.
ND = Not detected.
Bold = Chemical is a chemical of potential concern in either the discrete data set or the ISM data set.

Table 7–8. Summary of Chromium Results

Station	Sample ID	Date	Depth (ft bgs)	Chromium Concentration (mg/kg) Total	Hexavalent	Comments
ISM area CBLss-001M						
CBLss-001M	CBLss-001M-SO	11/04/04	0–1	17	ND	Total Cr < BKG
CBLsb-007	CBLsb-007-5249-SO	03/22/10	0–1	14	--	Total Cr < BKG
CBLsb-007	CBLsb-007-5250-SO	03/22/10	1–4	14	--	Total Cr < BKG
CBLsb-007	CBLsb-007-5251-SO	03/22/10	4–7	14.6	--	Total Cr < BKG
ISM area CBLss-002M						
CBLss-002M	CBLss-002M-SO	11/04/04	0–1	430	ND	
CBLsb-008	CBLsb-008-5253-SO	03/22/10	0–1	25.7	--	Total Cr < BKG
CBLsb-008	CBLsb-008-5254-SO	03/22/10	1–2	18.5	--	Total Cr < BKG
ISM area CBLss-003M						
CBLss-003M	CBLss-003M-SO	11/04/04	0–1	240	**5.4J**	
CBLss-003M	CBLss-003M-5876-SO	08/10/12	0–1	520J	0.46J	
CBLsb-011	CBLsb-011-5261-SO	03/23/10	0–1	8.6	--	Total Cr < BKG
CBLsb-011	CBLsb-011-5262-SO	03/23/10	1–4	12.1	--	Total Cr < BKG
CBLsb-011	CBLsb-011-5263-SO	03/23/10	4–4.5	12.6	--	Total Cr < BKG
CBLsb-026	CBLsb-026-5881-SO	08/09/12	0–1	390J	2.2J	
CBLsb-026	CBLsb-026-5882-SO	08/09/12	1–1.8	920J	**6.4J**	
ISM area CBLss-004M						
CBLss-004M	CBLss-004M-SO	11/04/04	0–0.5	150	ND	
ISM area CBLss-005M						
CBLss-005M	CBLss-005M-SO	11/04/04	0–1	920	--	
CBLss-005M	CBLss-005M-5877-SO	08/10/12	0–1	1000J	0.32J	
CBLsb-010	CBLsb-010-5257-SO	03/22/10	0–1	2100	--	
CBLsb-010	CBLsb-010-5258-SO	03/22/10	1–4	698	--	
CBLsb-025	CBLsb-025-5878-SO	08/10/12	0–1	1700J	**19J**	
CBLsb-025	CBLsb-025-5879-SO	08/10/12	1–2	930J	**39J**	
ISM area CBLss-006M						
CBLss-006M	CBLss-006M-SO	11/04/04	0–1	19	ND	Total Cr < BKG
CBLsb-012	CBLsb-012-5265-SO	03/22/10	0–1	12.9	--	Total Cr < BKG
CBLsb-012	CBLsb-012-5266-SO	03/22/10	1–3	13.8	--	Total Cr < BKG

bgs = Below ground surface.
BKG = Facility-wide background concentration: 17.4 mg/kg for surface soil and 27.2 for subsurface soil, however, the two horizons are combined at C Block Quarry due to mixing.
CBLss-00#M = ISM sample location for surface soil sample.
CBLsb-0## = soil boring location for discrete surface and subsurface soil sample.
Cr = Chromium.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.
mg/kg = Milligrams per kilogram.
ND = Not detected.
-- = No value available, chemical not analyzed.
< = Less than.
Bold = Hexavalent chromium concentration exceeded the residential regional screening level (3 mg/kg) adjusted for a 1E-05 risk level and the National Guard Trainee facility-wide cleanup goal of 2.3 mg/kg.

Table 7–9. Summary of Historical COPECs per the Characterization of 14 AOCs

Group	COPEC	Shallow Soil	Sediment	Surface Water
Inorganic Chemicals	Arsenic	X	--	--
	Chromium	X	--	--
	Copper	X	--	--
	Lead	X	--	--
	Mercury	X	--	--
Explosives	TNT	X	--	--
	2-amino-4,6-Dinitrotoluene	X	--	--
	4-amino-2,6-Dinitrotoluene	X	--	--
Propellants	Nitrocellulose	X	--	--

Adapted from Table CBL-14 from the Characterization of 14 AOCs (MKM 2007).
AOC = Area of Concern.
COPEC = Chemical of Potential Ecological Concern.
TNT = 2,4,6-Trinitrotoluene.
-- = Chemical not identified as a COPEC in this data set.
X = Quantitative COPEC, exceeds ecological screening value (ESV), does not have an ESV, or is a persistent, bioaccumulative, and toxic compound.

Table 7–10. Survey of Proximity to the AOC of Various Ecological Resources

Natural Resource	Natural Resources Inside Habitat Area	Proximity Within or Near the AOC	Distances from the AOC to Nearest Resource[a]
Wetlands	Surveyed, none known	None	1,300 ft southwest 1,600 ft east
Rare species	No known sightings	None	2,400 ft west-southwest 3,300 ft west (See text for species names)
Beaver dams	None	None	2,800 ft southeast 4,100 ft north-northeast
100-year floodplain	None	None	2,200 ft west
Stream sampling[b]	None	None	Approximately 3,800 ft west
Pond sampling[b]	None	None	Approximately 1,800 ft west

[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 2005b).
AOC = Area of concern.
ft = Feet.

Table 7–11. Summary of Integrated COPECs for Surface Soil

COPEC	MDC (mg/kg)	ESV (mg/kg)	Ratio of MDC to ESV	Comments
Chromium	2,100	26	80.8	None
Copper	126	28	4.5	None
Lead	27.7	11	2.5	None
Mercury	0.067	0.00051	131	PBT compound
2-Amino-4,6-Dinitrotoluene	0.16	No ESV	--	None
3-Nitrotoluene	0.018	No ESV	--	None
4-Amino-2,6-Dinitrotoluene	0.13	No ESV	--	None
Carbazole	0.029	No ESV	--	None

Table excludes nutrients.
-- = Not applicable, no ESV is available for comparison.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and toxic compound.

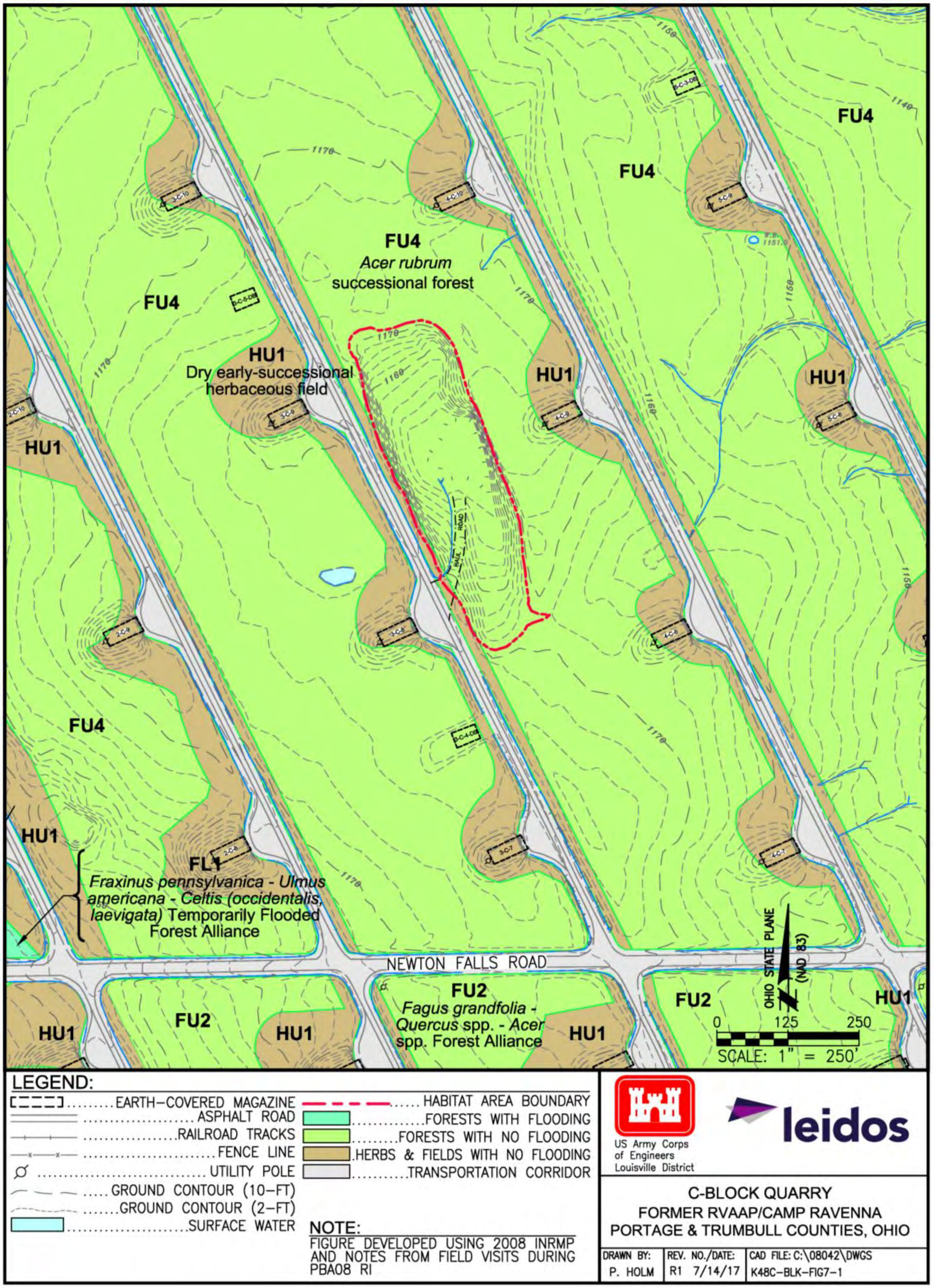

Figure 7–1. Natural Resources Inside and Near Habitat Area at C Block Quarry

8.0 REMEDIAL INVESTIGATION CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

This RI Report for C Block Quarry 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. A CSM incorporating all available information is also 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., groundwater), exit pathways from the AOC, and if 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

Quality-assured sample data from the 2004 Characterization of 14 AOCs and the 2010 and 2012 PBA08 RI were used to evaluate nature and extent of contamination at C Block Quarry. All available sample data were evaluated to determine suitability for use in various key RI data screens and evaluations (i.e., nature and extent, fate and transport, and risk assessment). Evaluating data suitability for use in the PBA08 RI involved two primary considerations: whether the data represented current AOC conditions and sample collection methods (e.g., discrete vs. ISM).

Soil samples from the 2004 (Characterization of 14 AOCs) data set were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 and 2012 PBA08 RI. The soil samples collected in 2004 were collected as ISM samples and covered the entire ground surface of the quarry and no activities (dumping or quarrying) have occurred since then. Therefore, the data set was considered representative of current conditions at C Block Quarry. No soil samples from the 2004 data set were eliminated from the screening process.

Data collected in 2010 and 2012 as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil (0–1 ft bgs) during prior investigations and characterizing subsurface soil (greater than 1 ft bgs) (not previously sampled). The PBA08 RI sampled locations with the greatest likelihood of contamination (e.g., within ISM sample areas where initial screening criteria was exceeded) which were analyzed for chemicals identified in historical investigations. Additionally, asbestos was evaluated in identified debris and soil.

8.3 SUMMARY AND CONCLUSIONS OF NATURE AND EXTENT OF CONTAMINATION

Nature and extent of contamination in surface soil (0–1 ft bgs) and subsurface soil (greater than 1 ft bgs) were evaluated in the RI. Data from the Characterization of 14 AOCs and 2010 and 2012 PBA08 RI effectively characterized the nature and extent of contamination at the AOC. Surface water and sediment were not evaluated, as these media are not present on the AOC. To support the evaluation of nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report (USACE 2010a). It can be concluded that the vertical and horizontal extent of chemical contamination is defined, and no further sampling is needed to evaluate C Block Quarry.

8.3.1 Surface and Subsurface Soil

Metals were identified as potential contaminants from former disposal operations (chromium, lead, and mercury) and were thoroughly evaluated across the quarry as a whole. The highest inorganic chemical concentrations were observed in the southern portion of the AOC (ISM sample areas CBLss-003M, CBLss-004M, and CBLss-005M, and borings CBLsb-025, and CBLsb-026). The chromium concentration was particularly high at 920 mg/kg at CBLss-005M, but was below the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Location CBLsb-025 had hexavalent chromium concentrations of 19J mg/kg at 0–1 ft bgs and 39J mg/kg at 1–1.8 ft bgs, which was above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

Explosives were thoroughly evaluated across the AOC as a whole. The maximum concentrations for 2-amino-4,6-DNT; 4-amino-2,6-DNT; and nitrocellulose (observed in CBLss-004M in the southern portion of the AOC) were all below their respective SLs and were not considered COPCs. TNT at CBLss-004M had a surface soil concentration of 22 mg/kg, which exceeded the SL, but was below the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

PAH concentrations were detected at CBLss-005M and CBLsb-011, at the southern end of the AOC. All 12 SVOC SRCs were detected in the 1–4 ft bgs interval at CBLss-011. However, concentrations in subsurface soil at this location were less than SLs, except for benzo(a)pyrene. Benzo(a)pyrene was detected at a concentration (0.4 mg/kg) that exceeded its SL of 0.022 mg/kg; therefore, benzo(a)pyrene was identified as a COPC. The benzo(a)pyrene concentration was detected above the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg).

VOCs, pesticides, and PCBs were not detected in surface soil and subsurface soil; propellants were not detected in subsurface soil in C Block Quarry.

8.3.2 Asbestos-Containing Material

A certified State of Ohio Department of Health Asbestos Hazard Evaluation Specialist collected samples and conducted an ACM survey. The ACM survey included visually inspecting the entire quarry, identifying suspect materials, estimating the approximate quantity of suspected ACM, and collecting six bulk samples and one soil sample for analysis by PLM.

Four of six bulk samples contained asbestos fibers and were considered friable. The ACM survey indicated several areas of exposed transite/shingle and steel panels with block insulation and paper within C Block Quarry. The survey indicated that suspect ACM occurred in an area of approximately

2,750 ft^2, although visible debris occupied less than 10 ft^2. PLM analysis of suspect ACM debris samples indicated transite shingles and insulation material contained up to 35% asbestos fibers. Samples of firebrick and suspected burn residue/cinder did not contain detectable asbestos fiber.

The one soil sample collected during the ACM survey near a pile of material with suspected ACM contained less than 1% asbestos fiber. Additionally, nine soil samples collected from PBA08 RI soil borings did not contain detectable asbestos fibers.

8.4 SUMMARY AND CONCLUSIONS OF CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport at C Block Quarry was evaluated using 1) groundwater data collected to date at the AOC, and 2) modeling to assess the potential for SRCs to leach from surface and subsurface soil and impact groundwater beneath the sources. Groundwater samples were collected from 5 monitoring wells around C Block Quarry during 13 separate sampling events under the Characterization of 14 AOCs (MKM 2007) and the FWGWMP from January 2005 to November 2016 to assess the potential impact that historical site activities may have had on groundwater. Explosives, propellants, VOCs, pesticides, perchlorate, and cyanide results were all below the screening level (MCL, Resident Receptor FWCUG, or Resident Tap Water RSL). Only seven chemicals [hexavalent chromium, manganese, PCB-1248, benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and bis(2-ethylhexyl)phthalate] exceeded the screening levels.

The fate and transport evaluation concluded that chromium and mercury were not potentially impacting groundwater through soil screening analysis (i.e., by comparing their maximum soil concentrations to the MCL-based GSSLs), and lead and hexavalent chromium were not expected to reach the water table from the source area within 1,000 years. The fate and transport evaluation identified TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT as final CMCOPCs. None of these final CMCOPCs were detected in AOC groundwater samples collected from 2009–2013. A qualitative assessment concluded that CMCOPCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts. The contaminant fate and transport evaluation concludes that no further action is required for soil to be protective of groundwater.

8.5 SUMMARY AND CONCLUSIONS OF THE HUMAN HEALTH RISK ASSESSMENT

The HHRA identified COCs and conducted risk management analysis to determine if COCs pose unacceptable risk to the Resident Receptor. If there is no unacceptable risk to the Resident Receptor, it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor. However, if unacceptable risk is identified for the Resident Receptor, the risk to the National Guard Trainee and Industrial Receptor is evaluated.

Media of concern at C Block Quarry are surface soil and subsurface soil. Surface water and sediment were not present within the C Block Quarry. Hexavalent chromium was identified as a COC to be carried forward for potential remediation in surface soil and subsurface soil for Unrestricted (Residential) and Military Training Land Uses. No COCs were identified for Commercial/Industrial Land Use.

8.6 SUMMARY AND CONCLUSIONS OF THE ECOLOGICAL RISK ASSESSMENT

The Level I ERA presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. There is chemical contamination present in surface soil at C Block Quarry; there is no permanent sediment or surface water at the AOC. This contamination was identified using discrete soil data collected for the PBA08 RI. There are eight integrated COPECs identified in surface soil. Ecological resources at C Block Quarry were compared to the list of important ecological places and resources. None of the 39 important places and resources were present, and there is nothing ecologically significant at C Block Quarry. The ERA summarizes the chemicals and resources in detail to demonstrate that there is contamination at C Block Quarry, but no important or significant ecological resources are present. Consequently, the ERA for C Block Quarry concludes with a Level I Scoping Level Risk Assessment and a recommendation that no further action is required to be protective of ecological resources.

8.7 UPDATED CONCEPTUAL SITE MODEL

The CSM is presented in this section to incorporate results of this RI. Elements of the CSM include:

1. Primary and secondary contaminant sources and release mechanisms,
2. Contaminant migration pathways and discharge or exit points,
3. Potential receptors with unacceptable risk, and
4. Data gaps and uncertainties.

The following sections describe each of the above elements of the CSM for C Block Quarry. Figures contained in earlier sections of the report that illustrate AOC features, topography, groundwater and surface water flow directions, and nature and extent of SRCs are cited to assist in visualizing key summary points of the revised CSM.

8.7.1 Primary and Secondary Contaminant Sources and Release Mechanisms

No operational facilities representing primary contaminant sources were located at the AOC. Primary sources exist at C Block Quarry, such as debris and ACM. No material is believed to have been placed in the quarry since the 1960s. Secondary sources also exist at C Block Quarry, such as contaminated soil. The exposure risk associated with these media is evaluated in this RI Report. The site was used for disposing annealing process liquids (chromic acid) and spent pickle liquor containing lead, mercury, chromium, and sulfuric acid from brass finishing operations. This material was reportedly dumped on the ground surface. The volume of liquid waste disposed of at C Block Quarry is unknown. Many other chemicals and ACM were analyzed during the site investigations and are discussed in this report.

The mechanisms for release of contaminants from secondary sources are limited due to the AOC's physical characteristics. The bottom of the quarry is fully enclosed by a quarry wall, which confines the extent of contaminants in soil to the quarry bottom (Figure 3-1). Contaminants may be released from secondary sources through dissolution by surface water runoff and leaching to groundwater or by physical dispersal of contaminated soil or debris particles through erosional processes. Erosional transport processes are confined to short distances with the quarry bottom, which is heavily vegetated and has no engineered or natural drainage conveyances.

8.7.2 Contaminant Migration Pathways and Exit Points

8.7.2.1 Surface Water Pathways

Surface water drainage conveyances or streams do not exist within C Block Quarry, and there are no surface water exit points from the quarry. Topography at the AOC directs runoff into the quarry bottom (Figure 3-1). Surface water pathways for contaminant migration are limited to short distances within the quarry bottom. Contaminants migrate from soil sources via surface water primarily by particle-bound contaminants moving through surface water runoff and dissolved constituents being transported in surface water.

In the case of particle-bound contaminant migration, contaminants will be mobilized during periods of high flow (e.g., rain events). Upon reaching the lowest elevation of the quarry bottom where temporary ponding of water may occur, the particulates will settle out as sediment accumulation. Sediment-bound contaminants would not be re-suspended or migrate from the low points in the quarry bottom.

Dissolved phase contaminant migration in surface water is relevant with respect to leaching processes to groundwater. Temporary ponding of surface water runoff in the lowest points of the quarry is likely during heavy rainfall events or periods of snowmelt; however, visual observations during various investigations have not indicated evidence of long-term standing water. Infiltration rates and evapotranspiration processes appear sufficiently high to prevent long-term water retention in the quarry bottom.

8.7.2.2 Groundwater Pathways

The estimated direction of groundwater flow at C Block Quarry is to the southeast. This reflects the April 2017 facility-wide potentiometric data (TEC-Weston 2018). Water level elevations in AOC wells range from 1,132.02–1,138.96 ft amsl with the highest elevation at well CBLmw-003. Potentiometric data indicate the groundwater table occurs within bedrock zone throughout the AOC. Groundwater discharge to surface water features (e.g., via base flow to streams or springs) does not occur within the AOC boundary.

Groundwater samples were collected from 5 monitoring wells around C Block Quarry during 13 separate sampling events under the Characterization of 14 AOCs (MKM 2007) and the FWGWMP from January 2005 to November 2016 to assess potential impact historical site activities may have had on groundwater. Contaminant leaching pathways from soil to the water table are through non-native fill and debris material, typically less than 7 ft thick, overlying sandstone bedrock with an overall average hydraulic conductivity of 3.80E-04 cm/s. Only seven chemicals [hexavalent chromium, manganese, PCB-1248, benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and bis(2-ethylhexyl)phthalate] exceeded the screening levels. A qualitative assessment concluded that CMCOPCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts. The contaminant fate and transport evaluation concludes that no further action is required for soil to be protective of groundwater.

8.7.3 Potential Receptors

In February 2014, the Army and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The Technical Memorandum 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 (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., Commercial/Industrial and Military Training), and the other Land Uses do not require evaluation.

The HHRA identified hexavalent chromium as a COC requiring remediation in surface and subsurface soil for the Resident Receptor and National Guard Trainee but did not identify a COC requiring remediation for the Industrial Receptor.

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. 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. Ecological resources at C Block Quarry were compared to the list of important ecological places and resources. None of the 39 important places and resources were present, and there is nothing ecologically significant at C Block Quarry.

8.7.4 Uncertainties

Uncertainties are inherent in the CSM depending on the density and availability of data. The CSM for C Block Quarry is overall well defined using existing data, and major data gaps do not remain to be resolved. However, some uncertainties for the CSM include:

1. The lack of established RVAAP-specific background concentrations for identifying SRCs for PAHs is a source of uncertainty. Evaluating potential former RVAAP process-related sources

and other common anthropogenic sources using available PAH environmental data minimizes the impact of this uncertainty on the conclusions of the RI.

2. While this RI addresses soil, sediment, and surface water, additional ongoing investigations are being conducted for the Facility-wide Groundwater AOC.

8.8 RECOMMENDATION OF THE REMEDIAL INVESTIGATION

Based on the investigation results, C Block Quarry has been adequately characterized, and further investigation is not warranted at this AOC. The nature and extent of potentially impacted media has been sufficiently characterized; the fate and transport modeling did not identify soil CMCOCs impacting groundwater; and no ecological risk was identified. However, the HHRA identified hexavalent chromium as a surface and subsurface soil COC for the Resident Receptor and the National Guard Trainee Receptors in C Block Quarry. Additionally, asbestos debris was identified in soil samples. Analyses of remedial alternatives are not warranted for sediment or surface water based on the absence of these media. The recommended path forward is to evaluate remedial alternatives for C Block Quarry in an FS.

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9.0 REMEDIAL ACTION OBJECTIVES, CLEANUP GOALS, AND VOLUME CALCULATIONS

This section presents the RAOs, appropriate CUGs for remedial actions, and volume estimates of soil requiring remediation to attain specific Land Use scenarios. The RAOs are in accordance with NCP and CERCLA RI/FS guidance, which specify receptors, exposure routes, and desired exposure levels. CUGs establish acceptable exposure levels to be protective of human health while considering potential Land Uses and provide the basis for screening, evaluating, and selecting a remedial alternative. This section also presents the estimated volume of soil exceeding the respective CUGs. The volume estimates present the estimated quantity and location of soil requiring remediation to attain a specific Land Use scenario.

9.1 FUTURE USE

The potential future use for C Block Quarry is Commercial/Industrial Land Use. Although residential use is not anticipated at the former RVAAP or at this AOC, Unrestricted (Residential) Land Use was evaluated in this FS in accordance with Defense Environmental Restoration Program Manual 4715.20 (DoD 2012).

Because Military Training Land Use requires monitoring personnel exposure and documenting site usage for training purposes, the Army has elected to evaluate only alternatives associated with Commercial/Industrial Land Use and Unrestricted (Residential) Land Use in this FS. Descriptions of these Land Uses, as outlined in the Technical Memorandum (ARNG 2014), are provided in the following subsections.

9.1.1 Commercial/Industrial Land Use

Commercial/Industrial Land Use represents receptors who work full time at the former RVAAP/Camp Ravenna AOCs. The Industrial Receptor is the representative receptor for Commercial/Industrial Land Use.

This Land Use is characterized by activities consistent with full-time employees or career military personnel who are expected to work daily at the facility over their career. The evaluation of the additional Commercial/Industrial Land Use using the USEPA's industrial RSLs will be completed to assess the potential of an AOC or MRS to be used for fulltime occupational activities (ARNG 2014).

9.1.2 Unrestricted (Residential) Land Use

Unrestricted (Residential) Land Use is considered protective for, and may be applied to, any and all categories of Land Use on the former RVAAP/Camp Ravenna, without further restriction. The Resident Receptor is the representative receptor for Unrestricted (Residential) Land Use.

9.2 REMEDIAL ACTION OBJECTIVES

The RI for C Block Quarry concluded that concentrations of hexavalent chromium in soil at and near sample locations CBLss-003M and CBLss-005M exceeded the residential RSL of 3 mg/kg. Additionally, friable ACM (e.g., transite and black tar paper) was intermixed with the soil. Accordingly, the RAOs for C Block Quarry are as follows:

- Prevent Resident Receptor exposure to hexavalent chromium in soil with concentrations above 3 mg/kg at sample locations CBLss-003M and CBLss-005M and prevent Resident Receptor and Industrial Receptor exposure to friable ACM.

Achieving these RAOs may not result in attaining Unrestricted (Residential) Land Use, as an alternative may protect the Resident Receptor by implementing institutional controls. Accordingly, the protectiveness of the Industrial Receptor (representing Commercial/Industrial Land Use) is considered and discussed in this evaluation.

9.3 REMEDIAL ACTION CLEANUP GOALS

The HHRA identifies sample locations requiring remediation to meet the RAOs. Figure 9-1 presents the estimated extent of contamination. The HHRA recommends 3 mg/kg as a CUG for hexavalent chromium for the Resident Receptor to support the remedial alternative selection process. In addition, for any remedial action taking place to remove subsurface friable ACM, soil samples will be collected and analyzed for asbestos content. The CUG for asbestos in soil is non-detectable using test methods with an analytical sensitivity of at least 0.25% by weight.

The CUGs for C Block Quarry are presented in Table 9-1.

Table 9–1. Remedial Cleanup Goals for C Block Quarry

Soil Contaminant	Remedial Cleanup Goal
Hexavalent Chromium	3 mg/kg[a]
Asbestos	Non-detectable[b]

mg/kg = Milligrams per kilogram.

[a] The hexavalent chromium cleanup goal of 3 mg/kg is applicable to the Resident Receptor. Hexavalent chromium is not a COC for the Industrial Receptor, as there were no exceedances of the Industrial RSL of 63 mg/kg.

[b] Non-detectable concentration of asbestos will be determined by using test methods with an analytical sensitivity of at least 0.25% by weight.

9.4 VOLUME CALCULATIONS OF SOIL REQUIRING REMEDIATION

The estimated volume of soil requiring remediation is based on RI data available at the time of this FS. As indicated in the development of remedial alternatives, alternatives may contain actions (e.g., trenching to identify ACM) that will refine the actual volume requiring remediation. The horizontal extent of soil requiring remediation for hexavalent chromium includes ISM sample locations CBLss-003M and CBLss-005M. In addition, a portion of CBLss-002M is included in the area requiring remediation, as friable ACM was identified in this area.

The vertical extent of soil requiring remediation is based on the findings from soil borings CBLsb-025 and CBLsb-026; the approximate depth to bedrock identified from these two soil borings is 4 ft bgs. Hexavalent chromium exceedances of the residential RSL (3 mg/kg) were to 2 ft bgs. Accordingly, the soil depth requiring remediation to attain Unrestricted (Residential) Land Use is estimated to be 2 ft bgs. Table 9-2 and Figure 9-1 present the estimated soil volume of the contamination.

Table 9–2. Estimated Volume Requiring Remediation

Medium	Treatment Interval (ft bgs)	Surface Area (ft^2)	In Situ		In Situ with Constructability[a]		Ex Situ[a,b]	
			Volume (ft^3)	Volume (yd^3)	Volume (ft^3)	Volume (yd^3)	Volume (ft^3)	Volume (yd^3)
Soil	0–2	13,654	27,308	1,011	34,135	1,264	40,962	1,517

[a] Constructability factor accounts for over excavation and sloping of sidewalls, and addresses limitations of removal equipment. The in situ volume is increased by 25% for a constructability factor.

[b] Includes 20% swell factor.

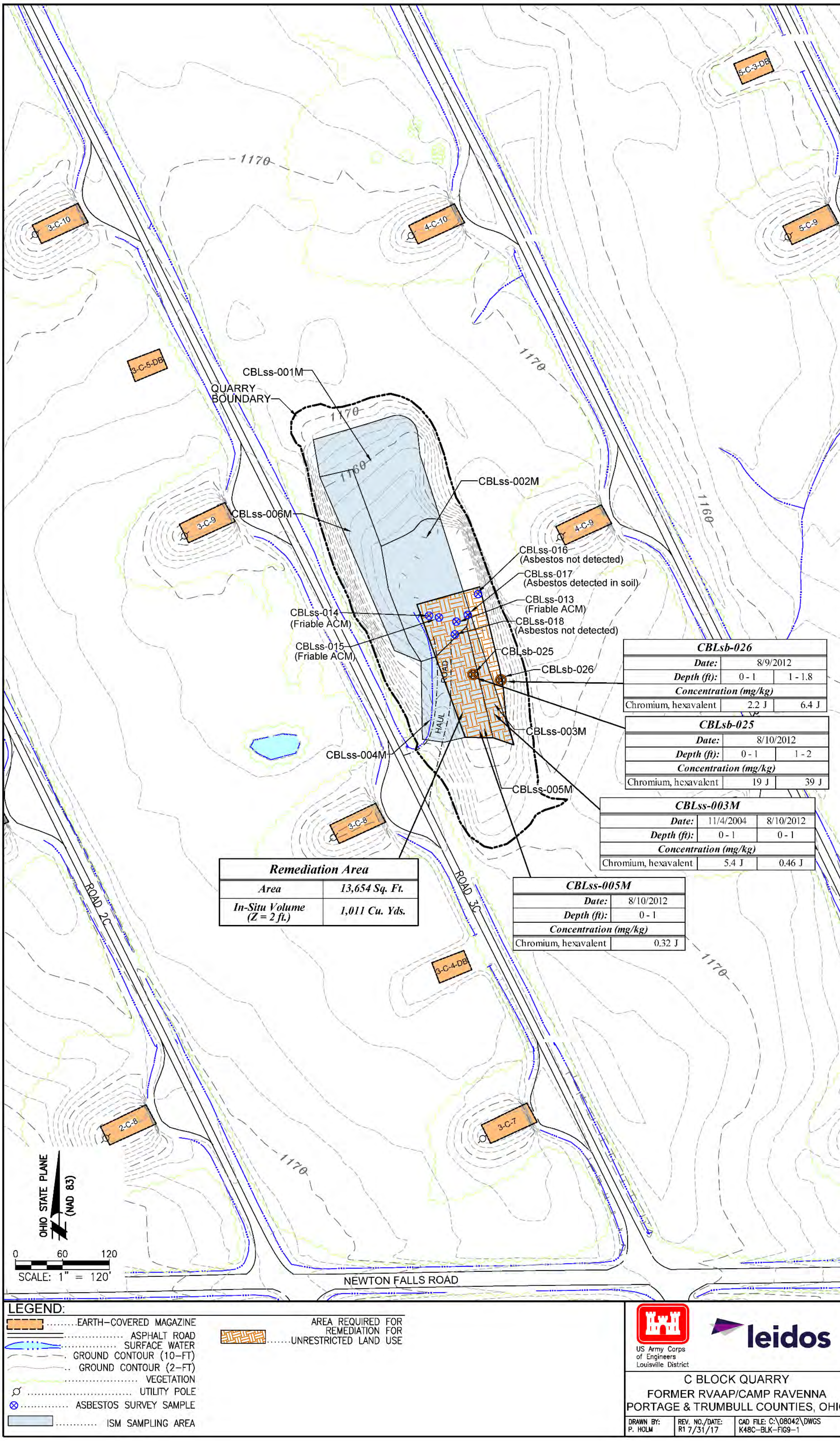
bgs = Below ground surface.

ft = Feet.

ft^2 = Square feet.

ft^3 = Cubic feet.

yd^3 = Cubic yard.



CBLsb-026		
Date:	8/9/2012	
Depth (ft):	0 - 1	1 - 1.8
Concentration (mg/kg)		
Chromium, hexavalent	2.2 J	6.4 J

CBLsb-025		
Date:	8/10/2012	
Depth (ft):	0 - 1	1 - 2
Concentration (mg/kg)		
Chromium, hexavalent	19 J	39 J

CBLss-003M		
Date:	11/4/2004	8/10/2012
Depth (ft):	0 - 1	0 - 1
Concentration (mg/kg)		
Chromium, hexavalent	5.4 J	0.46 J

CBLss-005M	
Date:	8/10/2012
Depth (ft):	0 - 1
Concentration (mg/kg)	
Chromium, hexavalent	0.32 J

Remediation Area	
Area	13,654 Sq. Ft.
In-Situ Volume (Z = 2 ft.)	1,011 Cu. Yds.

Figure 9–1. Estimated Extent of Soil Requiring Remediation

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10.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

10.1 INTRODUCTION

CERCLA Section 121 specifies that remedial actions must comply with requirements or standards under federal or more stringent state environmental laws that are "applicable or relevant and appropriate to the hazardous substances or particular circumstances at the AOC." In interpreting ARARs, it is inherently assumed that human health and the environment will be protected. This section summarizes potential federal and state chemical-, location-, and action-specific ARARs for potential remedial actions at the AOC.

ARARs include federal and state regulations designed to protect the environment. Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR 300.5). USEPA stated in the NCP that applicable requirements are those requirements that would apply if the response action were not taken under CERCLA.

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site" (40 CFR 300.5).

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs but are to-be-considered guidance [40 CFR 300.400(g)(13)].

CERCLA on-site remedial response actions must only comply with the substantive requirements of a regulation and not the administrative requirements. The definitions of "applicable" and "relevant and appropriate" require that the federal or state requirements be substantive [i.e., cleanup standards; standards of control; and other substantive requirements, criteria, or limitations (40 CFR §300.5)]. Substantive is further defined in USEPA guidance as "those requirements that pertain directly to actions in the environment" (USEPA 1988a). Administrative requirements are not considered ARARs and are described as those mechanisms of laws or regulations that facilitate implementation of the substantive requirements or methods or procedures by which substantive requirements are made effective. Certain administrative requirements should be observed if they are useful in determining cleanup standards at the site (Federal Register, Volume 55, page 8666). Conversely, off-site actions are subject to the full requirements of the applicable standards or regulations, including all administrative and procedural requirements.

Although remedial actions for AOCs at National Priorities List sites must comply only with the substantive requirements of federal or state environmental regulations, the Ohio Revised Code does not provide a similar permit waiver for actions conducted under the Ohio EPA Remedial Response Program Policy. Ohio EPA's DERR Policy DERR-00-RR-034 states "it has been DERR's policy to require responsible parties to acquire and comply with all necessary permits, including the substantive and administrative requirements." However, a DFFO was entered into on June 10, 2004, that provided certain exemptions from the Ohio Administrative Code (OAC) administrative requirements and required groundwater monitoring and remediation at the former RVAAP to be performed under the CERCLA process. The DFFO includes provisions for compliance that may result in the potential negation of all provided exemptions within the DFFO in the event non-compliant activities are identified.

10.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

USEPA classifies ARARs as chemical-, action-, and location-specific to provide guidance for identifying and complying with ARARs (USEPA 1988a).

- Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, allow numerical values to be established. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment (USEPA 1988a).
- Action-specific ARARs are rules, such as performance-, design-, or other activity-based rules, that place requirements or limitations on actions.
- Location-specific ARARs are rules that place restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations (USEPA 1988a).

As explained in the following paragraph, rules from each of these categories are ARARs only to the extent that they relate to the degree of cleanup.

CERCLA Section 121 governs cleanup standards at CERCLA sites. ARARs originate in the subsection of CERCLA that specifies the degree of cleanup at each AOC: CERCLA Section 121(d). In Section 121(d)(2), CERCLA expressly directs that ARARs are to address specific COCs at each AOC, specifying the level of protection to be attained by any chemicals remaining at the AOC. CERCLA Section 121(d)(2) provides that, with respect to hazardous substances, pollutants, or contaminants remaining on-site after completing a remedial action, an ARAR is:

> "Any standard, requirement, criteria, or limitation under any Federal environmental law … or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation."

CERCLA Section 121(d)(2) further states that the remedial action must attain a level of control established in rules determined to be ARARs.

In most cases, ARARs will be chemical-specific. Action- or location-specific requirements will be ARARs to the extent that they establish standards addressing COCs that will remain at the AOC. In addition, CERCLA Section 121(d)(1) directs that remedial actions taken to achieve a degree of cleanup that is protective of human health and the environment are to be relevant and appropriate under the circumstances presented by the release. An evaluation of the regulatory requirements has shown there are no chemical-specific ARARs for the chemicals identified in various media at the AOC.

10.2.1 Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements

A review of the regulations indicated there are no potential chemical-specific ARARs for the COC.

10.2.2 Potential Action-Specific Applicable or Relevant and Appropriate Requirements

Potential excavation and disposal of contaminated environmental media at the AOC will trigger potential ARARs associated with land disturbance and emission controls. OAC 3745-15-07 requires that nuisance air pollution emissions be controlled. This includes controlling potential fugitive dust from soil handling excavation activities. In addition, any construction (e.g., soil disturbance activities that would encompass over 1 acre) would trigger the storm water requirements found in 40 CFR Part 450. These requirements mandate that erosion and sedimentation control measures be designed and implemented to control erosion and sediment runoff.

The presence of ACM in soil at the AOC will trigger potential ARARs associated with asbestos emission control. OAC 3745-20-05 requires discharge of visible emissions to the outside air be controlled during asbestos waste handling. C Block Quarry is not considered an “Inactive Asbestos Waste Disposal Site”; however, relevant and appropriate aspects of OAC Section 3745-20-07: Standards for Inactive Asbestos Waste Disposal Sites are considered.

Because excavation would include generating and managing contaminated media, RCRA requirements would be considered potential ARARs for this activity. RCRA requirements mandate that a generator must determine whether a material is (or contains, in the case of environmental media) a hazardous waste under OAC 3745-52-11. If a material is determined to be, or contain, a listed hazardous waste or exhibits a hazardous waste characteristic, additional management requirements under RCRA must be followed as an ARAR under CERCLA.

These requirements include how hazardous waste is stored, treated, transported, and disposed of. In addition to the substantive requirements associated with managing and storing material RCRA hazardous waste (or found to contain such waste), they prescribe standards for disposing hazardous material. These requirements include land disposal restrictions (LDRs) prohibiting disposal of specific chemicals until they are treated to a specified level or by a specific treatment technology.

USEPA cautions that LDRs should not be used to determine site-specific cleanup levels for soil (USEPA 2002). The purpose of LDRs is to require appropriate treatment of RCRA hazardous waste that is to be disposed of to minimize short- and long-term threats to human health or the environment based upon available technology. Performing treatment to meet LDR standards is different from the CERCLA approach to remediation, which analyzes risk and then develops soil cleanup standards based on the risk present, and may result in soil cleanup levels that are different from those of a risk-based approach. Nevertheless, if RCRA hazardous waste is generated from the CERCLA action and is disposed of on-site, the material must meet the standards established in the LDRs.

For LDRs to be triggered as potential ARARs, RCRA hazardous waste must be present. This requires that soil contains contaminants derived from RCRA-listed waste or exhibits a characteristic of RCRA hazardous waste and that soil is managed in a way that "generates" hazardous waste. One exception to generation when managing wastes during remediation is the AOC approach. Specified management of wastes within USEPA's AOC policy does not generate hazardous waste.

If soil is managed in a manner that generates hazardous waste, such as removing it to an aboveground container and then redepositing the soil within the land unit for disposal, then LDRs become potential ARARs. Potential LDR ARARs in Ohio are variances from treatment standards in OAC Section 3745-270-44, LDR standards for contaminated debris in OAC Section 3745-270-45, Universal Treatment Standards (UTSs) in OAC Section 3745-270-48, and Alternative Standards for Contaminated Soil in OAC Section 3745-270-49. Only the alternative soil treatment standards are explained in this document.

Ohio has adopted the alternative soil treatment standards promulgated by USEPA in its Phase IV LDR rule, effective August 1998. Under the alternative soil treatment standards, all soil subject to treatment must be treated as follows:

1. For non-metals (except carbon disulfide, cyclohexanone, and methanol), treatment must achieve 90% reduction in total constituent concentration, subject to item 3 below.
2. For metals and carbon disulfide, cyclohexanone, and methanol, treatment must achieve 90% reduction in constituent concentrations, as measured in leachate from the treated media [tested according to the Toxicity Characteristic Leaching Procedure (TCLP)], or 90% reduction in total constituent concentrations (when a metal removal treatment technology is used), subject to item 3 below.
3. When treating any constituent subject to a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as "90% capped by 10xUTS."
4. USEPA and Ohio EPA RCRA regulations provide a site-specific variance from the soil treatment standards for contaminated soil. If approved, alternative risk-based LDR treatment standards can be applied that minimize short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede soil treatment standards.

If soil is found to be contaminated but not a RCRA hazardous waste, management and disposal of this material would be subject to the requirements associated with managing and disposing solid waste within the state of Ohio.

Potential action-specific ARARs are listed in Table 10-1.

10.2.3 Potential Location-Specific Applicable or Relevant and Appropriate Requirements

Location requirements include, but are not limited to, those established for potential remedial activities conducted within wetlands, within a floodplain area, or with respect to federal- or state-listed species. Generally, for wetlands and floodplains, alternatives are required to be developed to conduct remedial activities within the sensitive area; if that is not feasible, adverse effects from any actions taken within the sensitive area must be mitigated to the extent possible. These requirements do not relate to specific chemicals, nor do they change the degree of cleanup in the sense of protecting human health or the environment from the effects of harmful substances. Rather, their purpose is to protect sensitive areas to the extent possible. Under CERCLA Section 121(d), relevance and appropriateness are related to the circumstances presented by the release of hazardous substances, with the goal of attaining a degree of cleanup and controlling further releases to ensure the protection of human health and the environment.

No wetlands are present within C Block Quarry, and no wetlands are expected to be disturbed during execution of a remedial action at this site. Any action taken by the federal government must be conducted in accordance with the requirements established under the National Environmental Policy Act, Endangered Species Act, National Historic Preservation Act, Native American Graves Protection and Repatriation Act, and state burial laws, and federal and state wetlands and floodplains construction and placement of materials considerations, even though these laws and rules do not establish standards, requirements, limitations, or criteria relating to the degree of cleanup for chemicals remaining on-site at the close of the response actions.

Table 10–1. Potential Action-Specific ARARs

Medium and Citation	Description of Requirement	Potential ARAR Status	Standard
Prohibition of air pollution nuisances (e.g., fugitive dust) OAC Section 3745-15-07	These rules prohibit a release of nuisance air pollution that endangers the health, safety, or welfare of the public or causes personal injury or property damage.	Applies to any activity that could result in the release of a nuisance air pollutant. This would include dust from excavation or soil management processes.	Any person undertaking an activity is prohibited from emitting nuisance air pollution.
Asbestos Emission Control OAC Section 3745-20-05	This rule establishes the standards for asbestos waste handling.	Applies to any activity that could result in discharge of visible emissions to the outside air during the collection, processing, packaging, transporting, or deposition of any asbestos-containing waste material.	Discharge of visible emissions to the outside air is prohibited during asbestos waste handling.
Asbestos Emission Control OAC Section 3745-20-07	This rule establishes the standards for inactive asbestos waste disposal sites.	Applies to inactive asbestos waste disposal sites that could result in discharge of visible emissions to the outside air. Although the site is not considered an inactive waste disposal site, standards and requirements may be relevant and appropriate.	Discharge of visible emissions to the outside air from an inactive asbestos waste disposal site is prohibited or controls are required to prevent exposure of ACM.
Storm water requirements at construction sites 40 CFR Part 450	These rules require that storm water controls be employed at construction sites that exceed 1 acre.	Applies to any construction activity that exceeds 1 acre.	Persons undertaking construction activities (including grubbing and land clearing) at an AOC where the construction footprint is over 1 acre must design and implement erosion and runoff controls.
Generation of contaminated soil or debris OAC Section 3745-52-11	These rules require that a generator determine whether a material generated is a hazardous waste.	Applies to any material that is or contains a solid waste. Must be characterized to determine whether the material is or contains a hazardous waste.	Any person that generates a waste as defined must use prescribed methods to determine if the waste is considered characteristically hazardous using the prescribed methods.
Management of contaminated soil or debris that is or contains a hazardous waste OAC Sections 3745-52-30 through 3745-52-34	These rules require that hazardous waste be properly packaged, labeled, marked, and accumulated on-site pending on- or off-site disposal.	Applies to any hazardous waste or medium containing a hazardous waste that is generated from on-site activities.	All hazardous waste must be accumulated in a compliant manner. This includes proper marking, labeling, and packaging such waste in accordance with the specified regulations. Containers or container areas will be inspected where hazardous waste is accumulated on-site.

Table 10-1. Potential Action-Specific ARARs (continued)

Medium and Citation	Description of Requirement	Potential ARAR Status	Standard
Soil contaminated with RCRA hazardous waste OAC Section 3745-270-49 OAC Section 3745-270-48 UTS	These rules prohibit land disposal of RCRA hazardous waste subject to them, unless the waste is treated to meet certain standards that are protective of human health and the environment. Standards for treating hazardous waste-contaminated soil prior to disposal are set forth in the two cited rules. Using the greater of either technology-based standards or UTS is prescribed.	LDRs apply only to RCRA hazardous waste. This rule is considered for ARAR status only upon generating a RCRA hazardous waste. If any soil is determined to be hazardous under RCRA and if it will be disposed of on-site, this rule is potentially applicable to disposal of the soil.	All soil subject to treatment must be treated as follows: 1. For non-metals (except carbon disulfide, cyclohexanone, and methanol), treatment must achieve 90% reduction in total constituent concentration (primary constituent for which the waste is characteristically hazardous, as well as for any organic or inorganic UHC), subject to item 3 below. 2. For metals and carbon disulfide, cyclohexanone, and methanol, treatment must achieve 90% reduction in constituent concentrations as measured in leachate from the treated media (tested according to the TCLP) or 90% reduction in total constituent concentrations (when a metal removal treatment technology is used), subject to item 3 below. 3. When treating any constituent subject to achieve a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as "90% capped by 10xUTS."

Table 10-1. Potential Action-Specific ARARs (continued)

Medium and Citation	Description of Requirement	Potential ARAR Status	Standard
Soil/debris contaminated with RCRA hazardous waste – variance OAC Section 3745-270-44	The Ohio EPA Director will recognize a variance approved by the USEPA from the alternative treatment standards for hazardous contaminated soil or for hazardous debris.	Potentially applicable to RCRA hazardous soil or debris that is generated and placed back into a unit and that will be disposed of on-site.	A site-specific variance from the soil treatment standards that can be used when treating concentrations of hazardous constituents higher than those specified in the soil treatment standards, minimizing short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede the soil treatment standards.

ACM = Asbestos-containing material.
AOC = Area of concern.
ARAR = Applicable and relevant or appropriate requirement.
CFR = Code of Federal Regulations.
LDR = Land disposal restriction.
OAC = Ohio Administrative Code.
Ohio EPA = Ohio Environmental Protection Agency.
RCRA = Resource Conservation and Recovery Act.
TCLP = Toxicity Characteristic Leaching Procedure.
UHC = Underlying hazardous constituent.
USEPA = U.S. Environmental Protection Agency.
UTS = Universal Treatment Standard.

11.0 TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and describes the GRAs, remedial technologies, and process options that will ultimately be used to develop remedial alternatives with the most appropriate technologies available based on the COC (hexavalent chromium in soil) and AOC characteristics (e.g., soil type and presence of ACM).

11.1 GENERAL RESPONSE ACTIONS

GRAs are actions that may be implemented to satisfy the RAOs. These actions may be individual or a combination of responses. The following GRAs are applicable to C Block Quarry:

- No action,
- Institutional controls,
- Containment, and
- Removal.

Treatment is a GRA involving biological, chemical, physical, or thermal treatment to reduce chemical concentrations at a site. Although in situ or ex situ treatment may be implemented to address hexavalent chromium in soil, the remedial action would still need to address the presence of ACM in soil. Accordingly, treatment alternatives are not considered practical or feasible to address the combined contaminants (hexavalent chromium and ACM) within C Block Quarry soil.

11.2 SCREENING OF TECHNOLOGIES

11.2.1 No Action

The no action GRA is evaluated as the baseline to which other remedial alternatives are compared. No action may be an appropriate alternative if no unacceptable risk is present at the AOC. This GRA provides a baseline against which to compare other more proactive alternatives. In this alternative, no action is taken at the AOC to reduce any risk to human health or the environment. Any existing actions, such as restrictions or monitoring, are discontinued.

No action is retained for remedial alternative development.

11.2.2 Institutional Controls

Institutional controls include engineering measures (i.e., fencing and warning signs) and non-engineering measures (i.e., administrative or legal controls) used to prevent or limit exposure to hazardous substances. Institutional controls do not reduce contaminant mobility, volume, or toxicity.

Implementation of institutional controls can prevent Resident Receptor exposure to hexavalent chromium and ACM. Given that there are no COCs for Commercial/Industrial Land Use, the Army may select institutional controls that allow for the Industrial Receptor to use the site with administrative controls (e.g., no-digging restriction) to be protective from ACM.

If institutional controls are selected as a component of a remedial alternative, the effectiveness of the remedy must undergo five-year reviews. The primary goal of the five-year reviews is to evaluate the implementation and performance of the remedy to determine if the remedy is or will be protective of human health and the environment. The five-year reviews are discontinued when the remedy achieves CUGs for Unrestricted (Residential) Land Use.

Institutional controls, such as restricting the use of the site to the Industrial Receptor and having no-digging restrictions, are retained for remedial alternative development.

11.2.3 Containment

Containment technologies (e.g., clay cap and soil covers) are often used to prevent, or significantly reduce, the migration of contaminants in soil or sediment. In general, containment is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards, technical impracticality, and/or unrealistic cost. The implementation of a containment technology would prevent Unrestricted (Residential) Land Use (e.g., cover would not be allowed to be disturbed while contaminants are in place).

Containment technologies would add no benefit to C Block Quarry because there are no Industrial Receptor COCs that need to be contained to attain Commercial/Industrial Land Use. Although a cap or soil cover would prevent Industrial Receptor exposure to ACM, the practicality, implementability, and cost of removing the small quantity of surficial ACM significantly outweighs the option to implement a cover.

Containment technologies are not retained for remedial alternative development.

11.2.4 Removal

Removing contaminated soil from the AOC reduces or eliminates the potential for long-term human and environmental exposure to chemicals exceeding concentrations determined to be protective for a given Land Use. Removing soil may be combined with pre-treatment prior to off-site disposal, or soil may be shipped without pre-treatment.

Disposal and handling, after removal, involve the final and permanent placement of waste material in a manner protective of human health and the environment. The contaminated soil is disposed of on-site in an engineered facility or off-site in a permitted or licensed facility (i.e., a regulated landfill). Similarly, concentrated waste resulting from treatment processes is disposed of on-site in a permanent disposal cell or off-site in an approved disposal facility.

Removal is retained for remedial alternative development.

12.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section describes the remedial alternatives developed and retained from the technology screening process. The retained remedial alternatives are composed of implementable and cost-effective technology types and process options that address contaminants in soil at C Block Quarry.

The retained remedial alternatives are:

- Alternative 1: No Action.
- Alternative 2: Surficial ACM Removal and Land Use Controls (LUCs).
- Alternative 3: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.

A detailed description of each remedial alternative is provided in the following sections.

12.1 ALTERNATIVE 1: NO ACTION

The no action alternative is required for evaluation under the NCP. This alternative is the baseline to which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) will be discontinued and no future actions will take place to protect human receptors or the environment. Contaminants in soil will not be removed or treated.

12.2 ALTERNATIVE 2: SURFICIAL ASBESTOS-CONTAINING MATERIAL REMOVAL AND LAND USE CONTROLS

Alternative 2 consists of 1) removing the surficial ACM through use of non-intrusive, no-digging methods to prevent Industrial Receptor exposure to ACM in surface soil; 2) implementing LUCs to prevent the Industrial Receptor from digging and possibly encountering subsurface ACM; 3) implementing LUCs to prevent Resident Receptor use of the site; and 4) performing five-year reviews to assess the effectiveness of LUCs and whether there is a need to modify them.

This alternative will meet the RAOs by:

1. Implementing LUCs to prevent Unrestricted (Residential) Land Use of the site and corresponding Resident Receptor exposure to hexavalent chromium and ACM.
2. Removing surficial ACM and implementing no-digging restrictions to prevent Industrial Receptor exposure to ACM.

Components of this remedial alternative are summarized in the following subsections.

12.2.1 Surficial Asbestos-Containing Material Removal

Alternative 2 will include the removal of ACM that was observed on the ground surface at C Block Quarry. An estimated 10 yd^3 of exposed ACM (e.g., transite/shingle and steel panels with block insulation and paper) were observed to be in surface soil at C Block Quarry. As part of the ACM removal, the site will undergo a new, updated inspection to ensure exposed ACM is identified.

The ACM will be removed by a certified Asbestos Hazard Abatement Specialist. Personnel will execute the removal with proper personal protective equipment (PPE), as required by Occupational Safety and Health Administration asbestos removal requirements. If needed, water will be used to mist the ACM to ensure asbestos does not become airborne during the removal. The ACM will be removed and placed in an appropriate-sized container that has a 12-mil liner. The container will be sealed, adequately marked in accordance with U.S. Department of Transportation requirements, and shipped for disposal at an approved landfill. Appropriate waste manifests will accompany each waste shipment. Only regulated and licensed transporters and vehicles will be used.

12.2.2 Asbestos-contaminated Soil Assessment

Ten soil samples within C Block Quarry were analyzed for asbestos. Nine of the samples had no detections and one of the samples had a detection at less than 1% chrysotile. Although asbestos content in soil is considered nonfriable, this section further evaluates the potential of asbestos traveling beyond the LUC boundary.

Wind and sediment erosion at the C Block Quarry AOC is negligible. As presented in Figure 2-1, soil within the C Block Quarry AOC boundary is predominantly surrounded by approximately 25-ft-high walls created during the quarry operations. These high walls will reduce the likelihood of wind erosion. The AOC is heavily vegetated, as further confirmed during a site walk with Ohio EPA conducted in 2017, which will deter soil erosion. In addition, surface water is not a permanent feature of the site, and rain events generally do not create ponds or surficial flow.

As presented in Figure 5-5, the one sample location that had asbestos in soil is in flat terrain, very near the approximately 25-f- high quarry wall, and thus is unlikely to result in the limited asbestos in soil traveling beyond the LUC boundary.

12.2.3 Land Use Controls

Under this remedial alternative, the Army will implement the LUCs listed below to achieve the performance objectives for C Block Quarry:

1. Prevent Resident Receptor use of the site, as hexavalent chromium in soil above the residential RSL of 3 mg/kg will remain on-site.
2. Prevent intrusive and digging activities, as friable ACM potentially exists in the subsurface soil.
3. Install signs to enhance compliance with digging restrictions at the site.
4. Install Seibert stakes to ensure high visibility of the site boundary.
5. Maintain the LUC training program.

12.2.4 Land Use Control Remedial Design

A LUC remedial design (RD) will be developed to present the site's Land Use, activities, RAOs, and LUC requirements for C Block Quarry. The LUC requirements will include LUC objectives, Land Use restrictions, site disturbance restrictions, sign specification, potential modification and termination of LUCs, monitoring and reporting requirements, CERCLA five-year reviews, LUC enforcement, and property transfers.

This information will be presented in an attachment to the *Property Management Plan for the Designated Areas of Concerns and Munitions Response Sites* (USACE 2012d). The PMP identifies LUCs and restrictions for specific AOCs/MRSs within the former RVAAP. The procedures within the PMP are intended to comply with the Department of Defense Manual, Defense Environmental Restoration Program Management, Number 4715.20, March 9, 2012 (Department of Defense Office of the Under Secretary of Defense for Acquisition, Technology and Logistics), and Ohio Revised Code 5913.10.

12.2.5 Five-Year Reviews

CERCLA Section 121(c) five-year reviews will be conducted for C Block Quarry to assess the effectiveness of LUCs and whether there is a need to modify them. The Army will verify whether the LUCs continue to be properly documented and maintained. Each review of the remedy will evaluate whether Land Use has changed. If the risk levels have changed since initial LUC implementation, LUC modifications will be considered, which may include a change in monitoring frequency. A five-year review report will be submitted.

12.3 ALTERNATIVE 3: EXCAVATION AND OFF-SITE DISPOSAL – ATTAIN UNRESTRICTED (RESIDENTIAL) LAND USE

Hexavalent chromium is identified as a Resident Receptor COC in soil. Additionally, ACM (e.g., transite/shingle and steel panels with block insulation and paper) is present on the ground surface at C Block Quarry. This remedial alternative includes a subsurface evaluation to determine if and where ACM is present in the subsurface soil, pre-excavation and waste characterization sampling, excavation and disposal of surface and subsurface soil to remove COC-contaminated soil and ACM, and site restoration.

This alternative will meet the RAOs by removing soil with hexavalent chromium concentrations exceeding the residential RSL of 3 mg/kg and removing surface and any potential subsurface friable ACM.

This remedial alternative requires coordination of remediation activities with Ohio EPA, OHARNG, and the Army. Coordinating with stakeholders during implementation of the excavation minimizes health and safety risks to on-site personnel and potential disruptions of the former RVAAP/Camp Ravenna activities. The time period to complete this remedial action is relatively short and does not include an operation and maintenance (O&M) period to assess impacts from soil, as Unrestricted (Residential) Land Use is achieved.

Components of this remedial alternative are summarized in the following subsections.

12.3.1 Subsurface Asbestos-Containing Material Evaluation

Friable ACM was identified on the ground surface during the RI. Potential exposure to the Resident Receptor includes digging to 13 ft bgs, although the maximum depth to bedrock at C Block Quarry is estimated to be 7 ft bgs. This alternative will include excavating test trenches throughout the quarry bottom to identify any possible subsurface ACM. Additional areas in which ACM is present in soil will be removed and disposed of accordingly.

12.3.2 Pre-Excavation and Waste Characterization Sampling

To coincide with, and support, development of the RD, pre-excavation sampling will be conducted to confirm the limits of soil excavation and minimize the time required to implement the remedial action. Due to the presence of friable ACM, the soil removed per this alternative is assumed to be disposed of as ACM. However, waste characterization samples will be collected from the areas requiring removal. The waste characterization samples will be collected as ISM samples from the areas undergoing this remedy to provide data to properly profile the waste and determine if it is characteristically non-hazardous or hazardous. Each ISM sample analysis may include (but is not limited to) TCLP metals, TCLP SVOCs, TCLP pesticides, TCLP herbicides, reactive cyanide, reactive sulfide, and PCBs.

12.3.3 Remedial Design

An RD will be developed prior to initiating remedial actions. This RD will outline construction permitting requirements; site preparation activities (e.g., staging and equipment storage areas, truck routes, and storm water controls); requirements for removing, controlling, and transporting ACM; extent of the excavation; sequence and description of excavation and site restoration activities; decontamination; and segregation, transportation, and disposal of various waste streams. Engineering and administrative controls (e.g., erosion and health and safety) will be developed during the active construction period to ensure remediation workers and the environment are protected. In addition, the RD will specify the sampling protocol and analytical methods to be used for asbestos analysis and chemical analysis of the soil.

As part of the development of the RD, the site will undergo a new, updated inspection to ensure exposed ACM is identified. Additionally, this RD will contain an Asbestos Soil Abatement Plan to outline requirements specific to the removal of ACM, including identifying key personnel and PPE, specifying air monitoring requirements, and stating the site control measures.

12.3.4 Soil Excavation and Disposal

Prior to any ground disturbance, the excavation area will be surveyed and demarcated by stakes. Erosion control material, such as silt fences and straw bales, will be installed as needed to minimize sediment runoff. Dust generation will be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water. The health and safety of remediation workers, on-site Camp Ravenna employees, and the general public will be covered in a site-specific health and safety plan.

Asbestos abatement-trained personnel will install asbestos caution tape and signage to demarcate the regulated areas. A decontamination unit will be erected with connecting water and filter drain that will be properly disposed of.

All personnel entering the asbestos work areas will have appropriate PPE for asbestos work. PPE may include full-body coveralls and half-mask air-purifying respirators equipped with high-efficiency particulate air (HEPA) filters. During the excavation, asbestos air samples will be collected in accordance with Occupational Safety and Health Administration Class I and Class II asbestos removal requirements. Water will be used to mist the excavated soil.

Once adequately wetted, the soil will be removed by a front-end loader and placed in a 12-mil, lined, roll-off dumpster or haul truck for transport and disposal at an approved landfill. Oversized debris will be crushed or otherwise processed to meet disposal facility requirements. The lateral and vertical extents of excavation defined in Table 9-2 account for the hexavalent chromium exceedance and ACM in soil to 2 ft bgs. Additional excavation may be required to remove ACM from the subsurface below 2 ft bgs based on the subsurface ACM evaluation described in Section 12.3.1.

Once the soil is loaded, the container will be covered and affixed with appropriate signage to the truck, as required for transportation to the approved landfill. All trucks are inspected prior to exiting the AOC. Appropriate waste manifests accompany each waste shipment. Only regulated and licensed transporters and vehicles will be used. All trucks travel pre-designated routes within Camp Ravenna.

Excavated soil will be disposed of at an existing off-site facility licensed and permitted to accept the characterized waste stream. The selection of an appropriate facility considers the types of waste, location, transportation options, and cost. Waste streams with different constituents and/or characteristics may be generated. Disposal cost savings are possible by utilizing specific disposal facilities for different waste streams.

12.3.5 Confirmatory Sampling

Once the vertical and lateral extents of the excavation are complete and there is no visible ACM, confirmation samples will be collected from the excavation floor and sidewalls. The confirmation samples will be analyzed for hexavalent chromium and asbestos content. If the analyses indicate the hexavalent chromium concentration or asbestos content in soil exceeds the CUGs, further excavation will be conducted. If confirmation sample results are less than CUGs, further soil removal is not required, and the area can be restored.

12.3.6 Restoration

Upon completion of soil excavation, all disturbed and excavated areas will be backfilled with clean soil and graded to meet neighboring contours. The backfill will come from a clean source that was previously sampled and approved for use by Ohio EPA. After the area is backfilled and graded, workers will apply a seed mixture (as approved by OHARNG) and mulch. Restored areas will be inspected and monitored as required in the storm water best management practices established in the RD.

13.0 ANALYSIS OF REMEDIAL ALTERNATIVES

13.1 INTRODUCTION

This section presents a detailed analysis of the viable remedial alternatives retained and developed throughout the technology screening process. The purpose of this detailed analysis is to provide stakeholders ample information to identify and select an appropriate remedy and prepare the PP. Based on this detailed analysis, one or more of the retained alternatives are recommended for soil requiring remediation at C Block Quarry.

CERCLA guidance suggests the principal element of the selected remedy should reduce volume, toxicity, or mobility. If the selected remedy's principal element does not meet this criterion, an explanation as to why must be presented. In addition, the remedy must meet the following four statutory requirements:

- Be protective of human health and the environment,
- Comply with ARARs (or provide justification for a waiver),
- Be cost effective, and
- Use permanent solutions and treatment or recovery technologies to the maximum extent practicable.

There are nine established NCP evaluation criteria used to perform a detailed analysis of remedial alternatives to ensure the selected alternative meets the above CERCLA statutory requirements. The nine criteria are grouped into three categories: threshold, balancing, and modifying criteria.

13.1.1 Threshold Criteria

There are two evaluation criteria classified as threshold criteria. This criteria group relates directly to statutory findings. Threshold criteria must be met by the selected remedy. The evaluation criteria in this group are:

1. Overall protection of human health and the environment, and
2. Compliance with ARARs.

Each alternative must be evaluated to determine how it achieves and maintains protection of human health and the environment. An alternative is considered to be protective of human health and the environment if it complies with medium-specific CUGs. Similarly, each remedial alternative must be assessed to determine how it complies with ARARs or, if a waiver is required, an explanation of why a waiver is justified must be presented.

13.1.2 Balancing Criteria

There are five evaluation criteria classified as balancing criteria. This group represents the primary criteria upon which the detailed and comparative analysis of each remedial alternative are based. The evaluation criteria in this group are:

3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility, or volume through treatment;
5. Short-term effectiveness;
6. Implementability; and
7. Cost.

Long-term effectiveness and permanence evaluates the magnitude of residual risk (risk remaining after implementing the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that provide the highest degree of long-term effectiveness and permanence leave little or no untreated waste at the AOC, make long-term maintenance and monitoring unnecessary, and minimize the need for LUCs.

Reduction of toxicity, mobility, or volume through treatment evaluates the ability of the alternative to reduce the toxicity, mobility, or volume of the waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment are also assessed.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve media-specific preliminary CUGs.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal, state, and local agencies.

Cost analyses estimate the dollar cost of each alternative. The cost estimates in this report are based on reference manuals, historical costs, vendor quotes, and engineering estimates. Costs are reported in base year 2017 dollars. The cost estimates are for guidance in project evaluation and implementation and are believed to be accurate within a range of -30% to +50%, in accordance with USEPA guidance (USEPA 1988b). Actual costs could be higher than estimated due to unexpected conditions or potential delays. Details and assumptions used in developing cost estimates for each of the alternatives are provided in Appendix K.

13.1.3 Modifying Criteria

There are two evaluation criteria categorized as modifying criteria. Modifying criteria are formally evaluated as part of the ROD and after the public has had an opportunity to comment on the PP. This criteria group consists of:

8. State acceptance, and
9. Community acceptance.

State acceptance considers comments received from agencies of the state of Ohio. Ohio EPA is the primary state agency supporting this investigation. Ohio EPA, as well as other state agencies, will provide comments on the FS and the preferred remedy presented in the PP. This criterion is addressed in the Responsiveness Summary of the ROD.

Community acceptance considers comments made by the community, including stakeholders, on the alternatives being considered. Comments will be solicited and accepted from the community on the FS, and the preferred remedy will be presented in the PP. This criterion is addressed in the Responsiveness Summary of the ROD.

Modifying criteria are future activities. These actions are the same for the retained alternatives. Therefore, the detailed analysis of the remedial alternatives does not include an evaluation of modifying criteria. The detailed analysis of the retained remedial alternatives for C Block Quarry is presented in the following sections. This analysis is based on seven evaluation criteria (two threshold and five balancing criteria).

13.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

A detailed analysis of each alternative against the seven NCP evaluation criteria is contained in the following sections. The detailed analysis further defines each alternative (if necessary), compares the alternatives against one another, and presents considerations common to the alternatives.

As presented in Section 12.0, the following remedial alternatives were retained for C Block Quarry:

- Alternative 1: No Action.
- Alternative 2: Surficial ACM Removal and LUCs.
- Alternative 3: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.

13.2.1 Alternative 1: No Action

Under this alternative, no remedial actions will take place for any media to meet the RAOs. The contaminated soil posing unacceptable risk to the Resident Receptor and friable ACM will be left in place. Existing access restrictions (e.g., Camp Ravenna perimeter fence) will not be continued.

Environmental monitoring will not be performed, and no restrictions on Land Use will be implemented.

13.2.1.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective, as a soil COC posing unacceptable risk to the Resident Receptor and ACM will remain on-site.

13.2.1.2 Compliance with ARARs

Potential ARARs for remediating soil at C Block Quarry are presented in Section 10.0. Because no action would be taken to address the contamination, Alternative 1 would not meet any ARARs and is considered not compliant.

13.2.1.3 Long-Term Effectiveness and Permanence

Alternative 1 will have no long-term management measures to prevent Resident Receptor exposure to hexavalent chromium concentrations exceeding the residential RSL of 3 mg/kg or any receptor's exposure to ACM. Existing security will be discontinued, and there will be no access controls or LUCs at C Block Quarry.

13.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 will not reduce the toxicity, mobility, or volume of the COC. This alternative will not remove or treat soil with concentrations of the hexavalent chromium above the residential RSL of 3 mg/kg.

13.2.1.5 Short-Term Effectiveness

Alternative 1 will have no additional short-term health risks to the community, remediation workers, or the environment. This remedial alternative will offer no short-term benefits or progress to achieve the RAOs.

13.2.1.6 Implementability

Because it does not change the existing condition at C Block Quarry, this alternative will not require any additional effort to implement.

13.2.1.7 Cost

The present value cost to complete Alternative 1 is $0. No capital and O&M costs are associated with this alternative.

13.2.2 Alternative 2: Surficial Asbestos-Containing Material Removal and Land Use Controls

Alternative 2 implements the removal of surficial ACM and LUCs. The LUCs limit activities in C Block Quarry to those identified for Industrial Receptor and other essential security, safety, and natural resources management activities, with the addition of prohibiting digging or subsurface activities. Implementing Alternative 2 does not result in Unrestricted (Residential) Land Use of the site.

13.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 is protective of the Resident Receptor by implementing LUCs to not allow for Unrestricted (Residential) Land Use, thereby preventing Resident Receptor exposure to COCs and ACM. Alternative 2 is protective of the Industrial Receptor, as no soil COCs require remediation for the Industrial Receptor, ACM on the ground surface will be removed, and no-digging LUCs will prevent exposure to potential subsurface ACM.

The ERA concluded there is chemical contamination and possible risk but no important or significant ecological resources at C Block Quarry, and the recommendation is no further action for protection of ecological resources (Section 7.3). Under Alternative 2, current risk is not reduced, and the ecological importance of the AOC remains unchanged. Current Land Use allows for sustainability of terrestrial habitat for ecological receptors.

13.2.2.2 Compliance with ARARs

There are no identified chemical- or location-specific ARARs for Alternative 2. Due to the presence of asbestos, the requirements of OAC 3745-20-07(A)(1-3) are considered a potential ARAR. This requirement stipulates that no visible asbestos emissions may be discharged. Due to the nature of the AOC (currently vegetated), discharge of visible emissions is not expected with LUCs preventing ground disturbance. Land Use and access controls ensure that disturbance of the AOC will not occur, thus eliminating emissions. This alternative complies with the identified requirements.

13.2.2.3 Long-Term Effectiveness and Permanence

Alternative 2 is protective in the long-term for the Commercial/Industrial Land Use with the addition of no-digging restrictions. As indicated previously, the Army does not intend to use C Block Quarry for Unrestricted (Residential) Land Use.

This alternative implements removal of surficial ACM and LUCs to prevent Industrial Receptor exposure to ACM. LUCs currently exist at the former RVAAP/Camp Ravenna. Exposure to contaminants in soil at C Block Quarry will be controlled by restricting future Land Use and maintaining a LUC training program. The AOC will undergo CERCLA five-year reviews and monitoring while COCs or ACM prevent Unrestricted (Residential) Land Use.

13.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not achieve a reduction in the toxicity or volume of contaminated media. The mobility of ACM currently on the ground surface will be reduced when transported to an off-site disposal facility.

13.2.2.5 Short-Term Effectiveness

This alternative includes removal of surficial ACM (estimated 10 yd^3 of material) through non-intrusive, no-digging methods, which include the potential for worker exposure during removal of ACM as well as exposure to the community during transportation of ACM. Workers would follow a health and safety plan and wear appropriate PPE to minimize exposures. Mitigation measures are used to minimize short-term impacts, such as erosion and dust control, during construction. Additional mitigation measures due to handling ACM would include having an Asbestos Hazard Abatement Specialist on-site, adequately wetting the asbestos before removal, and ensuring removed material is wrapped in minimum 12-mil liner and sealed prior to transport.

Remedial actions include 30 years of O&M, as this AOC is not released for Unrestricted (Residential) Land Use.

13.2.2.6 Implementability

Alternative 2 is technically implementable. Removal of the small quantity of ACM and waste handling are conventional activities in construction projects of this kind. However, due to the type of waste (friable ACM), only select disposal facilities are available that can accept generated waste, and enhanced personnel protection is required.

LUCs being implemented currently exist at the former RVAAP/Camp Ravenna, and new controls are implementable with proper oversight of the Army. C Block Quarry currently has administrative access restrictions implemented at the AOC.

13.2.2.7 Cost

The present value cost to complete Alternative 2 is approximately $108,534 (in base year 2017 dollars). This alternative includes an O&M period. See Appendix K for a detailed description of Alternative 2 costs.

13.2.3 Alternative 3: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use

Under this alternative, removal and off-site disposal will be implemented to remove contaminated soil and ACM at C Block Quarry that pose unacceptable risk to the Resident Receptor. No additional controls are required because, if the site is protective of the Resident Receptor, it is considered protective of all potential RVAAP receptors, as established in the Technical Memorandum (ARNG 2014).

13.2.3.1 Overall Protection of Human Health and the Environment

Under this alternative, contaminated soil will be excavated and removed from C Block Quarry. Removing contaminated soil from the AOC, as described in the remedial alternative, results in the AOC being protective of human health for Unrestricted (Residential) Land Use and will be protective of all potential RVAAP receptors.

The ERA concluded there is chemical contamination and possible risk but no important or significant ecological resources at C Block Quarry, and the recommendation is no further action for protection of ecological resources (Section 7.3). Current Land Use allows for sustainability of terrestrial habitat for ecological receptors. Excavating soil disrupts approximately 13,654 ft^2 (0.31 acres) of the forest and shrubland area. The small cleared area should recover from excavation activities in 1 to 5 years.

13.2.3.2 Compliance with ARARs

There are no identified chemical- or location-specific ARARs for Alternative 3. However, there are action-specific ARARs for this alternative. Those requirements identified as ARARs deal primarily with characterizing, managing, and disposing contaminated soil generated from excavation. Disturbing the soil will also trigger ARARs for controlling fugitive dust emissions and potentially may trigger ARARs for erosion-control measures. The presence of ACM within the excavation footprint also will trigger ARARs related to asbestos emission control, as defined in Table 10-1. However, if the entirety of the ACM is removed from the surface and subsurface soil at C Block Quarry, the relevance or appropriateness of OAC Section 3745-20-07 for inactive asbestos waste disposal sites would no longer be applicable. Potential ARARs are presented in Section 10.0.

13.2.3.3 Long-term Effectiveness and Permanence

Alternative 3 will provide long-term effectiveness and permanence. Contaminated soil will be excavated and transported to an off-site disposal facility to result in Unrestricted (Residential) Land Use, thereby mitigating risk to human health and the environment. Accordingly, LUCs will not be required when the removal activities are complete. No CERCLA five-year reviews or O&M sampling will be required.

13.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 will involve excavating contaminated soil for disposal in a permitted solid waste landfill. This alternative will reduce the mobility of hexavalent chromium and ACM by placing the contaminated soil in an engineered, lined disposal cell at the landfill. This alternative will not reduce the toxicity or volume of the contaminated soil.

13.2.3.5 Short-Term Effectiveness

There will be potential short-term worker and community exposures associated with Alternative 3. Workers have the potential to be exposed during excavation activities; however, a health and safety plan that identifies appropriate PPE for workers will minimize and/or eliminate exposures. The community near the excavation area and along the route to the disposal facility may be exposed during removal and transportation activities.

Mitigation measures during excavation, such as erosion and dust control, and asbestos emission control, will minimize/eliminate potential short-term impacts. The community will be protected during soil transport by inspecting vehicles before and after use, decontaminating as needed, covering the transported waste, observing safety protocols, following pre-designated routes, and limiting the distance to the disposal facility. Transportation risk associated with material leaks will increase with distance and volume of material. Transportation of soil to an off-site disposal facility will comply with all applicable state and federal regulations. Pre-designated travel routes will be established, and an emergency response program will be developed to facilitate any potential accident response.

Excavating the soil and restoring the AOC is estimated to be completed in less than 1 month. Storm water controls will be monitored weekly for 5 weeks, or until the vegetation is 70% established. Upon completing the excavation and site restoration activities, C Block Quarry will be released for Unrestricted (Residential) Land Use.

13.2.3.6 Implementability

Alternative 3 can be implemented after the RD is developed and approved by stakeholders and all appropriate coordination with local, state, and federal agencies is completed. The RD will contain an Asbestos Soil Abatement Plan to outline requirements specific to the removal of ACM, including identifying key personnel and PPE, specifying air monitoring requirements, and stating the site control measures.

Excavating soil, constructing temporary roads, and conducting waste handling are conventional, straightforward construction techniques and methods. In addition, asbestos abatement-trained personnel will install asbestos caution tape and signage to demarcate the regulated areas. A decontamination unit will be erected with connecting water and filter drain that will be properly disposed. All personnel entering the asbestos work areas will have appropriate PPE for asbestos work that may include full-body coveralls and half-mask air-purifying respirators equipped with HEPA filters. These additional requirements associated with ACM make Alternative 3 slightly more difficult to implement.

Excavation activities will be coordinated with Camp Ravenna and OHARNG to minimize alterations and/or impacts to OHARNG proceedings. The RD will identify access routes to the AOC for heavy equipment and provide steps to minimize potential hazards to on-site personnel. Developing the RD and coordinating with local, state, and federal agencies increases the implementation difficulty of Alternative 3.

13.2.3.7 Cost

The present value cost to complete Alternative 3 is approximately $390,224 (in base year 2017 dollars). This alternative does not include an O&M period subsequent to the soil removal, as Unrestricted (Residential) Land Use is achieved. See Appendix K for a detailed description of Alternative 3 costs.

13.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The comparative analysis provides a means by which remedial alternatives can be directly compared to one another with respect to common criteria. Table 13-1 provides a comparative analysis of the alternatives.

Overall protection and compliance with ARARs are threshold criteria that must be met by any alternative to be eligible for selection. If any alternative is considered "not protective" for overall protection of human health and the environment or "not compliant" for compliance with ARARs, it is not eligible for selection as the recommended alternative.

Alternative 1 is not protective of human health and is not compliant with ARARs. In addition, Alternative 1 does not meet the RAOs to prevent Resident Receptor exposure to soil with concentrations of hexavalent chromium above the residential RSL (3 mg/kg) or prevent exposure to ACM. Therefore, Alternative 1 is not eligible for selection.

For the remaining alternatives, the balancing criteria (short- and long-term effectiveness; reduction of contaminant toxicity, mobility, or volume through treatment; ease of implementation; and cost) are used to select a recommended alternative among the alternatives that satisfies the threshold criteria. The remaining alternatives are scored amongst one another for each of the balancing criteria and a total score is generated.

Alternative 2 – Surficial ACM Removal and LUCs scores the highest and is the recommended alternative. This alternative scores highly in short-term effectiveness and implementability, as the minimal ACM removal will have low risks and limited exposure to workers and the public. In addition, LUCs are already implemented at the former RVAAP/Camp Ravenna, and the cost to implement Alternative 2 is significantly less than the cost of Alternative 3.

Table 13–1. Summary of Comparative Analysis of Remedial Alternatives

NCP Evaluation Criteria	Alternative 1: No Action	Alternative 2: Surficial ACM Removal and LUCs	Alternative 3: Excavation and Off-Site Disposal – Attain Unrestricted (Residential) Land Use
Threshold Criteria	***Result***	***Result***	***Result***
1. Overall Protection of Human Health and the Environment	Not protective	Protective	Protective
2. Compliance with ARARs	Not compliant	Compliant	Compliant
Balancing Criteria	***Score***	***Score***	***Score***
3. Long-term Effectiveness and Permanence	Not applicable	1	2
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Not applicable	1	2
5. Short-term Effectiveness	Not applicable	2	1
6. Implementability	Not applicable	2	1
7. Cost	Not applicable ($0)	2 ($108,534)	1 ($390,224)
Balancing Criteria Score	*Not applicable*	*8*	*7*

Any alternative considered "not protective" for overall protection of human health and the environment or "not compliant" for compliance with ARARs is not eligible for selection as the recommended alternative. Therefore, that alternative is not scored as part of the balancing criteria evaluation.

Scoring for the balancing criteria is as follows for applicable alternatives: Most favorable = 2, least favorable = 1. The alternative with the highest total balancing criteria score is considered the most feasible.

ACM = Asbestos-containing material.

ARAR = Applicable or relevant and appropriate requirement.

NCP = National Oil and Hazardous Substances Pollution Contingency Plan.

LUC = Land use control.

14.0 CONCLUSIONS AND RECOMMENDED ALTERNATIVE

14.1 CONCLUSIONS

The primary purposes of this RI/FS Report are to review the history of C Block Quarry, summarize RI activities, evaluate results of the RI, develop RAOs and remedial alternatives, and present a recommended alternative to address contaminated soil at the AOC.

Sediment and surface water are not present or media of concern at this AOC. Conclusions of the ERA indicate remedial actions are not needed to protect ecological resources. Fate and transport modeling indicates soil remediation to protect groundwater is not warranted. Remedial actions specific to the groundwater medium at C Block Quarry will be evaluated in a separate report.

The HHRA identified one COC (hexavalent chromium) in soil at C Block Quarry that posed unacceptable risk for the Resident Receptor, which prevents achieving Unrestricted (Residential) Land Use without appropriate remedial actions. In addition, ACM was observed in the ground surface at the site. Accordingly, the RAOs for C Block Quarry were established as follows:

- Prevent Resident Receptor exposure to hexavalent chromium in soil with concentrations above 3 mg/kg at sample locations CBLss-003M and CBLss-005M and prevent Resident Receptor and Industrial Receptor exposure to friable ACM.

CUGs were established and remedial alternatives were developed and evaluated to determine the most feasible remedial alternative at C Block Quarry. The remedial alternatives considered are as follows:

- Alternative 1: No Action.
- Alternative 2: Surficial ACM Removal and LUCs.
- Alternative 3: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.

These alternatives are applicable and are compared against one another to provide information of sufficient quality and quantity to justify the selection of a remedy. The following section provides the recommended alternative for the contaminated soil at C Block Quarry.

14.2 RECOMMENDED ALTERNATIVE

The recommended alternative for C Block Quarry is Alternative 2: Surficial ACM Removal and LUCs. Alternative 2 meets the threshold and primary balancing criteria and meets the RAOs by removing ACM on the ground surface and implementing LUCs to prevent Unrestricted (Residential) Land Use and prohibit digging by the Industrial Receptor. The cost of Alternative 2 is $108,534, which includes O&M costs.

The next step in the CERCLA process is to prepare a PP to solicit public input on the remedial alternatives. The PP will present these alternatives with the preferred remedial alternative for C Block Quarry. Comments on the PP provided by state and federal agencies and the public will be presented in the Responsiveness Summary section of the C Block Quarry ROD. The ROD will briefly summarize the history, characteristics, and risks of the AOC and will document the selected remedy.

15.0 AGENCY COORDINATION AND PUBLIC INVOLVEMENT

The Army is the lead agency responsible for executing the CERCLA process and ultimately completing an approved ROD for soil, sediment, and surface water at C Block Quarry. 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 C Block Quarry environmental investigation, restoration efforts, and final selection of a remedy.

As described in Section 13.0, two of the nine NCP evaluation criteria are known as “modifying criteria”: state acceptance and community acceptance. These criteria provide a framework for obtaining the necessary agency coordination and public involvement in the remedy selection process.

15.1 STATE ACCEPTANCE

State acceptance considers comments received from agencies of the state of Ohio on the proposed remedial alternative. Ohio EPA is the lead regulatory agency for supporting decisions regarding C Block Quarry. This RI/FS 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 C Block Quarry meets the needs of the state of Ohio and fulfills the requirements of the DFFO (Ohio EPA 2004). Ohio EPA provided comments on this RI/FS Report and will provide comments on the subsequent PP and ROD. The Army will obtain Ohio EPA concurrence prior to the final selection of the remedy for soil, sediment, and surface water at C Block Quarry.

15.2 COMMUNITY ACCEPTANCE

Community acceptance considers comments provided by community members. CERCLA 42 U.S. Code 9617(a) emphasizes early, constant, and responsive community relations. The Army has prepared a *Community Relations Plan for the Ravenna Army Ammunition Plant Restoration Program* (Vista 2016) to facilitate communication between the Camp Ravenna and the community surrounding Ravenna, Ohio, during environmental investigations and potential remedial action. 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. Code 9617(a) requires an Administrative Record to be established “at or near the facility at issue.” Relevant documents regarding the former RVAAP/Camp Ravenna 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
Environmental Office
1438 State Route 534 SW
Newton Falls, OH 44444

Access to Camp Ravenna is restricted but can be obtained by contacting the environmental office at (614) 336-6136. 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 former RVAAP 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 issuing the RI/FS Report and the PP. As required by the CERCLA regulatory process and the Community Relations Plan (Vista 2016), the Army will hold a public meeting and request public comments on the PP for C Block Quarry. 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.

16.0 REFERENCES

American Cancer Society 2015. Cancer Facts & Figures 2015. Website: www.cancer.org. 2015.

ARNG (Army National Guard) 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). February 2014.

ATSDR (Agency for Toxic Substances and Disease Registry) 1995. *Public Health Statement for Polycyclic Aromatic Hydrocarbons (PAHs)*. United States Department of Health and Human Services, Public Health Service. August 1995.

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, Volume 3, Issue 4. 1994.

BTAG (U.S. Army Biological Technical Assistance Group) 2005. *Technical Document for Ecological Risk Assessment: Process for Developing Management Goals*. August 2005.

DoD (U.S. Department of Defense) 2012. *Defense Environmental Restoration Program (DERP) Management,* Manual Number 4715.20. March 2012.

DoD-MERIT 2011. *Chemical & Material Emerging Risk Alert, Hexavalent Chromium (Cr(VI)).* Chemical & Material Risk Management Directorate, Office Under the Secretary of Defense Acquisition, Technology & Logistics, Risk Alert #01-11. Website: http://www.denix.osd.mil/cmrmp/ecmr/ecprogrambasics/resources/chemical-material-emerging-risk-alert-for-hexavalent-chromium-cr-vi/. January 2011.

EQM (Environmental Quality Management, Inc.) 2010a. *Facility-wide Groundwater Monitoring Program Report on the January 2010 Sampling Event, Ravenna Army Ammunition Plant, Ravenna, Ohio*. July 2010.

EQM 2010b. *Facility-wide Groundwater Monitoring Program Annual Report for 2009, Ravenna Army Ammunition Plant, Ravenna, Ohio*. March 2010.

EQM 2015. *Final Facility-wide Groundwater Monitoring Program Annual Report for 2014, Former Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio*. March 2015.

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.

Leidos 2019. *Facility-wide Groundwater Monitoring Program, RVAAP-66 Facility-wide Groundwater, Annual Report for 2018*. 2019.

MADEP (Massachusetts Department of Environmental Protection) 2002. *Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil*. May 2002.

MKM (MKM Engineers, Inc.) 2004. *Sampling and Analysis Plan Addendum for the Characterization of 14 RVAAP AOCs at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. October 2004.

MKM 2007. *Final Characterization of 14 AOCs at Ravenna Army Ammunition Plant.* March 2007.

Mogul (Mogul Corporation) 1982. *Soil and Sediment Analysis Performed for: Ravenna Arsenal, Ravenna, Ohio*. May 1982.

Mogul 1986. *C Block Quarry Soil Contamination Survey, Ravenna Arsenal, Ravenna, Ohio*. December 1986.

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.

ODNR (Ohio Department of Natural Resources) 2016. *Ohio's Listed Species*. http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/information/pub356.pdf. 2016.

OHARNG (Ohio Army National Guard) 2009. *Land Use Summary Table,* personal communication from Katie Elgin OHARNG, 21 August 19, 2009.

OHARNG 2014. *Integrated Natural Resources Management Plan at the Camp Ravenna Joint Military Training Center, Portage and Trumbull Counties, Ohio*. December 2014.

Ohio EPA (Ohio Environmental Protection Agency) 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.

RVAAP (Ravenna Army Ammunition Plant) 2013. *DNT Isomers, RVAAP-66 Facility-wide Groundwater, Ravenna Army Ammunition Plant, Ravenna, Ohio.* Memorandum from Mark Patterson, RVAAP Facility Manager to Eileen Mohr, Ohio EPA. March 25, 2013.

Teaf, Christopher M.; Douglas J. Covert; and Srikant R. Kothur 2008. *Urban Polycyclic Aromatic Hydrocarbons (PAHS): A Florida Perspective.* Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy: Volume 13, Article 23. 2008.

TEC-Weston 2016. *Facility-wide Groundwater Monitoring Program, RVAAP-66 Facility-wide Groundwater, Annual Report for 2015, Former Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio*. May 2016.

TEC-Weston 2018. *Facility-wide Groundwater Monitoring Program' RVAAP-66 Facility-wide Groundwater, Annual Report for 2017, Former Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio*. July 2018.

U.S. Government 1950. Office Memorandum – Conference on Waste Disposal. Operations Division to Post Engineer. March 1950.

USACE (U.S. 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 for 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 the Ravenna Army Ammunition Plant, Ravenna, Ohio*. April 2001.

USACE 2002. *Louisville Chemistry Guideline (LCG). Environmental Engineering Branch Louisville District*. June 2002.

USACE 2003. *RVAAP Facility Wide Ecological Risk Work Plan*. April 2003.

USACE 2005a. *RVAAP Facility-wide Human Health Risk Assessors Manual – Amendment 1*. December 2005.

USACE 2005b. *Facility-wide Biological and Water Quality Study 2003 Ravenna Army Ammunition Plant, Ravenna, Ohio, Part I-Streams, Part II-Ponds*. November 2005.

USACE 2009a. *PBA 2008 Supplemental Investigation Sampling Analysis Plan Addendum No. 1 Ravenna Army Ammunition Plant, Ravenna, Ohio*. December 2009.

USACE 2009b. *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. 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. *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 2012b. *Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-13 Building 1200*. March 2012.

USACE 2012c. *Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-48 Anchor Test Area*. January 2012.

USACE 2012d. *Property Management Plan for the Designated Areas of Concerns and Munitions Response Sites*. April 2012.

USACHPPM (U.S. Army Center for Health Promotion and Preventative Medicine) 1996. *Hazardous and Medical Waste Study No. 37-EF-5360-97 Relative Risk Site Evaluation, Ravenna Army Ammunition Plant*. November 1996.

USATHAMA (U.S. Army Toxic and Hazardous Materials Agency) 1978. *Installation Assessment of Ravenna Army Ammunition Plant, Records Evaluation Report No. 132*. November 1978.

USATHAMA 1982. *Installation Reassessment of Ravenna Army Ammunition Plant, Records Evaluation Report No. 132R.* December 1982.

USDA (US. Department of Agriculture) 1978. *Soil Survey of Portage County, OH*. 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.

USDA 2011. *PLANTS database.* Natural Resources Conservation Service. http://plants.usda.gov. 2011.

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.

USEPA 1988a. *CERCLA Compliance with Other Laws manual: Interim Final*. Office of Emergency and Remedial Response, Washington D.C. August 1988.

USEPA 1988b. *Guidance for Conducting Remedial Investigation/Feasibility Studies under CERCLA*. October 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 1996. *Ecological Significance and Selection of Candidate Assessment Endpoints*. ECO Update. Volume 3, Number 1. EPA 540/F-95/037. January 1996.

USEPA 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. June 1997.

USEPA 2002. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*. Office of Emergency and Remedial Response, Washington D.C. September 2002.

USEPA 2010. *Integrated Risk Information System (IRIS) Database*. Office of Research and Development, Washington, D.C. 2010.

USEPA 2016. Risk-Based Screening Table-Generic Tables. Website: http://www.epa.gov/risk/risk-based-screening-table-generic-tables. May 2016.

USFS (U.S. 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.

USFWS (U.S. Fish and Wildlife Service) 2016. *Listed species believed or known to occur in Ohio*. Environmental Conservation Online System (ECOS). http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=OH&status=listed. 2016.

USGS (U.S. Geological Survey) 1968. *Mineral Resources of the Appalachian Region*. U.S. Geological Survey Professional Paper No. 580. 1968.

USGS 1998. *Ecoregions of Indiana and Ohio* (2 sided color poster with map, descriptive text, summary tables, and photographs). Primary authors: Woods, A.J., J.M. Omernik, C.S. Brockman, T.D. Gerber, W.D. Hosteter, and S.H. Azevedo. USGS, Reston, VA. Scale 1:500,000. Online: ftp://newftp.epa.gov/EPADataCommons/ORD/Ecoregions/oh/OHINFront.pdf. 1998.

Vista (Vista Sciences Corporation) 2016. *Community Relations Plan for the Ravenna Army Ammunition Plant Restoration Program*. June 2016.

Winslow, J.D. and G.W. White, 1966. *Geology and Ground-water Resources of Portage County, Ohio*. Geological Survey Professional Paper 511. 1966.