DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
HEADQUARTERS, UNITED STATES ARMY GARRISON, REDSTONE
4488 MARTIN ROAD
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REPLY TO
ATTENTION OF

Environmental Management Division May 10, 2022

Mr. Stephen A. Cobb
Chief, Land Division
Alabama Department of Environmental Management
Post Office Box 301463
Montgomery, Alabama 36130-1463

Reference:

a. The Installation Restoration Program at Redstone Arsenal, Alabama, AMIM-REP-ER (EPA ID AL7 210 020 742).

b. Resource Conservation and Recovery Act Corrective Action Program at Redstone Arsenal, Alabama (EPA ID AL7 210 020 742).

c. Redstone Arsenal's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit Corrective Action (AHWMMA) Permit dated July 19, 2021.

Dear Mr. Cobb:

This letter transmits the submittal of the Slip Sheets for the Revision 1 Corrective Measures Implementation Work Plan, RSA-271, Former Boiler House, Building 7729, Operable Unit 10, US Army Garrison-Redstone, Madison County, Alabama for your review.

Revisions include:

- Title Page
- Main text: Chapter 5 (page 5-2 and 5-3) (slip pages in redline strikeout)
- RTCs: Responses to ADEM comments dated November 22, 2021.
- A final clean copy of the CMIP in PDF.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Copies of this correspondence are being furnished to Mr. Jojuan Pressley, Alabama Department of Environmental Management; Mr. Robert Pope, Superfund and Emergency

Management Division USEPA Region 4, Mr. Cesar Zapata, Land, Chemicals and Redevelopment Division USEPA Region 4.

My point of contact for this request is Ms. Holly Gallier, Environmental Management Division, 256-955-6967 or email holly.m.gallier.civ@army.mil.

Sincerely,

Clint Howard

Clint Howard
Chief, Environmental Restoration Branch
Division

Enclosure

Revision 1
Corrective Measures Implementation Work Plan
RSA-271, Former Boiler House, Building 7729
Operable Unit 10
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Prepared for:

Mission & Installation Contracting Command
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Contract No. W91ZLK-13-D-0018
APTIM Project No. 501021
Task Order 0003

April 2022

Revision 1
Corrective Measures Implementation Work Plan
RSA-271, Former Boiler House, Building 7729
Operable Unit 10
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Kenneth J Hurley
Kenneth J. Hurley
Alabama PE No. 25249

11/4/2021
Date

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Executive Summary

Aptim Federal Services, LLC, on behalf of the U.S. Army Garrison–Redstone, has prepared this corrective measures implementation work plan for Redstone Arsenal, Madison County, Alabama, under the management of the U.S. Army Environmental Command. The Mission & Installation Contracting Command has contracted Aptim Federal Services, LLC under Contract Number W91ZLK-13-D-0018 to perform environmental remediation services at Redstone Arsenal under the Resource Conservation and Recovery Act Corrective Action program. This corrective measures implementation work plan has been developed to provide technical guidance for implementing groundwater corrective measures selected for RSA-271, Former Boiler House, Building 7729, Operable Unit 10. This work plan incorporates applicable elements of Redstone Arsenal's Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit Corrective Action Permit and the most recent edition of the Alabama Environmental Investigation and Remediation Guidance. This work plan is submitted to fulfill, in part, the requirements listed in Section VI.E.1 of the Permit. As specified in Section VI.E.3 of the Permit, a request for permit modification is included as part of this plan.

RSA-271 occupies approximately 0.25 acre and is situated in the southeastern part of the Missile Production Complex. The site lies within groundwater unit RSA-146. The land use for RSA-271 is identified as industrial.

A Resource Conservation and Recovery Act facility investigation was performed at RSA-271 to evaluate potential environmental impacts from historical activities conducted at the site by the United States Army. The investigations at RSA-271 focused on potential releases from historical activities and structures. These included a former fuel oil underground storage tank used to fuel the boiler and compressor, two blow-off/hot well oil separation systems, and the former sanitary sewer junction associated with the oil separation systems. Based on available information collected during historical and recent inspection activities, the Resource Conservation and Recovery Act facility investigation report concluded that the Army's historical operations at RSA-271 have resulted in groundwater contamination which poses an unacceptable threat to human health if groundwater were used as a source of potable drinking water.

The Resource Conservation and Recovery Act facility investigation concluded that concentrations of methylene chloride, 1-methylnaphthlene, and naphthalene in soil pose a potential threat to groundwater quality beneath the site. A weight-of-evidence approach was used to evaluate the single detection of methylene chloride in soil present at a concentration greater than its dilution-attenuation factor of 4 soil screening level. Based on this evaluation, methylene chloride is determined to not pose a leaching threat.

For 1-methylnaphthlene and naphthalene an additional Alabama Risk-Based Corrective Action Risk Management-2 fate and transport evaluation was performed for the RSA-271 site. This evaluation included modeling to determine if an action is needed for the small volume of soil around the former underground storage tank pit with concentrations of 1-methylnaphthalene and naphthalene that exceeded the Redstone Arsenal generic dilution-attenuation factor 4 soil screening levels. The modeling concluded that concentrations of 1-methylnaphthlene and naphthalene in soil do not pose a threat to groundwater quality. However, it was determined the modeling requires field verification. Therefore, soil verification samples will be collected as part of the corrective measures for RSA-271 and subjected to synthetic precipitation leaching procedure testing to determine the need for a soil action. If soil verification samples fail the synthetic precipitation leaching procedure, corrective action will be implemented for soil. A cleanup plan for soil is included in this work plan to address that potential need.

The development of corrective measures was warranted for five contaminants in groundwater (manganese, 1-methylnaphthalene, 2-nitrotoluene, perchlorate, and trichloroethene). Additionally, a number of chemicals of concern in groundwater did not pose unacceptable risk to potential receptors but exceed screening values and will be included in groundwater monitoring in the corrective measures to meet the Alabama Department of Environmental Management's concern that the concentrations are not increasing to where they could pose unacceptable risks.

The following table presents the chemicals of concern that require action or monitoring for RSA--271:

SWMU	COCs Requiring Action in Vadose Zone Soil	COCs Requiring Action in Groundwater	COCs for Monitoring in Groundwater	SWMU Responsible for Groundwater Action
RSA-271	Failing residential risk: None Failing industrial risk: None Exhibiting a leaching to groundwater concern: Possibly 1-methylnaphthalene, naphthalene at source*/None at point of exposure Exhibiting a potential soil vapor concern: None	1-Methylnaphthalene 2-Nitrotoluene TCE Perchlorate Manganese	<u>Degradation Parameters</u> 1,1-Dichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene Vinyl chloride	RSA-271

SWMU	COCs Requiring Action in Vadose Zone Soil	COCs Requiring Action in Groundwater	COCs for Monitoring in Groundwater	SWMU Responsible for Groundwater Action
			COCs that exceed 2021 RSLs 3-Nitrotoluene 2,4,6-Trinitrotoluene 1,3-Dinitrobenzene Nitrobenzene Nitroglycerin Naphthalene 2-Methylnaphthalene Benzo(a)anthracene Dibenz(a,h)anthracene Dibenzofuran 2-Amino-4,6-dinitrotoluene 4-Amino-2,6-dinitrotoluene	

* To be confirmed through design optimization sampling to include synthetic precipitation leaching procedure (SPLP) testing during corrective measures.

The U.S. Army Garrison-Redstone intends to clean up the soil (if required after field verification testing) and groundwater contamination at RSA-271. The following cleanup goals have been set to achieve the corrective measure objectives:

Chemical of Concern	Cleanup Goal (micrograms per liter)	Basis for Cleanup Goal
Manganese	433	Risk[a]
1-Methylnaphthalene	10.1	Risk[a]
2-Nitrotoluene	3.13	Risk[a]
Perchlorate	15	Health Advisory Level[b]
Trichloroethene	5	Maximum contaminant level

[a]Cleanup goal based on hypothetical future use of groundwater for potable purposes and a cumulative 1E-05 cancer risk or hazard index of 1 in the case of manganese.

[b]Cleanup goal based on the Interim Drinking Water Health Advisory level of 15 micrograms per liter (Department of Defense, 2009, "Perchlorate Release Management Policy", Memorandum from Wayne Arny to Deputy Assistant Secretaries of the Army, Navy and Air Force, 4 April).

Degradation products for chemicals of concern in groundwater will also be monitored. The following monitoring acceptance goals have been established for the following common degradation products for the site chemical of concern trichloroethene.

Medium	Degradation Product	Monitoring Acceptance Goal (micrograms per liter)	Basis for Monitoring Acceptance Goal
Groundwater	1,1-Dichloroethene	7	Maximum contaminant level

Medium	Degradation Product	Monitoring Acceptance Goal (micrograms per liter)	Basis for Monitoring Acceptance Goal
Groundwater	cis-1,2-Dichloroethene	70	Maximum contaminant level
Groundwater	trans-1,2-Dichloroethene	100	Maximum contaminant level
Groundwater	Vinyl chloride	2	Maximum contaminant level

The following monitoring acceptance goals have been established for chemicals of concern for monitoring.

Groundwater Monitoring Parameter	Monitoring Acceptance Goal [a]
3-Nitrotoluene	Regional screening level
2,4,6-Trinitrotoluene	Regional screening level
1,3-Dinitrotoluene	Regional screening level
Nitrobenzene	Regional screening level
Nitroglycerin	Regional screening level
Naphthalene	Regional screening level
2-Methylnaphthalene	Regional screening level
Benzo(a)anthracene	Regional screening level
Dibenz(a,h)anthracene	Regional screening level
Dibenzofuran	Regional screening level
2-Amino-4,6-dinitrotoluene	Regional screening level
2-Amino-4,6-dinitrotoluene	Regional screening level

[a]The maximum contaminant level was selected as the monitoring acceptance goal, if available. The most recent regional screening level for tap water (the lower of values based on an incremental lifetime cancer risk of 1E-06 and hazard quotient of 0.1) will be selected as the monitoring acceptance goal for chemicals with no maximum contaminant level.

The selected corrective measure addresses the groundwater contamination by implementing the following:

- Soil excavation and off-site disposal
- Monitored natural attenuation.
- Land-use controls.

The U.S. Army Garrison-Redstone has elected to excavate and dispose of contaminated soil should the results of the verification sampling and analysis of these soils by synthetic precipitation leaching procedure indicate a soil action is required and implement a groundwater monitoring program to measure the reductions achieved due to natural attenuation and validate that the natural attenuation process continues to contribute to site restoration. Through the provisions of the Army's groundwater interim record of decision and the Army's site access control program, future groundwater resources beneath RSA-271 or elsewhere on Redstone

Arsenal may not be developed for potable purposes, and groundwater withdrawals for nonpotable uses must be managed until remedies are selected in the final records of decision for the various groundwater units within Redstone Arsenal. This ongoing monitoring will allow the Army to assess the rate of long-term groundwater recovery and to ensure protection for residents living outside of the boundaries of Redstone Arsenal.

1.0 Introduction

Aptim Federal Services, LLC (APTIM), on behalf of the U.S. Army Garrison-Redstone (hereinafter referred to as the Army), has prepared this corrective measures implementation (CMI) work plan for RSA-271, a surface media site requiring corrective measures at Redstone Arsenal (RSA), Madison County, Alabama, under the management of the U.S. Army Environmental Command. The Mission & Installation Contracting Command has contracted APTIM under Contract Number W91ZLK-13-D-0018 to perform environmental remediation services at RSA under the Resource Conservation and Recovery Act (RCRA) Corrective Action program (U.S. Environmental Protection Agency [EPA] ID # AL7 210 020 742) in accordance with RSA's Alabama Hazardous Wastes Management and Minimization Act (AHWMMA) Hazardous Waste Storage Facility/Thermal Treatment/Solid Waste Management Unit (SWMU) Corrective Action Permit dated July 19, 2021 (hereinafter referred to as the Permit) (Alabama Department of Environmental Management [ADEM], 2021). This CMI work plan has been developed to provide technical guidance for implementing the soil and groundwater corrective measures selected for SWMU RSA-271, Former Boiler House, Building 7729, located within Operable Unit (OU) 10.

This CMI work plan incorporates applicable elements of the Permit (ADEM, 2021) and the most recent edition of the Alabama Environmental Investigation and Remediation Guidance (AEIRG) (ADEM, 2017a). This CMI work plan is submitted to fulfill in part the requirements listed in Section VI.E.1 of the Permit. As specified in Sections VI.E.3 and VIII.B.6 of the Permit, requests for permit modification and an environmental use restriction are included as part of this work plan. This plan protects human health and the environment from hazardous constituents at concentrations exceeding applicable limits.

1.1 Purpose

The purpose of this CMI work plan is to describe the corrective measures selected for use at RSA-271 to address contamination posing unacceptable risk to human health or the environment. Groundwater contaminants at RSA-271 are manganese; perchlorate; 1-methylnaphthalene; 2-nitrotoluene; and trichloroethene (TCE).

The nature and extent of contamination was presented in the RSA-271 RCRA facility investigation (RFI) report (APTIM, 2020a), which was approved by ADEM on April 16, 2020. An Alabama Risk-Based Corrective Action (ARBCA) evaluation for human health and a screening-level ecological risk assessment (SLERA) were prepared for RSA-271 as part of the RFI. The ARBCA evaluation concluded that chemicals in soil do not pose unacceptable human health risks to commercial/industrial or hypothetical future residential receptors. However, based on the results of the soil-to-groundwater migration evaluation, three chemicals (1-methylnaphthalene, naphthalene, and methylene chloride) detected in soil at the former underground storage tank (UST) location were considered to be a potential ongoing source of contamination to groundwater from the soil-to-groundwater migration pathway. However, further evaluation determined that soils do not pose a threat to groundwater quality beneath the site (Section 2.3.3 and Appendix G).

A screening-level vapor evaluation conducted as part of the ARBCA evaluation showed that volatile organic compound (VOC) concentrations in soil and groundwater are unlikely to pose an unacceptable health threat to occupants of the existing building or buildings (including residential buildings) erected on site in the future. The results of the SLERA indicated the chemicals of potential ecological concern in surface soil at RSA-271 are unlikely to pose hazards to ecological receptor communities and/or populations, and further evaluation of ecological hazards at RSA-271 is not warranted. The RFI report concluded that the exposure to groundwater underlying the site, if groundwater is developed as a potable source in its present condition, may pose an unacceptable health risk to commercial/industrial or hypothetical future residential receptors. A groundwater monitoring program is proposed to evaluate the progress of natural attenuation processes and track the trend of chemicals of concern (COC) in groundwater exceeding cleanup goals (CG) to meet the groundwater corrective measure objective (CMO).

This CMI work plan has been prepared to describe the technical approach and rationale for conducting the field activities that will be performed prior to and during implementation of the groundwater corrective measures. The CMI work plan focuses on groundwater because the RFI determined that soil poses no unacceptable risks.

1.2 Redstone Arsenal Location and Description

RSA occupies approximately 38,300 acres and is approximately 10 miles long from north to south and 6 miles wide from east to west. Development within RSA has largely centered on the historical production (and later disposal) of conventional and chemical munitions, and more recently, development and testing of missiles and rockets.

The U.S. Fish and Wildlife Service permits the Army to use 1,085 acres in the southern and central portion of RSA on the Wheeler National Wildlife Refuge (WNWR) (along Wheeler Reservoir, Indian Creek, and Huntsville Spring Branch). Established in 1938 to provide protection for wildlife, WNWR encompasses 34,500 acres on the Tennessee Valley Authority's Wheeler Reservoir. RSA-271 lies outside the WNWR boundary.

1.3 RSA-271 Site Description and History

RSA-271 is located in the northeastern portion of groundwater unit RSA-146. RSA-146 occupies the southeastern quadrant of RSA between Huntsville Spring Branch and the Tennessee River. RSA-271 occupies approximately 0.25 acre and is situated in the southeastern part of the Missile Production Complex (Figures 1-1 and 1-2). Nearby surface media sites are all no-further-action (NFA) sites and include RSA-089 to the northwest; RSA-138M to the north; RSA-097 to the west; and RSA-137O, which is within the footprint of the RSA-271 site boundary.

RSA records indicate that Building 7729 was constructed as Army Building B-529 in 1942. Initially, the building housed a steam boiler fueled from a 2,800-gallon UST formerly located east of the building. A small oil/water separator (OWS) consisting of a blow-off/hot well pit was located at the west end of Building 7729. RSA records indicate that this system was removed from use but left in place, and a larger, high-capacity blow-off/hot well was installed south of Building 7729 in 1974. The junction of both OWS systems with the sanitary sewer system was located northwest of the building. The boiler was utilized until 1982. From 1982 to demolition in the mid-1990s the building was used for storage (Shaw Environmental, Inc. [Shaw], 2005).

Building 7729 was still in place but emptied of all equipment during a 1996 environmental baseline survey (EBS) (Conestoga-Rovers and Associates, 1996). The Phase I EBS summary for Building 7729 assumed that a fuel storage tank existed, but the report notes that there was no visible evidence of the UST when the inspection was performed. RSA records list the 2,800-gallon UST as being removed in September 1998. The building is not present in the 2000 aerial photograph, indicating demolition sometime between 1996 and 2000. During a 2004 visual survey associated with a limited site assessment, the building, original blow-off/hot well, and sewer junction were no longer present. However, the replacement blow-off/hot well was still in place. During ongoing Missile Production Complex construction activities in October 2011, the replacement blow-off/hot well overflow pit was inadvertently breached, and the contents were released onto the ground surface. A spill response for a petroleum release was completed, including collection and analysis of post-response samples. The data showed that the spill response had adequately removed the assumed petroleum contamination and prevented further release to the site environment. Results from the post-response samples were below preliminary screening values (PSV) for the petroleum compounds.

RSA-271 was established as a SWMU following the RSA-146 potential source area (PSA) investigation (Shaw, 2005). As a result of the PSA investigation process, the Army recommended the creation of RSA-271 to facilitate a more focused and thorough evaluation of the data to determine whether chemicals used at RSA-271, including fuel and compressor oils, contributed to environmental contamination. At the time, based upon its limited use as a boiler house, RSA-271 was assigned as an RSA petroleum, oil, and lubricants program site. However, in accordance with the Permit (ADEM, 2020), this site was evaluated more completely during completion of the RFI (APTIM, 2020a).

According to the RSA Master Plan, the land use for this site is classified as industrial. Where practical, the Army has restricted entry into the SWMUs by fencing them and/or placing warning signs at key entry points. RSA-271 is not fenced; however, access to RSA property is restricted, and RSA-271 lies within the highly secure access area surrounding the Raytheon Operational Area.

General installation-wide environmental setting information, including discussions of regional stratigraphic and structural geology, surface and subsurface hydrology, and other physiographic and geographic topics are presented in the installation-wide work plan (IT Corporation (IT), 2002) and the RSA-146 groundwater unit RFI report (CB&I Federal Services LLC [CB&I], 2015a). Site-specific environmental setting information is included in the RFI report for RSA-271 (APTIM, 2020a) and summarized in Section 1.4 of this plan.

1.4 Summary of Physical Setting

Contaminant fate and transport is dictated by the physical and chemical characteristics of the site-related contaminants. The effects of physical, chemical, and biological processes on the constituents control the potential fate (degradation) and transport (movement). The fate and transport evaluation provides key input to the human health risk assessment by identifying all transport mechanisms working at the site and subsequently determining which exposure pathways are relevant to the risk evaluation. A summary of the site-specific fate and transport mechanisms working at the RSA-271 site is presented here.

The physical setting influences both the migration of contaminants from the site and the fate of contaminants once they enter the environment. Elements of the physical setting pertinent to the preparation of this CMI work plan are discussed in Sections 1.4.1 through 1.4.3.

1.4.1 Topography and Surface Hydrology

Prior to Missile Production Complex construction in the 2010s, the site was mostly open scrub/grassland with scattered areas of small trees and planted pines along its eastern and northwestern boundaries. There are no remaining legacy buildings or structures within the site (Figure 1-2). As is typical of developed areas within RSA, the former buildings at RSA-271 are topographically higher than the surrounding forest land and swampy areas. No permanent surface water or other aquatic habitat features exist within the boundary of RSA-271. A large wetland/pond is located across Eagle Road, approximately 500 feet south and east of the site (Figure 1-1). The entire site lies above the 100-year floodplain.

1.4.2 Geology

Soil

The subsurface geologic setting beneath RSA-271 and adjacent sites includes overburden consisting of low-permeability, red, brown, and gray clay; silty clay; and silt. Intervals of chert and chert fragments increase with depth. The thickness of the overburden at the site, as determined by the depth to auger refusal in site soil borings, ranges from 31.8 feet (271-RS2375) to 56 feet (14602A10-HP03) (APTIM, 2020a). Although there is little compositional variation within the overburden, the residuum does not transmit groundwater uniformly. Groundwater infiltration follows preferred pathways because zones of higher hydraulic conductivity developed during soil-forming processes. Preferred pathways within the overburden directly affect contaminant migration and distribution within the soil column.

Residual clay generally has low horizontal and vertical hydraulic conductivities. At a given location, a layer of chert within the clay may decrease vertical hydraulic conductivity and increase horizontal conductivity, while isolated nodules of chert may increase the vertical conductivity. Preferred groundwater flow pathways in the overburden also include macropores caused by rotting tree roots and burrowing animals.

Additionally, microfractures may be created within the clay during raveling, a process in which the clay slowly subsides as it is eroded and carried away by groundwater in bedrock fractures and conduits. Vertical movement of the soil caused by raveling or sloughing into fractures and conduits results in the development of microfractures in the overlying material. The microfractured clay soils have higher hydraulic conductivities than undisturbed clay and also act as preferred groundwater flow pathways.

Bedrock

Depth to bedrock across this portion of RSA ranges from 31.8 to 56 feet below ground surface (bgs) (APTIM, 2020a). This variable depth to bedrock is due to solution weathering of the upper bedrock surface (epikarst). Lithological data from bedrock wells installed across this portion of RSA indicate that the shallow bedrock first encountered correlates with middle to upper Tuscumbia Limestone and exhibits well-developed karst features. The Fort Payne is underlain by the Chattanooga Shale, a dark gray to black, fissile shale.

1.4.3 Groundwater Hydrogeology

RSA-271 is located within the boundaries of the larger RSA-146 groundwater unit (Figure 1-1). Groundwater beneath RSA-271 occurs in the unconsolidated overburden and the upper portion of the carbonate bedrock. The overburden and upper bedrock comprise an interconnected, aquifer. At depth, groundwater occurs under semiconfined conditions, flowing along discrete joints and bedding-plane partings. The water table across RSA-271 and the larger RSA-146 groundwater unit is generally flat, mimicking local topography. Depth to groundwater in overburden wells at RSA-271 fluctuates seasonally and ranged from 13.4 feet to a maximum 20.3 feet bgs. Excluding the data from 271-RS1630, the depth to groundwater averaged 17.7 feet bgs when the wells were sampled. Figure 1-3 shows the potentiometric surface in November 2012 and the regional RSA-146 potentiometric surface (CB&I, 2015a). Based on groundwater elevations in the overburden wells (shown on Figure 1-3), groundwater appears to flow primarily to the southeast. Construction data for existing site monitoring wells are provided in Table 1-1.

1.5 Document Organization

This CMI work plan is organized into the following six chapters:

- Chapter 1.0, *Introduction*, presents the purpose and overview of the document and includes a brief site description, including the topography, geology, and hydrogeology associated with the site.
- Chapter 2.0, *Investigation Results*, presents additional background information about the project sites, including nature and extent of contamination, fate and transport summary, site risks, and the final site conceptual site models (CSM).
- Chapter 3.0, *Decision Summary*, describes the basis for the action, including the CMO, the CGs, and a summary of the corrective measures.
- Chapter 4.0, *Corrective Measures Implementation*, describes the support and field activities necessary to implement the corrective measures for groundwater.
- Chapter 5.0, *Contingencies*, describes the potential for variances which could arise during execution of the corrective measures described herein.
- Chapter 6.0, *References*, provides the references that contributed to the preparation of this CMI work plan.

The following plans and supporting documentation are included as appendices to this CMI work plan:

- Appendix A Request for Redstone RCRA Permit Modification
- Appendix B ADEM Concurrence Letter
- Appendix C Corrective Measures Implementation Schedule

- Appendix D Site-Specific Health and Safety Plan
- Appendix E Data Collection Quality Assurance Project Plan
- Appendix F Groundwater Monitoring Plan
- Appendix G ARBCA Fate and Transport Model
- Appendix H Standard Operating Procedure 4.0 – Waste Management
- Appendix I Construction Quality Assurance Plan
- Appendix J Alabama Best Management Practices.

2.0 Investigation Results

This chapter presents additional background information for RSA-271, including the investigation history, nature and extent of contamination, the fate and transport summary, human health and ecological risks, and the final CSM.

2.1 Investigation History

The following investigations were conducted at RSA-271:

- Phase I and II EBSs at the Redstone Arsenal Rocket Engine North Plant Area (Conestoga-Rovers & Associates, 1996; CH2M Hill, 1998)
- RSA-146 PSA Investigation (Shaw, 2005)
- In Situ Waste Characterization Sampling (Shaw, 2010a)
- Post-Release Response Investigation Sampling (Shaw, 2011a)
- RSA-271 RFI Sampling (Shaw, 2011b,c, 2012a,b, 2013a; CB&I, 2014, 2017a).

A complete discussion of the investigations at RSA-271 is available in the RSA-271 RFI report (APTIM, 2020a). The RFI report received ADEM concurrence on April 16, 2020.

The data collected during the investigations show that groundwater under the site poses an unacceptable health risk to current and future receptors due to elevated concentrations of manganese, perchlorate, 1-methylnaphthalene, 2-nitrotoluene, and TCE. RSA-271 soil poses no unacceptable risk to human health or the environment; however, the RFI concluded that 1-methylnaphthalene, methylene chloride, and naphthalene in soil may pose a potential leaching threat to groundwater. Additional evaluation of the potential leaching threat is presented in Section 2.3 and Appendix G.

2.2 Nature and Extent of Contamination

The investigations to date have provided sufficient characterization data for determining the nature and extent of contamination. Sections 2.2.1 and 2.2.2 present a summary of the nature and extent of contamination at RSA-271 as documented in the RFI report (APTIM, 2020a). To maintain consistency with earlier documents (e.g., RFI and corrective measures study) the terminology of referring to screening values as PSVs will be used when discussing site investigation results. Currently, ADEM has adopted EPA regional screening levels (RSL) as the state-approved screening values in lieu of maintaining state-specific PSVs. Chapters of this plan that discuss the actions for the site will use the term “RSL.” The summary tables prepared during the completion of the RFI were updated by screening the analytical data against the most recent EPA RSLs (EPA, 2021). Two explosive compounds, 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene, were found to be present in the groundwater data exceeding the most recent RSLs and were added to the COC list. These tables are included in Appendix G.

2.2.1 Soil

The nature and extent of contamination present within site soil at the RSA-271 was evaluated during the RFI process. A summary of findings and conclusions for soil is as follows:

2.2.1.1 Surface Soil

Metals. Site-to-background evaluation concluded that all metals in surface soil are most likely naturally occurring or background related.

VOCs. VOCs were not detected in site surface soils at concentrations exceeding the residential RSLs, including locations adjacent to the two former blow-off/hot wells or the former UST.

Semivolatile Organic Compounds. The semivolatile organic compound (SVOC) benzo(a)pyrene was detected at concentrations exceeding the RSL at three surface soil locations (Figure 2-1).

Explosive Compounds. No surface soil samples were analyzed for explosives at the RSA-271 site.

2.2.1.2 Subsurface Soil

Metals. Site-to-background evaluation concluded that all metals in subsurface soil are most likely naturally occurring or background related.

VOCs. VOCs were not detected in site subsurface soils at concentrations exceeding the residential RSLs, including locations adjacent to the two former blow-off/hot wells or the former UST.

Semivolatile Organic Compounds. No SVOCs were detected at concentrations above the RSLs in any of the subsurface soil samples.

Explosive Compounds. Explosives were not detected in concentrations above RSLs in the one soil sample collected within the RSA-271 site and analyzed for explosives.

2.2.2 Groundwater

Metals. Anomalous concentrations of iron and manganese at levels above both the RSLs and background screening values (BSV) are present in a localized area near the UST pit (Figure 2-2). These anomalous iron and manganese detections have been adequately delineated at the site. As noted in the RFI report, the elevated concentrations of iron and manganese above naturally occurring background concentrations result from the low redox conditions induced by degradation of fuel components and VOCs. The low redox conditions resulted in the dissolution of naturally occurring manganese oxide or iron oxide minerals in the water-bearing zone, which increased the dissolved manganese and iron concentrations in the surrounding groundwater.

VOCs. In groundwater, TCE has been identified in the monitoring well data as intermittently (September 2012 data only) exceeding the RSL. Groundwater sample results for two more recent wells (271-RS2707 and 271-RS2708) installed and sampled in 2015 within the same general areas were below RSLs (i.e., maximum contaminant levels [MCL]) (Figure 2-3). TCE in groundwater is widespread at RSA and will be included in the corrective measures for this site although off-site sources are known to exist and are thought to be the source of most of the dissolved constituents in RSA-271 groundwater.

TCE is a major constituent of the regional groundwater contamination within the RSA-146 groundwater unit and present in historical groundwater results from several surface sites adjacent to RSA-271, including the RSA-097 site. While TCE exceedances in wells from RSA-271 were observed in September 2012, no RSL exceedances have been observed in site-related wells since that time. Nonetheless, TCE will be considered a site-related COC in groundwater and will be addressed as such.

SVOCs. Site groundwater has been impacted by polynuclear aromatic hydrocarbons (PAH), primarily naphthalene, 1-methylnaphthalene, dibenzofuran, and high molecular weight (HMW) PAHs. PAH RSL exceedances appear to cluster at the locations of the replacement blow-off/hot well and the former UST. The detections have been adequately delineated, as shown on Figure 2-4.

Explosives. Six explosive compounds (1,3 dinitrobenzene, 2,4,6 trinitrotoluene, 2-nitrotoluene, 3 nitrotoluene, nitrobenzene, and nitroglycerin) were detected in concentrations above RSLs in three overburden groundwater wells (271-RS1631, 271-RS1632, and 271 RS2374) during the November 2012 sampling event. Explosive compounds are present in groundwater in concentrations exceeding RSLs semi-regionally across this portion of the RSA 146 groundwater unit and are likely not site related (Figure 2-5).

Perchlorate. Perchlorate was detected in well 271-RS2374 at a concentration (24.1 micrograms per liter [µg/L]) exceeding the RSL of 15 µg/L (Figure 2-6). Perchlorate groundwater detections are most likely part of the overall commingled RSA-146 groundwater unit plume.

2.3 Summary of RSA-271 Contaminant Fate and Transport Evaluation

2.3.1 Leaching from Soil to Groundwater

At RSA-271, the major potential contaminant migration pathway was identified as leaching of site-related contaminants from soil to the underlying water table as a result of the downward percolation of infiltrating rainfall. Overland transport of soil contaminants by wind or water is unlikely at RSA-271 because the site is relatively level and well vegetated.

Compounds identified through comparison to dilution-attenuation factor (DAF) 4 soil screening levels (SSL) (Shaw, 2011d) as having potential to leach to groundwater include 1-methylnaphthalene, naphthalene, and methylene chloride from the former UST pit soils. Methylene chloride is discussed below along with relevant lines of evidence. The SVOCs 1-methylnaphthalene and naphthalene are addressed in Chapter 3 as COCs in soil that potentially require action.

Methylene chloride. The RFI concluded that methylene chloride in soil had a potential, although slight, to pose a threat to the underlying groundwater from the soil to groundwater migration pathway. However, because there does not appear to be a soil source for methylene chloride, additional lines of evidence must be considered. These include:

- Methylene chloride is a common laboratory contaminant,
- It was detected at a concentration greater than the RSA-specific DAF_4 SSL in only one subsurface soil sample out of a total of 34 subsurface soil samples (less than 3 percent).
- It was not detected at concentrations greater than the RSA-specific DAF_4 SSL in surface soil,
- In the 36 groundwater samples collected for this site for VOCs, methylene chloride was not detected and thus does not exceed its RSL in any sample. These results include samples from groundwater monitoring well 271-RS1632, which is adjacent to 271-SB007. Given the operational history of this site, if a soil source were present, it would have migrated to groundwater by now which supports that no source is currently present.
- The sample from 271-SB007 (15 to 17 feet bgs), with the methylene chloride result that exceeds the DAF_4 SSL was collected from soils directly below the level of the former tank bottom, and the VOC portion of the sample was flagged as requiring

dilution by the laboratory due to the presence of petroleum fuel in the matrix. Common laboratory contaminants are often introduced during the sample cleanup and dilution process.

- The results from 271-RS1632 that was installed directly adjacent to 271-SB007 exhibited lower concentrations of VOCs and did not require dilution. This sample did not exhibit detected methylene chloride concentrations. Sample locations are presented on Figure 2-2.

In conclusion, these results support that the single methylene chloride SSL exceedance is more likely the result of the analytical process rather than from site-related contamination. Therefore, action based on the soil to groundwater migration pathway for methylene chloride is not warranted since no soil source is present at the site. The SVOCs 1-methylnaphthalene and naphthalene are addressed in Chapter 3 as COCs in soil that potentially require action.

2.3.2 Attenuation and Biodegradation

Over time, contaminant concentration and mass in groundwater are reduced due to the combined effects of physical attenuation (adsorption, dilution, dispersion, and volatilization) and biochemical attenuation (intrinsic biodegradation). Physical natural attenuation processes such as dilution and dispersion are the most significant reasons for reduced chemical concentrations. Physical attenuation depends on the velocity of water flow and rate of mixing. Biological degradation can also occur in water or soil under aerobic or anaerobic conditions. Biodegradation is one of the few processes working in the aquifer that can transform a toxic substance (i.e., a groundwater contaminant) into a less harmful or innocuous product of an organism's metabolism. Many chlorinated solvents such as TCE exhibit relatively low rates of natural biotic degradation and sometimes persist in the subsurface for extended periods of time depending on the conditions of the site. However, under anaerobic conditions, TCE is known to degrade at a rate useful for achieving CGs (Bouwer et al., 1984; Bouwer, 1994). Perchlorate and explosives can also be biodegraded under anaerobic conditions (Gorontzy, 1994).

2.3.3 Conclusions

Methylene chloride is a common laboratory contaminant that can be present as the result of laboratory procedures. It is not a chemical that is in the CSM for RSA-271, and it is not associated with past site operations. There has been sufficient time for methylene chloride to have already leached to groundwater, so if leaching occurred or was occurring on site, the site groundwater data would be expected to show at least detectable levels in groundwater. However, methylene chloride is not detected in site groundwater. The likely source for methylene chloride is the analytical process. Based on this information, NFA is planned to address methylene chloride concentrations in soil. The SVOCs 1-methylnaphthalene and naphthalene are addressed in Chapter 3 as COCs in soil that potentially require action.

2.4 Site Risk Summary

An ARBCA evaluation for human health and a SLERA were performed for RSA-271 as part of the RFI (APTIM, 2020a). These evaluations are summarized in Sections 2.5.1 through 2.5.3. The complete ARBCA evaluation for human health and the ecological risk evaluation are provided in the RFI report (APTIM, 2020a).

2.4.1 Land and Resources Use

According to the RSA Master Plan, the land use at RSA-271 is designated as industrial.
RSA-271 is located in the Spring Branch land-use district in the southeastern portion of RSA. No surface water is present on the site. The current use of RSA-271 is not residential, nor is it expected to be in the future. The residential scenario was included in the ARBCA evaluation in order to determine if this site is eligible for unrestricted reuse in accordance with ADEM requirements. In the Permit, issued under the AHWMMA, ADEM has specified that investigations must comply with AEIRG and ARBCA guidance. In order to determine if this site is eligible for unrestricted reuse as defined in Alabama Administrative Code (AAC) 335-5 (ADEM, 2013), risks to a residential site user were assessed.

There is no current potable use of groundwater at RSA-271. An installation-wide interim record of decision (IROD) was instituted to prevent potable use and provide management control over nonpotable uses of all groundwater beneath RSA. The IROD for installation-wide groundwater (Shaw, 2007) was approved by EPA Region 4 and ADEM in September 2007. Monitoring of the environmental use restrictions and controls specified in the groundwater land-use controls (LUC) remedial design (Shaw, 2009a) has been conducted annually by the Army. These annual reports have shown that the LUCs have been effective in controlling and preventing use or exposure to groundwater at RSA, including RSA-271.

2.4.2 Human Health ARBCA Evaluation

The human health risk assessment for RSA-271 was prepared as part of the RFI (APTIM, 2020a) in accordance with ADEM guidance (ADEM, 2008) and consists of a three-tiered process: the preliminary screening level (PSL) evaluation (first tier), the Risk Management (RM)-1 evaluation (the second tier), and the RM-2 evaluation (the third tier). In the case of RSA-271, the RM-1 evaluation was not performed; instead, the evaluation proceeded directly from the PSL evaluation to the cumulative risk assessment in the RM-2 evaluation.

The PSL evaluation consists of a simple comparison of site concentrations with PSVs, which were based on the EPA (2014) RSLs, based on the lower of an individual excess lifetime cancer risk (IELCR) of 1E-6 and a noncancer hazard index (HI) of 0.1. In the case of groundwater, MCLs were used as the PSVs, if available (EPA, 2012). Otherwise, tap water RSLs were used (EPA, 2014). Residential PSVs were selected for the RSA-271 evaluation in order to consider alternatives to attain unrestricted land use.

The PSL evaluation was conducted for all chemicals that were determined to be site related. Inorganics with maximum detected concentrations (MDC) that did not exceed their BSVs or shown in a site-to-background evaluation to be naturally occurring were judged not to be site related and not evaluated further. Site concentrations of all other detected chemicals were compared to PSVs in the PSL evaluation. A constituent was identified as a COC if the MDC was greater than its PSV.

Five PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were identified as COCs in total soil for RSA-271. Two metals, perchlorate, six explosive compounds, seven PAHs, dibenzofuran, and TCE were identified as COCs in groundwater because their MDCs exceeded their PSVs. In addition, five metals and seven VOCs were identified as COCs in groundwater only because they have MCLs. In groundwater, all constituents that have MCLs, whether or not they are exceeded, are identified as COCs for inclusion in the RM-2 evaluation.

The COCs identified in the PSL evaluation were brought forward for evaluation in the cumulative risk assessment (RM-2 evaluation). Receptor scenarios evaluated in the cumulative risk assessment included a commercial worker, a construction worker, and a hypothetical residential receptor.

Although RSA's current mission makes residential site use unlikely, a hypothetical future residential receptor was evaluated as required by ADEM (2008) to evaluate future use without restrictions and determine whether remedial measures and/or LUCs are warranted to achieve NFA status. Groundwater was evaluated as if developed as a source of potable water in the future. Risks from exposure to groundwater were assessed even though groundwater use at this site is currently precluded and nonpotable uses are managed by RSA's site access control (SAC) program (Army, 2012) in accordance with the terms of the installation-wide groundwater IROD (Shaw, 2007). This IROD is interim in nature. Therefore, evaluating risks from exposure to groundwater is required in order to select final corrective measures for groundwater.

The ARBCA guidance considers an IELCR of 1E-05 to be the target cumulative risk. The target noncancer hazard is an HI of 1.0. Estimated cumulative risks/hazards at or below these targets do not require additional action.

Cumulative IELCR and HI estimates for all receptor scenarios for RSA-271 are summarized in Table 2-1. As noted therein, the cumulative IELCR estimates for exposure to soil alone are below the ADEM trigger level of 1E-05 for all of the receptors. No cumulative HI was estimated because no chemicals in soil were identified as non-cancer-based COCs. No chemicals were identified as relevant COCs in soil for any receptor scenario.

The cumulative IELCR for exposure to groundwater hypothetically developed as a potable source exceeded the ADEM trigger level of 1E-5 for the commercial worker and hypothetical residential receptor, but not for the construction worker (Table 2-1). The cumulative HI for exposure to groundwater exceeded the threshold level of 1 for all receptors. Table 2-2 shows a summary of the RM-2 evaluation of human health for RSA-271. It shows the COCs identified through the ARBCA evaluation that require action. As shown in Table 2-2, no COCs requiring action were identified in soil. COCs in groundwater requiring action for one or more receptor scenarios are manganese, perchlorate, 2-nitrotoluene, 1-methylnaphthalene, and TCE. Receptor-specific risk-based target levels were calculated for all the relevant COCs; however, the MCL (5 µg/L) will be adopted as the cleanup level for TCE in groundwater.

In addition to the ARBCA, a screening-level evaluation of vapor intrusion was conducted for RSA-271 as part of the RFI (APTIM, 2020a) to determine whether or not there has been a release of VOCs to groundwater or soil at RSA-271 that may volatilize and migrate upward to pose an unacceptable risk to occupants of commercial/industrial buildings or a hypothetical residential building. It was concluded that VOCs in soil and groundwater do not represent a source that would pose an unacceptable health threat by the vapor intrusion pathway

In conclusion, exposure to RSA-271 soils poses no unacceptable health risk to any of the receptors evaluated herein under commercial/industrial or residential site use. Exposure to groundwater developed as a potable source may pose a threat under either a commercial or residential site-use scenario. However, potable groundwater use at this site is precluded now and, in the future, and nonpotable uses are managed by RSA's SAC program according to the terms of the installation-wide groundwater IROD.

2.4.3 Screening-Level Ecological Risk Assessment

A SLERA was completed for RSA-271 as part of the RFI (APTIM, 2020a). The surface soil data for RSA-271 were compared to their respective BSVs and ecological screening values (ESV). A

WOE evaluation was completed to further evaluate the constituents identified in the initial screening. The WOE evaluation examined a number of lines of evidence in order to draw conclusions as to whether site-related constituents at RSA-271 have the potential to pose hazards to ecological receptors.

The initial comparison of the detected constituent concentrations in RSA-271 surface soil to ESVs and BSVs identified seven metals (calcium, cobalt, copper, lead, manganese, thallium, and zinc) and total high molecular weight PAHs as preliminary chemicals of potential ecological concern that required further assessment. The WOE evaluation concluded that none of these chemicals in surface soil was found to require further evaluation. All of the other constituents detected in surface soil samples from RSA-271 were detected at concentrations less than their respective ESVs and/or BSVs and considered to pose insignificant ecological hazards. Based on the results of this ecological evaluation, it was concluded that further evaluation of ecological hazards at RSA-271 is not warranted (APTIM, 2020a).

2.5 Final Conceptual Site Model

A CSM was developed during the RFI to guide the investigation at RSA-271 based on historical operations, site information, and evaluation of available soil and groundwater data. Figure 2-8 presents the final CSM from the RFI for RSA-271. The final CSM includes a list of potential contaminant sources, migration pathways, investigated media, impacted media, COCs, and potential human and ecological receptors.

Potential contaminants from past operations at former Building 7729 are constituents of fuel and compressor oils from the boiler system. These chemicals of potential concern (COPC) include fuel-related VOCs such as aromatic and aliphatic hydrocarbons, which are in the target compound list (TCL) for VOC analytes; SVOCs, primarily PAHs and larger aliphatic hydrocarbons, which are in the TCL for SVOC analytes; and metals sloughed from heating or lubricated parts or present as corrosion inhibitors in cooling fluids. All target analyte list (TAL) metals except for thallium were considered to be in the CSM of this site because of the range of activities at this site.

Because of the surrounding site uses and the site's inclusion in the former North Plant area, other chemicals such as chlorinated solvents, perchlorate, and explosives could be present in groundwater underlying this site from historical releases elsewhere within the former North Plant area. These chemicals have been evaluated in the RFI but are not considered to be in the CSM of RSA-271.

As shown on Figure 2-8, potential receptors could be exposed to contaminated groundwater. Current human receptors are limited to groundskeeper and industrial workers. Future potential receptors include all current receptors plus, under a future land reuse scenario, hypothetical child and adult residents.

2.6 Summary

Based on the results of the RFI for RSA-271 and the supplemental evaluation of the soil-to-groundwater migration pathway, corrective measures are recommended for RSA-271 groundwater to address unacceptable risks to potential receptors. Additionally, a number of COCs in groundwater exceed PSVs but did not pose unacceptable risk to potential receptors. To meet ADEM's concern that the concentrations are not increasing to levels that could pose unacceptable risks, they will be included in groundwater monitoring in the corrective measures.

No COCs requiring action were identified in soil based on risks to human health or threats to ecological receptors. Based on the results of the refined fate and transport evaluations, there is no source material in soil posing a threat to groundwater at the selected, conservative, point of exposure.

The COCs that require an action and those that are for monitoring for RSA-271 and the Army's plan for addressing these COCs are summarized in the following table:

SWMU	COCs Requiring Action in Vadose Zone Soil	COCs Requiring Action in Groundwater	COCs for Monitoring in Groundwater	SWMU Responsible for Groundwater Action
RSA-271	Failing residential risk: None Failing industrial risk: None Exhibiting a leaching to groundwater concern: Possibly 1-methylnaphthalene, naphthalene at source*/None at point of exposure Exhibiting a potential soil vapor concern: None	1-Methylnaphthalene 2-Nitrotoluene TCE Perchlorate Manganese	<u>Degradation Parameters</u> 1,1-Dichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene Vinyl chloride <u>COCs that exceed 2021 RSLs</u> 3-Nitrotoluene 2,4,6-Trinitrotoluene 1,3-Dinitrobenzene Nitrobenzene Nitroglycerin 2-Methylnaphthalene Benzo(a)anthracene Dibenz(a,h)anthracene Dibenzofuran Naphthalene 2-Amino-4,6-dinitrotoluene 4-Amino-2,6-dinitrotoluene	RSA-271

* To be confirmed through design optimization sampling to include synthetic precipitation leaching procedure (SPLP) testing during corrective measures.

3.0 Decision Summary

The RFI report for RSA-271 (APTIM, 2020a) concluded that COCs (VOCs, SVOCs, perchlorate, one explosive compound, and one metal) are present in groundwater under the site and pose unacceptable risks if groundwater was used as a source of potable drinking water, and also concluded that no contaminants in soil pose unacceptable risks to human health or ecological receptors. The results from the RFI report concluded that 1-methylnaphthalene and naphthalene in soil pose a leaching threat to groundwater. Although ARBCA fate and transport modeling results indicate no threat to groundwater from the presence of these chemicals in soil, the modeling will be verified by collecting source area soil samples and subjecting these samples to SPLP testing and evaluation by the method described in Section 4.2.1 of the RFI (CB&I, 2017), prior to implementing the soil excavation at the site. This chapter identifies the CMOs based on the results of the RFI and provides CGs that can be used in evaluating alternatives that rely on reduction in concentrations to achieve the CMOs.

3.1 Basis for the Action

Corrective measures are required for soil and groundwater for the COCs requiring action and for those that require monitoring. The Army intends to achieve closure for RSA-271 through the implementation of soil and groundwater corrective measures as they are needed protect human health.

3.2 Objectives of the Corrective Measures

Based on the results of the RFI, the CMO for RSA-271 is as follows:

- Prevent human exposure via any exposure route (ingestion, inhalation, or dermal contact) to groundwater contaminated with any of the site COCs (manganese, 1-methylnaphthalene, TCE, 2-nitrotoluene, and perchlorate) at concentrations that exceed their groundwater CGs.

- Ensure that soil concentration of 1-methylnaphthalene and naphthalene are not posing a threat to groundwater beyond the established point of exposure (well location 271-RS2622).

3.3 Applicable Regulations

Corrective measures and CGs are developed based on considerations of applicable laws and regulations as well as consideration of concentrations that will achieve an acceptable risk/hazard. The CGs will comply with applicable laws and regulations and be set such that an acceptable risk/hazard will be achieved. The following laws and regulations are relevant to RSA-271 groundwater and its potential for potable use:

- Safe Drinking Water Act of 1974 non-zero MCL goals and MCLs (40 Code of Federal Regulations Part 141)
- Alabama MCLs (AAC Chapter 335-7-2).

Federal MCLs have generally been adopted by Alabama. As a result, federal MCLs are used as CGs for groundwater unless superseded by a state MCL. When a contaminant does not have a federal or state MCL, a CG is developed based on risk as discussed in Section 3.4 for manganese, 2-methylnaphthalene, 2-nitrotoluene, and perchlorate.

Other laws and regulations may affect alternative evaluation and selection. Table 3-1 lists relevant guidance and regulations pertinent to the RSA-271 corrective measures.

3.4 Selected Corrective Measure Cleanup Goals

Corrective measure CGs are established to protect human health and the environment while also meeting applicable regulations for alternatives that rely on concentration reduction. The identification of CGs must consider the environmental issues at the site and the receptors that are affected. CGs are relevant to alternatives that reduce concentrations, such as groundwater treatment or monitored natural attenuation (MNA). As noted in Section 3.3, federal MCLs are adopted as groundwater CGs for those substances which have them, unless superseded by a state MCL. CGs for other substances are typically based on risk considerations. ADEM (2008) considers an IELCR of $1x10^{-5}$ as the target cumulative cancer risk level and an HI of 1 as the target hazard limit. The CGs for RSA-271 were developed in light of the ADEM guidance. CGs for groundwater and soil are presented in Tables 3-2 and 3-3, respectively. Chemicals exceeding the RSL in groundwater but warranted no CG per the risk assessment will be monitored. These chemicals and their associated monitoring acceptance goals are presented in Table 3-3.

Groundwater

The RFI (APTIM, 2020a) concluded that manganese, perchlorate, 2-nitrotoluene, 1-methylnaphthalene, and TCE would pose an unacceptable risk to the commercial worker, construction worker, and hypothetical resident receptors should groundwater be used for potable purposes in the future (Table 2-2).

The CGs for COCs identified in RSA-271 groundwater and monitoring acceptance goals (MAG) for the common degradation products for TCE are shown in Table 3-2. For COCs for action with MCLs (i.e., TCE), the MCLs are selected as the CGs. The CG for perchlorate is selected as the EPA Interim Drinking Water Health Advisory Level (HAL) of 15 µg/L. This HAL was established as the approved Army groundwater CG for perchlorate in a memorandum from the U.S. Department of Defense in 2009 (U.S. Department of Defense, 2009). The target cancer risk of 1E-05 is used as the basis for development of the CGs for other chemicals without MCLs. The RFI report (APTIM, 2020a) presents the development of risk-based target levels for groundwater for different risks levels (Table D-22 of the RFI report [APTIM, 2020a]).

The following chemicals were detected in groundwater at concentrations exceeding RSLs but do not require calculation of a risk-based threshold level since the human health ARBCA evaluation determined that they do not pose a threat to human receptors: 3-nitrotoluene, 2,4,6-trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, nitroglycerin, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, naphthalene, 2-methlynaphthalene, benzo(a)anthracene, dibenz(a,h)anthracene, and dibenzofuran. These compounds will be included in future groundwater monitoring during the corrective measures for RSA-271.

Soil

Based on comparisons to the conservative DAF_4 SSLs, two chemicals (1-methylnaphthane and naphthalene) were determined to warrant an action during corrective measures due to the theoretical potential for these chemicals to leach to groundwater (Shaw, 2011d) directly under the source area. In order to determine the need for or extent of a soil action, site-specific soil SSLs were developed for 1-methylnaphthane and naphthalene using the groundwater resource protection module ADEM's ARBCA software package (ADEM, 2010) at a selected point of exposure.

Appendix G summarizes the fate and transport modeling used to develop site-specific SSLs for 1-methylnaphthane and naphthalene. Specifically, the ARBCA model software was developed to be consistent with ADEM guidance (ADEM, 2008; 2017b) for groundwater resource protection as discussed in Sections 6.9, and 9.3.9 of ADEM's ARBCA manual. This software package uses site-specific parameters for soil and groundwater which were integrated with updates to the default exposure factors, physical parameters, and toxicity values within the model to develop a site-specific leaching factor which includes the dilution attenuation factors for mixing with groundwater in the mixing zone. A second dilution attenuation factor is calculated in the software package using the Domenico Model for horizontal transport to the assigned point of exposure (POE). Using these factors, the ARBCA model calculates source area soil concentrations that are protective of groundwater at the POE (see Figure B-1 in ADEM, 2017 for a diagram of this process). For RSA-271, the POE has been selected as the nearest off-site well from the source area in the downgradient direction of groundwater flow (abandoned monitoring well 271-RS2622). These risk-based threshold levels (RBTLs) are compared with the MDCs in site soils as shown below:

Parameter	RBTL (milligrams per kilogram)	Maximum Soil Concentration (milligrams per kilogram)	Result
Naphthalene	2.17	1.6	Current MDC is less than the site-specific RBTL
1-Methylnaphthalene	21.1	4.78	Current MDC is less than the site-specific RBTL

The resulting site-specific RBTLs for RSA-271 for these chemicals compared to the maximum site concentrations in soil indicate that there is no source material posing a threat to groundwater at the most likely conservative point of exposure. Note that these values are less than the residential soil RSLs for 1-methylnaphthalene (18 milligrams per kilogram) and naphthalene (3.8 milligrams per kilogram). However, the full extent of contamination to the DAF_4 SSLs has not been established. Therefore, a soil action including a design optimization sampling program, is planned for this site. This design optimization sampling program will include SPLP testing of soil samples to be collected to determine the extent of source material that may pose a threat to groundwater beyond the point of exposure. CGs for naphthalene and 1-methylnaphthalene in both soil and in leachate collected using the SPLP process have been calculated as shown in Appendix G and presented in Table 3-3.

3.5 Scope and Role of Response Action

The environmental concerns at RSA are extremely complex. Work is underway or has been completed at over 200 sites in the Installation Restoration Program at RSA. To ensure protection from exposure to potentially contaminated groundwater under RSA-271 and elsewhere on RSA, a groundwater IROD has been approved for installation-wide groundwater LUCs (Shaw, 2007; 2009a). This IROD selected LUCs for groundwater as the interim remedy. LUCs have been implemented to prevent potable use of groundwater and manage nonpotable uses such that exposure to contaminated groundwater is minimized (Shaw, 2009a). This interim remedy (i.e., LUCs) will form the basis of a site-specific LUC to remain in place for the groundwater under RSA-271 until CGs have been achieved. In addition, the Army-regulated SAC program is currently in place to control access to the RCRA sites at RSA. This program prevents inadvertent exposure to contamination in the interim until required remediation is accomplished (Army, 2012). Via the SAC program, the installation of wells for drinking water is prevented, and all requests for the installation of wells for industrial processes or agricultural purposes on RSA are subject to Army review and approval. This program prevents the use of groundwater as a source of drinking water and allows nonpotable uses of groundwater to be managed.

3.5.1 Overall Corrective Measures Strategy for Redstone Arsenal

The overall strategy for cleanup at RSA has been presented to the regulators in two cleanup strategy documents, the *Installation-Wide Groundwater Cleanup Strategy* (Shaw, 2009b) and the *Installation-Wide Strategy for Cleanup of Impacted Wetlands* (Shaw, 2010b). The overall RSA cleanup strategy includes the following elements:

- Expedite evaluation and release of surface media sites to allow for efficient, mission-related property reuse.
- Expedite cleanup of source areas at surface media sites and secondary sources of ongoing groundwater contamination, including dense nonaqueous-phase liquid.
- Prevent exposures to surface media and groundwater that may result in unacceptable risks through the use of the Army's SAC program and from implementation of the groundwater LUCs selected in RSA's groundwater IROD until site-specific corrective measures can be implemented. This IROD is interim in nature. However, the decision to implement permanent LUCs will occur in conjunction with the RSA-146 groundwater unit.
- Coordinate the evaluation of groundwater units and their associated surface sites so that approval of groundwater RFIs is not delayed by unresolved surface media site issues.
- Design and implement an installation-wide monitoring network to monitor corrective measures progress and ensure that the selected remedies are protective of human health and the environment on a long-term basis.

The corrective measures for RSA-271 are consistent with the overall corrective measures strategy for RSA. The corrective measures will support the Army and the federal government overall in reducing future short-term and long-term financial liabilities associated with managing this site and the underlying groundwater unit, RSA-146.

3.5.2 Scope of Problems Addressed by RSA-271 Corrective Measures

The corrective measures at RSA-271 are intended to treat contaminated soil and groundwater that represents an unacceptable risk or hazard to the industrial and hypothetical future user of groundwater for potable purposes from contamination by perchlorate, TCE, 1-methylnaphthalene, naphthalene, manganese, and 2-nitrotoluene.

3.6 Extent of Contaminated Soil and Groundwater

Figures 2-2 thru 2-7 presented the distribution of metals, TCE, SVOCs, explosives, and perchlorate, respectively, in RSA-271 groundwater at concentrations exceeding RSLs and the extent of PAHs exceeding the soil to groundwater leaching DAF4 SSLs. Figures 3-1 and 3-2 provides a summary of locations with COCs in soil and groundwater exceeding their respective

CGs. PAH CG exceedances are present in subsurface soil below 10 feet bgs and are restricted to a relatively small area (approximately 200 square feet) near the UST pit (Figure 3-1).

Manganese was detected at a concentration of 9,090 µg/L, exceeding its CG (433 µg/L), in one well (271-RS1632) that was placed in the pit of the former UST (Figure 3-2). This well has been abandoned. TCE is the only VOC that exceeded the CG (5 µg/L) with a detection of 190 µg/L in monitoring well 271-RS130 (now abandoned)

SVOCs in groundwater with detections above RSLs were limited to PAHs (mainly naphthalene and methylnaphthalenes) and the SVOC dibenzofuran (Figure 2-4). Exceedances occurred in wells at or near the removed UST pit and the replacement blow-off/hot well overflow pit. 1-Methylnapthalene exceeded its CG (10.1 µg/L) in monitoring wells 271-RS1632, -RS2707, and -RS1631 (Figure 3-2). The SVOC groundwater plume is bounded by nondetects in downgradient well 271-RS2709, indicating the plume is restricted to the area just around the former UST pit. The existing data indicate the area of the SVOC plume (i.e., 1-methylnaphthalene) is approximately 0.1 acres.

Although 2-nitrotoluene was detected in groundwater at concentrations above its RSL, it did not exceed its CG (3.13 µg/L). Perchlorate in groundwater exceeded its CG (15 µg/L) in well 271-RS2374 with a detection of 24.1 µg/L (Figure 3-2). Detected perchlorate appears to be part of the commingled RSA-146 groundwater unit plumes which extend beneath RSA-271.

3.7 Corrective Measures Evaluation and Selection

The following information summarizes the analysis of technologies and alternatives and the selection of the corrective measures for this site in the corrective measures study report (APTIM, 2020b).

3.7.1 Summary of Corrective Measures Alternatives Evaluation

Groundwater technologies that could actively treat, passively attenuate, or prevent exposure to the COCs for action were considered during the evaluation. The following groundwater technologies were considered and retained during this evaluation as stand-alone technologies or components of the corrective measures:

- No Action
- Soil Excavation and Off-Site Disposal
- LUCs
- Enhanced MNA.

Following the initial evaluation, three corrective measures alternatives for contaminated soil and groundwater at RSA-271 were evaluated:

- **Alternative 1**: No Action. No active corrective measures would be taken to address the contaminated groundwater at RSA-271. Because this alternative would not be protective of human health and the environment, it is not considered a good candidate for corrective measures at RSA-271. The no-action alternative, however, is included in the detailed evaluation process consistent with state and federal guidelines. Evaluation of the no-action alternative serves as a baseline for evaluating other corrective measures.

- **Alternative 2**: MNA and LUCs. Alternative 2 involves the use of MNA to achieve the CMO for groundwater at RSA-271. Groundwater monitoring to assess contaminant reductions via natural attenuation would be conducted in three existing and one new monitoring wells within the existing contaminant plumes. Groundwater monitoring and reporting would be conducted for 30 years (Years 0 through 30).

- **Alternative 3**: Soil Excavation and Off-Site Disposal, Enhanced MNA, and LUCs. Soils exceeding the GCs for naphthalene and 1-methylnaphthalene, as determined by verification sampling coupled with SPLP analysis and ARBCA method evaluation, will be excavated and transported off-site for disposal. The excavation would then be backfilled with a layer of oxygen-releasing compound (ORC) to enhance MNA in the source area and clean soil to complete site restoration. Groundwater monitoring to assess contaminant reductions via natural attenuation would be conducted in three existing and three newly installed sentinel monitoring wells. Groundwater monitoring and reporting will continue until groundwater CGs have been attained or for 25 years if attainment has not been realized by that date (Years 1 through 26).

Alternative 3 verification sampling and SPLP analysis will ensure that soils containing the highest concentrations of naphthalene and 1-methylnaphthalene have been sampled and evaluated to determine if soil remediation is necessary. If necessary to excavate soil to achieve soil GCs, the results of the soil verification sampling will provide definition of the area of soil requiring excavation. Natural attenuation by physical and biological processes is expected to naturally degrade the dissolved constituents to groundwater GCs. The MNA portion of the remedy will include sampling groundwater for COCs and geochemical parameters until CGs have been attained. As shown on Figure 3-2, 1-methylnaphthalene concentrations in groundwater decrease with distance away from the UST pit and source area monitoring wells 271-RS2707 and 271-RS2708. The time required to achieve the CG for 1-methylnaphthalene can be estimated using the 1-methylnaphthalene concentration data for wells 271-RS2707 and the abandoned, downgradient well 271-RS2622 and assuming a first-order attenuation (EPA, 1998).

As shown on Figure 3-3, the attenuation model predicts plume core 1-methylnaphthalene concentrations be below the CG of 10.1 µg/L in approximately 26 years from the date the soil source is no longer capable of supplying a flux of 1-methylnaphthalene to groundwater.

3.7.2 Selected Corrective Measure – Soil Excavation and Off-Site Disposal, MNA, and LUCs

The Army concluded that Alternative 3, Soil Excavation and Off-Site Disposal, MNA, and LUCs most appropriately addresses the contaminated soil and groundwater at RSA-271.

The goals of the corrective measures for soil and groundwater are:

- Verify if site soils contain concentrations of napththalene and 1-methylnaphthalene that are acting as a continuing source of groundwater contamination. Soil sampling, SPLP analysis, and ARBCA method evaluation will be utilized for that determination.

- Excavate contaminated soil with COC concentrations exceeding the CGs, if present

- Place a layer of ORC in the bottom of the excavation to enhance MNA in the source area

- Maintain existing LUCs for groundwater to protect potential receptors until CGs in groundwater are attained for COCs requiring action.

- Implement a MNA program until all COCs requiring action have attained CGs for three consecutive years. At that time, the Army may request a permit modification to cease the MNA program.

3.8 Request for Permit Modification

The Revision 4 RSA-271 RFI report received ADEM concurrence on April 16, 2020. A copy of the ADEM concurrence letter for the RFI report is included in Appendix B. The request for permit modification accompanies the CMI work plan for RSA-271 and presents the supporting information, including all procedures necessary to implement and monitor the final corrective measures for the site in accordance with AAC R.335-14-8-.04 (2) (Appendix A). The inclusion of this request for permit modification meets requirements specified in Section VI.E.3 of the Permit.

4.0 Corrective Measures Implementation

This chapter provides an overview of the field activities planned to complete corrective measures for soil and groundwater at RSA-271.

Work discussed in this chapter will be completed in accordance with the procedures outlined in this CMI work plan and other approved documentation as appropriate.

4.1 General Scope

The general scope of work for RSA-271 activities is expected to include the following:

- Mobilization/demobilization (multiple phase)
- Design optimization sampling
- Baseline groundwater sampling
- Utility clearance and marking
- Installation of surface water and erosion controls
- Surveying and marking the proposed excavation areas
- Excavation of contaminated soil
- Confirmation sampling and analysis of the excavated areas
- Waste characterization sampling
- Transport and disposal of excavated soils (nonhazardous) at an off-site Subtitle D facility
- Site restoration, including backfilling of excavation areas using clean borrow soil and revegetation
- Placing ORC in the bottom of the excavation to treat the PAHs in groundwater within the source area.
- MNA (enhanced MNA in the source area and groundwater sampling and reporting).

The general schedule for implementation of corrective measures at RSA-271 is provided in Appendix C. The schedule is approximate. The dates of actual implementation will depend on document review time, Raytheon Operational Area access schedule, coordination with other sites, and field conditions encountered during implementation.

Communication and coordination during the CMI will follow the guidelines provided in the project management plan for the Army and its contractors, and RSA's community involvement plan (CB&I, 2015b). As per the RCRA permitting process, public involvement will occur during the permit modification process.

4.1.1 Procurement and Subcontracting

Subcontracted services and materials required for the completion of the project may include the following:

- Storm water erosion and sediment controls
- Vegetation clearing
- Soil boring and monitoring well installation and development
- Surveying
- Groundwater sampling
- Analytical laboratory services
- Remediation-derived waste (RDW)/investigation-derived waste (IDW) transportation and disposal (e.g., drill spoils, excavated soil, sampling, and purge and decontamination water).

Support equipment and materials will be procured through equipment vendors and scientific supply vendors and shipped directly to the site. Support equipment includes excavators, dump trucks, portable storage, radios, relief stations, eyewashes, sampling supplies and equipment, health and safety supplies and equipment (e.g., personal protective equipment [PPE], air monitoring equipment [e.g., photoionization detector]), and other miscellaneous supplies (e.g., wooden stakes and pin flags).

4.1.2 Field Personnel

The following field personnel may be utilized to complete field corrective measure activities:

- Site supervisor
- Site safety officer
- Field quality control site manager
- Field geologist
- Groundwater sampling technician(s)
- Equipment operator
- Laborer.

Drilling and surveying activities will be subcontracted. Excavation activities and groundwater sampling may be performed in house or subcontracted. The number and schedule of personnel will be adjusted during the project as required for completion.

4.1.3 Quality Control Inspections for Field Activities

Inspections will be performed to determine compliance with this work plan. The inspection criteria are included in the field audit checklist (Appendix E) and will be verified during inspection activities. Inspections may be performed and verified through visual observation, measurement of materials or equipment, examination of documentation/certification, evaluation of performance, or testing.

Inspections will be performed using a three-phase inspection method. Participants in the inspections typically include, but are not limited to, the field personnel, the project quality control manager, the regulatory representative, and the project health and safety representative. The preparatory inspection(s) are performed prior to start-up and will examine training, procedures, equipment and materials, work plans and documents, and overall readiness to perform work. Initial inspection(s) are performed upon beginning a particular phase of work and include an examination of the quality of workmanship and a review of control testing for compliance with work plan requirements. Follow-up inspection(s) are then performed to verify compliance with procedures. Follow-up inspections will ensure a continuation of quality and safety standards established during preparatory and initial inspections until completion of the definable work feature. Final follow-up inspection(s) will be conducted at the completion of the activity. The final follow-up inspection will be performed to ensure that the completed feature of work meets the work plan requirements. Any deficiencies noted during this inspection will be documented and a determination will be made as to the corrective actions necessary to mitigate the deficiency. All significant deficiencies will be corrected prior to completion of the activity. Records of inspections will be maintained in the project files. At a minimum, inspection files will include inspection reports/checklists, inspection responses, any supporting documents, and applicable comments.

4.1.4 Daily Reports

The requirements for preparation and submittal of daily project documentation are outlined in the CQAP (Appendix E). As indicated in the CQAP, the daily reports (including daily construction logs, etc.) will be provided to the Project Manager or designee during CMI activities.

4.1.5 Safety and Health Requirements

All personnel involved in the corrective measures will follow this work plan and abide by the health and safety requirements presented in the SSHP prepared by the contractor responsible for implementing the corrective measures (Appendix D).

4.2 Preliminary Activities

Preliminary activities include mobilization, surveying, utility marking, obtaining dig permits, protection of existing site features, and requirements for base access and Raytheon Operational Area access. All field personnel will follow this work plan and abide by the health and safety requirements presented in the SSHP.

4.2.1 Job Order Request

A job order request that describes the proposed activities will be submitted to the Army's Environmental Management Division 3 to 4 weeks prior to field activities for review and approval. This information is provided to RSA through a system that affords various RSA entities the opportunity to review the proposed activities and verify that impacts to RSA resources (e.g., natural, cultural, etc.) are properly managed. The job order request requires an active common access card and appropriate permissions to input the information into the system by the subcontractor. It could take a significant amount of time to obtain a common access card and permissions required for submittal. In addition, it may take several weeks to obtain approval of the job order request.

4.2.2 Mobilization

Upon notice to proceed, the CMI contractor will begin mobilization, including the deployment of personnel, equipment, subcontractors, and materials necessary to commence CMI activities at RSA-271. After field mobilization, a preconstruction meeting and safety orientation will be held to review the proposed approach and the sequencing of work to ensure that clear lines of communication are established. All necessary site-specific safety training will be conducted at this time. Site-specific training will also include project objectives, entry onto RSA, entry onto Raytheon Operational Area, SAC, security procedures, and communication procedures.

4.2.3 Access to Redstone Arsenal

Obtaining access requires registering at RSA Visitor's Center located near Gate 9 on Rideout Road. Access to RSA must first be requested thru the Environmental Office prior to arriving at Gate 9. Badge requests for access to RSA should be submitted at least two weeks ahead of the date needed to allow for approval and processing by the RSA host organization. Upon presentation of proper identification and completion of a background check, RSA will issue an installation access badge. Temporary passes may be required for some vehicles. Upon registration, personnel may access RSA through any of the gates in operation at RSA. Access to RSA is subject to change based upon security alerts or status (e.g., terrorist threat condition, force protection condition).

Military and government personnel may use current military (active, retired, or family) or federal government identification. Additional information can be obtained from the Redstone Arsenal Visitors Center located at Gate 9 at (256) 876-1122 or the Vehicle Registration Office at (256) 876-5770.

After field mobilization, a preconstruction meeting and safety orientation will be held to review the proposed approach and the sequencing of work to ensure that clear lines of communication are established. All necessary site-specific safety training will be conducted at this time.

4.2.4 Digging Permit and Utility Marking

Prior to conducting any intrusive site activities, a digging permit will be requested from the RSA Directorate of Public Works. As part this of permit, RSA will locate and mark underground utilities in the vicinity of the proposed soil excavation, soil borings, and monitoring wells at RSA-271. The procedure requires notification by telephone ([256] 876-9881) within 14 days of intrusive activities.

The digging permit must be renewed every 30 days. To avoid temporary shutdown, a request for permit extension will be made at least 1½ weeks prior to expiration.

4.2.5 Site Control

The contractor will use temporary construction fencing materials, barricades, and/or warning tape, as necessary, to prevent access of non-operating personnel from areas where corrective measures operations are occurring in compliance with the SSHP. Warning signs may be posted at conspicuous locations around the perimeter of the work areas to discourage unauthorized entry. The sign spacing will be approximately 50 feet. An equipment storage and material laydown area will be coordinated with RSA and designated during mobilization.

4.2.6 Storm Water Erosion and Sediment Controls

Soil excavation, soil boring, and monitoring well installation and sampling activities may result in land disturbance if significant clearing of vegetation and or trees is required for installation or access. Storm water management and erosion and sediment control will be provided in accordance with the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas (Alabama Soil and Water Conservation Committee, 2018), as required.

Best management practices (BMP) (surface stabilization, runoff conveyance, sediment control, stormwater management, etc.) will be used to divert clean water away from a disturbed site, minimize erosion and sedimentation, and prevent pollution of water and land at the sites. Installation of temporary controls will be coordinated to maintain effective and continuous control of erosion and pollution. The primary erosion control techniques will be silt fencing and hay bales. Erosion control devices will be inspected at least once per week and following any accumulation of rainfall 0.75 inch or more within a 24-hour period. Sediment deposits will be manually removed from the silt fence after each qualifying rainfall event or when sediment reaches one half of the barrier height. Removed sediment will be added to the contaminated soil for subsequent disposal. Repair of damaged erosion control devices and damaged areas around and beneath the devices will be initiated within 24 hours of report. The final location of erosion and sedimentation controls, if required, will be determined during pre-construction meetings with RSA and subcontractors. Upon completion of the project, erosion and sedimentation control devices will be removed.

4.2.7 Vegetation Clearing

As necessary, APTIM will clear trees/vegetation that impede soil excavation, soil boring, and monitoring well installation or sampling. Vegetation (briers, shrubs and trees) will be removed and chipped for mulch (beneficial use) for Army reuse or sale. Any trees located within the excavation area less than or equal to 2 feet in diameter will be cut at grade and either chipped and stockpiled within the footprint of the excavation area or transported to the construction and demolition (C&D) landfill.

Clearing of trees with a diameter of 3 inches or greater (at breast height) is limited to December 1 through March 31 to protect known or potential roost trees of the Indiana and the northern long-eared bats during the active season of April 1 through November 30 in Alabama. This time-of-year restriction may be altered to protect roost habitat during April 1 through November 30, with project specific consultation with the Alabama U.S. Fish and Wildlife Service (USFWS) Field Office. The time-of-year restriction may be waived if USFWS protocol surveys have been completed to verify absence.

4.2.8 Verification Soil Sampling

Soil sampling will be completed at two locations near the former UST pit (Figure 4-1). Each soil boring will be sampled from 10 to 12 and 16 to 18 feet bgs and analyzed for total and SPLP method VOCs and SVOCs.

Soil sampling will be completed using direct-push technology methods and will follow Standard Operating Project Procedure (SOPP) No. 6, *Subsurface Soil Sampling* (Shaw, 2013b and as updated). Subsurface soil data will be evaluated following the methodology in Section 4.2 of the RFI report (CB&I, 2017).

4.2.9 Monitoring Well Installation and Development and Baseline Sampling

Three new overburden monitoring wells are proposed for installation at RSA-271 to better monitor downgradient groundwater concentrations (Figure 4-1). Well installation rationale follows:

- 271-RS2994: Overburden replacement sentinel well for 271-RS2622. Designed to monitor contaminant migration downgradient of the site (southeast).
- 271-RS3003: Overburden sentinel well designed to monitor contaminant migration downgradient of the site (east).
- 271-RS3004: Overburden sentinel well designed to monitor contaminant migration downgradient of the site (south).

New monitoring wells will be installed in accordance with the procedures outlined in SOPP No. 17, *Monitoring Well Installation* (Shaw, 2013b and as updated). New overburden wells will be constructed of 2-inch-diameter Schedule 40 polyvinyl chloride, with a 10-foot screen, completed with aboveground protective casing and guard posts, and completed to an estimated depth of approximately 40 feet below ground surface.

Upon completion, the well will be developed in accordance with SOPP No. 8, *Well Development* (Shaw, 2013b and as updated). Following well installation (completion, development, and survey), pertinent well data and records shall be submitted to the Installation Restoration Branch of the Environmental Management Division at the RSA. Additional information concerning the proposed monitoring wells is provided in Appendix F (Table F-3). Baseline sampling will be completed for all six monitoring wells, as described in Appendix F.

4.2.10 Locating, Marking, and Surveying of Well Locations

Existing monitoring wells within close proximity of the work zone will be conspicuously marked in the field for protection. If a monitoring well is inadvertently damaged during field activities, the well will be inspected and, if possible, repaired. The well will be closed and replaced in kind if damaged beyond repair.

A licensed land surveyor will be subcontracted to survey new monitoring well locations. The surveyor will mark items in the field with highly visible wooden stakes, tape, or pin flags. Surveying methods will follow the procedures specified in the CQAP (Appendix I).

4.2.11 Stockpile Work Area

A soil stockpile work area will be established at RSA-271 for staging excavated contaminated soil prior to waste characterization and disposal and for staging of clean backfill from an off-site source, if necessary. The contaminated soil will be stockpiled in maximum of 200-cubic yard piles. Clean backfill material will be stockpiled separately. The soil work area will be lined with heavy plastic sheeting and surrounded by a 1-foot-high berm to prevent runoff water and soil migration. A preliminary site layout including stockpile locations is shown on Figure 4-2.

4.3 Excavation of Contaminated Soil

The proposed excavation area and the site layout are shown on Figure 4-2. The excavation is 10 feet long by 20 feet wide (200 square feet). The approximate volume of the contaminated soil is 4,000 cubic feet or approximately 148 bank cubic yards of soil. Assuming a bulking factor of 1.3 from excavating, the disturbed or loose volume will be approximately 200 loose cubic yards.

When the excavation areas have been cleared and the excavation limits have been demarcated, APTIM will begin excavating from the designated areas using a backhoe or excavator. The excavations will extend to a depth of 20 feet. All excavations will be conducted in accordance with the Safety and Health Regulations for Excavations (Occupational Safety and Health Administration 29 Code of Federal Regulations Part 1926 Subpart P). Excavations over 4 feet deep will be shored, sloped (1½:1, horizontal:vertical), or benched as required. Spoils will be placed a minimum of 3 feet from the edge of the excavation. Loose soil or rocks will be removed from the sides of excavation walls. Personnel will not enter any excavation over 4 feet deep that is not properly sloped or benched.

Following excavation, soil confirmation samples will be collected from the sidewalls of each excavation to verify that the CG for PAHs (Table 3-3) have been achieved. Section 4.4 discusses the collection of confirmation samples. Because the excavation is planned to stop at the water table (~20 feet bgs), no excavation floor samples will be collected. If the sidewall confirmation samples do not achieve the CG, they will be expanded out a minimum of one bucket width (approximately 3 feet) and resampled.

The excavated material will be temporarily stockpiled or staged prior to waste characterization sampling and off-site disposal. The excavated material will be segregated (contaminated versus uncontaminated), staged on impervious material such as plastic sheeting, and covered with waterproof material (i.e., tarpaulin or 10-mil plastic sheeting). Containment will control runoff, leaching, or fugitive dust emissions. Measures will be taken to prevent any surface runoff from entering into or washing away from the stockpile. The excavated areas will be adequately secured from the public and filled as soon as possible.

If necessary, dust at the site will be controlled with water using a water truck with hose and sprayers and mulch such as straw. Dry exposed areas will be misted with water until the surface is wet and repeated as needed. Visual observation will assure that water will be applied at rates so that runoff does not occur. In addition, all other equipment used at the site during operations will be operated in a manner that prevents further migration of contamination. Polymers, tackifiers, stabilizers, or chlorides will not be used for dust control. An action level of ½ the Occupational Safety and Health Administration particulate not otherwise specified threshold respirable fraction (2.5 milligrams per cubic meter) within or directly downwind of the work areas will be used to determine when dust suppression is needed. Dust levels will be monitored using a Data Ram PDR 1000 or equivalent real-time aerosol monitor.

4.4 Confirmation Sampling

Following completion of the excavations, confirmation soil samples will be collected within the excavation areas to ensure that the soil contaminant concentrations do not exceed the CG. The confirmation sampling design is statistically based and follows the guidelines set forth in (1) Section 9.6 of ADEM *General Soil Sample Collection Standard Operating Procedure (SOP) #2150, Rev. 1.1* (ADEM, 2018); (2) the August 13, 2010 guidance from ADEM, *In-situ Sampling for the Purposes of Waste Characterization/Disposal of Soil* (ADEM, 2010); and (3) Pacific Northwest National Laboratory (2012) *Visual Sample Plan* (Pacific Northwest National Laboratory, 2012).

The proposed excavation is small in area (10 feet by 20 feet) but relatively deep (~20 feet bgs). Sidewall samples will be collected in the center of each sidewall at depth intervals not to exceed 5 feet. The points will include a center point of the sidewall section plus aliquots from the upper and lower left and right quadrants of the sidewall section. Confirmation samples will not be collected from the excavation floor, as the floor elevation represents the water table and as such the excavation cannot practically be deepened. The confirmation sample locations are shown on Figure 4-3.

Confirmation samples will be sent to an off-site analytical laboratory for analysis of the PAHs identified as COCs (EPA Method 8260B) on a 5-day turnaround basis. Confirmation samples will be collected in accordance with the DCQAP provided as Appendix E. Sample designations are shown in Worksheet No. 18 of Appendix E.

Soils from the perimeter walls of the excavation will be collected at the designated locations using the excavator bucket and a Terra Core Sampler used to collect the samples from soil in the excavator bucket.in accordance with Worksheet No. 20 in the DCQAP (Appendix E) and SOPP Nos. 2.0, 5.0, 6.0, and 24.0 (HydroGeoLogic, Inc. [HGL], 2019). Sample collection logs will be filled out to document the sampling in accordance with SOP No. 1.0 (HGL, 2019).

Confirmation samples will be collected using routine quality assurance/quality control sample frequencies (i.e., 10 percent field duplicates, 5 percent matrix spike/matrix spike duplicate). All sample containers, preservatives, and holding times will conform to the requirements specified in Worksheet No. 20 in the DCQAP (Appendix E).

All analytical data generated from this project will be managed in accordance with the procedures specified in the DCQAP, except only the final confirmation sample results will be validated. Sample documentation, custody, packaging, and shipping will follow the procedures specified in the DCQAP. Custody will be maintained at all times by the CMI contractor sampling team prior to shipment to the analytical laboratory using typical chain-of-custody forms.

4.5 Waste Characterization

Contaminated soils will be stockpiled as discussed in Section 4.4. For planning purposes, one soil stockpile will be generated during the RSA-271 excavation (~100 loose cubic yards). Grab samples will be collected from three exterior points of the stockpile from a depth between 0 and 2 feet. Two additional samples will be taken from the interior of the pile at a depth between 2 and 5 feet. The grab samples from the five points within each decision unit will be composited. Waste characterization samples will be sent to an off-site analytical laboratory for total PAHs and toxicity characteristic leaching procedure (TCLP) SVOCs. Stockpile samples will be collected in accordance with the DCQAP provided as Appendix E. No additional quality assurance/quality control samples (other than the method-required batch quality control) will be required for the waste characterization samples.

Upon receipt of the analytical data, the waste characterization sample results will be compared to the regulatory levels for TCLP SVOCs and total PAHs. If the TCLP results indicate that the concentrations are below the RCRA regulatory criteria, the suspected stockpiled contaminated soil will be shipped to an off-site permitted Subtitle D landfill for disposal as nonhazardous special waste and the suspected stockpiled uncontaminated soil will be used as backfill.

4.6 Remediation-Derived Waste Management

The management of excavated soils is discussed in Section 4.4. Waste transportation and disposal are discussed in Section 4.7. Other RDW generated during the CMI activities at RSA-271 is expected to include silt fencing (i.e., erosion control material) decontamination fluids, and disposable PPE.

Solid RDW, liquid RDW, and PPE are examples of RDW that will be managed. All RDW will be containerized, labeled, and stored in compliance with the provisions of AAC r. 335-14 as applicable and as discussed in the AEIRG (ADEM, 2017a). PPE that is contaminated by site media will be disposed of with the contaminated waste stream (i.e., PPE generated during soil excavation will be disposed with the soil). PPE that is uncontaminated will be placed in trash bags and disposed in a dumpster as normal household trash. Other types of RDW, if generated, will be managed in accordance with Table 2 of Appendix G of AEIRG (ADEM, 2017a).

In determining whether to manage RDW as nonhazardous or hazardous, factors such as generator knowledge and real-time field measurements or observations will be considered. AAC r. 335-14-3.01(2) allows the use of generator knowledge in the hazardous waste determination process. Generator knowledge consists of an evaluation of the following four factors:

1. Process Knowledge – The site processes are evaluated to determine whether any activity might have generated a listed waste which still persists in soil or groundwater.

2. Past Management Practices –IDW resulting from various site investigation activities have been managed at RSA for over 20 years. Changes to regulations directing this management have been minor. The Army intends to follow management practices which have been accepted by ADEM during prior investigations.

3. Sampling Results from Past Waste Characterization Sampling – Historical waste characterization sampling may indicate whether future IDW or RDW is likely to be a nonhazardous waste or to have characteristics of a hazardous waste.

4. Sampling Results from Past Soil and Groundwater Sampling – Historical sampling results from soil and groundwater sampling may indicate whether future IDW or RDW is likely to be a nonhazardous waste or to have characteristics of a hazardous waste.

Historical uses of RSA-271 indicated the primary soil COPCs are fuel-related PAHs that are not regulated by RCRA. It is unlikely that the excavated soil would be classified as a listed or a characteristic waste. There are no known current or historical processes that occurred at RSA-271 that would indicate that any listed waste codes would apply to IDW/RDW.

Wastes will be containerized, labeled, and stored in compliance with the provisions of AAC r. 335-14 as applicable and as discussed in the AEIRG (ADEM, 2017a). Heavily soiled PPE will be drummed after use and subsequently disposed based on the analytical results of the waste characterization soil samples.

For RDW considered to be nonhazardous using generator knowledge and field observations, liquid waste will be containerized and stored on site pending sampling and analysis. Analytical testing and subsequent evaluations will be performed to determine if soil may be disposed of off site at a Subtitle D landfill. Sampling and analysis of RDW are discussed in Appendix E.

Any RDW determined to be hazardous will be managed and disposed of the waste as specified in SOPP No. 4.0, *Investigation Derived Waste* (Appendix H). None of the waste streams generated during CMI at RSA-271 are anticipated to generate any hazardous waste. For nonhazardous water RDW, possible management options include processing through RSA's sewage treatment plant or an appropriate RCRA-permitted facility.

4.7 Waste Soil Transportation and Disposal

A licensed transportation and disposal subcontractor will be used to complete these activities. It is assumed that the soil will be disposed as special waste (nonhazardous) at a Subtitle D landfill. Transportation and disposal of the excavated waste will begin after approval by the selected waste disposal facility and ADEM or the applicable regulatory agency for the selected disposal facility (typically 4 to 6 weeks after receipt of Solid Waste Profile Sheet). Prior to transport, an RSA representative will review and sign the waste manifest.

During loading, APTIM will document the quantities of waste loaded onto the dump truck and facilitate the Bill of Lading or shipping paper documentation for the nonhazardous waste shipments. Transportation will comply with all U.S. Department of Transportation regulations. APTIM will coordinate with the transporters so that the waste will be shipped to arrive on schedule at the landfill. APTIM will also receive written approval from the landfill (and ADEM, if required) prior to shipping waste to their facility. The landfill will provide APTIM with a certificate of disposal for each load received and processed.

4.8 Site Restoration and Demobilization

4.8.1 ORC Placement, Backfilling, and Site Restoration

Upon verification that the confirmation samples from an excavation area are below the relevant CGs for that area, the excavation area will be backfilled until the area has been restored to its original grade. Prior to backfilling 400 pounds of ORC will be spread evenly across the bottom of the excavation. The ORC will dissolve and add oxygen to the aquifer in the source area enhancing biodegradation of the PAHs in this area. An appropriate amount of fill material will be brought in from an approved off-site borrow source. As a contingency, representative samples of the borrow source material will be collected to confirm it is acceptable for use as backfill at the site should an approved location not be available. The borrow material sampling, if required, will include one 5-point composite sample analyzed for TCL SVOCs, TCL pesticides/polychlorinated biphenyls, and target analyte list metals and one sample analyzed for TCL VOCs. Borrow samples will be collected in accordance with the DCQAP provided as Appendix E.

The analytical results for target analyte list metals will be screened against BSVs and residential soil RSLs as supplemented by a site-to-background evaluation, if needed. Soil concentrations for VOCs, SVOCs, and pesticides/polychlorinated biphenyls will be screened against their respective residential soil RSLs to demonstrate that the material is acceptable for use. An existing borrow source may be utilized, if the borrow material sample collected previously meets the parameters listed above and this previous sample is still representative of the borrow soil that would be used at RSA-271.

The backfill material will be dumped near the excavation area using a dump truck and placed in the excavation in lifts no greater than 1 foot high, with each lift compacted by the excavator prior to placement of the next lift. During backfilling, dust control will be implemented as discussed in Section 4.3. Once the area has been backfilled and compacted, clean topsoil will be placed over it. The disturbed area will then be seeded and mulched to promote revegetation and reduce the potential for soil erosion. Seed and mulch will be applied to all disturbed areas according to the Alabama Soil and Water Conservation Committee (ASWCC) Permanent Seeding BMP (ASWCC, 2018).

The applied grass mixture used will depend on the date scheduled for planting and the area planted. Refer to the Alabama Department of Transportation (ALDOT) Standard Specifications (ALDOT, 2018) Section 860.01 for seed mixture for Zone 1-Areas Subject to Frequent Mowing. Initial temporary planting of annual ryegrass is tentatively scheduled to occur in late fall to early winter (November and December). Permanent planting of bermudagrass and white Dutch clover is tentatively scheduled to occur in late spring to early summer (April and May).

A site inspection will be conducted approximately 4 weeks after the seeding to confirm the revegetation is successful. If revegetation is unsuccessful, the site will be reseeded until an adequate stand of vegetation is present. All temporary fencing, plastic sheeting, hay bales, wooden stakes, and other project-related items will be removed from the site and disposed in accordance with SOP No. 4.0, *Investigation Derived Waste* (Shaw, 2013b).

4.8.2 Equipment Decontamination

An area will be designated within the boundary of the work areas at RSA-271, adjacent to vehicular ingress and egress areas, for equipment decontamination. A decontamination pad typically consists of a soil-bermed area covered with multiple layers of visqueen sheeting where gross contamination can be removed from equipment. The decontamination pad will contain a sump area or low area where wash water from pressure washing will drain to be pumped into a portable holding tank. Decontamination fluids will be sampled for total PAHs. Decontamination fluids will be managed as discussed in Section 4.6.

Nondisposable sampling equipment will be decontaminated prior to beginning work at the site and prior to the collection of individual samples to prevent cross contamination and maintain the integrity of the environmental samples collected. All nondisposable equipment will be decontaminated in accordance with procedures specified in the RSA installation-wide quality assurance program plan (HGL, 2019), which was prepared in accordance with Appendix E of the AEIRG (ADEM, 2017a).

4.8.3 Temporary Storm Water, Erosion Control, and Sediment Control Removal

Upon completion of site restoration activities, temporary erosion and sediment controls will be removed and disposed of off site at the RSA construction and debris landfill or with the RDW from the excavation. The silt fence will remain in place until after the vegetation is established. When the silt fence is removed, the posts will be pulled from the ground and the remaining disturbed area will be reseeded. Excess soils will be removed from the silt fence and disposed of with the RDW from the excavation.

4.8.4 Demobilization

Personnel, equipment, and subcontractors will be demobilized from the project site after completion of remedial activities. A small crew and minimal equipment will be retained as required to remove surplus materials and clean staging areas.

Demobilization will primarily consist of disassembly, packing, and return of rented equipment to suppliers and travel for personnel back to their home offices.

4.9 Corrective Measures Implementation Reporting

A CMI report will be prepared in accordance with Section VIII.D of the Permit and AEIRG (ADEM, 2017a) as discussed in this section. If completion of the CMI requires more than 180 days, the Army will submit quarterly CMI progress reports in accordance with Section VIII.D.1 of the Permit. The CMI report will include the following:

a) A description of activities completed

b) As-built construction drawings presenting the final limits of soil excavations at each site and the locations of confirmation samples

c) Waste manifests indicating the handling of the excavated material that has been shipped off site to a certified disposal facility

d) Monitoring data (soil, air, dust, and water) collected for any reason during the construction period for the purposes of monitoring potential for human and ecological exposure

e) Certification, prepared in accordance with AAC 335-13-8-02 (2)(d) by RSA and a registered professional engineer (State of Alabama), that the corrective measures required by the Permit are complete

f) Appendices consisting of site photographs, analytical reports, data validation documentation, and waste manifests.

4.10 Post-Construction Scheduled Activities

Post-construction scheduled activities include groundwater monitoring and data evaluation, inspections, and reporting.

4.11 Groundwater Monitoring

Groundwater monitoring will be performed in two phases: baseline groundwater sampling during Year 0 followed by annual groundwater sampling Years 1 through 26 or until COCs (manganese, 1-methylnaphthalene, 2-nitrotoluene, TCE, and perchlorate) reach CGs in the monitored wells for three consecutive years.

Note that sequential dechlorination of TCE is occurring (TCE → cis-1,2-dichloroethene [DCE]→ vinyl chloride [VC]) in the groundwater beneath the site. Additionally, 1,1-DCE will be included with the three major components of the degradation sequence (TCE, cis-1,2-DCE, and VC) as 1,1-DCE can be created during the abiotic degradation of TCE (Mattes et al, 2010). Therefore, groundwater monitoring will include the following common degradation products for the site COCs TCE: 1,1,DCE, cis-1,2-DCE, trans-1,2-DCE, and VC. Although TCE is only marginally elevated above its CG (7 parts per billion versus 5 parts per billion), TCE and its degradation products (1,1-DCE, cis-1,2-DCE, and VC) will be monitored until TCE and other COCs for action have attained their CGs for three consecutive years. Note that TCE is present at RSA-271 as a result of groundwater migration from RSA-138M and RSA-097 and other nearby degreaser sites. After the COCs for action have attained their CGs for three consecutive years, Army will request that ADEM allow groundwater monitoring to be discontinued.

The corrective measures study recommended that six wells would be included in the groundwater monitoring program to evaluate enhanced MNA processes in the source area and MNA processes in down and cross gradient areas at the site. The following wells will be included in the groundwater monitoring program:

- 271-RS2707 to monitor the plume core adjacent to the former UST pit
- 271-RS2708 contaminated well south of the former UST pit
- 271-RS2709 cross gradient well located east of the former UST pit

- 271-RS2994 proposed overburden well installed as a downgradient effectiveness well.

- 271-RS3003 proposed overburden well installed as a downgradient/cross-gradient effectiveness well.

- 271-RS3004 proposed overburden well installed as a downgradient/cross-gradient effectiveness well.

Baseline sampling will be completed from groundwater monitoring wells as identified on Figure 4-1. The six monitoring wells cited will also be sampled during annual sampling events until CGs are achieved.

The rationale for well selection, frequency of sampling, procedures and analytical parameters, and reporting is discussed in detail in Appendix F. Seasonal and storm-related trends in temperature and rainfall influence surface water and groundwater flow conditions. Precipitation is the principal source of groundwater recharge, either directly through infiltration and percolation through the vadose zone (unsaturated overburden) or as runoff to streams, which may also recharge groundwater. Rainfall contributes to groundwater recharge primarily during the winter when deciduous trees are leafless, reducing overall transpiration (APTIM, 2020a). As determined by an evaluation of previous monitoring results, annual groundwater sampling will be performed in the late winter or early spring season, providing the most representative picture of groundwater quality for the site.

The Army may propose to perform groundwater sampling during the dry season if the evaluation of the RSA-271 groundwater monitoring data determines this may be useful to observe notable differences between the wet and dry season. For example, the Army has taken this approach at the open burn/open detonation units where annual groundwater monitoring alternates between the wet and dry season. The Army review of the monitoring data collected during the previous years of effectiveness monitoring will be completed in consultation with ADEM in order to develop a technically sound approach that is agreeable to both ADEM and the Army. The samples will be collected using low-flow purging and sampling techniques. The long-term groundwater monitoring samples will be analyzed for the analytes and field parameters identified in Table 4-1 and Appendix F.

- One baseline groundwater sampling event in Year 0. Baseline groundwater monitoring will be performed to define water quality conditions at the site. Groundwater samples will be collected from six monitoring wells and analyzed for VOCs, SVOCs, explosives, perchlorate, and manganese. Note that only COCs for action or COCs for monitoring will be reported. Full TCL suites will not be reported.

- Annual groundwater sampling in Years 1 through 26. Groundwater samples will be collected from six monitoring wells during each sampling event and analyzed for VOCs, SVOCs, explosives, perchlorate, and manganese. Note that only COCs for action or COCs for monitoring will be reported. Full TCL suites will not be reported.

In addition to the COCs for action (and the biodegradation products for TCE), groundwater monitoring will include the constituents that did not contribute to unacceptable human health risk but did exceed the RSL (3-nitrotoluene, 2,4,6-trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, nitroglycerin, naphthalene, 2-methlynaphthalene, benzo[a]anthracene, dibenz[a,h]anthracene, dibenzofuran, 2-amino-4,6-dinitrotoluene, and 4-amino-4,6-dinitrotoluene). If concentrations of these constituents are equal or less than their RSLs for three consecutive years, the Army may petition ADEM to eliminate these constituents from the groundwater monitoring program. Monitoring for these constituents will also cease when all COCs for action have met their CGs pending ADEM approval of Army's request to discontinue monitoring.

Natural attenuation field tests will also be performed for dissolved iron (ferrous) and standard field measurements (dissolved oxygen, oxidation-reduction potential, pH, temperature, conductivity, and turbidity).

4.11.1 Data Evaluation and Interpretation

The primary objective of the groundwater monitoring program for RSA-271 is to determine whether the corrective measures reduce COC concentrations in groundwater beneath the site to levels determined to be acceptable to human health (i.e., CGs). Any statistical analysis used as part of this evaluation will follow AAC 335-14-5-.06(8)(h) and EPA guidance for groundwater monitoring at RCRA facilities (EPA, 1989; 1992; 2009).

Non-statistical methods may also be used to characterize RSA-271 groundwater conditions and may include the following:

- ***Hydrographs.*** Graphs of water levels versus time may be constructed to determine increases, decreases, seasonal, or man-made fluctuations in groundwater levels.
- ***Potentiometric Surface Maps.*** Depths to groundwater from multiple wells may be used to construct potentiometric surface contour maps and estimate flow directions.
- ***Concentration-versus-Time Plots.*** Graphs of COC concentrations versus time at each well will be constructed for each data set subjected to trend analysis. This supports the identification of trends and helps determine if concentration changes are related to changes in water level, changes in groundwater flow directions, or natural attenuation.

- ***Plume Maps.*** Maps depicting the physical distribution of chemical constituents will aid in determining movement of plumes.

- ***Geochemical Evaluation.*** For inorganic constituents that fail statistical comparison tests, geochemical evaluation may be performed to determine which concentrations may be naturally elevated and which concentrations may have a contaminant source.

4.11.2 Inspections

LUCs for groundwater implemented as part of RSA's Installation-wide groundwater IROD will be continued until final remedies are selected for groundwater site RSA-146. The controls specified as part of the Installation-wide groundwater IROD will continue to protect potential receptors until CGs in groundwater are attained for COCs requiring action at RSA-271. The Army's SAC program is used to implement the groundwater LUCs. Via the SAC program, the installation of wells for drinking water will be prevented, and all requests for the installation of wells for industrial processes or agricultural purposes for RSA-271and all other locations on RSA will be subject to Army review and approval.

General site inspections of RSA-271 shall be conducted annually to verify that LUCs are being properly implemented per the environmental restriction.

- A site inspection to verify whether any new wells have been installed at RSA-271. This inspection will also be used to verify that usage of the wells is in accordance with the Army SAC program.

- If additional wells are discovered, or if any wells are being used in a manner inconsistent with the Army SAC program, ADEM shall be notified within 10 days. Corrective actions will be initiated within 10 days of identifying the need for such actions.

LUC inspections will be documented in the CMI effectiveness reports.

4.11.3 Reporting

The corrective action program, as described in this work plan, will treat constituents that exceed their CGs using MNA. The groundwater monitoring program (Appendix F) establishes a monitoring well network capable of providing data that will be used to assess changes in the rate and extent of groundwater contamination. The corrective action will begin in accordance with the date established by the Permit modification. The annual groundwater monitoring reports will provide sufficient data to demonstrate the effectiveness of the Army's groundwater monitoring program as well as show that the corrective action program satisfies the requirements of AAC Rule 335-14-5-.06(11).

RSA will provide CMI effectiveness reports on an annual basis. The effectiveness of groundwater LUCs will also be reported in the annual monitoring reports. These reports will document the groundwater monitoring results and the status of the LUCs. The initial CMI effectiveness report will be submitted approximately 12 months after the CMI report. This will allow sufficient time for the laboratory analysis, reporting, and validation of the analytical data from the groundwater samples collected during the first year of groundwater monitoring. The subsequent CMI effectiveness reports will be then submitted annually beginning approximately 12 months after the initial CMI effectiveness report.

The initial CMI effectiveness report will include all of the groundwater monitoring data collected during the first year of the LTM at RSA-271. Subsequent reports will include the results of the annual groundwater monitoring events along with the results from any other groundwater monitoring conducted as part of the RSA-271 CMI during that period. Recommendations for changes to the sampling frequency, wells sampled, and parameters for analysis, if appropriate, will be included in the reports. The Army acknowledges that changes to the sampling program may require modifications to RSA's AHWMMA permit.

At a minimum, the groundwater monitoring report will include a discussion of sampling activities, tables, and maps to document contaminant concentrations in groundwater, and an evaluation of the groundwater contaminant data. Record keeping for data and reports are described in the installation-wide QAPP (Shaw, 2013a).

Corrective measures under AAC Rule 335-14-5-.06(11)(e) may be terminated once the concentrations of hazardous constituents under Rule 335-14-5-.06(4) are reduced to levels below their respective concentration limits under Rule 335-14-5-.06(5). Groundwater monitoring will be conducted annually and continue until the groundwater analytical results indicate the CGs have been attained for the groundwater COCs at RSA-271 for three consecutive years. At that time, the Army may request a permit modification to cease groundwater monitoring in accordance with AAC 335-14-5-.06(11)(f).

5.0 Contingencies

The implementation of corrective measures is based on the best information currently available for RSA-271. It is recognized that variations from this CMI work plan may be required during the execution phase of the work in order to fully address actual site conditions in a timely manner that is protective of human health and the environment. The Army, ADEM, or other relevant parties may take actions to grant such variances from this CMI work plan during the corrective measures process. Any variance will be documented and communicated at the time of occurrence and included with the completion report for the site.

Some potential site conditions that may be encountered at RSA-271 are discussed in this chapter.

5.1 Discovery of Munitions and Explosives of Concern/Chemical Warfare Materiel

Available information including the RSA Chemical Warfare Materiel (CWM) Probability Map dated April 2019, historical records and recent environmental sampling data was reviewed with respect to munitions and explosives of concern, CWM, or chemical agent (CA) potential at RSA-271. The review indicated that the probability of encountering measurable concentrations of CWM or degradation products is unlikely. The probability of encountering unexploded ordnance (UXO) is low. Based on this evaluation, it was determined that CA monitoring or UXO avoidance support will not be required for the CMI. However, in the event any suspicious item is encountered that cannot be positively identified by qualified UXO personnel as not presenting an explosive hazard, all work shall stop and the Project Manager and Health and Safety Manager will be notified and will be responsible for following the notification requirements in RSA 75-4 (Army, current version). If the suspicious item can be positively identified by qualified UXO personnel as not presenting an explosive or CA hazard or once the hazard has been removed, work will proceed. Further information on this hazard identification, notification, and removal process is presented in RSA's installation-wide accident prevention plan (Shaw, 2013c).

5.2 Well Closure

No wells are planned for closure at RSA-271. However, wells at the site located affected by future construction activities at the Raytheon Complex (e.g., new test cell) may require closure and replacement. Wells will be closed in accordance with an ADEM approved well closure plan, SOPP No. 21, *Monitoring Well and Borehole Abandonment* (Shaw, 2013b), and the AEIRG (ADEM, 2017a). Wells requiring closure will be replaced in kind unless the Army and ADEM agree that the well is no longer needed at RSA. Documentation of the well closure activities will be submitted to ADEM along with a request for a permit modification for any affected wells included in the groundwater monitoring program for RSA-146 or RSA-271 corrective measures.

If needed, any replacement monitoring wells will be installed following the well closure. Well replacements would be limited to wells damaged or closed as required by construction projects. Replacement wells would be installed in accordance with procedures outlined in SOPP No. 17.0, *Monitoring Well Installation* (Shaw, 2013a). Currently, no replacement wells are planned for RSA-271.

5.3 MNA Contingencies

Several conditions could potentially arise in the future that may require alternative actions to complete the corrective measures. These include the measurement of constituents at levels exceeding groundwater cleanup levels along the perimeter of the site or increasing concentrations in the site interior. As part of this CMIP, a performance and compliance well network consisting of six monitoring wells will be monitored to evaluate changes in contaminant concentrations or the contaminant plume (i.e., plume size, plume migration, etc.). Wells proposed for sampling have been selected to monitor these potential changes. When an exceedance is detected in a perimeter well with historical nondetect concentrations or with trace contaminant levels, the well in question will become a candidate for re-sampling on a more frequent basis. Recommendations for contingency measures will be presented, as required, in the monitoring reports. Recommendations may include changes to the monitoring plan, adding additional monitoring wells, or the implementation of additional remedial technologies, such as in situ bioremediation, as appropriate. Potential performance monitoring parameters that may be collected to assist in determining the effectiveness of the remedy are provided in Table 5-1.

The annual reports will provide a summary of groundwater data, data evaluation, conclusions, and recommendations for additional action, including contingencies that may need to be implemented to reach corrective action objectives in a reasonable amount of time.

5.4 Discovery of Free Product

Free product, otherwise known as light nonaqueous phase liquid (LNAPL), has never been observed at the RSA-271 but there is a possibility that it might be present and was not observed during the RFI. In the event LNAPL or evidence of LNAPL is encountered during future soil boring activities or future groundwater monitoring events, such as elevated photoionization detector readings, observed odors, or sheens, Army will implement a series of actions to address this issue. These actions may include but are not limited to quarterly groundwater gauging to provide insight into the seasonal groundwater fluctuations observed at the site, coupled with monitoring for the presence of free product during each quarterly monitoring event and/or installation of an observation piezometer in or near the tank pit using a long, slotted screen (such as 30 feet of screen) to provide an enhanced ability to observe potential LNAPL if present.

If during these additional efforts, a sheen or free product is observed, Army will propose an additional supplemental remedy such as, initially, the use of an LNAPL absorbent sock placed within the well where free product has been observed. Additional remedies will be scoped with ADEM if this contingency is initiated.

5.5 Lack of Clear Groundwater Flow Direction

Because of the Brownfields Type development of the Raytheon Missile Facility, the majority of wells in the vicinity of RSA-271 were abandoned and even on-site wells were abandoned quickly in the RFI phase. Abandoned wells are shown on Figure 2-3 in this CMIP. As a result, it is not possible to provide current potentiometric surface maps based on the very limited existing on-site wells as the existing well layout of the site does not provide adequate coverage. During corrective measures for this site, this deficiency will be remedied as three downgradient wells are planned for installation. However, if groundwater flow direction during the MNA program does not appear to be consistent with the expected flow direction, additional wells will be installed in other locations to the north or northeast of the site in the event that the planned well coverage does not provide enough information to demonstrate groundwater flow directions from this site.

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ATTACHMENT 1

LIST OF ACRONYMS AND ABBREVIATIONS

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter
$\mu g/m^3$	micrograms per cubic meter
ºC	degrees Celsius
ºF	degrees Fahrenheit
%D	percent difference
%R	percent recovery
1,1,2-TCA	1,1,2-trichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-Dichloroethene
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid
2,4-D	2,4-dichlorophenoxyacetic acid
2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
AAC	Alabama Administrative Code
AAFES	Army and Air Force Exchange Service
AAP	Army Ammunition Plant
AB	ambient blank
ABLM	adult blood lead model
ABP	agent breakdown products
ABS	dermal absorption factor
ACAD	AutoCadd
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing material
ACSIM	Assistant Chief of Staff for Installation Management
ADAF	age-dependent adjustment factor
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEC	U.S. Army Environmental Command
AEDA	ammunition, explosives, and other dangerous articles
AEDB	Army Environmental Database
AEIRG	Alabama Environmental Investigation and Remediation Guidance
AEL	airborne exposure limit
AER	annual effectiveness report
AERMOD	American Meteorology Society/Environmental Protection Agency Regulatory Model
AET	apparent effects threshold
AF	soil-to-skin adherence factor
AFFF	Aqueous Fire Fighting Foam
AFS	air filtration system
AGC	advanced geophysical classification
AGS	Alabama Geographic Society
AHA	ammunition holding area
AHWMMA	Alabama Hazardous Wastes Management and Minimization Act
AIPH	Army Institute of U.S. Public Health
AL	Alabama
ALDOT	Alabama Department of Transportation
ALNHP	Alabama Natural Heritage Program
amb.	amber
AMCOM	U.S. Army Aviation and Missile Command
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
amsl	above mean sea level (1988 North American Vertical Datum, NAVD 88)
ANOVA	Analysis of Variance
AOC	area of concern
AOI	area of investigation
AP	armor piercing
APEC	areas of potential ecological concern
APHC	U.S. Army Public Health Center
APT	armor-piercing tracer
APTIM	Aptim Federal Services, LLC
AR	Army Regulation
AR/COC	analysis request/chain of custody
ARAR	applicable or relevant and appropriate requirement
ARBCA	Alabama Risk-Based Corrective Action
AREE	area requiring environmental evaluation
ARFO	ammunition returned from overseas
Army	U.S. Army
AS	air sparging
ASCII	American Standard Code for Information Interchange
ASP	Ammunition Supply Point
ASR	archives search report
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
ASV	alternative screening value
ASWCC	Alabama Soil and Water Conservation Committee
AT	averaging time; arsenic trichloride
ATF	Bureau of Alcohol, Tobacco, Firearms and Explosives
atm-m^3/mol	atmosphere cubic meters per mole
ATS	alternative treatment standard
ATT	Applied and Technical Training
ATSDR	Agency for Toxic Substances and Disease Registry
ATTN	attention
ATV	all-terrain vehicle
AUF	area use factor
AWARE	Associated Water and Air Resources Engineers, Inc.
AWBC	alternative water balance cover

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
AWQC	ambient water quality criteria
AWQS	ambient water quality standard
B	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)
BAF	bioaccumulation factor
$BAF_{soil-to-invert}$	soil-to-invertebrate bioaccumulation factor
BaOH	barium hydroxide
BAP	benzo(a)pyrene
BCF	bioconcentration factor
BCT	BRAC Cleanup Team
BCY	bank cubic yards
BDCM	bromodichloromethane
BCEE	bis(2-chloroethyl)ether
BEHP	bis(2-ethylhexyl)phthalate
BEM	Buried Explosion Module
BERA	baseline ecological risk assessment
BFB	bromofluorobenzene
BFE	base flood elevation
BFM	bonded fiber matrix
BG	Bacillus globigii
bgs	below ground surface
Bhate	Bhate Environmental Associates, Inc.
BHC	hexachlorocyclohexane
BHHRA	baseline human health risk assessment
BIM	basic information map
BIP	blow(n)-in-place
bkg	background
bls	below land surface
BMP	best management practice
BOD	biological oxygen demand
Bp	soil-to-plant biotransfer factors
BR	bedrock
BR-D	deep bedrock
BRAC	Base Realignment and Closure
BSAF	biota-to-sediment accumulation factors
BSC	background screening criterion
BSCRN	bottom of screen
BSV	background screening value
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethyl benzene, and xylenes
BTOC	below top of casing
BTV	background threshold value
BW	body weight
BZ	breathing zone
C	ceiling limit value
C&D	Construction & Demolition
Ca	carcinogen
CA	chemical agent; corrective action
CAA	Clean Air Act
CAB	chemical warfare agent breakdown products
CACM	Chemical Agent Contaminated Media
$CaCO_3$	calcium carbonate
CAIS	chemical agent identification set
CalEPA	California Environmental Protection Agency
CAMU	corrective action management unit
CAP	corrective action plan; Contractor Acquired Property
CAR	corrective action request
CARA	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosives (CBRNE) Analytical and Remediation Activity
CAS	Chemical Abstracts Service
CASE	Corrective Action System Effectiveness
CASNO	Chemical Abstract Service identification number
CASRN	Chemical Abstracts Service Registry Number
CB	chlorobenzene
CB&I	CB&I Federal Services LLC
CBC	Chemical and Biological Center
CBFM	collodial borescope flowmeter
CBMPP	construction best management practices plan
CBR	chemical, biological, and radiological
CBRN	chemical, biological, radiological, nuclear
CBRNE	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosives
CBZ	chlorobenzene
CCAL	continuing calibration
CCB	continuing calibration blank
CCC	criterion continuous concentration
CCDC	Combat Capabilities Development Command
CCl_4	carbon tetrachloride
CCV	continuing calibration verification
CD	compact disk; Consent Decree
CDE	Chemical Defense Equipment
CDI	chronic daily intake
CDR	Contract Discrepancy Report
CDTF	Chemical Defense Training Facility
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CESAS	Corps of Engineers South Atlantic Savannah
CF	conversion factor
CFC	chlorofluorocarbon
CFDP	Center for Domestic Preparedness
CFR	Code of Federal Regulations

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
cfs	cubic feet per second
C_{fw}	contaminant concentration in fish from surface water
CG	phosgene (carbonyl chloride); cleanup goal
CGI	combustible gas indicator
ch	inorganic clays of high plasticity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CIH	Certified Industrial Hygienist
cis-1,2-DCE	cis-1,2-Dichloroethene
CK	cyanogen chloride
Cl	chloride, chlorinated
CLIN	contract line item number
ClO_4^-	perchlorate
CLP	Contract Laboratory Program
CLPILM	EPA CLP's prefix designation for the inorganic metals analysis statement of work
CLP M	EPA CLP's prefix designation for the mercury analysis statement of work
CM	corrective measure
cm	centimeter
cm/hour	centimeters per hour
cm^2	cubic centimeter
cm^2/second	square centimeters per second
cm^3/g	cubic centimeters per gram
CMA	U.S. Army Chemical Materials Activity; corrective measure alternative
CMC	criterion maximum concentration
CMD	corrective measures design
CMI	corrective measures implementation
CMICR	corrective measures implementation completion report
CMIP	corrective measures implementation work plan
CMO	corrective measure objective
CMS	corrective measures study
CMT	Continuous Multichannel Tubing
CN	chloroacetophenone
CNB	chloroacetophenone, benzene, and carbon tetrachloride
CNS	chloroacetophenone, chloropicrin, and chloroform
CO	carbon monoxide
CO_2	carbon dioxide
Co-60	cobalt-60
CoA	Code of Alabama
COAC	chemical of analytical concern
COC	when discussing chemicals, COC means chemical of concern; when discussing field paperwork, COC means chain of custody
COE	Corps of Engineers
COI	constituent of interest
Con	skin or eye contact
COPAC	chemical of potential analytical concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
COR	Contracting Officer's Representative
CP	communication plan; Competent Person
CPARS	Contractor Performance Assessment Reporting System
CPFF	cost plus fixed fee
CPOM	coarse particulate organic matter
CPSS	chemicals present in site samples
CPVC	chlorinated polyvinyl chloride
C_{pw}	chemical of potential ecological concern concentration in pore water
CQA	construction quality assurance
CQAP	construction quality assurance plan
CQCSM	Construction Quality Control System Manager
CRA	Conestoga-Rovers and Associates
CRDL	contract-required detection limit
CRL	certified reporting limit
CRP	community relations plan; compliance-related program
CRQL	contract-required quantitation limit
CRSA	Central Redstone Arsenal
CRZ	contamination reduction zone
CS	ortho-chlorobenzylidene-malononitrile
CSA	confirmation sampling activities
CSDWP	Comprehensive Site-Specific Demolition Work Plan
C_{sed}	chemical of potential ecological concern concentration in sediment from groundwater
CSEM	conceptual site exposure model
CSM	conceptual site model
CSP	chemical site plan
CSP	corrugated steel pipe
CSS	chemical safety submission
SCWGP	Construction Stormwater General Permit
CT	carbon tetrachloride
CTC	cost to completion
ctr.	container
CVAA	2-chlorovinylarsenous acid
C_w	contaminant concentration in water
CWA	when discussing chemicals, CWA means chemical warfare agent; when discussing laws, CWA means Clean Water Act
CWM	If used in the text of a document this acronym means chemical warfare materiel; if used in an analytical table which summarizes container requirements, this acronym means clear, widemouth container
CWS	Chemical Warfare Service
CX	dichloroformoxime
D	duplicate; duplicate contamination; when used as a validation qualifier, D means dilution
D2PC	Personal Computer Program for Chemical Hazard Prediction
DAD	average dermally absorbed dose
DAVS	detector-aided visual survey
D&I	detection and identification

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
DA	Department of the Army; diphenylchloroarsine
DA PAM	Department of the Army Pamphlet
DAAMS	Depot Area Air Monitoring System
DA_{event}	dermal dose absorbed per event
DAF	dilution-attenuation factor
DAF4	dilution-attenuation factor 4
DANC	decontamination agent, non-corrosive
DAP	diammonium phosphate
DASAF	Department of the Army Safety Office
DAVS	detector-aided visual survey
DBA	dibenz(a,h)anthracene
DBCP	1,2-dibromo-3-chloropropane
DBX	depth bomb explosive
DC	District of Columbia
DCA	dichloroethane
DCB	decachlorobiphenyl
DCE	dichloroethene
DCMA	Defense Contract Management Agency
DCQAP	data collection quality assurance plan
DD	Decision Document
DD	Department of Defense (form only)
DDD	dichlorodiphenyldichloroethane (this is an industry standard acronym for this chemical)
DDE	dichlorodiphenyldichloroethene (this is an industry standard acronym for this chemical)
DDESB	Department of Defense Explosives Safety Board
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEHP	bis(2-ethylhexyl)phthalate
DEMIL	Demilitarization Areas
DEP	depositional soil
DERP	Defense Environmental Restoration Program
DES	Directorate of Environment and Safety
DF	dilution factor
DFTPP	decafluorotriphenylphosphine
DFOW	Definable Feature of Work
DGM	digital geophysical mapping
DHC	*Dehalococcoides* sp.
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DL	detection limit
DLA	Defense Logistics Agency
DM	adamsite
DMBA	dimethylbenz(a)anthracene
DMM	discarded military munitions
DMMP	dimethylmethylphosphonate
DNAPL	dense nonaqueous-phase liquid
DNB	dinitrobenzene
DNBZ	dinitrobenzene
DNOC	4,6-dinitro-2-methylphenol
DNT	dinitrotoluene
DO	dissolved oxygen
DoD	U.S. Department of Defense
DODI	Department of Defense Instruction
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology
DQCR	Daily Quality Control Report
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DSERTS	Defense Site Environmental Restoration Tracking System
DSMOA	Defense and State Memorandum of Agreement
DSN	Defense Switched Network
DSR	demolition and site restoration
DSS	data sufficiency summary
DTSC	Department of Toxic Substances Control
DU	decision unit
DUA	data usability assessment
DVD	digital versatile disc or digital video disc
DWEL	drinking water equivalent level
e.g.	for example
E3	Electromagnetic Environmental Effects
EB	equipment blank
EBS	environmental baseline study
EC_{20}	effects concentration for 20 percent of a test population
EC_{50}	effects concentration for 50 percent of a test population
EC	Emergency Coordinator
ECBC	Edgewood Chemical and Biological Center
Eco-RGRG	ecological risk-based remedial goal
Eco-SSL	ecological soil screening level
ECM	earth covered magazine
ED	exposure duration
EDD	electronic data deliverable
EDQL	ecological data quality level
EDS	explosive destruction system

Acronym	Definition
EDTA	ethylenediaminetetracetic acid
EE/CA	engineering evaluation and cost analysis
EEL	estimated exposure level
EF	exposure frequency
EFR	enhanced fluid recovery
Eh	oxidation-reduction potential
ELAP	Environmental Laboratory Accreditation Program
Elev.	elevation
EM(1)	electromagnetic
EM(2)	Engineer Manual
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EMI	electromagnetic induction
Empirical	Empirical Laboratories, LLC
EMSI/EL	Environmental Management Services, Inc./Environmental Laboratories
EMT	emergency medical technician
EOC	Emergency Operation Center
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team; EOD Technology, Inc.
EP	exit pathway
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPDS	Emergency Personnel Decontamination Station
EPIC	Environmental Photographic Interpretation Center
EPP	Environmental Protection Plan
EPRI	Electrical Power Research Institute
EPT	Ephemeroptera, Plecoptera, Trichoptera
EQ	EQ Environmental Quality Company
EQL	estimated quantitation limit
ER	equipment rinsate; USACE Engineer Regulation
ERA	ecological risk assessment
ERH	electrical resistive heating
ERIS	Environmental Restoration Information System
ER-L	effects range-low
ER-M	effects range-medium
ERMA	Environmental Remediation Services Multiple Award
ES	exposed site
ESA	ecologically sensitive area
ESB	Equilibrium Partitioning Sediment Benchmark
ESE	Environmental Science and Engineering, Inc.
ESL	ecological screening level
ESP	explosives site plan
ESMP	Endangered Species Management Plan; Explosives Safety Management Program
ESS	explosives safety submission
ESTCP	Environmental Security Technology Certification Program
ESV	ecological screening value
ET	exposure time
ET_{sw}	exposure time - surface water
EU	exposure unit
EUR	Environmental Use Restriction
EV	event frequency
E-W	east to west
Excel	Excel Geophysical Services
Exp.	Explosives
ExplorTech	ExplorTech, LLC
EXTOXNET	Extension Toxicology Network
Ey	Etowah silty clay loam
EZ	exclusion zone
FA	focus area
FA	fraction absorbed
FAC	facultative wetland
FACU	facultative upland
FACW	facultative wetland
FADL	Field Activity Daily Log
FAE	fuel-air explosive
FAR	Federal Acquisition Regulations
FAV	final acute value
FB	field blank
FBI	Family Biotic Index
FCM	food chain multiplier
FCSV	food chain screening value
FCV	final chronic value
FD	field duplicate
FDA	U.S. Food and Drug Administration
Fe^{+2}	ferrous iron
Fe^{+3}	ferric iron
FEC	fluid electrical conductivity
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFA	Federal Facilities Agreement
FFCA	Federal Facilities Compliance Act
FFE	field flame expedient
FFP	firm fixed price
FFS	focused feasibility study
FI	fraction of exposure; filtered
FID	flame ionization detector
FIFRA	Federal Insecticide, Fungicide, & Rodenticide Act
FLUTe	Flexible Liner Underground Technologies, Ltd. Co.
FM-ARNGTC	Fort McClellan Army National Guard Training Center

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
f_{oc}	fraction organic carbon
FOIA	Freedom Of Information Act
FOMRA	Former Ordnance Motor Repair Area
FOST	Finding of Suitability to Transfer
Foster Wheeler	Foster Wheeler Environmental Corporation
FR	Federal Register
Frtn	fraction
FS	feasibility study
FSH	Fort Sam Houston
FSP	field sampling plan
FS smoke	sulfur trioxide and chlorosulfonic acid
ft	foot, feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
ft^2	square feet
ft^2/day	square feet per day
FTA	Fire Training Area
FUP	fixed unit price
FWV	fieldwork variance
FY	fiscal year
g	gram
G&M	Geraghty and Miller, Inc.
g/cm^3	grams per cubic centimeter
g/m^2	grams per square meter
g/m^3	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GA	tabun
GAC	granular activated carbon
GAF	General Aniline and Film; gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin (isopropyl methylphosphonofluoridate)
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
GCL	geosynthetic clay liner
GCMR	Geophysical Classification for Munitions Response
GCWD	Gulf Chemical Warfare Depot
GCWS	Gulf Chemical Warfare Service
GEAE	Generic Ecological Assessment Endpoint
GED	General Equivalency Diploma
GEDIT	gaseous electron donor injection technology
GFAA	graphite furnace atomic absorption
GIP	geophysical investigation plan
GIS	geographic information system
GNSS	Global Navigation Satellite System
GPCR	gas phase chemical reduction
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GRA	general response action
GRIM	Groundwater Responsibility Information Matrix
GRO	gasoline range organics
GS	ground scar
GSA	when discusing the federal government requirements, GSA means General Services Administration; when discussing geology, GSA means Geologic Survey of Alabama
GSE	Great Southern Engineering
GSR	green and sustainable remediation
GST	ground stain
GSV	geophysical systems verification
GUC	groundwater use control
GW	groundwater
GWDT	Groundwater Design Team
GWMZ	groundwater monitoring well, multizone
GWTR	groundwater monitoring well
H&S	health and safety
H_2O_2	hydrogen peroxide
H_2S	hydrogen sulfide
HA	hand auger; hazard assessment
HAL	Health Advisory level
HAMUST56	Huntsville Arsenal Mustard Plant 2, Lines 5 & 6
Harmon	Harmon Engineering Associates, Inc.
HAZMATCAD™	Hazardous Material Chemical Agent Detector
HAZWOPER	Hazardous Waste Operations and Emergency Response
HBESL	health-based environmental screening level
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)
HCE	hexchloroethane
HCl	hydrochloric acid
HD	distilled mustard (bis-[dichloroethyl]sulfide); hazard division
HDPE	high-density polyethylene
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
HEAT	High Explosive Anti-Tank
HEPA	high-efficiency particulate air
HEGA	high-efficiency gas absorber

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
Herb.	herbicides
HFD	hazardous fragment distance
HHAWQS	human health Alabama water quality standard
HHRA	human health risk assessment
HHRE	human health risk evaluation
HI	hazard index
HI_{COC}	total hazard index for a given relevant COC, for a given receptor added across all exposure routes for given source medium
Hi_{cum}	cumulative hazard index summed across chemicals and source media
HI_{TO}	total hazard index for a given target organ for a given receptor
Hm	hot measurement
HMW	high molecular weight
HMX	cyclotetramethylenetetranitramine; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocane
HN	hydrogen mustard
HNC	hydrogen cyanide
HNO_3	nitric acid
HP	hydropunch
HPLC	high-performance liquid chromatography
HQ	hazard quotient
HQ_{COCi}	hazard quotient for the target organ of interest estimated for the ith COC
$'HQ_i$	hazard index for a given chemical summed across exposure routes and source media
$'HQ_{Ri}$	hazard quotient for the given chemical for exposure route i
HQ_{screen}	screening-level hazard quotient
hr	hour
HRR	Historical Records Review
HS	mustard
HSA	hollow-stem auger
HSB	Huntsville Spring Branch
HSDB	Hazardous Substances Data Bank
HSF	historic site feature
HSMR	Huntsville Spring Branch at Martin Road
HT	British Mustard
HTPB	hydroxy-terminated polybutadiene
HTRW	hazardous, toxic, and radioactive waste
HTW	hazardous and toxic waste
HUB	Historically Underutilized Business
HWCL	hazardous waste control limit
HWSA	Hazardous Waste Storage Area
HWSU	hazardous waste storage unit
HY	hydrostratigraphic unit
HYPN	hydropunch
Hz	hertz
I	out of control, data rejected due to low recovery
I-565	Interstate 565
IAP	Installation Action Plan
IATA	International Air Transport Authority
I-AVSS	instrument-aided visual surface sweep
IC	Incident Commander
ICAL	initial calibration
ICAM	improved chemical agent monitor
ICB	initial calibration blank
ICP	inductively coupled plasma
ICS	interference check sample
ICV	initial calibration verification
ID	identification; inside diameter
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDM	investigative-derived media
IDQTF	Intergovernmental Data Quality Task Force
IDS	intrusion detection system
IDW	investigation-derived waste; investigative-derived waste
i.e.	that is (in other words)
IELCR	individual excess lifetime cancer risk
$IELCR_{coc}$	total individual excess lifetime cancer risk for a given relevant chemical of concern, for a given receptor added across all exposure routes for a given source medium
$'IELCR_{Cum}$	cumulative cancer risk for a given receptor summed across chemicals and source media
$'IELCR_{Ri}$	cancer risk for the given chemical in a given source medium for exposure route i
$'IELCR_T$	total cancer risk for the given chemical in a given source medium summed across exposure routes
$IELCR_{(Ti)}$	total cancer risk for chemical i in a given source medium summed across exposure routes
IEOC	Installation Emergency Operations Center
IERC	Installation Environmental Response Coordinator
IEUBK	Integrated Exposure Uptake Biokinetic
IF	ingestion factor; inhalation factor
IHF	interim holding facility
IIP	intrusive investigation plan
ILCR	incremental lifetime cancer risk
ILM	EPA CLP's prefix designation for the inorganic metals analysis statement of work for EPA contract laboratory program
IM	interim measure; isobutyl methacrylate
IMO	interim measure objective
IMU	inertial measurement unit
IM-AE	isobutyl methacrylate polymer AE
IMPA	isopropylmethyl phosphonic acid
in.	inch
Inc.	Incorporated
Ing	ingestion
Inh	inhalation
INT	interface
IOSC	Installation On-Scene Coordinator

Acronym	Definition
IOU	integrator operable unit
IP	ionization potential
IPS	International Pipe Standard
IR	ingestion rate
IRAO	interim remedial action objective
IRAP-h	Industrial Risk Assessment Program-Human Health
IRDMIS	Installation Restoration Data Management Information System
IR_f	fish ingestion rate
'IR_{sw}	ingestion rate
IRFNA	inhibited red fuming nitric acid
IRIS	Integrated Risk Information System
IROD	interim record of decision
IRP	Installation Restoration Program
IRSL	industrial regional screening level
IS	incremental sampling
ISAB	in situ anaerobic bioremediation
ISBN	International Standard Book Number
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ISEB	in situ enhanced bioremediation
ISL	initial screening level
ISO	industry standard object
ISSC	Installation Support Services Contractor
ISTD	in situ thermal destruction
ISTT	in situ thermal treatment
IT	IT Corporation
ITEMS	IT Environmental Management System^{TM}
ITRC	Interstate Technology and Regulatory Council
IV	intervention value
IVS	instrument verification strip
IW	installation-wide
IWGW	installation-wide groundwater
IWGWMP	Installation-Wide Groundwater Monitoring Program
IWWP	installation-wide work plan
J	estimated concentration
J&E	Johnson and Ettinger
JD	jurisdictional determination
JOR	job order request
K	conductivity
KAPSDIDS	Kinetically Adjustable Pore Spaace Dilation Injection Delivery System
K_d	soil-water distribution coefficient
Kd_{bs}	bed sediment-sediment pore water partition coefficient
KeV	kilo electron volt
kg	kilogram
kg/m^3	kilograms per cubic meter
$KMnO_4$	potassium permanganate
KO	Contracting Officer
K_{oc}	organic carbon partioning coefficient
K_{ow}	octanol-water partition coefficient
K_p	permeability coefficient
kPa	kilopascal
kVA	kilovolt-ampere
L	if used as part of the units of measure, the acronym stands for "liter", if used as a chemical name, this acronym stands for lewisite
L/cm^3	liters per cubic centimeter
L/day	liters per day
L/kg/day	liters per kilogram per day
LANL	Los Alamos National Laboratory
lb	pound
LBP	lead-based paint
lbs/year	pounds per year
LC	liquid chromatography
LC_{50}	lethal concentration for 50 percent population tested
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LD_{50}	lethal dose for 50 percent population tested
LDD	lost, damage, or destruction
LEL	lower explosive limit
LF	Leaching Factor
LGAC	liquid-phase granular activated carbon
LiDAR	Light Detection and Ranging
LL	low level
LLC	limited liability company
LNAPL	light nonaqueous-phase liquid
LOAEL	lowest-observed-adverse-effects level
LOD	limit of detection
LOEC	lowest-observable-effect-concentration
LOQ	limit of quantitation
LSA	limited site assessment
LSV	leachate screening value
LTO	long-term operation
LTM	long-term management
LTV	leachate threshold value
LUC	land-use control
LUCAP	land-use control assurance plan
LUCER	land-use control effectiveness report
LUCIP	land-use control implementation plan
LWSV	liquid waste screening value

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
m	meter
m/year	meters per year
m/yr	meters per year
m/second	meters per second
m^3/hour	cubic meters per hour
m^3/kg	cubic meters per kilogram
MACOM	Major Command
MADEP	Massachusetts Department of Environmental Protection
MADL	minimum analytical detection limit
MAG	monitoring acceptance goal
MARB	Munitions Assessment Review Board
max	maximum
MB	method blank
MC	munitions constituents
MCDZ	McDonald Creek discharge zone
MCE	Maximum Credible Event
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCPA	4-chloro-2-methylphenoxyacetic acid
MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
MCS	media cleanup standard
MD	munitions debris; Mahalanobis Distance
MDAS	Material Documented as Safe
MDC	maximum detected concentration
MDCC	maximum detected constituent concentration
MDEH	Material Documented as an Explosive Hazard
MDL	method detection limit
MEA	monoethanolamine
MEC	munitions and explosives of concern
MEE	methane, ethane, and ethene
MEP	Multiple Extraction Procedure
MeV	mega electron volt
MFD	maximum fragment distance
Mfp	Mississippian Fort Payne
mg	milligrams
mg/cm^2	milligrams per square centimeter
mg/cm^2/day	milligrams per square centimeter per day
mg/cm^2/event	milligrams per square centimeter per event
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligram per kilogram day
mg/kgbw/day	milligrams per kilogram of body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mgal	million gallons
MGFD	munition with the greatest fragmentation distance
mh	highly plastic, inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
MHz	megahertz
MI	multi-incremental
MICC	Mission & Installation Contracting Command
MIDAS	Munitions Items Desposition Action System
MiHPT	Membrane Interface Hydraulic Profile Tooling
min	minimum
MIMS	Munitions Information Management System
MINICAMS	miniature continuous air monitoring system
MIS	Management Information System; multiple incremental samples
mL	milliliter
mm	millimeter
MMAS	Mobile Munitions Assessment Systems
MMBtu/hr	million Btu per hour
MMCS	Missile and Munitions Command School
MM-CX	Military Munitions Center of Expertise
MMOA	mutagenic mode of action
MMRP	Military Munitions Response Program
Mn^{+4}	manganese
MNA	monitored natural attenuation
MnO_4-	permanganate ion
MNR	monitored natural recovery
MOA	Memorandum of Agreement
MOCA	4,4-methylene-bis(2-chloroaniline)
MOGAS	motor vehicle gasoline
MOUT	Military Operations in Urban Terrain
MP	Military Police
MPA	methyl phosphonic acid
MPC	maximum permissible concentration; measurement performance criteria
MPM	most probable munition
MPPEH	Material Potentially Presenting an Explosive Hazard
MPR	4.2-Inch Mortar Proofing Range
MPVE	multiphase vapor extraction
MQL	method quantitation limit
MQO	measurement quality objective
MR	molasses residue; munitions response
MRA	munitions response area
MRC	multiple round container
MRL	method reporting limit
MRL	minimal risk level
MRR	Materials Receiving Report
MRS	Munitions Response Site

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
mS/cm	millisiemens per centimeter
mS/m	millisiemens per meter
MS/MSD	matrix spike/matrix spike duplicate
MSD	when discussing laboratory QC, MSD means matrix spike duplicate; when discussing explosives, MSD means minimum separation distance
MSFC	George C. Marshall Space Flight Center
msl	mean sea level
Mt	Mississippian Tuscumbia Limestone
MTBE	methyl tertiary butyl ether
M&TE	measurement and test equipment
mV	millivolts
MW	monitoring well
Na	sodium
N/A	not applicable
NA	not applicable
NAD	North American Datum
NAD83	North American Datum of 1983
$NaMnO_4$	sodium permanganate
NAPL	nonaqueous-phase liquid
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NAVD 88	North American Vertical Datum, 1988 adjustment
NAVD88	North American Vertical Datum of 1988
NB	nitrobenzene
NBA	Northern Burial Area
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NDA	Northern Disposal Area
NDMA	n-nitrosodimethylamine
NDPA	n-nitroso-di-n-propylamine
NE	northeast
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Protection Act
NEW	net explosive weight
NFA	no further action
NFG	National Functional Guidelines
NFPA	National Fire Protection Agency
NG	National Guard
ng/L	nanograms per liter
NGB	National Guard Bureau
NGP	National Guardsperson
NGVD	National Geodetic Vertical Datum
Ni	nickel
NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NJDEP	New Jersey Department of Protection
NLM	National Library of Medicine
NLT	no later than
NMEA	National Marine Electronics Association
No.	number
NO_3^-	nitrate
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
NOEC	no-observable-effect concentration
NONEL	non-electric
NOI	Notice of Intent
NOT	Notice of Termination
NP	nitropropyl
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPW	net present worth
NR	not requested
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
NRL	Naval Research Laboratory
NRT	near real time
ns	nanosecond
NS	not surveyed
N-S	north to south
NSA	New South Associates, Inc.
NT	nitrotoluene
nT	nanotesla
nT/m	nanoteslas per meter
NTCRA	Non-Time Critical Removal Action
NTIS	National Technical Information Service
NTP	National Toxicology Program
NTU	nephelometric turbidity unit
nv	not validated
NY DOH	New York State Department of Health
O&G	oil and grease
O&M	operation and maintenance
O_2	oxygen

Acronym	Definition
O_3	ozone
OB/OD	open burn/open detonation
OBL	obligate
OCDD	octachlorodibenzo-p-dioxin
OD	outside diameter; other (nonmunitions) debris
OE	ordnance and explosives
OEC	Ordnance Explosives Center
OEHHA	Office of Environmental Health Hazard Assessment (of the California Environmental Protection Agency)
OESS	Ordnance and Explosives Safety Specialist
OGMS	Ordnance Guided Missile School
oh	organic clays of medium to high plasticity
OH·	hydroxyl radical
ol	organic silts and organic silty clays of low plasticity
OMEMS	Ordnance Munitions and Electronic Maintenance School
OP	organophosphorus; organochlorine pesticide
ORA	Operational Range Assessment
ORAP	Operational Range Assessment Program
Ord	Ordovician
ORP	oxidation-reduction potential
OSA	Open Storage Area
OSC	On-Scene Coordinator
OSD	overage/shortage/damage
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
OVA	organic vapor analyzer
OVB	overburden
OVB-S	shallow overburden
OVM	organic vapor monitoring
OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector
OWS	oil/water separator
oz	ounce
P&T	pump and treat
PA	preliminary assessment; probability assessment
PA3	Plant Area 3, Incendiaries Manufacturing
PAED	Public Access Exclusion Distance
PAH	polynuclear aromatic hydrocarbon
PAL	preliminary action level
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PBAA	polybutadiene acrylic acid
PBAN	polybutadiene/acrylic acid/acrylonitrile
PBC	performance-based contract
PBMS	performance-based measurement system
PC	permeability coefficient
PCA	tetrachloroethane
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	tetrachloroethene
PCHL	2,3,4,5-6-pentachlorocyclohexanol
PCMIA	Personal Computer Memory Card International Association
PCP	pentachlorophenol
PCR	polymerase chain reaction
PCWM	Potential Chemical Warfare Materiel
PD	phenyldichloroarsine
PDA	Personal Digital Assistant
PDB	polyethylene diffusive bag sampler
PDF	Portable Document Format
PDS	Personnel Decontamination System; post-digestive spike
PDT	Project Delivery Team
PEC	probable effect concentration
PEF	particulate emission factor
PEL	permissible exposure limit
PELA	P.E. LaMoreaux and Associates, Inc.
PERA	preliminary ecological risk assessment
PERC	perchloroethene
PES	potential explosive site
Pest.	pesticides
PETN	pentaerythritol tetranitrate
PFAS	polyfluoroalkyl substance
PFO	palustrine forested wetland
PFOA	perfluorooctanoic acid
PFOS	perfluorooctyl sulfonate
PFT	portable flamethrower
PG	professional geologist
pg/g	picograms per gram
PgM	program manager
pH	measure of acidity/alkalinity; hydrogen ion activity (negative of the logarithm, base 10)
PHC	principal hazardous constituent
PID	photoionization detector
PIEZ	piezometer
PINS	portable isotopic neutron microscopy
PK	packer
PLS	Professional Land Surveyor
PLS	Professional (licensed) Land Surveyor
PM	project manager
PMC	Program Management Contract

Acronym	Definition
PNMSCM	Product Manager for Non-Stockpile Chemical Materiel
PMP	Project Management Plan
PMTP	Program Management Team Plan
POC	point of contact
POL	petroleum, oils, and lubricants
POTW	publicly owned treatment works
POW	prisoner of war; palustrine open water
Powell	John Powell Chemical Company
PP	Proposed Plan
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
ppmw	parts per million by weight
PPMP	Print Plant Motor Pool
PPRTV	provisional peer-reviewed toxicity values
ppt	parts per trillion
ppT	parts per thousand
PQL	practical quantitation limit
PR	potential risk
PRA	preliminary risk assessment
PRE	preliminary risk evaluation
PRG	preliminary remediation goal
PRO	petroleum range organics
PS	chloropicrin
PSA	potential source area
PSL	preliminary screening level
PSS	palustrine scrub shrub
PSSC	potential site-specific chemical
PSV	preliminary screening value
pt	peat or other highly organic silts
PT1	an incendiary mixture in munitions
PTFE	Polytetrafluoroethylene (Teflon)
PTMP	program team management plan
PTSM	principal threat source material
PVC	polyvinyl chloride
PWS	performance work statement
PZ	piezometer
QA	quality assurance
QA/QC	quality assurance/quality control
QAM	quality assurance manual
QAO	quality assurance officer
QAPP	quality assurance project plan
QASAS	Quality Assurance Specialist Ammunition Surveillance
QASP	Quality Assurance Surveillance Plan
QC	quality control
QCP	quality control plan
QCSM	Quality Control Site Manager
QCSR	quality control summary report
Q-D	quantity-distance
QL	quantitation limit
QP	Qualified Person
Q-Q	quantile-quantile
QSAR	quantitative structure-activity relationship
QSM	quality systems manual
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
QuickSilver	QuickSilver Analytics, Inc.
R	when used as a validation qualifier, R means rejected; when used as a lab qualifier, R means resample; when used in text, R means retardation factor
R&A	relevant and appropriate
R^2	coefficient of determination
RA	remedial action
RAGS	Risk Assessment Guidance for Superfund
RA(O)	remedial action (operations)
RAO	remedial action objective
RAP	recommended action plan
RAR	remedial action report
RARE	Redstone Arsenal Rocket Engine
RASA	Redstone Arsenal Support Activity
RAWP	remedial action work plan
Raytheon	Raytheon Company
RBA	relative bioavailability
RBC	risk-based concentration
RBP	Rapid Bioassessment Protocol
RBRG	risk-based remedial goal
RBSC	risk-based screening concentration
$RBSC_I$	risk-based screening concentration for industrial soil
$RBSC_R$	risk-based screening concentration for residential soil
$RBSC_T$	risk-based screening concentration for tap water
RBTL	risk-based target level
$RBTL_{coc}$	risk-based target level for a given relevant COC, receptor, and source medium
RC	representative concentration; response complete
RC_{coc}	representative concentration of the relevant COC in the given medium
RCA	root cause analysis
RCMD	Recovered Chemical Materiel Directorate
RCRA	Resource Conservation and Recovery Act

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
RCRA CA	Resource Conservation and Recovery Act Corrective Action
RCWM	Recovered Chemical Warfare Materiel
RD	remedial design
RDECOM	U.S. Army Research, Development, and Engineering Command
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine; cyclotrimethylenetrinitramine; 1,3,5-trinitro-1,3,5-triazine (cyclonite); Royal Demolition Explosive
REAT	Regional Environmental Acquisition Tools
REC	Record of Environmental Consideration
REG	regular field sample
REL	recommended exposure limit; reference exposure level
RER	Record of Environmental Review
Rev	Revision
RF	response factor
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RFI	RCRA facility investigation
RFQ	request for quotation
RG	remedial goal
RGO	remedial goal option
RI	remedial investigation
RIP	remedy in place
RL	reporting limit
RM	risk management
RM-1	Risk Management-1
RM-2	Risk Management 2
RME	reasonable maximum exposure
RMP	risk management plan
Ro	Robertsville silt loam
ROD	Record of Decision
ROF	report of findings
ROI	radius of influence
ROP	Redstone Ordnance Plant
ROPS	roll over protection system
RPD	relative percent difference
RR	range residue
RRF	relative response factor
RRSE	Relative Risk Site Evaluation
RRSL	residential regional screening level
RS	prefix for groundwater monitoring well at Redstone Arsenal
RSA	Redstone Arsenal
RSD	relative standard deviation
RSL	Regional Screening Level
RSP	Redstone Arsenal spring
RTAP	Real-Time Analytical Platform
RTC	Redstone Test Center
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
RTO	regenerative thermal oxidizer
RTOP	Request for Task Order Proposal
RTS	robotic total station
RTTC	Redstone Technical Test Center
Rust	Rust Environment and Infrastructure, Inc.
s/n	signal-to-noise ratio
SA	exposed skin surface area; source area
SAA	satellite accumulation area
SAC	site access control
SACIMS	Site Access Control Information Management System
SACP	Site Access Control Plan
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
SAR	structure-activity relationship
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SC	specific conductance
SCG	storage compatibility group
SCBA	self-contained breathing apparatus
Sch.	schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDS	safety data sheet
SDSW	sediment/surface water
SDWA	Safe Drinking Water Act
SDZ	surface danger zone
SED	Software Engineering Directorate
SEE	steam enhanced extraction
SF	cancer slope factor
SFSP	site-specific field sampling plan
SGF	standard grade fuels
Shaw	Shaw Environmental, Inc.
SHP	safety and health plan
SI	site inspection
SIC	sulfur-impregnated carbon
Sil	Silurian
SIM	Selective Ion Monitoring
SIR	secondary investigation report
SL	standing liquid

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
SLERA	screening-level ecological risk assessment
SLERAP	screening-level ecological risk assessment protocol
SM	sulfur monochloride
SMDP	Scientific Management Decision Point
SMF	smoke munitions filling
SMF 3	Smoke Munitions Filling Plant 3
SMP	site management plan
SNR	signal-to-noise ratio
SO_4	sulfate
SOD	soil oxidant demand
SOP	standard operating procedure
SOPP	standard operating project procedure
SP	submersible pump
SPA	single point anomaly
SPCC	system performance calibration compound
SPCS	State Plane Coordinate System
SPLP	synthetic precipitation leaching procedure
SPM	sample planning module
SPRG	spring
SQG	sediment quality guideline
SQRT	screening quick reference tables
SRA	streamlined human health risk assessment; saturated response area
SRB	sulfate-reducing bacteria
SRI	supplemental remedial investigation
SRM	standard reference material
SS	surface soil
SSC	site-specific chemical
SSHO	site safety and health officer
SSHP	site-specific safety and health plan
SSL	soil screening level
SSSL	site-specific screening level
SSTL	site-specific target level
SSPA	site-specific probability assessment
STB	supertropical bleach; site to background
STC	source-term concentration
STD	standard deviation
Std. units	standard units
STEL	short-term exposure limit
STP	sewage treatment plant
STL	Severn-Trent Laboratories
STT	sludge thickener tank
SU	sampling unit when used in a grid for incremental sampling; when used as a unit for pH, this acronym stands for standard unit
SUXOS	senior UXO supervisor
SV	screening value
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SW-846	U.S. EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*
SW	surface water
SWCC	State of Alabama Soil and Water Conservation Committee
SWMU	solid waste management unit
SWTR	surface water
SZ	support zone
TA	test area
TAL	target analyte list
TAT	turn around time
TB	trip blank
TBC	to be considered
TBD	to be determined
TC	toxicity characteristic
TCA	trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofurans
TCE	trichloroethene
TCH	thermal conductive heating
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TCMX	tetrachloro-m-xylene
TCRA	time critical removal action
TDGCL	thiodiglycol
TDGCLA	thiodiglycol chloroacetic acid
TDS	total dissolved solids
TEA	triethylaluminum
TEC	threshold effect concentration
TeCA	1,1,2,2-tetrachloroethane
TEF	toxicity equivalency factor
TEGDN	triethylene glycol dinitrate
TEGN	triethylene glycoldinitrate
TEMP	temperature
TEMTADS	Time-Domain Electromagnetic Multisensor Tower Array Detection System
TEQ	toxic equivalency quotient
TERC	Total Environmental Restoration Contract
Tetryl	trinitrophenylmethylnitramine
TEU	Technical Escort Unit
THI	target hazard index
Thiokol	Thiokol Corporation
TIC	tentatively identified compound
TIR	thermal infrared survey
TLV	threshold limit value
TM	Technical Manual

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
TMP	temperature measuring point
TMPW	temporary groundwater monitoring well
TN	Tennessee
TNB	trinitrobenzene
TNT	trinitrotoluene
TO	task order
TOC	use top of casing when defining the well depth; use total organic carbon when defining a general chemistry parameter
TOI	target of interest
TOW	tube-launched, optically-tracked, wire-guided missile
TP	Technical Paper
TPH	total petroleum hydrocarbon
TPI	three-phase inspection
TPP	Technical Project Planning
TR	target cancer risk
TRADOC	U.S. Army Training and Doctrine Command
TRINITY	Trinity Analysis and Development Corp.
TRPH	total recoverable petroleum hydrocarbons
TRS	TRS Group Inc.
TRV	toxicity reference value
TSA	temporary storage area
TSCA	Toxic Substances Control Act
TSCRN	top of screen
TSDF	treatment, storage, and disposal facility
TSLC	target soil leachate concentration
TSS	total suspended solids
TTAP	treatment system tap (port)
TTZ	target treatment zone
Tu	Tupelo silt loam
TVA	Tennessee Valley Authority
TWA	time-weighted average
TXDOT	Texas Department of Transportation
TX-3	small rocket motor used for ballistics testing
U	not detected above reporting limit
U.S.	United States (of America)
UB	potential blank contamination
UCL	upper confidence limit
UCLM	upper confidence limit of the mean
UCR	upper certified range
UDMH	unsymmetrical dimethyl hydrazine
UF	uncertainty factor
UFP	Uniform Federal Policy
UIC	underground injection control
UJ	not detected, estimated due to data validation anomaly
UNEP	United Nations Environment Program
UNO	United Nations Organization
UPL	upper prediction limit; upland
UR	not detected; rejected due to data validation anomaly
URF	unit risk factor
USACE	U.S. Army Corps of Engineers
USACMLS	U.S. Army Chemical School
USAEC	U.S. Army Environmental Command
USAEHA	U.S. Army Environmental Hygiene Agency
USAESCH	U.S. Army Engineering Support Center, Huntsville
USAMPS	U.S. Army Military Police School
USAPHC	U.S. Army Public Health Command
USATCES	U.S. Army Technical Center for Explosive Safety
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	United States Code
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance limit
UTM	Universal Transverse Mercatir
UTS	universal treatment standard
UTV	utility terrain vehicle
UXO	unexploded ordnance
UXOSP	unexploded ordnance sweep personnel
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VC	vinyl chloride
VCE	Virtual Contracting Enterprise
VGIC	liquid-phase granular activated carbon
VI	vapor intrusion
VISL	vapor intrusion screening level
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VP	soil vapor point
VQ	validation qualifier
vs	versus
VSI	visual site inspection
VSL	vapor screening level
VSP	Visual Sample Plan
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)

List of Abbreviations and Acronyms
Redstone Arsenal, Madison County, Alabama

Acronym	Definition
WAC	Women's Army Corps
WBGT	wet bulb globe temperature
WDTA	Waste Disposal Trench Area
WNWR	Wheeler National Wildlife Refuge
WOE	weight of evidence
WP	white phosphorus
WPL	worker population limit
WPS	Waste Profile Sheet
WQC	water quality criteria
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WTP	water treatment plant
WWI	World War I
WWII	World War II
WWTP	wastewater treatment plant
X	Data collected in a manner that is now considered to be inconsistent with good scientific practice. These data are considered unusable. However, since these data exist in the database, additional definitive samples may be needed to verify the presence or absence of any positively detected result.
XRF	x-ray fluorescence
yd^3	cubic yards
ZVI	zero-valent iron

TABLES

Table 1-1

Well Construction Summary
Overburden Monitoring Wells
RSA-271 RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Well Number	Monitored Zone	Status	Installation Date	Latitude	Longitude	Depth to Bedrock (ft bgs)*	Top of Casing Elevation (ft amsl)	Ground Elevation (ft amsl)	Installed Well Depth (ft bgs)	Screened Interval (ft bgs)	Well Diameter (inches)	Screen Slot Size (inches)	Well Construction Material
271-RS2707	OVB	ACTIVE	11-Nov-15	34° 37' 37.416" N	86° 35' 36.7548" W	39.5	586.894	584.442	39.5	29.1 - 39.1	2.0	0.010	PVC
271-RS2708	OVB	ACTIVE	11-Nov-15	34° 37' 36.8832" N	86° 35' 36.8232" W	36.5	585.014	582.798	36.5	26.1 - 36.1	2.0	0.010	PVC
271-RS2709	OVB	ACTIVE	11-Nov-15	34° 37' 37.5024" N	86° 35' 36.1032" W	36.3	586.045	583.656	36.3	25.9 - 35.9	2.0	0.010	PVC

* Based upon auger refusal during well installation.
ABD - Abandoned; month and year.
amsl - Above mean sea level.
bgs - Below ground surface.
ft - Feet.
OVB - Overburden.
PVC - Polyvinyl chloride.

Table 2-1

Summary of Receptor Cancer Risk and Noncancer Hazard for Chemicals of Concern
Reasonable Maximum Exposure
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

CANCER RISK

Receptors	Total Soil IELCR	Groundwater IELCR	CUMULATIVE RISK SOIL	CUMULATIVE RISK SOIL AND GROUNDWATER
Industrial Receptors:				
Commercial Worker	4.2E-07	1.2E-04	4.2E-07	1.2E-04
Construction Worker	1.9E-08	5.3E-06	1.9E-08	5.3E-06
Hypothetical Residential Receptors:				
Child Resident [a]	1.4E-06	9.9E-05	1.4E-06	1.0E-04
Adult Resident [a]	5.2E-07	2.1E-04	5.2E-07	2.1E-04
Lifetime Resident [a]	1.9E-06	3.1E-04	1.9E-06	3.1E-04

NONCANCER HAZARD

Receptors	Total Soil HI	Groundwater HI	CUMULATIVE HI SOIL	CUMULATIVE HI SOIL AND GROUNDWATER
Industrial Receptors:				
Commercial Worker	NA	14	NA	14
Construction Worker	NA	16	NA	16
Hypothetical Residential Receptors:				
Child Resident [a]	NA	49	NA	49

[a] Risk associated with the hypothetical residential receptor; child and adult resident risk are summed to estimate the cancer risk for the lifetime resident.
Noncancer hazard estimates are based on the hypothetical child resident only.
HI - Hazard index.
IELCR - Individual excess lifetime cancer risk.
NA - Not applicable.

Table 2-2

Conclusions of the ARBCA RM-2 Evaluation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Receptors	Exposure to Soil [a]	COCs Requiring Action in Soil [b]	Exposure to Groundwater [a]	COCs Requiring Action for Exposure to Groundwater [c]
Commercial Worker	√	(None)	X	Manganese 1-Methylnapthalene Trichloroethene
Construction Worker	√	(None)	X	Manganese Trichloroethene
Hypothetical Resident	√	(None)	X	Manganese Perchlorate 2-Nitrotoluene 1-Methylnapthalene Trichloroethene

Notes:

√ Cumulative cancer risk and noncancer hazard were found to be acceptable.

X Cumulative cancer risk and noncancer hazard were found to be unacceptable.

[a] Risk conclusions exclude inorganics found to be naturally occurring.

[b] Conclusions regarding risk and identification of COCs requiring action in soil exclude consideration of contribution of risk from exposure to groundwater.

[c] Chemicals with maximum detected concentrations below their maximum contaminant levels are not included as significant contributors from exposure to groundwater.

ARBCA - Alabama Risk-Based Corrective Action.
COC - Chemical of concern.
COPAC - Chemical of potential analytical concern.
PSV - Preliminary screening value.
RM-2 - Risk-Management-2.

Table 3-1

Potential Federal and State Regulations Applicable to Corrective Measures
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicability	Comments
Federal			
Safe Drinking Water Act, 42 U.S.C. Section 300 – National Primary Drinking Water Standards - 40 CFR Part 141	Applicable to the use of public water systems. Establishes maximum contaminant level, monitoring requirements, and treatment techniques.	Applicable	Federal drinking water goals are used by ADEM to establish cleanup standards.
Safe Drinking Water Act, 42 U.S.C. Section 300 – Maximum Contaminant Level Goals - 40 CFR Part 141 Subpart F	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects.	Applicable	Federal drinking water goals are used by ADEM to establish cleanup standards.
State			
Alabama Drinking Water Standards ADEM 335-7-2	Applicable to the use of public water systems. Establishes maximum contaminant level, monitoring requirements, and treatment techniques.	Applicable	Drinking water standards established by ADEM based on Federal drinking water goals.
Alabama Solid Waste Act, Code of Alabama, Title 22, Chapter 27	Establishes sitewide program to provide for the safe management of nonhazardous wastes.	Applicable	Nonhazardous waste may be generated during monitoring or corrective measure activities.
Alabama Solid Waste Management Regulations, ADEM 335-13-1 through 335-13-8	Establishes minimum criteria for the processing, recycling, transportation, and disposal of solid wastes and the design, location, and operation of solid waste disposal facilities.	Applicable	Nonhazardous waste may be generated, transported, or disposed as part of monitoring or corrective measure activities.
Alabama Wellhead Protection Program, ADEM 335-7-12	Establishes requirements for the closure or abandonment of groundwater monitoring or extraction wells.	Applicable	Applicable if monitoring wells are constructed or closed.
Alabama Uniform Environmental Covenants Program, ADEM 335-5	Establishes the requirements for environmental use restrictions on federal facility property.	Potentially Applicable	The use of land-use controls may be considered as a component of the corrective measures for this site.

ADEM – Alabama Department of Environmental Management.
CFR – Code of Federal Regulations.

Table 3-2

Summary of Groundwater Cleanup Goals
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County Alabama

Chemical of Concern	Regulation-Base CG (mg/L)	Cancer-Based CG (mg/L)	Cancer Basis	Noncancer-Based CG (mg/L)	Noncancer Basis	Selected Groundwater Cleanup Goal (mg/L)
Manganese	NA	NA	NA	4.33E-01	HI = 1.0, target organ CNS/neurotoxicity	4.33E-01
Perchlorate	0.015 [b]	NA	NA	NA	NA	1.50E-02
2-Nitrotoluene	NA	3.13E-03	Risk = 1.0E-06	NA	NA	3.13E-03
1-Methylnaphthalene	NA	1.01E-02	Risk = 9.0E-06	NA	NA	1.01E-02
Trichloroethene	0.005 [a]	NA	NA	NA	NA	5.00E-03

Common Degradation Parameters for Trichloroethene

Monitoring Parameter	Selected Monitoring Acceptance Goal (µg/L)	Basis for Monitoring Acceptance Goal
1,1-Dichloroethene	7	MCL
cis-1,2-Dichloroethene	70	MCL
trans-1,2-Dichloroethene	100	MCL
Vinyl chloride	2	MCL

COCs with MDCs over RSL but not Risk Drivers

Monitoring Parameter	Selected Monitoring Acceptance Goal (µg/L)	Basis for Monitoring Acceptance Goal [c]
3-Nitrotoluene	0.17	2021 RSL
2,4,6-Trinitrotoluene	0.98	2021 RSL
1,3-Dinitrobenzene	0.2	2021 RSL
Nitrobenzene	0.14	2021 RSL
Nitroglycerin	0.2	2021 RSL
2-Methylnaphthalene	3.6	2021 RSL
Benzo(a)anthracene	0.030	2021 RSL
Dibenz(a,h)anthracene	0.025	2021 RSL
Dibenzofuran	0.79	2021 RSL
Naphthalene	0.17	2021 RSL

Table 3-2

Summary of Groundwater Cleanup Goals
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County Alabama

2-Amino-4,6-dinitrotoluene	0.19	2021 RSL
4-Amino-2,6-dinitrotoluene	0.19	2021 RSL

[a] Unless otherwise noted the regulation-based RBTL on the maximum contaminant levels (U.S. Environmental Protection Agency [EPA], 2018, *2018 Edition of the Drinking Water Standards and Health Advisories* , EPA 822-S-12-001, Office of Water, Washington, District of Columbia, April).

[b] The Interim Drinking Water Health Advisory level (HAL) of 15 µg/L (Department of Defense [DoD], 2009, “Perchlorate Release Management Policy”, Memorandum from Wayne Arny to Deputy Assistant Secretaries of the Army, Navy and Air Force, 4 April).

[c] RSL - ADEM groundwater regional screening level (RSL). Based on EPA Tapwater RSLs to reflect an incremental lifetime cancer risk of 1E-6 or a hazard index of 0.1 (EPA, 2021, Regional Screening Levels for Chemical Contaminants at Superfund Sites, May). RSL for Naphthalene does not include the route to route extrapolation of the inhalation unit risk to an oral slope factor.

CG - Cleanup goal.
HI - Hazard index.
MCL - Maximum contaminant level.
mg/L - Milligram per liter.
NA - Not applicable.
RBTL - Risk-based target level.
RSL - Regional screening level.
µg/L - Microgram per liter.

Table 3-3

Summary of Soil and SPLP Leachate Cleanup Goals

Parameter	Soil Cleanup Goal (milligrams per kilogram)	Basis	SPLP Cleanup Goal (micrograms per liter)	Basis
Naphthalene	2.17	ARBCA Groundwater Resource Protection Model	1.33E+00	DAF $_4$ SSL and Horizontal DAF from ARBCA Groundwater Resource Protection Model
1-Methylnaphthalene	21.1		7.87E+01	

ARBCA - Alabama Risk-based Corrective Action

DAF$_4$SSL - Dilution-attenuation Factor 4 Soil Screening Level

SPLP - Synthetic Precipitation Leaching Procedure

Table 4-1

Groundwater Monitoring Schedule
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Location	Zone	Rationale for Inclusion	Sampling Event Schedule	Analyses
271-RS2707	Overburden	Monitor plume core adjacent to former UST pit	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese
271-RS2708	Overburden	Contaminated well south of the former UST pit	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese
271-RS2709	Overburden	Cross gradient uncontaminated well east of the former UST pit	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese
271-RS2994[a]	Overburden	Downgradient Point of Compliance well	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese
271-RS3003[a]	Overburden	Downgradient/Crossgradient Point of Compliance well	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese
271-RS3004[a]	Overburden	Downgradient/Crossgradient Point of Compliance well	Baseline, Annual	VOCs, SVOCs, Explosives, Perchlorate, and Manganese

[a] Monitoring wells 271-RS2994, 271-RS3003, and 271-RS3004 are proposed for installation and sampling.

SVOC – Semivolatile organic compound.
UST – Underground storage tank.
VOC – Volatile organic compound.

Table 5-1

Parameters and their Role in Anaerobic Biodegradation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Performance Parameter	Data Use	Performance Expectation
Chemicals of Concern (COC)	Used to determine the regulatory compliance for COCs, the values by which success of the remediation system will be measured.	COCs and degradation products typically are expected to decline within the treatment zone after substrate addition.
Methane, Ethane, Ethene	Elevated levels of methane indicate fermentation is occurring in a highly anaerobic environment and that reducing conditions are appropriate for anaerobic degradation. For chlorinated aliphatic hydrocarbons (CAH) elevated levels of ethene and ethane (at least an order of magnitude greater than background levels) can be used to infer anaerobic dechlorination of CAHs. Note that ethane and ethene can be subject to rapid biodegradation so their absence in a sample does not necessarily mean that CAH biodegradation is not occurring.	Methane levels >1.0 mg/L are desirable but not required for dechlorination to occur. Methane levels <1.0 mg/L and the accumulation of cis-1,2-DCE, VC, or other CAHs could indicate that additional substrate is required to shift reducing conditions into an environment suitable for reduction of these compounds.
Total Organic Carbon/Dissolved Organic Carbon (TOC/DOC)	Indicator of natural organic carbon present at site during baseline characterization and as an indicator of substrate distribution during performance monitoring. TOC/DOC concentrations >20-50 mg/L are desired in the anaerobic treatment zone.	Stable or declining TOC/DOC levels <20 mg/L in conjunction with elevated levels of VOCs and alternate electron acceptors indicate additional substrate is required to sustain the anaerobic treatment zone.
Dehalococcoides (DHE) or other appropriate microorganisms or functional genes	Used to determine the presence of DHE or other appropriate microorganism at baseline periods or after bioaugmentation.	DHE or other appropriate microorganism will be detected and increase as a consequence of adding electron donor to create anaerobic conditions or increase after inoculation with DHE or other appropriate microorganism-containing culture.
Ammonia	Ammonia can represent a form of biologically available nitrogen. Used to determine if groundwater environment is sufficiently reducing nitrogen.	Indicator parameter only.

Table 5-1

Parameters and their Role in Anaerobic Biodegradation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Performance Parameter	Data Use	Performance Expectation
Nitrate	Nitrate is an alternate electron acceptor for microbial respiration in the absence of oxygen. Depleted levels of nitrate (relative to background) indicate that the groundwater environment is sufficiently reducing nitrate.	Indicator parameter. Nitrate level <1.0 mg/L is desirable for anaerobic in situ bioremediation.
Nitrite	In most aquifers the concentration of nitrate is naturally much higher than nitrite, and total nitrate/nitrite can be used as an estimate of nitrate.	Indicator parameter.
Manganese (Mn)	Mn(IV) is an alternate electron acceptor for microbial respiration in the absence of oxygen and nitrate. An increase in dissolved Mn(II) or total manganese indicates that the groundwater environment is sufficiently reducing to sustain Mn reduction and for anaerobic dechlorination to occur.	Elevated levels of dissolved Mn could indicate a competing terminal electron accepting processes to anaerobic degradation of COCs.
Major Cations (Ca, Mg, Na, K)	Major cations along with major anions are good general groundwater chemistry parameters and are inexpensive to analyze.	Only as a check if the system is not working as planned.
Ferrous Iron (Fe[II])	Ferric iron is an alternate electron acceptor for microbial respiration in the absence of oxygen and nitrate. Reduction of ferric iron produces ferrous iron. Elevated levels of ferrous iron indicate that the groundwater environment is sufficiently reducing to sustain iron reduction and for anaerobic dechlorination to occur.	Elevated levels of ferrous iron can indicate a competing terminal electron accepting processes to anaerobic degradation of COCs.
Biologically Available Iron (Fe[III])	Bioassay with quantification of bioavailable solid-phase ferric iron Fe(III), which is a competing electron acceptor. Optional method that can be used to determine competition from iron reduction. Might also affect potential abiotic reactions.	Recommended only for clastic sediments with potential for significant iron concentrations. Also, can be used as a diagnostic tool if sulfate reduction or methanogenic redox conditions cannot be achieved.
Sulfate $(SO_4)^{-2}$	Sulfate is an alternate electron acceptor for microbial respiration in the absence of oxygen, nitrate, Mn, and ferric iron. Depleted concentrations of sulfate relative	Sulfate levels <20 mg/L are desirable but not required for anaerobic dechlorination to occur. High levels of

Table 5-1

Parameters and their Role in Anaerobic Biodegradation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Performance Parameter	Data Use	Performance Expectation
	to background indicate that the groundwater environment is sufficiently reducing to sustain sulfate reduction and for anaerobic dechlorination to occur.	sulfate in conjunction with the absence of TOC/DOC indicate additional substrate might be required to promote anaerobic degradation.
Sulfide	By-product of sulfate reduction. Sulfide typically precipitates with iron minerals, but elevated levels of sulfide might be toxic to dechlorinating microorganisms.	Elevated levels of sulfide in conjunction with elevated levels of CAHs can indicate that iron compounds should be added to precipitate sulfides and reduce toxicity effects.
Hydrogen Sulfide	Useful for determining biological activity in vadose zone and generation of biogenic methane.	Explosive levels of noxious levels of hydrogen sulfide accumulating in structures or utilities can pose a health risk.
Bromide or Iodide	Used as a conservative groundwater tracer.	Indicator parameter for tracer tests.
Carbon Dioxide (CO_2)	Carbon dioxide is a by-product of both aerobic and anaerobic degradation. Elevated levels of carbon dioxide indicate microbial activity has been stimulated.	Indicator parameter.
pH	Biological processes are pH sensitive, and the ideal range of pH for degrading bacteria is 6 to 8. Outside of a range of 5 to 9, biological activity is less likely to occur.	pH levels within a range of 5 to 9 are desirable. pH<5 indicates that a buffering agent might be required to sustain high rates of biodegradation.
Oxidation Reduction Potential (ORP)	ORP of groundwater provides data on whether or not anaerobic conditions are present. Reducing conditions are required for anaerobic dechlorination of CAHs. Used in conjunction with other geochemical parameters to determine whether or not groundwater conditions are optimal for anaerobic biodegradation.	Positive ORP values (>0.0 mV) in conjunction with elevated levels of DO and the absence of TOC/DOC can indicate that additional substrate is required to promote anaerobic biodegradation.

Table 5-1

Parameters and their Role in Anaerobic Biodegradation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

Performance Parameter	Data Use	Performance Expectation
Dissolved Oxygen (DO)	DO should be depleted in an anaerobic bioremediation system. DO <0.5 mg/L generally indicates an anaerobic pathway suitable for anaerobic dechlorination to occur.	DO concentrations >1.0 mg/L in conjunction with elevated levels of CAHs and the absence of TOC/DOC indicate additional substrate might be required to promote anaerobic dechlorination.
Temperature	General water quality parameter used as a well purging stabilization indicator. Microbial activity is slower at lower temperatures.	Indicator parameter. Typically used as a well purge stabilization parameter.
Specific Conductance	General water quality parameter used as a well purging stabilization indicator. Can correlate with and support interpretations of other geochemical analyses.	Indicator parameter. Typically used as a well purge stabilization parameter.
Fraction of Organic Carbon (f_{oc})	Fraction of organic carbon in the aquifer matrix is used to calculate retardation factors for dissolved contaminant transport and to estimate the amount of contaminant mass sorbed to the aquifer matrix.	A large portion of contaminant mass might be sorbed to the aquifer matrix.
Volatile Fatty Acids (VFAs)	VFAs are an indicator of substrate distribution and are also degradation products of more complex substrates (e.g., vegetable oils or carbohydrates). Fermentation of VFAs produces molecular hydrogen for anaerobic biodegradation.	Measurable concentrations of VFAs (>10-20 mg/L) are desirable in the treatment zone. The presence of mg/L concentrations of propionate or butyrate is considered favorable. Absence of measurable VFAs in conjunction with elevated levels of CAHs and alternate electron acceptors indicates additional substrate might be required to sustain the anaerobic treatment zone.
Alkalinity	Indicator of biodegradation and the buffering capacity of the aquifer (neutralization of weak acids). Used in conjunction with pH. An increase in alkalinity and stable pH indicates the buffering capacity of the aquifer is sufficient to neutralize metabolic acids produced by degradation of substrates.	Concentrations of alkalinity that remain at or below background in conjunction with pH <5 indicates that a buffering agent could be required to sustain high rates of anaerobic dechlorination.

Table 5-1

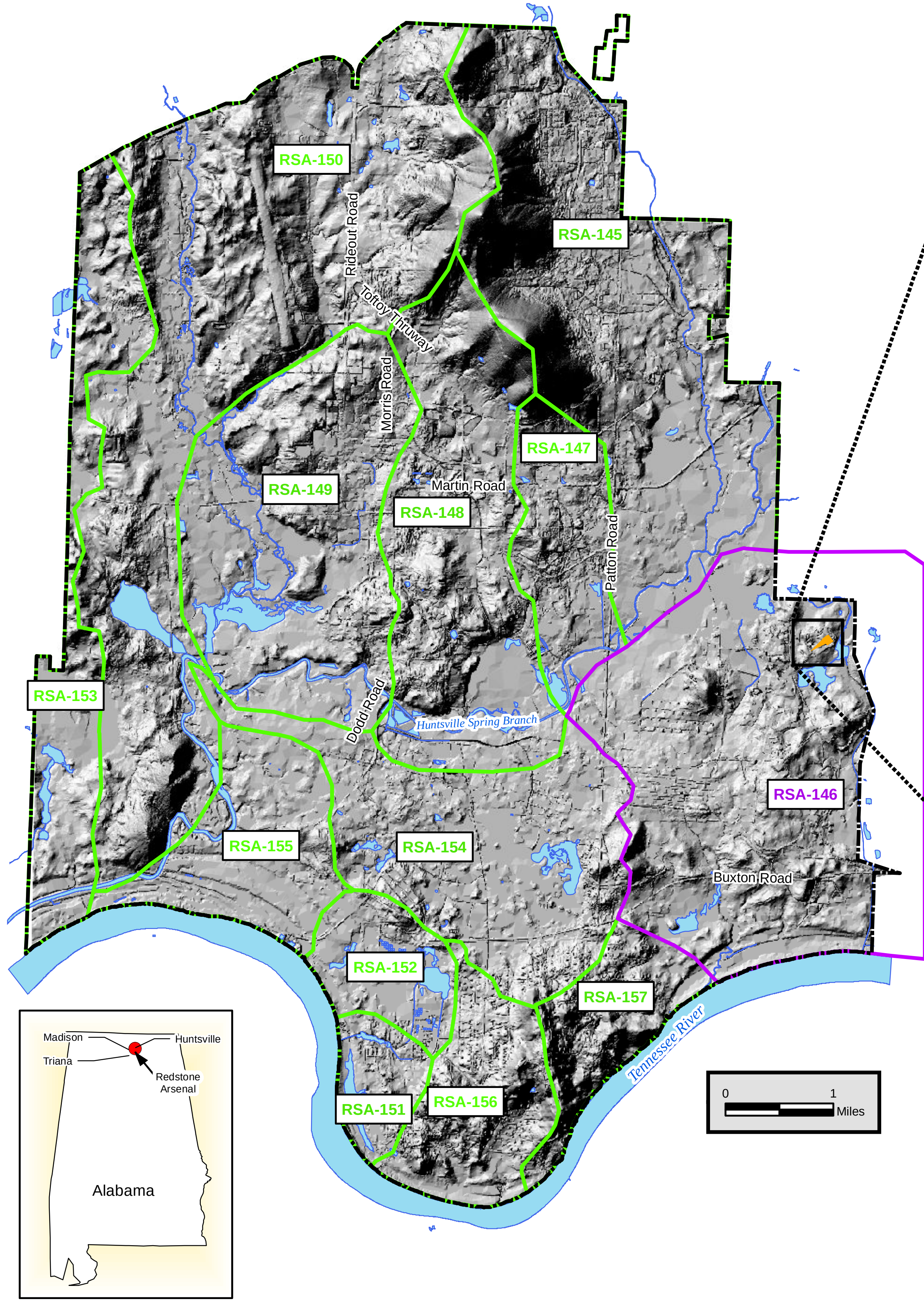
Parameters and their Role in Anaerobic Biodegradation
RSA-271 Corrective Measures Implementation Work Plan
Redstone Arsenal, Madison County, Alabama

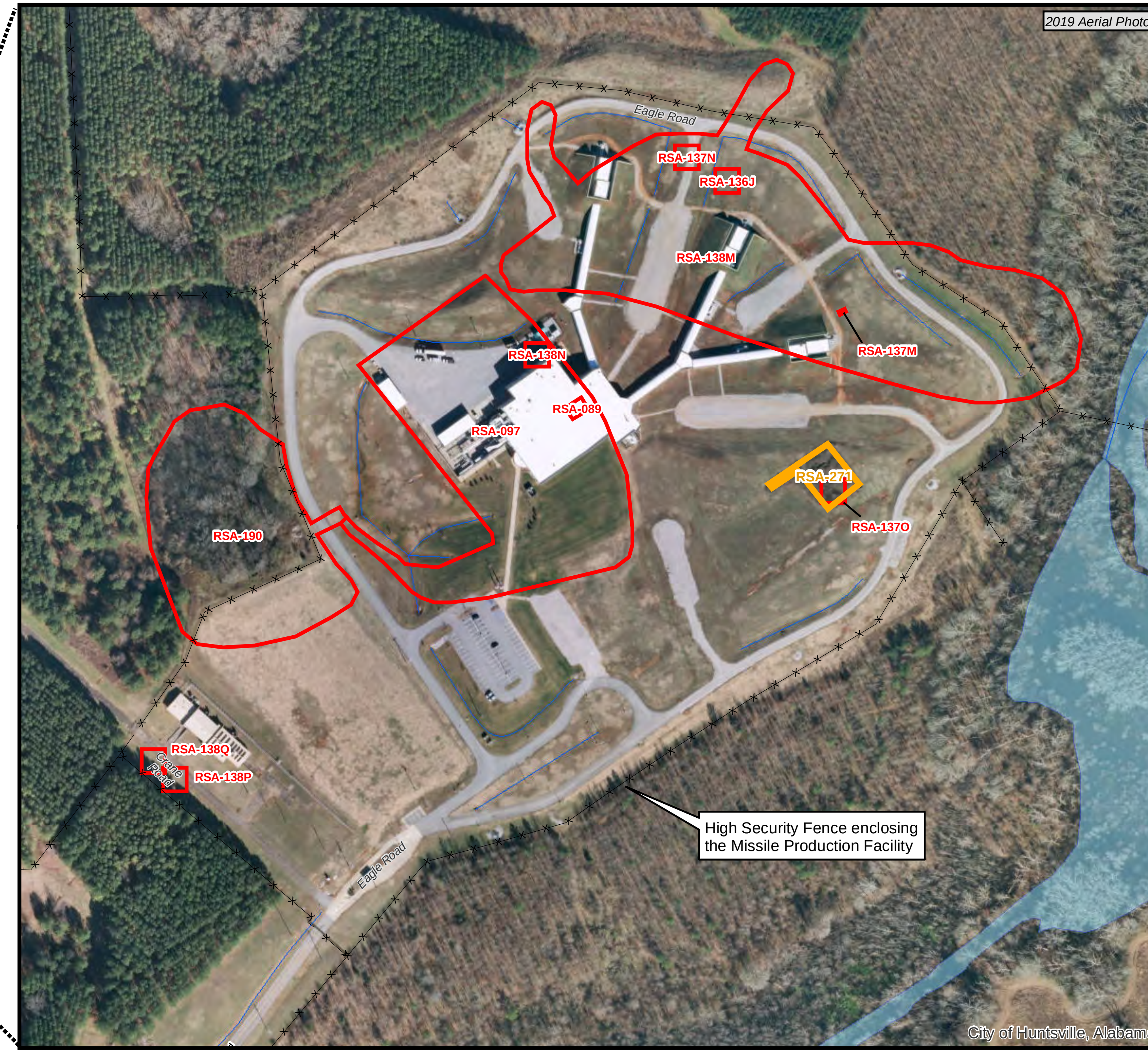
Performance Parameter	Data Use	Performance Expectation
Dissolved Phosphate	Nutrient needed for microbial growth. Might be needed as a substrate amendment.	May indicate need for phosphate amendment.
Chloride	General water quality parameter. Chloride is also produced by anaerobic dechlorination of CAHs. Elevated levels of chloride can indicate that dechlorination is occurring if observed concentrations are greater than three times background and consistent with CAH molar concentrations.	Indicator parameter only.

Source: Table Adapted from Interstate Technology and Regulatory Council, *In Situ Bioremediation of Chlorinated Ethene: DNAPL Source Zones,*2008.

CAH – Chlorinated aliphatic hydrocarbon.
COC – Chemical of concern.
DOC – Dissolved organic carbon.
mg/L – Milligrams per liter.
mV – Millivolt.
ORP – Oxidation reduction potential.
TOC – Total organic carbon.
VFA – Volatile fatty acid.

FIGURES





Legend

- RSA-271 Site Boundary
- No Further Action (NFA) for Surface Media Site Boundary
- RSA-146 Groundwater Unit Boudary
- Groundwater Unit Boudary
- RSA Installation Boundary
- Water Bodies
- Surface Drainage Features (Some Ephemeral)
- Fence

Figure 1-1

RSA-271
Site Location Map

Redstone Arsenal
Madison County, Alabama

1 inch = 300 feet

0 150 300 600 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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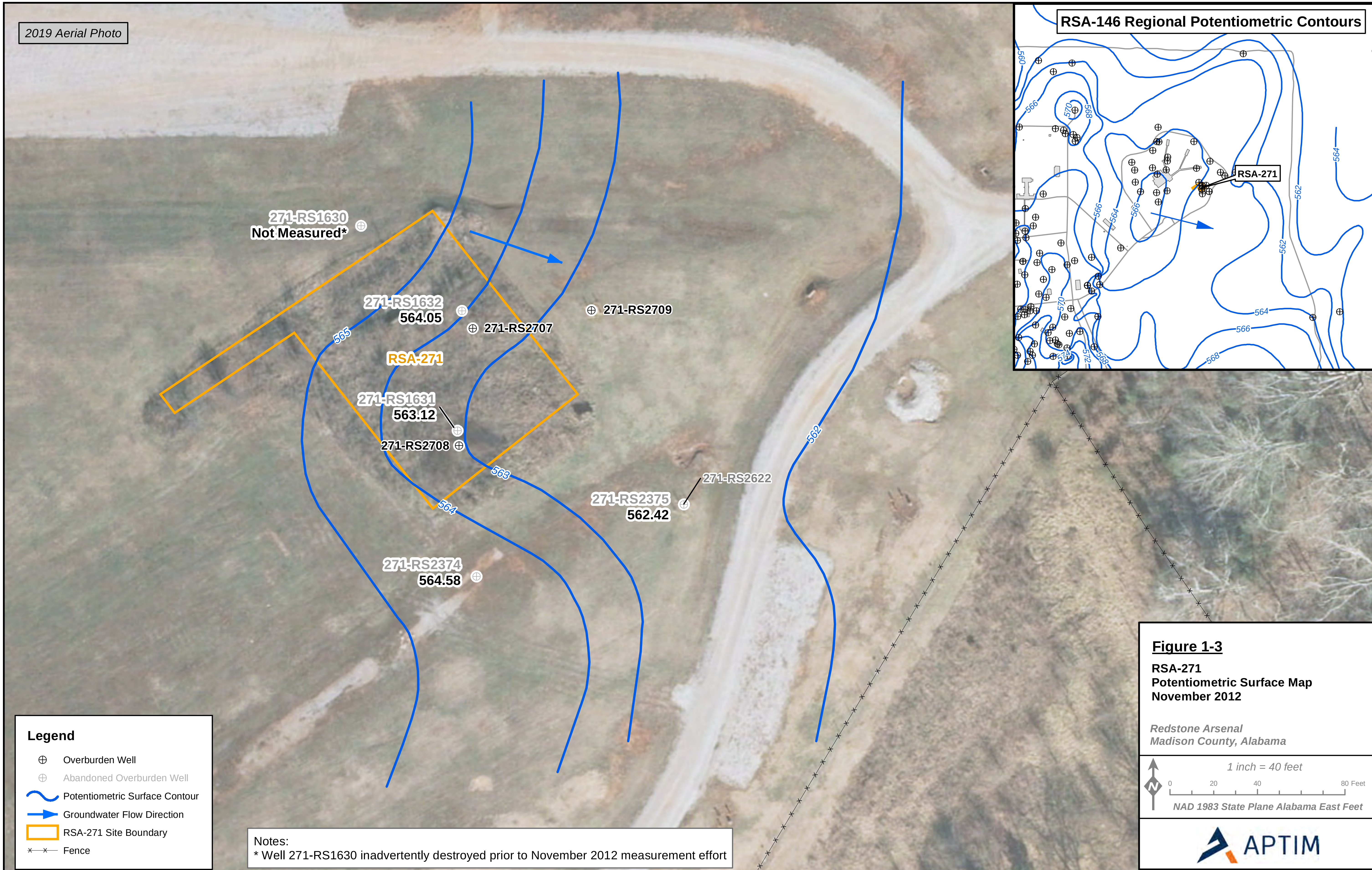

Figure 1-3

RSA-271
Potentiometric Surface Map
November 2012

Redstone Arsenal
Madison County, Alabama

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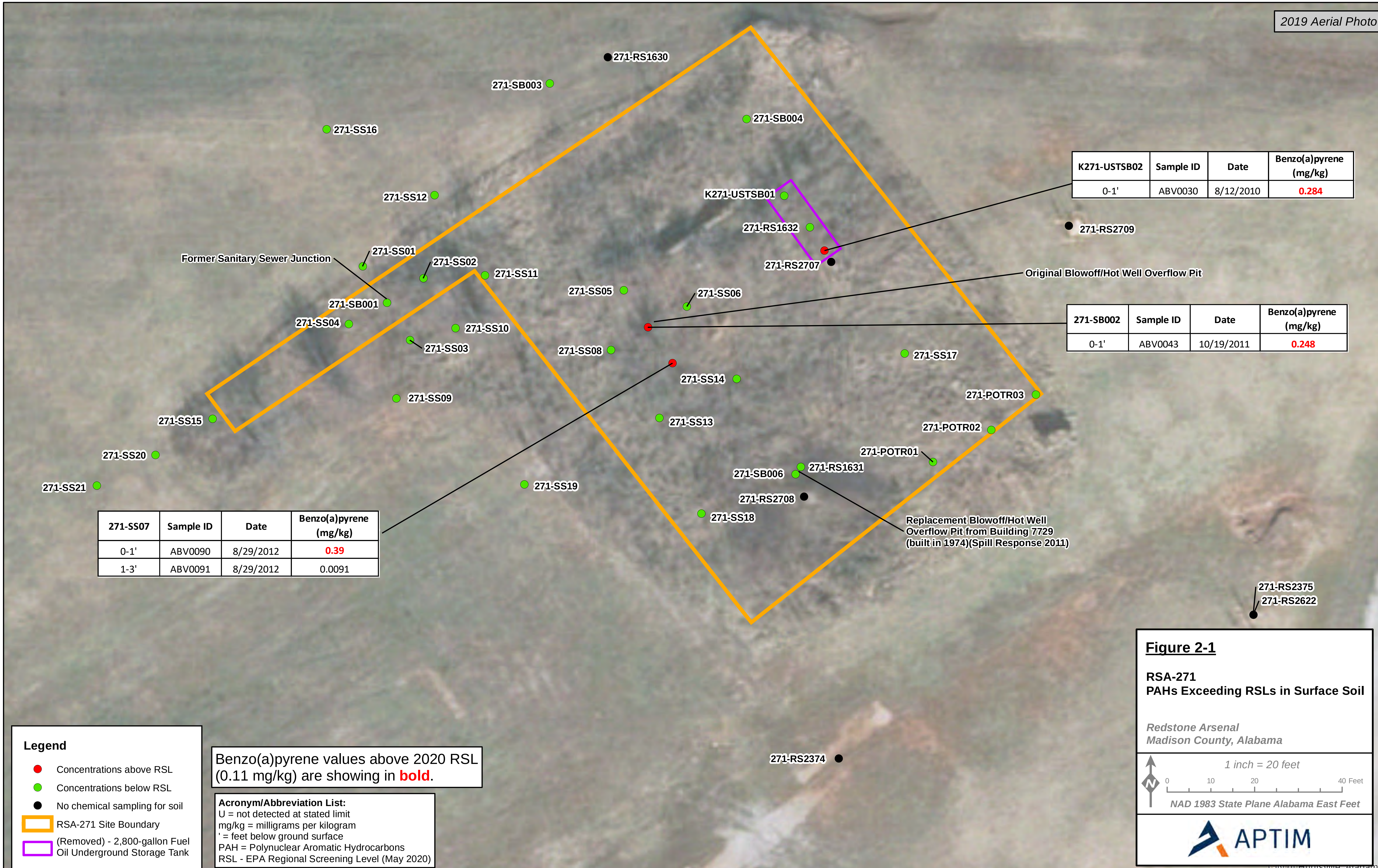

K271-USTSB02	Sample ID	Date	Benzo(a)pyrene (mg/kg)
0-1'	ABV0030	8/12/2010	**0.284**

271-SB002	Sample ID	Date	Benzo(a)pyrene (mg/kg)
0-1'	ABV0043	10/19/2011	**0.248**

271-SS07	Sample ID	Date	Benzo(a)pyrene (mg/kg)
0-1'	ABV0090	8/29/2012	**0.39**
1-3'	ABV0091	8/29/2012	0.0091

Legend

- Concentrations above RSL
- Concentrations below RSL
- No chemical sampling for soil
- RSA-271 Site Boundary
- (Removed) - 2,800-gallon Fuel Oil Underground Storage Tank

Benzo(a)pyrene values above 2020 RSL (0.11 mg/kg) are showing in **bold**.

Acronym/Abbreviation List:
U = not detected at stated limit
mg/kg = milligrams per kilogram
' = feet below ground surface
PAH = Polynuclear Aromatic Hydrocarbons
RSL - EPA Regional Screening Level (May 2020)

Figure 2-1

RSA-271
PAHs Exceeding RSLs in Surface Soil

Redstone Arsenal
Madison County, Alabama

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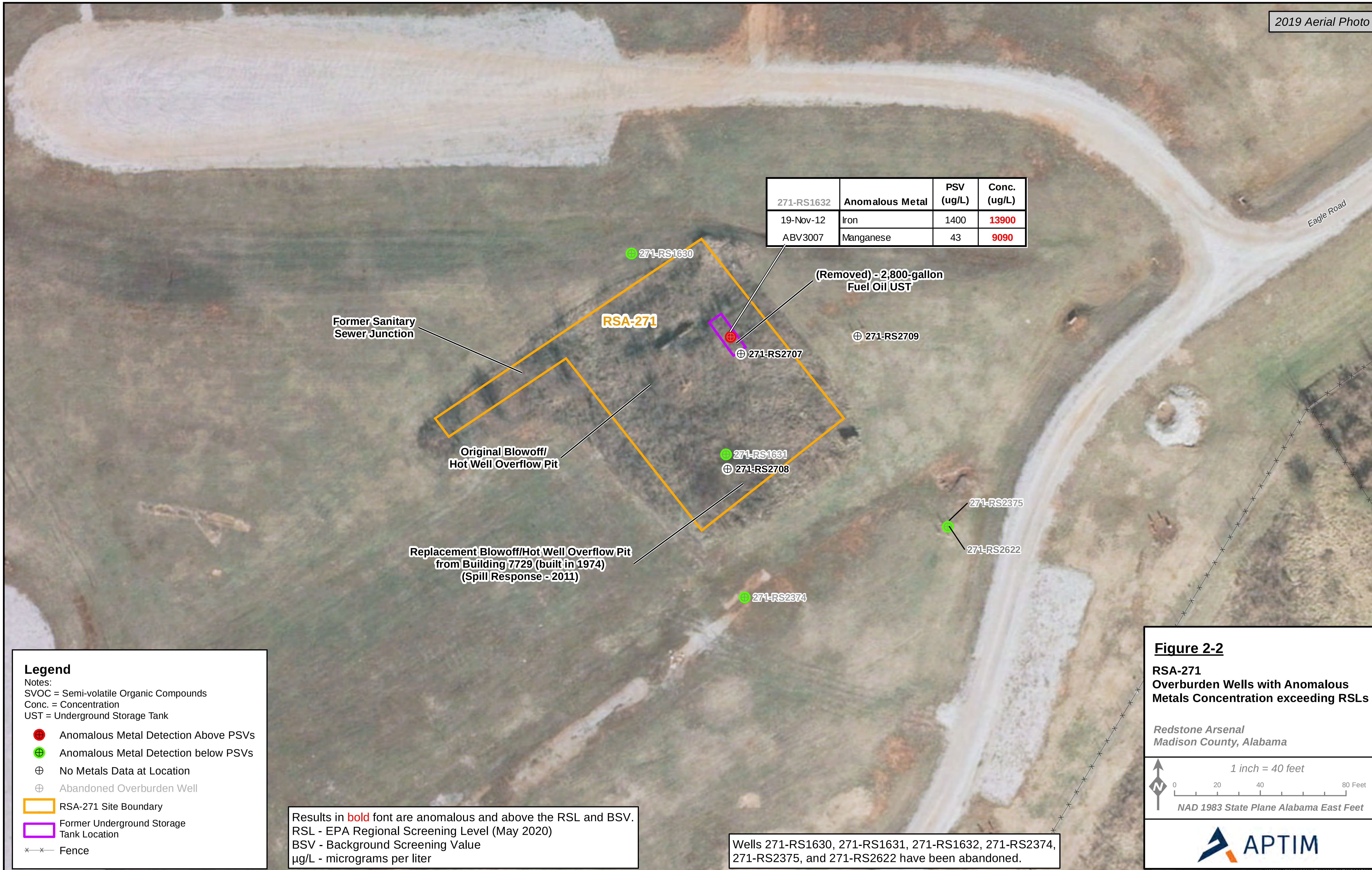

271-RS1632	Anomalous Metal	PSV (ug/L)	Conc. (ug/L)
19-Nov-12	Iron	1400	**13900**
ABV3007	Manganese	43	**9090**

Legend

Notes:
SVOC = Semi-volatile Organic Compounds
Conc. = Concentration
UST = Underground Storage Tank

- Anomalous Metal Detection Above PSVs
- Anomalous Metal Detection below PSVs
- No Metals Data at Location
- Abandoned Overburden Well
- RSA-271 Site Boundary
- Former Underground Storage Tank Location
- Fence

Results in **bold** font are anomalous and above the RSL and BSV.
RSL - EPA Regional Screening Level (May 2020)
BSV - Background Screening Value
µg/L - micrograms per liter

Wells 271-RS1630, 271-RS1631, 271-RS1632, 271-RS2374, 271-RS2375, and 271-RS2622 have been abandoned.

Figure 2-2

RSA-271
Overburden Wells with Anomalous Metals Concentration exceeding RSLs

Redstone Arsenal
Madison County, Alabama

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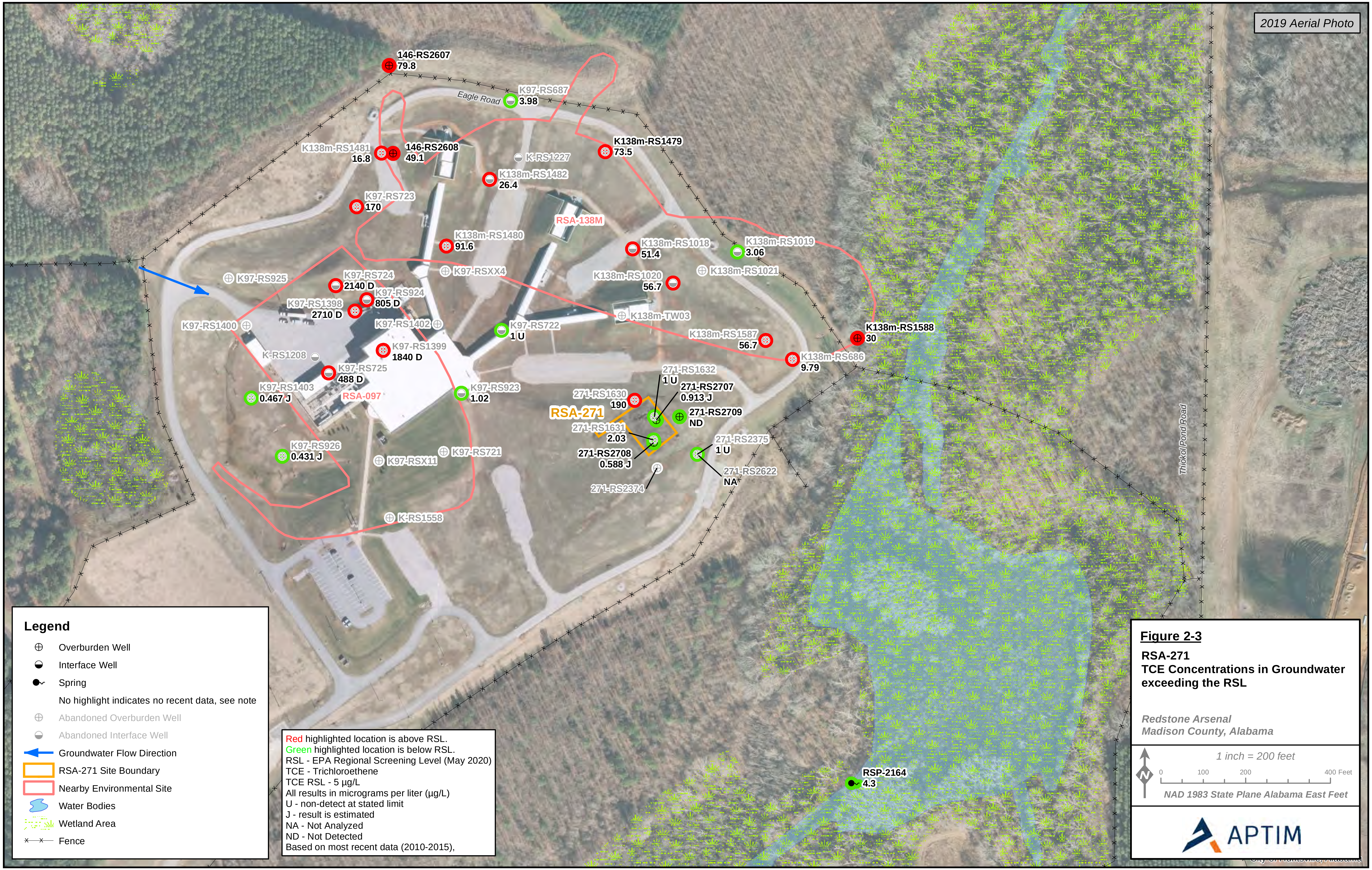

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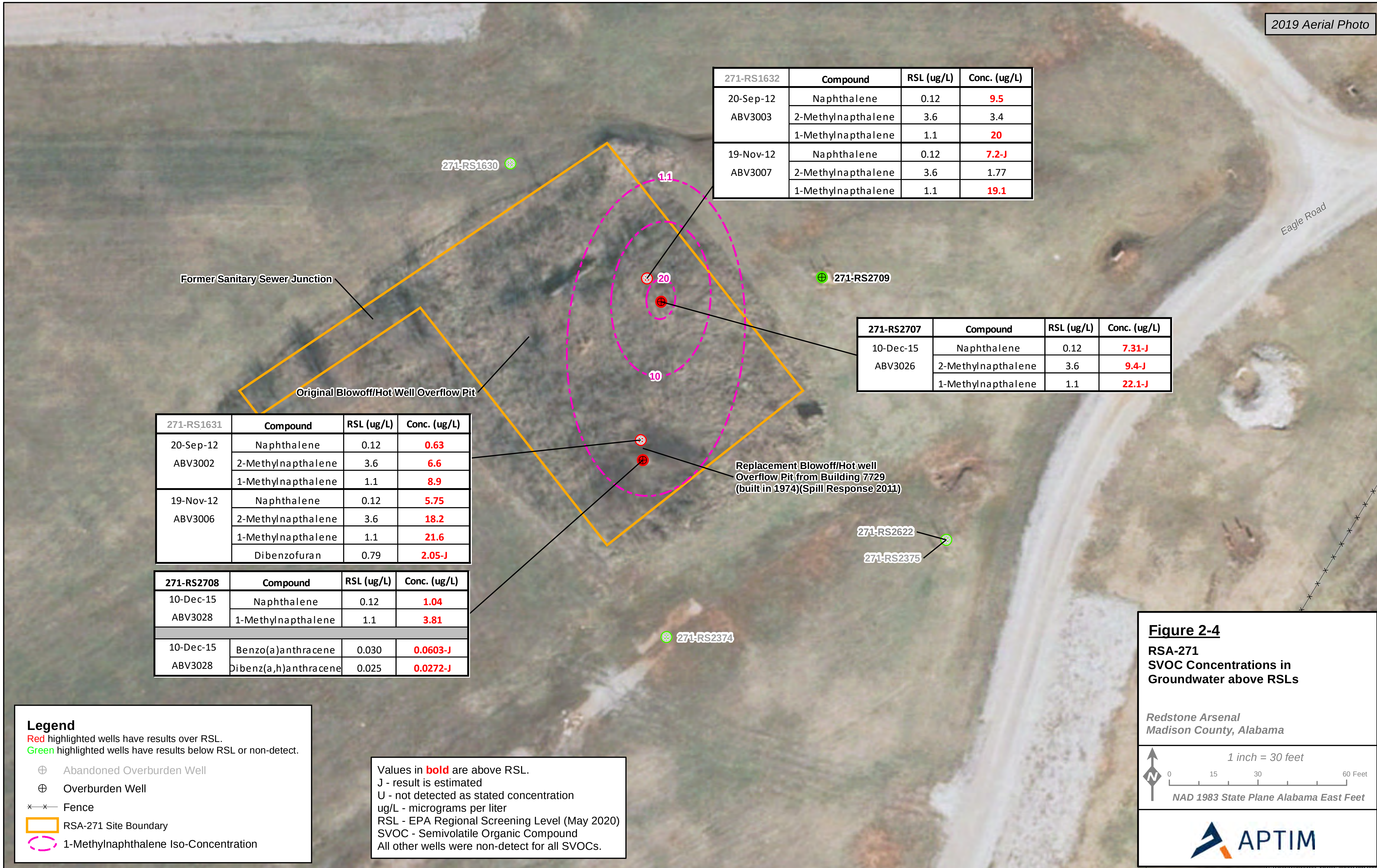

271-RS1632	Compound	RSL (ug/L)	Conc. (ug/L)
20-Sep-12 ABV3003	Naphthalene	0.12	**9.5**
	2-Methylnapthalene	3.6	3.4
	1-Methylnapthalene	1.1	**20**
19-Nov-12 ABV3007	Naphthalene	0.12	**7.2-J**
	2-Methylnapthalene	3.6	1.77
	1-Methylnapthalene	1.1	**19.1**

271-RS2707	Compound	RSL (ug/L)	Conc. (ug/L)
10-Dec-15 ABV3026	Naphthalene	0.12	**7.31-J**
	2-Methylnapthalene	3.6	**9.4-J**
	1-Methylnapthalene	1.1	**22.1-J**

271-RS1631	Compound	RSL (ug/L)	Conc. (ug/L)
20-Sep-12 ABV3002	Naphthalene	0.12	**0.63**
	2-Methylnapthalene	3.6	**6.6**
	1-Methylnapthalene	1.1	**8.9**
19-Nov-12 ABV3006	Naphthalene	0.12	**5.75**
	2-Methylnapthalene	3.6	**18.2**
	1-Methylnapthalene	1.1	**21.6**
	Dibenzofuran	0.79	**2.05-J**

271-RS2708	Compound	RSL (ug/L)	Conc. (ug/L)
10-Dec-15 ABV3028	Naphthalene	0.12	**1.04**
	1-Methylnapthalene	1.1	**3.81**
10-Dec-15 ABV3028	Benzo(a)anthracene	0.030	**0.0603-J**
	Dibenz(a,h)anthracene	0.025	**0.0272-J**

Legend

Red highlighted wells have results over RSL.
Green highlighted wells have results below RSL or non-detect.

- ⊕ Abandoned Overburden Well
- ⊕ Overburden Well
- Fence
- RSA-271 Site Boundary
- 1-Methylnaphthalene Iso-Concentration

Values in **bold** are above RSL.
J - result is estimated
U - not detected as stated concentration
ug/L - micrograms per liter
RSL - EPA Regional Screening Level (May 2020)
SVOC - Semivolatile Organic Compound
All other wells were non-detect for all SVOCs.

Figure 2-4

RSA-271
SVOC Concentrations in Groundwater above RSLs

Redstone Arsenal
Madison County, Alabama

1 inch = 30 feet

0 15 30 60 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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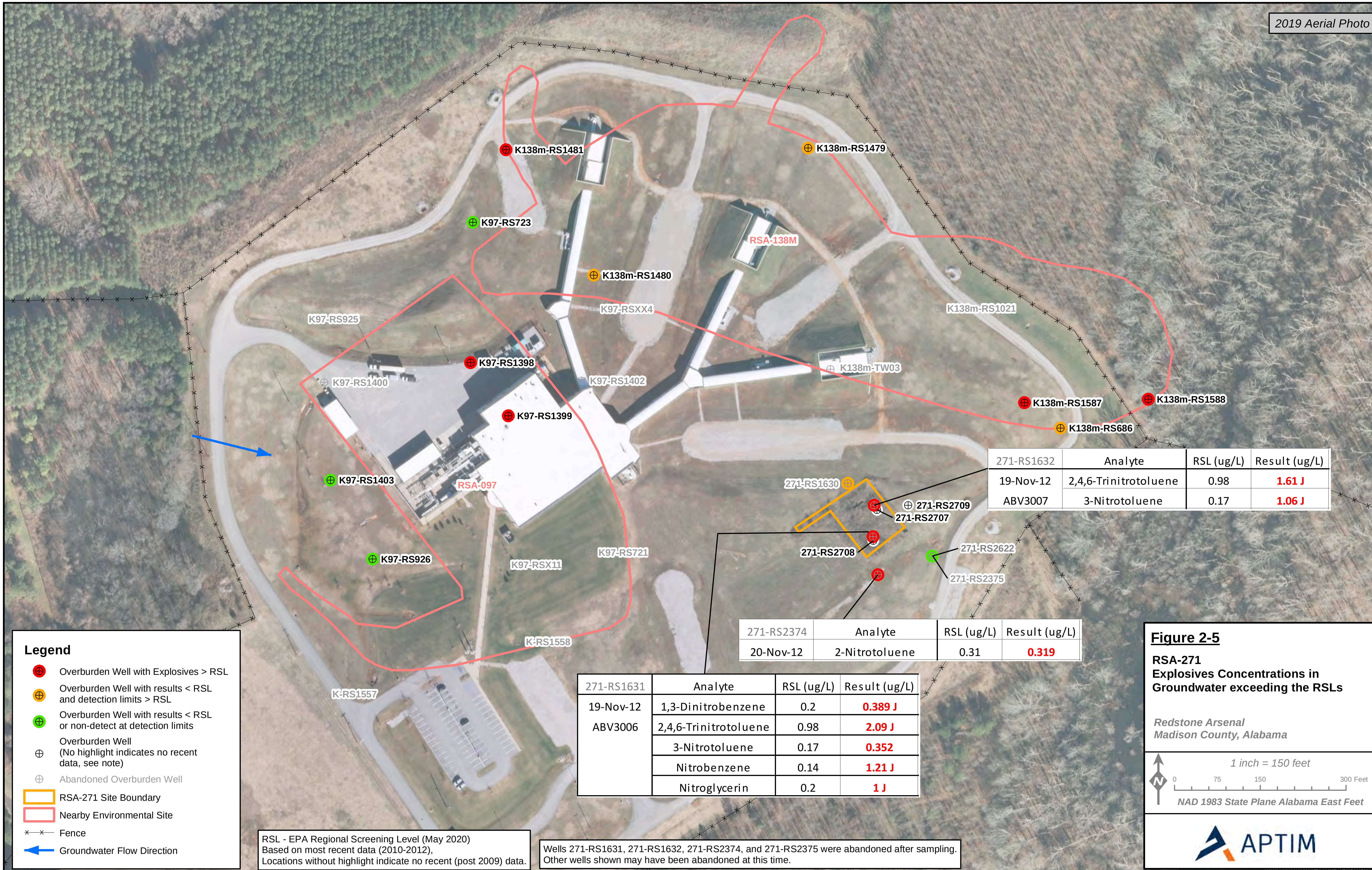


271-RS1632	Analyte	RSL (ug/L)	Result (ug/L)
19-Nov-12	2,4,6-Trinitrotoluene	0.98	**1.61 J**
ABV3007	3-Nitrotoluene	0.17	**1.06 J**

271-RS2374	Analyte	RSL (ug/L)	Result (ug/L)
20-Nov-12	2-Nitrotoluene	0.31	**0.319**

271-RS1631	Analyte	RSL (ug/L)	Result (ug/L)
19-Nov-12	1,3-Dinitrobenzene	0.2	**0.389 J**
ABV3006	2,4,6-Trinitrotoluene	0.98	**2.09 J**
	3-Nitrotoluene	0.17	**0.352**
	Nitrobenzene	0.14	**1.21 J**
	Nitroglycerin	0.2	**1 J**

Legend

- Overburden Well with Explosives > RSL
- Overburden Well with results < RSL and detection limits > RSL
- Overburden Well with results < RSL or non-detect at detection limits
- Overburden Well (No highlight indicates no recent data, see note)
- Abandoned Overburden Well
- RSA-271 Site Boundary
- Nearby Environmental Site
- Fence
- Groundwater Flow Direction

RSL - EPA Regional Screening Level (May 2020)
Based on most recent data (2010-2012),
Locations without highlight indicate no recent (post 2009) data.

Wells 271-RS1631, 271-RS1632, 271-RS2374, and 271-RS2375 were abandoned after sampling.
Other wells shown may have been abandoned at this time.

Figure 2-5

RSA-271
Explosives Concentrations in Groundwater exceeding the RSLs

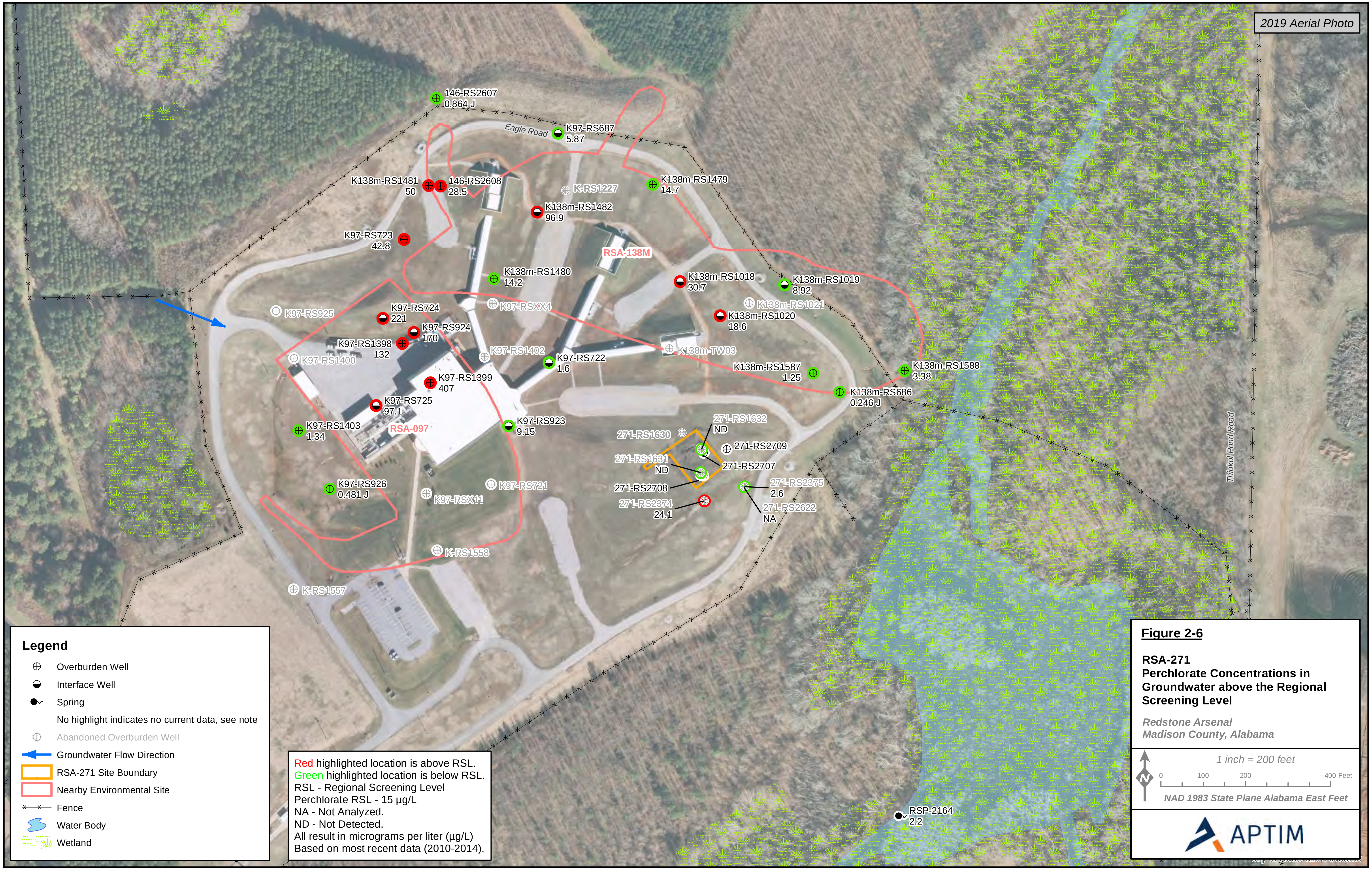
Redstone Arsenal
Madison County, Alabama

1 inch = 150 feet

0 75 150 300 Feet

NAD 1983 State Plane Alabama East Feet

APTIM



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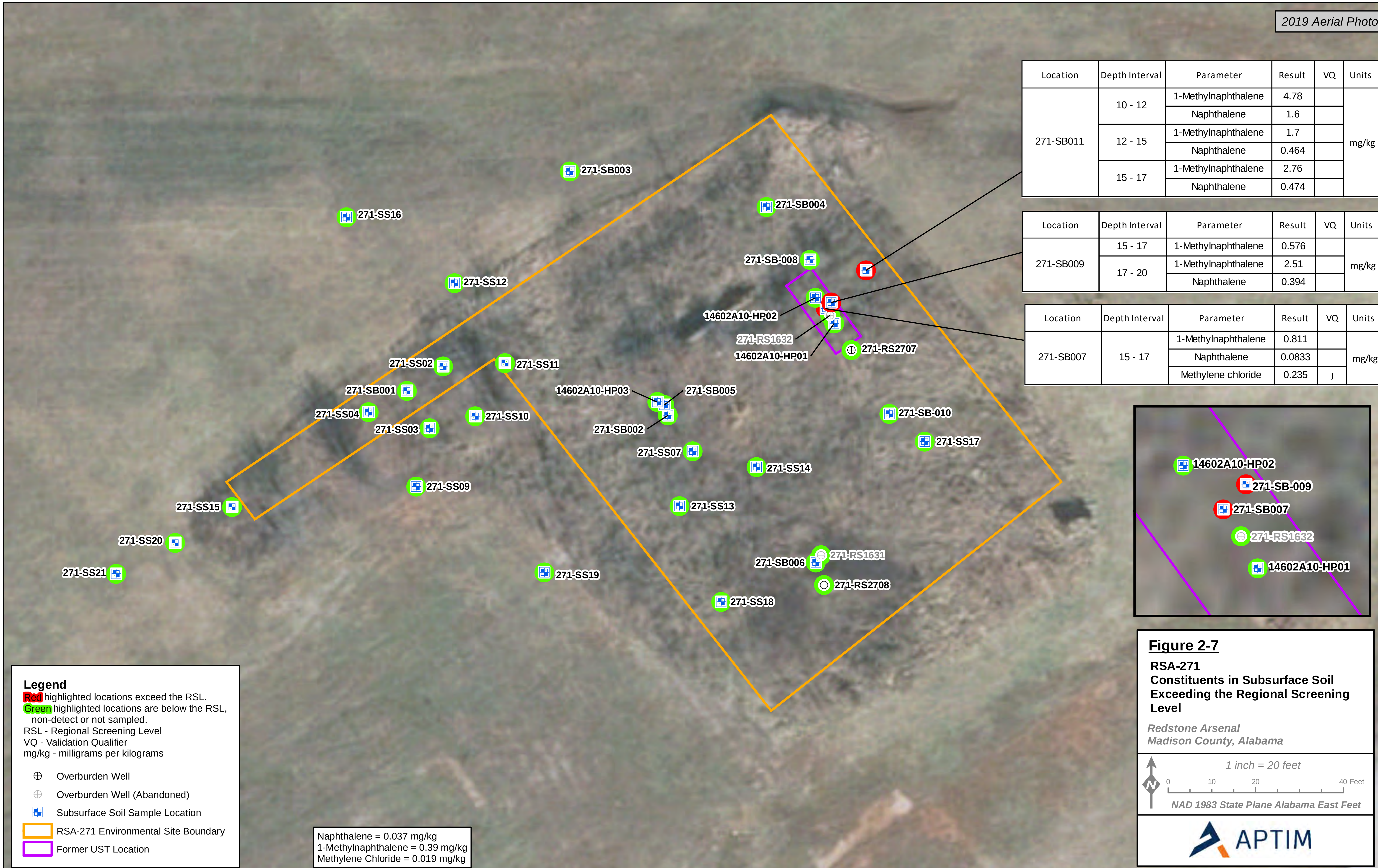

Location	Depth Interval	Parameter	Result	VQ	Units
271-SB011	10 - 12	1-Methylnaphthalene	4.78		mg/kg
		Naphthalene	1.6		
	12 - 15	1-Methylnaphthalene	1.7		
		Naphthalene	0.464		
	15 - 17	1-Methylnaphthalene	2.76		
		Naphthalene	0.474		

Location	Depth Interval	Parameter	Result	VQ	Units
271-SB009	15 - 17	1-Methylnaphthalene	0.576		mg/kg
	17 - 20	1-Methylnaphthalene	2.51		
		Naphthalene	0.394		

Location	Depth Interval	Parameter	Result	VQ	Units
271-SB007	15 - 17	1-Methylnaphthalene	0.811		mg/kg
		Naphthalene	0.0833		
		Methylene chloride	0.235	J	

Legend

Red highlighted locations exceed the RSL.
Green highlighted locations are below the RSL, non-detect or not sampled.
RSL - Regional Screening Level
VQ - Validation Qualifier
mg/kg - milligrams per kilograms

Overburden Well
Overburden Well (Abandoned)
Subsurface Soil Sample Location
RSA-271 Environmental Site Boundary
Former UST Location

Naphthalene = 0.037 mg/kg
1-Methylnaphthalene = 0.39 mg/kg
Methylene Chloride = 0.019 mg/kg

Figure 2-7

RSA-271
Constituents in Subsurface Soil Exceeding the Regional Screening Level

Redstone Arsenal
Madison County, Alabama

APTIM

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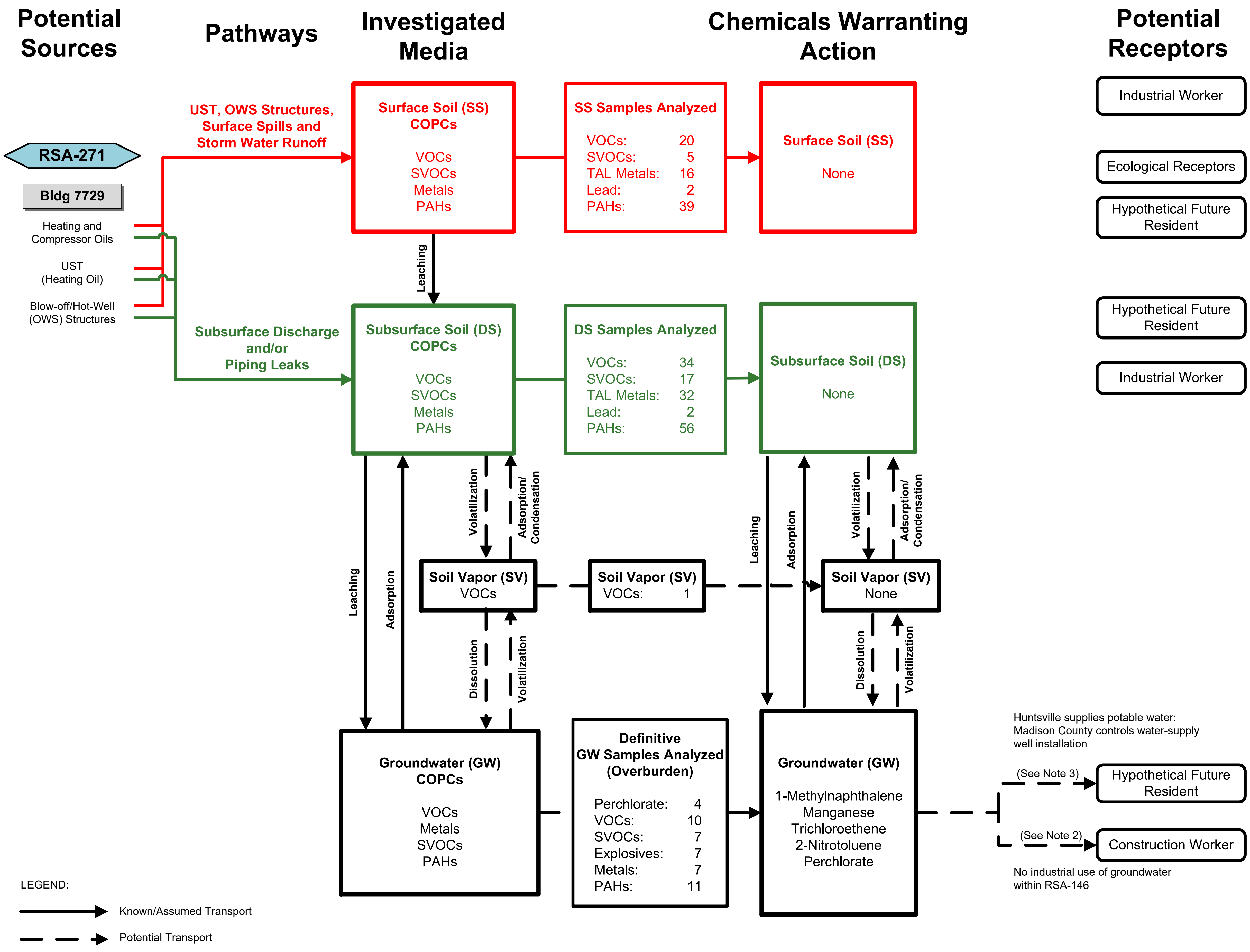

NOTES:

1. The current and anticipated future land use of this area is designated as industrial.
2. At Redstone Arsenal, unmanaged exposure to Installation Restoration Program sites is prevented by the Arsenal's Site Access Control Program. Current and potential future receptors include groundskeeper and construction worker. The residential receptor evaluation will determine if the site is safe for trespassers.
3. The hypothetical residential receptor provides the basis for establishing some remedial responses including justification for the selection of land-use controls. Sites that do not exceed acceptable risk limits for a residential receptor can be released for any use without restriction.
4. Non-fuel related VOCs, perchlorate and explosives were included in the analytical suite for groundwater only because they are in the CSM for the underlying groundwater unit (RSA-146).
5. Samples were analyzed for TCL, VOCs, and SVOCs and TAL metals. Not all chemicals on these standard lists are within the CSM of this site. See the text in Section 2.5 for discussion.

ACRONYMS:

COPCs	Chemicals of Potential Concern
CSM	Conceptual Site Model
MW	Molecular Weight
OWS	Oil Water Separator
PAHs	Polynuclear Aromatic Hydrocarbons
SVOCs	Semivolatile Organic Compounds
TAL	Target Analyte List
TCL	Target Compound List
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds

Common acronyms are listed in the report acronyms list.

Figure 2-8

RSA-271
Conceptual Site Model

Redstone Arsenal
Madison County, Alabama

APTIM

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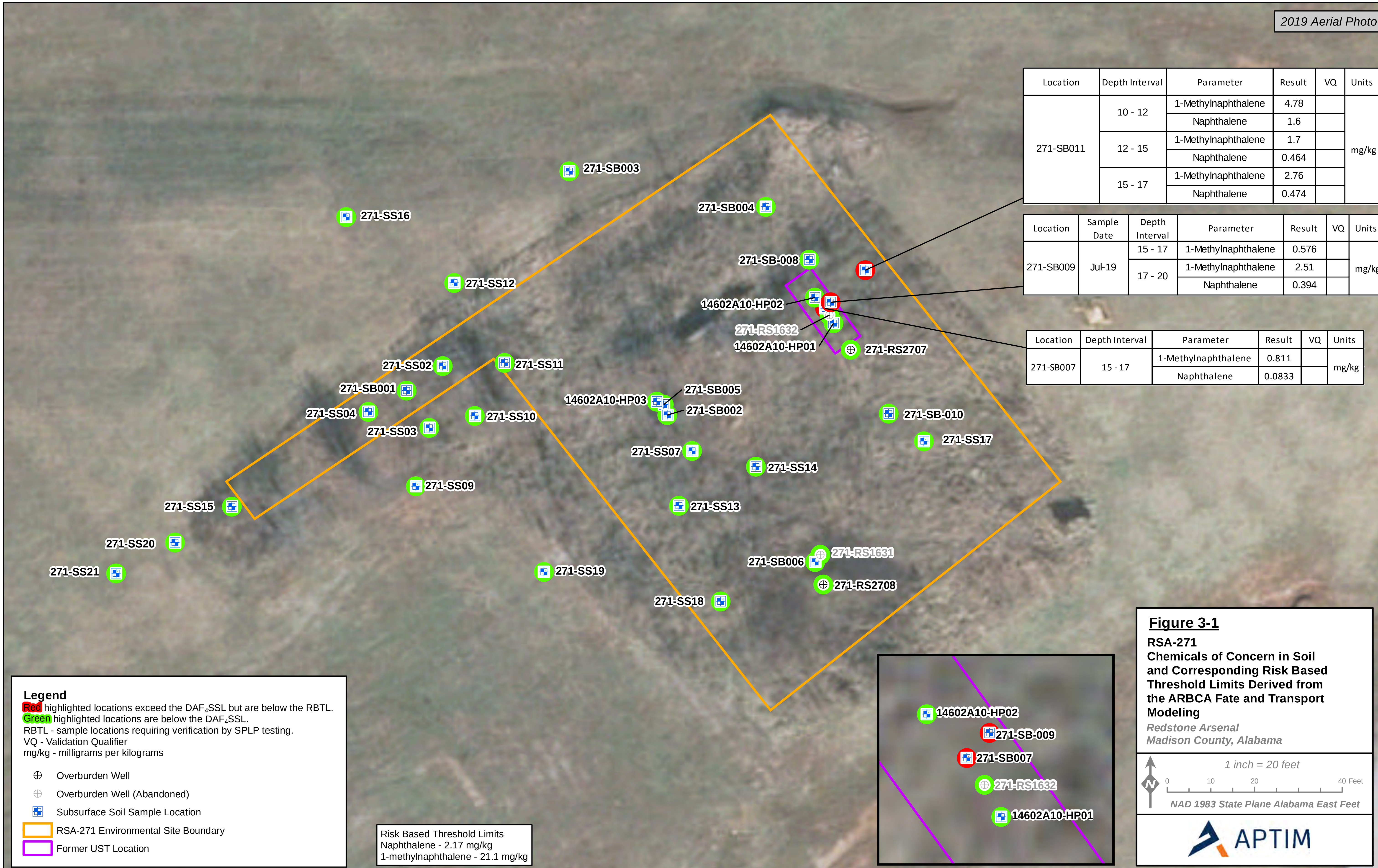
B. Hodges



Location	Depth Interval	Parameter	Result	VQ	Units
271-SB011	10 - 12	1-Methylnaphthalene	4.78		mg/kg
		Naphthalene	1.6		
	12 - 15	1-Methylnaphthalene	1.7		
		Naphthalene	0.464		
	15 - 17	1-Methylnaphthalene	2.76		
		Naphthalene	0.474		

Location	Sample Date	Depth Interval	Parameter	Result	VQ	Units
271-SB009	Jul-19	15 - 17	1-Methylnaphthalene	0.576		mg/kg
		17 - 20	1-Methylnaphthalene	2.51		
			Naphthalene	0.394		

Location	Depth Interval	Parameter	Result	VQ	Units
271-SB007	15 - 17	1-Methylnaphthalene	0.811		mg/kg
		Naphthalene	0.0833		

Legend

Red highlighted locations exceed the DAF_4SSL but are below the RBTL.
Green highlighted locations are below the DAF_4SSL.
RBTL - sample locations requiring verification by SPLP testing.
VQ - Validation Qualifier
mg/kg - milligrams per kilograms

- Overburden Well
- Overburden Well (Abandoned)
- Subsurface Soil Sample Location
- RSA-271 Environmental Site Boundary
- Former UST Location

Risk Based Threshold Limits
Naphthalene - 2.17 mg/kg
1-methylnaphthalene - 21.1 mg/kg

Figure 3-1

RSA-271
Chemicals of Concern in Soil and Corresponding Risk Based Threshold Limits Derived from the ARBCA Fate and Transport Modeling

Redstone Arsenal
Madison County, Alabama

APTIM

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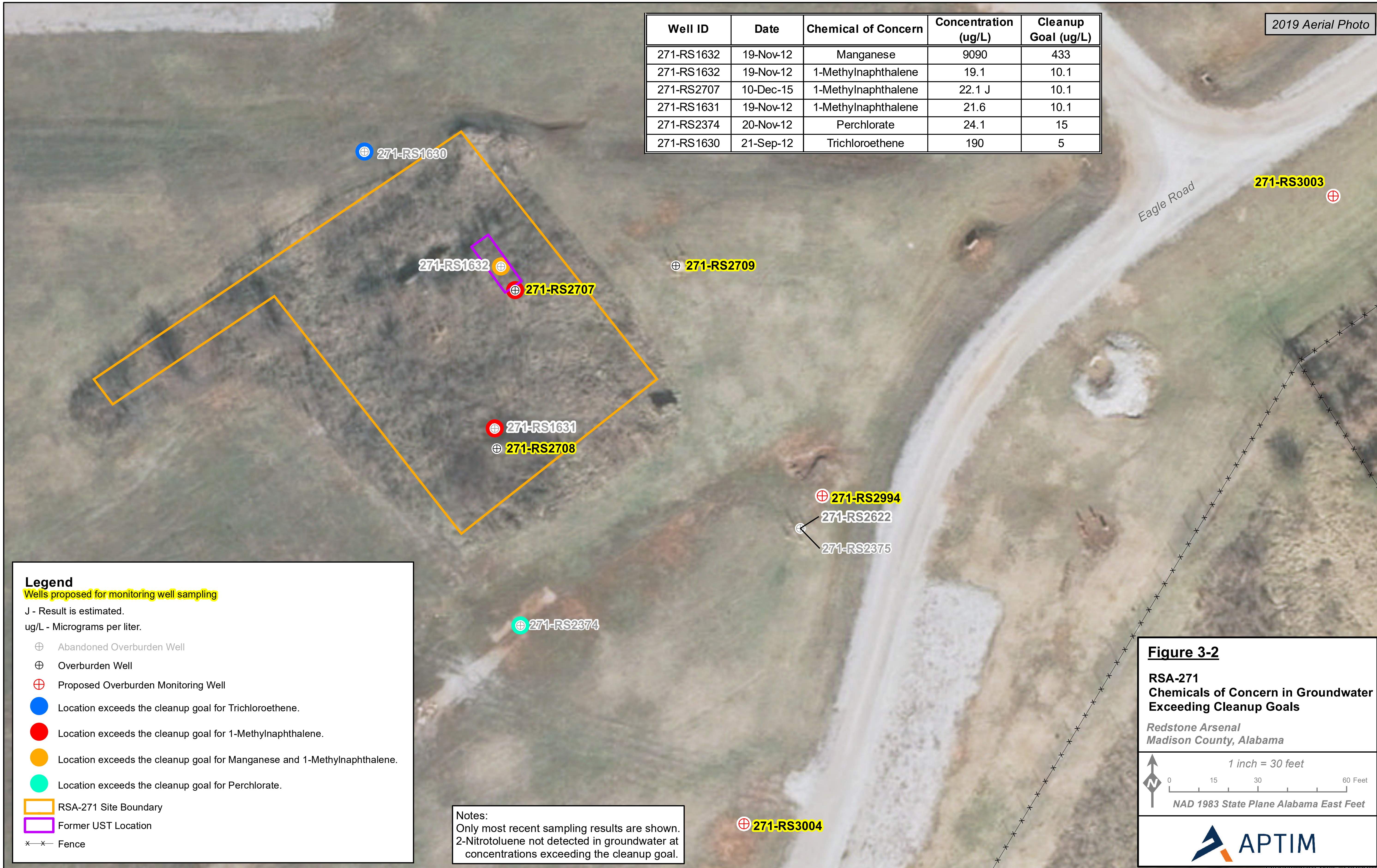


Well ID	Date	Chemical of Concern	Concentration (ug/L)	Cleanup Goal (ug/L)
271-RS1632	19-Nov-12	Manganese	9090	433
271-RS1632	19-Nov-12	1-Methylnaphthalene	19.1	10.1
271-RS2707	10-Dec-15	1-Methylnaphthalene	22.1 J	10.1
271-RS1631	19-Nov-12	1-Methylnaphthalene	21.6	10.1
271-RS2374	20-Nov-12	Perchlorate	24.1	15
271-RS1630	21-Sep-12	Trichloroethene	190	5

Legend

Wells proposed for monitoring well sampling

J - Result is estimated.

ug/L - Micrograms per liter.

- Abandoned Overburden Well
- Overburden Well
- Proposed Overburden Monitoring Well
- Location exceeds the cleanup goal for Trichloroethene.
- Location exceeds the cleanup goal for 1-Methylnaphthalene.
- Location exceeds the cleanup goal for Manganese and 1-Methylnaphthalene.
- Location exceeds the cleanup goal for Perchlorate.
- RSA-271 Site Boundary
- Former UST Location
- Fence

Notes:
Only most recent sampling results are shown.
2-Nitrotoluene not detected in groundwater at concentrations exceeding the cleanup goal.

Figure 3-2

RSA-271
Chemicals of Concern in Groundwater Exceeding Cleanup Goals

Redstone Arsenal
Madison County, Alabama

APTIM

Figure 3-3

Alternative 3 - Attenuation Rate Calculation for 1-Methylnaphthalene in Groundwater (Excavation and MNA)
RSA-271
Redstone Arsenal, Madison County, Alabama

1-Methylnaphthalene Cleanup Goal = 10.1 µg/L

Location	271-RS2707	271-RS2622						Slope	R^2
Distance (ft)	0	115						0.0500	1.0000
Concentration (µg/L)	22.1	1.01						(from graph)	
ln Concentration	3.096	0.010							

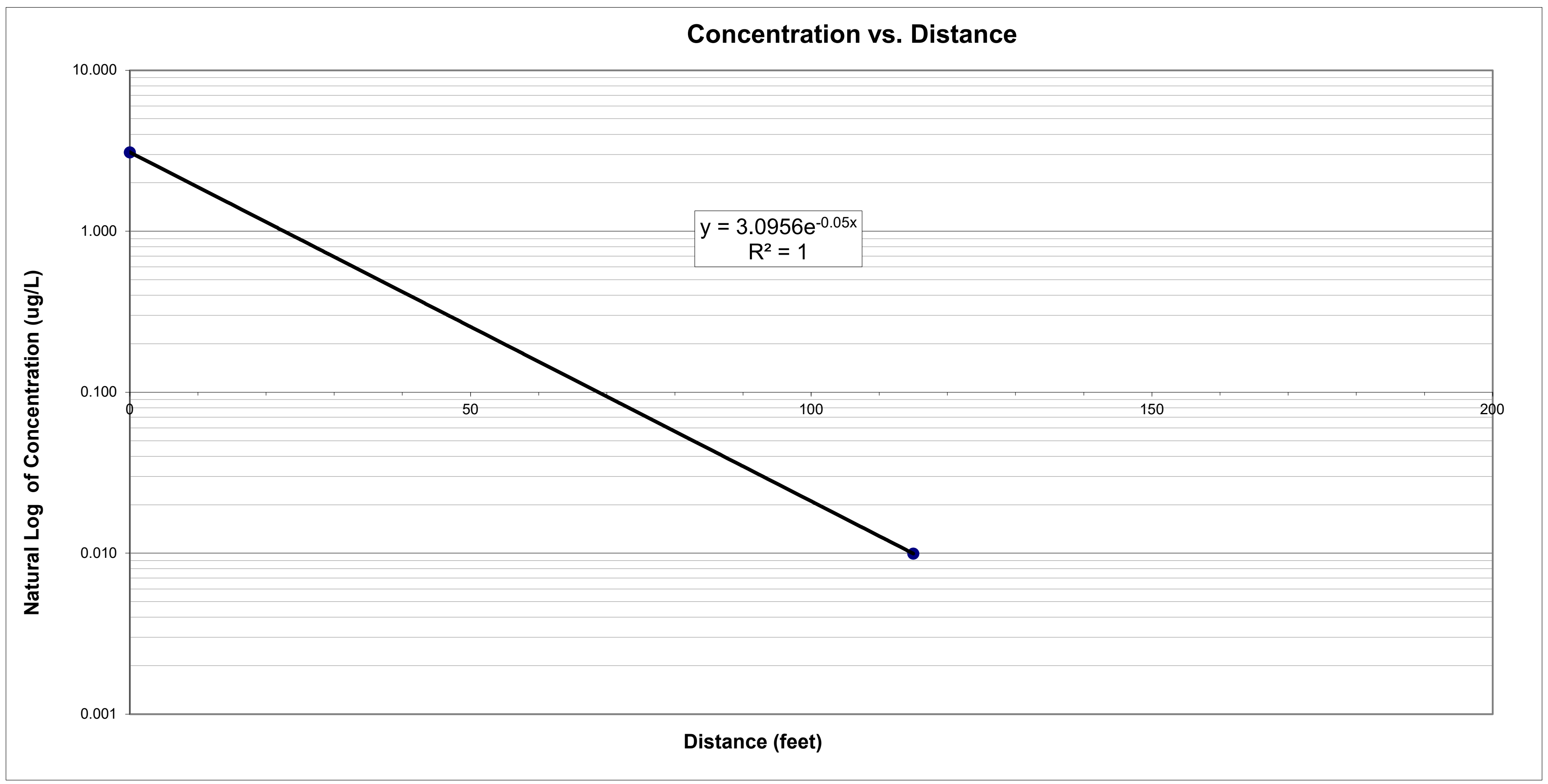
$C_{final} = C_{initial} e^{-kt}$
C_{final} = final concentation at time t (µg/L)
$C_{initial}$ = initial concentration in plume (µg/L)
k = attenuation (1/year) = 0.190
(EPA 1998, Equation C.3.27)
t = time (years)

Hydraulic Conductivity	1.63	ft/day	
Hydraulic Gradient	0.033	ft/ft (RSA-271 value)	
Effective Porosity	0.47	(geometric mean of 17 measurements from RSA-146)	
Groundwater seepage velocity, V_s =	0.116	ft/day	42.2 ft/year
Average apparent groundwater velocity, v =	0.6	ft/year	

Bulk Attenuation Rate

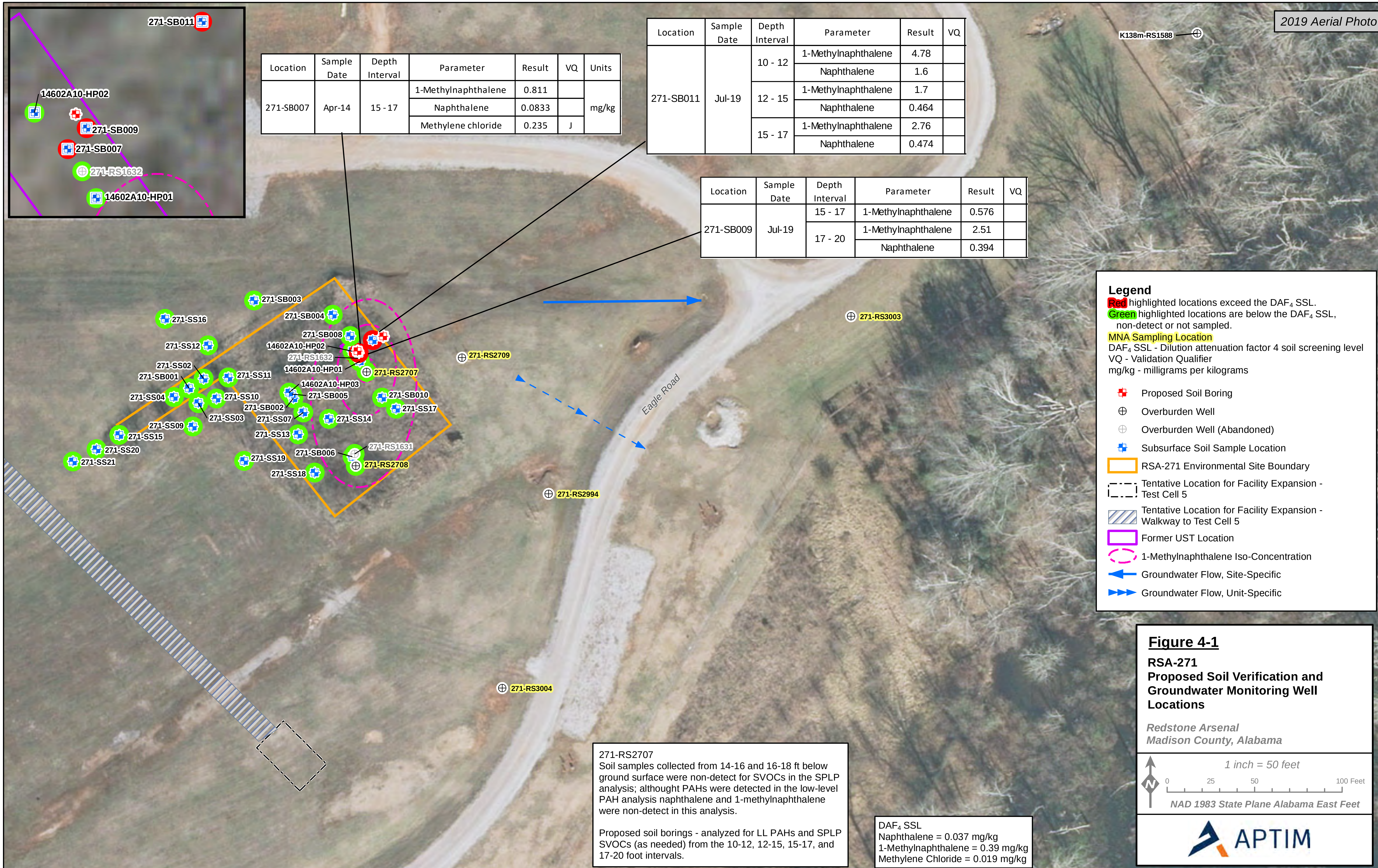
Slope (k/V_s) =	0.0500 /ft
Bulk attenuation rate (k) =	2.110 /year
Half-life =	-0.33 years
Apparent attenuation rate (k) =	0.0316

Leachable fraction of 1-methylnaphthalene in soil excavated in Year 1
Assumed starting concentration = 22.1 ug/L



Date	Time (t) (year)	Modeled Groundwater Concentration (µg/L)	Measured Groundwater Concentration (µg/L)	Time (t) (year)	Modeled Groundwater Concentration (µg/L)
2012	-8	20.0	20.0	21	11.7
	-7	19.4		22	11.4
	-6	18.8		23	11.0
2015	-5	22.1	22.1	24	10.7
	-4	22.1		25	10.3
	-3	22.1		26	10.0
	-2	22.1		27	9.7
2019	-1	22.1		28	9.4
	0	22.1		30	9.1
	1	22.1		30	8.8
	2	21.4		31	8.6
	3	20.7		32	8.3
	4	20.1		33	8.0
	5	19.5		34	7.8
	6	18.9		35	7.5
	7	18.3		36	7.3
	8	17.7		37	7.1
	9	17.2		38	6.9
	10	16.6		39	6.6
	11	16.1		40	6.4
	12	15.6		41	6.2
	13	15.1		42	6.0
	14	14.6		43	5.8
	15	14.2		44	5.7
	16	13.7		45	5.5
	17	13.3		46	5.3
	18	12.9		47	5.2
	19	12.5		48	5.0
	20	12.1		49	4.8

Reference: U.S. Environmental Protection Agency (EPA), 1998, ***Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water***, EPA/600/R-98/128,



Location	Sample Date	Depth Interval	Parameter	Result	VQ	Units
271-SB007	Apr-14	15 - 17	1-Methylnaphthalene	0.811		mg/kg
			Naphthalene	0.0833		
			Methylene chloride	0.235	J	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB011	Jul-19	10 - 12	1-Methylnaphthalene	4.78	
			Naphthalene	1.6	
		12 - 15	1-Methylnaphthalene	1.7	
			Naphthalene	0.464	
		15 - 17	1-Methylnaphthalene	2.76	
			Naphthalene	0.474	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB009	Jul-19	15 - 17	1-Methylnaphthalene	0.576	
		17 - 20	1-Methylnaphthalene	2.51	
			Naphthalene	0.394	

Legend

Red highlighted locations exceed the DAF_4 SSL.
Green highlighted locations are below the DAF_4 SSL, non-detect or not sampled.
MNA Sampling Location
DAF_4 SSL - Dilution attenuation factor 4 soil screening level
VQ - Validation Qualifier
mg/kg - milligrams per kilograms

- Proposed Soil Boring
- Overburden Well
- Overburden Well (Abandoned)
- Subsurface Soil Sample Location
- RSA-271 Environmental Site Boundary
- Tentative Location for Facility Expansion - Test Cell 5
- Tentative Location for Facility Expansion - Walkway to Test Cell 5
- Former UST Location
- 1-Methylnaphthalene Iso-Concentration
- Groundwater Flow, Site-Specific
- Groundwater Flow, Unit-Specific

271-RS2707
Soil samples collected from 14-16 and 16-18 ft below ground surface were non-detect for SVOCs in the SPLP analysis; althought PAHs were detected in the low-level PAH analysis naphthalene and 1-methylnaphthalene were non-detect in this analysis.

Proposed soil borings - analyzed for LL PAHs and SPLP SVOCs (as needed) from the 10-12, 12-15, 15-17, and 17-20 foot intervals.

DAF_4 SSL
Naphthalene = 0.037 mg/kg
1-Methylnaphthalene = 0.39 mg/kg
Methylene Chloride = 0.019 mg/kg

Figure 4-1

RSA-271
Proposed Soil Verification and Groundwater Monitoring Well Locations

Redstone Arsenal
Madison County, Alabama

1 inch = 50 feet
0 25 50 100 Feet
N
NAD 1983 State Plane Alabama East Feet

APTIM

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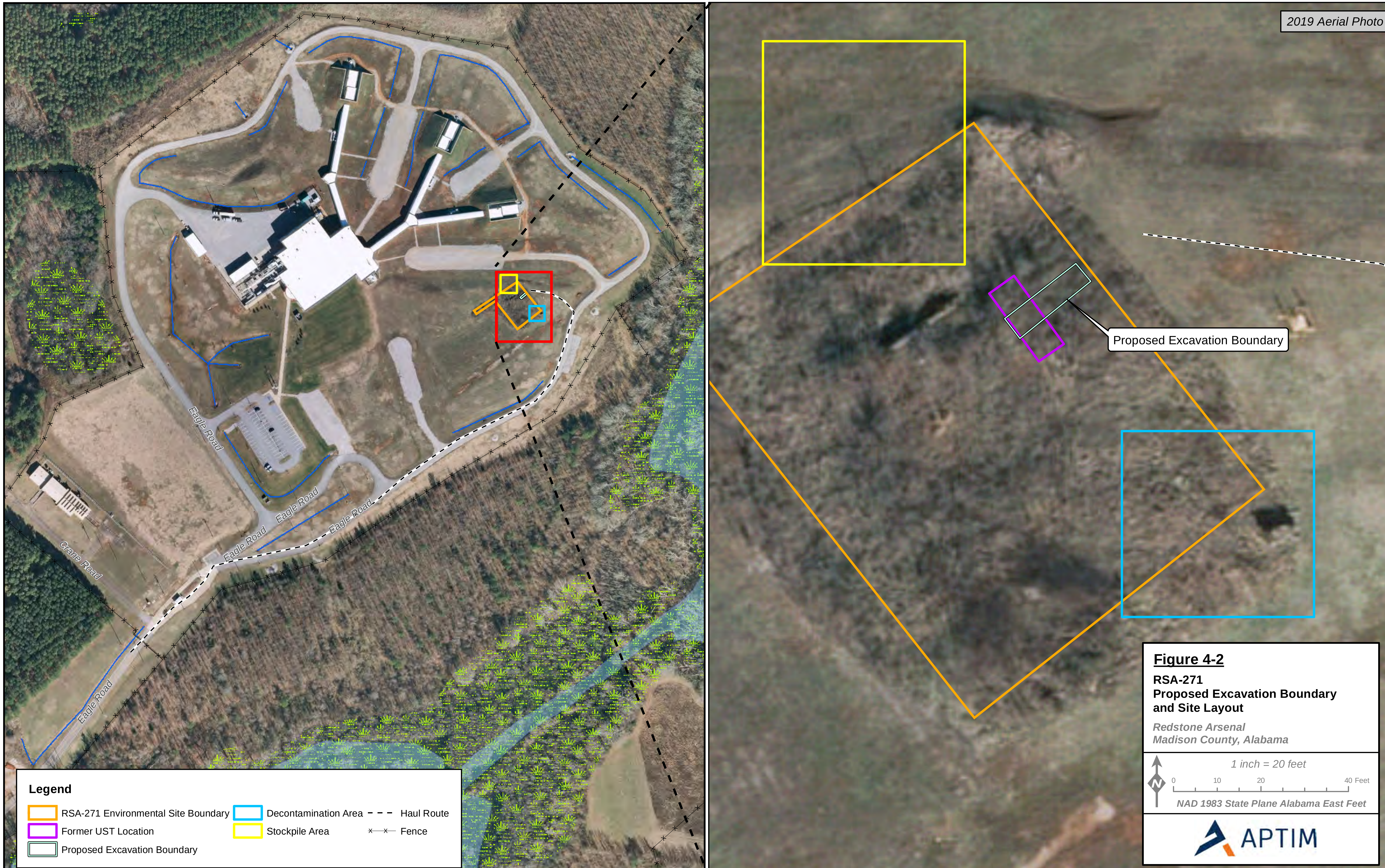

Figure 4-2

RSA-271
Proposed Excavation Boundary and Site Layout

Redstone Arsenal
Madison County, Alabama

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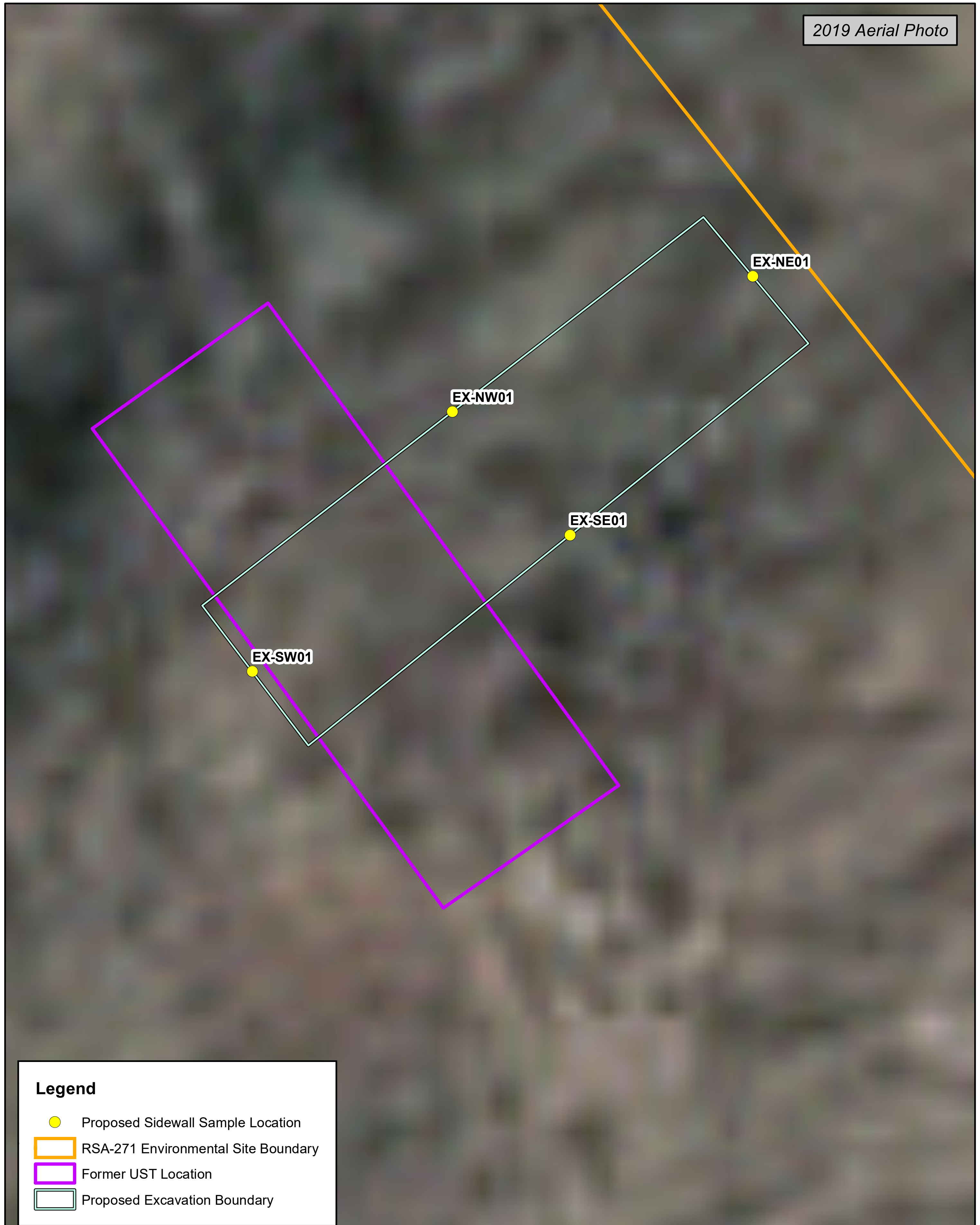

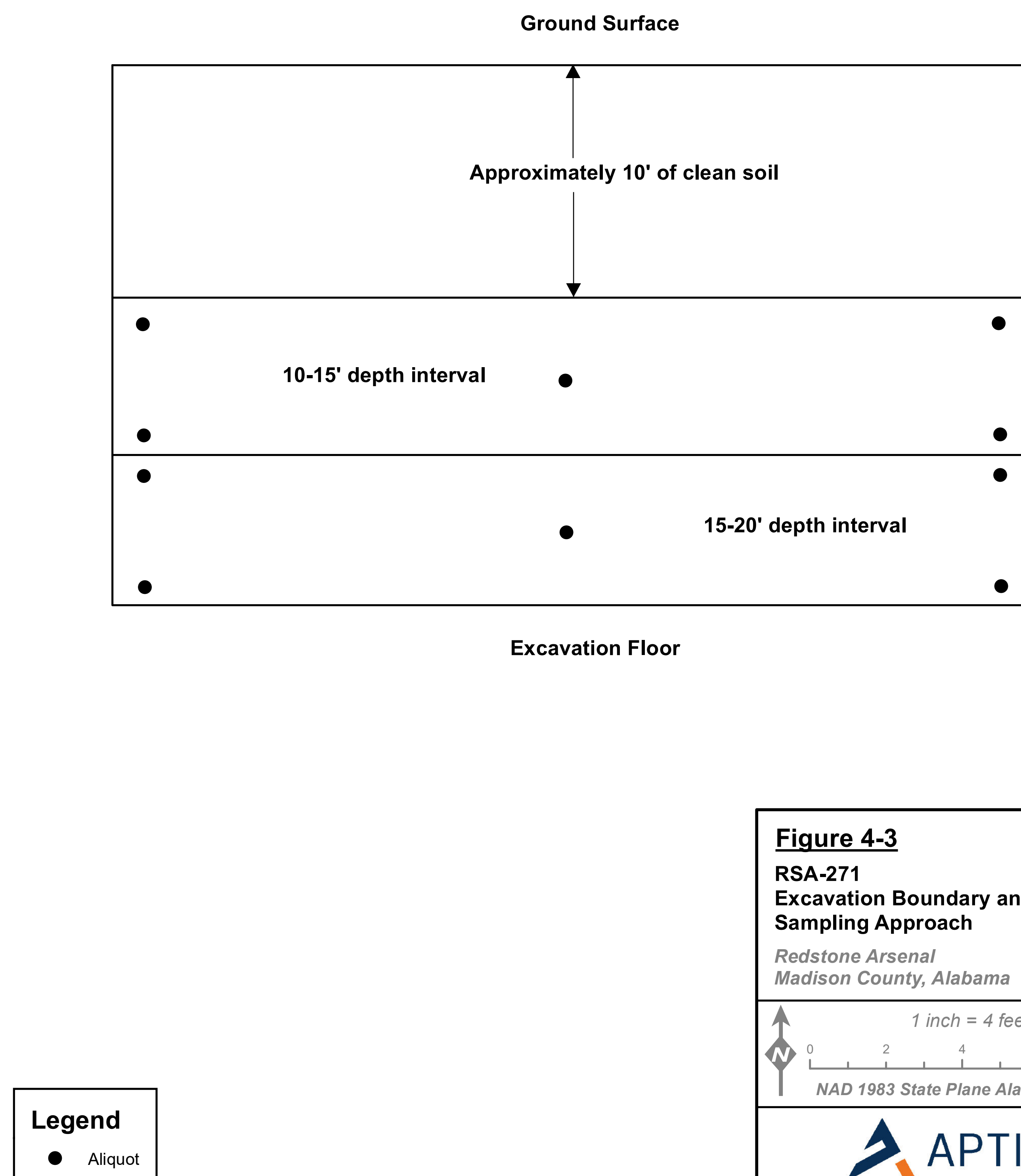

Figure 4-3

RSA-271
Excavation Boundary and Sidewall Sampling Approach

Redstone Arsenal
Madison County, Alabama

1 inch = 4 feet

0 2 4 8 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

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APPENDIX A

REQUEST FOR REDSTONE RCRA PERMIT MODIFICATION

REQUEST FOR PERMIT MODIFICATION FOR
RSA-271, FORMER BOILER HOUSE, BUILDING 7729
U.S. ARMY GARRISON – REDSTONE MADISON COUNTY, ALABAMA
NOVEMBER 2021

A1.0 Introduction

As specified in Section VI.E.3 of the Alabama Department of Environmental Management (ADEM) Resource Conservation and Recovery Act (RCRA) permit, (hereafter referred to as the Permit) (last modified on July 19, 2021 [ADEM, 2021]), a request for permit modification is to be submitted along with a corrective measures implementation (CMI) work plan. The U.S. Army Garrison–Redstone (Army) has been directed to include this request for permit modification in an appendix to the CMI work plan. Therefore, this request for permit modification has been prepared for Solid Waste Management Unit RSA-271, Former Boiler House, Building 7729, Operable Unit 10, at Redstone Arsenal (RSA) in Madison County, Alabama. ADEM has concurred with the RCRA facility investigation (RFI) report prepared for the site, and the Army is ready to implement corrective measures the site.

As part of the RFI report, the Army requested that ADEM move the site from Table VI.2 to Table VI.6 in the Permit and list the site as requiring corrective measures for soil and groundwater. ADEM subsequently moved RSA-271 to Table VI.6 in Permit Modification No. 15 (ADEM, 2020).

This request for permit modification presents the supporting information, including all procedures necessary to implement the corrective measures for RSA-271, in accordance with Alabama Administrative Code R. 335-14-8-.04(2).

A2.0 Facility and Site Description

RSA is located in the southwestern portion of Madison County, which is in the northern portion of Alabama. RSA is a U.S. Army facility that encompasses approximately 38,300 acres and is approximately 10 miles long from north to south and 6 miles wide from east to west. The Army controls 36,459 acres of the total acreage, of which approximately 15,500 acres are woodlands, 5,360 acres are leased for agricultural use, and approximately 12,000 acres are managed as military test areas/ranges.

RSA-271 occupies approximately 0.25 acre and is situated in the southeastern part of the Missile Production Complex located in the southeastern quadrant of RSA, between Huntsville Spring Branch and the Tennessee River. RSA records indicate that Building 7729 was constructed as Army Building B-529 in 1942. Initially, the building housed a steam boiler fueled from a 2,800-gallon underground storage tank (UST) formerly located east of the building. A small oil/water separator (OWS) consisting of a blow-off/hot well pit was located at the west end of Building 7729. RSA records indicate that this system was removed from use but left in place, and a larger, high-capacity blow-off/hot well was installed south of Building 7729 in 1974. The junction of both OWS systems with the sanitary sewer system was located northwest of the building. The building was demolished sometime between 1996 and 2000.

A3.0 Investigative History

Environmental investigations were initiated at RSA-271 in 1996 to determine if and to what extent historical site operations had impacted the environment. The investigations included the following:

- Phase I and II Environmental Baseline Surveys at the Redstone Arsenal Rocket Engine North Plant Area (Conestoga-Rovers & Associates, 1996; CH2M Hill, 1998)
- RSA-146 Potential Source Area Investigation (Shaw Environmental, Inc. [Shaw], 2005)
- In Situ Waste Characterization Sampling (Shaw, 2010a)
- Post-Release Response Investigation Sampling (Shaw, 2011a)
- RSA-271 RFI Sampling (Shaw, 2011b,c, 2012a,b, 2013; CB&I Federal Services LLC [CB&I], 2014, 2015a, Aptim Federal Services, LLC [APTIM], 2020a).

A complete discussion of the investigations at RSA-271 is available in the RSA-271 RFI report (APTIM, 2020a). The report received ADEM concurrence on April 16, 2020. Based on the conclusions of the RFI (APTIM, 2020a) and ADEM concurrence, RSA-271 was moved from Table VI.2 to Table VI.6 in the Permit and listed as requiring corrective measures to be performed for soil and groundwater.

A4.0 Scope of the Corrective Measures

The overall strategy for cleanup at RSA has been presented to the regulatory agencies in two cleanup strategy documents, the *Installation-Wide Groundwater Cleanup Strategy* (Shaw, 2009a) and the *Installation-Wide Strategy for Cleanup of Impacted Wetlands* (Shaw, 2010b). The scope of the corrective measures for RSA-271 is consistent with these strategies.

The corrective measure at RSA-271 is directed towards the soil and groundwater contamination at the site. Exposure to soil does not present an unacceptable health threat to industrial or hypothetical future resident receptors or to ecological receptors. However, the RFI concluded that 1-methylnaphthalene, methylene chloride, and naphthalene in soil pose a potential leaching threat to groundwater. A weight-of-evidence approach has been used to evaluate the single detection of methylene chloride in soil present at a concentration greater than its dilution-attenuation factor 4 (DAF_4) soil screening level (SSL). Based on this evaluation, methylene chloride is determined to not pose a leaching threat.

For 1-methylnaphthlene and naphthalene, an Alabama Risk-Based Corrective Action (ARBCA) Risk Management-2 fate and transport evaluation was performed for the RSA-271 site. This evaluation included modeling to determine if an action is needed for the small volume of soil around the former underground storage tank pit with concentrations of 1-methylnaphthlene and naphthalene that exceeded the RSA generic DAF_4 SSLs. The modeling concluded that concentrations of 1-methylnaphthlene and naphthalene in soil do not pose a threat to groundwater quality. However, it was determined the modeling requires field verification. Therefore, soil verification samples will be collected as part of the corrective measures for RSA-271 and subjected to synthetic precipitation leaching procedure testing to determine the need for a soil action. Soil excavation is included in this CMIP until field verification testing determines whether the soil action is necessary.

The contaminants in groundwater would pose unacceptable risk to potable users now or in the future. Potable groundwater use is currently restricted by the installation-wide groundwater interim record of decision (IROD) (Shaw, 2007) and the site access control program (Army, 2012). No contaminants pose an unacceptable health threat via the vapor intrusion pathway to occupants of future buildings (APTIM, 2020a).

The Army has elected to perform the following corrective measures to address groundwater contamination:

- Excavate deep soil (10 to 20 feet below ground surface) contaminated with 1-methylnaphthalene and naphthalene and dispose of off-site in a permitted disposal facility.

- Place a layer of oxygen release compound in the bottom of the excavation to enhance monitored natural attenuation (MNA) in the source area

- Use MNA to track the reduction of all chemicals of concern (COC) for action and monitoring in overburden groundwater.

- The land-use controls (LUC) for groundwater will be implemented for RSA-271 until cleanup goals (CG) are attained for COCs requiring action at RSA-271.

- Implement a MNA program until all COCs requiring action have attained CGs for three consecutive years. At that time, the Army will request a permit modification to remove the LUCs and cease the MNA program.

A5.0 Site Characteristics

This chapter is a summary of the site characteristics and conceptual site model (CSM) for RSA-271.

RSA-271 occupies approximately 0.25 acre in the southeastern portion of the Missile Production Complex and is situated about 100 feet northwest of Eagle Road and approximately 300 feet southeast of newly constructed Building 07745. There are no remaining legacy buildings or structures within the site (CMIP, Figure 1-2), which is covered primarily in grasses. The topography within RSA-271 consists of flat open scrub or grassland. The site is surrounded by graded areas and buildings associated with the Missile Production Complex. A large wetland/pond is located across Eagle Road and approximately 500 feet south and east of the site.

Overall, topographic relief in this area of RSA is subdued due to grading and use of engineered fill to level the building sites, provide drainage, and raise building foundations as necessary to prevent flooding of the buildings and roads. Elevation at RSA-271 ranges from approximately 582 to approximately 586 feet above mean sea level. The entire site lies outside the 100-year floodplain.

The thickness of the overburden at the site ranges from 31.8 feet to 56 feet below ground surface (bgs). RSA-271 is located within the boundaries of the larger RSA-146 groundwater unit. Based on groundwater elevations in the overburden wells in November 2012 (RFI Report Figure 1-3), overburden groundwater appears to flow primarily to the southeast. Depth to groundwater in overburden wells at RSA-271 fluctuates seasonally and ranged from 13.4 feet to a maximum 20.3 feet bgs, with an average depth to groundwater of 17.7 feet bgs (when discounting suspect data) (APTIM, 2020a).

The primary sources of contamination investigated at RSA-271 included in the CSM were related to potential spills and subsurface discharge (e.g., UST, oil/water separator structures, piping and/or sewer leaks) from historical equipment at former Building 7729 (e.g., UST, OWS, boiler system).

A6.0 Investigative Results

This chapter is a summary of the investigative results, including evaluations of fate and transport for RSA-271.

The RFI risk evaluations determined that concentrations of constituents in soil do not pose a potential threat to human health receptors or ecological receptors that inhabit this site. However, the human health risk evaluation determined that manganese, 1-methylnaphthalene, trichloroethene (TCE), 2-nitrotoluene, and perchlorate present an unacceptable health threat to commercial and industrial workers and/or a future hypothetical resident if the groundwater is developed as a potable source.

The primary contaminant migration mechanism that operated at the RSA-271 site is the leaching of site-related chemicals from soil to soil pore water (leachate) and subsequent transport to the water table as a result of the downward percolation of infiltrating rainfall. The RFI evaluation identified 1-methylnaphthalene and methylene chloride in one subsurface soil sample and naphthalene in two subsurface soil samples at concentrations above the RSA-specific DAF_4 SSL. However, no surface soil detections exceeded their respective leachate-based SSLs. No other constituents in soil were determined to pose a potential leaching threat to groundwater.

A7.0 Land and Resources Use

A7.1 Land Use

Land use at RSA-271 is designated as industrial in the RSA Master Plan.

A7.2 Current Groundwater Use

Groundwater under RSA is not currently used for any potable uses. RSA's installation-wide groundwater IROD (Shaw, 2007) and LUC remedial design (Shaw, 2009b) and the Army's site access control program (Army, 2012) prevent the current use of groundwater for potable purposes and ensure that any nonpotable uses of groundwater are reviewed and evaluated by the Army prior to being permitted.

A7.3 Future Groundwater Use

The proposed selected corrective measures for RSA-271 soil and groundwater are expected to achieve CGs over time, and future use of groundwater under the site would be possible. However, under the provisions of the Army's installation-wide groundwater IROD (Shaw, 2007) and the Army's site access control program (Army, 2012) and a site-specific LUC to be implemented for RSA-271, future groundwater resources beneath RSA-271 and elsewhere on RSA may not be developed for potable purposes, and groundwater withdrawals for nonpotable uses must be managed until remedies are selected in the final decision documents for the various groundwater units within RSA. In the meantime, as part of the Permit, ADEM has required that the Army perform annual monitoring of wells located within the RSA perimeter (ADEM, 2020). This annual monitoring will allow the Army and ADEM both to assess the rate of long-term groundwater recovery and ensure protection for residents living outside of the boundary of RSA (CB&I, 2015b).

A8.0 Site Risks

An ARBCA human health evaluation and screening-level ecological risk assessment (SLERA) were performed for RSA-271 (APTIM, 2020a). The site risks are summarized in this chapter.

A8.1 Human Health Risk

The ARBCA human health evaluation concluded that no chemicals in soils require further action before the site can be released for either commercial/industrial or residential use based on the risk associated with direct exposure pathways. Further evaluation (modeling and weight-of-evidence evaluation) determined that 1-methylnaphthalene, methylene chloride, and naphthalene do not pose a leaching threat to groundwater (see Section 2.3.3 and Appendix G of the CMIP). The ARBCA evaluation concluded that manganese, TCE, 1-methylnaphthalene, 2-nitrotoluene, and perchlorate are relevant COCs in groundwater.

A8.2 Vapor Intrusion

A screening-level vapor intrusion evaluation was conducted at the site to identify the potential for risk in future buildings from exposure to indoor air vapors originating from VOC contamination in soil or groundwater. The screening-level evaluations showed that no contaminants in groundwater pose an unacceptable health threat to occupants of existing or future buildings at the site.

A8.3 Ecological Risk

A SLERA was conducted to evaluate the potential for ecological risks posed by site-related chemicals at RSA-271 (APTIM, 2020a). Chemicals of potential ecological concern (COPEC) were identified in surface soil at the site through consideration of background and ecological screening values. Site-related constituents in surface soil were subjected to a COPEC refinement process, which examined a number of lines of evidence in order to determine whether site-related constituents have the potential to pose hazards to ecological receptors. The SLERA concluded that exposure to surface soil is unlikely to pose hazards to ecological receptors and that further evaluation of ecological hazards is not warranted at RSA-271.

A9.0 Objectives of the Corrective Measures and Cleanup Goals

The RFI (APTIM, 2020a) defined the nature and extent of contamination and evaluated potential risks to current and future receptors and concluded that no further action for soil is required. In the ARBCA evaluation, no chemicals in soil were identified as relevant COCs warranting further action. The SLERA concluded that constituents in surface soil at RSA-271 do not pose hazards to ecological receptors. The RFI also concluded that future potable use of groundwater at RSA-271 could pose a potential risk to human health due to the concentrations of manganese, TCE, 1-methylnaphthalene, 2-nitrotoluene, and perchlorate in groundwater. No contaminants pose an unacceptable health threat via the vapor intrusion pathway to occupants of future buildings (APTIM, 2020a).

Based on the results of the RFI, the corrective measure objective (CMO) for RSA-271 is as follows:

- Prevent human exposure via any exposure route (ingestion, inhalation, or dermal contact) to groundwater contaminated with any of the COCs (manganese, 1-methylnaphthalene, TCE, 2-nitrotoluene, and perchlorate) at concentrations that exceed their groundwater CGs.
- Ensure that soil concentration of 1-methylnaphthalene and naphthalene are not posing a threat to groundwater beyond the established point of exposure (well location 271-RS2622).

These objectives will protect current and future human health and the environment from exposure to contaminated media at RSA-271.

Corrective measure CGs are established to protect human health and the environment while also meeting applicable regulations for alternatives that rely on concentration reduction. The identification of CGs must consider the environmental issues at the site and the receptors that are affected. The U.S. Environmental Protection Agency (EPA) National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations §300.430[3][B] and [C]) identifies $1x10^{-6}$ as a level at or below which cancer risk is considered to be minimal. Levels from $1x10^{-6}$ to $1x10^{-4}$ represent a risk management range within which cancer risks may or may not be subjected to further action. Cancer risk levels above $1x10^{-4}$ are generally considered to be unacceptable and require further action. The Army has adopted the EPA perspective on cancer risk as expressed in the National Contingency Plan. ADEM (2017), however, considers a total individual excess lifetime cancer risk of $1x10^{-5}$ as the trigger level at which risk-based target levels must be developed to guide site management. The CGs for RSA-271 were calculated in light of the ADEM guidance.

The development of corrective measures was warranted for manganese, 1-methylnaphthalene, 2-nitrotoluene, perchlorate, and TCE in groundwater and 1-methylnaphthalene and naphthalene in soil. A limited soil excavation will be completed if verification soil sampling indicates 1-methylnaphthalene and naphthalene are capable of leaching out of the soil at concentrations which will degrade water quality. .Additionally, a number of COCs in groundwater did not pose unacceptable risk to potential receptors but exceed preliminary screening values during the RFI and will be included in groundwater monitoring program until it can be demonstrated in annual reports not to pose a concern (i.e., concentration less than the current ADEM regional screening level [RSL]).

For COCs requiring action with maximum contaminant levels (MCL), the MCLs are selected as the CGs. For the other groundwater COCs requiring action, the CGs are based on risk, with the objective of achieving a cumulative cancer risk of 1E-05 and a cumulative hazard index of 1 or less.

The COCs that require an action and those that are for monitoring for RSA-271 and the Army's plan for addressing these COCs are summarized in the following table:

Solid Waste Management Unit	Chemicals of Concern Requiring Action in Vadose Zone Soil	Chemicals of Concern Requiring Action in Groundwater	Chemicals of Concern for Monitoring in Groundwater	SWMU Responsible for Groundwater Action
RSA-271	Failing residential risk: None Failing industrial risk: None Exhibiting a leaching to groundwater concern: Possibly 1-methylnaphthalene, naphthalene at source*/None at point of exposure Exhibiting a potential soil vapor concern: None	1-Methylnaphtalene 2-Nitrotoluene TCE Perchlorate Manganese	3-Nitrotoluene 2,4,6-Trinitrotoluene 1,3-Dinitrobenzene Nitrobenzene Nitroglycerin Naphthalene 2-Amino-4,6-dinitrotoluene 4-Amino-2,6-dinitrotoluene 2-Methlynaphthalene Benzo(a)anthracene Dibenz(a,h)anthracene Dibenzofuran Degradation Parameters 1,1-Dichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene Vinyl chloride	RSA-271

'* To be confirmed through SPLP testing during corrective measures.

The Army intends to clean up the groundwater contamination at RSA-271. The following CGs have been set to achieve the CMOs for soil:

Parameter	Site-Specific RBTL (milligrams per kilogram)	Maximum Soil Concentration (milligrams per kilogram)	Result
Naphthalene	2.17	1.6	MDC is less than the site-specific SSL
1-Methylnaphthalene	21.1	4.78	MDC is less than the site-specific SSL

The Army intends to clean up the groundwater contamination at RSA-271. The following CGs have been set to achieve the CMOs for groundwater:

Chemical of Concern	CG (μg/L)	Basis for CG
Manganese	433	Risk[a]
1-Methylnaphthalene	10.1	Risk[a]
2-Nitrotoluene	3.13	Risk[a]
Perchlorate	15	Health Advisory Level[b]
TCE	5	MCL

[a]CG based on hypothetical future use of groundwater for potable purposes and 1E-05 cancer risk.
[b]CG based on the Interim Drinking Water Health Advisory level of 15 μg/L (U.S. Department of Defense, 2009).
μg/L – Micrograms per liter.

Degradation products for TCE in groundwater will also be monitored. The following monitoring acceptance goals (MAG) have been established for the following common degradation products for the site COC TCE.

Medium	Degradation Product	MAG (μg/L)	Basis for MAG
Groundwater	1,1,Dichloroethene	7	MCL
Groundwater	cis-1,2-Dichloroethene	70	MCL
Groundwater	trans-1,2-Dichloroethene	100	MCL
Groundwater	Vinyl chloride	2	MCL

The following MAGs have been established for COCs for monitoring.

Unit	Monitoring Parameter	MAG[a]
RSA-271	Benzo(a)anthracene	RSL
	Dibenz(a,h)anthracene	RSL
	Dibenzofuran	RSL
	1,3-Dinitrobenzene	RSL
	2-Methlynaphthalene	RSL
	Naphthalene	RSL
	Nitrobenzene	RSL
	Nitroglycerin	RSL
	3-Nitrotoluene	RSL
	2-Amino-4,6-dinitrotoluene	RSL
	4-Amino-2,6-dinitrotoluene	RSL
	2,4,6-Trinitrotoluene	RSL

[a]The MCL was selected as the MAG, if available. The most recent RSL for tap water (hazard quotient of 0.1) will be selected as the MAG for chemicals with no MCL.
[b]The MCL was selected as the MAG.

Each COC for monitoring only will be monitored on the same schedule as COCs for action until it attains its MAG for three consecutive years or monitoring is no longer necessary for any COC for action, whichever comes first.

A10.0 Description and Comparison of Alternatives

A technology screening was performed to evaluate a number of corrective measures that are potentially applicable to the contaminated groundwater at RSA-271, including no action, LUCs, and MNA (APTIM, 2020b). The feasible technologies were packaged into three corrective measure alternatives and further evaluated against 11 evaluation criteria.

The following corrective measure alternatives for were evaluated for RSA-271:

- Alternative 1 – No Action
- Alternative 2 –MNA and LUCs
- Alternative 3 – Soil Excavation, Enhanced MNA, and LUCs

A11.0 Selected Corrective Measures

Alternative 3 was selected as the most appropriate corrective measure to address the contaminated soil and groundwater at RSA-271. Alternative 3 will entail limited excavation and off-site disposal of contaminated soil (if required), Enhanced MNA, and LUCs to prevent potential exposure to COCs in groundwater until the CMO is achieved.

A12.0 Public Involvement

Public participation requirements specified under Alabama Administrative Code 335-14-8-.08(6) will be met during the permit modification process for the RSA-271 corrective measures. In addition, the Army intends to inform the public of the proposed RSA-271 corrective measures in a newspaper announcement in local newspapers. In both cases, the public will be provided an opportunity to review and comment on the proposed RSA-271 corrective measures.

A13.0 Conclusions

This request for permit modification presented the supporting information needed to allow ADEM to modify the Permit, in accordance with Alabama Administrative Code R. 335-14-8-.04(2), with respect to the cleanup status at RSA-271.

A14.0 References

Alabama Department of Environmental Management (ADEM), 2021, ***Redstone Arsenal's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility, Thermal Treatment, Solid Waste Management Unit Corrective Action Permit,*** 19 July.

Alabama Department of Environmental Management (ADEM), 2017, ***Alabama Risk-Based Corrective Action Guidance Manual***, Revision 3, 2017.

Aptim Federal Services, LLC (APTIM), 2020a, ***Revision 4, RCRA Facility Investigation Report, RSA-271, Former Boiler House, Building 7729, Operable Unit 10, U.S. Army Garrison- Redstone, Madison County, Alabama***, dated October 18, 2018 and revised with slip sheets on February 11, 2020.

Aptim Federal Services, LLC (APTIM), 2020b, ***Final Corrective Measures Study Report, RSA-271, Former Boiler House, Building 7729, Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama***, November.

CB&I Federal Services LLC (CB&I), 2015a, ***Revision 1, RCRA Facility Investigation Report, RSA-146 Groundwater Site, Groundwater Unit GW-02, Operable Unit 19, U.S. Army Garrison-Redstone, Madison County, Alabama,*** prepared for Mission & Installation Contracting Command, December.

CB&I Federal Services LLC (CB&I), 2015b, ***Revision 1 Annual Monitoring Report: 2013 Installation-Wide Groundwater Monitoring, U.S. Army Garrison-Redstone, Madison County, Alabama***, February.

CB&I Federal Services LLC (CB&I), 2014, ***Site-Specific Field Sampling Plan for Additional Data Collection at RSA-271, Former Boiler House (Building 7729), Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama***, December.

CH2M Hill, 1998, ***Draft Final Report of Findings, RARE North Plant Phase II EBS, Redstone Arsenal, Madison County, Alabama***, prepared for the U.S. Army Corp of Engineers, Mobile District, Mobile, Alabama, April.

Conestoga-Rovers & Associates, 1996, ***Environmental Baseline Study Phase I Report, Redstone Arsenal Rocket Engine Assembly Facility (RARE), South Plant, Redstone Arsenal, Madison County, Alabama*** prepared for the U.S. Army Corp of Engineers, Mobile District, Mobile, Alabama, May.

Shaw Environmental, Inc., 2013, ***Site-Specific Field Sampling Plan for Additional Data Collection at RSA-271, Former Boiler House (Building 7729), Operable Unit 10***, U.S. Army-Garrison-Redstone, Madison County, Alabama, September.

Shaw Environmental, Inc. (Shaw), 2012a, ***Amendment (Additional RFI Sampling) to Final, Site-Specific Field Sampling Plan for a Secondary Investigation/ARBCA at RSA-271, Former***

Boiler House (Building 7729), Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama, August.

Shaw Environmental, Inc. (Shaw), 2012b, ***Data Summary, Additional RFI Sampling, RSA-271, U.S. Army Garrison-Redstone, Madison County, Alabama***, November.

Shaw Environmental, Inc. (Shaw), 2011a, ***Draft, Sampling and Analysis Plan, Proposed Immediate Response to OWS Removal-Closure at RSA-271, U.S. Army Garrison-Redstone, Madison County, Alabama***, September.

Shaw Environmental, Inc. (Shaw), 2011b, ***Revision 1/Draft-Final Site-Specific Field Sampling Plan, RCRA Facility Investigation/Site Inspection, Subgroup 4L Sites: RSA-187, RSA-213, RSA-215, RSA-239, RSA-271, RSA-A; Subgroup 4P Sites: RSA-193, RSA-203; RCRA Facility Investigation/Remedial Investigation Subgroup 4L Sites: RSA-201, RSA-204;Subgroup 4P Site: RSA-083; Operable Units 09, 10, and 11, U.S. Army, Garrison-Redstone, Madison County, Alabama***, January.

Shaw Environmental, Inc. (Shaw), 2011c, ***Amendment to Final, Site-Specific Field Sampling Plan for a Secondary Investigation/ARBCA at RSA-271, Former Boiler House (Building 7729), Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama***, June.

Shaw Environmental, Inc. (Shaw), 2010a, ***Final, Site-Specific Field Sampling Plan for a Secondary Investigation/ARBCA at RSA-271, Former Boiler House (Building 7729), Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama***, September.

Shaw Environmental, Inc., (Shaw), 2010b, ***Final Installation-Wide Strategy for Cleanup of Impacted Wetlands, U.S. Army Garrison-Redstone, Madison County, Alabama***, Rev 1, May.

Shaw Environmental, Inc. (Shaw), 2009a, ***Final Installation-Wide Groundwater Cleanup Strategy, Redstone Army Garrison, Madison County, Alabama,*** prepared for U.S. Army Environmental Command, December.

Shaw Environmental, Inc. (Shaw), 2009b, ***Final Installation-Wide Groundwater Land-Use Control Remedial Design, Redstone Arsenal, Madison County, Alabama***, prepared for U.S. Army Corps of Engineers-Savannah District, May.

Shaw Environmental, Inc. (Shaw), 2007, ***Final Interim Record of Decision, Interim Remedial Action for Installation-Wide Groundwater, Redstone Arsenal, Madison County, Alabama***, prepared for U.S. Army Corps of Engineers, Savannah District, September.

Shaw Environmental, Inc. (Shaw), 2005, ***Draft RSA-146 Potential Source Area Investigation, Redstone Arsenal, Madison County, Alabama***, prepared for the U.S. Army Corps of Engineers, Savannah District, Savannah, Georgia, January.

U.S. Army Garrison-Redstone (Army), 2012, ***Redstone Arsenal Environmental Site Access Control Program***, Redstone Arsenal Regulation 200-7, September.

U.S. Department of Defense, 2009, Memorandum from Wayne Arny to Deputy Assistant Secretaries of the Army, Navy and Air Force, ***Perchlorate Release Management Policy***, April.

APPENDIX B

ADEM CONCURRENCE LETTER

Lance R. LeFleur
Director

Alabama Department of Environmental Management
adem.alabama.gov
1400 Coliseum Blvd. 36110-2400 ▪ Post Office Box 301463
Montgomery, Alabama 36130-1463
(334) 271-7700 ▪ FAX (334) 271-7950

Kay Ivey
Governor

April 16, 2020

ELECTRONICALLY TRANSMITTED

Mr. A. Keith Cook, Chief
Environmental Management Division
US Army Garrison – Redstone Arsenal
4488 Martin Road
Redstone Arsenal, AL 35898

Re: **ADEM Review and Concurrence:**
Revision 4 RCRA Facility Investigation (RFI) *Report, RSA-271, Former Boiler House, Building 7729, Operable Unit 10,* dated October 18, 2018 and revised with slip sheets on February 11, 2020
Redstone Arsenal, Madison County, Alabama
USA EPA I.D. Number AL7 210 020 742

Dear Mr. Keith Cook:

The Alabama Department of Environmental Management (ADEM or the Department) has completed the review of the aforementioned document, dated October 18, 2018 and revised with slip sheets on February 11, 2020. Based on this review, the Department has determined that Redstone Arsenal's (RSA) Revision 4 RFI Report for RSA-271 has resolved all comments on the previous versions of this document and concurs with the recommendation of corrective measures for the soil and groundwater. The chemicals of concern (COCs) to be addressed by corrective measures have been listed in the Summary of Chemicals table of the RFI report. The COCs for soil include 1-Methylnaphthalene, Methylene chloride, and Naphthalene. The COCs for groundwater include 1-Methylnaphtalene, 2-Nitrotoluene, TCE, Perchlorate, and Manganese.

Therefore, RSA should submit a Corrective Measures Implementation (CMI) Plan for RSA-271 within 120 calendar days of receipt of this letter. ADEM will move RSA-271 to Table VI.6 (sites requiring a Corrective Measures Implementation Plan) in the facility's Alabama Hazardous Wastes Management and Minimization Act (AHWMMA) permit as part of the next permit modification.

If you have any questions on this matter, please contact Mr. Jojuan Pressley of the Facilities Engineering Section via e-mail at jojuan.pressley@adem.alabama.gov or at (334) 271-7747.

Sincerely,

Jason Wilson, Chief
Governmental Hazardous Waste Branch
Land Division

JW/RDA/JP/tlp

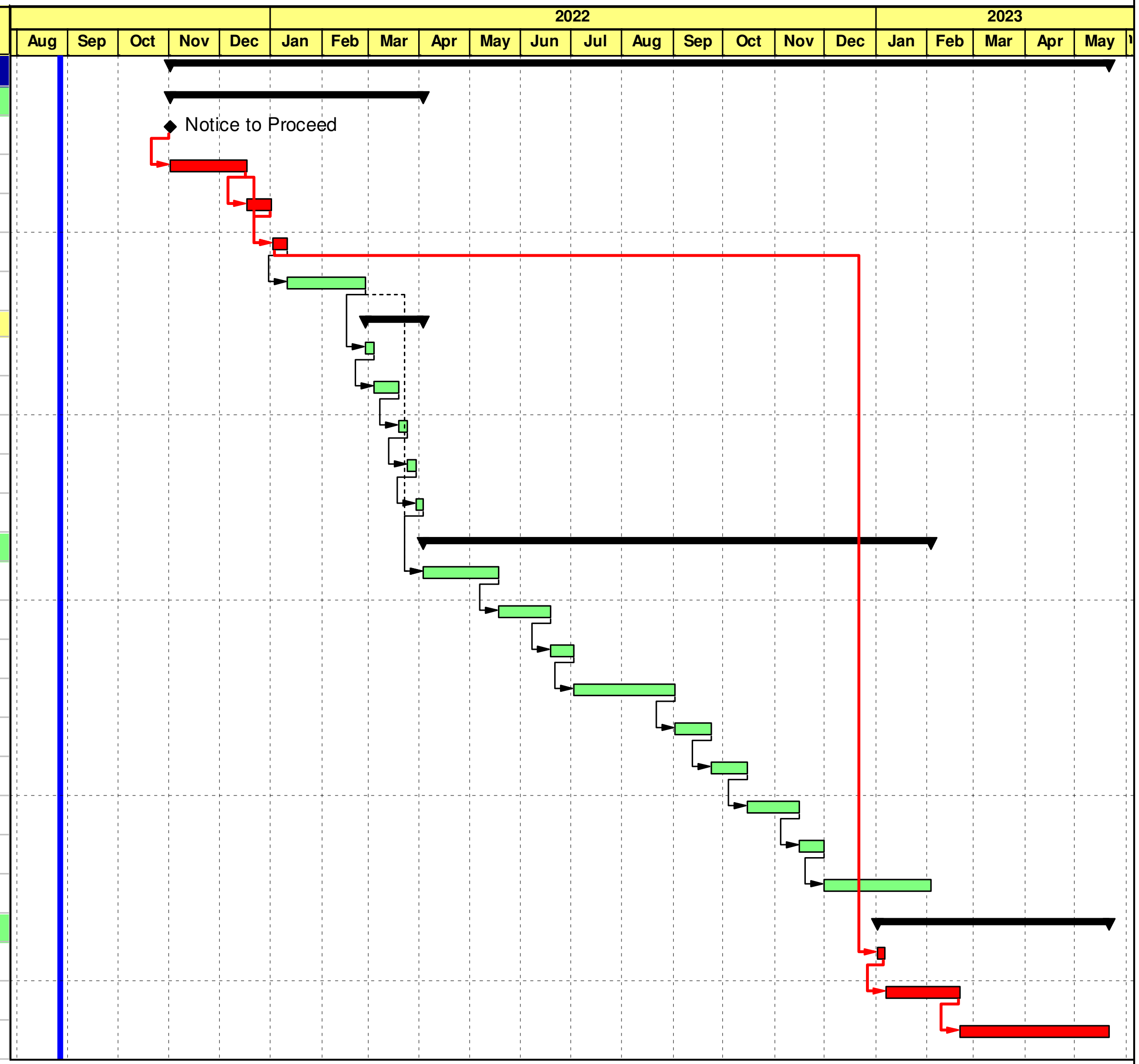
cc via email:
Ashley Mastin, ADEM
Daniel Arthur, ADEM
Clint Howard, Redstone Arsenal
Brian Roberson, NASA MSFC
Robert Morris, USA EPA Region IV
Rob Pope, USA EPA Region IV
Angelique Ortiz, Redstone Arsena

APPENDIX C

CORRECTIVE MEASURES IMPLEMENTATION SCHEDULE

RSA-271 Corrective Measures Implementation

Activity Name	OD	Start	Finish
RSA-271 Corrective Measures Implementati	567	01-Nov-21	21-May-23
CMI Construction	154	01-Nov-21	03-Apr-22
Notice to Proceed	0	01-Nov-21*	
CMI Procurement Package	45	01-Nov-21	17-Dec-21
Saoil Sampling and Well Installation	15	18-Dec-21	01-Jan-22
Baseline GW Sampling Event	10	02-Jan-22	11-Jan-22
Analyses and Data Validation	45	11-Jan-22	27-Feb-22
Soil Excavation	35	27-Feb-22	03-Apr-22
Mobilization	5	27-Feb-22	04-Mar-22
Excavation	15	04-Mar-22	19-Mar-22
Waste Hauling and Disposal	5	19-Mar-22	24-Mar-22
Backfilling	5	24-Mar-22	29-Mar-22
Site Restoration and Demobilization	5	29-Mar-22	03-Apr-22
CMI Report	295	03-Apr-22	03-Feb-23
CMI Report, Rev 0 - Army	45	03-Apr-22	18-May-22
Army Review CMI Report, Rev 0	30	18-May-22	18-Jun-22
Submittal of CMI Report, Rev 0 to ADEM-EPA	14	18-Jun-22	02-Jul-22
Regulatory Review CMI Closure Report, Rev 0	60	02-Jul-22	01-Sep-22
Response to Regulatory Comments CMI Report, Rev 0	21	01-Sep-22	23-Sep-22
Prepare and Submit CMI Plan, Rev 1 to Army	21	23-Sep-22	15-Oct-22
Army Review CMI Plan - Rev 1	30	15-Oct-22	15-Nov-22
Submittal of CMI Plan, Rev 1 to ADEM-EPA	14	15-Nov-22	30-Nov-22
Regulatory Review CMI Plan, Rev 1	60	30-Nov-22	03-Feb-23
Groundwater Sampling Years 1-26	140	02-Jan-23	21-May-23
Groundwater Sampling	5	02-Jan-23	06-Jan-23
Analyses and Data Validation	45	07-Jan-23	20-Feb-23
CMI Effectiveness Annual Report	90	21-Feb-23	21-May-23



Remaining Level of Effort
Actual Level of Effort
WBS Summary
Actual Work
Remaining Work
Critical Remai...

Data Date: 27-Aug-21

APPENDIX D

SITE-SPECIFIC SAFETY AND HEALTH PLAN

Site-Specific Safety and Health Plan
Corrective Measures Implementation
RSA-271, Former Boiler House, Building 7729
Operable Unit 10
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Prepared for:

Mission & Installation Contracting Command
ATTN: MICC Center – FSH
2205 Infantry Post Road
Fort Sam Houston, Texas 78234-1361

Prepared by:
Aptim Federal Services, LLC
11400 Parkside Drive, Suite 400
Knoxville, TN 37934

Contract No. W91ZLK-13-D-0018
APTIM Project No. 501021
Task Order 0003

November 2021

The following Site-Specific Safety and Health Plan (SSHP) has been designed for the methods presently contemplated by Aptim Federal Services, LLC (APTIM)) for execution of the proposed work. Therefore, the SSHP may not be appropriate if the work is not performed by or using the methods presently contemplated by APTIM. In addition, as the work is performed, conditions different from those anticipated may be encountered and the SSHP may have to be modified. Therefore, APTIM only makes representations or warranties as to the adequacy of the SSHP for currently anticipated activities and conditions. This Site-Specific Safety and Health Plan Attachment must be used in conjunction with the Installation-Wide Accident Prevention Plan (October 2019).

Reviews and Approvals

11/4/2021

Mark Shoemaker, Project Manager
Aptim Federal Services, LLC

Date

11/4/2021

Winston D. Russell, Health and Safety Manager
Aptim Federal Services, LLC

Date

11/4/2021

Brian Rhodes, APTIM Quality Control
Site Manager
Aptim Federal Services, LLC

Date

Acknowledgements

The approved version of this site-specific safety and health plan (SSHP) for corrective measures implementation of groundwater at RSA-271 has been provided to the Quality Control Site Manager (QCSM). I acknowledge my responsibility to provide the QCSM with the equipment, materials, and qualified personnel to implement fully all safety requirements in this SSHP. I will formally review this plan with the health and safety staff at least annually until project completion.

Mark Shoemaker, APTIM Project Manager — 11/4/2021 Date

I acknowledge receipt of this SSHP from the Project Manager and that it is my responsibility to explain its contents to all site personnel and cause these requirements to be fully implemented. Any change in conditions, scope of work, or other change that might affect worker safety requires me to notify the Project Manager and the Health and Safety Manager.

Brian Rhodes, APTIM QCSM — 11/4/2021 Date

Safety and Health Plan
Acknowledgement Form

I have been informed of and will abide by the procedures set forth in this site-specific safety and health plan for the RSA-271 corrective measures implementation at Redstone Arsenal. By signing this acknowledgement form, I certify receipt of hazard communication training required for safe performance of my job at Redstone Arsenal, Madison County, Alabama.

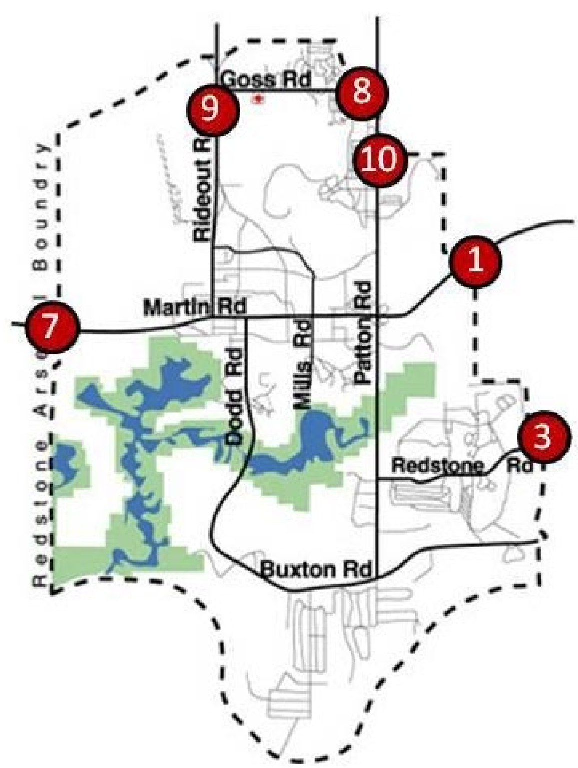
Printed Name	Signature	Representing	Date

Redstone Arsenal Gate Hours

Location	Weekdays	Weekends
Gate 1	0530 - 2100*	Closed
Gate 3	0530 - 1300**	0530 - 1300
Gate 7	0530 - 2100	Closed
Gate 8	0530 - 2100	0530 - 2100
Gate 9	24/7	24/7
Gate 10	Closed	Closed
Visitor Center 1	0600 - 1430	Closed
Visitor Center 9	0600 - 1700	Closed

* Truck lane at Gate 1 open 0530 - 1300, Monday - Friday
** Gate 3 outbound lanes will remain open until 1800
*** Gate 7 outbound lanes will remain open until 2100

Gate hours and conditions are subject to change due to homeland defense initiatives; therefore, the point of contact for the most current gate operational hours is the Provost Marshall Office at (256) 876-4195.



Redstone Project Emergency Contacts

Fire Department (ask for RSA Fire Department) 911

Fire Department (from cellular phone) ....(256) 876-2117

Ambulance (HEMSI) 911

Installation Emergency Operations Center (non-911 emergencies) ....(256) 313-1043

Military Police ....(256) 876-2222

Huntsville Hospital (Emergency Room) ....(256) 265-8144

Huntsville Hospital (Trauma Center) ....(256) 265-8137

Chemical Agent Emergencies (state that you are at Redstone) 911

UXO Emergencies (state that you are at Redstone) 911

UXO Nonemergencies/Reporting Only ....(256) 313-3297

Installation Operations Center (IOC) ....(256) 313-1043

Garrison Safety Office ....(256) 876-2944
    Michael Moore, Safety Manager ....(256) 313-3297
    DSN ....(256) 897-3297
    Keith Coates, Safety & Occupational Health Specialist ....(256) 876-3383
    Bobby Taylor, Safety & Occupational Health Specialist ....(256) 313-3294
    Jonathan Niedergeses (MEC support) ....(256) 876-6027

Primary Site Emergency Contact (Barry Hodges, Site Manager, U.S. Army Garrison-Redstone) ....(256) 329-1327

Clint Howard, U.S. Army Garrison, Chief, Installation Restoration Branch ....(256) 843-3702

    (Mobile/Cellular) ....(256) 758-7084

Raytheon Safety Engineer, Anthony Moore ....(256) 213-5822

    (Mobile/Cellular) ....(256) 924-8197

Raytheon EHS Manager, Lisa Winchester ....(256) 213-5892

    (Mobile/Cellular) ....(502) 664-6894

National Response Center ....(800) 424-8802

Poison Control Center ....(800) 222-1222

EPA Region 4 ....(404) 347-3931

Mark Shoemaker, APTIM Project Manager ....(865) 560-7927
    (Mobile/Cellular) ....(865) 771-4133

Brian Rhodes, APTIM QCSM (RSA Field Office)
    (Mobile/Cellular) ....(256) 714-4200

Winston D. Russell (Doug), APTIM H&S Manager ....(865) 560-7918
    (Mobile/Cellular) ....(865) 414-9545

Brian Rhodes APTIM SSHO (RSA Field Office)
    (Mobile/Cellular) ....(256) 714-4200

APTIM Hot Line (APTIM incident reporting) ....(800) 537-9540 opt. 2

Redstone Project Emergency Contacts (Continued)

Dr. William Nassetta, CORE Occupational Physician ....(225) 756-2673
Occupational Health Center, Crestwood Family Practice ....(256) 721-9916
Crestwood Workers Care Madison ....(256) 830-8930

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D1.0 Site Work Plan Summary

Project Objective. Aptim Federal Services, LLC (APTIM), on behalf of the U.S. Army Garrison-Redstone, has prepared this site-specific safety and health plan (SSHP) for Redstone Arsenal (RSA), Madison County, Alabama, under the management of the U.S. Army Environmental Command. The Mission & Installation Contracting Command has contracted Bay West LLC under Contract Number W9124J-18-D-0001, Delivery Order W9124J18F00B2 to perform environmental remediation and restoration and program management services at RSA under the Resource Conservation and Recovery Act Corrective Action Program in accordance with RSA's hazardous waste permit (U.S. Environmental Protection Agency ID #AL7210020742). This SSHP has been developed to provide safety, health, and environmental guidance for implementing the corrective measures selected for RSA-271, Former Boiler House, Building 7729, Operable Unit 10.

The corrective measures implementation (CMI) work plan describes the corrective measures necessary to support groundwater sampling and monitored natural attenuation (MNA) for groundwater at RSA-271. The situation warranting action at RSA-271 is future potable use of groundwater beneath RSA-271 contaminated with 1-methylnaphthalene, trichloroethene (TCE), 2-nitrotoluene, perchlorate, and manganese that would pose an unacceptable threat to human health.

A long-term groundwater monitoring program will be conducted until cleanup goals are achieved for the groundwater contaminants.

Project Tasks. Project activities to meet the corrective measures objectives in support of corrective measures are detailed in the RSA-271 CMI work plan. APTIM will perform the following field activities:

- Mobilization/demobilization
- Utility clearance and marking
- Soil sampling with DPT
- Monitoring well installation with hollow-stem auger and well development
- Vegetation clearance
- Protection and/or closure of existing monitoring wells
- Excavation of contaminated soil

- Post-excavation soil confirmation sampling and analysis
- Waste characterization sampling
- Transport and disposal of excavated soils contaminated with PAHs as nonhazardous waste (Subtitle D landfill)
- Site restoration, including placement of oxygen-releasing compound (ORC) in the bottom of the excavation, application of backfill and topsoil and revegetation with approved grass mixtures
- Surveying
- Groundwater Sampling

Personnel Requirements. Up to eight employees are anticipated for the corrective measures at RSA-271. All personnel on this site shall have received training, informational programs, and medical surveillance as outlined in the Installation-Wide Accident Prevention Plan for Environmental Remediation, Restoration and Program Management Services and be familiar with the requirements of this SSHP.

Training and medical surveillance documentation will be maintained by APTIM and provided to the Contracting Officer's Representative prior to work when personnel are finalized.

D2.0 Site Characterization and Analysis

D2.1 Anticipated Hazards

The activity hazard analysis included in Chapter 5.0 lists project-specific practices to be utilized to reduce or eliminate anticipated site hazards. The activity hazard analysis indicates specific chemical and physical hazards that may be present and encountered during each task. Below each task is a list of hazards and specific actions that will be taken to control the respective hazards. These control measures may include work practice controls, engineering controls, health and safety policy reference, and/or use of appropriate personal protective equipment (PPE).

Contaminants in groundwater require corrective measures. Below is a summary of the nature and extent of contamination from the Resource Conservation and Recovery Act facility investigation (RFI) report (Aptim Federal Services, LLC (APTIM), 2020).

- All metals in surface and subsurface soil were determined to be naturally occurring or present at concentrations less than residential preliminary screening values. In groundwater, results not consistent with background for manganese and iron were detected at concentrations above preliminary screening values in one well that was placed in the pit of the former underground storage tank.

- Few volatile organic compounds (VOC) were detected in soil, and none are currently present at concentrations greater than their respective residential preliminary screening values. In groundwater, TCE is the only VOC that exceeded its preliminary screening value. However, TCE results for groundwater have not exceeded its preliminary screening value since the initial round of groundwater sampling in September 2012.

- One semivolatile organic compound, the polynuclear aromatic hydrocarbon benzo(a)pyrene, was detected in surface soil samples at concentrations above residential preliminary screening values in two locations. Semivolatile organic compounds were not detected at concentrations above preliminary screening values in subsurface soil samples.

- Polynuclear aromatic hydrocarbons associated with fuel oils were also present in groundwater at concentrations above preliminary screening values, along with dibenzofuran.

- Groundwater samples were analyzed for explosives, and six explosive compounds were detected at concentrations above preliminary screening values. Perchlorate in groundwater exceeded preliminary screening values in two of the four samples analyzed. Concentrations appear to be part of the commingled plumes that extend beneath RSA-271.

The RFI concluded that 1-methylnaphthalene, methylene chloride, and naphthalene in soil pose a leaching threat to groundwater and verification subsurface soil samples will be collected as part of these CMs. A soil excavation is planned, included in this CMIP, and will be implemented if verification testing fails evaluation by ADEM methods.

Exposure to RSA-271 soils poses no unacceptable health risk to any of the receptors evaluated under commercial/industrial or residential site use. Groundwater is contaminated with 1-methylnaphthalene, manganese, TCE, 2-nitrotoluene, and perchlorate, which pose a threat if groundwater is developed as a potable source.

Munitions and Explosives of Concern /Chemical Warfare Materiel/Chemical Agent. Available information including the RSA Chemical Warfare Materiel (CWM) Probability Map dated April 2019, historical records, and recent environmental sampling data was reviewed with respect to munitions and explosives of concern (MEC), CWM, or chemical agent (CA) potential at RSA-271. The review indicated that the probability of encountering measurable concentrations of CWM/CA or degradation products is unlikely and a low probability of encountering unexploded ordnance (UXO). On-call UXO “stand by” support will be utilized for low-probability UXO. The hazard evaluation process is documented in the MEC/CWM/CA hazard form provided in Attachment 1. Based on this evaluation, it was determined that CA monitoring or UXO avoidance support will not be required for the corrective measures. However, in the event any suspicious item is encountered that cannot be positively identified as not presenting an explosive hazard, all work shall stop and the Project Manager and Health and Safety Manager will be notified. The Project Manager will be responsible for following the notification requirements in the RSA Explosives Safety Management Program, including contacting the on-call UXO support through the U.S. Army Aviation and Missile Command Safety Office. If the suspicious item can be positively identified by qualified UXO personnel as not presenting an explosive or chemical agent hazard or the hazard has been removed, work will proceed.

D2.2 COVID-19 Virus Hazards

Coronavirus Disease 2019 (COVID-19) is a respiratory disease caused by the SARS-CoV-2 virus. COVID-19 spread from China to many other countries around the world, including the United States. The COVID-19 pandemic is impacting all aspects of daily life, including travel, trade, tourism, food supplies, and financial markets. Procedures and information for awareness and education, screening methods, contamination prevention and sanitation, and reporting and illness/exposure management are presented in Attachment 2 (AMS-710-01-FM-04201, COVID-19 Control Plan [CCP]).

- A continual assessment of hazards is required to maintain a current awareness of exposures and the effectiveness of current controls. These methods will ensure employees have access to current information on how the pandemic is progressing, known site-specific exposures, site-specific controls and how to effectively implement them, and reporting requirements.

- Employees can be exposed both at the job site and away from the job site. Fever/chills, coughing, shortness of breath/difficulty breathing, fatigue, muscle/body aches, headache, new loss of taste or smell, sore throat, congestion/runny nose, nausea/vomiting, and diarrhea are currently the primary symptoms that may occur between 2 and 14 days from contraction of the virus. It is critical to remind employees to identify any of these symptoms and to quickly isolate employees who are symptomatic from other employees.

- Current medical understanding is that the virus is primarily transmitted via respiratory droplets. The virus can potentially survive on varying surfaces from hours to multiple days. Primary routes of entry include the mouth, eyes and nose. Practices such as “sick employees stay at home,” social distancing, and use of face masks as applicable will be used as prevention measures against the virus spread. Sanitation of work areas, office trailers, and restroom facilities will be performed regularly, including additional attention to personal hygiene and hand washing.

- APTIM has suspended all non-essential business travel. Essential business travel must be approved by APTIM leadership. Anyone approved to travel will be screened prior to reporting back to the job site.

- Additional reporting and illness management procedures will also be implemented as a management tool to help understand the virus and prevent it's spread. This includes a listing of roles and responsibilities for APTIM's management team, employees, and medical providers. APTIM expects subcontractors to protect their employees through compliance with APTIM's CCP or through the development and implementation of a COVID-19 control plan specific to their risks. APTIM and U.S. Army Engineering and Support Center, Huntsville leadership must approve subcontractor plans before implementation at the job site.

- Effective November 7, 2021, APTIM is enforcing vaccination mandate in accordance with President Biden's Executive Order September 24, 2021. APTIM employees and lower tier subcontractors shall be fully vaccinated by December 8, 2021.

These requirements are in effect at least for the duration of the pandemic. The APTIM COVID-19 Task Force will amend these requirements or suspend their operation when no longer necessary.

D2.3 General Site Information

RSA is located in southern Madison County, Alabama, and bounded by the city of Huntsville to the north and east and the Tennessee River to the south. The towns of Madison and Triana are northwest and southwest of the facility, respectively. RSA encompasses approximately 38,300 acres, and the Department of the Army controls 36,459 acres of that total, of which approximately 15,500 acres are woodlands, 5,360 acres are leased for agricultural use, and approximately 12,000 acres are used for test ranges. The National Aeronautics and Space Administration was granted 1,841 acres in the central part of RSA for the George C. Marshall Space Flight Center. Prior to this land grant in 1960, the area occupied by George C. Marshall Space Flight Center was used by the Army. Approximately 2,900 acres owned by the Tennessee Valley Authority and 4,100 acres of the Wheeler National Wildlife Refuge are within the boundaries of RSA.

RSA-271 is located in the northeastern portion of groundwater unit RSA-146. RSA-146 occupies the southeastern quadrant of RSA between Huntsville Spring Branch and the Tennessee River. RSA-271 occupies approximately 0.25 acre and is situated in the southeastern part of the Missile Production Complex. Nearby surface media sites include RSA-089 to the northwest, RSA-138M to the north, and RSA-097 (a no-further-action [NFA] site) to the west. NFA site RSA-137O is within the footprint of RSA-271.

The investigation at RSA-271 focused on contamination resulting from historical operations associated with Building 7229 (formerly Army Building B-529), located within the RSA-271 site. Initially, the building housed a steam boiler fueled from a 2,800-gallon underground storage tank formerly located east of the building. A small oil/water separator (OWS) consisting of a blow-off/hot well pit was located at the west end of Building 7729. RSA records indicate that this system was removed from use but left in place, and a larger, high-capacity blow-off/hot well was installed south of Building 7729 in 1974. The junction of both OWS systems with the sanitary sewer system was located northwest of the building.

RSA-271 was established as a solid waste management unit following the RSA-146 potential source area (PSA) investigation (Shaw Environmental, Inc., 2005). As a result of the PSA investigation process, the Army recommended the creation of RSA-271 to facilitate a more focused and thorough evaluation of the data to determine whether chemicals used at RSA-271, including fuel and compressor oils, contributed to environmental contamination.

D3.0 Personal Protective Equipment

The work activities will begin in the following levels of protection.

Task	Initial Level of PPE
Mobilization and Demobilization	Level D
Installation of Surface Water and Erosion Controls	Level D
Vegetation Clearing	Level D
Soil Sampling, Well Installation, and Well Development	Modified Level D
Survey and Marking	Level D
Groundwater Sampling	Level D
Excavation of Contaminated Soils and Placement of Emulsified Vegetable Oil	Level D
Confirmation Soil Sampling	Level D
Backfilling	Level D
Waste Characterization Sampling	Level D
Transportation and Disposal	Level D
Site Restoration	Level D

Complete descriptions of Level D and Modified Level D protection follow.

Level D. The following equipment will be used for Level D protection:

- Sleeved shirt and long pants
- Leather gloves (when handling sharp objects)
- Nitrile or PVC gloves (when handling potentially contaminated materials)
- Steel/composite-toed safety boots
- Safety glasses

- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Modified Level D. The following equipment will be used for Modified Level D protection:

- Permeable Tyvek®, Kleenguard, or its equivalent
- Latex, Nitrile or polyvinyl chloride boot covers
- Nitrile gloves (outer)
- Lightweight nitrile gloves (inner)
- Steel/composite-toed safety boots
- Safety glasses
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Operators of pressure washing equipment shall wear a face shield, metatarsal guards for the protection of the feet, and leg guards. This will be required in addition to Modified Level D PPE.

D4.0 Site Monitoring

The contaminants of concern from groundwater sampling are metals (manganese), VOCs (TCE), semivolatile organic compounds (1-methylnaphthalene), explosive compounds (2-nitrotoluene), and perchlorate. Chemical exposure to compounds is extremely unlikely based on their low concentrations detected during previous site investigations. Air monitoring for VOCs will be conducted as a conservative safety measure utilizing a photoionization detector with minimum 10.6-electron volt lamp during the following activities:

- Installation, development, and sampling of wells
- Excavation of contaminated soil.

During excavation activities, monitoring will be conducted for visible dust in the breathing zone of employees as well as the area immediately downwind of the excavation. In the event visible dust is observed, dust suppression measures will be implemented. If visible dust cannot be adequately controlled, work will stop and the program HSE Manager will be contacted to determine necessary action.

Action levels for air monitoring are provided in Table 4-1. Table 4-2 provides the minimum air monitoring frequency and locations.

D5.0 Activity Hazard Analysis

The activity hazard analysis (Table 5-1) is provided for the following corrective measures activities at RSA.

- Mobilization/demobilization
- Utility clearance and marking
- Soil sampling with DPT
- Monitoring well installation with HAS and well development
- Vegetation clearance
- Protection and/or closure of existing monitoring wells
- Excavation of contaminated soil
- Post-excavation soil confirmation sampling and analysis
- Waste characterization sampling
- Transport and disposal of excavated soils contaminated with PAHs as nonhazardous waste (Subtitle D landfill)
- Site restoration, including placement of ORC in the bottom of the excavation, application of backfill and topsoil, and revegetation with approved grass mixtures
- Surveying
- Groundwater sampling.

D5.1 Personnel

All project personnel shall participate in the daily tailgate safety/job safety analysis meetings and be instructed on the following requirements:

- Before digging or drilling, the existence and locations of underground pipe, electrical equipment, and gas lines will be determined. This will be done in accordance with AMS-710-02-PR-01610, *Utility Contact Prevention* (Attachment 3), by contacting the appropriate RSA representative to mark the location of the lines. If RSA personnel’s knowledge of the area is incomplete, an appropriate device such as ground-penetrating radar, air knife, geophysics, or equivalent to protect personnel and minimize APTIM liability will be used to locate the service line.

- If equipment is located in the vicinity of overhead power lines, a minimum distance of 15 feet must be maintained between the lines and any point on the equipment. If the lines have appreciable sag or windy conditions exist, this distance shall be 20 feet.

- Only hand digging shall occur within 3 feet of underground utilities. Once the lines are exposed and confirmed by hand digging or soil vacuum methods, heavy equipment can be used but must remain 3 feet from the exposed utility. A spotter shall be required at all times when working near exposed lines.

All occupational injuries or illness shall be immediately reported and investigated in accordance with APTIM Management System procedures. Attachment 4 contains the Incident Reporting Management Procedure. Injuries that require emergency medical evaluation/treatment shall be cared for by Huntsville Hospital ([256] 265-8137). A map and directions to the hospital from the RSA-271 site area are provided as Figure 1. If you call 911 for emergency medical services with a cellular phone, you must state that you are located on Redstone Arsenal in order for the call to be directed to the proper emergency management office. Any suspect chemical agent exposure requires notification to the Redstone Arsenal Fire Department. In the event a medical emergency occurs, notify the Garrison Installation Operations Center (IOC) at (256) 313-1043 after initial emergency contacts have been completed in order to update IOC on the situation.

Injuries that require medical treatment beyond on-site first aid but are not life threatening or severe in nature shall be cared for and evaluated by an occupational physician. The occupational clinics, Crestwood Family Practice ([256] 721-9916) or Crestwood Workers Care Madison Clinic ([256] 830-8930), have been selected for APTIM employees working at RSA. A map and directions from the site to the occupational clinic and the Crestwood Workers Care Madison Clinic are provided on Figure 1. Subcontractors are encouraged to establish their own occupational medicine services prior to work on site.

D5.2 Drilling Operations

Applicable sections of AMS Procedure No. AMS-710-02-PR-07200, *Drill Rig Operations* (Attachment 5), will be followed during all drilling operations for the installation of new monitoring wells.

D5.3 Heavy Construction Equipment

Field activities will be performed using either subcontractor or locally rented equipment. APTIM plans to mobilize the following types of heavy equipment:

- Direct-push/hollow-stem auger drill rig.

- Excavator/backhoe to excavate contaminated soil and place ORC in the bottom of the excavation prior to backfilling

- Front-end loader/skid steer to consolidate soil and move fill material
- Bulldozer to move, place, and prepare fill material
- Steel-wheeled compactor for compaction of fill material
- Large-capacity water truck (or equivalent) for site dust control and hydration of import material for compaction
- Portable fuel tank (mounted on pickup truck).

All equipment operators will be familiar with the requirements for inspection and operation of their assigned equipment. Before equipment is placed into use and on a daily basis, the operator is to inspect and verify that it is in safe operating condition. The following guidelines will be adhered to while operating heavy construction equipment:

- Equipment will not be operated in a manner that will endanger persons or property, nor will the safe operating speeds or loads be exceeded.
- Getting on or off of equipment while it is in motion is prohibited.
- Equipment will be operated in accordance with the manufacturer's instructions and recommendations.
- Determinations of road conditions and structures will be made in advance to verify that clearances and load capacities are safe for the passage of equipment.
- All machinery or equipment will be shut down and positive means taken to prevent its operation while repairs or manual lubrications are being done. Equipment designed to be serviced while running is exempt from this requirement.
- Buckets, blades, dump bodies, and similar equipment will be either fully lowered or blocked when being repaired or when not in use. All controls will be in a neutral position, with the engines stopped and brakes set, unless work being performed on the machine requires otherwise, per manufacturer recommendations.
- No guard, safety appliance, or device will be removed from machinery or equipment or made ineffective except for making immediate repairs, lubrications, or adjustments, and then only after the power has been shut off. All guards and devices will be replaced immediately after completion of repairs and adjustments and before power is turned on.
- Mechanized equipment will be shut down prior to and during fueling operations. Closed systems, with automatic shut-off, which prevent spillage if connections are broken, may be used to fuel diesel-powered equipment left running.
- Personnel will not work, pass under, or ride in the buckets or booms of loaders in operation.

- All self-propelled construction equipment, whether moving alone or in combination, will be equipped with a reverse signal alarm.
- Seat belt use is required while operating equipment.

Spotters for the operator will be the only personnel allowed in the vicinity of the heavy equipment. Spotters will stay out of the boom radius area. Personnel needing to approach heavy equipment while operating will observe the following protocols:

- Wear high-visibility vests meeting American National Standards Institute specifications.
- Make eye contact with the operator (and spotter).
- Signal the operator to cease heavy equipment activity.
- Approach the equipment only after the operator has given signal to do so.

D5.4 Heat Stress

If employees are performing moderate to heavy physical work during construction/remediation operations in standard permeable cotton or synthetic work clothing, monitoring of environmental heat stress parameters is advisable when the ambient air temperature exceeds 90 degrees Fahrenheit (°F) and any time discomfort due to heat stress is either noticed or reported. If employees are wearing impermeable protective clothing, physiological monitoring is advisable beginning at 70 °F and any time discomfort due to heat stress is either noticed or reported. Heat stress monitoring methods as well as signs, symptoms, treatment, and prevention are presented in AMS Procedure No. AMS-710-01-PR-00600, *Heat Stress Prevention and Control* (Attachment 6).

D5.5 Cold Stress

Cold weather conditions can be hazardous to the health and safety of employees, endanger the stability of the body system, and cause problems such as hypothermia and frostbite. It is of vital importance that adequate precautions are taken to alleviate the effect of cold environments and to ensure that personnel can work safely and efficiently. To minimize impacts from cold stress, the requirements established in AMS-710-01-PR-00700, *Cold Stress Prevention and Control*, shall be followed (Attachment 7).

D5.6 Excavation and Trenching

During excavation and trenching, AMS-710-02-PR-01600, *Excavation and Trenching* (Attachment 8), must be followed. This procedure complies with Occupational Safety and Health Administration Regulations 1926.650 through 1926.652 and EM 385 1-1. No one is permitted to enter any excavation greater than 4 feet deep unless it is made safe for entry and inspected by the competent person. Sloping system requirements shall be in accordance with 29 Code of Federal Regulations 1926 Subpart P, Appendix B. Sloping shall take into account at a minimum the angle of incline required to prevent a cave-in with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

All excavation shall be performed from a stable ground position. Daily inspections of the excavation shall be made as needed throughout work shifts and after every rainstorm or other hazard-increasing occurrence by a competent person who has received training and is competent in excavation safety. The competent person shall determine the likelihood of a cave-in, and reasonable actions such as sloping or shoring shall be taken if the walls appear to be unstable. Slide rail systems shall be installed per the lower tier subcontractor's approved health and safety plan and in accordance with AMS-710-02-PR-02100, *Rigging Plan and Rigging Safety* (Attachment 9), and AMS-710-02-PR-01900, *Mobile Crane Safety* (Attachment 10). Excavations classified as confined space shall follow AMS-710-02-01700, *Confined Spaces* (not attached). When it is necessary for personnel to be near the excavation for photodocumentation, an excavation-competent person must deem it safe to do so. Otherwise, all photographs of the excavation shall be performed by the excavator operator from within the cab when it is safe to do so.

All spoil shall be located at least 3 feet from the edge of the excavation to prevent loading on the excavation platform. The excavation shall be guarded on all sides by barricades or caution tape at least 10 feet from the edge. Class II protection around excavations within the delineated exclusion zone shall be utilized.

D6.0 References

Aptim Federal Services, LLC (APTIM), 2020, ***Revision 4 RCRA Facility Investigation Report, RSA-271, Former Boiler House, Building 7729, Operable Unit 10, Redstone Madison County, Alabama,*** dated October 18, 2018 and revised with slip sheets on February 11, 2020.

Shaw Environmental, Inc., 2005, ***Draft RSA-146 Potential Source Area Investigation, Redstone Arsenal, Madison County, Alabama***, January.

TABLES

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

Substance [CAS]	IP[a] (eV)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Coal tar pitch volatiles (pyrene, phenanthrene, acridine, chrysene, anthracene & benzo(a)pyrene [65996-93-2]	NA	Inh Con	dermatitis, bronchitis, [potential occupational carcinogen	Eye: Irrigate immediately Skin: Soap wash Breath: Respiratory support Swallow: Immediate medical attention Aspiration: Immediate medical attention	0.2 mg/mg^3 0.2 mg/mg^3 0.1 mg/mg^3	NA	PEL TLV REL	Ca [80 mg/m^3]
Fuel oil (diesel oil, medium)	None	Ing Inh Con	Ingestion causes nausea, vomiting, and cramps; depressed central nervous system, headache, coma, death; pulmonary irritation; kidney and liver damage; aspiration causes severe lung irritation, coughing, gagging, dyspnea, substernal stress, pulmonary edema; bronchopneumonia; excited, then depressed, central nervous system.	Eye: Irrigate promptly Skin: Soap wash Breath: Respiratory support Swallow: Immediate medical attention Aspiration: Immediate medical attention	NA	NA	PEL TLV REL	NA

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

Substance [CAS]	IP[a] (eV)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Gasoline [8006-61-9]	None	Inh Ing Con	Intoxication, headaches, blurred vision, dizziness, nausea; eye, nose throat irritation; potential kidney and other cancers. Carcinogenic.	Eye: Irrigate immediately (15 min) Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	300 ppm Ca, lowest feasible conc. (LOQ 15 ppm)	500 ppm	PEL TLV REL	1400 ppm 10% LEL
Hydrogen chloride (hydrochloric acid) [74-90-8]	12.74	Inh Ing Con	Inflamed nose, throat, larynx; cough, burns throat, choking; burns eyes, skin; dermatitis; in animals; laryngeal spasm; pulmonary edema.	Eye: Irrigate immediately Skin: Water flush immediately Breath: Respiratory support Swallow: Immediate medical attention	NIOSH REL C 5 ppm (7 mg/m3) OSHA PEL C 5 ppm (7 mg/m3)	C5 ppm C5 ppm C5 ppm	PEL TLV REL	100 ppm
Isopropyl alcohol (isopropanol) [67-63-0]	10.16	Inh Ing Con	Mild irritation of the eyes, nose, and throat; drowsiness, dizziness, headache; dry, cracked skin.	Eye: Irrigate immediately Skin: Water flush Breath: Respiratory support Swallow: Immediate medical attention	400 ppm 400 ppm 400 ppm	500 ppm 500 ppm 500 ppm	PEL TLV REL	2,000 ppm

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

(Page 3 of 6)

Substance [CAS]	IP[a] (eV)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Manganese [7439-96-5] (metal)	NA	Inh Ing	Parkinson's; asthenia, insomnia, mental confusion; metal fume fever: dry throat, cough, chest tightness, dyspnea (breathing difficulty), rales, flu-like fever; low-back pain; vomiting; malaise (vague feeling of discomfort); lassitude (weakness, exhaustion); kidney damage	Breath: Respiratory support Swallow: Immediate medical attention	5 mg/m^3 (ceiling) 1 mg/m^3	3 mg/m^3	PEL TLV REL	500 mg/m^3
Methanol	10.85	Inh Abs Ing Con	Irritated eyes, headache, drowsiness, lightheadedness, nausea, vomiting, disturbance in vision, blindness.	Eye: Irrigate immediately Skin: Water flush promptly Breath: Fresh air Swallow: Immediate medical attention	NIOSH REL TWA 200 ppm (260 mg/m3) ST 250 ppm (325 mg/m3) [skin] OSHA PEL TWA 200 ppm (260 mg/m3)	200 ppm (skin) 200 ppm (skin) 250 ppm (skin)	PEL TLV REL	6000 ppm

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

Substance [CAS]	IP[a] (eV)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Nitric acid [7697-37-2]	11.95	Inh Ing Con	Irritated eyes, mucous membranes, and skin; delayed pulmonary edema, pneumonitis, bronchitis; dental erosion.	Eye: Irrigate immediately Skin: Water flush promptly Breath: Respiratory support Swallow: Immediate medical attention	2 ppm 2 ppm 2 ppm	4 ppm 4 ppm 4 ppm	PEL TLV REL	100 ppm
2-Nitrotoluene [88-72-2]	9.43	Inh Abs Ing Con	Anoxia, cyanosis; headache, lassitude (weakness, exhaustion), dizziness; ataxia; dyspnea (breathing difficulty); tachycardia; nausea, vomiting.	Eye: Irrigate immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	2 ppm (skin) 2 ppm (skin) 2 ppm (skin)	NA	PEL TLV REL	200 ppm
Petroleum hydrocarbons (Examples: oils, grease, diesel) *[See specific compound and/or product-specific SDS*	Varies	Inh Ing Con Abs	Irritated skin, eyes, nose, and throat; headache, dizziness; dermatitis; some components of gasoline and diesel exhaust are carcinogenic	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical Attention	Varies by compound	Varies by compound	NA	Varies by compound

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

Substance [CAS]	IP[a] (eV)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Portland cement	NA	Inh	Fine gray powder that can be irritating if inhaled or in eyes.	Eye: Irrigate immediately Skin: Soap wash flush Breath: Respiratory support Swallow: Immediate medical attention	10 mg/m^3 15 mg/m^3 total dust 5 mg/m^3 respirable fraction 10 mg/m^3/total dust 5 mg/m^3 respirable fraction	NA	TLV PEL REL	NA
Trichloroethylene (TCE, trichloroethene) [79-01-6]	9.45	Inh Ing Con	Headache, vertigo; visual disturbance, tremors, somnolence, nausea, vomiting; irritated eyes; dermatitis; cardiac arrhythmia paresthesia. Carcinogenic.	Eye: Irrigate Immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	100 ppm 10 ppm 25 ppm* *(10 hr TWA)	C200 ppm;300ppm* 100 ppm Ca *5 Min peak in any 2 hrs	PEL TLV REL	Ca [1,000 ppm]

Chemical substances italicized represent material that will be used onsite and is not representative of site contaminants.

[a]IP - Ionization potential (electron volts).
[b]Route - Inh, Inhalation; Abs, Skin absorption; Ing, Ingestion; Con, Skin and/or eye contact.
[c]TWA - Time-weighted average. The TWA concentration for a normal work day (usually 8 or 10 hours) and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day
without adverse effect.
[d]STEL - Short-term exposure limit. A 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the TWA is not exceeded.
[e]PEL - Occupational Safety and Health Administration (OSHA) permissible exposure limit (29 CFR 1910.1000, Table Z).
TLV - American Conference of Governmental Industrial Hygiene (ACGIH) threshold limit value—TWA.
REL - National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit.
[f]IDLH (NIOSH)—Immediately dangerous to life or health (NIOSH). Represents the maximum concentration from which, in the event of respirator failure, one could escape within 30

Table 2-1

Toxicological and Physical Properties of Chemicals
RSA-271
Redstone Arsenal, Madison County, Alabama

minutes without a respirator and without experiencing any escape-impairing or irreversible health effects.
NE - No evidence could be found for the existence of an IDLH (NIOSH Pocket Guide to Chemical Hazards, Pub. No. 90-117, 2012).
C - Ceiling limit value which should not be exceeded at any time.
Ca - Carcinogen.
NA - Not applicable or not available.
LEL - Lower explosive limits.
LC_{50} - Lethal concentration for 50 percent of population tested.
LD_{50} - Lethal dose for 50 percent of population tested.
NIC - Notice of intended change (ACGIH).

References:

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Odor Threshold for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989.
Respirator Selection Guide, 3M Occupational Health and Safety Division, 2014.
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Workplace Environmental Exposure Levels, American Industrial Hygiene Association, 1992.

Table 4-1

Action Levels
RSA-271
Redstone Arsenal, Madison County, Alabama

<u>When in Level D Modified/D PPE</u>

Analyte	Action Level[a]	Required Action[b]
VOCs	≥ 5 ppm above background in BZ	Stop activities, suspend work activities for 15 to 30 minutes; if readings are sustained, contact HSM [b].
Oxygen	≥ 19.5%, <22.5%	Normal operations
	< 19.5%, >22.5%	Stop work, evacuate work area; contact HSM.
Flammable vapors	≥ 10% LEL	Stop work, evacuate work area; contact HSM [b].
	< 10% LEL	Continue operations, monitor for VOCs.

<u>When in Support Zone</u>

Analyte	Action Level[a]	Required Action
VOCs	≥ 1 ppm above background in BZ	Evacuate support zone and re-establish perimeter of exclusion zone.

[a] Four instantaneous peaks in any 15-minute period or a sustained reading for 5 minutes in excess of the action level will trigger a response.

[b] Contact with the HSM must be made prior to continuance of work. The HSM may then initiate perimeter/integrated air sampling along with additional engineering controls.

<	-	Less than.
≥	-	Greater than or equal to.
>	-	Greater than.
BZ	-	Breathing zone.
HSM	-	Health and safety manager.
LEL	-	Lower explosive limit.
mg/m^3	-	Milligrams per cubic meter.
PPE	-	Personal protective equipment.
ppm	-	Parts per million.
VOC	-	Volatile organic compound.

<u>No one is permitted to downgrade levels of PPE without authorization from the HSM/Certified Industrial Hygienist.</u>

Table 4-2

Air Monitoring Frequency and Location
RSA-271
Redstone Arsenal, Madison County, Alabama

Work Activity	Instrument	Frequency	Location
Monitoring well installation and development	PID LEL/O_2	Periodically (initially then every 15 minutes)	BZ of employees and near borehole
Groundwater sampling	PID LEL/O_2	Periodically (initially then every 15 minutes)	BZ of employees and at wellhead
Waste characterization sampling	LEL/O_2 PID	Periodically	BZ of employees
Soil Excavation and Loading	PID LEL/O_2	Periodically (initially then every 15 minutes)	BZ of employees

BZ - Breathing zone.
LEL - Lower Explosive Limit
PID - Photoionization detector 10.6-electron volt lamp
O_2 - Oxygen.

Table 5-1.01 Activity Hazard Analysis

Activity/Work Task: **Mobilization (and Demobilization)**	Overall Risk Assessment Code (RAC) (Use highest code)					**M**
Project Location: RSA-271, Redstone Arsenal Huntsville AL	**Risk Assessment Code (RAC) Matrix**					
Contract Number: W91ZLK-13-D-0018	**Severity**	**Probability**				
Date Prepared: July 21, 2020		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by (Name/Title): WD Russell/HSE Manager	Catastrophic	E	E	H	H	M
	Critical	E	H	H	M	L
Reviewed by (Name/Title):	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L

Notes: (Field Notes, Review Comments, etc.) Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment. Notes: (Field Notes, Review Comments, etc.) Completion of this AHA serves as certification of hazard assessment.	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)	
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk** **H = High Risk**
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk** **L = Low Risk**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Travel at project site.	Vehicle operation.	See vehicle operation AHA	18.A	**M**
Arrival of new personnel at site.	Untrained personnel.	All personnel working on hazardous, toxic, and radioactive waste (HTRW) shall submit HAZWOPER training certificates [40-hour, 8-hour (if applicable), and supervisor (if applicable)] to a Site Safety and Health Officer (SSHO). All personnel shall attend a site safety orientation. Other training certifications shall also be made available on site.	01.B 28.A	**L**
	Medical qualifications.	All personnel working on HTRW shall submit current physician's certificate stating that employee is participating in an appropriate medical surveillance program meeting 29 Code of Federal Regulation (CFR) §1910.120	01.C	**L**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Arrival of new personnel at site (continued).	Unfamiliarity with site, general (chemical, physical, environmental) site hazards, project safety rules and hazard control procedures, chain of command, and emergency procedures.	All personnel shall attend the site orientation training. The site orientation shall include a review of the phone locations, evacuation routes, and any special requests from the manager of the facility. After personnel are trained in the contents of the Accident Prevention Plan (APP), APP Addenda, they shall sign the APP Acknowledgment Form. Personnel who may participate in intrusive activities shall attend Munitions and Explosives of Concern Awareness Training. All pertinent AHAs shall be reviewed with personnel (as applicable). Post all hazard warning signs, emergency maps, and emergency phone numbers.	01.B.03 01.E.01 28 03.A.01.b	**L**
Unload equipment/prepare site.	Failure to properly plan daily activities.	A Job Safety Analysis (JSA), as required by AMS-710-05-FM-01708 “Job Safety Analysis (JSA),” shall be prepared by the crew prior to commencing daily activities. The JSA may be used as a component of the morning Tailgate Safety Meeting. The JSA shall be revised at any time throughout the workday when new tasks are initiated, unforeseen circumstances arise, or if working conditions change. Personnel shall implement Hazard Assessment Resolution Program.		**L**
	Heavy lifting, strains, and sprains.	No individual employee is permitted to lift any object that weighs over 50 pounds. Proper lifting techniques shall be used. Multiple employees or use of mechanical lifting devices are required for lifting objects over the 50-pound limit.	14.A.01	**L**
	Use of mechanical equipment.	Only qualified personnel shall be permitted to operate equipment. Mechanical equipment shall be inspected daily. Deficiencies in equipment shall be noted on the inspection form. Equipment found to be unsafe shall not be used. All equipment shall be operated at safe speeds and in a safe manner. Equipment operators shall wear safety belts and hearing protection. Ground personnel shall not position themselves between equipment and stationary objects. Personnel are only permitted to approach equipment after a signal from the operator	18.G	**L**
Prepare site.	Hand injuries.	Items to be handled shall be inspected for sharp edges prior to being handled. Personnel shall wear leather gloves when handling sharp materials. Personnel shall be aware of and avoid pinch point hazards.	05.A.08	**L**
	Fire.	Fire extinguishers shall be placed in work areas. The SSHO shall establish smoking areas in compliance with the facility policy. Engines shall be shut off before refueling. A 40-B/C fire extinguisher shall be available at refueling areas. Smoking shall not be permitted near fueling areas. Use caution with vehicle exhaust systems in grassy areas.	09.E.01 09.A.06	**L**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Prepare site (continued).	Chemical hazards.	The Exclusion Zones and Contamination Reduction Zones shall be set-up and appropriately marked with signage. The Emergency Eyewash station shall be inspected, cleaned, filled, and then placed in service. Notify all personnel of the emergency eyewash station location.	28 06.B.02.b 06.B.01.b	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment - Level D: Hard hat* Safety glasses Safety-toed boots Work gloves ANSI Class 2 reflective warning vests Equipment: Fire extinguishers Emergency eyewash First aid kit Deep-Woods Off or Ultrathon Repel Permanone, Permethrin Drinking water Weather radio or AM/FM radio	Competent Person (CP) / Qualified Person (QP): Brian Rhodes – CP/SSHO Brian Rhodes – QP/First Aid and CPR Training Requirements: Site safety orientation Applicable AHAs HAZWOPER 40-Hour Qualified equipment operators Lifting/back safety Fire extinguisher use Emergency procedures Biological hazard identification and control National Lightning Safety Institute Lightning Safety procedures	Daily site safety inspection (SSHO) Brian Rhodes Daily site safety inspection (QCO) –Brian Rhodes Check Known Allergies Questionnaire, training, and medical certifications against personnel roster Mechanized equipment (daily) Overhead and underground utilities Housekeeping (daily) Fire extinguisher (weekly) Vehicle inspection daily Equipment and tools inspection daily and before use Survey areas for poisonous plants, insects, and animals Check body for ticks

Table 5-1.02 Activity Hazard Analysis

Activity/Work Task: Installation of Surface Water and Erosion Controls	**Overall Risk Assessment Code (RAC) (Use highest code)**	**M**
Project Location: RSA-271, Redstone Arsenal Huntsville AL	**Risk Assessment Code (RAC) Matrix**	
Contract Number: W91ZLK-13-D-0018		
Date Prepared: 7-21-20		
Prepared by (Name/Title): WD Russell/HSE Manager		
Reviewed by (Name/Title):		
Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.		
Notes: (Field Notes, Review Comments, etc.) Completion of this AHA serves as certification of hazard assessment.		

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)

	RAC Chart
"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk** **L = Low Risk**

Job Steps	Hazards	Controls	RAC
Verify emergency communications are readily available. Identify overhead hazards and provide protective measures prior to equipment delivery. Establish lay-down area. Establish safe vehicle travel routes.	New personnel and visitors. Unfamiliarity with: scope of work, site lay-out, site hazards (chemical, physical, environmental), safety rules / hazard control procedures, chain of command, base rules, and emergency procedures.	Verify any new personnel have attended a site safety orientation, which includes training in the contents of the Accident Prevention Plan (APP), the work plans, Hazard Communication. Verify training certifications for personnel are available and kept in on-site personnel files. Review emergency procedures and evacuation plans.	L

Job Steps	Hazards	Controls	RAC
Continued from above. Off-load equipment or materials.	Use of subcontractors.	Communicate each subcontractor's assigned HSE representative identity to personnel. Subcontractors to identify, designate in writing (on the appropriate AHAs, AMS-710-02-FM-4201, and AMS-710-02-FM-04202), and provide appropriately trained and experienced competent and qualified personnel as required by AMS-710-02-PR-04200, Competent/Qualified Person Procedure. Subcontractors to provide certifications those operators are qualified on equipment they plan to use on site. Verify subcontractor-provided equipment are suitable for the tasks.	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
Construct erosion controls. Set up environmental management, spill prevention, and spill response controls. Maintain good housekeeping.	Changing tasks and conditions.	Prepare a Job Safety Analysis (JSA) prior to commencing each activity. Revise the JSA at any time throughout the workday when new tasks are initiated, unforeseen circumstances arise, or if working conditions change. Continuously review job steps, hazards, and hazard mitigation measures for each work task in accordance with the APTIM Step Back 5X5 procedure. Use the focused I-CARE observation process to identify and correct safe work conditions and behaviors, at risk behaviors and conditions, and imminent hazard situations and conditions.	L
	Loss of situational awareness (knowing what is going on around you).	Stop work - do not proceed until situational awareness is regained by all members of the work team. Retain or regain situational awareness: • Be alert for deviations from standard procedures. • Watch for changes in the performance of other team members. • Be proactive - provide information in advance. • Identify problems in a timely manner. • Show you are aware of what's going on around you - stay alert for changing conditions. • Communicate effectively. • Stay mindful of the activity status; continually assess and reassess the situation • Ensure all expectations are shared for complete awareness by the entire team. Increase situational awareness when near heavy equipment operations, vehicle use, and all high hazard activities.	L
	Improper hygiene - chemical exposure, illness.	Portable hand wash stations shall be provided for readily available access. Portable toilets shall be established in project support areas. Portable toilets shall be maintained in a clean condition and regularly serviced.	L
	Struck-by vehicles or heavy equipment - crushing.	Establish pedestrian routes to provide safe access to and from parking lots, lay down areas, and work areas. Establish vehicle routes to avoid pedestrian routes. Establish vehicle routes to minimize the need for reversing operations. Establish a "reverse in" parking plan for site vehicles (i.e., passenger cars and trucks). Provide warning signs and visibility aids as suitable traffic control measures in areas of restricted visibility or with width, or weight limits. Provide physical barriers, such as safety banks or stop blocks, to restrain vehicles near edges of roadways, excavations, pits, sensitive structures, etc. Observe base speed limits. Keep away from operating heavy equipment; never enter the swing radius of equipment unless equipment is shut-down.	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
	Contact with overhead and underground utilities - electrocution, fires, explosions, property damage, and equipment damage.	Identify overhead utilities in work areas and travel routes. All underground utilities must be located and marked prior to all intrusive activities. Obtain base digging permit prior to the start of any intrusive activities. Provide signage for overhead hazard warnings and underground utility mark-outs. Remain aware of overhead power lines or other overhead utilities and maintain safe clearances. Use spotters when necessary.	L
See job steps above.	Heavy lifting - strains, sprains.	No individual worker is permitted to lift any object that weighs over 50 pounds. Multiple employees or the use of mechanical lifting devices are required for lifting objects over the 50-pound limit. Personnel shall use proper lifting techniques such as keeping back straight, lifting with legs, limiting twisting, and getting help in moving bulky/heavy materials and equipment.	L
	Hand injuries - laceration, pinch points, crush, burns, amputation.	Items to be handled shall be inspected for sharp edges, rough surfaces, etc. Personnel shall wear appropriate gloves when handling equipment or materials with sharp edges, splinters, burrs, rough surfaces, etc. Personnel shall wear cut resistant gloves when using cutting tools. Personnel shall be aware of and avoid pinch point hazards (vehicle doors, tailgates, fence gates/latches, hinged boxes, equipment unloading/loading, pulleys, belts, drum-lid rings, between two drums, between drum and other object, etc.). Do not wrap rope, cables, wires, etc. around hands or fingers.	L
	Slips, trips, and falls - strains, sprains, fractures.	Understand the hazards of slips, trips, and falls – consider the consequences. Increase your awareness, keep alert, stay focused, and know your environment. Slow down - take smaller steps and lower your center of gravity when necessary. Do not jump from equipment or elevated surfaces. Use three-point contact rule for entering/exiting vehicles, trucks, and equipment. Be cautious and use stair rails when using stairs. Use caution when walking on wet, muddy, uneven, icy, or snow-covered surfaces. Eliminate, mark, provide warning signs, or barricade slip, trip, and fall hazards. Maintain proper illumination in work areas and passageways. Maintain sufficient clean and clear work areas, passageways, and stairways. Clean-up work areas throughout the day, before leaving work area, and at the end of each workday. STOP 100% fall protection required when working at heights over 6 feet.	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
	Noise - hearing impairment, distractions, and reduced communications.	Proper hearing protection shall be used as necessary to control noise exposures. Noise dosimetry shall be performed to verify hearing protection is adequate. Efforts shall be made to minimize noise whenever possible (for example, generator noise may be minimized by positioning the equipment away from the work area).	L
See job steps above.	Injury or damage from use of mechanical / heavy equipment - struck-by, crushing, roll-over, overhead or underground hazards, falls.	Only qualified personnel shall be permitted to operate equipment. Inspect equipment daily. Verify all mechanical guards and backing alarms are in place and functioning properly. Note equipment deficiencies on the inspection form. Do not use unsafe equipment. Operator to wear safety belt, operate the equipment at safe speeds and in a safe manner, and is prohibited from using telephone while operating equipment. Review hand signals and communication procedures between operators and spotter. Personnel are only permitted to approach equipment after a signal from the operator. Ground personnel and spotter shall wear high visibility vests, stay out of swing radius, and not position themselves between equipment and stationary objects. Evaluate conditions to determine proper equipment to use for task. Obtain proper equipment for task.	L
	Use of forklift - crushing, pinch-points, roll-over, impalement, or overhead hazards, electrocution.	Forklift operators must have proper qualifications with valid license. Read and follow manufacturer's operating manual. Follow all equipment warnings. Know the capacity and operating characteristics of the forklift equipment being used. Wear seatbelt when operating a forklift. Do not allow riders for any reason on forklift. Always use three point contacts when mounting or dismounting a forklift. or pass under the raised pallet forks, mast, carriage, boom or attachments. Survey operation area for overhead hazards before use. De-energize or otherwise control electrical hazard from overhead power lines. Carry the load low – at minimum clearance. Use a spotter whenever necessary. Refer to manufacturer's operating manual before adjusting forks. Identify all pinch points before making adjustments. Wear heavy duty gloves and keep hands away from all pinch points. No loads shall be suspended from the forks without use of a manufacturer-approved lifting device (e.g., a “truss boom”). Never use attachments unless specifically authorized by the manufacturer of the forklift. Extendable-boom forklifts are subject to decreasing lift capacity as the boom is extended and the center of gravity changes. Prior to performing the lift, the following shall be documented: the total weight of the lift (i.e., the cumulative weight of the truss boom, load,	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
		and rigging), the capacity of the forklift at the maximum boom extension, and the percentage of the forklift capacity at the maximum boom extension to be used for the pick and placement.	
	Injury from use of tools and general equipment - laceration, electric shock, entanglement, vision/hearing impairment.	Select the proper tool – do not improvise. Tools shall be appropriate for the task and maintained in good condition. Read and follow manufacturer's operator manual for tools before use. Wear appropriate PPE including gloves, eye protection, face, and hearing protection appropriate for the tool in use. Inspect all power and hand tools before each use (do not use damaged tools). Verify proper guards or shields are present on power tools before use. Check your position, footing, and grip before tool use. Avoid distraction, keep your focus, and concentrate on the job. Maintain a steady pace when using tools and take adequate rest periods. Keep electric cords untangled and out of the way of rotating tools. Protect electric tools, extension cords, and portable lights with ground-fault circuit interrupters (GFCI). Use double-insulated power tools when possible. Power tools that are not double-insulated must have ground pin in place. Use the safest cutting tool for the job (e.g., knives with automatic retractable blades, scissors, strippers, etc.). Any unprotected blade tool must be the last resort when choosing a cutting tool.	L
	Fire - burns, smoke inhalation, property damage.	Use hot work permitting system for any flame or spark producing activities. Establish smoking areas and smoke only in designated areas. Only discard cigarette butts in proper receptacles – never discard cigarette butts onto the ground. Smoking shall not be permitted within 50 feet of fueling operations. Store gasoline in safety cans with flash arresters and spring-loaded vents. Shut off engines and allow to cool before refueling. A fire extinguisher appropriate for all types of work being conducted shall be placed in the work area.	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
See job steps above.	Poor housekeeping - slips, trips, falls, fire, spills, or environmental damage.	Job sites shall comply with company housekeeping policies as described in AMS-710-02-PR-00100, Housekeeping. Regular inspections of the job site shall be performed to assure ongoing safe work areas. Clean and organize work areas regularly during the shift and throughout the day to eliminate tripping or fire hazards. Keep work areas clear and maintain a clean and organized work environment. Keep areas free of debris or unused materials. Maintain secured storage areas, and provide locations for equipment and materials storage. Tools should be kept in good condition and stored properly when not in use. Protect cutting edges of tools, and assure tools are stored where they will not present a tripping hazard. Prepare, communicate, implement, and maintain a Site Environmental Management Plan (AMS-710-04-FM-00401) as required by AMS-710-04-PR-00400, Site Environmental Management Plan. Flammable, combustible, toxic, and other hazardous materials shall be stored in approved containers in designated areas that are appropriate for the different hazards that they pose as required by AMS-710-04-PR-04102, Chemical Storage and Compatibility. Regularly clean and maintain equipment. Use secondary containment, guards, or drip pans when possible to prevent hazards from spills or leaks. Properly dispose of any used absorbent materials. Waste materials shall be properly disposed throughout the work day. All waste and recycle containers shall be readily accessible and clearly labeled.	**L**
	Biological hazards (poisonous and irritating plants, such as poison ivy, poison oak, and poison sumac) - contact dermatitis sometimes leading to infection.	Learn to identify poisonous and irritating plants. Inspect work areas to identify if poisonous and irritating plants are present. Identify workers who are known to be especially sensitive to irritating plants and plan work accordingly. Clear plant/vegetation around work areas, but avoid unnecessary clearing. Wear Tyvek® coveralls and disposable gloves to avoid skin contact with irritating plants when clearing vegetation and when in areas suspected to have irritating plants. Immediately notify SSHO if you suspect contact with irritating plants.	**L**

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
See job steps above.	Biological hazards (insects/bees) - bites and stings, distraction, irritation, infection, allergic reaction.	Review injury and illness potential with workers. Expect to encounter insects when working in warm weather – especially at locations with vegetation present. Use protective insect repellents containing DEET (Deep Woods Off or equivalent), unless individual allergies and sensitivities prevent its use. Inspect areas for bee nests and insect activity prior to commencing work in that area. Wear long-sleeved shirts when working in areas with mosquitos and ticks. Check limbs/body for insects/insect bites upon removing PPE and during showering. Notify the SSHO of insect bites, stings, irritations, rashes, or flu-like symptoms.	L
	Severe weather - electrocution, struck by materials or debris.	The SSHO to plan for and prepare for hazardous weather. The SSHO to identify the nearest suitable storm and tornado shelter at each work location. The SSHO will verify that the storm and tornado shelters are accessible and available. The SSHO to monitor local conditions, the lightning detector, weather reports, and radar when the risk for hazardous weather is elevated. Prepare excavations and work areas in advance when high winds or flooding are predicted at the site. Work activities will be suspended prior to weather conditions becoming too hazardous so that workers have ample time to seek safe shelter. Evacuate to tornado shelters when tornado warnings are sounded or at any time it becomes appropriate to seek shelter while there is still enough time to safely do so. Lightning procedure: • When a thunderstorm has formed and is within 20 miles of the site, as measured with a “Strike Alert” lightning detector, the Site Manager and SSHO will begin planning for employees to cease outdoor activities, safely evacuate the field, and take appropriate shelter. • When active lightning is sighted and detected to be within 10 miles and approaching the site, the Site Manager and/or SSHO will issue a directive to “clear the field” and cease all outdoor work activities. Personnel shall be evacuated to safe areas (inside vehicles, buildings, or storm and tornado shelters as appropriate). • The post-lightning, “all clear, return to the field” direction will be given after a thirty (30) minute interval from the last reportable strike that was within ten (10) miles of the site, after consideration has been given to the additional lightning potential of any other on-coming storm cells.	L

Table 5-1.02 Activity Hazard Analysis

Job Steps	Hazards	Controls	RAC
See job steps above.	Heat stress - exhaustion, rash, heat stroke.	Drink plenty of water when under heat stress conditions (up to 8.5 oz. every 10 minutes under high heat stress conditions). Provide for adequate electrolyte replacement, adjust work activities, take breaks to cool down as needed, use sunscreen, and provide shade or cooled shelter during rest periods.	L
	Cold stress - frost bite; hypothermia.	Wear insulating clothing in layers. Monitor for cold stress in accordance with the requirements of the APP. Drink warm beverages when under cold stress conditions, avoid caffeine, take breaks to warm up as needed, and provide heated areas for rest periods.	L

Table 5-1.02 Activity Hazard Analysis

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment: • Hard hats meeting ANSI/ISEA Z89.1 • Safety glasses with side shields meeting ANSI/ISEA Z87.1 • Safety-toed boots meeting ASTM 2413 (safety toe tennis shoes prohibited) • Impact resistant work gloves when handling equipment and materials • Cut resistant gloves when using cutting tools • Class 2 high visibility vests, when working near roads, moving equipment, or vehicles • Hearing protection, as necessary • Electrical PPE (section 130.7, NFPA 70E, 2015) **Equipment:** • First aid kit • Fire Extinguishers • GFCI • Heavy duty extension cords (S, ST, SO, STO, SJ, SJO, SJT, SJOT) • Drinking water • Hazard warning signs • Caution tape, barricades, fencing • Fork lift • Hand wash station • Electrical tools and equipment (section 130.7, NFPA 70E, 2015) • Insect repellant with DEET	**Competent Person (CP) / Qualified Person (QP):** CP/ SSHO Brian Rhodes **Training Requirements:** • Site safety orientation • Emergency procedures • Hazard communication • Hearing conservation • Work plans • Applicable AHAs • Lifting/back safety (proper lifting techniques) • Qualified fork lift operator • Good housekeeping practices • Fire extinguisher use • Biological hazard identification and control • Tornado shelter location • Lightning safety procedures • Heat stress prevention and heat stroke treatment	**Inspections:** • Daily Site HSE inspection (Supervisors): ______________________ • Daily HSE inspection (SSHO): Briaan Rhodes • Overhead/underground utilities • Vehicle inspection (daily) • Mechanized equipment (U.S. Army Corps of Engineers form prior to use) • Mechanized equipment (daily) • Fork lift (daily) • Equipment and tools inspection (daily and before use) • Housekeeping (daily) • Rigging for proper rating tag; visual inspection for wear or fraying (before each use) • Fire extinguishers (monthly) • Housekeeping (daily) • Survey areas for poisonous plants, insects, and animals • Verify tornado shelter is available

Table 5-1.02 Activity Hazard Analysis

Signature Log Activity Hazard Analysis (AHA), Installation of Surface Water and Erosion Controls

Printed Name	Signature	Representing	Date

Table 5-1.03 Activity Hazard Analysis

Activity/Work Task: Vegetation Clearing	Overall Risk Assessment Code (RAC) (Use highest code)							M
Project Location: RSA-271, Redstone Arsenal, Huntsville, AL	**Risk Assessment Code (RAC) Matrix**							
Contract Number: W91ZLK-13-D-0018	**Severity**	**Probability**						
Date Prepared: 7-21-20		Frequent	Likely	Occasional	Seldom	Unlikely		
Prepared by (Name/Title): WD Russell/HSE Manager	Catastrophic	E	E	H	H	M		
	Critical	E	H	H	M	L		
Reviewed by (Name/Title):	Marginal	H	M	M	L	L		
	Negligible	M	L	L	L	L		

Notes: (Field Notes, Review Comments, etc.)
Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.

Notes: (Field Notes, Review Comments, etc.)
Completion of this AHA serves as certification of hazard assessment.

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk**
	H = High Risk
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk**
	L = Low Risk

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Arrival of new personnel at site.	Unfamiliarity with: site, general site hazards, project safety rules, chain of command, and emergency procedures.	• All personnel shall attend the site orientation training.	01.B.03 01.E.01 28	L
Vegetation removal.	Poor planning.	• Complete Job Safety Analysis for each task, as specified in AMS-710-05-PR-01700 "Work Area Hazard Assessment Process." Use Hazard Assessment Resolution Program frequently – for each task to be completed.		L
	Heavy lifting, strains, and sprains.	• No individual employee is permitted to lift any object that weighs over 50 pounds. Proper lifting techniques shall be used. Multiple employees or the use of mechanical lifting devices are required for lifting objects over the 50-pound limit.	14.A.01	L
	Struck-by/against.	• Wear reflective warning vests when exposed to vehicular traffic. Personnel working on or near roads and only remain on road long enough to complete work. Personnel walking along roadway shall stay off roadway as far as possible and walk on the side facing traffic.	05.F	L
	Intrusive activities.	• Follow procedure for Intrusive Activities Permit in Accident Prevention Plan (APP) prior to commencing clearing and grubbing activities. Follow MEC avoidance techniques in accordance with EP 75-1-2 during all vegetation removal.	25.A.01	L

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Vegetation removal (continued).	Slips, trips, and falls.	• Keep work areas clear and maintain housekeeping. Personnel shall not jump from elevated surfaces. Personnel shall use caution when walking on rocky, slippery, or uneven terrain.	14.C.01-10	L
	Hand injuries.	• Items to be handled shall be inspected for sharp edges prior to being handled. Personnel shall wear leather gloves when handling sharp materials. Personnel shall be aware of and avoid pinch point hazards.	05.A.08	L
	Use of heavy equipment.	• Only qualified personnel shall be permitted to operate equipment. Heavy equipment shall be inspected daily after the initial U.S. Army Corps of Engineers inspection (and documented.) Do not use unsafe equipment. All equipment shall have backing alarms. All equipment shall be operated at safe speeds and in a safe manner. Equipment operators shall wear safety belts. Personnel are only permitted to approach equipment after a signal from the operator. Ground personnel, working near heavy equipment, shall wear high visibility conspicuity vests. Ground personnel shall not enter the swing radius of equipment. Ground personnel shall not position themselves between equipment and stationary objects. Personnel shall verify all mechanical guards are in place and functioning properly. Moving equipment shall be equipped with a back-up alarm. All equipment shall be shut down with energies dissipated prior to performing maintenance activities - lock out/tag out procedures may apply. Only qualified mechanics shall work on or repair heavy equipment. Heavy equipment shall be equipped with Falling Object Protective Structure. Ground personnel shall stay clear at least twice the distance of the height of the tree being pushed over.	18.A 18.G 18.B 05.F 18.B.12	L
	Injury from chain saws, wood/falling trees, chips, cuts, and noise.	• Chain saw operators shall wear a specially designed helmet system (consisting of head, face, and hearing protection). Use gloves and chaps at all times when using saw. Operators shall wear chain saw protective boots with steel toes. Secure loose fitting clothing with duct tape. Keep other personnel at least two tree lengths away from tree being felled. Operators shall have escape routes planned that are at 45 degrees from the projected direction of the falling tree. Keep escape routes clear of all tools, materials, and wood/brush. Always cut away from the body. Shut off chain saws when walking between work areas. Have spotter assist when falling large or tall trees. Only cut trees, logs, or branches from ground height. Shut off engines before freeing pinched chains. Chain saw operators shall always hold the saw with both hands during cutting operations. Inspect chain saw before each use. Do not use saws in which any safety feature is not functioning. Frequently check and adjust tension on chain. Do not use saws with or dull cutters. Do not increase force used as cutters become dull. The idle speed shall be properly adjusted to prevent the chain from moving when the engine is idling. Keep bar groove clean. Use only new chains or professionally sharpened chains. Replace sprockets, which show signs of wear. Remain alert to kickback hazards and keep a firm, proper grip on chain saw at all times. All chain saws shall be equipped with automatic chain brake and other anti-kickback devices. Use wedges to prevent binding of the chain. Do not cut with the tip (nose) of the bar. Do not use dull chains. Do not overreach with chain saw. Personnel shall not operate chain saws above shoulder height. Personnel shall be familiar with cutting techniques.	13.F 13.A 31.C	L

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Vegetation removal (continued).	Tree pruning, falling, and brush removal/chipping.	• Machete use is prohibited. Personnel operating weed whackers shall wear hearing protection and eye/face protection. Steel blade use on weed whackers is prohibited. The procedures outlined in *Safety and Health Requirements Manual*, Sections 31.C, 31.D and 31.E shall be conveyed to all personnel involved in the operations. Remain clear of feed and discharge chutes on chippers.	31.C 31.D 31.E	L
	Fatigue.	• Chainsaw and equipment operators shall be given ample rest breaks.		L
	Insect bites/West Nile virus.	• Wear personal protective equipment (PPE) and tape joints to keep insects away from the skin. Use protective insect repellents containing N,N-diethyl-m-toluamide, such as, 3M Ultrathon or equivalent and clothing insecticide preparations containing permethrins (Repel Permanone or equivalent) to prevent insect bites. Check limbs/body for insects/insect bites before showering. Notify Site Safety and Health Officer (SSHO) of flu-like symptoms.	06.D.01	L
	Contact dermatitis and poison ivy.	• Check around work areas to identify if poison ivy is present. Wear long-sleeve shirts/trousers or Tyvek® coveralls to avoid skin contact with plants or other skin irritants. Learn to identify poisonous plants. • Avoid unnecessary clearing of plant/vegetation areas. • Cover vegetation with plastic (visqueen) where sampling position raises exposure potential. Apply protective cream/lotion to exposed skin to prevent poison ivy or similar reactions. Identify workers who are known to contract poison ivy.	06.D.03	L
	Severe weather.	• The SSHO will monitor weather conditions each day in order to plan and prepare for hazardous conditions. The SSHO will identify a suitable tornado shelter at each work location. Work activities will be suspended prior to weather conditions becoming hazardous so that workers have ample time to seek shelter. Upon seeing lightning or hearing thunder, outdoor activities shall be suspended and personnel shall be evacuated to safe areas (inside vehicles, buildings, or tornado shelters as appropriate). Follow procedures outlined in the APP.	06.I	L
	Hazardous atmospheres.	• Personnel shall immediately notify the SSHO if odors are detected.		L
	Heat stress and cold stress.	• Follow procedures outlined in the Site Safety and Health Plan.	06.I	L
	Dust.	• Dust shall be monitored and controlled. PPE use is required when working in contaminated areas.	28	L
	Fire.	• Smoking shall be permitted in designated areas. Vehicles shall not be parked in tall dry grass. • Engines shall be shut off before refueling. A 10-B:C fire extinguisher shall be available when refueling. Smoking shall not be permitted near fueling areas. Gasoline shall be stored in safety cans with flash arrestors and spring-loaded vents.	09.E.01 09.A.06 09.B.08	L

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment - Level D - Modified: Hard hat Safety glasses Safety-toed boots Work gloves ANSI Class 2 reflective warning vests Disposable coveralls and protective gloves (when contact with irritating plants possible) Helmet systems for chain saw use Protective chaps for chain saw use Hearing protection Equipment: Magnetometers Excavator Fire extinguishers Emergency eyewash First aid kit Deep-Woods Off or Ultrathon Repel Permanone Drinking water Weather radio or AM/FM radio Chain saws Extra chains Plastic or wood wedges	Competent Person (CP) / Qualified Person (QP): Brian Rhodes – CP/SSHO Brian Rhodes– QP/First Aid and CPR Training Requirements: Site safety orientation Applicable AHAs HAZWOPER 40-Hour Qualified equipment operators Lifting/back safety Fire extinguisher use Biological hazard identification and control Emergency procedures Tornado shelter locations National Lightning Safety Institute Lightning Safety procedures	Daily site safety inspection (SSHO) – Daily site safety inspection (QCO) – Check Known Allergies Questionnaire Housekeeping (daily) Fire extinguisher (weekly) Vehicle inspection daily Overhead and underground utilities Mechanized equipment (daily) Equipment and tools inspection daily and before use Survey areas for poisonous plants, insects, and animals Check body for ticks Verify tornado shelter available Monitor approaching storms

Table 5-1.04 Activity Hazard Analysis

Activity/Work Task: Surveying and Marking	Overall Risk Assessment Code (RAC) (Use highest code)					M
	Risk Assessment Code (RAC) Matrix					
Project Location: RSA-271, Redstone Arsenal, Huntsville AL	Severity	Probability				
Contract Number: W91ZLK-13-D-0018		Frequent	Likely	Occasional	Seldom	Unlikely
Date Prepared: 7-21-20	Catastrophic	E	E	H	H	M
Prepared by (Name/Title): WD Russell/HSE Manager	Critical	E	H	H	M	L
Reviewed by (Name/Title):	Marginal	H	M	M	L	L
Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.	Negligible	M	L	L	L	L
	Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above)					
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.				RAC Chart	
Notes: (Field Notes, Review Comments, etc.) Completion of this AHA serves as certification of hazard assessment. Appropriate work gloves will be worn when entering the work environment and during all work-related activities. Gloves will not be removed until the worker leaves the work environment.	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible				E = Extremely High Risk H = High Risk	
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.				M = Moderate Risk L = Low Risk	

Job Steps	Hazards	Controls	RAC
Walking the Site Lifting Equipment and Materials.	Slips, trips, and falls	• Inspect work areas for washes, potholes, or other surface irregularities that could cause slips, trips or falls. • Always establish good footing. • Maintain good housekeeping. Keep walkways clear of debris and tools.	L
	Muscle strains	• Observe 50 lb individual lifting limit. • Don't lift and twist. • Get help for loads greater than 60 lbs. • Train workers in safe lifting techniques.	L
Mobile Equipment	Striking workers or equipment	• Use spotters when backing. • Inspect area for overhead and underground hazards. • Know the safest route to and from your work area. • Use flags, traffic cones to control traffic.	L
Changed or Unanticipated Conditions	Safety or health hazards that may be derived from changed or unanticipated conditions	Modify the AHA as often as necessary to address new or unanticipated hazards. Use "Job Safety Analysis" form to facilitate field documentation.	NA

Table 5-1.04 Activity Hazard Analysis

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment: • Hard hats meeting ANSI/ISEA Z89.1 • Safety glasses with side shields meeting ANSI/ISEA Z87.1 • Safety-toed boots meeting ASTM 2413 (safety toe tennis shoes prohibited) • Impact resistant work gloves when handling equipment and materials • Cut resistant gloves when using cutting tools • Class 2 high visibility vests, when working near roads, moving equipment, or vehicles • Hearing protection, as necessary • Electrical PPE (section 130.7, NFPA 70E, 2015) **Equipment:** • First aid kit • Fire Extinguishers • GFCI • Heavy duty extension cords (S, ST, SO, STO, SJ, SJO, SJT, SJOT) • Drinking water • Hazard warning signs • Caution tape, barricades, fencing • Hand wash station • Electrical tools and equipment (section 130.7, NFPA 70E, 2015) • Insect repellant with DEET	**Competent Person (CP) / Qualified Person (QP):** CP/ SSHO Brian Rhodes____________________ Alternate CP/ SSHO ________________________ QP/First Aid and CPR ______________________ QP/First Aid and CPR ______________________ **Training Requirements:** • Site safety orientation • Emergency procedures • Hazard communication • Hearing conservation • Work plans • Applicable AHAs • Good housekeeping practices • Fire extinguisher use • Biological hazard identification and control • Tornado shelter location • Lightning safety procedures • Heat stress prevention and heat stroke treatment	**Inspections:** • Daily Site HSE inspection (Supervisors): ____________________________________ • Daily HSE inspection (SSHO): ____________________________________ • Overhead/underground utilities • Vehicle inspection (daily) • Inspect non-construction equipment and power tools per manufacturer requirements. • Housekeeping (daily) • Fire extinguishers (monthly) • Housekeeping (daily) • Survey areas for poisonous plants, insects, and animals • Verify heavy weather / tornado shelter is available

Table 5-1.04 Activity Hazard Analysis

Signature Log -AHA 5.0: Activity Hazard Analysis (AHA), Utility and Land Survey

Printed Name	Signature	Representing	Date

Table 5-1.05 Activity Hazard Analysis

Activity/Work Task: Welll Installation and Groundwater Sampling	Overall Risk Assessment Code (RAC) (Use highest code): **M**
Project Location: RSA-271, Redstone Arsenal, Huntsville, AL	
Contract Number: W91ZLK-13-D-0018	
Date Prepared: 7-21-20	
Prepared by (Name/Title): WD Russell/HSE Manager	
Reviewed by (Name/Title):	

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

RAC Chart

- **E = Extremely High Risk**
- **H = High Risk**
- **M = Moderate Risk**
- **L = Low Risk**

Notes: (Field Notes, Review Comments, etc.)
Completion of this AHA serves as certification of hazard assessment.

Job Steps	Hazards	Controls	RAC
Travel on and off project site (vehicular).	Vehicle Operation.	See AHA for Vehicle Operations	L
Arrival of new personnel at site. Identify overhead and underground utilities. Set up and inspect specialty equipment. Operate equipment. Drill/bore holes. Install well casings. Place filter pack, seals, and grout. Provide surface completion. Develop well. Collect water levels and sample.	Newly hired personnel and visitors. Unfamiliarity with: site, general (chemical, physical, environmental) site hazards, project safety rules and hazard control procedures, chain of command, and emergency procedures.	All personnel working in hazardous, toxic, and radioactive waste (HTRW) areas (well drilling into contaminated water) shall submit Hazardous Waste Operations and Emergency Response (HAZWOPER) training certificates (40-hour, 8-hour refresher [if applicable], 8-hour supervisor [if applicable]) to the Site Safety and Health Officer (SSHO). All personnel shall attend a site safety orientation. After personnel are trained in the contents of the Accident Prevention Plan (APP) and the Site Safety and Health Plan (SSHP), they shall sign the APP Acknowledgment Form and the SSHP Acknowledgment Form. All training certifications held by personnel shall also be made available and kept in on-site personnel files. Review emergency procedures and evacuation plans.	L

Job Steps	Hazards	Controls	RAC
See principal job steps above.	Medical qualifications and hearing conservation.	All personnel working in HAZWOPER-regulated areas shall submit current physician's certificate stating that employee is participating in an appropriate medical surveillance program meeting Title 29, Code of Federal Regulations (CFR), §1910.120 and the Interim Guidance (2012)..	L
	Complacency.	All personnel shall attend the morning safety meetings to re-focus themselves to hazards, emergency procedures and equipment, operational aspects, and change(s) in site/work conditions. Recommended control measures for the hazards shall be part of the discussion.	L
	Failure to properly plan daily activities.	A Job Safety Analysis (JSA), as required by AMS-710-05-PR-01700, Work Area Hazard Assessment Process, shall be prepared by the crew prior to commencing daily activities. The JSA shall be used as a component of the morning Safety Meeting. The JSA shall be revised at any time throughout the workday when new tasks are initiated, unforeseen circumstances arise, or if working conditions change. Personnel shall implement Hazard Assessment Resolution Process and Safety Step Back.	L
	Heavy lifting, strains, and sprains.	Proper lifting techniques shall be used. No individual worker is permitted to lift any object that weighs over 50 pounds. Multiple employees or the use of mechanical lifting devices are required for lifting objects over the 50-pound limit.	L
	Fire.	Fire extinguishers shall be available in work areas. A 20A:B/C fire extinguisher shall be available when refueling at the project site. The SSHO shall establish smoking areas. Smoke only in designated areas. Only discard cigarette butts in proper receptacles – never discard cigarette butts onto the ground. Smoking shall not be permitted within 50 feet of fueling operations. Use caution with vehicle exhaust systems in grassy areas. Do not run vehicles while parked in grassy areas. Engines shall be shut off before refueling. Follow AHA "Fueling Operations." Obtain APTIM hot work permit and RSA Fire Department concurrence.	L
	Overhead utilities.	Before equipment is moved, the travel route shall be surveyed for overhead and terrain hazards. The minimum distances from electrical lines must be observed in accordance with EM-385-1-1 Table 11-1. Power lines shall be assumed to be energized unless verified to be de-energized and visibly grounded. Operation beneath a power line that has not been verified as de-energized and grounded must maintain clearance distances stated above. A high-visibility elevated warning line or barricade shall be erected at the minimum approach distance. Each work crew member shall be trained in the electrocution hazards and emergency procedures associated with energized power lines. RSA public works personnel who may be required to deenergize overhead electric lines shall follow NFPA 70E requirements and be familiar with arc flash protection requirements.	L

Job Steps	Hazards	Controls	RAC
See principal job steps above.	Underground utilities.	Follow the procedure for intrusive activities in the APP. Follow procedure for intrusive activities in the APP SSHP and follow AMS-710-02-FM-01601, Excavation Permit, and AMS-710-02-PR-01610, Identifying Underground Installations, shall be followed.Utilities shall be located and marked prior to commencing intrusive activities. The Alabama One Call Law must be followed. Contact Digger's Hotline of Alabama at least 10 days but not less than 48 hours prior to commencing intrusive activities off base, excluding weekends or any state or federal holidays. Retain a copy of mark-out ticket for documentation purposes and QC purposes.On base utilities shall be cleared by the RSA Public Works Department. Documentation of utility mark-out must be completed using the Utility Mark-out Documentation form. No boring work is to be performed until all utility mark-outs are verified.Hand clear upper 5 feet of bore hole or seek Authorization to Drill permit. Intrusive activities may not proceed until an AMS-710-02-FM-01601, Excavation Permit has been issued for any intrusive activity below 12 inches depth including hand borings, DPT, etc.	L
	Slips, trips, and falls.	Understand the hazard of slips, trips, and falls – consider the consequences. Do not jump from equipment or elevated surfaces. Clean-up work areas throughout the day and at the end of each workday. Use three-point contact rule for entering/exiting vehicles, trucks, and equipment. Use hand rails and other stationary objects (door frames, door knobs, steering wheels, walls, etc) to increase stability. Use extra caution when walking on wet, muddy, or other slippery surfaces. Increase your awareness, keep alert, stay focused, and know your environment. Provide warning signs or cordon off areas where necessary. Consider postponing work as necessary and feasible. Avoid slippery areas when possible. Stay away from slopes, hills, and grades. Be cautious when using stairs. Remove snow and ice when possible (shoveling, chipping, and salt application). Apply traction aids, such as sand, gravels, and straw. Choose footwear wisely. Slow down - take smaller steps. Lower your center of gravity when necessary. Maintain proper illumination in work areas. Fall protection must be provided and used when personnel are exposed to fall hazards greater than 6 feet.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Hand injuries.	Items to be handled shall be inspected for sharp edges, splinters, burrs, rough surfaces, etc. prior to being handled. Personnel shall wear leather or appropriate ANSI cut resistant gloves when handling materials with sharp edges, splinters, burrs, rough surfaces, etc. Personnel shall be aware of and avoid pinch point hazards.	L
	Contaminated water	Avoid physical contact with potentially contaminated water and soil.	L
	Use of mechanical equipment.	Only qualified personnel shall be permitted to operate equipment. Forklift operators must be licensed. Mechanical equipment shall be inspected daily. Deficiencies in equipment shall be noted on the inspection form. Equipment found to be unsafe shall be taken out of serviced. Equipment operators shall wear safety belts and hearing protection (as necessary). All equipment shall be operated at safe speeds and in a safe manner. Ground personnel shall not position themselves between equipment and stationary objects (stay out of swing radius). Personnel are only permitted to approach equipment after a signal from the operator.	L
	Injury from drill rig use.	A copy of the drill rig manual shall be available at the job site. All components of the rig that has a direct bearing on the safety of the operation shall be inspected at the beginning of each shift and when possible, observed during operation. Do not use rig if it is not in a safe operating condition. The rig shall be positioned in a level fashion with stands and outriggers set. All guards for moving machinery shall be in place. Be aware of pinch-point hazards and work in a manner to prevent injuries. Keep hands out of areas that may present a pinching hazard and personnel shall not position themselves between equipment. Crewmembers shall not wear loose coveralls, clothing, or jewelry.The operator shall verbally alert employees and visually ensure employees are clear from dangerous parts of equipment prior to starting or engaging equipment. Be aware of and avoid hot surfaces from heat generated from engine and rope friction (such as cathead). Drilling equipment shall be equipped two easily accessible emergency shutdown devices, one for the operator and one for the helper. All crewmembers, including geologists, shall know the location and operation of the kill switches. Augers shall be equipped with an auger guard or position sensor brake.Drill rods shall be neither run nor rotated through rod slipping devices: no more than one foot of drill rod column shall be hoisted above the top of the drill mast.Drill rod tool joints shall not be made up, tightened, or loosened while the rod column is supported by a rod slipping device.Clean augers or other tools only when rotating/actuating mechanisms are in neutral and stopped. Use long handle shovels to remove auger spoils.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Struck by and against (vehicles and equipment)	Wear PPE with high visibility vests when walking or working near moving equipment or vehicles. Personnel shall not be permitted in the swing radius of the equipment. Personnel shall maintain a safe distance from operations. Do not assume equipment and vehicle operators have seen you unless operator have made eye contact with you and signaled to you. Warning signs and signalmen may be necessary.	L
	Electrical.	GFCIs shall be used on all power tools and extension cords. Extension cords, power tools, and lighting equipment shall be inspected before each use, protected from damage, and kept out of wet areas. The extension cords amp rating will exceed the sum of amp ratings of equipment connected to them. Only qualified electricians are permitted to work on electrical circuits. Electricians must follow NFPA 70 E (2014) when working on electrical circuits.	L
	Injury from use of tools.	Select the proper tool – do not improvise. Inspect all power and hand tools before each use (do not use damaged tools). Tools shall be appropriate for the task and maintained in good condition. Check your position, footing, and grip before tool use. Avoid distraction, keep your focus, and concentrate on the job. Personnel shall maintain a steady pace when using tools and take adequate rest periods. Keep electric cords untangled and out of the way of rotating tools. Use double-insulated power tools when possible. Protect electric tools with ground-fault circuit interrupters (GFCIs).	L
	Open borings.	The boring/well shall be covered, secured, and flagged when work is not in progress.	L
	Dust.	Control dust by maintaining equipment operation rates. Control dust by applying water. Personnel shall stay out of dust and work from upwind when possible.	L
	Use of operational chemicals.	Read and follow SDS for each chemical used. Do not use any chemical that you have not been trained to safely use. Provide ventilation as necessary. Wear proper PPE. Properly label all containers.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Use of portable generators.	Review operator manual before use. Keep the generator dry and do not use in rain or wet conditions. Dry your hands (if wet) before touching the generator. Use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads (S, ST, SO, STO, SJ, SJO, SJT, SJOT). Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin. Check operator's manual for generator grounding requirements, if any. Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite. Do not use portable generators in areas with dry grass unless area has been adequately cleared of the grass. Use hearing protection when working near a generator. Use proper lifting procedures when moving portable generators. Do not use indoors or in areas with poor ventilation without performing air monitoring for carbon monoxide.	L
	Noise.	All personnel shall wear hearing protection when exposed to high noise levels. All personnel shall wear hearing protection when operating powered hand tools or noisy equipment. Personnel working in vicinity of noisy tools or equipment shall wear hearing protection. Noise dosimetry shall be performed to verify hearing protection is adequate.	L
	Welding, cutting, and grinding or any other operation producing spark or ignition sources (hot work).	A Hot Work permit must be available and properly completed. Welder helmets, tinted cutting goggles, aprons, leathers, and gloves shall be available and utilized for welding and cutting operations. Faceshield must be worn for all grinding operations. Remove dry grasses from areas where hot work will be performed. Do not perform hot work when conditions are dry and windy. Combustible materials must be protected from slag, heat, and sparks. All torch valves and gas supplies must be shut off when work is suspended. Oxygen cylinders in storage and fuel gases shall be separated by a fire resistive wall or by a distance of 20 feet. "No Smoking" signs shall be posted around cylinder storage area. The pressure on the working side of the acetylene regulator should not be greater than 15 psig. All oxygen-fuel gas cutting or welding shall be equipped with reverse-flow check valves between torch & hoses. Inspect the hoses for defects before each use. All pressure gauges and regulators shall be in proper working order. Inspect welding equipment daily.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Welding, cutting, and grinding or any other operation producing spark or ignition sources (hot work).	The electric welding unit shall be shutdown when leads are unattended. Frames of electric welders shall be grounded. Workers and the public shall be shielded from rays, flashes, sparks, molten metal and slag. Identify all hot surfaces with signs or tags to protect workers from burns. Provide a fire watch equipped with a fire extinguisher for at least 1-hour after hot work has been completed. Only qualified personnel shall operate welding and cutting equipment. A Hot Work permit must be available and properly completed. Welder helmets, tinted cutting goggles, aprons, leathers, and gloves shall be available and utilized for welding and cutting operations. Faceshield must be worn for all grinding operations. Remove dry grasses from areas where hot work will be performed. Do not perform hot work when conditions are dry and windy. Combustible materials must be protected from slag, heat, and sparks. All torch valves and gas supplies must be shut off when work is suspended. Oxygen cylinders in storage and fuel gases shall be separated by a fire resistive wall or by a distance of 20 feet. "No Smoking" signs shall be posted around cylinder storage area. All oxygen-fuel gas cutting or welding shall be equipped with reverse-flow check valves between torch & hoses. Inspect the hoses for defects before each use. All pressure gauges and regulators shall be in proper working order. Inspect welding equipment daily. The electric welding unit shall be shutdown when leads are unattended. Frames of electric powered welders shall be grounded. Workers and the public shall be shielded from rays, flashes, sparks, molten metal and slag. Identify all hot surfaces with signs or tags to protect workers from burns. Provide a fire watch equipped with a fire extinguisher for at least 1-hour after hot work has been completed. Coordinate hot work activities with the RSA Fire Department.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Use of pumps and hoses.	Understand the injury potential when using pumps and associated equipment. Review operator's manual for recommended operating procedures. Utilize appropriate PPE and always wear safety glasses and face shield when disconnecting hoses. Monitor for carbon monoxide from exhaust in areas with limited ventilation. Keep away from hot exhaust and hot surfaces. Use proper lifting procedures for pumps and hoses. Get help as necessary. Maintain control of hose ends when moving hoses to prevent striking self or other workers. Secure hoses with lashing to prevent whipping - do not allow hoses to whip. Identify and avoid pinch points. Secure cam lock fittings with safety clips/ties.	L
	Insect bites and stings.	Review injury and illness potential with workers. Inspect work areas for bee nests and activity prior to commencing work in that area. Wear PPE, such as disposable coveralls, to keep insects away from the skin. Expect to encounter insects when working in warm weather – especially at locations with vegetation present. Use protective insect repellents containing DEET (Deep Woods Off) to prevent insect bites, unless individual allergies and sensitivities prevent its use. Consider applying Permethrin (Repel Permanone or equivalent) preparations to clothing to repel ticks, chiggers, mosquitoes, and/or spiders. Check limbs/body for insects/ insect bites upon removing PPE and again during showering. Immediately notify supervisor or SSHO of insect bites, stings, irritations, rashes, or flu-like symptoms.	L
	Contact dermatitis from poisonous and irritating plants (poison ivy, poison oak, and poison sumac).	Learn to identify poisonous and irritating plants. Check around work areas to identify if poisonous and irritating plants are present. Identify workers who are known especially sensitive to poisonous and irritating plants and plan work accordingly. Wear Tyvek® coveralls to avoid skin contact with irritating plants. Immediately notify the SSHO if you suspect you contacted an irritating plant. Avoid unnecessary clearing of plant/vegetation areas. See job steps above.Follow additional procedures outlined in the SSHP.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Heat stress.	Allow several days for workers to acclimatize to elevated ambient temperatures. Monitor for heat stress and perform physiological monitoring in accordance with the requirements of the SSHP. Drink plenty of water when under heat stress conditions (~ 1 quart per hour). Provide for adequate electrolyte replacement. Personnel shall take required breaks to cool down as needed. Provide shade or shelter during rest periods.	L
	Cold stress.	Workers should dress in layers in response to the conditions. Monitor for cold stress in accordance with the requirements of the SSHP. Drink warm beverages when under cold stress conditions , but avoid caffiene. Personnel shall take required breaks to warm up as needed. Provide heated areas for rest periods.	L

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment Modified Level D: Refer to SSHP. Equipment: Fire Extinguishers First Aid Kit Drinking water Weather radio Drill rig Support vehicle/trailer PID 10.6 eV lamp Combustible gas indicator	Competent Person (CP) / Qualified Person Brian Rhodes___________________ Training Requirements: HAZWOPER 40-Hour Site safety orientation Emergency procedures Hazard communication Applicable AHAs Qualified equipment operators Lifting/back safety Fire extinguisher use Biological hazard identification and control Storm shelter location Lightning safety procedures All site personnel will attend safety orientation and be certified to be able to wear their assigned respirator (if required).	Daily site safety inspection (SSHO) – ________________ Check Known Allergies Questionnaire, training, and medical certifications against personnel roster Mechanized equipment initial inspection Mechanized equipment (daily) Housekeeping (daily) Fire extinguisher (weekly) Vehicle inspection daily Equipment and tools inspection daily and before use Verify weather no less than twice a day and prior to commencing burn operations

Table 5-1.06 Activity Hazard Analysis

Activity/Work Task: **Vehicle Operations**	Overall Risk Assessment Code (RAC) (Use highest code)					**L**
Project Location: RSA-271, Redstone Arsenal, Huntsville AL	**Risk Assessment Code (RAC) Matrix**					
Contract Number: W91ZLK-13-D-0018	**Severity**	**Probability**				
Date Prepared: 7-21-20		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by (Name/Title): WD Russell/ HSE Manager	Catastrophic	**E**	**E**	**H**	**H**	**M**
	Critical	**E**	**H**	**H**	**M**	**L**
Reviewed by (Name/Title):	Marginal	**H**	**M**	**M**	**L**	**L**
	Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.) Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)	
	"**Probability**" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk**
Notes: (Field Notes, Review Comments, etc.) Completion of this AHA serves as certification of hazard assessment.		**H = High Risk**
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk** **L = Low Risk**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Project vehicle use.	Operation of motor vehicles and trucks-General.	All company owned, leased, or rented vehicle operations shall comply with the requirements of AMS 710-02-PR-02700 Non Commercial Motor Vehicle Safety All company owned, leased, or rented commercial vehicle operations shall comply with the requirements of AMS 710-02-PR-03900 Commercial Motor Vehicle Safety" Subcontractors operating motor vehicles shall comply with all federal, state, and local traffic regulations. Subcontractors shall only use vehicles that are in good condition and safe to operate. All personnel shall drive defensively and wear seat belts while vehicles are in motion.	18.A.01 18.A.02 18.A.03 18.C.02 18.C.03	**L**
	Operation of motor vehicles and trucks-Accidents.	In the event of an accident: stop; call for medical assistance; notify police; complete AMS-710-02-FM-02710 Supervisors First Report of Auto Incident and submit to your supervisor. If a APTIM employee is injured, the AMS forms, AMS-710-05-FM02402 Release for Medical Opinion and Return to Work, and must completed at the health clinic or Emergency Room	01.D.01	**L**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Project vehicle use (continued).	Operation of motor vehicles and trucks-Backing.	Back into parking spaces upon arrival, whenever possible. When preparing to move or back vehicles at the project site, walk around the vehicle before backing to identify any new conditions or obstructions. Use a spotter when backing whenever possible, and sound horn prior to backing. Determine and agree upon hand signals (between spotter and driver) before attempting to back vehicle. Check the rear-view and side mirrors prior to backing. (Note: All vehicles, other than automobiles, must have small convex mirrors attached to the side mirrors.) Back slowly in areas of obstructed vision. Anticipate others who may be backing out into your pathway and adjust accordingly.	18.C.14 08.B.04 08.B.06	L
	Operation of motor vehicles and trucks - Unfamiliar with the vehicle.	Familiarize yourself with the vehicle before moving. Review the dashboard controls, steering radius, overhead, and side clearances. Locate windshield wipers and lights. Properly adjust mirrors and seat.		L
	Operation of motor vehicles and trucks-Speed.	Obey all posted speed limits. Radar detectors are prohibited in all company owned, leased, or rented vehicles. Reduce travel speed during hazardous conditions (i.e., rain, fog, snow).	08.B.06 18.C.04 18.C.05	L
	Operation of motor vehicles and trucks-Spacing/Distance.	Identify if your vehicle has anti-lock brakes. Follow the 3-second rule. Increase the 3-second rule as necessary during hazardous travel conditions. Always leave yourself an “out” during travel – this applies to stoplights as well. When stopping, make sure that you leave enough distance between you and the car in front of you (you should be able to see the rear tires of the vehicle in front, when stopped). When at a red light, and it turns green, use the “delayed start” technique, by counting to three before you take your foot off the brake. DO NOT TAILGATE! Allow extra spacing and braking time for trucks and vehicles towing trailers. Trailers shall be equipped with brakes.		L
	Operation of motor vehicles and trucks-Skids.	If the vehicle has begun to skid out of control, turn the steering wheel in the direction of the skid and re-adjust the wheel, as necessary. Slow travel speeds during hazardous travel conditions. Use 4-wheel drive, if available, when driving vehicles off road, on steep inclines, muddy conditions, etc. Do not take vehicles “off road” if they cannot be operated safely.	18.C.05	L

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Project vehicle use (continued).	Operation of motor vehicles and trucks-Blind Spots.	Become familiar with blind spots associated with your vehicle. Adjust mirrors properly. Make sure you use your directional signals. Always look over your shoulder to ensure the lane is clear when changing lanes.		L
	Operation of motor vehicles and trucks-Cellular phones.	Exercise caution when approaching other driver's blind spots. Do not use handheld cellular phones while driving procedure AMS-710-02-PR-056. Pull over to the side of the road when making a call.	18.C.01	L
	Operation of motor vehicles and trucks-Equipment Failure.	Perform daily inspections of your vehicle. Any vehicle with mechanical problems that may endanger the safety of the driver, passengers, or the public shall not be used.	18.A.03 18.A.04	L
	Operation of motor vehicles and trucks-Spacing/Distance.	Ensure safety equipment is in the vehicle. Safety equipment should include a spare tire, jack, first-aid kit, fire extinguisher, and flashlight. Flares and/or reflective triangles shall be available in larger trucks. Verify that the proper documentation is in the vehicle - documentation includes an operation manual for the vehicle, insurance card, vehicle registration, and APTIM Incident forms.	18.A.03	L
	Operation of motor vehicles and trucks- Influenced by drug and alcohol.	Never drive under the influence of drugs or alcohol. Disciplinary action, including termination, will be taken against anyone who is convicted of or who pleads no-contest to the charges of driving under the influence in accordance with substance Abuse Program procedure AMS-710-01-PR-03600. Project-assigned hourly employees are not permitted to operate company owned, leased, or rented vehicles after 10:00 p.m. without written authorization from their supervisor.	01.C.02	L
	Operation of motor vehicles and trucks-Driver Attitude/Fatigue.	Do not operate any vehicle when abnormally tired, temporarily disabled, or under the influence of drugs or alcohol. Keep an even temper when driving. Do not let the actions of others affect your attitude. Avoid "highway-hypnosis" and "falling asleep at the wheel." Take plenty of breaks when driving long distances. Rotate driving responsibility with your partner. No employee is authorized to operate a company vehicle (including rentals) after being on-duty for a period of 12-hours. No employee may drive for more than 10-hours in a single on-duty period.	01.C.04	L
	Operation of motor vehicles and trucks-Vehicle Loading.	DO NOT OVERLOAD the vehicle. Secure all equipment within the body of the vehicle. Do not block side view mirrors with load. Do not transport Department of Transportation manifested hazardous materials without a commercial driver's license. Dispatch all equipment and personnel with proper forms and identification.	18.C.13 18.C.16	L

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment – N/A: Equipment: Seatbelt Spare tire and jack First aid kit Fire extinguisher Flashlight Operations manual for the vehicle Insurance card Vehicle registration Accident report forms	Competent Person (CP) / Qualified Person (QP): Brian Rhodes – CP/SSHO Brian Rhodes – QP/First Aid and CPR Training Requirements: Site safety orientation Licensed vehicle operators Defensive driving (all APTIM personnel)	Daily site safety inspection (SSHO) –Brian Rhodes Daily site safety inspection (QCO) –Brian Rhodes Vehicle inspections (daily) Vehicle inspections (prior to trips greater than 50 miles for APTIM provided vehicles)

Table 5-1.07 Activity Hazard Analysis

Activity/Work Task: **COVID-19 Job Site Practices**	Overall Risk Assessment Code (RAC) (Use highest code)					L
Project Location: RSA-271, Redstone Arsenal, Huntsville AL						
Contract Number: W91ZLK-13-D-0018		**Risk Assessment Code (RAC) Matrix**				
Date Prepared:		Probability				
Prepared by (Name/Title):	Severity	Frequent	Likely	Occasional	Seldom	Unlikely
Stop-Work Authority: All Aptim Federal Services, LLC (APTIM) employees, subcontractors, vendors, and site visitors associated with this APTIM site have the responsibility and the authority, without fear of reprimand or retaliation, to immediately stop any work activity that presents a danger to themselves, co-workers, clients, the public, or the environment.	Catastrophic	E	E	H	H	M
	Critical	E	H	H	M	L
	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L
	Step 1: Review each Hazard with identified "Controls". Determine RAC (see above).			**RAC CHART**		
Notes: (Field Notes, Review Comments, etc.) Completion of this AHA serves as certification of hazard assessment.	Probability: Likelihood the activity will cause a Mishap (Near Miss, Incident, or Accident). Identify as Frequent, Likely, Occasional, Seldom or Unlikely			**E -- Extremely High Risk**		
	Identify as Catastrophic, Critical, Marginal, or Negligible			**H -- High Risk**		
	Step 2: Identify the RAC (probability vs. severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of the AHA			M = Moderate Risk		
				L = Low Risk		

Job Steps (Work Sequences)	**Specific Anticipated Hazards**	**Controls**	**RAC**

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Management Responsibilities	Lack of planning contributing to increased risk of Infection	- Management shall follow guidance in the APTIM project specific COVID-19 Virus Control Plan. - Management shall continually check the APTNet Corna Virus Webpage for the latest CDC's Interim Guidance and update recommendations and make adjustments to the AHA, as appropriate. - Management shall designate a representative to monitor for signs of illness in the workplace, and if someone is showing symptoms, management shall ask them to leave. - Management shall designate a representative to take employees' temperatures with a digital forehead thermometer that is disinfected appropriately between applications. This should be done PRIOR TO any individual entering the job site. Individuals' temperatures should also be taken when leaving or at the end of their shift. Management shall keep records of the temperatures taken. Note that some people with COVID-19 may not have a fever, so this should not be the only means of detection. - Management shall separate sick employees immediately. CDC recommends that employees who appear to have acute respiratory illness symptoms (i.e. cough, shortness of breath) upon arrival to work or become sick during the day should be separated from other employees and be sent home immediately. Individuals that have been asked to leave should NOT be allowed to enter any occupied area at any time prior to leaving.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Management Responsibilities (continued)	Lack of planning contributing to increased risk of infection	- Management shall provide tissues and encourage employees to cover their noses and mouths with a tissue (or elbow or shoulder if a tissue is not available) when coughing or sneezing. - Management shall provide disposable hand towels and no-touch trash receptacles. - Limit the exchange/sharing of paper documents by encouraging use of electronic communication whenever possible. - Do not allow sharing of tools or any multi-user devices and accessories such as iPads, laptops, hand-held radios, computer stations, etc. - Provide soap and water and hand sanitizer with alcohol content between 60% and 90% in the workplace. Ensure that adequate supplies are maintained. Place hand sanitizers in multiple locations on the job site, in the office, in or around portable toilets, or in conference rooms to encourage hand hygiene. - Provide disposable gloves where appropriate; instruct workers to wash hands after removing gloves. - Communicate key CDC recommendations (and post signage where appropriate) to your staff and tradespeople: 1. How to Protect Yourself 2. If You are Sick 3. COVID-19 Frequently Asked Questions 4. Place posters that encourage staying home when sick, cough and sneeze etiquette, and hand hygiene at the entrance to your workplace and in other workplace areas where they are likely to be seen. - Management shall communicate with Human Resources for practices for managing sick time related to COVID-19.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Restricting Job Site Visitors	Possible Exposure by Unvetted Visitor	- Restrict the number of visitors to the job site, including the trailer or office. - All visitors should be screened in advance. If the visitor can answer "yes" to any of the following questions (without identifying which question applies), the visitor will not be permitted to access the facility. The questions are: ○ Have you been asked to self-quarantine since December 2019? ○ Have you been in close contact with any person(s) who has been asked to self-quarantine since December 2019? ○ Have you experienced a recent onset of any illness-related symptoms, such as fever, cough, or shortness of breath? ○ Have you traveled outside of North America in the past 14 days? ○ Have you been in close contact with any person(s) who have traveled outside of North America in the last 14 days? ○ Have you been in close contact with any person(s) who has been diagnosed with COVID-19?	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Workers Entering Occupied Job-Site Trailers	Exposing Others or Being Exposed to COVID-19	Many contractors and service technicians may perform construction and maintenance activities within occupied job-site trailers. These work locations present their own unique hazards with regards to COVID-19 exposures. Electricians, and heating, ventilation, and air conditioning (HVAC) technicians are examples of these types of workers. All such workers should evaluate the specific hazards when determining best practices related to COVID-19. - Require the customer to clean and sanitize the work area prior to the workers' arrival on site. - Technicians should sanitize the work areas themselves upon arrival, throughout the workday, and immediately before departure. Refer to CDC guideline: Clean & Disinfect. - Require customers to keep household pets away from work area. - Ask that occupants keep a personal distance of 6 feet at minimum. - Do not accept payments on site (no cash or checks exchanged). Require electronic payments over the phone or online. - Workers should wash hands immediately before starting and after completing the work. Refer to CDC guideline: When and How to Wash Your Hands.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Additional PPE Recommendations for COVID-19	Lack of Protection from COVID-19 Exposure	- Gloves should be worn when practical while on site and during routine cleaning/disinfecting and/or while providing care to someone who is sick. If gloves are not typically required for the task, then a nitrile glove may be used as practical. - Remember: The type of glove worn should be appropriate to the task. - Eye protection should be worn all times while on site, or as practical. - Follow local jurisdiction (County and/or State) and federal guidance (CDC) for wearing face masks. APTIM will continue to provide and recommend employees to wear face masks. - Do not share personal protection equipment (PPE). - Utilize disposable gloves where appropriate; instruct workers to wash hands after removing gloves. - Ensure used PPE is disposed of properly. - Sanitize reusable PPE per manufacturer's recommendation prior to each use.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Social Distancing on the Job Site or in the Office	Transmission of COVID-19 by Close Proximity	- Discourage hand-shaking and other contact greetings. - To limit the number of people on a job site, allow non-essential personnel to work from home when possible. - Keep a minimum of a 6 foot distance between individuals when possible. - Do not host large group meetings. CDC recommends that we avoid gatherings of 10+ people. Conduct meetings on-line or via conference call. - Do no stack trades on each other. - Do not share tools. Tools must be disinfected after each employee use. - If shuttling employees, ensure proper distancing. Encourage employees to provide their own transportation, when possible. - Employees should NEVER share personal protection equipment (PPE). - Do not use a common water cooler. Provide individual water bottles or instruct employees to bring their own. - Do not congregate in lunch areas. - Take breaks and lunch in shifts to reduce the size of the group in the break area at any one time to less than 10 people. - No communal food shall be permitted on the job site until further notice, i.e., donuts, pizza, buffets, etc.	L
Proper Hand Washing	COVID-19 Spreads by improperly washed/unwashed hands Touching Face with contaminated hands	- All job sites should have hand washing stations readily available to all workers on the project and should be well stocked and maintained. - Hand washing stations should be cleaned and sanitized regularly. - All workers should wash hands frequently and thoroughly using soap and water for at least 20 seconds, especially before and after eating, smoking, or drinking, and after blowing your nose, coughing, or sneezing. - Refer to the CDC guideline; "When and How to Wash Your Hands." - Do not touch your face, eyes, mouth, nose, or ears.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Routine Environmental Cleaning of Jobsite / Office	Virus transmitted on contaminated surfaces	- Routine cleaning shall be performed on all frequently touched surfaces on the job site. This includes, however is not limited to, workstations, countertops, handles, doorknobs, gang boxes, shared tools and equipment. - The use of appropriate cleaning agents and directions shall be utilized to perform all cleaning. Ensure all exposed workers are trained on the hazards of the cleaning chemicals used in the workplace in accordance with OSHA Hazard Communication standard. Employers must comply with OSHA Bloodborne Pathogen standards, including the proper disposal of regulated waste and PPE. - Any trash from offices or job site should be emptied frequently by someone wearing gloves. After changing the trash, the employee should throw the gloves away and wash their hands. - Disinfectant spray will be provided for portable bathrooms and is to be used to disinfect common contact surfaces before and after each use. During summer months, the portable bathrooms shall be serviced by the supplier company twice per week. - All common break areas, lunch and break rooms will be cleaned once per workday. - Employees performing cleaning will be issued proper PPE, such as nitrile gloves and eye or face protection as needed.	L

Table 5-1.07 Activity Hazard Analysis

Job Steps (Work Sequences)	Specific Anticipated Hazards	Controls	RAC
Managing Sick Employees	Sick Employees Infecting Others	- Management shall actively encourage sick employees to stay home. - Employees who have symptoms of acute respiratory illness are recommended to stay home and not return to work until they are free of fever (100.4° F [38.0° C] or greater using an oral thermometer), signs of a fever, and any other symptoms for at least 24 hours, without the use of fever-reducing or other symptom-altering medicines (e.g. cough suppressants). - Separate sick employees. CDC recommends that employees who appear to have acute respiratory illness symptoms (i.e. cough, shortness of breath) upon arrival to work or become sick during the day should be separated from other employees and be sent home immediately. - If an employee is well but has a family member at home with COVID-19, they should notify their supervisor. Refer to CDC guidance for how to conduct a risk assessment. - If an employee is confirmed to have COVID-19, inform fellow employees of possible exposure to COVID-19 in the workplace, but maintain confidentiality as required by the Americans with Disabilities Act (ADA). Ask the affected employee to identify those other employees whom he/she came into contact with before the employee departs. Employees who worked in close proximity (3- to 6-feet) to a coworker with confirmed COVID-19 should also be sent home and referred to CDC guidance for how to conduct a risk assessment. - Communicate your company's Human Resources practices for managing sick time related to COVID-19.	L

Table 5-1.07 Activity Hazard Analysis

Equipment to be Used	Training Requirements & Competent or Qualified Personnel Names	Inspection Requirements
Soap and Water (Any Kind/Brand)	Scrub surface diligently for at least 30 seconds. Interferes with fats in virus shell.	Rinse off with water. Properly discard of towels.
Bleach (Active ingredient - sodium hypochlorite)	Wipe over surfaces. Leave on surface for 10-15 minutes. Wipe with clean cloth.	Use as directed on bottle. Discard of towels properly.
Isopropyl Alcohol/Rubbing Alcohol (at least 70% denatured alcohol)	Clean surface with soap and water. Dry. Wipe Alcohol on. (do not dilute) Let evaporate.	Use and store per manufacturer's recommendations. Flammable. Use in well-ventilated areas. Poisonous. For topical use only. Do not ingest.

Table 5-1.08 Activity Hazard Analysis

Activity/Work Task: Waste Management	Overall Risk Assessment Code (RAC)					M
Project Location: RSA-271 Redstone Arsenal Huntsville AL	**Risk Assessment Code (RAC) Matrix**					
Contract Number: W91ZLK-13-D-0018	**Severity**	**Probability**				
Date Prepared: 09/23/20		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by: Ray Clark	Catastrophic	E	E	H	H	M
	Critical	E	H	H	M	L
Reviewed by: WD Russell, HSE Manager	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L
Notes: (Field Notes, Review Comments, etc.) This AHA serves as the hazard assessment	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)					
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom or Unlikely.				**RAC Chart**	
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible				**E = Extremely High Risk** **H = High Risk**	
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.				**M = Moderate Risk** **L = Low Risk**	

Job Steps	Hazards	Controls	RAC
Drums Handling	Handling heavy objects	Observe proper lifting techniques. Obey sensible lifting limits (50 lbs. maximum per person manual lifting). Use mechanical lifting equipment (handcarts, trucks, and forklift) to move large loads, awkward loads. Check and secure drum lids before moving.	M
	Caught in/between moving parts/pinch points	Identify and understand parts of equipment, which may cause crushing, pinching, rotating, or similar motions. Remove all jewelry, especially rings, bracelets, watches Watch hand placement and foot placement Assure guards are in place to protect from these parts of equipment during operations. Abrasion resistant work gloves when the possibility of pinching, or other injury may be caused by moving / handling large or heavy objects. Maintain all equipment in a safe condition. Keep all guards in place during use. De-energize and lock-out machinery before maintenance or service.	M

Job Steps	Hazards	Controls	RAC
Drums Handling (continued)	Slips, trips, falls	Clear walkways, platforms, access steps and work areas of equipment, tools, and debris. Mark, identify, or barricade other obstructions. Work areas, platforms, and walkways should be kept free of materials, debris, and obstructions such as ice, grease, or oil that could cause a surface to become slick or otherwise hazardous. Maintain three-point contact when mounting / dismounting heavy equipment. Maintain good housekeeping.	M
	Sharp objects	Wear abrasion resistant work gloves. Inspect hand tools before use. Keep guards in place during use.	M
	Vehicle traffic	Use spotter when backing. Survey route to work locations. Inform crew of hazards. Wear reflective vest when exposed to heavy equipment or traffic.	M
	Struck by/against heavy equipment, protruding objects	Isolate equipment swing area. Require backup alarms on all heavy equipment. Make eye contact with operators before approaching equipment. Understand and review hand signals.	L
	Inhalation and contact with hazardous substances	Review hazardous properties of site contaminants with workers before work begin. Monitor breathing zone pursuant to SSHP. Avoid skin contact with contaminated waste. Avoid inhalation of dust or vapors.	M

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
• Level D: hard hat, safety glasses, safety boots, ear protection, abrasion resistant gloves • Hand tools • Drum dolly • Forklift	• Tailgate Safety Meeting • Site-specific orientation • HAZWOPER 40-hr. • HAZWOPER 8-hour refresher • 8-hr Supervisor training • Forklift operator training • TBD – CP/SSHO	• Use this AHA as a checklist • Inspect all equipment and tools prior to use per manufacturer requirements.

Table 5-1.09 Activity Hazard Analysis

Activity/Work Task: **Excavation & Backfill**	Overall Risk Assessment Code (RAC) (Use highest code)					**M**
Project Location: RSA-271 Redstone Arsenal	**Risk Assessment Code (RAC) Matrix**					
Contract/Project Number: W91ZLK-09-D-0006	**Severity**	**Probability**				
Date Prepared: 10/20/21		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by (Name/Title):	Catastrophic	E	E	H	H	M
	Critical	E	H	H	M	L
Reviewed by (Name/Title): Doug Russell	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L
Notes: (Field Notes, Review Comments, etc.) This AHA serves as certification of hazard assessment.	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)					
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.				**RAC Chart**	
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible				**E = Extremely High Risk** **H = High Risk**	
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.				**M = Moderate Risk** **L = Low Risk**	

Job Steps	Hazards	Controls	RAC
Verify overhead and underground utilities locations. Set up equipment for operation. Inspect equipment for use. Inspect work area where equipment is to be used. Isolate work area, as appropriate. Move equipment to work area.	Newly hired personnel and visitors. Unfamiliarity with: site, general (chemical, physical, environmental) site hazards, project safety rules and hazard control procedures, chain of command, and emergency procedures.	All personnel shall attend a site safety orientation. After personnel are trained in the contents of the Accident Prevention Plan (APP) and the Site Safety and Health Plan (SSHP), they shall sign the APP Acknowledgment Form and the SSHP Acknowledgment Form. Review emergency procedures and evacuation plans.	M
	Unqualified operator(s).	Verify operator is qualified and authorized for the equipment being used. Only personnel authorized by employer shall operate equipment.	M
	Failure to properly plan daily activities.	A Job Safety Analysis (JSA) shall be prepared by the crew prior to commencing daily activities. The JSA shall be used as a component of the morning Tailgate Safety Meeting. The JSA shall be revised at any time throughout the workday when new tasks are initiated, unforeseen circumstances arise, or if working conditions change. Personnel shall implement Hazard Assessment Resolution Process and Safety Step Back.Personnel to conduct focused and leading indicator Target observations.	M

Job Steps	Hazards	Controls	RAC
See job steps above.	Complacency.	All personnel shall attend the morning safety meetings to re-focus themselves to hazards, emergency procedures and equipment, operational aspects, and change(s) in site/work conditions. Recommended control measures for the hazards shall be part of the discussion.	**M**
	Fire.	Fire extinguishers shall be available in work areas. A 4-A:60-B:C fire extinguisher shall be available when refueling at the project site. Excavators shall be equipped with a 10-B:C fire extinguisher. The SSHO shall establish smoking areas. Smoke only in designated areas. Only discard cigarette butts in proper receptacles – never discard cigarette butts onto the ground. Smoking shall not be permitted within 50 feet of fueling operations. Use caution with vehicle exhaust systems in grassy areas. Do not run vehicles or equipment while parked in dry, grassy areas. Engines shall be shut off and allowed to cool before refueling. Follow AHA for “Fueling Operations.”	**M**
	Unsafe equipment.	Before excavating equipment is placed in use at the project, it shall be inspected and tested in accordance with the manufacturer’s recommendations and shall be certified in writing by a competent person to meet the manufacturer’s recommendations. Subsequent re-inspections will be conducted at least annually thereafter. These inspections shall be documented on a Checklist for Construction Equipment. All safety deficiencies noted during the inspection shall be corrected prior to the equipment being placed in service at the project. All excavating equipment shall be inspected by the operator prior to use on the project and shall then be inspected on a daily basis.Deficiencies in equipment shall be noted on the inspection form. Do not use equipment that is not in proper operating condition. Attach a “Danger – Do Not Use” tag to inoperable equipment, remove key from equipment, and give key to the supervisor when notifying him/her of the inoperable equipment.. Verify all manufacturers' safety guards, features, controls, back-up alarms, horns, and equipment are functioning properly and as intended by the manufacturer. Install and maintain equipment attachments and their operating systems according to manufacturer's specifications. Make frequent visual inspections of quick-disconnect systems (systems for connecting attachments to excavators) especially after changing attachments. Verify controls are properly labeles as to equipment function.	**M**

Job Steps	Hazards	Controls	RAC
See job steps above.	Overhead/aboveground hazards and utilities.	Follow legacy Safety Procedure HS-308, “Underground/Overhead Utility Contact Prevention”. Overhead and aboveground hazards shall be evaluated prior to moving equipment on the project site. Complete a Site Layout Plan prior to mobilizing the equipment. The plan shall identify all overhead and aboveground hazards in the active work area(s) and travel routes - include utilities, pipe racks, structures, restricted areas, pedestrian routes, and equipment/vehicle traffic. Power lines shall be assumed to be energized unless verified to be de-energized and visibly grounded. Operation beneath a power line that has not been verified as de-energized and grounded must maintain clearance distances stated below. Nominal System Voltage — Minimum Required Clearance Distance Up to 50 kV — 10 feet (3 m) Over 50 - 200 kV — 15 feet (4.6 m) Over 200 - 350 kV — 20 feet (6 m) Over 350 - 500 kV — 25 feet (7.6 m) Over 500 – 750 kV — 35 feet (10.7 m) Over 750 – 1,000 kV — 45 feet (13.7 m) For over 1,000 kV, the minimum required clearance distance will be established by the utility owner/operator or professional engineer who is a qualified person with respect to electrical power transmission and distribution. Identify and provide temporary visual barriers that help prevent encroachment with the lines. In areas where it is not feasible to use barricades, spotters shall be provided; however, the minimum clearance distances from electrical lines must be observed. Each work crew member shall be trained in the electrocution hazards and emergency procedures associated with contacting energized power lines. Post overhead hazard warning signs as necessary.	M

Job Steps	Hazards	Controls	RAC
See job steps above.	Underground utilities and other underground hazards.	Follow legacy Safety Procedure HS-308, "Underground/Overhead Utility Contact Prevention". Follow any additional procedures for intrusive activities identified in APP and Work Plan prior to commencing intrusive activities. Utilities shall be located and marked prior to commencing intrusive activities. Contact utility one-call service (811) at least 48 hour but not more than 10 days prior to commencing intrusive activities, excluding weekends or any state or federal holidays. Retain a copy of mark-out ticket for documentation purposes and QC purposes. Documentation of utility mark-out must be completed using the Utility Mark-out Documentation form (EIG-HS-308.03). Evaluate the work areas, ground conditions, and travel paths to identify any sensitive underground structures, unstable areas, dangerous slopes, and existing open excavations. Complete a Site Layout Plan prior to mobilizing the equipment. The plan shall identify all underground utilities and other underground hazards in the active work areas and travel routes. Cease work immediately if unknown utilities or utility markers are uncovered. Use manual excavation within 3 feet of known utilities. Each work crew member shall be trained in electrocution hazards, explosion/fire hazards, and emergency procedures associated with contacting energized power lines and pipelines. Immediately contact Public Works Department in event utilities are encountered that were not previously marked. Notify Public Works in event any damage to utilities occur.	M
	Hand injuries.	Personnel shall wear appropriate leather, heavy cotton or synthetic gloves when handling materials with sharp edges, splinters, burrs, rough surfaces, etc. Items to be handled shall be inspected for sharp edges, splinters, burrs, rough surfaces, etc. prior to being handled. Personnel shall be aware of and avoid pinch point hazards.	M
	Noise.	All personnel shall wear hearing protection when operating noisy equipment. Personnel working in vicinity of noisy equipment shall wear hearing protection. Verify personnel noise exposures are safe by performing noise dosimetry.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Use of excavators and backhoes.	Only qualified personnel shall be permitted to operate equipment. It is the responsibility of the operator to read and understand the manufacturer's operator manual, the manufacturer's recommendations for each type and model of equipment to be operated, and the requirements of AMS-710-02-PR-05700 prior to operating equipment. Operators must know the capacity and operating characteristics of the equipment to be operated. When mounting or dismounting equipment, clean shoes and hands before climbing. Always use handrails, grab rails, and steps. Maintain a three-point contact/control with steps and handholds. Never jump on or off equipment. Never attempt to mount or dismount a moving machine. Do not use steering wheel or control levers as a handhold. Lower the boom (and loader when equipped) to a safe position with the bucket/attachment on the ground and turn off the excavator before dismounting equipment. The equipment must be attended at all times or attachments must be placed in the “transport lock position” or lowered to the ground. The operator is responsible for keeping the windows clear and keeping cab clean at all times. Equipment operators must wear seat belt at all times and keep body (hands, arms, legs, head, etc.) inside the protected area of the cab. Operations are to be performed only from the operators control station. All equipment shall be operated at safe speeds and in a safe manner. If equipped with such, use the machine stabilizers. Loads must be carried as low as possible to maintain stability of the equipment and operator visibility. Do not operate equipment on grades steeper than those specified by the manufacturer. When operating on a sloped area, always move up or down the slope and not across the slope. Avoid making turns on inclines. If it is necessary, make turns wide and slowly with load carried low. When traveling up or down inclines, do so with loaded buckets facing uphill and empty buckets facing downhill. The operator of equipment shall not use cellular telephone devices or head/earphones for entertainment purposes while operating equipment. The use of cell phones and other communication devices are permitted for job-related communications or emergency situations, when the equipment is not operating.	**M**

Job Steps	Hazards	Controls	RAC
See job steps above.	Use of excavators and backhoes (continued).	The operator shall not use attachments for which they were not designed to be used for, e.g., using a bucket to transport telephone poles. Follow the manufacturer's instructions for using positive locks on quick-disconnect equipment. Securely latch attachments such as quick-disconnect buckets before beginning work. Make frequent visual inspections of quick-disconnect systems — especially after changing attachments. The operator is to stay alert and focused at all times when the excavator or backhoe is in operation.	**M**
	Struck by and against	Wear PPE with high visibility vests when walking or working near moving equipment or vehicles. Prevent unauthorized workers or bystanders from entering work areas with equipment operations. Verify **"DANGER – STAY CLEAR"** (or equivalent) warning sign(s) is visibly posted on the equipment. Personnel shall maintain a safe distance from operations. Keep alert for movement of equipment, loads, excavations, piles, and ejected matter. Personnel shall not be permitted in the swing radius of the equipment. Precautions must be implemented to keep personnel out of excavations and at least 10 ft. (3 m) away from the equipment and its maximum boom and/or counterweight swing radius when operating. Accessible areas within the swing radius of the equipment are to be barricaded to prevent personnel from being struck or crushed, as appropriate. Do not approach an excavator or backhoe without first establishing communication with the operator or spotter (eye contact and then a signal to proceed after the equipment has been shut down: • Excavator bucket planted, powered down, and controls locked. • Backhoe bucket planted, engine shut off. Don't allow anyone to stand under a suspended load or the boom, arm, or bucket. Operator to stop operations if personnel are observed within the swing radius.	**M**

Job Steps	Hazards	Controls	RAC
See job steps above.	Spotter operations.	Use designated spotters as necessary and as determined by the operator or supervisor. Establish communication before starting work – hand signals, whistles, radios, air horn, audible alarm, or other means of effective jobsite communication. When a designated spotter is used, the equipment shall not be moved unless the designated spotter giving signals is in full view of the operator. The spotter must maintain line of site or communication with the equipment operator. For movement of mobile equipment in congested areas, a designated spotter shall be in full view of the operator and shall direct the movement. In some cases, multiple spotters may be required.	**M**
	Sampling from bucket.	Position the sampling support and collection area on the cab side of the excavator to minimize operator blind spots created by the excavator boom assembly. Verify the operator is aware of your intention to collect samples from the bucket. Prior to sampling, the equipment operator shall fully lower the bucket to the ground, set the safety lockout lever to isolate joystick controls, decelerate the engine to idle level and signal the sample technician it is safe to approach the bucket. For backhoes, the bucket shall be planted on the ground and the engine shut down prior to approaching the bucket to obtain a sample. Keep out from between the excavator bucket and fixed objects, vehicles, or equipment when sampling. The operator should swing the machine to where the boom is at least at a 45-degree angle away from the excavation.	M
	Excavation hazards.	Follow the project Excavation/Trenching Plan.	**M**
	Dust or potential airborne hazards from ORC	Control dust by maintaining equipment operation rates. Control dust by applying water. Personnel shall stay out of dust and work from upwind when possible. ORC will be placed with equipment located upwing of the backfilling operation.	**M**

Job Steps	Hazards	Controls	RAC
See job steps above.	Slips, trips, and falls.	Understand the hazards of slips, trips, and falls – consider the consequences. Do not jump from equipment or elevated surfaces. Clean-up work areas throughout the day and at the end of each workday. Use three-point contact rule for entering/exiting vehicles, trucks, and equipment. Use hand rails and other stationary objects (door frames, door knobs, steering wheels, walls, etc.) to increase stability. Use extra caution when walking on wet, muddy, frosty, icy, or snow-covered surfaces. Consider postponing work as necessary and feasible. Increase your awareness, keep alert, stay focused, and know your environment. Stay away from slopes, hills, and grades. Be cautious when using stairs. Remove snow and ice when possible (shoveling, chipping, and salt application). Apply traction aids, such as sand, gravels, and straw. Lower your center of gravity when necessary. Slow down - take smaller steps.	M
	Insect bites and stings.	Review injury and illness potential with workers. Inspect work areas for bee nests and activity prior to commencing work in that area. Wear PPE, such as disposable coveralls, to keep insects away from the skin. Expect to encounter insects when working in warm weather – especially at locations with vegetation present. Use protective insect repellents containing DEET (Deep Woods Off or equivalent) to prevent insect bites, unless individual allergies and sensitivities prevent its use. Consider applying Permethrin (Repel Permanone or equivalent) preparations to clothing to repel ticks, chiggers, mosquitoes, and/or spiders. Check limbs/body for insects/ insect bites upon removing PPE and again during showering. Immediately notify supervisor or SSHO of insect bites, stings, irritations, rashes, or flu-like symptoms.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Contact dermatitis from poisonous and irritating plants (poison ivy, poison oak, and poison sumac).	Learn to identify poisonous and irritating plants. Check around work areas to identify if poisonous and irritating plants are present. Identify workers who are known especially sensitive to poisonous and irritating plants and plan work accordingly. Wear Tyvek® coveralls to avoid skin contact with irritating plants. Immediately notify the SSHO if you suspect you contacted an irritating plant. Avoid unnecessary clearing of plant/vegetation areas. Follow additional procedures outlined in the APP.	L
	Severe weather.	The SSHO to monitor weather conditions each day in order to plan and prepare for hazardous conditions. The SSHO to identify the nearest suitable storm shelter at each work location. Upon seeing lightning or hearing thunder, outdoor activities shall be suspended and personnel shall be evacuated to safe areas (inside vehicles, buildings, or tornado shelters as appropriate).	M
	Heat stress.	Allow several days for workers to acclimatize to elevated ambient temperatures. Monitor for heat stress and perform physiological monitoring in accordance with the requirements of the APP. Drink plenty of water when under heat stress conditions (~ 1 quart per hour). Provide for adequate electrolyte replacement. Personnel shall take required breaks to cool down as needed. Provide shade or shelter during rest periods.	M
	Cold stress.	Workers should dress in layers in response to the conditions. Monitor for cold stress in accordance with the requirements of the APP. Drink warm beverages when under cold stress conditions, but avoid caffeine. Personnel shall take required breaks to warm up as needed. Provide heated areas for rest periods.	L

Job Steps	Hazards	Controls	RAC
See job steps above.	Struck by material	Personnel shall never place themselves under suspended/overhead loads. Material shall be loaded over the dump bed and not allowed to pass over operator cab. Haul units shall be equipped with adequate Falling Object Protective Structure. All loads are to be covered when traveling on the road weather on base or off base. NO driver operator shall climb into truck or over 6 feet above ground level with out proper fall protection	L

Equipment to be Used	Training Requirements/Competent or Qualified Personnel Name(s)	Inspection Requirements
Personal Protective Equipment Hard hat Safety glasses with side shields Safety-toed boots Work gloves Class 2 high visibility vests Hearing protection, as necessary Other Equipment: Fire Extinguishers Caution tape Excavation perimeter protection First Aid Kit Drinking water Weather radio Insect repellant with DEET (Deep Woods Off™ or equivalent) Repel Permanone™ Communication devices	Competent Person (CP) / Qualified Person (QP): CP/SSHO ______________________________ Alternate CP/SSHO_______________________ QP/First Aid and _________________________ QP/First Aid and CPR _____________________ Training Requirements (as determined by the SSHO): Site safety orientation Emergency procedures Hearing conservation Applicable AHAs Lifting/back safety Fire extinguisher use Biological hazard identification and control Storm shelter location Lightning safety procedures Heat stress prevention and heat stroke treatment Cold stress prevention	Daily site safety inspection (SSHO) James Vigerust Daily site safety inspection (QCO) ___________________ Initial and daily equipment inspections. Overhead utilities and hazards (prior to operating equipment in area) Locate underground utilities (prior to intrusive activities) Excavation (at least daily) Housekeeping (daily) Fire extinguisher (monthly) Equipment and tools inspection (daily and before use) Survey areas for poisonous plants, insects, and animals(each work area) Check body for ticks (each evening during tick season) Identify closest usable storm shelter that is available

Table 5-1.10 Activity Hazard Analysis

Activity/Work Task: **Equipment Decontamination**	Overall Risk Assessment Code (RAC) (Use highest code)					**M**
Project Location: Redstone Arsenal Huntsville AL	**Risk Assessment Code (RAC) Matrix**					
Contract Number: W91278-16-D-0059	**Severity**	**Probability**				
Date Prepared: 10-26-18		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by (Name/Title): Doug Russell/HSE Manager	Catastrophic	**E**	**E**	**H**	**H**	**M**
	Critical	**E**	**H**	**H**	**M**	**L**
Reviewed by (Name/Title):	Marginal	**H**	**M**	**M**	**L**	**L**
	Negligible	**M**	**L**	**L**	**L**	**L**

Notes: (Field Notes, Review Comments, etc.)

Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk** **H = High Risk**
Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk** **L = Low Risk**

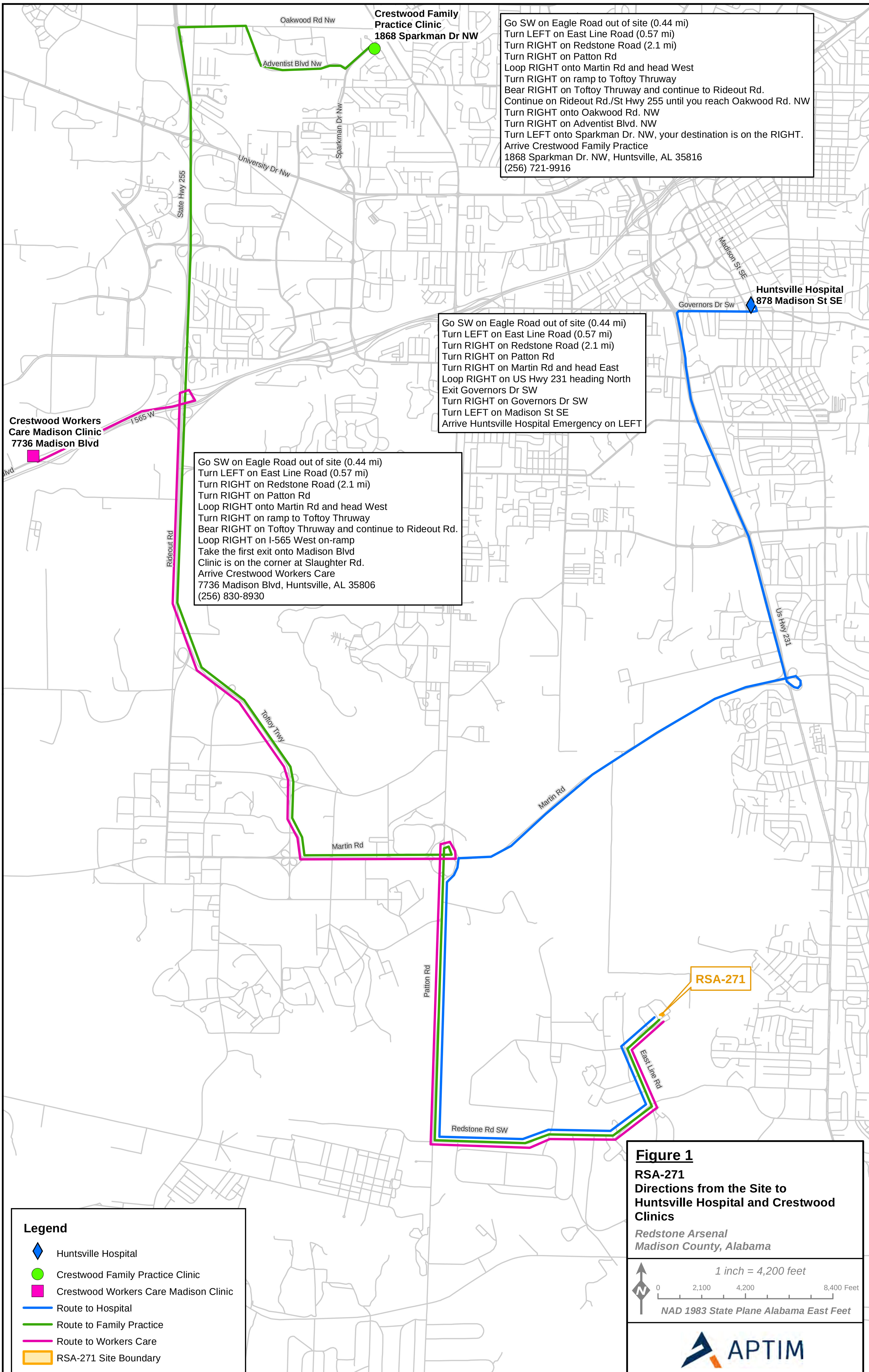
Job Steps	Hazards	Controls	EM 385-1-1	RAC
Clean equipment.	Failure to properly plan daily activities.	Complete a Job Safety Analysis (JSA) for each task, as specified in AMS-710-05-PR-01700 "Work Area Hazard Assessment Process". Use Hazard Assessment Resolution Program frequently – for each task to be completed.		**M**
	Exposure to contaminants.	Maintain work zones and decontamination areas. Level D - Modified personal protective equipment shall be worn as required in the Accident Prevention Plan or Site Safety and Health Plan. Personnel shall perform proper decontamination procedures each time when exiting the Exclusion Zone.	28 05.A.01	**L**
	Poor lighting.	Additional lighting shall be put in place as necessary. Temporary lighting shall be protected with ground fault circuit interrupters (GFCI).	07.A.01 11.D.05	**L**
	Slips, trips, and falls.	Work areas shall be kept organized during work activities. Housekeeping shall be maintained. Personnel shall use caution when walking/working on wet surfaces.	14.C.01-10	**M**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Clean equipment (continued).	Electrical.	GFCIs shall be used on all power tools and extension cords. Extension cords, power tools, and lighting equipment shall be inspected before each use, protected from damage, and kept out of wet areas.	11.D.05 11.A.03	**M**
	Heavy lifting.	No individual employee is permitted to lift any object that weighs over 50 pounds. Proper lifting techniques shall be used. Multiple employees or the use of mechanical lifting devices are required for lifting objects over the 50-pound limit.	14.A.01	**M**
	Noise.	Personnel shall wear hearing protection when operating pressure washer.	05.C	**L**
	Fire.	Fire extinguishers shall be placed in work areas. Smoking shall only be allowed in designated areas.	09.E.01 09.A.06	**L**
	Heat stress.	Personnel shall drink plenty of cool water. Personnel shall pace themselves while performing strenuous work and take adequate breaks in a cool area.	06.I 02.C	**M**
	Use of pressure or steam washer.	The pressure/steam washer shall be inspected before each use. The manufacturer's instruction manual shall be used to guide the inspection process. Personnel shall be trained in the use of the washing equipment. All personnel working in the equipment decontamination area shall be trained in the emergency shut-off procedures for the equipment being used. The minimum amount of steam/pressure that will complete the job should be used. Pressure washers exceeding 3000 psi shall not be used without the approval of the Health and Safety Manager. The spray from such equipment shall only be directed at surfaces to be cleaned and never at body parts or other personnel. Personnel in the immediate area shall use face shields and metatarsal/shin guards. Personnel shall keep firm grip on wand and not point it at anything that is not being washed. Pressure washer operators must maintain good footing. The trigger on the wand shall never be wired/fixed open. Operators are to take adequate breaks to avoid fatigue. Hot surfaces shall be avoided. Units shall be shut off and allowed to cool 15 minutes prior to re-fueling (if gas-powered). Carbon monoxide shall be monitored if gas-powered pressure washers are used in poor ventilated locations. Carbon monoxide concentrations shall not be allowed to exceed 25 parts per million within any indoor areas.	13.A.02 13.A.02 09.B.21 13.A.12	**L**

Job Steps	Hazards	Controls	EM 385-1-1	RAC
Clean equipment (continued).	Spills of decontamination water.	All waste handling activity shall be performed on visqueen (polyethylene sheeting) lined work surfaces. Waste liquids shall be stored with secondary containment. Lids and bungs shall be secured when drums are in storage or are being moved. Spill cleanup equipment shall be readily available when handling wastes. Drums containing waste shall be inspected on a daily basis. Spills shall be immediately reported to the Site Safety and Health Officer.	09.B.18	**L**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
Personal Protective Equipment - Level D - Modified: Hard hat* Safety glasses Safety-toed boots Work gloves (outer) Nitrile exam gloves (inner) Vinyl rain-gear or Poly Tyvek Face shields Metatarsal covers Protective over-boots Hearing protection Equipment: GFCI Fire extinguishers Emergency eyewash Pressure washer or steam cleaner First aid kit Drinking water Weather radio or AM/FM radio Spill control equipment	Competent Person (CP) / Qualified Person (QP): Brian Rhodes – QP/SSHO Brian Rhodes – QP/First Aid and CPR Training Requirements: Site safety orientation HAZWOPER 40-Hour Lifting/back safety Fire extinguisher use Emergency procedures National Lightning Safety Institute Lightning Safety procedures	Daily site safety inspection (SSHO) –Brian Rhodes Daily site safety inspection (QCO) –Brian Rhodes Housekeeping (daily) Fire extinguisher (monthly) Equipment and tools inspection daily and before use Monitor approaching storms

FIGURES



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ATTACHMENT 1

EVALUATING MEC/CWM/CA HAZARDS IN SUPPORT OF HTRW ACTIVITIES

OU Number: 10 **Date: 9/3/20** **Name of person completing form: Doug Russell**

Site Name: RSA-271 **Title: HSE Manager**

Job Number: 501021 **Signature:** ______________

	Yes	No
1a. Have the historical records available for this HTRW site been reviewed?	☒	☐

If the answer to **1a.** is yes, proceed to **1b.**
If the answer to **1a.** is no, review site information prior to completing this form.

	Yes	No
1b. Is there recent information (site walk, worker interviews, etc.) that indicates a potential MEC/CWM hazard at this site?	☐	☒

Proceed to **2**.

2. According to the records review, this site is known or suspected to have been used for:

	Yes	No
2a. Manufacturing, production, or shipping of conventional MEC:	☐	☒
Live fire testing of any conventional ordnance:	☐	☒
Conventional MEC training:	☐	☒
Storage of conventional MEC:	☐	☒
Disposal or demilitarization of conventional MEC:	☐	☒
Other (specify):		

	Yes	No
2b. Manufacturing, production, or shipping of chemical agent:	☐	☒
Research or testing of chemical agent:	☐	☒
Chemical agent related training:	☐	☒
Storage of chemical agent:	☐	☒
Disposal or demilitarization of chemical agent:	☐	☒
Live fire testing of any CWM ordnance:	☐	☒
Other (specify):		

Any **2a** question answered "YES" indicates UXO support is required for all site activities. If all **2a** questions are answered "NO", UXO support may not be required. Refer to Installation-Wide Accident Prevention Plan (APP) for additional information concerning UXO support. Proceed to question **2b**.

Any **2b** question answered "YES" requires the remainder of this form to be completed. If all **2b** questions are answered "NO", near real-time monitoring for chemical agent will not be required and completing the remainder of this form is not required. Refer to SSHP for additional information concerning agent monitoring.

OU Number: 10 **Site Name: RSA-217**
Job Number: 501021 **Date: 9/3/20**

3. For sites where the manufacturing, testing, storage, or disposal of CWM is suspected:	**Yes**	**No**
Is there evidence that the CWM is/was containerized in potentially unexploded ordnance:	☐	☐
Is there evidence that the CWM is/was containerized in nonexplosive containers:	☐	☐
Is there evidence that the CWM is open to the environment (i.e., in an open container or free liquid/solid in the soil/water):	☐	☐
Is there evidence that the CWM hazard has been removed from the site or that the site has been decontaminated:	☐	☐
Has the site been previously monitored or sampled for chemical agent or agent breakdown products:	☐	☐
For any "YES" above, was the agent or breakdown product identified?	☐	☐

For any "Yes", list types of agent (mustard, lewisite, etc.) and the form (in MEC, in drum, etc.) the CWM is expected to be found (or state "unknown"):

Agent:

List agent breakdown products identified:

Continue to page 3 of 5

OU Number: 10 Site Name:
Job Number: 501021 **Date: 9/3/20**

4. Defining the Potential for the Presence of CWM:	**Agent Monitoring Requirements for Site Activities:**
4a. Frequent Presence Potential – Definition: Occurs very often, continuously experienced. CWM is known or to be present at the site in a condition (within MEC and/or nonexplosive container, or in an uncontainerized form in sufficient volume that weathering of the product has not rendered it harmless) that will cause potential harm to personnel if it is encountered.	Mandatory personal and perimeter air monitoring using the DAAMS, MINICAMS, and RTAP collection/analysis methods with off-site surety laboratory confirmation of all environmental samples. Specific monitoring criteria (equipment types and sampling station placement, percentage of personnel monitored, etc.) to be established in the Site Specific Safety and Health Plan (SSHP).
4b. Likely Presence Potential – Definition: Occurs several times. CWM is known or highly suspected to be present at the site in a condition (within MEC and/or nonexplosive container, or in an uncontainerized form in sufficient volume that weathering of the product has not rendered it harmless) that will cause potential harm to personnel if it is encountered.	Mandatory personal and perimeter air monitoring using the DAAMS, MINICAMS, and RTAP collection/analysis methods with off-site surety laboratory confirmation of all environmental samples. Specific monitoring criteria (equipment types and sampling station placement, percentage of personnel monitored, etc.) to be established in the Site Specific Safety and Health Plan (SSHP).
4c. Occasional Presence Potential - Definition: Occurs sporadically. CWM is suspected to have been present at the site, but has been previously removed and/or decontaminated, or has been open to the environment such that it is expected to have degraded and been rendered harmless.	The need for personal and perimeter air monitoring using the DAAMS, MINICAMS, and RTAP collection/analysis methods with off-site surety laboratory confirmation of all environmental samples will be reviewed on a site-by-site basis. Specific monitoring criteria (equipment types and sampling station placement, percentage of personnel monitored, etc.) to be established in the Site Specific Safety and Health Plan (SSHP).
4d. Seldom Presence Potential - Definition: Remotely possible; could occur at some time. CWM is suspected to have been present at the site, but has been previously removed and/or decontaminated, or has been open to the environment such that it is expected to have degraded and been rendered harmless.	The need for personal and perimeter air monitoring using the DAAMS, MINICAMS, and RTAP collection/analysis methods with off-site surety laboratory confirmation of all environmental samples will be reviewed on a site-by-site basis. Specific monitoring criteria (equipment types and sampling station placement, percentage of personnel monitored, etc.) to be established in the Site Specific Safety and Health Plan (SSHP).
4e. Unlikely Presence Potential – Definition: Can assume will not occur, but not impossible. No indications that CWM will be present in quantity or reactivity (in munitions, projectiles, drums, etc.).	No specific personal or area monitoring for chemical agents required beyond what is specified in the SSHP.

Continue to page 4 of 5

OU Number: 10 **Site Name: RSA-271**

Job Number: 501021 **Date: 9/3/20**

5. Based on the information provided in questions 1 through 5, above, the following guidelines will be used for establishing PPE requirements for activities to be performed at this site; Specific details are provided in the SSHP:	
5a. High Exposure Potential - High exposure potential is determined by evaluating the potential presence of CWM in conjunction with the task(s) to be performed, as well as the specific location and duration of the task(s).	Subject to review by the APTIM health and safety manager, PPE for all personnel in the exclusion zone at a site identified as having a "High Exposure Potential" will be Level B (supplied air) or Level C (full-face NIOSH approved CBRN respirator with CBRN cartridges) and chemically resistant coveralls. Specific PPE requirements are in the SSHP for this site.
5b. Moderate Exposure Potential - Moderate exposure potential is determined by evaluating the potential presence of CWM in conjunction with the task(s) to be performed, as well as the specific location and duration of the task(s).	Subject to review by the APTIM health and safety manager, PPE for all personnel in the exclusion zone at a site identified as having a "Moderate Exposure Potential" will be Modified Level D (disposable coveralls and NIOSH approved CBRN escape respirator) carried by all personnel. Specific PPE requirements are in the SSHP for this site.
5c. Low Exposure Potential - Low exposure potential is determined by evaluating the potential presence of CWM in conjunction with the task(s) to be performed, as well as the specific location and duration of the task(s).	Subject to review by the APTIM health and safety manager, no additional PPE requirements above those stated in the SSHP are needed for sites identified as having "Low Exposure Potential." Specific PPE requirements are in the SSHP for this site.

Review of available information indicates the presence potential at this site is considered to be:
MEC / LOW
CWM Presence Potential / UNLIKELY
Exceptions/Explanations: Based on June 2015 RSA CWM UXO probability maps.

Review Signatures:

APTIM UXO Technical Manager ____________ Date: 9/3/20 APTIM H&S Specialist ____________ Date: 9/3/20

Additional Notes and Explanations:

RSA-271 is located within the former Redstone Ordnance Plant Line 1 operations area and later the Thiokol Corporation/Redstone Arsenal Rocket Engine North Plant area. RSA-271 consists of a vacant area (approximately 0.25 acres) and is the location of a former UST used to support the operation of the boiler unit in former Building 7729.

The Army built Building 7729 (B-529) in 1942. During Redstone Ordnance Plant operations, Building 7729 was used as a steam heating plant (boiler house). Following the acquisition by Thiokol Corporation (circa 1950), the building continued to be used as a boiler house until 1982. Subsequently, it was used as a maintenance storage area. A list of removed USTs maintained by the Redstone Compliance Group indicates that a 2,800-gallon steel UST (installation date unknown) was removed in 1998. During the steam house/boiler operations, the UST was used to store fuel oil #2.

Based on UXO probability map (June 2015) RSA-271 is rated as a “low” probability to encounter MEC. Aptim will maintain standby UXO support in event suspicious items are encountered.

CWM is rated “unlikely” therefore no near real-time air monitoring or chemical agent surety screening is required.

ATTACHMENT 2

AMS-710-01-FM-04201, COVID-19 CONTROL PLAN

COVID-19 CONTROL PLAN

COVID-19 VIRUS CONTROL PLAN, REDSTONE ARSENAL, MADISON COUNTY, ALABAMA

1.0 GENERAL

Coronavirus Disease 2019 (COVID-19) is a respiratory disease caused by the SARS-CoV-2 virus. COVID-19 spread from China to many other countries around the world, including the United States. The COVID-19 pandemic is impacting all aspects of daily life, including travel, trade, tourism, food supplies, and financial markets. This plan defines site-specific efforts regarding:

- Awareness and Education
- Screening Methods
- Contamination Prevention and Sanitation
- Reporting and Illness/Exposure Management

This COVID-19 Control Plan (CCP) is applicable to all APTIM employees at this jobsite. APTIM expects subcontractors to protect their employees through compliance with APTIM's CCP or through the development and implementation of a COVID-19 control plan specific to their risks. APTIM and U.S. Army Engineering and Support Huntsville Center (CEHNC) leadership must approve subcontractor plans before implementation at the jobsite.

These requirements are in effect at least for the duration of the pandemic. The APTIM COVID-19 Task Force will amend these requirements or suspend their operation when no longer necessary.

2.0 CONTROLS

2.1 Awareness and Education

A continual assessment of hazards is required to maintain a current awareness of exposures and the effectiveness of current controls. These methods will ensure employees have access to current information on how the pandemic is progressing, known site-specific exposures, site-specific controls and how to effectively implement them, and reporting requirements.

- At a minimum, COVID-19 training shall be provided via new hire orientation, daily toolbox talks, usual risk assessment tools including JSA's, TARGET observation program, Near Miss/Great Catch reporting, findings from inspections, informational postings and informal discussions with supervision or employees.
- On-going assessment of local, state and federal guidelines from organizations such as the Center for Disease Control (CDC), Occupational, Safety, and Health Administration (OSHA), and Alabama Department of Public Health (ADPH) are required by all leadership employees to maintain an accurate understanding of the current threats.
- The APTIM Corporate COVID-19 Task Force meets regularly to evaluate APTIM's pandemic efforts and implement appropriate responses.

- APTIM maintains a corporate COVID-19 resource page providing guidance from the CDC, WHO, as well as APTIM-specific information. This page is located on the company intranet and available to all employees with an email address.

2.2 Screening Methods

Employees can be exposed both at the jobsite and away from the jobsite. Fever, coughing, and shortness of breath are primary symptoms that may occur between two and fourteen days from contraction of the virus. It is critical to remind employees to identify any of these symptoms and to quickly isolate employees who are symptomatic from other employees.

- Employees are reminded to continually evaluate themselves for the onset of any symptoms, particularly fever, coughing or shortness of breath.
- APTIM will use the screening questionnaire in Appendix 1 for all site workers upon first reporting for the project work or if site workers are returning from and extended break, furlough, leave of absence for medical or vacation. Client-required questionnaires may be used in lieu of Appendix 1 where applicable.
- Infrared thermometers will be deployed as available and as necessary to assess all employees for potential fevers prior to entering the designated jobsite work site. A screening station will be located at the entrance to the jobsite parking lot where each employee's temperature will be screened while sitting in their vehicle.
- A temperature measured as greater than 100.4 ºF is considered a fever.
    - Employees registering a fever may sit isolated for no more than 10 minutes in their vehicle before being rechecked to confirm the fever. If a temperature of 100.4 ºF or greater is registered after the second reading, the employee will be sent home.
- Any employee experiencing symptoms of illness will be isolated from the workforce and sent home.
- If the screening tool in Appendix 1 is used, APTIM may separate employees and send employees home, as warranted, depending on the answers to questions in the tool, read in accordance with current guidance from the "CDC" or other applicable health organization.
- An employee who notices a co-worker exhibiting or complaining of symptoms of acute respiratory illness (fever, coughing, shortness of breath) has Stop Work Authority if they are concerned about another's health. The immediate supervisor should be notified, and HSE contacted to evaluate how to proceed and limit further exposure. Of course, we absolutely expect employees to treat each other with respect and dignity, in keeping with APTIM's policies and collaborative culture. Harassment, bullying or other mistreatment of employees because of a suspicion of symptoms is grounds for discipline, up to and including termination of employment.
- APTIM may require employees to complete fitness for duty evaluations as needed to respond to an objective concern for the health or safety of an employee and co-workers. The Supervisor must discuss a request for a fitness for duty evaluation with HR and HSE in advance; HSE will coordinate the fitness for duty process.

2.3 Contamination Prevention and Sanitation

Current medical understanding is that the virus is primarily transmitted via respiratory droplets. The virus can potentially survive on varying surfaces from hours to multiple days. Primary routes of entry include the mouth, eyes and nose.

A. **Sick Employees Stay Home:** Any employee who is experiencing symptoms of acute respiratory illness (fever, cough, shortness of breath) shall notify the employee's supervisor and not report to work.

B. **Social Distancing Practices:**

- Whenever possible, everyone is to maintain a minimum 6ft. distance from other people. This practice insulates individuals from potential exposure to respiratory droplets. If situations require close contact, time within 6ft. should be minimized. Employees are also to not touch other employees unless absolutely necessary to complete a task. Any touching should be followed by adequately disinfecting as soon as possible. Employees capable or working remotely have been asked to do so to incrementally reduce the numbers of employees on the jobsite.
- Visitors, sales representatives, and others whose presence on-site is not business critical are restricted from visiting the jobsite until further notice. The APTIM Project Manager must approve any deviation request in advance.
- Break times, including lunch times, have been staggered to minimize interactions with others. Additional lunch tents have been ordered to allow further distancing.
- Whenever possible, meetings are to be conducted via teleconference rather than in person. No in-person meeting is to exceed 10 people.

C. **Sanitation Measures:**

- Employees should not cover any cough or sneeze with their hands but should use a tissue or the elbow to contain the cough or sneeze. This process reduces contamination on hands and in air. Employees must properly wash their hands following any cough or sneeze.
- At a minimum, all employees shall conduct adequate hand washing prior to eating, before and after preparing food, following use of the restroom, following sneezing or coughing, and following touching of the face, especially the mouth, eyes or nose.
  - Adequate hand washing is achieved by following these five steps:
    - Wet your hands with clean, running water (warm or cold); turn off the tap, and apply soap.
    - Lather your hands by rubbing them together with the soap. Lather the backs of your hands, between your fingers, and under your nails.
    - Scrub your hands for at least 20 seconds. Need a timer? Hum the “Happy Birthday” song from beginning to end twice.

    - Rinse your hands well under clean, running water.
    - Dry your hands using a clean towel or air dry them.

- Do not touch your eyes, nose or mouth. Sores should also stay covered and protected. These measures are to prevent routes of entry. If the face, eyes, nose or mouth must be touched, employees shall adequately wash their hands prior to, and after.
- Cloth Face Masks: Wherever possible, APTIM is working to ensure that employees can work at least 6' away from other individuals, in order to maintain the recommended social distance in this pandemic. Employees working in an area where they can avoid prolonged interaction with others can choose to use a cloth mask. Please see Appendix 2 for information from the CDC about making cloth masks, directions on how to don and doff these masks, and laundering the masks. HSE will work with employees who are working on tasks that require working within 6' feet of others for a prolonged period to help plan steps to minimize this close contact work and to ensure that, where required, employees have adequate respiratory protection suited to the job task (such as NIOSH-approved, particulate filtering masks). Cloth masks are not a good substitute in these situations.
- Additional hand washing stations have been provided and are serviced and maintained daily by the provider of the stations.
- If handwashing stations are not immediately available, employees should use hand sanitizer containing at least 60% alcohol. Hand sanitizer should not be used in lieu of handwashing if hands are visibly soiled. Hand sanitizer is readily available for employees to frequently disinfect their hands throughout the jobsite.
    - Use hand sanitizer in the following manner:
        1. Apply the gel product to the palm of one hand. (Read the label to learn the correct amount).
        2. Rub your hands together.
        3. Rub the gel over all the surfaces of your hands and fingers until your hands are dry. This process should take around 20 seconds.
- Portable restrooms are disinfected daily by the restroom provider and witnessed by APTIM employees.
- Our business processes such as TARGET, JSA's, 5x5's, inspections, etc. are heavily reliant on the shared handling of paper. Paper is another vehicle to share potential contamination. The site must assess and implement measures to minimize exposure to paper, limit interactions among employees, discontinuing use of shared pens, use personal protective measures (such as gloves) and disinfection following handling.
    - Shared pens will not be allowed.
    - Job site sign-in sign-out will be done when employee shows up at screening tent. A screening tent attendee will record the employee entering and exiting time – individual employees will not touch the sign in log and signatures will be waived during implementation of this control plan.

- All other jobsite paperwork will be handled with proper nitrile gloves while practicing social distancing and completed for the task at hand. Once paperwork is completed, the QCSM will file the paperwork electronically and the paperwork will be immediately placed in a secured suitable plastic storage box. Future handling of such paperwork will be done under strict adherence to the contamination prevention and sanitation procedures described herein.

D. **Travel Limitations:**

- APTIM has suspended all non-essential business travel. Essential business travel must be approved by APTIM leadership. Anyone approved to travel will be screened prior to reporting back to the jobsite.

2.4 Reporting and Illness Management

2.4.1 General

2.4.1.1 To ensure both prompt medical evaluation and prevention of any potential contamination to the jobsite, APTIM requires employees to immediately report any symptoms (fever, cough, or difficulty breathing), no matter how slight, to HSE.

2.4.1.2 APTIM will communicate appropriate notifications to CEHNC in accordance with established protocols and in keeping with applicable privacy laws.

2.4.1.3 Employees experiencing symptoms of any illnesses are to stay home. Please take the necessary steps for your health and safety and the health and safety of your co-workers. Notification to supervision is required. Employees who are experiencing any symptoms are not to report to work until the employee has been symptom and fever free for at least 72 hours without the assistance of fever reducing medications

2.4.1.4 HSE, working with Site Leadership and HR, maintains a confidential log of information related to employees who are symptomatic, who test positive for COVID-19, or who were potentially exposed someone outside of work who was positive (test, diagnosis or suspected). The log should include the name of the affected employees, the potential exposure or test date, date of onset and description of symptoms (if symptomatic), information about the exposure event, dates of expected quarantine, and status. HSE, working with Site Leadership, also maintains a confidential log of any employees on the jobsite potentially exposed by “close contact” to another COVID-19 positive (test, diagnosed or suspected) employee, including the potential exposure date, any testing information, a description of the potential exposure, the dates of any quarantine period, and a status update.

2.4.1.5 Site Leadership is responsible to notify HSE and HR of any COVID-19 positive (test, diagnosis or suspicion).

2.4.1.6 If an employee's illness appears to be personal and non-emergent, APTIM will direct the employee to see his or her personal health care provider.

2.4.1.7 Cases potentially work-related will be evaluated at:

Crestwood Family Practice – (256) 721-9916
Crestwood Workers Care Madison – (256) 830-8930

For cases potentially work-related, consideration should be given to allowing the affected employee to self-transport to seek medical care in order to maintain social distancing of 6ft. or greater. Vehicles offering adequate distance, such as passenger vans may also be used. Vehicles used for transport are disinfected following the trip.

2.4.1.8 Return to Work Protocol

APTIM follows current CDC recommendations for returning employees to work after COVID-19 diagnosis or exposure. Please see Appendix 3 for a flow chart setting forth these criteria. Information about return to work protocols is also contained in the sections below.

2.4.2 Potential or Known Exposure to COVID-19 or Employees with Symptoms:

2.4.2.1 Symptomatic employees

If an employee is experiencing symptoms of acute respiratory illness and a fever (greater than 100.4 degrees Fahrenheit, or 37.8 degrees Celsius), the employee must not come to work. The employee must alert his or her supervisor that he or she is symptomatic and is staying away from work. Supervisors should alert HSE immediately once they receive information that an employee is staying home with acute respiratory illness symptoms. Please see Potential Workplace Exposure section below for the required analysis of potential exposure to symptomatic employees.

2.4.2.2 Diagnosed Employees

Employees testing positive for COVID-19 are required to follow their health care provider's orders and will not be allowed back onsite until cleared by the health care provider to return to work. Recognizing strains on the medical system during this pandemic, APTIM will work with employees to balance the need for information on the employee's fitness to work with the availability of a health care provider. We will follow CDC guidelines for return to work criteria for employees who test positive or are presumed positive for COVID-19.

Please see Potential Workplace Exposure section below for the required analysis of potential exposure to symptomatic employees.

2.4.2.3 Potentially exposed but asymptomatic employees

If an employee has been exposed to:

a. a household member or intimate partner or

b. has provided care in a household without using recommended infection control precautions, or
c. had had “close contact” (< 6 feet) for a “prolonged” period of time

to a person with symptomatic COVID-19 (can be a laboratory-confirmed disease or a clinically compatible illness) but the employee does not have symptoms, the employee may also need to stay home and not come to work or may be able to continue work, subject to workplace protections being in place, if the employee is working in a critical infrastructure position. (see section below).

The potential exposure period is the 48-hour period before the person with symptomatic COVID-19 began experiencing symptoms.

Please note the following definitions of “close contact” and “prolonged” (from CDC guidance):

Factors to consider when defining close contact include proximity, the duration of exposure (e.g., longer exposure time likely increases exposure risk), whether the individual has symptoms (e.g., coughing likely increases exposure risk) and whether the individual was wearing a facemask (which can efficiently block respiratory secretions from contaminating others and the environment).

Prolonged exposure varies on the length of time of exposure from 10 minutes or more to 30 minutes or more. Brief interactions are less likely to result in transmission; however, symptoms and the type of interaction (e.g., did the person cough directly into the face of the individual) remain important.

The potentially exposed employee must alert the employee’s supervisor, and HSE will work with the employee to determine whether, following CDC guidelines, the employee must remain self-quarantined and not at the worksite for 14 days from the last exposure to the confirmed or suspected COVID-19 individual.

Asymptomatic Employees Working in Critical Infrastructure Positions:

- Potentially exposed but asymptomatic employees who are working in “Critical Infrastructure” positions whose presence is critical to the ongoing progress of the project may continue to work with the following required protective measures in place: Prescreen: A temperature screening to confirm the absence of a fever (100.4 ºF) and a symptom assessment is required prior to entering the jobsite.
- Regular Monitoring: Ongoing self-monitoring with assistance from HSE to ensure the employee remains asymptomatic and fever free.
- Wear a Mask: The employee should wear a face mask at all times while in the workplace for 14 days after last exposure. Employee-supplied face masks are acceptable (see Appendix 2), or a site can issue a face mask (where supplies are adequate).
- Social Distance: The employee should maintain social distancing of at least 6ft. from other individuals. Any encroaching of 6ft. requires additional controls, such as adequate respiratory protection. (Contact HSE for support)

- Disinfect and Clean: The jobsite must clean and disinfect all areas such as offices, bathrooms, common areas, shared equipment routinely.

If the employee becomes sick during the day, the employee should be sent home immediately. Surfaces in their workspace should be cleaned and disinfected. Information on persons who had contact with the ill employee during the time the employee had symptoms and 2 days prior to symptoms should be compiled. Others at the facility with close contact within 6 feet of the employee during this time would be considered exposed.

2.4.2.4 Potential Workplace Exposure

APTIM will inform employees of a potential workplace exposure, while maintaining confidentiality (i.e., without revealing the infected individual's name unless otherwise directed by the CDC, ADPH, or directives from CEHNC).

APTIM will analyze whether any other employees were potentially exposed to an employee diagnosed with COVID-19 through "close contact" with the diagnosed employee during the 48-hour period before the diagnosed employee started experiencing symptoms. Following CDC recommendations and directives, APTIM will direct potentially exposed asymptomatic employees to self-quarantine and remove them from the jobsite for a 14-day period from the date of the employee's last exposure to the confirmed or suspected positive individual.

Please see above for information about potentially exposed but asymptomatic employees working in critical infrastructure. These employees can continue to work, as long as they remain asymptomatic and the workplace protections set forth above are in place. Employees are eligible to continue receiving per diem (if the employee is otherwise eligible for per diem) during the time the employee is not able to work because the employee is experiencing symptom of acute respiratory illness (fever, cough, shortness of breath) or is quarantined and away from home. The employee may need to provide medical documentation in order to be considered for continued per diem while they're not at work.

2.5 Roles and Responsibilities

2.5.1 Project Manager

- Responsible for oversight and coordination of the CCP implementation to ensure consistency in program content and efficient use of resources.
- Responsible for ensuring that all employees adhere to the procedures, including training and awareness of CCP issues.
- Responsible to ensure communication of project expectations regarding the CCP.
- Support and endorse the Project HSE Management System and CCP.
- Ensure compliance to the CCP by all employees, subcontractors, and vendors.
- Provide the resources necessary for implementation of the CCP.

- Ensure that adequate Emergency Response Procedures are in place for the evacuation of employees.

2.5.2 Superintendents or Senior UXO Supervisor

- Assists the Project Manager in ensuring that all employees adhere to the procedures, including training and awareness of CCP issues.
- Assists the Project Manager in ensuring communication of project expectations regarding the CCP.
- Actively support the CCP.

2.5.3 Project HSE Manager

- Review and analyze new data on COVID-19 risk, prevention, and management.
- Identify and provide training and awareness materials.
- Provide leadership with health risk assessment efforts for each area of the project.
- Identify and communicate program expectations (i.e., diagnosis, treatment and notification) to preferred medical providers.
- Review COVID-19 incident data.

2.5.4 Employees

- Adhere to all program requirements regarding prevention and mitigation measures.
- Participate actively and vocally in the awareness program.
- Report any suspected symptoms of acute respiratory illness (fever, coughing, shortness of breath) immediately to the supervision.
- Stay home when sick.
- Provide regular updates to Project Management regarding anticipated return to work if the employee is required to stay home due to quarantine or illness

2.5.5 Preferred Occupational Medical Provider

- Use rapid diagnosis method to test for COVID-19.
- Report confirmed or unconfirmed cases of COVID-19 to APTIM HSE Manager.
- Communicate with Project HSE Manager to related to COVID-19 diagnosis and treatment as needed.
- Ensure clinic staff understands COVID-19 requirements for diagnostic, and treatment.

3.0 Resources:

COVID-19 CONTROL PLAN

PUBLIC HEALTH RECOMMENDATIONS FOR COMMUNITY-RELATED EXPOSURE, HTTPS://WWW.CDC.GOV/CORONAVIRUS/2019-NCOV/PHP/PUBLIC-HEALTH-RECOMMENDATIONS.HTML

IMPLEMENTING SAFETY PRACTICES FOR CRITICAL INFRASTRUCTURE WORKERS WHO MAY HAVE HAD EXPOSURE TO A PERSON WITH SUSPECTED OR CONFIRMED COVID-19, https://www.cdc.gov/coronavirus/2019-ncov/community/critical-workers/implementing-safety-practices.html

DISCONTINUATION OF ISOLATION FOR PERSONS WITH COVID-19 NOT IN HEALTHCARE SETTINGS (INTERIM GUIDANCE) **HTTPS://WWW.CDC.GOV/CORONAVIRUS/2019-NCOV/HCP/DISPOSITION-IN-HOME-PATIENTS.HTML**

APPENDIX 1
COVID-19 QUESTIONNAIRE

APPENDIX 1 – COVID-19 QUESTIONNAIRE

Name:	
Contact Number:	
Date:	
Department:	
Supervisor:	

Question	
Have you traveled internationally or within the US in the last 14 days?	Yes/No
If Yes, What country? When was your travel concluded?	
Have you been on a cruise (domestic, foreign, ocean, river) in the last 14 days?	Yes/No
Have you had any of the following interactions with an individual who has symptoms and/or has laboratory-confirmed COVID-19: • Have had close contact • Sat on an aircraft or public transportation vehicle within 6 feet (e.g. two airline seats) • Live in the same household as, are in a physical relationship with, or are caring for someone at home • "**Close contact**" means: a) being within approximately 6 feet (2 meters) of a COVID-19 case for a prolonged period; close contact can occur while caring for, living with, visiting, or sharing a healthcare waiting area or room with a COVID-19 case– *or* b) having direct contact with infectious secretions of a COVID-19 case (e.g., being coughed on). If yes, when was the last time you had "close contact" or interaction with the individual? (note: if close contact was within 48 hours before symptoms started, further evaluation necessary.	Yes/No
Are you currently experiencing (now or in the last 72 hours) any symptoms of fever, chills, cough, shortness of breath, or sore throat?	Yes/No
Have you been tested for COVID-19 in the last 14 days? If yes, have you received your results?	
If yes to any questions above and you have been at company facilities, please continue	
What other job sites or offices have you visited in the last 14 days?	
Have you attended any meetings in person in the last 14 days? If yes, who was present?	
What is your desk/office/work location?	

APPENDIX 2
INSTRUCTIONS RELATED TO CLOTH MASKS

Use of Cloth Face Coverings to Help Slow the Spread of COVID-19

How to Wear Cloth Face Coverings

Cloth face coverings should—

- fit snugly but comfortably against the side of the face
- be secured with ties or ear loops
- include multiple layers of fabric
- allow for breathing without restriction
- be able to be laundered and machine dried without damage or change to shape

CDC on Homemade Cloth Face Coverings

CDC recommends wearing cloth face coverings in public settings where other social distancing measures are difficult to maintain (e.g., grocery stores and pharmacies), **especially** in areas of significant community-based transmission.

CDC also advises the use of simple cloth face coverings to slow the spread of the virus and help people who may have the virus and do not know it from transmitting it to others. Cloth face coverings fashioned from household items or made at home from common materials at low cost can be used as an additional, voluntary public health measure.

Cloth face coverings should not be placed on young children under age 2, anyone who has trouble breathing, or is unconscious, incapacitated or otherwise unable to remove the cloth face covering without assistance.

The cloth face coverings recommended are not surgical masks or N-95 respirators. Those are critical supplies that must continue to be reserved for healthcare workers and other medical first responders, as recommended by current CDC guidance.

Should cloth face coverings be washed or otherwise cleaned regularly? How regularly?

Yes. They should be routinely washed depending on the frequency of use.

How does one safely sterilize/clean a cloth face covering?

A washing machine should suffice in properly washing a cloth face covering.

How does one safely remove a used cloth face covering?

Individuals should be careful not to touch their eyes, nose, and mouth when removing their cloth face covering and wash hands immediately after removing.

cdc.gov/coronavirus

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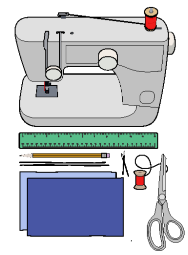
COVID-19 CONTROL PLAN

Sewn Cloth Face Covering

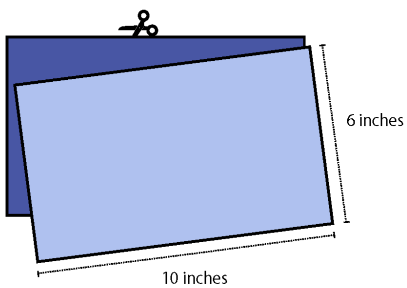
Materials

- Two 10”x6” rectangles of cotton fabric
- Two 6” pieces of elastic (or rubber bands, string, cloth strips, or hair ties)
- Needle and thread (or bobby pin)
- Scissors
- Sewing machine

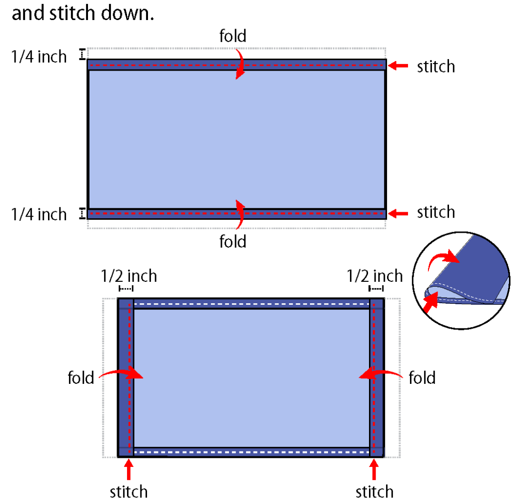


Tutorial

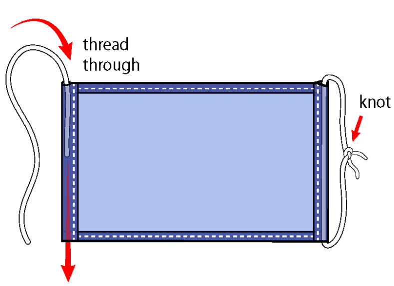
1. Cut out two 10-by-6-inch rectangles of cotton fabric. Use tightly woven cotton, such as quilting fabric or cotton sheets. T-shirt fabric will work in a pinch. Stack the two rectangles; you will sew the cloth face covering as if it was a single piece of fabric.



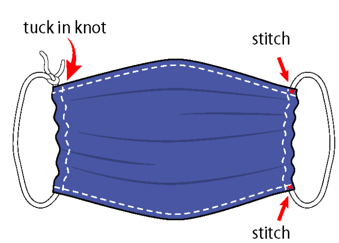
2. Fold over the long sides ¼ inch and hem. Then fold the double layer of fabric over ½ inch along the short sides and stitch down.



3. Run a 6-inch length of 1/8-inch wide elastic through the wider hem on each side of the cloth face covering. These will be the ear loops. Use a large needle or a bobby pin to thread it through. Tie the ends tight.
Don’t have elastic? Use hair ties or elastic head bands. If you only have string, you can make the ties longer and tie the cloth face covering behind your head.



4. Gently pull on the elastic so that the knots are tucked inside the hem.
Gather the sides of the cloth face covering on the elastic and adjust so the cloth face covering fits your face. Then securely stitch the elastic in place to keep it from slipping.

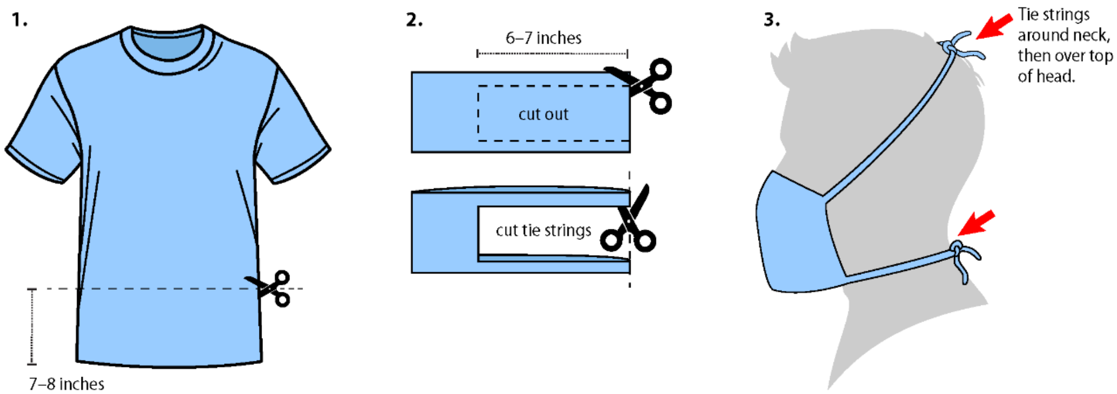


Quick Cut T-shirt Cloth Face Covering (no sew method)

Materials

- T-shirt
- Scissors

Tutorial

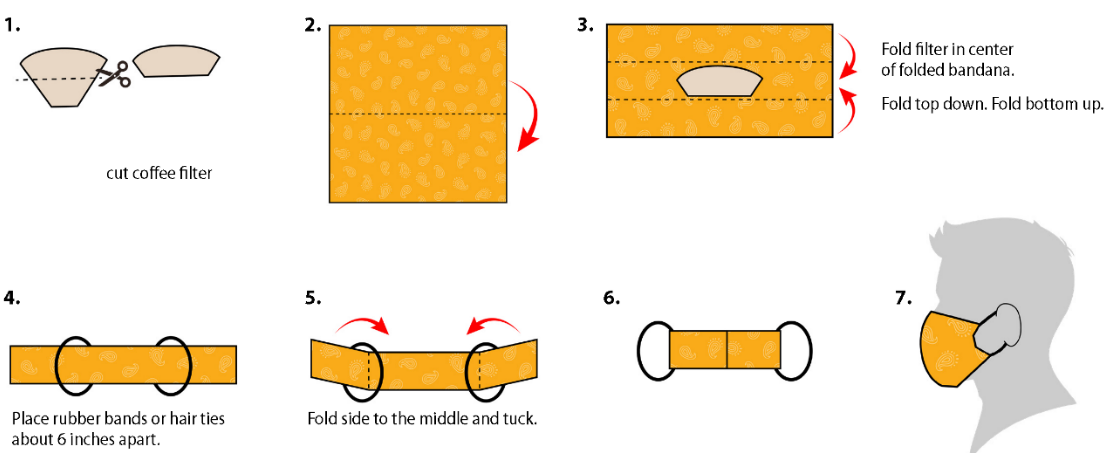


Bandana Cloth Face Covering (no sew method)

Materials

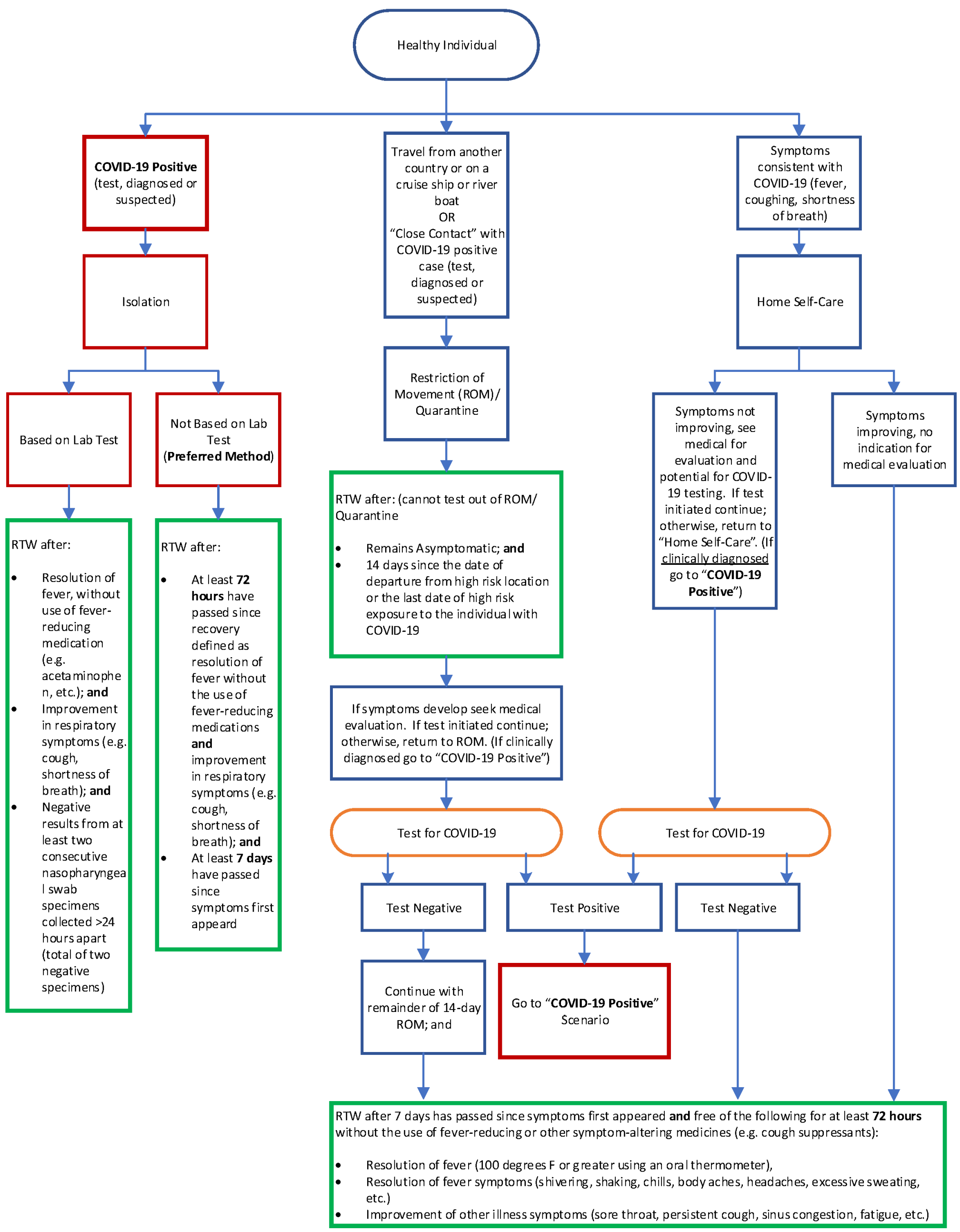
- Bandana (or square cotton cloth approximately 20"x20")
- Coffee filter
- Rubber bands (or hair ties)
- Scissors (if you are cutting your own cloth)

Tutorial



APPENDIX 3 RETURN TO WORK PROTOCOL

RETURN TO WORK (RTW) FLOWCHART
COVID-19



ATTACHMENT 3

AMS-710-02-PR-01610, UTILITY CONTACT PREVENTION

PROCEDURE

Procedure Number:

AMS-710-02-PR-01610

Revision:

0

Procedure Owner:

HSE

Issuing Authority:

VP HSE

Approval Date:

9/3/2019

UTILITY CONTACT PREVENTION

0	Initial Issue	M, Karr	9/3/2019
Rev	**Changes**	**Approved**	**Date**

Parent Document: N/A

1.0 PURPOSE

The purpose of this document is to provide the minimum requirements to ensure that all utilities are properly identified, to prevent personal injury, property damage and/or causing negative impact to the surrounding community and environment.

The following deliverables are defined within this procedure:

Deliverable	Producer	Customer
Authorization to Drill Permit Form (AMS-710-02-FM-01611)	Competent Person – Utility Contact Prevention	Project Manager HSE Employees External Client
Utility Mark-Out Documentation Form (AMS-710-02-FM-01612)	Competent Person – Utility Contact Prevention	Project Manager HSE Employees External Client
Intrusive Activities Checklist (AMS-710-02-CK-01613)	Competent Person – Utility Contact Prevention	Project Manager HSE Employees External Client

2.0 SCOPE

This procedure applies to all APTIM sites planning above ground or intrusive activities, where the utility locations and clearances are not positively identified.

Work conducted around overhead power lines with mobile equipment is addressed in AMS-710-02-PR-06600, Equipment Operation Around Overhead Power Lines.

This procedure authorizes implementation of local, or client required procedures, when those procedures are more protective. Applicable local and/or client specific procedures shall be documented in the project-specific Health and Safety Plan (HASP), Work Plan, or Accident Prevention Plan.

2.1 Exceptions

Exceptions must be approved per the requirements of AMS-710-05-PR-01300, HSE Request for Variances.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Project Managers

- APTIM Utility Contact Prevention – Competent Person
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors

3.1 APTIM Managers

APTIM Managers are to ensure their Project Managers are adhering to these expectations.

3.2 APTIM Project Managers

Project Managers have to designate their Competent Persons and ensure they're implementing these expectations.

3.3 APTIM Utility Contact Prevention – Competent Person

See detailed responsibilities in section 4.1.1.

3.4 APTIM Supervisors, Employees, Contractors and Subcontractors

Supervisors, employees, contractors and subcontractors are required to not proceed or act outside of the expectation.

4.0 PROCEDURE

4.1 Underground Utility Contact Avoidance during Intrusive Activities

4.1.1 Preliminary Requirements

4.1.1.1 The Project Manager - Designates a Competent Person – Utility Contact Prevention (UCP), to manage the aspects of work associated with the intrusive activities, supervise the employees who have the potential to contact any utilities, and fulfill the requirements of this procedure.

4.1.1.2 The Competent Person - UCP is responsible for the following:

- Determining location-specific regulations and client requirements for the notification, identification, locating, marking, contact prevention, and protection of utilities.
- Ensuring boundaries of intrusive activities have been clearly marked, prior to contacting utility locating services.
- Ensuring National One-call center and/or other utility locating services have been contacted, and formal notification of the pending intrusive activities has been completed.

- Ensuring that utility owners are contacted to mark the location of their facilities in the area of the intrusive activities. They shall obtain and document the utility mark-out confirmation number or ticket number provided by the One Call Center. Generally, this notification for a mark-out request must be made from at least two (2) business days (48 hours) to three (3) business days (72 hours) before beginning intrusive activities.
- Ensuring private utility locating services have been contacted and have completed mark-outs, in areas not covered by a One-call center.
- Ascertaining the requirements for maintaining the open ticket with the One Call Center (or local equivalent), client, and/or property owner after the initial formal notification and taking action required to maintain the open ticket, until intrusive activities are completed.
- Ensure time requirements for allowing utility owners to mark locations are met, and authorizing intrusive activities, after satisfaction that all utilities have been located and marked.
- Ensuring all above ground utilities are marked, flagged, or otherwise protected, in areas where equipment could come into contact with them.
- Photograph all utility markings.
- Ensure markings are protected and preserved as feasible.

4.1.1.3 Due to the sensitivity and costs associated with damage to fiber optic cables, the Competent Person - UCP must ensure and document verbal contact and an agreement with the fiber optic cable owner, for all work within 50 feet of fiber optic cables. Additional protective measures for intrusive activities near fiber optic cables shall be specified in site specific HASP, Site Safety Plan, etc.

4.1.1.4 The Competent Person - UCP must verify that the necessary emergency procedures to be taken if underground utilities become damaged are provided in the HASP, work plan, Job Safety Analysis, or Activity Hazard Analysis. These emergency procedures must be conveyed to employees as specified in Section 4.2.3, Field Crew Training (below).

4.1.2 General Requirements

4.1.2.1 A designated Competent Person - UCP shall be onsite at all times when intrusive activities are conducted.

4.1.2.2 Overhead utility locations must be marked where heavy equipment or other equipment has the potential for contacting overhead or adjacent utilities. Where required by law, advanced notification to the utility company may be required for any work where potential exists for incidental contact with utility lines. Daily site inspections are required to determine where activities will take place and to ensure all adjacent above ground utilities are identified, marked, and/or protected, to prevent contact. Provide updated information to employees in daily tailgate meetings.

4.1.2.3 Maintain a minimum of 10 feet from overhead power lines, up to 50 kV. Adjust distances based on voltages over 50 kV by adding 0.4 inches per kV to the minimum 10 foot clearance. 20 feet of separation from lines, is required if voltage is unknown. Spotters are required to ensure safe clearance is maintained.

4.1.2.4 Prior to conducting any intrusive activities, the Competent Person - UCP must verify the Intrusive Activities Checklist (AMS-710-02-CK-01613) and the Utility Mark-out Documentation form (AMS-710-02-FM-01612) have been completed. No intrusive activities work is to be performed until all utility mark-outs are verified and until the facility owner-members have all provided the appropriate positive response.

4.1.2.5 Location specific procedures may not always be conveyed to contractors. The property owner, client, and/or facility operator must be consulted on the issue of underground utilities. All knowledge of past and present utilities must be evaluated prior to conducting work.

4.1.2.6 Only hand digging is permitted within 3 feet of underground high voltage lines, product lines, gas lines, or fiber optic cables. Once the line or cable is exposed, heavy equipment can be used but must remain at least 3 feet from the exposed line or cable.

4.1.2.7 If possible, shoveling/digging should be conducted parallel to the expected utility run.

4.1.3 Operating Requirements Specific to Excavation Activities

4.1.3.1 Refer to Section 5.0, Terminology to determine the applicable activities considered to be included as excavation.

4.1.3.2 The requirements of AMS-710-02-PR-01600, Excavation and Trenching must be followed.

4.1.3.3 After all mark outs have been completed, and the excavation locations have been accepted by the Competent Person - UCP prior to mechanical excavation, each utility identified inside the excavation location must be hand dug or vacuum excavated to a verify the utility location. The utility locations must be exposed in enough locations to verify its path of travel. If possible, the excavation location should be moved away from any utilities.

4.1.3.4 All utilities exposed during an excavation will be protected from accidental damage.

4.1.3.5 Utilities which are found to change elevation (shallower or deeper) or direction of run (curve) require UCP approval prior to soil removal/excavation operations.

4.1.3.6 When excavating close to a utility, outside the required 3 foot radius, the excavator should have a spotter to assist and guide the excavation equipment operator.

4.1.3.7 While the excavation is open, underground installations shall be protected, supported, or removed as necessary to safeguard employees.

4.1.3.8 The utility owner should be contacted for guidance on protecting the utility from damage when backfilling excavations. When excavation is complete, as practical, 6 inches of soil may be placed over the utility to shield/protect during backfilling operations

4.1.3.9 Areas of refusal (tree roots, large rocks, concrete structures) which prevent either digging to depth or exposing utilities require UCP approval prior to beginning soil removal operations.

4.1.4 Operating Requirements Specific to Drilling Activities

4.1.4.1 Refer to Section 5.0, Terminology to determine the applicable activities considered to be drilling activities.

4.1.4.2 Follow all requirements in Section 4.1.1. & 4.1.2

4.1.4.3 After all mark outs have been completed, prior to drilling, each individual location must be hand dug or vacuum excavated to a minimum of 5 feet below ground surface (bgs).

4.1.4.4 Should the local geology be prone to refusal or should there be any other reason the drilling location cannot be cleared to a minimum of 5 feet bgs by hand digging or vacuum extraction, then the appropriate geophysical techniques should be utilized to verify the drilling location is clear of utilities to 5 feet bgs.

4.1.4.5 At any drilling location that cannot be cleared by hand digging or vacuum extraction, then an Authorization to Drill Permit (AMS-710-02-FM-01611) must be approved by the Director of Operations (or designee, which may be delegated to the business line manager for each area) in addition to the project/program manager/director. The SBU HSE lead may be consulted, but signature is not required.

4.1.5 Operating Requirements for Boring & Trenching Activities at Retail Fuel Dispensing Stations

4.1.5.1 Work in and around known retail fuel systems (lines and tanks) may be best performed by a licensed, APTIM approved tank subcontractor.

4.1.5.2 Gauge tank pit observation wells prior to beginning drilling activities.

4.1.5.3 Locate emergency shut off system prior to drilling activities.

4.1.5.4 Look for any visual indications that product lines or utilities have been installed in boring location (cracked concrete, sagging concrete, patched concrete, trench cuts, etc.)

4.1.5.5 Establish “No Drill Zones” if possible. No Drill Zones are areas around UST’s, gas dispensers, lines or the canopy of retail fuel dispensing stations.

4.1.5.6 Boring and trenching activities at retail fuel dispensing systems should be moved to a pea gravel free area of the site when possible.

4.1.5.7 If relocation is not possible, an air knife or vacuum extraction approach will be used for pre-clearance of underground utilities.

4.1.5.8 If pea gravel is encountered, stop work and either move the bore hole location or install with vacuum extraction techniques to a depth of 5 feet, if possible.

4.1.5.9 Standard pre-clearance tools (i.e. hand augurs, post hole diggers, spud bars, etc.) are prohibited when working in and around pea-gravel due to the possibility of damage to fiberglass tanks and lines from tool strikes.

4.1.6 Operating Requirements Specific to Sheet Piling Activities

4.1.6.1 Follow Section 4.1.4, Operating Requirements Specific to Drilling Activities.

4.1.6.2 After all mark outs have been completed, prior to installation of piling, each utility identified inside the sheet piling location must be hand dug or vacuum excavated to a verify the utility location. Additional planning may be necessary to change the location of the sheet piling location or the location of the utilities.

4.2 Training Requirements

4.2.1 Competent Person – Utility Contact Prevention

The Competent Person UCP must have successfully completed APTIM's internal Underground and Overhead Utility Contact Prevention training. It is the Project Manager's responsibility to verify that the Competent Person –UCP has completed training prior to overseeing activities.

4.2.2 Competent Person - Excavation Training

The Competent Person - Excavation shall have documented training or documented experience in excavation activities.

4.2.3 Field Crew Training

4.2.3.1 Prior to assignment of work, the Competent Person - UCP will provide the above and underground utilities information obtained to affected field crew personnel via the job safety analysis (JSA). Information will include:

- The utilities identified in work areas that may be affected by operations.
- The location and depth of the utilities associated with the affected essential services
- Any conditions on the proposed intrusive activities work and clearance requirements.

4.2.3.2 Prior to assignment of work, the Competent Person - UCP will also provide the following information to affected field crew personnel:

- The requirements of this procedure.

- The required work practices and controls to prevent contacting utilities.
- The emergency procedures necessary if utilities are damaged.
- The roles and responsibilities of each worker within the work crew.

4.3 Incident Reporting Requirements

4.3.1 Employees are required to immediately report to their direct supervisor any utility contact incident or near miss incident.

4.3.2 All incidents involving utility contact shall be reported by the Competent Person – UCP and site supervisor as required by AMS-710-05-PR-02200, Incident Reporting.

4.3.3 Any damage caused or discovered to natural gas, liquid petroleum, or any hazardous liquid utilities, underground utilities must be immediately reported by the Competent Person – UCP, to emergency services, to the facility owner, and utility owner.

4.3.4 All other utilities contact, and damages are to be reported to the facility operator and the One Call Center (or local equivalent) by the Competent Person - UCP.

4.3.5 The Competent Person - UCP shall verify that all other local reporting requirements are met, e.g., reporting underground pipeline damages involving excavation in Texas to the Railroad Commission of Texas.

5.0 TERMINOLOGY

Key terms within the context of the procedure. Terminology is to be listed in a table as shown below:

Term	Definition
As-Built Drawings	As-built drawings are blueprints that are usually obtained from the facility owner or client. They show original buried utilities and any modifications that have been made.
Company	APTIM
Competent Person – Utility Contact Prevention	Assigned by the Project Manager: An APTIM employee who is capable of identifying existing and predictable hazards presented by utilities located at an APTIM site that may be, hazardous, or dangerous to employees, could result in property damage, or negatively impact the community or environment. The Competent Person Utility Contact Prevention has successfully completed APTIM's in-house 'Underground/Overhead Utility Contact Prevention' training course, possesses an appropriate educational background, field experience, and has the authority to correct deficiencies or take prompt corrective measures to eliminate them. The required identification and documentation procedure for competent persons is specified in AMS-710-02-PR-04200, Competent/Qualified Person Procedure.

Drilling Activities	Any mechanical or manual penetration of the earth's surface using drilling, boring, auguring, or similar type of equipment. For the purposes of this procedure, drilling activities include the use of direct-push equipment and driving equipment such as hammers, impact hammers, vibratory drivers, or similar types of equipment.
Driving Activities	Any mechanical or manual penetration of the earth's surface using driving equipment. Driving activities include the installation of piles, sheet piles, poles, stakes, and fence posts.
Excavation	Any operation in which earth, rock, or other material in or on the ground is moved, removed, or otherwise displaced by means of any tools, power equipment or explosives, and includes, without limitation, grading, trenching, digging, ditching, drilling, augering, boring, tunneling, scraping, cable or pipe plowing, piling, and driving. Any manmade cut, cavity, trench, or depression in an earth surface formed by earth removal.
Excavation Activities	Any mechanical or manual penetration of the earth's surface using heavy equipment such as excavators, backhoes, dozers, etc. Excavation activities also include manual use of hand shovels, pick-axes, etc. The use of 3-foot or larger diameter augers is also considered excavation activity.
Fiber Optic Cables	Optical communication cables that are buried underground.
Intrusive Activities	Any mechanical or manual penetration of the earth's surface, including drilling activities, driving activities, and/or excavation activities using drilling equipment, driving equipment, or excavating equipment.
No Drill Zones	No Drill Zones are areas located on retail petroleum sites where drilling is not permitted due to the presence of Underground Storage Tanks's (UST's), gas dispensers, lines or the canopy of retail fuel dispensing stations.
One Call Center	811-One Call, Dig Safe, Miss Dig, etc. dial-in telephone number for requesting the location and mark-out of buried utilities, such as gas lines, electrical lines, telephone/cable lines, sewer lines, and water lines
Private Utility Locating Service	A private utility locating service is a firm established to locate underground utilities using specialized locating equipment, such as ground penetrating radar location devices or radio transmitter type utility locating equipment.
Site	Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities, and/or project sites.
Site Survey	Inspection of the site to look for signs of buried utilities that may not be indicated through as-built drawings or through utility locating services. The survey typically involves inspection of overhead electrical services, basements, utility rooms, garages,

	etc., for signs of old electrical conduits or fuel/water/septic lines.
Utility	Any active or inactive above ground or subsurface structure that is or was designed to service a public or private facility. These may include, but are not limited, to the following: • Electric power lines • Propane lines • Natural gas lines • Telephone lines • Telephone cables • Fiber optic lines • Fiber optic cables • Water lines • Steam and pneumatic lines • Sewer/sewage lines • Drain lines • Underground storage tanks • Septic tanks • Process or product lines • Reclaimed water lines
Vacuum Excavator	Equipment that excavates underground utilities with a combination of alternating water-and-air or air-and air pulsations (e.g., air knife, water knife, etc.)

6.0 REFERENCES

Forms/checklists and other supporting policies, work processes, and procedures, included in the body of the procedure.

6.1 Required Forms/Checklists

Forms and checklists that are required for use by the procedure should be listed in Section 6.1.

AMS-710-02-FM-01611	Authorization to Drill Permit Form
AMS-710-02-FM-01612	Utility Mark-Out Documentation Form
AMS-710-02-CK-01613	Intrusive Activities Checklist

6.2 Other Internal References

AMS-710-02-PR-04200	Competent/Qualified Person Procedure
AMS-710-02-PR-06600	Working Around Overhead Power Lines with Mobile Equipment
AMS-710-02-PR-01600	Excavation and Trenching
AMS-710-05-PR-01300	HSE Request for Variances

AMS-710-05-PR-02200	Incident Reporting

6.3 Other External References

None

7.0 ATTACHMENTS

Attachment	Attachment Title
None	

ATTACHMENT 4

APTIM INCIDENT NOTIFICATION, REPORTING, AND MANAGEMENT PROCEDURE

Aptim Federal Services, LLC Incident Notification, Reporting, and Management Procedure

Directions, Notes, and Reminders

- **Follow this procedure step-by-step for all incidents.**
- **This procedure has limited application to subcontractors. Assist subcontractors with medical emergencies (as applicable) and then immediately notify the Program H&S Manager for guidance.**
- **Periodically review this procedure in order to be familiar with the steps - prior to an incident occurring.**
- **For injuries and vehicle accidents, secure the scene to prevent additional injury/incident, administer on-site first aid, and arrange for emergency assistance prior to making any other notifications.**
- **The Site Supervisor is responsible for making all other notifications to:**
  - **CORE Health Networks (must be notified while employee is en route to medical care facility): 877-347-7429**
  - **Help Desk / Hot Line: 800-537-9540**
  - **Project Manager: Mark Shoemaker 865-771-4133 (cell)**
  - **Marcia Musgrave: 419-429-5520**
- **The Site Supervisor (or SSHO) is responsible for notifying the Program H&S Manager or Alternate H&S Manager by telephone prior to making any other notifications (other than calling 911 and CORE).**
- **The Site Supervisor or SSHO shall accompany all injured personnel to the CORE clinic or to the hospital emergency room.**
- **The Project Manager shall notify the Program Manager in person or by telephone no later than two hours after the incident and the U.S. Army Garrison Chief, Installation Restoration Branch (256) 842-3702.**
- **All incident reports shall be completed by typing (when feasible and applicable).**
- **All incident reports shall be submitted (email or fax) to the Program H&S Manager or Alternate H&S Manager for review and distribution.**
- **Complete all the blanks on the INCIDENT NOTIFICATION AND COMMUNICATION CONTACT LIST (page 6) and post near all site telephones.**

Aptim **Federal Services**, **LLC Incident Notification, Reporting, and Management Procedure**

Action	Who / When	Under what circumstances	How	Notes
1. Notify Site Supervisor for all incidents (no matter how minor)	Injured person, first person recognizing incident, driver/passenger, or employee causing damage *Immediately*	All incidents no matter how minor (including minor cuts, scratches, minor strains/sprains, and insect bites)	In person or by telephone	Site Supervisor to make note of very minor incidents (such as band-aid over scratch) in field logbook
2. For ***life-threatening injuries / illnesses*** - make scene safe, contact local emergency personnel For ***non life-threatening injuries / illnesses*** - make scene safe, transport injured person to doctor at an occupational medical facility See Clinic Route Maps and Directions For ***vehicle accidents*** – make scene safe, notify police, aid injured parties For ***equipment / property damage*** - make scene safe, prevent further damage or injuries	Site Supervisor *Immediately (concurrently with next step if injury or illness)* Site Supervisor *Immediately (concurrently with next step if injury or illness)* Driver/passenger *Immediately* Employee causing damage *Immediately*	In case of serious injury or illness requiring off-site medical care	Via ambulance Via vehicle	Site Supervisor or Site Safety Officer must immediately go to emergency care facility. Follow AMS-710-01-PR-03600 post accident alcohol and drug testing procedure. Site Supervisor or Site Safety and Health Officer must transport and stay with injured person until released from care. Make medical personnel aware of "restricted work will be provided" and "no prescriptions if possible" policies. CORE clinics are the preferred urgent care facilities when possible, unless injury is severe and victim is transported by ambulance.
3. Notify CORE Health Networks (for injuries / illnesses to APTIM employees only)	Site Supervisor *Immediately, prior to transporting the injured employee, unless injuries are life threatening*	• Serious injury requiring off-site medical care • If employee states that he/she has been exposed to any chemical or biological substance • If illness is work related	CORE Medical 877-347-7429 Note: Outside Continental US call: 225-614-9561	Not required for temporary agency and subcontractor labor Provide name of injured employee, name and phone # of treating medical facility, description of the incident CORE will help with medical facility coordination and follow-up care
4. Notify Program H&S Manager (if unsure, see contact list) Notify Alternate H&S Manager if Program H&S Manager cannot be contacted. (if unsure, see contact list)	Site Supervisor *Immediately (concurrently with providing transportation to occupational medical facility or EMS transport to hospital)*	All incidents except on-site first aid cases	See Incident Notification and Communication Contact List (attached)	Program H&S Manager will notify H&S Director

Action	Who / *When*	Under what circumstances	How	Notes
5. Notify APTIM Notification Hotline / Help Desk	Site Supervisor *As soon as possible. Prior to sending an individual for medical treatment*	• Illness and/or injury (doctors cases and above) • Any utility damage • Property damage (damage > $5,000) • Vehicle accidents (All) • Criminal activity (i.e. bomb threat, theft) • Natural disaster (all) • Explosion and/or fires • Environmental spills/releases (incidents that requires regulatory notification or have an offsite impact) • Regulatory agency visit • Fatalities	APTIM Notification Hotline / Help Desk Phone Number: 800-537-9540 Note - Outside the Continental US call: 225-215-5056	Request name of Hotline / Help Desk operator for future reference and note date/time of notification
6. Complete forms: *Injuries and illnesses*: • Authorization for Release of Protected Medical Information • Authorization for Treatment of Occupational Injury/Illness • Return-To-Work Examination Form *and* fax to CORE *and* email or fax to Program H&S Manager	Injured employee and medical facility personnel (Site Supervisor or Site Safety and Health Officer is responsible for verifying forms are completed) *Prior to leaving medical facility*	• Serious injury requiring off-site medical care • If employee states that he/she has been exposed to any chemical or biological substance	Fax to CORE: 225.292.8986 Email or fax to Program H&S Manager	Site Supervisor or Site Safety and Health Officer must take these forms (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300)
7. Call Project Manager and notify of incident (Remind Project Manager of notification responsibilities to Program Manager)	Site Supervisor *As soon as reasonably possible*	If Hot Line / Help Desk notification is required (see # 5 above)	See Incident Notification and Communication Contact List	Project Manager will verbally report incident to upper level of Operations/Business Line Management *As soon as reasonably possible*
8. Notify Marcia Musgrave	Site Supervisor	All incidents involving personnel (injuries, illnesses, vehicle accidents)	419-429-5520	

	Action	Who / When	Under what circumstances	How	Notes
9.	Call back Program H&S Manager to report on status of *injured / ill employee*	Site Supervisor *Prior to employee leaving medical facility*	All injuries and illnesses requiring off-site medical care	See Incident Notification and Communication Contact List (attached)	
10.	Complete forms (typed electronically): *OSHA Recordable Cases* • Supervisor's Employee Injury/Illness Report Form • Injured Employee Statement • Witness Statement Form(s) *First Aid Cases (Doctor's)* • Supervisor's Employee Injury/Illness Report • Injured Employee Statement • Witness Statement Form(s) Email or Fax completed forms to Program H&S Manager and CORE	• Site Supervisor • Witnesses *As soon as possible – no later than 24 hours*	All injuries, illnesses, and first aide cases	Email or fax to Program H&S Manager See Incident Notification and Communication Contact List (attached) Fax to CORE 225.292.8986	Site Supervisor should have these forms with him/her at all times (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300)
11.	Complete forms (typed electronically): *Chargeable Vehicle Accidents* • Vehicle Accident Report • Witness Statement Form(s) • Driving Record Certification (Procedure HS800) *Non-Chargeable Vehicle Accidents* • Vehicle Accident Report • Witness Statement Form(s) *Equipment, Property Damage and General Liability Incidents* • Equipment, Property Damage and General Liability Loss Report • Witness Statement Form(s) Email or Fax completed forms to Program H&S Manager	• Site Supervisor • Witnesses *As soon as possible – no later than 24 hours*	All vehicle accidents and /or all property damage	Email or fax to Program H&S Manager Health See Incident Notification and Communication Contact List (attached)	Supervisor should have these forms with him/her at all times (Contained in 710-01-PR-02100, AMS-710-05-PR-02200, and AMS-710-05-PR-02300)

Aptim **Federal Services**, **LLC Incident Notification, Reporting, and Management Procedure**

Action	Who / When	Under what circumstances	How	Notes
12. Complete these additional forms (typed electronically): *OSHA Recordable Cases* • Incident Investigation Report *First Aid Cases (Doctor's)* • Incident Investigation Report *Chargeable Vehicle Accidents* • Incident Investigation Report *Non-Chargeable Vehicle Accidents* • Incident Investigation Report *Equipment, Property Damage and General Liability Incidents* • Incident Investigation Report *Near Miss* • Incident Investigation Report	Site Supervisor *As soon as possible – no later than 72 hours of incident*	Near Misses	Email or fax to Program H&S Manager See Incident Notification and Communication Contact List (attached)	Supervisor should have these forms with him/her at all times Contact Program H&S Manager for blank electronic forms or access:
• SharePoint electronic Near Miss Report Email or Fax completed forms to Program H&S Manager	*As soon as possible – no later than 96 hours of incident*	All other Near Misses	Contact Program H&S Manager	Do not include any employee or project identification information – *these reports are anonymous*
13. Perform "Incident Review Board" (ARB) - Coordinate through Program H&S Manager	Program H&S Manager *Within 10 days of incident*	OSHA Recordable Cases Chargeable Vehicle Accidents		
Perform "Incident Review Board" (IRB) to extract lessons learned - Coordinate through Program H&S Manager		Doctor's First Aid Cases Utility damage or significant property damage		An IRB is outside of the AMS requirements for an ARB.

Aptim Federal Services, LLC Incident Notification and Communication Contact List

Project Number: 501226 Project/Office Name/Location: RSA ERMA SB / Redstone Arsenal, Huntsville, AL

Name	Phone Number(s)	Fax Number	E-mail
Federal Services Notification Hotline/Helpdesk	800-537-9540 Opt. 2	N/A	N/A
CORE (Must be notified prior to or during transport to medical treatment center)	877-347-7429	225-292-8986	N/A
Medical Services Administrative Manager Marcia Musgrave	419-429-5520 (office) 419-819-7848 (mobile)	419-429-5526	marcia.musgrave@aptim.com
APTIM H&S Manager: Kym Edelman, CIH, CSP	757-640-6928 (office) 757-435-5384 (cell)	n/a	kym.edelman@aptim.com
APTIM ERMA Program Manager: Steven Moran	865-560-7905 (office) 865-607-91484 (cell)	865-560-7956	Steve.g.moran@aptim.com
APTIM ERMA Project Manager: Mark Shoemaker	772-285-8205 (cell)	865-560-7956	mark.shoemaker@aptim.com
APTIM Federal E&D QA/H&S Director – Tricia Felt	303-741-7426 (office) 817-233-8212 (cell)	n/a	tricia.felt@aptim.com

Note: Incident reports shall be faxed or emailed <u>only</u> to the Program H&S Manager (or Alternate H&S Manager) for review and proper distribution.

ATTACHMENT 5

AMS-710-02-PR-07200, DRILL RIG OPERATIONS

PROCEDURE

Procedure Title:	**Drill Rig Operations**	**AMS Number:**	**AMS-710-02-PR-07200**
Procedure Owner:	**Corporate HSE**	**Issuing Authority:**	**APTIM Quality Management**

DRILL RIG OPERATIONS

INT	Issued for Interim Use	M. Hadacek & S. Lachney	7/30/2017
Rev	**Changes**	**Approved**	**Date**

1.0 PURPOSE

This procedure describes the minimum requirements for the safe operation of conventional drilling equipment.

2.0 SCOPE

This procedure applies to all APTIM Sites where the possibility of employee exposure to drill rig hazards exists.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Vendors
- APTIM Site Visitors

4.0 PROCEDURE

4.1 Training

All members of drilling crews must possess the required state or local licenses necessary to perform such work. The drill crew must also receive site-specific health and safety training prior to beginning work and must participate in safety meetings. Prior to arriving at a project site, the drilling crew must be familiar with the operation, inspection, safety features, emergency procedures and maintenance requirements of the equipment.

4.2 Inspections

Before being placed into service, the drilling equipment will be inspected by the lead driller in accordance with the manufacturer's guidelines. The APTIM site supervisor will accompany the lead driller during this initial inspection. Inspections shall be documented in the field activity daily log and shall demonstrate that all installed safety equipment is functional prior to beginning work.

4.3 Set Up

4.3.1 The drill rig must be properly blocked and levelled prior to raising the derrick. The wheels which remain on the ground will be chocked and the parking brake set. The rig can only be moved after the derrick has been lowered.

4.3.2 General preparatory drilling requirements include:

4.3.2.1 Before drilling, the existence and location of underground utilities will be determined and marked as defined in AMS-710-02-PR-01610 Identifying Underground Installations.

4.3.2.2 All drilling should occur at a minimum of 5 feet from any known or suspected location of an underground structure or utility.

4.3.2.3 A hand auger or posthole digger must be utilized to positively identify utilities when drilling is anticipated to occur within 5 feet (1.5 m) of an underground utility.

4.3.3 If drilling is conducted in the vicinity of overhead power lines clearance distances must meet the requirements in AMS-710-02-PR-06600 Work Around Overhead Power Lines With Mobile Cranes & Derricks.

4.3.3.1 Work area access must be restricted from vehicular/pedestrian traffic by utilizing temporary fencing or warning tape.

4.3.3.2 If lubrication fittings are not accessible with guards in place, machinery must be stopped and lockout/tagout procedures utilized before oiling and greasing. Refueling and other maintenance operation such as lubrication or refilling hydraulic and oil reservoirs shall not be done unless the drill rig engine has been turned off.

4.3.3.3 Rigging equipment for material handling must be inspected prior to use on each shift and as often as necessary to ensure safe work practices. Defective rigging must be removed from service immediately.

4.3.3.4 Lifting and transporting of drums should be completed using the appropriate equipment and following safe loading and unloading practices.

4.4 Hoisting Operations

4.4.1 Drillers must never engage the rotary clutch without watching the rotary table and ensuring it is clear of personnel and equipment.

4.4.2 Unless the drawworks is equipped with an automatic feed control, the brake must not be left unattended without first being tied down.

4.4.3 Drillers will not add or remove pipe from the drill stem without assistance of the driller's designated helper.

4.4.4 Drill pipe must not be hoisted until the driller verifies that the pipe is latched and the drilling assistant has signalled that he/she may safely hoist the load.

4.4.5 During instances of unusual loading of the derrick or mast, such as when making an unusually hard pull, only the driller will be on the rig floor and no one will be on the rig or derrick.

4.4.6 The brakes on the drawworks of the drilling rig shall be tested at the beginning of each shift to determine that they are in good working order.

4.4.7 A hoisting line with a load imposed will not be permitted to be in direct contact with any derrick member or stationary equipment unless it has been specifically designed for line contact.

4.4.8 Hoisting control stations must be kept clean and controls labelled as to their functions.

4.4.9 Under no circumstances will personnel be permitted to ride the traveling block or elevators, nor will the cat line be used as a personnel carrier.

4.5 Cat Line Operations

4.5.1 Only experienced drillers will be allowed to operate the cathead controls. The kill switch must be clearly labelled and operational prior to operation of the cat line.

4.5.2 The cathead area must be kept free of obstruction and entanglements.

4.5.3 The operator will not use more wraps than necessary to pick up the load. More than one layer of wrapping is not permitted.

4.5.4 Personnel must not stand near, step over, or go under a cable or cat line which is under tension.

4.5.5 Employees rigging loads on cat lines must:

4.5.5.1 Keep out from under the load

4.5.5.2 Keep fingers and feet where they will not be crushed

4.5.5.3 Be sure to signal clearly when the load is being picked

4.5.5.4 Use standard visual signals only, and not depend on shouting to co-workers

4.5.5.5 Make sure that the load is properly rigged, since a sudden jerk in the cat line may shift or drop the load.

4.6 Pipe Handling

4.6.1 Pipe must be loaded and unloaded, layer by layer, with the bottom layer pinned or blocked securely on all four corners. Each successive layer must be effectively blocked or chocked.

4.6.2 Workers will not be permitted to top off the load during loading, unloading, or transferring of pipe or rolling stock.

4.6.3 Employees must be instructed to never attempt to stop rolling pipe or casing. Employees must be instructed to stand clear of rolling pipe.

4.6.4 When pipe is being hoisted, personnel will use a sling to control the bottom end of the pipe.

4.7 Working Near Overhead Energized Lines

4.7.1 Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated in accordance with the clearance distances stated in AMS-710-02-PR-06600 Work Around Overhead Power Lines With Mobile Cranes & Derricks.

4.7.2 If insulating barriers that are rated for the voltage of the line being guarded are installed to prevent contact with the lines and are not a part of or an attachment to the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier after obtaining Corporate HSE approval.

4.8 Direct Push Sampling

4.8.1 Many subsurface sampling activities are now conducted using a direct push method. This method involves using a hydraulic hammer press to drive hollow steel rods vertically into the subsurface to obtain samples. The hazards associated with the use of this technique are somewhat similar to those of conventional drilling. The main difference is that percussion rather than rotational forces are used to reach sample depths.

5.0 REFERENCES

AMS-710-02-PR-06600	Working Around Overhead Power Lines With Mobile Cranes & Derricks
AMS-710-02-PR-01610	Identifying Underground Installations

6.0 TERMINOLOGY

None

7.0 EXHIBITS

Exhibit 7.1	AMS-720-01-FM-00020 – Business Glossary
Exhibit 7.2	AMS-720-01-FM-00021 – Technical Glossary

8.0 ATTACHMENTS

None

ATTACHMENT 6

AMS-710-02-PR-00600, HEAT STRESS PREVENTION AND CONTROL

Procedure Title:	Heat Stress Prevention and Control	AMS Number:	AMS-710-01-PR-00600
Procedure Owner:	HSE	Issuing Authority:	APTIM HSE

HEAT STRESS PREVENTION AND CONTROL

0	Added section 4.3.2	M. Hetzler	12/20/17
INT	Issued for Interim Use	M. Hadacek & S. Lachney	7/30/2017
Rev	**Changes**	**Approved**	**Date**

1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Heat Stress Prevention and Control on APTIM sites.

2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with a APTIM site.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors

4.0 PROCEDURE

APTIM sites shall use this procedure to establish the minimum guidelines to create the site specific procedure for heat stress prevention and control.

4.1 Heat Stress

4.1.1 Heat stress is the result of the combination of several factors. The following factors should be evaluated to determine the potential for heat stress.

4.1.1.1 Ambient temperature

4.1.1.2 Humidity

4.1.1.3 Radiant heat source

4.1.1.4 Direct sun exposure

4.1.1.5 Air movement

4.1.1.6 Contact with hot objects

4.1.1.7 Type of work required - heavy, moderate or light work

4.1.1.8 Required work clothing - the potential for heat stress increases as the impermeability of the work clothing increases

4.1.1.9 Employee conditioning and/or acclimatization

4.1.1.10 Previous project experience or history

4.1.1.11 Whenever it is determined that a heat stress environment exists heat stress preventive measures shall be implemented.

4.2 Preventive Measures

4.2.1 Heat stress is the combination of environmental and physical work factors that constitute the total heat load imposed on the body. One of the best ways to reduce heat stress on workers is to minimize the amount of heat in the workplace. However, there are some work environments where heat production is difficult to control, such as active steam lines, high ambient temperature processes, humid work areas, or radiant heat from the sun or a furnace. However, most heat related health problems can be prevented or the risk of developing them reduced. When unacceptable levels of heat stress can potentially occur, there are generally five approaches to a solution:

4.2.1.1 Modify the environment;

4.2.1.2 Modify the clothing or equipment;

4.2.1.3 Modify the work practices;

4.2.1.4 Modify the worker by heat acclimatization;

4.2.1.5 Modify production with a work/rest regiment.

4.2.2 Wearing Personal Protective Equipment (PPE) can place workers at considerable risk of developing heat stress. Health effects range from transient heat fatigue to serious illness or death. Regular monitoring and other preventive precautions shall be employed. For workers wearing semi-permeable or impermeable encapsulating ensembles, workers shall be monitored when the temperature in the work area is above 70ºF (21ºC).

4.2.3 Engineering Controls

4.2.3.1 A variety of engineering controls, including ventilation and spot cooling at points of high heat production, may be helpful. Shielding or insulation may be required as protection from radiant heat sources. Evaporative cooling and mechanical refrigeration are other ways to reduce heat by engineering controls. The use of extra air moving can be added to increase the turnover rate of interior air and remove heat inside enclosures. Cooling fans can increase air velocity and promote evaporation in hot conditions. Shutting down hot process or feed lines is most effective, but equipment modifications, such as using mechanical equipment over manual labor also reduce the exposure.

4.2.3.2 Auxiliary cooling systems can range from simple ice vests, pre-frozen and worn under the clothing, to more complex systems; however, cost of operation and maintenance vary considerably in all of these systems. Four auxiliary cooling systems presently available are:

- Water-cooled garments, such as water-cooled vest, undergarments, hoods, etc., which require a circulating pump, liquid container, and battery;
- Air-cooled garments, such as suits and hoods, that require a vortex tube, connecting hose and a constant source of compressed air;
- Ice pack vest, which although frozen before worn, do not provide continuous regulated cooling and require the use of backup frozen units every 2 to 3 hours; and
- Wetted over-garments, which can be as simple as wet cotton terry cloth coveralls worn over protective clothing; the wetted over garment works best when there is air blowing across the wet garment to increase evaporation.

4.2.4 Work Practices

4.2.4.1 Work practices can help reduce the risk of heat disorders. Making plenty of drinking water (including ice and cool water as appropriate) available at the workplace and urging workers to drink often shall be standard practice in all situations of potential heat stress. In high heat stress environments, an employee can lose as much as one quart of liquid per hour. When possible and especially during acclimatization, products that have been formulated to replace electrolytes and match the weight of the body fluids lost by the sweating process should be used. This is necessary to enable the body to quickly absorb replacement minerals. Do not use salt tablets.

4.2.4.2 Training supervisors to recognize and be able to correctly treat heat stress disorders is absolutely essential. Prospective workers physical conditions should also be considered when determining their fitness for working in a hot environment. Older workers, obese workers, and those workers taking some type of medication are usually at a greater risk.

4.2.5 Acclimatization

4.2.5.1 Acclimatization to heat through short exposures followed by longer periods of work in the hot environment can reduce heat stress. New employees and workers returning from an absence of two weeks or more should have a five-day period of acclimatization. This period should begin with a less than normal workload and time exposure on the first day and gradually build up to normal workload and exposure on the fifth day.

4.2.6 Work/Rest Regimen

4.2.6.1 There are many times when engineering and other controls are not sufficient, and administrative controls must be instituted for worker protection. One effective administrative control is the work/rest regimen that limits the time worked in the hot environment according to the type of work, environmental conditions, and clothing requirements. Work/rest periods are generally conservative because they are:

- Based on calculated approximations of heat stress and
- Designed to protect most workers. As a result, many acclimatized workers can work longer than the allotted time period.

4.2.6.2 Alternating work and rest periods with longer rest periods in a cool area (77°F. or less) can help workers avoid heat strain. Keep in mind that poor physical condition and/or medication will also impair the ability to work in a hot environment. Older, over-weight individuals or those in poor health may not be able to follow average work/rest regimens. Supervisors shall permit employees to take additional rest breaks as needed in potential heat stress conditions.

4.2.6.3 The APTIM HSE Department should be contacted for assistance in instituting work/rest schedules for the site.

4.3 Employee Training

4.3.1 For both employees and supervisory personnel, heat stress training is the key to avoiding problems. Employees must understand the reasons for using appropriate work practices in order for the program to succeed. A heat stress training program for employees shall cover the following:

4.3.1.1 Heat stress, its components and effects,

4.3.1.2 Signs and symptoms of heat disorders,

4.3.1.3 First-aid Practices for and potential health effects of heat stress,

4.3.1.4 Pre-disposing factors to heat stress; drug use, (including therapeutic) and alcohol in a hot work environment,

4.3.1.5 Protective clothing, equipment and its impact in hot environments,

4.3.1.6 Environmental and medical surveillance programs,

4.3.1.7 Importance of maintaining body fluids at normal levels,

4.3.1.8 Various engineering controls to reduce the impact of hot environments,

4.3.1.9 Administrative measures such as work/rest regimens in use to prevent heat stress,

4.3.1.10 Acclimatization; how it is achieved and its limitations, and

4.3.1.11 The components of the heat stress prevention program.

4.3.2 Supervisors must be trained in heat related illness prior to supervision of employees working in the heat

4.4 Flagging System

4.4.1 The status of the Heat Stress and Control plan will be communicated to the work force using a flagging system to correlate with the categories in section 4.5.

4.4.2 As the Heat Index category (color) changes, an SMS and email will go out to the Project team, including field HSE Supervisors or Representatives.

4.4.3 The field HSE Supervisors or Representatives are responsible for changing out the flag to the correct color so the crew can easily identify what category and precautions are in effect.

4.4.4 Flags should be placed in locations which are readily viewable from most areas such as established water, rest, or cooling areas.

4.5 Heat Stress Categories

4.5.1 The severity of heat exposure is determined by the calculated heat index.

4.5.2 The heat index is broken down into five (5) separate level designated by a color code.

4.5.2.1 The five **(5)** levels are green, yellow, orange, red and black. The significance of these colors is discussed in section 4.3.

4.5.3 The heat index is determined by either of three (3) methods:

4.5.3.1 Direct reading instrument such as a weather station, anemometer with built in heat index function, etc.

4.5.3.2 It is recommended for each project to have a direct reading hand held instrument for determining the heat stress, during the summer months. The Kestrel 3000 or equivalent Pocket Weather Meter is a commonly used instrument that is readily available providing a wide range of functions, including accurate relative humidity measurements. A picture of the Kestrel 3000 is shown below in figure 1.

4.5.4

Figure 1

4.5.4.1 Alternatively, calculating the heat index can be accomplished by measuring the ambient temperature and humidity separately to find the corresponding heat index (AMS-710-01-FM-00601).

4.5.4.2 Lastly, obtain the temperature and humidity from a reliable local weather/news source and utilize AMS-710-01-FM-00601 to determine the heat index.

4.5.5 Category precautions and water intake are captured in AMS-710-01-FM-00601 as a guide to be issued to field personnel.

4.6 Category GREEN - Caution

4.6.1 The initial or least severe category is GREEN. Heat indexes in GREEN are 37°C (98.6ºF) or less. When heat indexes fall within this category, the following conditions apply:

4.6.1.1 Heat Syndrome – Fatigue possible with prolonged exposure and physical activity. No significant risk of heat related illnesses.

4.6.1.2 Resting Times – Normal / scheduled break are sufficient during this period.

4.6.1.3 Water Needed – 250 ml (8.5 oz) every 20 – 30 minutes

4.6.1.4 Ensure Adequate Medical Services are available

4.6.1.5 Encourage workers to wear sunscreen

4.7 Category YELLOW – Extreme Caution

4.7.1 The next higher severity category is YELLOW. Heat indexes in YELLOW range between 38°C and 45°C (98.7ºF and 113ºF). When the heat index falls within this category, the following conditions apply:

4.7.1.1 Review Heat related illness topics with workers: how to recognize heat related illnesses, how to prevent it, and what to do if someone gets sick. Monitor workers closely

4.7.1.2 Heat Syndrome – Heat Cramps or Heat Exhaustion possible with prolonged exposure and physical activities.

4.7.1.3 Acclimatize workers

4.7.1.4 Resting Time – 5 minutes per each hour

4.7.1.5 Water Needed – 250ml (8.5 oz) every 20 minutes (average)

4.8 Category ORANGE – Danger

4.8.1 The next higher severity category is ORANGE. Heat indexes in ORANGE range between 46°C and 54°C (114.8ºF and 129.2ºF). When heat indexes fall within this category, the following conditions apply:

4.8.1.1 Limit Physical exertion

4.8.1.2 Adjust work activities

4.8.1.3 Use cooling techniques

4.8.1.4 Watch/communicate with workers at all times

4.8.1.5 Ensure Adequate Medical Services are available

4.8.1.6 Encourage workers to wear sunscreen

4.8.1.7 Heat Syndrome – Heat Cramps or Heat Exhaustion likely. Heat Stroke possible with prolonged exposure and physical activity.

4.8.1.8 Resting Time – 10 minutes per each hour

4.8.1.9 Water Needed – 250 ml (8.5 oz) every 10 minutes (average)

4.9 Category RED – Extreme Danger

4.9.1 The next higher severity category is RED. Heat indexes in RED range between 55°C and 59°C (129.3ºF and 138.2ºF). When heat indexes fall within this category, the following conditions apply:

4.9.1.1 Stop work if essential control methods are inadequate or unavailable.

4.9.1.2 Limit Physical exertion

4.9.1.3 Adjust work activities

4.9.1.4 Use cooling techniques

4.9.1.5 Watch/communicate with workers at all times

4.9.1.6 Ensure Adequate Medical Services are available

4.9.1.7 Encourage workers to wear sunscreen

4.9.1.8 Heat Syndrome – Heat Stroke imminent with following rest and water intake requirements.

4.9.1.9 Resting Time – 15 minutes per each hour

4.9.1.10 Water Needed – 250 ml (8.5 oz) every 10 minutes (average)

4.9.2 During Category RED conditions, the following additional precautions should be implemented:

4.9.2.1 Supervision should be on active alert to monitor their crew for signs and symptoms of heat stress. Maximum supervision should be present, during category R**ED** conditions to monitor the employees and ensure proper rest and water breaks are being followed.

4.9.2.2 Employees who are fasting for whatever reason (i.e. dieting regimen, religious obligations, etc) are not permitted to work during RED flag conditions. There is a significant health risk associated with fasting in RED flag conditions that can quickly progress into Heat Exhaustion or Heat Stroke.

4.9.2.3 Project First Aiders and Nurses should be put on alert in case an employee begins to exhibit heat stress symptoms.

4.9.2.4 Ear type thermometers with disposable covers should be available for monitoring an employee's core body temperature. Employees with core temperatures at or above 38°C (100.4°F) should remain out of the heat, until their temperature is reduced and stabilized.

4.9.2.5 Cold, wet towels must be available for first aid to assist in the cooling of someone experiencing heat stress symptoms. Cold towels applied to the inside of the forearms and neck serves as effective thermal receptors to cool the body's core temperature.

4.9.2.6 Air conditioned shelters are to be made available for anyone experiencing heat stress symptoms.

4.9.2.7 Electrolyte replenishment drink (i.e. Isostar, Pocari Sweat, etc) should be available to first aiders for anyone exhibiting serious signs of heat stress symptoms and / or dehydration.

4.9.2.8 Work involving considerable and / or repetitive climbing should be kept to a minimum.

4.9.2.9 A rescue plan should be in place to retrieve anyone who is not capable of removing themselves, under their own power.

4.10 Category BLACK

4.10.1 All work shall stop when heat index exceeds 59°C (138.3ºF). If the ambient temperature is below 35C (95ºF), regardless of humidity, there will be no BLACK flag.

4.10.2 Dispensation for critical activities can be allowed if approved by Supt, HSE Manager and Project Manager

4.10.3 Any work allowed in BLACK flag conditions must have a specific JSA detailing the precaution to be taken for the activity.

4.11 Technical Assistance

4.11.1 In some situations, we will accept work in extremely hot environments that cannot be controlled or mitigated. When faced with this type of situation, the APTIM Safety Department shall be notified for assistance.

5.0 REFERENCES

AMS-720-01-FM-00020	Business Glossary
AMS-720-01-FM-00021	Technical Glossary

6.0 TERMINOLOGY

Term	***Definition***
Heat Rash	Heat rash, also known as prickly heat, may occur in hot, humid environments where sweat is not easily removed from the surface of the skin by evaporation. This is common when using protective equipment especially impermeable clothing. Heat rash can become uncomfortable when extensive or complicated by infection.
Heat Cramps	Heat cramps, which are painful muscle spasms, are caused when workers fail to replace the body's salt loss that occurs during excessive perspiration (especially with non-acclimatized workers).
Heat Exhaustion	Heat exhaustion results from excessive loss of salt and/or water through sweating. The worker with heat exhaustion still sweats, but experiences extreme fatigue, weakness, giddiness, nausea or headache. The skin is clammy and moist, the complexion pale or flushed and the body temperature normal or slightly higher.
Heat Stroke	Heat stroke, the most serious health problem for workers in hot environments, is caused by the failure of the body's internal mechanism to regulate its core temperature. Sweating stops and the body can no longer rid itself of excess heat. Signs include: mental confusion, delirium, loss of consciousness, convulsions or coma, a body temperature of 105 degrees or higher and hot dry skin which may be red and flushed. Victims of heat stroke may die unless treated promptly and correctly.
Site	Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites.

7.0 EXHIBITS

Exhibit 7.1	AMS-710-01-FM-00601 – Heat Stress Index
Exhibit 7.2	AMS-710-01-FM-00602 – Evaporative Cooling Index

Exhibit 7.3 AMS-710-01-FM-00603 – Urine Color Test Chart

8.0 ATTACHMENTS

None

ATTACHMENT 7

AMS-710-02-PR-00700, COLD STRESS PREVENTION AND CONTROL

PROCEDURE

Procedure Title:	**Cold Stress Prevention and Control**	**AMS Number:**	**AMS-710-01-PR-00700**
Procedure Owner:	**HSE**	**Issuing Authority:**	**VP Health & Safety**

COLD STRESS PREVENTION AND CONTROL

INT	Added section 4.6.2.4	M. Hetzler	7/20/2018
INT	Issued for Interim Use	M. Hadacek & S. Lachney	7/30/2017
Rev	**Changes**	**Approved**	**Date**

1.0 PURPOSE

The purpose of this Procedure is to establish the minimum requirements for Cold Stress Prevention and Control on APTIM sites.

2.0 SCOPE

This procedure applies to all APTIM employees, contractors, subcontractors and visitors associated with a APTIM site.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

4.0 PROCEDURE

Each site shall make every attempt to prevent the possibility of incidents and accidents to employees when performing work activities in extreme cold weather environments through compliance with safety regulations, training of employees to properly perform their job activities and through employee involvement in safe work activities.

4.1 Cold Stress

Cold weather conditions can be hazardous to the health and safety of employees, endanger the stability of the body system, and cause problems such as hypothermia and frostbite. It is of vital importance that adequate precautions are taken to alleviate the effect of cold environments and to ensure that personnel can work safely and efficiently.

4.2 Precautions

4.2.1 The following factors may contribute to a cold injury:

4.2.1.1 Exposure to humidity

4.2.1.2 Exposure to high winds

4.2.1.3 Contact with wetness or metal

4.2.1.4 Inadequate clothing

4.2.1.5 Age

4.2.1.6 General health

4.2.2 The following physical conditions worsen the effect of cold exposure:

4.2.2.1 Allergies

4.2.2.2 Vascular disease

4.2.2.3 Excessive smoking

4.2.2.4 Excessive drinking

4.2.2.5 Specific drugs and medicines

4.2.3 Workers with blood vessel abnormalities (i.e., Raynauds phenomenon and acrocyanosis) shall take extra precautions to avoid chilling.

4.3 Requirements

4.3.1 Alcoholic products, including cough medication containing alcohol, shall not be taken prior to work in cold environments.

4.3.2 Sedative drugs shall not be taken prior to working in cold extremes.

4.3.3 An employee who becomes fatigued while working shall be removed to a warm environment and shall rest.

4.3.4 Double shifts and overtime shall be avoided in cold environments.

4.3.5 Personnel shall take breaks and rest periods in warm environments to help prevent cold stress disorders.

4.3.6 The outer layer of clothing shall be removed when entering the heated shelter. The other layers shall be loosened to allow for sweat evaporation.

4.3.7 Sitting or standing for prolonged periods of time shall be avoided in cold environments.

4.4 Wind chill Index

4.4.1 Air temperature alone is not sufficient to assess the cold hazard in certain environments. Therefore, the wind chill index along with the air temperature shall be used.

4.4.2 The wind chill index is the cooling effect of any combination of temperature and wind velocity or air movement. See Form number AMS-710-01-FM-00701.

4.4.3 The wind chill index takes into account the wind velocity.

4.4.3.1 An Anemometer shall be purchased to measure wind speed in areas where wind chill can be a factor.

4.4.3.2 HSE shall ensure through oversight and monitoring the anemometer is being used correctly.

4.4.4 The wind chill index shall be used to evaluate the cold hazard.

4.5 Control Measures

4.5.1 Engineering Controls - Cold stress can be reduced by the following controls:

4.5.1.1 General or spot heating shall be used to increase temperature at the site.

4.5.1.2 If work is being performed with bare hands for 10 or more minutes, special provisions shall be made to keep the worker's hands warm. Warm air jets, radiant heaters, or contact warm heaters should be supplied.

4.5.1.3 The work area shall be shielded if the air velocity at the site is increased by the wind, draft, or ventilation equipment.

4.5.1.4 At temperatures below 40°F, metal handles of tools and control bars shall be covered with thermal insulation.

4.5.1.5 When necessary, equipment and processes shall be substituted, isolated, relocated, or redesigned to reduce the cold stress.

4.5.1.6 Power tools, hoists, cranes, and lifting aids shall be used to reduce the metabolic workload.

4.5.1.7 Heated warming shelters such as tents, cabins, automobiles, or trucks shall be made available if work is performed continuously in an equivalent chill temperature of 30°F or below. Workers shall be encouraged to use them.

4.5.2 Administrative Controls - These controls include the following work practices and rules designed to reduce total cold stress burden on the body.

4.5.2.1 Scheduling a work/rest regime to reduce the peak of cold stress; enforcing scheduled work breaks. See Form number AMS-710-01-FM-00702.

4.5.2.2 Urging frequent intake of warm, sweet, caffeine-free, non-alcoholic drinks or soup provided at regular intervals.

4.5.2.3 Scheduling the coldest work for the warmest part of the day.

4.5.2.4 Moving work to warmer areas whenever possible; preplanning the activities prior to entering the cold environment.

4.5.2.5 Assigning extra workers to highly demanding jobs.

4.5.2.6 Allowing workers to pace themselves, and take extra work breaks when needed.

4.5.2.7 Providing relief workers for break times.

4.5.2.8 Teaching workers the basic principles of preventing cold stress and emergency response to cold stress.

4.5.2.9 Maintaining protective supervision or a buddy system for those who work at 20 degrees or below.

4.5.2.10 Allowing new employees time to adjust to conditions before they work full-time in cold environments.

4.5.2.11 Arranging work to minimize sitting or standing still for long periods at a time.

4.5.2.12 Reorganizing work procedures to ensure as much of a job as possible is performed in a warm environment.

4.5.2.13 Include the weight and bulkiness of clothing when estimating work performance criteria.

4.5.3 Personal Protective Equipment - It is the responsibility of the employee to dress in the clothing appropriate to the expected work conditions. The correct clothing shall be addressed in the following manner:

4.5.3.1 It is important to preserve the air space between the body and the outer layer of clothing in order to retain body heat.

4.5.3.2 It is most important to protect the feet, hands, head, and face. The hands and feet are the farthest from the heart and become cooled most easily. Keeping the head covered is important because as much as 40 percent of heat is lost when the head is exposed to the elements.

4.5.3.3 All clothing and equipment shall be fitted properly and not interfere with circulation.

4.5.3.4 Clothing shall be made of thin cotton. The cotton helps evaporate sweat by absorbing it and bringing it to the surface.

4.5.3.5 Clothing shall be of the loose fitting type. Tight clothing of synthetic fabrics interferes with evaporation.

4.5.3.6 Recommended first layer of clothing shall include a cotton T-shirt and shorts or underpants under cotton and wool thermal underwear. Two-piece long underwear is preferred because the top can be removed and put on as needed.

4.5.3.7 Socks with high wool content are best. When two pairs are worn, the inside sock should be smaller, and made of cotton.

4.5.3.8 Wool or thermal trousers are preferred. The best kind is either quilted or specially lined.

4.5.3.9 Belts are not recommended because they cut off the circulation at the waist. Suspenders are encouraged.

4.5.3.10 Trousers shall fit over the top of the boot to prevent snow and ice from entering.

4.5.3.11 Boots shall be felt-lined, rubber-bottomed, and leather-topped with a removable felt insole. Boots shall be waterproofed and socks shall be changed whenever the sock is sweat soaked.

4.5.3.12 Wool sweater over a cotton shirt shall be worn. Tops shall be worn in a layering effect to ensure proper insulation.

4.5.3.13 An anorak or snorkel coat or arctic parka shall fit loosely and have a drawstring at the waist. The sleeves shall fit snugly. A hood prevents the escape of warm air from the neck and also tunnels the warm air past the face to give a slightly warmer breathing air. A wool cap shall also be worn under the hood.

4.5.3.14 When wearing a hard hat, liners shall be worn.

4.5.3.15 A face mask or scarf is vital when working in cold wind. A ski mask gives better visibility than a snorkel hood. Face protectors shall be removed periodically to check to for frostbite.

4.5.3.16 Safety glasses with side shields shall be worn when out-of-doors. Special safety goggles to protect against ultraviolet light and glare are required when there is snow coverage which could cause a potential eye exposure hazard.

4.6 Training

4.6.1 The workers shall be instructed in safety and health procedures.

4.6.2 The training shall include the following instructions:

4.6.2.1 Proper rewarming procedures and appropriate first aid treatment.

4.6.2.2 Proper clothing practice.

4.6.2.3 Recognition of signs and symptoms of impending cold conditions such as hypothermia or excessive cooling of the body (even when shivering does not occur), frostnip, or frostbite. Safe work procedures.

4.6.2.4 Recognize the dangers and destructive potential caused by unstable snow build-up, sharp icicles, and ice dams and know how to prevent accidents caused by them.

4.7 First Aid

4.7.1 Frostbite

4.7.1.1 Never rub affected area. Rubbing may cause further damage to soft tissue.

4.7.1.2 Warm area gently by soaking in water. The water should start out cold and warm up about every 5 minutes by adding water that is 5° warmer. Do not immerse affected part in water that is more than 105°F. If a thermometer is not available, test the water temperature with your hand. If the water temperature is uncomfortable, it is too hot.

4.7.1.3 Keep the affected area under water until it looks red and feels warm.

4.7.1.4 Loosely bandage the area with dry, sterile dressing. If fingers and toes are frostbitten, place cotton or gauze between them before the loose bandage.

4.7.1.5 Do not break blisters.

4.7.1.6 Get professional help immediately.

4.7.2 Hypothermia

4.7.2.1 Remove any wet clothing and dry the victim.

4.7.2.2 Warm the body gradually by wrapping the victim in blankets or putting on dry clothing and moving the individual to a warmer place. Do not warm body quickly by immersing the person in hot water. Rapid warming can cause dangerous heart problems. If available, apply heating pads or other heating source to the body. Keep a protective barrier, such as towel, blanket, or clothing between heat source and victim to avoid burning the individual.

4.7.2.3 If the victim is alert, give warm liquid to drink. Never give liquids to an individual who is unconscious or semi-conscious.

4.7.2.4 Handle the victim gently.

4.7.2.5 Get professional help immediately.

5.0 REFERENCES

AMS-720-01-FM-00020	Business Glossary
AMS-720-01-FM-00021	Technical Glossary

6.0 TERMINOLOGY

Term	***Definition***
Anemometer	An instrument to measure wind speed.
Cold stress	The disruption of the body's thermal balance due to exposure to cold.
Core temperature	The temperature of the inner parts of the body most accurately determined by measuring with a rectal temperature.
Dehydration	The loss or deficiency of water in body tissues. The condition may result from inadequate water intake and/or excessive removal of water from the body.
Site	Any location, facility or project site where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites.

7.0 EXHIBITS

Exhibit 7.1	AMS-710-01-FM-00701 – Wind Chill Index
Exhibit 7.2	AMS-710-01-FM-00702 – Work/Warm-Up Schedule

8.0 ATTACHMENTS

None

ATTACHMENT 8

AMS-710-02-PR-01600, EXCAVATION AND TRENCHING

PROCEDURE

Procedure Title:	**Excavation and Trenching**	**AMS Number:**	**AMS-710-02-PR-01600**
Procedure Owner:	**HSE**	**Issuing Authority:**	**APTIM Quality Management**

EXCAVATION AND TRENCHING

INT	Issued for Interim Use	M. Hadacek & S. Lachney	7/30/2017
Rev	**Changes**	**Approved**	**Date**

1.0 PURPOSE

This procedure establishes the minimum requirements for Excavation and Trenching activities on APTIM sites.

The following deliverables are defined within this procedure:

- Excavation Permit (AMS-710-02-FM-01601)
- Daily Excavation Inspection Form (Short) (AMS-710-02-FM-01602)
- Daily Excavation Inspection Form (long) (AMS-710-02-FM-01603)
- Soil Classification Worksheet (AMS-710-02-FM-01604)
- Excavation and Trenching Awareness training for affected employees

2.0 SCOPE

This procedure is to be utilized for all excavation and trenching activities on APTIM sites.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this procedure:

- APTIM Managers
- APTIM Superintendent
- APTIM Supervisors
- APTIM Employees
- APTIM Contractors
- APTIM Subcontractors
- APTIM Visitors

4.0 PROCEDURE

This procedure establishes the minimum requirements for work, activities, inspections, and training, required for work in and around excavation and trenching operations on APTIM sites. This procedure will also apply to all APTIM subcontractors.

4.1 General

4.1.1 A designated Competent Person shall be onsite at all times when excavation activities are conducted.

4.1.2 APTIM Supervisors shall ensure employees, contractors, subcontractors, and visitors meet the requirements listed in this procedure when conduction excavation and trenching work.

4.1.3 Before any excavation can be started, an Excavation Permit (AMS-710-02-FM-01601) must be completed by the responsible Superintendent or equivalent with input from the Authorized Person for underground testing (utility identification) and the Excavation Competent Person. Appropriate Client approval and use of Client Excavation permit is also necessary where required by Client regulations. Client and/or utility company representatives shall be notified 24 hours prior to beginning excavations.

4.1.4 Underground Storage Tank (UST) Removal

AMS-710-02-WI-01601 contains specific instructions for trenches and excavations relating to UST removal.

4.1.5 Underground Utilities

4.1.5.1 Utility locating personnel shall locate and mark all known underground utilities within excavation area using utility locating equipment and techniques. The utilities shall be marked with paint or flags. For more guidance, please refer to AMS-710-02-PR-01610 (Identifying Underground Installations).

4.1.5.2 At least 3 feet (0.9144 m) of clearance between any underground utility and the cutting edge or point of powered excavation equipment will be maintained until the precise location of the utility is determined. Initial excavation within this 3 foot area will be conducted manually.

4.1.5.3 All utilities exposed during an excavation will be protected from accidental damage. Machine excavation within 3 feet (0.9 m) of a located utility requires a spotter.

4.1.5.4 The underground utilities information obtained shall be provided to affected personnel via the job safety analysis (JSA). Underground utilities information, in relation to proposed excavation work, means the following information about underground essential services that may be affected by the excavation:

- The utilities that may be affected
- The location, including the depth, of any pipes, cables or other plant associated with the affected essential services
- Any conditions on the proposed excavation work.

4.1.5.5 Any essential services information obtained must be readily available for inspection. The information must be available:

- For at least two (2) years after the incident occurs
- In every other case, until the excavation work is completed.

4.1.5.6 When working on a pressurized liquid system (i.e., site service water, processed cooling water, pumped sanitary system) with piping 1” or more in diameter in an excavation 4 foot or greater in depth where an engulfment hazard exists must:

- De-energize and drain the system
- Lockout/Tagout
- All persons entering the excavation, whether working on the system or not shall apply safety locks and danger tags to the system in accordance with AMS-710-02-PR-01500, Control of Hazardous Energy.
- No personnel shall be allowed in the excavation during pressure/leak testing.

4.1.6 The work area around a excavation over 4 feet (1.2 m) deep shall be, so far is reasonably practicable, secured from unauthorized access (including inadvertent entry).

4.1.7 When mobile equipment is operated adjacent to an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs.

4.1.8 Soil classification shall be made by the Competent Person or a registered Professional Engineer trained in soil classification. Based on the results of tests described in Exhibit 7.4, “Soil Classification Worksheet,” the competent person will classify each soil/rock deposit as stable rock, Type A, Type B, or Type C. When layers of soil/rock exist, the weakest layer will be classified; however, each layer may be classified individually when a more stable layer lies under a less stable layer. If the properties or conditions of a soil/rock deposit change in any way, re-evaluation will be required. Unclassified soil shall be assumed to be Class “C” and will be sloped 1½:1 or shored when the excavation exceeds 4 feet (1.2 m) in depth.

4.1.9 Each employee in an excavation shall be protected from cave-ins. Excavations over 4 feet (1.2 m) deep shall be shored, sloped, or benched as required. Excavations and the work scheduled to be performed in the excavation shall be evaluated by the Competent Person to determine if the shoring, sloping, or benching needs to begin at a depth less than 4 feet (1.2 m).

4.1.10 Shoring for excavations over 20 feet deep (6 m) shall be designed by a registered Professional Engineer and shoring installed shall be approved and signed off by a registered Professional Engineer.

4.1.11 Spoils must be placed a minimum of 3 feet (0.9 m) from the edge of the excavation. Loose soil or rocks shall be removed from the sides of excavation walls.

4.1.12 Excavations 4 feet (1.2 m) in depth or greater, shall have a stairway, ladder, ramp, or other safe means of egress within 25 feet (7.6 m) of any employee. Excavations that are less than 4 feet (1.2 m) in depth shall have safe access and egress for all employees with a maximum break in elevation of 19 inches (48.3 cm).

4.1.13 Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person.

4.1.14 Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

4.1.15 Excavations shall be inspected by a Competent Person and the results recorded on either AMS-710-02-FM-01602 or AMS-710-02-FM-01603:

4.1.15.1 Prior to entry

4.1.15.2 After rain or snowfall

4.1.15.3 After freezing and/or thawing temperatures occur

4.1.15.4 After any condition that can change the integrity of the soil

4.1.16 During rainy weather, work in excavations shall cease until the Competent Person has evaluated the excavation and the effect of the rain on the excavation. The Competent Person will maintain a regular inspection schedule to ensure the excavation stability and condition during rain events if employees continue to work in the excavation. Depending on the amount of rainfall, the duration of the rainfall and the soil type, the Competent Person may need to maintain continuous observation of the excavation conditions.

4.1.17 For excavations that have the potential for oxygen deficiency or to contain hazardous atmosphere, an atmosphere evaluation shall be performed. This test will be performed by the Construction HSE Manager or their designee. Indications of the potential for a hazardous atmosphere include, but are not limited to: gas lines, sewer lines, areas with hydrocarbons, and proximity to emissions sources for H_2S, SO_2, CO, CO_2 and other gases that are heavier than air. Excavations with hazardous atmospheres should be treated as a confined space.

4.1.18 Excavations shall be evaluated for hazards in addition to cave-in potential and atmospheric hazards. Electrical sources, energized (pressurized) pipes, underground tanks, etc. may also present a hazard to employees who are required to enter an excavation.

4.1.19 The Competent Person responsible for the crew working in the excavation shall inspect the excavation throughout the work period, record the observations on AMS-710-02-FM-01602, and stop operations when unsafe conditions exist.

4.1.20 Water shall not be allowed to accumulate in excavations at any time. Pumps, drains, or other means shall be used to remove water constantly.

4.1.21 Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems shall be provided, such as shoring, bracing, or underpinning to ensure the stability of such structures. Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be done unless:

- A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure;
- The excavation is in stable rock;
- A registered professional engineer has determined that the structure is sufficiently removed from the excavation so that it will be unaffected by the excavation activity; or
- A registered professional engineer has determined that such excavation work will not pose a hazard to employees.

4.1.22 Sidewalks, pavements and appurtenant structures shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures. The support system shall be capable of withstanding a minimum live load of 125 lb/ft.

4.1.23 Emergency rescue plans shall be developed and rescue equipment shall be readily available.

4.1.24 Employees will not be permitted to work under loads or near digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded provided the vehicles are equipped with a cab shield and/or canopy adequate to protect the operator from shifting or falling materials.

4.1.25 Employees exposed to falls by excavation crossings and walkways will be provided with fall protection in accordance with Procedure AMS-710-02-PR-00900 - Fall Protection.

4.2 Training

4.2.1 Employee Training

4.2.1.1 Each employee who works in or around an excavation shall be trained to recognize potential hazards associated with excavations: cave-in potential, fall hazards, safe entry and exit, proximity to excavating equipment, air quality, back-filling and compacting activities, protective systems, etc. This training shall be documented in accordance with AMS-710-05-PR-01900 (HSE Education and Training) and records maintained in the Site HSE files

4.2.1.2 Each individual assigned as an Excavation Competent Person shall have documented training (see 4.2.1.1) or shall send documentation of experience and qualifications in excavation activities to the Global HSE Education and Training Director for review.

5.0 REFERENCES

AMS-710-02-PR-00900	Fall Protection
AMS-710-02-WI-01601	Underground Storage Tank Removal
AMS-710-02-PR-01500	Control of Hazardous Energy
AMS-710-02-PR-01610	Identifying Underground Installations
AMS-710-05-PR-01900	HSE Education and Training

6.0 TERMINOLOGY

Term	***Definition***
Accepted Engineering Practices	Those requirements that are compatible with standards of practice required by a registered professional engineer.
Angle of Repose	The greatest angle above the horizontal plane at which a material will lie without sliding.
Authorized Person for Underground Testing	The person(s) designated by the Construction Manager to identify underground utilities using a combination of blue prints and underground testing equipment. This individual shall coordinate excavation activities with the Client (as applicable) and outside utility companies. Several individuals (such as the Piping Superintendent, Electrical Superintendent, Equipment Superintendent, and Field Engineer) may serve as Authorized Persons as necessary.
Benching (Benching system)	A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.
Cave-In	The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or other wise injure and immobilize a person.
Competent Person	One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.
Excavation	Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.
Excavation Competent Person	A person capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. The Construction Manager and Construction HSE Manager shall designate the Competent Person in writing and their qualifications shall be documented.
Hazardous Atmosphere	An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.
Protective System	A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face, into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.
Ramp	An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer	A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a “registered professional engineer” within the meaning of this standard when approving designs for "manufactured protective systems" or “tabulated data” to be used in interstate commerce.
Sheeting	Members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.
Shield	A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Shields may be pre-manufactured or job-built in accordance with 29 CFR 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."
Shoring (Shoring System)	A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.
Site	Any location, facility or project where APTIM is performing work. Sites may include, but are not limited to, laboratories, offices, shops, owned facilities, leased facilities and/or project sites.
Sloping (Sloping System)	A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.
Stable Rock	Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.
Structural Ramp	A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock is not considered structural ramps.
Support System	A structure such as underpinning, bracing, or shoring that provides support to an adjacent structure, underground installation, or the sides of an excavation.
Tabulated Data	Tables and charts approved by a registered professional engineer and used to design and construct a protective system.
Trench (Trench Excavation)	A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.
Type A Soil	Cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144kPa) or greater. Examples of cohesive soils are clay, silty clay, sandy clay, clay loam and, in

some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, soil is not Type A if:

- Soil is fissured
- Soil is subject to vibration from heavy traffic, pile driving, or similar effects
- Soil has been previously disturbed
- Soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater
- Material is subjected to other factors that would require it to be classified as a less stable material

Type B Soil

This classification refers to:

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa)
- Granular cohesionless soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and, in some cases, silty clay loam and sandy clay loam
- Previously disturbed soils except those which would otherwise be classified Type C soil
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subjected to vibration
- Dry rock that is not stable

Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B

Type C Soil

This classification refers to:

- Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less
- Granular soils including gravel, sand, and loamy sand
- Submerged soil or soil from which water is freely seeping
- Submerged rock that is not stable
- Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper

7.0 EXHIBITS

Exhibit 7.1	AMS-710-02-FM-01601 – Excavation Permit
Exhibit 7.2	AMS-710-02-FM-01602 – Daily Excavation Inspection Form (Short)
Exhibit 7.3	AMS-710-02-FM-01603 – Daily Excavation Inspection Form (long)
Exhibit 7.4	AMS-710-02-FM-01604 – Soil Classification Worksheet
Exhibit 7.5	AMS-720-01-FM-00020 – Business Glossary
Exhibit 7.6	AMS-720-01-FM-00021 – Technical Glossary

8.0 ATTACHMENTS

None

APPENDIX E

DATA COLLECTION QUALITY ASSURANCE PROJECT PLAN

Worksheet No. 1 Title and Approval Page

Data Collection Quality Assurance Plan
RSA-271, Former Boiler House, Building 7729
Operable Unit 10
U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Prepared for:

Mission & Installation Contracting Command
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Contract No. W91ZLK-13-D-0018
APTIM Project No. 501021
Task Order 0003

November 2021

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1.0 Introduction

This data collection quality assurance plan (DCQAP) has been developed as a standard document in support of the corrective measures implementation (CMI) at RSA-271. This document provides procedures, guidelines, and practices for the control of equipment, materials, and services anticipated to be used during the field sampling phases of groundwater sampling at the site.

1.1 Purpose

The purpose of this DCQAP is to define the methodology and practices that control the quality of work performed during implementation of the corrective measures at RSA-271. The objective of this DCQAP is to ensure that the data collected are of sufficient quality to verify that corrective measures have been accomplished. This DCQAP is intended for use in conjunction with the Redstone Arsenal installation-wide (IW) work plan (IT Corporation, 2002; Shaw Environmental, Inc. [Shaw], 2010) and the IW quality assurance program plan (QAPP) for the Program Management Contract (Shaw, 2013 and as updated), including updates resulting from changes in U.S. Environmental Protection Agency and Alabama Department of Environmental Management (ADEM) guidance documents. The work guidance documents that will govern the quality practices for this task will include the following:

- The CMI work plan and associated appendices
- The IW QAPP (Shaw, 2013 and as updated)
- The standard operating project procedures (IW QAPP Volume II) (Shaw, 2013).

Data collection will be in accordance with ADEM guidance (ADEM, 2017).

1.2 Document Organization

This document has been organized to present the DCQAP in the following format:

- Introduction – Chapter 1.0
- References – Chapter 2.0
- Uniform Federal Policy (UFP) QAPP worksheets (Chapter 3.0).

Chapter 1.0 provides a brief overview of this DCQAP and introduces the UFP QAPP worksheets. References are included in Chapter 2.0. The worksheets listed in Chapter 3.0 and attached to this DCQAP present a description of the proposed work in compliance with the UFP QAPP format. Worksheet No. 2, *Identifying Information*, provides a crosswalk to the IW QAPP, where needed, and summarizes the site-specific worksheets that are included in this DCQAP.

2.0 References

Alabama Department of Environmental Management (ADEM), 2017, ***Alabama Environmental Investigation and Remediation Guidance, Revision 4***, February.

IT Corporation, 2002, ***Draft-Final, Revision 2, Installation-Wide Work Plan, Redstone Arsenal, Madison County, Alabama***, June.

Shaw Environmental, Inc. (Shaw), 2013, ***Revision 2, Installation-Wide Quality Assurance Program Plan for the Program Management Contract, Volume I and Volume II, U.S. Army Garrison-Redstone, Madison County, Alabama***, May.

Shaw Environmental, Inc. (Shaw), 2010, ***Revision 2, Installation-Wide Work Plan, Final Appendices B, C, D, E, F, U.S. Army Garrison-Redstone, Madison County, Alabama***, prepared for U.S. Army Corps of Engineers, Savannah District, Georgia, September.

U.S. Department of Defense, 2019, ***Quality Systems Manual for Environmental Laboratories,*** Version 5.3, July.

U.S. Environmental Protection Agency (EPA), 1997, ***Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods***, SW-846, Third Edition, Office of Solid Waste, June.

U.S. Environmental Protection Agency (EPA), 1994, ***Region 3 Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses***, September.

U.S. Environmental Protection Agency (EPA), 1993, ***Region 3 Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses***, April.

3.0 Uniform Federal Policy Quality Assurance Project Plan Worksheets

The quality assurance requirements needed to support the sampling and data collection activities in this work plan were adopted under the UFP for QAPPs and implemented in a graded approach.

The crosswalk presented in Worksheet No. 2 provides direction to the related documents or information pertaining to the QAPP requirements. Where site-specific information is required to meet the elements of the UFP QAPP, the supplemental worksheets will be completed in their entirety and included with the crosswalk in this appendix. For this CMI work plan, the supplemental worksheets include the following:

- Worksheet No. 1 – Title and Approval Page
- Worksheet No. 2 – CMI Work Plan Identifying Information
- Worksheet No. 3 – Distribution List
- Worksheet No. 4 – Project Personnel Sign-Off Sheet
- Worksheet No. 14 – Summary of Project Tasks
- Worksheet No. 26 – Sampling Handling System.

The purpose of this DCQAP is to ensure that the data collected are of sufficient quality to verify that corrective measures have been accomplished at RSA-271. The objective of this DCQAP is to present the sampling rationale and provide the details required to complete the field efforts. This DCQAP is intended for use in conjunction with the IW work plan and the IW QAPP for the Program Management Contract.

Worksheet No. 2 CMI Work Plan Identifying Information

Site Name/Project Name	Redstone Arsenal, Madison County, Alabama
Site Location	Groundwater Unit RSA-146
Site Number/Code	RSA-271
Operable Unit (OU)	OU-10
Contractor Name	Aptim Federal Services, LLC
Contractor Number	W9124J-18-D-0001
Contract Title	Contract No. W91ZLK-13-D-0018, Task Order 0003
Work Assignment Number No. (Project No.)	APTIM Project Number 501021
Guidance Documents (Manuals, Guidelines, Plans, etc. Used to Prepare the DCQAP)	Intergovernmental Data Quality Task Force, 2005, *Uniform Federal Policy for Quality Assurance Project Plans* U.S. Department of Defense (DoD), Department of Energy (DOE) 2019, *DoD DOE Consolidated Quality Systems Manual for Environmental Laboratories* Version 5.3, July. DoD, 2018 *DoD General Data Validation Guidelines, Environmental Data Quality Workgroup*, February. U.S. Environmental Protection Agency (EPA), 2013, *National Functional Guidelines for Superfund Inorganic Data Review*, EPA 540-R-10/011 U.S. Environmental Protection Agency (EPA), 2008, *EPA National Functional Guidelines for Superfund Organic Methods Data Review*, EPA 540-R-08-01
Regulatory Program	Resource Conservation and Recovery Act (RCRA), Alabama Department of Environmental Management (ADEM) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA Region 4 (secondary)
Approval Entities	U.S. Army Garrison-Redstone, ADEM
Work Plan	☒ Corrective Measures Implementation (CMI) ☐ Generic Field Sampling Plan
Dates of Scoping Sessions	NA
Dates and Titles of SFSP Documents Written for Previous Site Work (if applicable)	References used to prepare the CMI Work Plan are found in Chapter 6.0 of the document.
Organizational Partners (stakeholders) and Their Connection with Lead Organization	U.S. Army Environmental Command U.S. Army Garrison-Redstone – Overseeing contractor performance under this contract, point of contact with regulators ADEM – State regulator overseeing RSA environmental and remediation activities
Data Users	Project/Task Leads, engineering, support personnel, U.S. Army Garrison-Redstone, ADEM, EPA Region 4

Worksheet No. 2 CMI Work Plan Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet / Documents
Project Management and Objectives		
2.1 Title and Approval Page	Title and Approval Page	Worksheet No.1 − *Title and Approval Page* Approval is provided by the certification of this CMIP.
2.2 Document Format and Table of Contents 2.2.1 Document Control Format 2.2.2 Document Control Numbering System 2.2.3 Table of Contents 2.2.4 QAPP Identifying Information	Table of Contents QAPP Identifying Information	The Table of Contents is provided following the Title and Approval page. Worksheet No.2 – *CMI Work Plan Identifying Information* – included in Appendix E of this CMIP.
2.3 Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	Distribution List Project Personnel Sign-Off Sheet	Worksheet No.3 − *Distribution List – included in Appendix E of this CMIP.* Worksheet No.4 – *Project Personnel Sign-Off Sheet* – included in Appendix E of this CMIP.
2.4 Project Organization 2.4.1 Project Organization Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and Certification	Project Organization Chart Communication Pathways Personnel Responsibilities and Qualifications Table Special Personnel Training Requirements Table	Worksheet No.5 − *Project Organizational Chart* is provided in the IW QAPP, Volume I (Shaw, 2013 and as updated). Worksheet No.6 – *Communication Pathways* Worksheet No. 6 is in the IW QAPP (Shaw, 2013 and as updated) Worksheet No.7 – *Personnel Responsibilities and Qualifications* Table (Appendix E, Section 2.0) Worksheet No.8 − *Special Personnel Training Requirements* Table There are no special training requirements for this task.
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	Project Planning Session Documentation (including “Data Needs” tables) Project Scoping Session Participants Sheet Problem Definition, Site History and Background Site Maps (historical and present)	Worksheet No.9 – *Project Scoping Sessions Participants Sheet* NA Worksheet No.10 − *Problem Definition* See Chapters 2.0 and 3.0 of the CMI Work Plan

Worksheet No. 2 CMI Work Plan Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet / Documents
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	Site-Specific Project Quality Objectives Measurement Performance Criteria Table	Worksheet No.11 − *Project Quality Objectives/Systematic Planning Process Statements* - Sample and data collection for this activity are not of investigative nature but are to track progress toward soil and groundwater corrective measures objectives and waste characterization. The planning and objectives have been defined in Chapter 3.0 of the CMIP. Worksheet No.12 − *Measurement Performance Criteria Tables* are presented in the QAPP (Shaw, 2013 and as updated)
2.7 Secondary Data Evaluation	Sources of Secondary Data and Information Secondary Data Criteria and Limitations Table	Worksheet No.13 – No secondary data will be generated by this monitoring, nor will any be used in future reporting.
2.8 Project Overview and Schedule 2.8.1 Project Overview 2.8.2 Project Schedule	Summary of Project Tasks Reference Limits and Evaluation Table Project Schedule/Timeline Table	Worksheet No.14 − *Summary of Project Tasks* – included in Appendix E of this CMIP. Worksheet No.15 − *Reference Limits and Evaluation* Table is presented in the QAPP, Volume I, Attachment 2a (Shaw, 2013 and as updated). Worksheet No.16 − *Project Schedule/Timeline Table* The corrective measures schedule is found in CMI Work Plan Appendix B and is based on the regulatory requirements.

Worksheet No. 2 CMI Work Plan Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet / Documents
Measurement/Data Acquisition		
3.1 Sampling Tasks 3.1.1 Sampling Process Design and Rationale 3.1.2 Sampling Procedures and Requirements 3.1.2.1 Sampling Collection Procedures 3.1.2.2 Sample Containers, Volume, and Preservation 3.1.2.3 Equipment/Sample Containers Cleaning and Decontamination Procedures 3.1.2.4 Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures 3.1.2.5 Supply Inspection and Acceptance Procedures 3.1.2.6 Field Documentation Procedures	Sampling Design and Rationale Sample Location Map Sampling Locations and Methods / Standard Operating Procedures (SOP) Requirements Table Analytical Methods/SOP Requirements Table Field QC Sample Summary Table Sampling SOPPs Project Sampling SOPP References Table Field Equipment Calibration, Maintenance, Testing, and Inspection Table	Worksheet No.17 − *Sampling Design and Rationale* for soil verification and confirmation and groundwater monitoring samples are presented in Sections 4.3 and 4.10.1, respectively, and Appendix F of the CMI Work Plan. Worksheet No.18 − *Sample Locations, Analytical, and SOPP Requirements* is included as Table F-1 in Appendix F (groundwater). Worksheet No.19 − *Analytical SOP Requirements Table* (Sample Containers Preservation and Holding Times) is presented in the QAPP, Volume I, Attachment 2a (Shaw, 2013 and as updated). Worksheet No. 20 – *Field Quality Control Sample Summary* is included as Table F-2 in Appendix F (groundwater). Worksheet No. 21 − *Project Sampling SOPP Reference* Table. There are no project-specific SOPPs. The complete list of SOPPs is provided in Worksheet No. 21 of the QAPP, Volume I (Shaw, 2013 and as updated). Additionally, copies of the field sampling SOPPs are provided in the QAPP, Volume II (Shaw, 2013 and as updated). Worksheet No. 22 − *Field Equipment Calibration Maintenance, Testing, and Inspection Table* This Table is presented in Worksheet No. 22 of the QAPP, Volume I (Shaw, 2013 and as updated).
3.2 Analytical Tasks 3.2.1 Analytical SOPs 3.2.2 Analytical Instrument Calibration Procedures 3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4 Analytical Supply Inspection and Acceptance Procedures	Analytical SOPs Analytical SOP References Table Analytical Instrument Calibration Table Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	Worksheet No. 23 − *Analytical Reference Table* - Laboratory is provided in the QAPP, Volume I, Attachment 2a (Shaw, 2013 and as updated). Worksheet No. 24 − *Analytical Instrument Calibration Table* - Laboratory is provided in the QAPP, Volume I, Attachment 2a (Shaw, 2013 and as updated). Worksheet No. 25 − Analytical Instrument and Equipment Maintenance, Testing, and Inspection are provided in the QAPP, Volume I, Attachment 2a (Shaw, 2013 and as updated).

Worksheet No. 2 CMI Work Plan Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet / Documents
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	Sample Collection Documentation Handling, Tracking, and Custody SOPs Sample Container Identification Example Chain-of-Custody (COC) Form and Seal	Worksheet No. 26 − *Sample Handling System* included in Appendix E of this CMIP. Worksheet No. 27 − *Sample Custody Requirements* are provided in the IW QAPP, Volume I (Shaw, 2013 and as updated). A sample Chain-of-Custody Form is provided in the IW QAPP, Volume I (Shaw, 2013 and as updated).
3.4 Quality Control (QC) Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	QC Samples Table Screening/Confirmatory Analysis Decision Tree	Worksheet No. 28 – *Laboratory QC Sample Tables* are presented in their entirety in the IW QAPP, Volume I Attachment 2a (Shaw, 2013 and as updated).
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables 3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management 3.5.5 Data Tracking and Control	Project Documents and Records Table Analytical Services Table Data Management SOPs	Worksheet No. 29 − Project Documents and Records Table (SOPP RSA-11.0, "Field-Generated Records Management" provides additional guidance and is included in the IW QAPP, Volume II (Shaw, 2013 and as updated). Worksheet No. 30 − Analytical Services Table is presented in its entirety in the IW QAPP, Volume I Attachment 2a (Shaw, 2013 and as updated).
Assessment/Oversight		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments 4.1.2 Assessment Findings and Corrective Action Responses	Assessments and Response Actions Planned Project Assessments Table Audit Checklists Assessment Findings and Corrective Action Responses Table	Worksheet No. 31 − *Planned Project Assessments Table*, Construction specific assessment and inspection are provided in Appendix D. Worksheet No. 32 − *Assessment Findings and Corrective Action Responses* SOPPs for quality assessments and reporting are listed in Worksheet No. 21 and a copy is provided in the IW QAPP, Volume II (Shaw, 2013 and as updated). The laboratory audit checklists and assessments are provided in the IW QAPP, Volume I (Shaw, 2013 and as updated).
4.2 QA Management Reports	QA Management Reports Table	Worksheet No. 33 − *QA Management Reports Table* SOPPs for quality assessment and reporting are provided in the IW QAPP, Volume II (Shaw, 2013 and as updated).

Worksheet No. 2 CMI Work Plan Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet / Documents
4.3 Final Project Report	All QA Management Reports attached Additional data quality concerns and resolution documentation	Worksheet No. 33 − *QA Management Reports Table* SOPPs for quality assessment and reporting are provided in the IW QAPP, Volume II (Shaw, 2013 and as updated).
Data Review		
5.1 Overview		
5.2 Data Review Steps 5.2.1 Step I: Verification 5.2.2 Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities 5.2.3 Step III: Usability Assessment 5.2.3.1 Data Limitations and Actions from Usability Assessment 5.2.3.2 Activities	Verification (Step I) Process Table Validation (Steps IIa and IIb) Process Table Validation (Steps IIa and IIb) Summary Table Usability Assessment	Worksheet No. 34 − *Verification (Step I) Process Table* is presented in the IW QAPP, Volume I (Shaw, 2013 and as updated). Worksheet No. 35 − *Validation (Steps IIa and IIb) Process Table* is presented in the IW QAPP, Volume I (Shaw, 2013 and as updated). Worksheet No. 36 − *Validation (Steps IIa and IIb) Summary Table* is presented in the IW QAPP, Volume I (Shaw, 2013 and as updated). Worksheet No. 37 − *Usability Assessment* is presented in the IW QAPP, Volume I (Shaw, 2013 and as updated).
5.3 Streamlining Data Review 5.3.1 Data Review Steps To Be Streamlined 5.3.2 Criteria for Streamlining Data Review 5.3.3 Amounts and Types of Data Appropriate for Streamlining	Automated Data Review A1 and A2 data files for each sample delivery group Verification sampling or as needed Applicable to 90 percent data that are not manually validated	Automated Data Review (Laboratory Data Consultants) will be used by the laboratory and the subcontracted lab to automatically review electronic data against the QAPP requirements.

Shaw Environmental, Inc. (Shaw), 2013, ***Revision 2, Installation-Wide Quality Assurance Program Plan for the Program Management Contract, Volume I and Volume II, U.S. Army Garrison-Redstone, Madison County, Alabama***, May, and as updated.

Worksheet No. 3 Distribution List

Corrective Measures Implementation Work Plan Recipients	Title	Organization	Telephone Number	E-mail Address
Paul Fluck	Contracting Officer's Representative	U.S. Army Corps of Engineers – Mobile District	251-690-3582	Paul.V.Fluck@usace.army.mil
Quang Nguyen	Environmental Support Manager	U.S. Army Environmental Command	813-240-5578	Quang.d.nguyen15.civ@mail.mil
Clint Howard	Chief, Installation Restoration Branch	U.S. Army Garrison - Redstone	256-842-3702	Joseph.c.howard1.civ@mail.mil
Larry Galloway	Army Site Task Manager	U.S. Army Garrison - Redstone	256-842-2850	larry.e.galloway.ctr@mail.mil
Holly Gallier	Army Site Task Manager	U.S. Army Garrison - Redstone	256-955-6967	holly.m.gallier.civ@mail.mil
JoJuan Pressley	Lead Remedial Project Manager	ADEM	334-271-7747	Jojuan.pressley@adem.alabama.gov
Mark Shoemaker	Project Manager	APTIM	865-560-7927	Mark.shoemaker@aptim.com
Emily Davis	Senior Scientist	APTIM	717-737-1049	Emily.davis@aptim.com
Brian Rhodes	Project QA/QC Manager	APTIM	256-714-4200	Brian.rhodes@aptim.com
Beth Crawford	Regulatory Specialist	APTIM	419-429-5519	Beth.crawford@aptim.com
Brian Rhodes	Quality Control Site Manager	APTIM	256-714-4200	Brian.rhodes@aptim.com
Vicki Graves	Project Chemist	APTIM	865-560-7818	Vicki.graves@aptim.com
Ken Hurley	Project Engineer	APTIM	865-560-7831	Kenneth.Hurley@aptim.com

Notes:
Copies of this data collection quality assurance plan will be distributed to the individuals above as part of the corrective measures implementation plan.

One controlled hard copy of the installation-wide work plan will be maintained in the field trailer as a reference for field workers. The field team members are required to be familiar with their applicable contents through required reading and the sign-off acknowledgement sheet. The contractor's quality control site manager will be the owner of the field copy of the installation-wide work plan and will be responsible to ensure that it is current and that all field sampling personnel have read the work controlling documents and have signed the acknowledgement form. A copy of the installation-wide guidance document will be maintained as a reference document in the possession of the field sampling team during the sampling event.

Worksheet No. 4 Project Personnel Sign-Off Sheet

Project Personnel	Title	Telephone Number	Signature	Date CMI Work Plan Read
Mark Shoemaker	Project Manager	865-560-7927		
Vicki Graves	Project Chemist	865-560-7818		
Emily Davis	Senior Scientist	717-737-1049		
Brian Rhodes	Project QA/QC Manager	256-714-4200		
Brian Rhodes	Quality Control Site Manager	256-714-4200		
Ken Hurley	Project Engineer	865-560-7831		
Field Personnel	Field Personnel	TBD		

CMI – Corrective measures implementation.

TBD – To be determined.

The individuals who sign above are certifying they have read the applicable sections of the Redstone Arsenal installation-wide quality assurance program plan and the data collection quality assurance plan. Upon completion, please forward the original signed form, with all columns completed, to the Quality Assurance/Quality Control Manager.

Worksheet No. 14 Summary of Project Tasks

The data collection activities conducted at RSA-271 will be completed in accordance with the standard operating project procedures (SOPP), the corrective measures implementation (CMI) work plan, and the installation-wide (IW) quality assurance program plan (QAPP) for the Program Management Contract (Shaw Environmental, Inc. [Shaw], 2013 or latest submission to Alabama Department of Environmental Management [ADEM]). Data collection for this CMI will be conducted for the following activities:

- Soil sampling using DPT methods
- Monitoring well installation
- Soil excavation and confirmation sampling
- Groundwater sampling in accordance with the groundwater sampling plan (Appendix F)
- Investigation-derived waste (IDW)/remediation-derived waste (RDW) characterization.

The following sections present a brief description of each data collection task and present the work controlling documents that provide guidance for proper data collection implementation. All data collection activities will be conducted in a manner that ensures the quality of the data is sufficient to meet the objectives identified in the CMI work plan.

14.1 Soil Sampling

Two soil borings (271-SB12 and 271-SB13) will be advanced within and east of the UST pit and soil samples collected using DPT methods. Sampling will be completed following Standard Operating Project Procedure (SOPP) Nos. 2.0 and 6.0 in the IW QAPP (Shaw, 2013).

14.2 Monitoring Well Installation and Development

Three new groundwater monitoring well will be installed in downgradient and crossgradient locations prior to the baseline groundwater sampling. The new wells (271-RS2994, 271-RS3003 and 271-RS3004) will be installed and developed in accordance with Standard Operating Project Procedure (SOPP) Nos. 17.0, 20.0, and 22.0 in the IW QAPP (Shaw, 2013).

Worksheet No. 14 Summary of Project Tasks

14.3 Excavation Confirmation, Waste Characterization, and Backfill/Borrow Material Sampling

14.3.1 Confirmation Soil Sampling

Following completion of the soil excavation, confirmation soil samples will be collected within the RSA-271 excavation ensure that the soil contaminant concentrations remaining at the site do not exceed specified cleanup goals for site contaminants. The sampling activities will include soil sampling along the perimeter sidewalls (as required in the CMI Work Plan). The confirmation samples will be collected as composite samples for PAHs following procedures described in the CMIP. The data collection and analytical program are presented in Worksheets No. 18 and No. 20 of this data collection quality assurance plan (DCQAP), respectively.

14.3.2 Borrow Source Sampling

Soil samples will be collected from the borrow source for chemical testing prior to placement to confirm that it is acceptable for use, if previous sampling of the borrow source material was not conducted. Soil borrow samples will be tested for chemical contamination for the parameters listed in WS 18 and 20.

Borrow samples, if needed, will be collected in accordance with SOPP No. 5.0, *Surface Soil Sampling* (Shaw, 2013) and as detailed in the CMI work plan. The sample collection and analytical requirements are presented in Section 4.5 of the CMI work plan and Worksheets No. 18 and No. 20 of this DCQAP, respectively.

14.3.3 Stockpile and Backfill

Contaminated or uncontaminated soils that are stockpiled during excavation activities at the site will be divided into individual stockpiles of up to 200-cubic yard volumes and sampled in accordance with the CMI Work Plan. Worksheets No. 18 and No. 20 in this DCQAP specify the required sampling and analytical suite

Worksheet No. 14 Summary of Project Tasks

14.4 Baseline and MNA Groundwater Sampling

Baseline groundwater sampling is proposed from three existing wells and three new wells for the performance monitoring system at RSA-271 to define water quality conditions across the RSA-271 groundwater unit. 4-1). Aptim Federal Services, LLC (APTIM) will list all groundwater sample designations and analytical parameters in Table F-1 (Appendix F), *Sample Locations, Analytical, and SOPP Requirements*. Quality assurance (QA)/quality control (QC) samples will be collected as presented in Table F-2 (Appendix F), *Field Quality Control Sample Summary.* Prior to collection of groundwater samples from the designated wells, static water levels will be measured at each well in accordance with SOPP No. 16, *Groundwater Level Measurements* (Shaw, 2013 or latest submission to ADEM). Groundwater sampling will be performed using a submersible pump for purging and low-flow sampling techniques in accordance with SOPP No. 7, *Groundwater Sampling* (Shaw, 2013 or latest submission to ADEM).

Samples will be tested for chemical contamination using the following U.S. Environmental Protection Agency (EPA) methods:

- Perchlorate by EPA Method 6850
- Volatile organic compounds (VOC) by EPA Method 5030B/8260C
- Semivolatile organic compounds (SVOC) with low level (LL) polynuclear aromatic hydrocarbons (PAH) by EPA Method 3510B/8270D
- Explosives by EPA Method 8330B
- Manganese by EPA Method 3005A/6010C.

Natural attenuation field tests will also be performed for dissolved iron (ferrous) and standard field measurements (dissolved oxygen, oxidation-reduction potential, pH, temperature, conductivity, and turbidity). Note that only the chemicals of concern for action or monitoring will be reported.

Worksheet No. 14 Summary of Project Tasks

14.4 Investigation and Remediation-Derived Waste Samples

IDW/RDW will be generated during this task, including soil cuttings and development/decontamination water from monitoring well construction, waste soil from the excavation, decontamination water from excavation activities and soil and groundwater sampling. The data collection for the IDW/RDW management and analytical requirements are presented in the CMI work plan and Table F-2 of the groundwater monitoring plan (Appendix F), respectively.

14.5 Equipment Decontamination

Equipment decontamination will be performed to maintain the integrity of the samples collected (i.e., to ensure that contaminants will not be introduced into samples from location to location). All sampling equipment will undergo a thorough decontamination prior to use in each well and prior to leaving the site, in accordance with the requirements specified in SOPP No. 3.0, *Field Equipment Decontamination* (Shaw, 2013 or latest submission to ADEM). All decontamination water will be containerized in accordance with SOPP No. 4.0, *Investigative Derived Waste* (Shaw, 2013 or latest submission to ADEM), and sampled as IDW/remediation-derived waste (Section 4.5 of the CMI work plan and Table F-2 of the groundwater monitoring plan [Appendix F]).

14.6 Field Documentation

Field personnel are responsible for accurately documenting field activities and maintaining the records in a protective manner, safeguarding against damage or loss until submitted to the site supervisor or the project files. All field records are to be accurate, complete, and legible and shall contain sufficient detail to allow future reconstruction of the recorded event by someone other than the originator. Records may be completed electronically or manually.

Personnel completing records/forms shall observe the following minimum requirements:

- Keep all record entries concise and legible: make all entries in dark blue or black, indelible ink.
- Complete all forms in such a manner as to accurately and thoroughly document the activity.
- Use the military clock (24-hour) when recording time.

Worksheet No. 14 Summary of Project Tasks

- When using a preprinted form, complete each blank or space. Mark “NA” or equivalent in each space that is not applicable to activity.
- Make any corrections or deletions required by drawing a single line throughout the entry and initialing and dating the correction.
- Do not use correction fluid/tape or erasers.

Worksheet No. 29, *Project Documents and Records Table*, in the IW QAPP (Shaw, 2013 or latest submission to ADEM) provides details on records generation, maintenance, and archival and retrieval methods.

14.7 Quality Assurance/Quality Control Sample Collection

As summarized in WS 18 and 20 and Table F-2, *Field Quality Control Sample Summary,* QC samples collected as part of data collection activities will include equipment rinsate samples, field duplicates, and matrix spike (MS)/matrix spike duplicate (MSD) samples to monitor decontamination procedures, sample handling procedures, and laboratory precision, accuracy, and sample matrix effects, respectively. Laboratory standard operating procedures (SOP) are listed in Worksheet No. 19, *Analytical SOP Requirements*, in the IW QAPP (Shaw, 2013 or latest submission to ADEM).

14.7.1 Equipment Rinsate Samples

Equipment rinsate samples are blank samples collected to determine if the decontamination process has removed residual contamination from sampling equipment. The rinsate sample will consist of ASTM International Type II reagent-grade water poured over or through decontaminated sampling equipment into the appropriate sample containers. The rinsate will be analyzed for the same analytical parameters as the environmental samples. The data obtained from the rinsate samples will be used in the data validation process. Equipment rinsate samples will be collected as needed in accordance with the IW QAPP (Shaw, 2013 or latest submission to ADEM).

14.7.2 Field Duplicates

Field duplicates will be collected to assess the precision of the analytical process utilized in the analysis of the samples collected. The field duplicates will consist of a second sample collected at the same location as the original sample. The duplicate samples will be collected at predetermined locations and will be collected, handled, and transported in the same manner as the original samples. One field duplicate will

Worksheet No. 14 Summary of Project Tasks

be collected for every 10 regular environmental samples collected. All sampled media will include at least one field duplicate (Shaw, 2013 or latest submission to ADEM). Field duplicates samples will not be collected for waste characterization samples since data validation is not required for waste characterization samples.

14.7.3 Matrix Spike/Matrix Spike Duplicates

MS/MSD samples will be collected to assess the laboratory precision, accuracy, and sample matrix effects. The MS/MSD samples will consist of a second and third sample collected at the same location as the original sample. The samples will be collected at predetermined locations and collected, handled, and transported in the same manner as the original samples. One MS/MSD will be collected for every 20 regular environmental samples collected. All sampled media will include at least one MS/MSD (Shaw, 2013 or latest submission to ADEM). MS/MSD samples will not be collected for waste characterization samples since data validation is not required for waste characterization samples.

14.8 Sample Handling Procedures and Holding Times

All sample containers, handling, packaging, and shipping will be in accordance with SOPP No. 15.0, *Non-Hazardous Sample Handling, Packaging and Shipping,* in the IW QAPP (Shaw, 2013 or latest submission to ADEM). Table F-2, *Field Quality Control Sample Summary,* provides the sample volume, sample container types, and sample frequency.

14.9 Sample Documentation Custody, Packaging, and Shipping

The field sampling team will maintain physical custody of the samples at all times prior to shipment to the analytical laboratory. Sample documentation custody, packaging, and shipping will be in accordance with SOPP No. 15.0, *Non-Hazardous Sample Handling, and Packaging and Shipping*, in the IW QAPP (Shaw, 2013 or latest submission to ADEM). Worksheet No. 26.0, *Sampling Handling System*, identifies the personnel and the organizations that are responsible for sample custody, packaging, and shipment.

Worksheet No. 14 Summary of Project Tasks

14.10 Data Management and Validation

All analytical data generated from this project are managed in accordance with the procedures specified in the IW QAPP (Shaw, 2013 or latest submission to ADEM). Samples collected during implementation of the sampling effort are analyzed using approved EPA SW-846 Update III Methods (EPA, 1997) in accordance with the *U.S. Department of Defense Quality Systems Manual* (U.S. Department of Defense, 2019 or latest approved) and laboratory SOPs as presented in Worksheet No. 19, *Analytical SOP Requirements*, in the IW QAPP (Shaw, 2013 or latest submission to ADEM). Reporting limits for the various analytes are appropriate for comparing data against the decision criteria.

Sample data are validated by the APTIM validation team using the U.*S. Department of Defense Quality Systems Manual, Version 5.3* (U.S. Department of Defense, 2019 or latest approved) for guidance. EPA Region 3 *Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses* (EPA, 1994) and *Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA, 1993) are applied during the blank evaluation portion of the validation activities. Specific QC criteria identified in the IW QAPP (Shaw, 2013 or latest submission to ADEM), analytical methods, and laboratory SOPs will be applied to all sample results. For those analytical methods not addressed by the validation guidelines, the evaluation is based on the published method requirements, laboratory-specific SOPs, and technical judgment following the logic of the Contract Laboratory Program validation guidelines for data qualification.

14.11 Inspections for Field Activities

Inspections are performed on materials or services to determine compliance with contractual, planning, and other requirements. Inspection criteria are established prior to the inspection and based upon project specifications, requirements, code specifications, and product acceptability. Acceptance criteria shall be adequate for the activity and be verified during inspection activities. Inspection may be performed and verified through visual observation, measurement of materials or equipment, examination of documentation/certification, evaluation of performance, or testing. Worksheet No. 31, *Planned Project Assessments Table*, in the IW QAPP (Shaw, 2013 or latest submission to ADEM), provides details on the types of inspections as well as the inspection frequency. Records of inspections are maintained in the project files. At minimum, inspection files will include inspection reports/checklists, inspection responses, any supporting documents, as well as applicable client comments.

Worksheet No. 18 Sampling Locations and Methods/SOPP Requirements

Sample Location	Sample Designation	Sample Depth (ft bgs) (a)	QA/QC Sample Designation: FD*	QA/QC Sample Designation: MS/MSD*	Analytical Suite
RSA-271 Excavation					
Confirmation Sample Locations					
EX-SW01	EX-SW01 -DS- ABV0200 -REG	10-15		EX-SW01-DS-ABV0200-MS/MSD	PAHs
	EX-SW01 -DS- ABV0201 -REG	15-20			PAHs
EX-NW01	EX-NW01 -DS- ABV0202 -REG	10-15	EX-NW01-DS-ABV0203-FD		PAHs
	EX-NW01 -DS- ABV0204 -REG	15-20			PAHs
EX-NE01	EX-NE01 -DS- ABV0205 -REG	10-15			PAHs
	EX-NE01 -DS- ABV0206 -REG	15-20			PAHs
EX-NW01	EX-NW01 -DS- ABV0207 -REG	10-15			PAHs
	EX-NW01 -DS- ABV0208 -REG	15-20			PAHs
Subsurface Soil Verification Sample Locations					
271-SB012	271-SB012 -DS- ABV0209 -REG	12-14			SPLP LL/PAHs
	271-SB012 -DS- ABV0210 -REG	17-19	271-SB012-DS-ABV0211-FD		SPLP LL/PAHs
271-SB013	271-SB013 -DS- ABV0212 -REG	12-14		271-SB013-DS-ABV0212-MS/MSD	SPLP LL/PAHs
	271-SB013 -DS- ABV0213 -REG	17-19			SPLP LL/PAHs
Equipment Rinsate					
271-SITE	271-SITE -WA- ABV8010 -ER	NA			LL/PAHs
Backfill Samples (Top 10 feet of Excavation Area)					
271-BCKFILEXC01	271-BCKFILEXC01 -SO- ABV9051 -REG	NA			PAHs
271-BCKFILEXC02	271-BCKFILEXC02 -SO- ABV9052 -REG	NA			PAHs
Backfill Samples (Benched Material)					
271-BCKFILBENCH01	271-BCKFILBENCH01 -SO- ABV9053 -REG	NA			PAHs
271-BCKFILBENCH02	271-BCKFILBENCH02 -SO- ABV9054 -REG	NA			PAHs
Waste Characterization					
271-SITE	271-SITE -SO- ABV9055 -REG	NA			PAHs
271-SITE	271-SITE -SO- ABV9056 -REG	NA			PAHs
Borrow Material					
271-BORROW01	013-BORROW01 -SO- ABV9057 -REG	NA			TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL Metals, Perchlorate, Explosives

*The MS/MSD locations are subject to change due to field conditions. Project chemist will be notified and data base updated accordingly.

Sampling SOP Reference

SOPP 1.0, Field Documentation; SOPP 2.0, Collection and Field Screening of Soil Samples; SOPP 3.0, Field Equipment Decontamination.
SOPP 4.0, Investigative Derived Waste, SOPP 6.0, Subsurface Soil Sampling.
SOPP 15.0, Non-Hazardous Sample Handling, Packaging, and Shipping; SOPP 22.0, Description of Geologic Materials.

Worksheet No. 20 Field Quality Control Sample Summary

	Analytical Method	Matrix	Total Number of Samples	FD	MS	MSD	Equip. Rinsate (1/event)	Trip Blank (1/cooler)	TAT Needed[a]	Sample Container/Preservation Requirements[b]	Holding Time	Total Number of Containers
RSA-271 Excavation												
Confirmation Samples												
PAH	3540C/8270D	Soil	8	1	1	1	1	0	5 Days	4 oz jar	14 days extraction; 40 days analysis	12
Subsurface Soil Verification Samples												
SPLP LL/PAHs	1312/3510C/8270D	Soil	4	1	1	1	1	0	5 Days	4 oz jar	14 days extraction; 40 days analysis	8
Backfill (Top 10 feet of Excavation Area) Samples												
PAH	3540C/8270D	Soil	2	1	1	1	1	0	5 Days	4 oz jar	14 days extraction; 40 days analysis	6
Backfill (Benched Material) Samples												
PAH	3540C/8270D	Soil	2	1	1	1	1	0	5 Days	4 oz jar	14 days extraction; 40 days analysis	6
Waste Characterization Samples												
PAH	3540C/8270D	Soil	2	0	0	0	0	0	5 Days	4 oz jar	14 days extraction; 40 days analysis	2
Borrow Soil Samples												
TCL VOCs	5035/8260B	Soil	1	1	1	1	0	0	Normal	2 Terra Cores in Methanol	14 days	8
TCL SVOCs	3540C/8270D	Soil	1	1	1	1	0	0	Normal	4-oz jar	14 days extraction; 40 days analysis	4
TCL Pesticides	3540C/8081B	Soil	1	1	1	1	0	0	Normal	4-oz jar	14 days extraction; 40 days analysis	4
TCL PCBs	3540C/8082A	Soil	1	1	1	1	0	0	Normal	4-oz jar	14 days extraction; 40 days analysis	4
Perchlorate	6850	Soil	1	1	1	1	0	0	Normal	4 oz jar; headspace required	28 Days	4
Explosives	8330B	Soil	1	1	1	1	0	0	Normal	4-oz jar	14 days extraction; 40 days analysis	4
TAL Metals	3050B/6010C/7471B	Soil	1	1	1	1	0	0	Normal	4-oz jar	6 Months; Mercury - 28 days	4

[a] Sample deliverables should include a Level IV, CLP-like data package and EDD for all samples with the exception of IDW samples that require certificates of analysis and EDD only.

[b] All samples should be cooled to 4 degrees Celsius in conjunction with preservation requirements noted prior to shipment to the laboratory

VOC - Volatile organic compound.
SVOC - Semivolatile organic compound.
LL PAHs - low level polynuclear aromatic hydorcarbons
PCBs- Polychlorinated biphenyls
SPLP-Synthetic precipitation leaching procedure
FD - Field duplicate.
IDW - Investigation-derived waste.

MS - Matrix spike.
MSD - Matrix spike duplicate.
TAT - Turnaround time.
TCL - Target compound list
TAL - Target analyte list

Worksheet No. 26 Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT (FIELD)
Sample Collection (Personnel/Organization): Brian Rhodes/APTIM
Sample Packaging (Personnel/Organization): Brian Rhodes/APTIM
Coordination of Shipment (Personnel/Organization): Vicki Graves or designee/APTIM
Type of Shipment/Carrier: Cooler/Lab Courier, UPS
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians/TBD
Sample Custody and Storage (Personnel/Organization): Sample Custodians/ TBD
Sample Preparation (Personnel/Organization): Extraction Lab, Metals Preparation Lab/ TBD
Sample Determinative Analysis (Personnel/Organization): GC/Liquid Chromatography Lab, GC/MS Lab, Metals Preparation Lab/ TBD
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (Number of days from extraction/digestion): 3 months from sample extraction/ digestion
Biological Sample Storage (Number of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodians/TBD
Number of Days from Analysis: 30 days from submittal of final report or 60 days from receipt, whichever is longer

TBD – To be determined.

Post sample collection in the field will be conducted in accordance with SOPP 15.0 *Non-Hazardous Sample Handling, Packaging, and Shipping.* This procedure is located in the RSA installation-wide quality assurance program plan, Volume II (Shaw, 2013 and as updated).

Specific laboratory sample custody procedures (receipt of samples, archiving, and disposal) will be used for all post-sample handling. Coolers will be received and checked for proper temperature. A sample cooler receipt form will be filled out to note the conditions and any discrepancies. The chain of custody will be checked against the sample containers for correctness. Samples will be logged into the database and given a unique log number, which can be tracked through processing. The Project Chemist will be notified of any problems.

APPENDIX F

GROUNDWATER MONITORING PLAN

Groundwater Monitoring Plan
RSA-271, Former Boiler House, Building 7729
Operable Unit 10

U.S. Army Garrison-Redstone
Madison County, Alabama
EPA ID No. AL7 210 020 742

Prepared for:

Mission & Installation Contracting Command
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Contract No. W91ZLK-13-D-0018
APTIM Project No. 501021
Task Order 0003

November 2021

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F1.0 Introduction

This groundwater monitoring (GWM) plan has been developed in support of the RSA-271 corrective measures implementation (CMI) plan. This document provides the details necessary to implement GWM. This GWM plan is designed to evaluate the effectiveness of the selected corrective measures, soil excavation and off-site disposal, monitored natural attenuation (MNA) and land-use controls (LUC), for the chemicals of concern (COC) in groundwater under RSA-271. This plan includes a listing of wells proposed for monitoring, a monitoring schedule, monitoring parameters and sampling and analytical methods, reporting, and records maintenance.

Objective and Scope

Groundwater COCs for RSA-271 include manganese, 1-methylnaphthalene, trichloroethene (TCE), 2-nitrotoluene, and perchlorate. The primary objective of this GWM plan is to track the progress of the selected corrective measures towards reducing these COCs to levels below the cleanup goals (CG). A second objective of the GWM plan is to monitor for common biodegradation parameters of COCs. Biodegradation parameters of TCE include 1,1-dichloroethene (DCE), cis-1,2- DCE, trans-1,2-DCE, and vinyl chloride.

In addition, the following chemicals were detected in groundwater at concentrations exceeding regional screening levels (RSL) but do not require calculation of a risk-based threshold level: 3-nitrotoluene, 2,4,6-trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, nitroglycerin, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, naphthalene, 2-methlynaphthalene, benzo(a)anthracene, dibenz(a,h)anthracene, and dibenzofuran. These compounds will be included in groundwater monitoring during the corrective measures for RSA-271.

This plan is designed to be easily modified, if necessary, in response to new hydrologic or geochemical data or changes in remedial, hydrologic, technical, or land-use conditions. Recommendations for changes to the GWM program will be documented in annual CMI effectiveness reports produced by the Army.

F2.0 RSA-271 Site Description

F2.1 Site Background

RSA is located in the southwestern portion of Madison County, which is in the northern portion of Alabama (Figure F-1). RSA is a U.S. Army facility that encompasses approximately 38,300 acres of land, all of which are either owned or controlled by the Army. Development within RSA has largely centered on the historical production (and later disposal) of conventional and chemical munitions and, more recently, development, testing, and evaluation of missiles and rockets. These processes have produced chemical wastes since operations began in the early 1940s.

RSA-271 is located in the northeastern portion of groundwater unit RSA-146. RSA-146 occupies the southeastern quadrant of RSA between Huntsville Spring Branch and the Tennessee River. RSA-271 occupies approximately 0.25 acre and is situated in the southeastern part of the Missile Production Complex. Nearby surface media sites include RSA-089 to the northwest, RSA-138M to the north, and RSA-097 (a no-further-action [NFA] site) to the west. NFA site RSA-137O is within the footprint of RSA-271. A brief site description is provided below, but a more comprehensive description is included in the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) report (Aptim Federal Services, LLC [APTIM], 2020).

The investigation at RSA-271 focused on contamination resulting from historical operations associated with Building 7229 (formerly Army Building B-529), located within the RSA-271 site. Initially, the building housed a steam boiler fueled from a 2,800-gallon underground storage tank formerly located east of the building. A small oil/water separator (OWS) consisting of a blow-off/hot well pit was located at the west end of Building 7729. RSA records indicate that this system was removed from use but left in place, and a larger, high-capacity blow-off/hot well was installed south of Building 7729 in 1974. The junction of both OWS systems with the sanitary sewer system was located northwest of the building.

RSA-271 was established as a solid waste management unit following the RSA-146 potential source area (PSA) investigation (Shaw Environmental, Inc. [Shaw], 2005). As a result of the PSA investigation process, the Army recommended the creation of RSA-271 to facilitate a more focused and thorough evaluation of the data to determine whether chemicals used at RSA-271, including fuel and compressor oils, contributed to environmental contamination.

F2.2 RSA-271 Geology/Hydrogeology

Detailed descriptions of the physical setting (geology/hydrogeology/surface hydrology) for the RSA-271 site is included in the RFI report (CB&I, 2017a). A summary is included here.

Topography and Surface Water Hydrology. Prior to Missile Production Complex construction in the 2010s, the site was mostly open scrub/grassland with scattered areas of small trees and planted pines along its eastern and northwestern boundaries (Figure F-2). There are no remaining legacy buildings or structures within the site. As is typical of developed areas within RSA, the former buildings at RSA-271 are topographically higher than the surrounding forest land and swampy areas. No permanent surface water or other aquatic habitat features exist within the boundary of RSA-271. A large wetland/pond is located across Eagle Road, approximately 500 feet south and east of the site. The entire site lies above the 100-year floodplain.

Geology. The subsurface geologic setting beneath RSA-271 and adjacent sites includes overburden consisting of low-permeability, red, brown, and gray clay; silty clay; and silt. Intervals of chert and chert fragments increase with depth. The thickness of the overburden at the site, as determined by the depth to auger refusal in site soil borings ranges from 31.8 feet (271-RS2375) to 56 feet (14602A10-HP03) (CB&I, 2017a). Although there is little compositional variation within the overburden, the residuum does not transmit groundwater uniformly. Groundwater infiltration follows preferred pathways because zones of higher hydraulic conductivity developed during soil-forming processes. Preferred pathways within the overburden directly affect contaminant migration and distribution within the soil column.

Residual clay generally has low horizontal and vertical hydraulic conductivities. At a given location, a layer of chert within the clay may decrease vertical hydraulic conductivity and increase horizontal conductivity, while isolated nodules of chert may increase the vertical conductivity. Preferred groundwater flow pathways in the overburden also include macropores caused by rotting tree roots and burrowing animals.

Additionally, microfractures may be created within the clay during raveling, a process in which the clay slowly subsides as it is eroded and carried away by groundwater in bedrock fractures and conduits. Vertical movement of the soil caused by raveling or sloughing into fractures and conduits results in the development of microfractures in the overlying material. The microfractured clay soils have higher hydraulic conductivities than undisturbed clay and also act as preferred groundwater flow pathways.

Depth to bedrock across this portion of RSA ranges from 31.8 to 56 feet below ground surface (bgs) (CB&I, 2017a). This variable depth to bedrock is due to solution weathering of the upper bedrock surface (epikarst). Lithological data from bedrock wells installed across this portion of RSA indicate that the shallow bedrock first encountered correlates with middle to upper Tuscumbia Limestone and exhibits well-developed karst features. The Fort Payne is underlain by the Chattanooga Shale, a dark gray to black, fissile shale.

Groundwater Hydrogeology. RSA-271 is located within the boundaries of the larger RSA-146 groundwater unit. Groundwater beneath RSA-271 occurs in the unconsolidated overburden and the upper portion of the carbonate bedrock. The overburden and upper bedrock comprise an interconnected, aquifer. At depth, groundwater occurs under semi-confined conditions, flowing along discrete joints and bedding-plane partings. The water table across RSA-271 and the larger

RSA-146 groundwater unit is generally flat, mimicking local topography. Depth to groundwater in overburden wells at RSA-271 fluctuates seasonally and ranged from 13.4 feet to a maximum 20.3 feet bgs. Excluding the data from 271 RS1630, the depth to groundwater averaged 17.7 feet bgs when the wells were sampled. Figure F-3 shows the potentiometric surface in November 2012 and the regional RSA-146 potentiometric surface (Shaw, 2015). Based on groundwater elevations in the overburden wells (shown on Figure F-3), overburden groundwater appears to flow primarily to the southeast.

F3.0 Proposed Groundwater Monitoring Plan

This groundwater monitoring program for RSA-271 identifies the wells proposed for monitoring, their sampling frequency and sampling parameters, sampling and analytical protocols, and quality assurance (QA)/quality control (QC) requirements.

Seasonal and storm-related trends in temperature and rainfall influence surface water and groundwater flow conditions. Precipitation is the principal source of groundwater recharge, either directly through infiltration and percolation through the vadose zone (unsaturated overburden) or as runoff to streams, which may also recharge groundwater. Rainfall contributes to groundwater recharge primarily during the winter when deciduous trees are leafless, reducing overall transpiration (APTIM, 2020). As determined by an evaluation of previous monitoring results, annual groundwater sampling will be performed in the late winter or early spring season, providing the most representative picture of groundwater quality for the site.

The Army may propose to perform groundwater sampling during the dry season if the evaluation of the RSA-271 groundwater monitoring data determines this may be useful to observe notable differences between the wet and dry season. For example, the Army has taken this approach at the open burn/open detonation units where annual groundwater monitoring alternates between the wet and dry season. The Army review of the monitoring data collected during the previous years of effectiveness monitoring will be completed in consultation with ADEM in order to develop a technically sound approach that is agreeable to both ADEM and the Army.

Changes to the groundwater monitoring program approved by ADEM will require a permit modification. The laboratory-specific reference limits and evaluation tables are presented in Worksheet No. 15 of the installation-wide (IW) quality assurance program plan (QAPP), Volume 1, Attachment 2a (Shaw, 2013 or most recent submission to ADEM), including updates resulting from changes in U.S. Environmental Protection Agency (EPA) and ADEM guidance documents.

Site-specific information listing the analyses to be performed and other analytical requirements is presented in Tables F-1 and F-2 of this groundwater monitoring program. The duration of monitoring is estimated at 26 years for the RSA-271 site, although groundwater monitoring would be terminated earlier if the concentrations of all COCs were below CGs before that time. Changes in the groundwater monitoring program can be adjusted in the recommendations section of each annual groundwater monitoring report. However, changes to the groundwater monitoring program will require a permit modification.

F3.1 Objectives

Groundwater sampling and analysis will be performed to evaluate the effectiveness of the natural attenuation of COCs across the remainder of the site. The monitoring program is designed to increase cost-effectiveness without compromising program and data quality using the following general strategies:

- Select and maintain a sufficient number of sampling points and an appropriate analytical suite to evaluate the progress of MNA in groundwater.
- Choose wells that act as location triggers to plume movement and are located to assess progress in achieving the groundwater CGs.
- Maintain surveillance for contaminant migration away from RSA-271.
- Reduce frequency of conventional and/or mainstream sampling programs.
- Utilize less expensive analytical programs instead of conventional and/or mainstream sampling programs.
- Initiate a streamlined data management and reporting information system.

F3.2 Sampling Frequency

Groundwater monitoring will include a baseline sampling event. Following the baseline sampling event, annual groundwater monitoring will be performed until groundwater analytical results indicate the CGs have been attained for the groundwater COCs at RSA-271 for three consecutive years.

Seasonal and storm-related trends in temperature and rainfall influence surface water and groundwater flow conditions. Precipitation is the principal source of groundwater recharge, either directly through infiltration and percolation through the vadose zone (unsaturated overburden) or as runoff to streams, which may also recharge groundwater. Rainfall contributes to groundwater recharge primarily during the winter when deciduous trees are leafless, reducing overall transpiration (APTIM, 2020). As determined by an evaluation of previous monitoring results, annual groundwater sampling will be performed in the late winter or early spring season, providing the most representative picture of groundwater quality for the site.

The Army may propose to perform groundwater sampling during the dry season if the evaluation of the RSA-271 groundwater monitoring data determines this may be useful to observe notable differences between the wet and dry season. For example, the Army has taken this approach at the open burn/open detonation units where annual groundwater monitoring alternates between the wet and dry season. The Army review of the monitoring data collected during the previous years of effectiveness monitoring will be completed in consultation with ADEM in order to develop a technically sound approach that is agreeable to both ADEM and the Army. In addition to the annual sampling events, supplementary sampling events may be conducted as needed to provide additional data needed by the Army and the CMI contractor to evaluate the effectiveness of MNA. These supplementary sampling events could occur as frequently as quarterly.

F3.3 Proposed Monitoring Wells

The following existing wells at RSA-271 are scheduled for GWM (Figure F-4):

No.	Monitoring Well	Zone	Rationale for Inclusion	Sampling Event Schedule
1	271-RS2707	Overburden	Monitor plume core adjacent to former underground storage tank (UST) pit	Baseline, Annual
2	271-RS2708	Overburden	Contaminated well south of the former UST pit	Baseline, Annual
3	271-RS2709	Overburden	Cross gradient uncontaminated well east of the former UST pit	Baseline, Annual
4	271-RS2994[a]	Overburden	Downgradient effectiveness monitoring well	Baseline, Annual
5	271-RS3003[a]	Overburden	Downgradient/Cross gradient effectiveness monitoring well	Baseline, Annual
6	271-RS3004[a]	Overburden	Downgradient/Cross gradient effectiveness monitoring well	Baseline, Annual

[a] Monitoring well 271-RS2994, 271-RS3003 and 271-RS3004 are proposed for installation and sampling.

Well locations included in the GWM program were selected based on their proximity to the areas of elevated COCs, upgradient locations for comparison to contaminated wells, and suitability as compliance monitoring locations downgradient of the RSA-271 site. The proposed monitoring wells will be reviewed as part of each annual monitoring report. If data from any of the proposed monitoring wells do not prove useful for evaluating the success in meeting CGs of the COCs at RSA-271, the Army will request a permit modification to remove or replace that well from the GWM program.

F3.3.1 Constituent List

Based on the human health risk assessment, the following COCs are to be monitored as part of the corrective measures: manganese, 1-methylnaphthalene, TCE, 2-nitrotoluene, and perchlorate. The following table summarizes the groundwater CGs for COCs:

COC	CG (µg/L)
Manganese	433
TCE	5
1-Methylnaphthalene	10.1
2-Nitrotoluene	3.13
Perchlorate	15

µg/L – Micrograms per liter.

Degradation products for TCE in groundwater will also be monitored. The following monitoring acceptance goals (MAG) have been established for the following common degradation products for the site COC TCE.

Medium	Degradation Product	MAG (µg/L)	MAG
Groundwater	1,1,DCE	7	MCL
Groundwater	cis-1,2-DCE	70	MCL
Groundwater	trans-1,2-DCE	100	MCL
Groundwater	Vinyl chloride	2	MCL

MCL – Maximum contaminant level.

For individual wells, additional analytes are added based on other factors such as the need to monitor historical RSL exceedances. Current guidance from the ADEM indicates that a site's groundwater corrective action must consider all of the COCs that were detected at concentrations greater than the RSL. While they do not have MCL- or risk-based CGs, five additional explosive compounds (3-nitrotoluene, 2,4,6-trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, and nitroglycerin) and five additional semivolatile organic compounds (SVOC) (naphthalene, 2-methlynaphthalene, benzo[a]anthracene, dibenz[a,h]anthracene, and dibenzofuran) will be included in the site's groundwater monitoring program and monitoring results compared to the MAGs. The following table summarizes the groundwater MAGs for COCs and constituents present at concentrations greater than associated RSLs:

Monitoring Parameter	MAG (µg/L)[1]
Benzo(a)anthracene	RSL
Dibenz(a,h)anthracene	RSL
Dibenzofuran	RSL
1,3-Dinitrobenzene	RSL
2-Methlynaphthalene	RSL
Naphthalene	RSL
Nitrobenzene	RSL
Nitroglycerin	RSL
3-Nitrotoluene	RSL
2-Amino-4,6-dinitrotoluene	RSL
4-Amino-2,6-dinitrotoluene	RSL
2,4,6-Trinitrotoluene	RSL

[1] The MCL was selected as the MAG, if available. The most recent RSL for tap water (hazard quotient of 0.1) will be selected as the MAG for chemicals with no MCL.

Each COC for monitoring only will be monitored on the same schedule as COCs for action until it attains its MAG for three consecutive years or monitoring is no longer necessary for any COC for action, whichever comes first.

All wells included in the monitoring program will be analyzed for:

- Volatile organic compounds (VOC), SVOCs, explosives, perchlorate, and manganese. Note that only COCs will be reported for each analytical suite.

In addition to the laboratory analytical parameters, some water quality parameters will be measured in the field during groundwater sampling events, including pH, temperature, conductivity, oxidation-reduction potential, dissolved oxygen, ferrous iron, and turbidity. Water levels will also be measured during each sampling event. This monitoring program will be used to evaluate progress toward meeting the corrective measure objective for groundwater and the CGs.

In order to meet the objectives of this GWM plan, GWM groundwater sampling will be conducted annually. As determined by an evaluation of previous monitoring results annual groundwater sampling will be performed in the season providing the most representative picture of groundwater quality for the site. The Army review of these data during this selection process will be completed in consultation with ADEM. Based on the effectiveness of MNA, additional sampling events may be proposed to gather additional data to evaluate groundwater conditions. Annual groundwater sampling and analysis for COCs will continue until CGs are met for three consecutive years.

F3.3.2 Sampling and Analytical Protocol

All data will be collected, stored, and managed in accordance with the requirements defined by the IW QAPP (Shaw, 2013 or most recent submission to ADEM) and the installation-wide accident prevention plan (CB&I Federal Services LLC [CB&I], 2017). Sampling will be completed following Standard Operating Project Procedure No. 7.0, *Groundwater Sampling* (Shaw, 2013). Groundwater sampling will be completed following methods described in the IW QAPP (Shaw, 2013 or most recent submission to ADEM). Prior to sampling the wells, static water levels will be measured in all wells. Water level measurements will be performed in accordance with Standard Operating Project Procedure (SOPP) No. 16.0, *Groundwater Level Measurements*.

Groundwater sampling will be performed using a submersible pump for purging and low-flow sampling techniques in accordance with SOPP No. 7.0, *Groundwater Sampling*. Additional guidance on sampling for VOCs and dissolved gases described on pages 7 and 8 of the EPA

Region 1 *Standard Operating Procedure for Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (EPA, 2017) will also be followed when sampling for these parameters.

The sampling technician will measure and record physical parameters of the groundwater during well purging to help determine when the well is ready to be sampled. Complete and accurate records in the groundwater well development/purge log are necessary in order to ensure accurate groundwater samples are being collected. Sample locations and analytical and SOPP requirements are provided in Table F-1.

Samples will be analyzed using EPA SW-846 methods as presented in the IW QAPP (Shaw, 2013 or most recent submission to ADEM), including updates resulting from changes in EPA and ADEM guidance documents. Sample containers, provided by the laboratory, are purchased precleaned and treated according to EPA specifications for the methods. The required sample containers for the analysis of constituents in groundwater at RSA-271 are provided as Table F-2. Sample volumes, preservation requirements, and holding times for the analytical methods performed on groundwater samples are also listed in Table F-2.

Sample preservation, packaging, and shipping will follow the procedures as specified in SOPP No. 15, *Non-Hazardous Sampling Handling, Packaging, and Shipping,* in the IW QAPP (Shaw, 2013 or most recent submission to ADEM).

Completed analysis request/chain-of-custody records will be secured and included with each shipment of coolers to the contracted laboratory.

F3.3.3 Quality Assurance/Quality Control

Groundwater media will be sampled and analyzed to meet the objectives of the performance monitoring plan. QA/QC samples will be collected for all sampling events in accordance with requirements established in the IW QAPP (Shaw, 2013 or most recent submission to ADEM) to assure long-term comparability of data. Samples will be analyzed by EPA-approved SW-846 methods of analysis where applicable, will comply with EPA definitive data requirements, and will be reported using both hard copy and electronic data packages. The sample collection/analytical matrix for the baseline and initial 5 years of performance sampling and analysis is presented in Table F-1 and includes the schedule for field QA sampling. All sample preparation and analysis shall be completed within the method-required holding times specified in Table F-2.

F4.0 Data Evaluation and Reporting

F4.1 Data Evaluation and Interpretation

Groundwater samples will be collected from the GWM wells specified in Section F3.3 of this GWM plan on an annual basis as shown on Figure F-4.

The primary objective of the GWM program for RSA-271 is to determine whether the corrective measures reduce concentrations of COCs in groundwater beneath the site to levels below the CGs. This will be determined based on the results of a statistical test or other methods. Statistical analysis will follow ADEM Administrative Code 335-14-5-.06(8)(h) and EPA guidance for GWM at RCRA facilities (EPA, 1989; 1992; 2009).

The following non-statistical methods may also be used to characterize RSA-271 groundwater conditions:

- **Hydrographs.** Graphs of water levels versus time may be constructed to determine increases, decreases, seasonal, or man-made fluctuations in groundwater levels.
- **Potentiometric Surface Maps.** Depths to groundwater from multiple wells may be used to construct potentiometric surface contour maps to estimate flow directions.
- **Concentration-versus-Time Plots.** Graphs of COC concentration versus time at each well will be constructed for each data set subjected to trend analysis. This supports the identification of trends and helps determine if concentration changes are related to changes in water level, changes in groundwater flow directions, or natural attenuation.
- **Plume Maps.** Map depicting the physical distribution of chemical constituents will aid in determining movement of plumes.

GWM will continue until the groundwater analytical results indicate the CGs have been attained for the groundwater COCs at RSA-271 for three consecutive years. Once a groundwater COC has attained CGs or a monitoring parameter has attained the preliminary screening value for three consecutive years, the Army will request a permit modification to cease GWM for that COC or if applicable to terminate all GWM for RSA-271.

F4.2 Reporting

The corrective action program as described in this work plan will treat constituents that exceed their CGs using MNA. The groundwater monitoring program establishes a monitoring well network capable of providing data that will be used to assess changes in the rate and extent of groundwater contamination. The corrective action will begin in accordance with the date established by the Permit modification. The annual groundwater monitoring reports will provide sufficient data to demonstrate the effectiveness of the Army's groundwater monitoring program as well as show that the corrective action program satisfies the requirements of ADEM Administrative Code Rule 335-14-5-.06(11).

RSA will require its contractors to submit a report following each sampling event. These reports will be used by the Army to generate the CMI progress report for corrective measures that require more than 180 days to complete. RSA will provide reports (e.g., CMI progress reports and CMI effectiveness reports) on an annual basis. The progress reports will contain a description of the portion of the CMI plan completed; summaries of deviations from the approved CMI plan during the reporting period, summaries of current and potential problems with recommended solutions and any corrective actions undertaken, monitoring data collected during the construction period, and projected work for the next period and impacts to the approved schedule. These reports will document the sampling results and the status of the LUCs.

The initial CMI effectiveness report will be submitted approximately 12 months after the CMI report. This will allow sufficient time for the laboratory analysis, reporting, and validation of the analytical data from the groundwater samples collected. The subsequent CMI effectiveness reports will be then submitted annually beginning approximately 12 months after the initial CMI effectiveness report.

The initial CMI effectiveness report will include all of the groundwater monitoring data collected during the first year of the LTM. Subsequent reports will include the results of the annual groundwater monitoring events along with the results from any other groundwater monitoring conducted as part of the RSA-271 CMI during that period. Recommendations for changes to the sampling frequency, wells sampled, and parameters for analysis, if appropriate, will be included in the reports. Any changes to the approved monitoring program would require a permit modification.

At a minimum, the groundwater monitoring report will include a discussion of sampling activities, tables and maps to document contaminant concentrations in groundwater, and an evaluation of the groundwater contaminant data. Other recommendations may include installation of additional monitoring wells and resampling for verification of sampling results. Installation of any new wells will be communicated to the Directorate of Public Works for addition to the well inventory. Record keeping for data and reports is described in the IW QAPP (Shaw, 2013 or most recent submission to ADEM).

F5.0 Monitoring Well Maintenance Plan

In order to maintain consistent data quality and track contaminant concentrations and migration, the GWM wells at RSA-271 will be maintained and replaced, as necessary. This chapter presents the well maintenance plan for these monitoring wells. Further details are presented in the IW QAPP (Shaw, 2013).

F5.1 Well Redevelopment

Wells may be redeveloped prior to sampling if any of the following conditions are exhibited at the well:

- Sediment accumulation in the well covers more than 5 percent of the total length of the well screen.
- Turbidity of groundwater is greater than 20 nephelometric turbidity units after the well has been purged prior to sampling.
- Recharge rate to the well has declined through time (e.g., recharge rates have declined to less than 60 percent of the recharge rate recorded in the initial development).

F5.2 Well Replacement or Closure

If, after two episodes of redevelopment, the well still does not meet the requirements set forth in Section 5.1, the well may be deemed nonfunctional and scheduled for replacement or closure. RSA personnel and ADEM staff will be consulted to determine whether closure or replacement is necessary. The procedures for well replacement or closure are outlined in the IW QAPP (Shaw, 2013 or most recent submission to ADEM).

F5.3 Well Inspections

Inspections will be performed to help ascertain the condition of monitoring wells within the GWM program and confirm the integrity of the monitoring wells has not been compromised. Wells will be inspected during each sampling event for the following:

- Well identification is legible
- Locks
- Locking cap
- Protective casing
- Bollards (stick-up wells only)
- Concrete pad.

Deficiencies will be corrected as soon as practical. If a well cannot be properly repaired, it will be closed and replaced.

F6.0 Information Required for ADEM Hazardous Waste Facility Permit

To facilitate the modification to RSA's Alabama Hazardous Wastes Management and Minimization Act permit (ADEM, 2020), information to be included in Tables VII.1, VII.2 and VII.3 has been summarized in Tables F-3, F-4 and F-5, respectively.

Table F-3 summarizes the monitoring well designations for RSA-271. Table F-4 presents the listing of COCs for RSA-271, while Table F-5 presents the CGs for these COCs.

F7.0 References

Alabama Department of Environmental Management (ADEM), 2020, ***Redstone Arsenal's Alabama Hazardous Wastes Management and Minimization Act Hazardous Waste Storage Facility, Thermal Treatment, Solid Waste Management Unit Corrective Action Permit, Modification No. 15***, September.

Aptim Federal Services, LLC (APTIM), 2020, ***Revision 4, RCRA Facility Investigation Report, RSA-271, Former Boiler House, Building 7729, Operable Unit 10, U.S. Army Garrison-Redstone, Madison County, Alabama***, dated October 18, 2018 and revised with slip sheets on February 11, 2020.

CB&I Federal Services LLC (CB&I), 2017, ***Accident Prevention Plan, U.S. Army Garrison-Redstone, Madison County, Alabama***, May.

Shaw Environmental, Inc. (Shaw), 2015, ***Revision 1 RCRA Facility Investigation Report, RSA-146 Groundwater Site, Groundwater Unit GW-02, Operable Unit 19, U.S. Army Garrison-Redstone, Madison County, Alabama,*** December.

Shaw Environmental & Infrastructure, Inc. (Shaw), 2013, ***Installation-Wide Quality Assurance Program Plan for the Program Management Contract, Revision 2, U.S. Army Garrison, Redstone, Madison County, Alabama***, May.

Shaw Environmental, Inc. (Shaw), 2005, ***Draft RSA-146 Phase I Remedial Investigation Report, Redstone Arsenal, Madison County, Alabama***, July.

U.S. Environmental Protection Agency (EPA) Region 1, 2017, ***Standard Operating Procedure for Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells***, EQASOP-GW4, Quality Assurance Unit, September

U.S. Environmental Protection Agency (EPA), 2009, ***Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance***, EPA/530/R-09/007, Office of Resource Conservation and Recovery Program Implementation and Information Division, March.

U.S. Environmental Protection Agency (EPA), 1992, ***Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Guidance***, Office of Resource Conservation and Recovery, July.

U.S. Environmental Protection Agency (EPA), 1989, ***Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance***, Office of Solid Waste, Waste Management Division, EPA/530/SW-89/026, July.

TABLES

Table F-1

Sample Locations, Analytical, and SOPP Requirements

Sample Location	Sample Designation	Sample Depth (ft bgs)	QA/QC Sample Designation		Analytical Suite
			FD*	MS/MSD*	
RSA-271					
Groundwater Baseline Sampling Locations Year 0 (Baseline) and Years 1-5					
271-RS2707	271-RS2707 -GW- ABV3030 -REG	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-RS2708	271-RS2708 -GW- ABV3031 -REG	NA	271-RS2708-GW-ABV3032-FD		VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-RS2709	271-RS2709 -GW- ABV3033 -REG	NA		271-RS2709-GW-ABV3033-MS/MSD	VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-RS2994	271-RS2994 -GW- ABV3034 -REG	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-RS3003	271-RS3003 -GW- ABV3035 -REG	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-RS3004	271-RS3004 -GW- ABV3036 -REG	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
Trip Blanks					
271-SITE	271-SITE -WA- 271TB0001 -TB	NA			VOCs-271
271-SITE	271-SITE -WA- 271TB0002 -TB	NA			VOCs-271
271-SITE	271-SITE -WA- 271TB0003 -TB	NA			VOCs-271
Equipment Rinsate Samples					
271-SITE	271-SITE -BW- ABV8003 -ER	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
271-SITE	271-SITE -BW- ABV8004 -ER	NA			VOCs-271, LL PAHs-271, Explosives-271, Perchlorate, Manganese
IDW Water Samples					
271-SITE	271-SITE -WA- ABV9037 -REG	NA			TCL VOCs, TCL Semivolatiles, Explosives, Perchlorate, Manganese
271-SITE	271-SITE -WA- ABV9038 -REG	NA			TCL VOCs, TCL Semivolatiles, Explosives, Perchlorate, Manganese
271-SITE	271-SITE -WA- ABV9039 -REG	NA			TCL VOCs, TCL Semivolatiles, Explosives, Perchlorate, Manganese
IDW Soil Samples[(a)]					
271-SITE	271-SITE -SO- ABV9040 -REG	NA			TCLP VOCs, TCLP Semivolatiles, TCLP Metals, Explosives

*The MS/MSD/FD locations are subject to change due to field conditions. Project chemist will be notified and data base updated accordingly.

VOCs-271 - 1,1-Dichloroethene (DCE), cis-1,2- DCE, trans-1,2-DCE, trichloroethene, and vinyl chloride

LL PAHs-271 - 1-Methylnaphthalene, 2-methlynaphthalene, and naphthalene

Explosives-271 - 2-Nitrotoluene, 3-nitrotoluene, 2,4,6 trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, nitroglycerin, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, benzo(a)anthracene, dibenz(a,h)anthracene, and dibenzofuran

(a) Not required after year 1

VOC - Volatile organic compound.
SVOC - Semivolatile organic compound.
LL PAHs - low level polynuclear aromatic hydorcarbons
TCLP-Toxicity characteristic leaching procedure
FD - Field duplicate.
IDW - Investigation-derived waste.
MS - Matrix spike.
MSD - Matrix spike duplicate.
TAT - Turnaround time.
TCL - Target compound list
TAL - Target analyte list

Table F-2

Field Quality Control Sample Summary

(Page 1 of 2)

Parameters	Analytical Method	Matrix	Total Number of Samples	FD	MS	MSD	Equip. Rinsate (1/event)	Trip Blank (1/cooler)	TAT Needed[a]	Sample Container/Preservation Requirements[b]	Holding Time	Total Number of Containers
RSA-271 Sampling												
Groundwater Baseline Samples Year 0 and Annual Sampling Years 1-5 (per event)												
VOCs -271	5030B/8260C	Water	6	1	1	1	2	3	Normal	3 x 40-mL vials w/ septa; HCl to pH<2	14 days	42
LL PAHs -271	3510B/8270D	Water	6	1	1	1	2	0	Normal	2 x 1L amber	7 days extraction; 40 days analysis	22
Perchlorate	6850	Water	6	1	1	1	2	0	Normal	125 mL poly (filter thru 0.2 micron filter); headspace required	28 days	11
Explosives-271	8330B	Water	6	1	1	1	2	0	Normal	2 x 1L amber	7 days extraction; 40 days analysis	22
Manganese	3005A/6010C	Water	6	1	1	1	2	0	Normal	1 x 250 ml HPDE HNO_3 to pH<2	6 months	11
IDW Water Samples												
VOCs -271	5030B/8260C	Water	3	0	0	0	0	0	Normal	3 x 40-mL vials w/ septa; HCl to pH<2	14 days	9
LL PAHs -271	3510B/8270D	Water	3	0	0	0	0	0	Normal	2 x 1L amber	7 days extraction; 40 days analysis	6
Perchlorate	6850	Water	3	0	0	0	0	0	Normal	125 mL poly (filter thru 0.2 micron filter); headspace required	28 days	3
Explosives-271	8330B	Water	3	0	0	0	0	0	Normal	2 x 1L amber	7 days extraction; 40 days analysis	6
TAL Metals	3005A/6010C/7470A	Water	3	0	0	0	0	0	Normal	1 x 250 ml HPDE HNO_3 to pH<2	6 months; Mercury - 28 days	3
IDW Soil Samples												
TCLP VOCs	1311/5030B/8260B	Soil	1	0	0	0	0	0	Normal	4 oz jar; no headspace	14 days	1
TCLP SVOC	1311/3510B/8270D	Soil	1	0	0	0	0	0	Normal	4 oz jar	14 days extraction; 7 days prep; 40 days analysis	1
TCLP Metals	1311/3005A/6010C/7470A	Soil	1	0	0	0	0	0	Normal	4 oz jar	6 months; Mercury - 28 days	1
Explosives	8330B	Soil	1	0	0	0	0	0	Normal	4 oz jar	14 days extraction; 40 days analysis	1

[a] Sample deliverables should include a Level IV, CLP-like data package and EDD for all samples.
of analysis and EDD only.

[b] All samples should be cooled to 4 degrees Celsius in conjunction with preservation requirements noted prior to shipment to the laboratory.

VOCs-271 - 1,1-Dichloroethene (DCE), cis-1,2- DCE, trans-1,2-DCE, trichloroethene, and vinyl chloride

Table F-2

Field Quality Control Sample Summary

(Page 2 of 2)

LL PAHs-271 - 1-Methylnaphthalene, 2-methlynaphthalene, and naphthalene
Explosives-271 - 2-Nitrotoluene, 3-nitrotoluene, 2,4,6 trinitrotoluene, 1,3-dinitrobenzene, nitrobenzene, nitroglycerin, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, benzo(a)anthracene, dibenz(a,h)anthracene, and dibenzofuran

VOC - Volatile organic compound.
SVOC - Semivolatile organic compound.
LL PAHs - low level polynuclear aromatic hydorcarbons
TCLP-Toxicity characteristic leaching procedure
CLP - Contract Laboratory Program.
EDD - Electronic data deliverable.
FD - Field duplicate.
L - Liter.

IDW - Investigation-derived waste.
MS - Matrix spike.
MSD - Matrix spike duplicate.
TAT - Turnaround time.
TCL - Target compound list
TAL - Target analyte list

Table F-3

Monitoring Well Designations
RSA-271
Redstone Arsenal, Madison County, Alabama

Well Identifier	Type	Latitude	Longitude	Depth to Bedrock (ft bgs)	Units Monitored	Depth (ft bgs)	Ground Elevation (ft amsl)	Top of Riser Elevation (ft amsl)	Screen Interval (ft bgs)	Monitored Zone
271-RS2994[a]	EFF	34° 37' 36.624" N	86° 35' 35.592" W	32.0	OVB	31.8	580.47	582.97	21.4-31.4	OVB
271-RS3003[b]	EFF	34° 37' 37.754" N	86° 35' 33.444" W	35.0	OVB	35.0	574.70	577.20	25-35	OVB
271-RS3004[b]	EFF	34° 37' 636" N	86° 35' 35.802" W	35.0	OVB	35.0	581.14	583.64	25-35	OVB
271-RS2707	EFF	34° 37' 37.416" N	86° 35' 36.7548" W	39.5	OVB	39.5	584.442	586.894	29.1-39.1	OVB
271-RS2708	EFF	34° 37' 36.8832" N	86° 35' 36.8232" W	36.5	OVB	36.5	582.798	585.014	26.1-36.1	OVB
271-RS2709	EFF	34° 37' 37.5024" N	86° 35' 36.1032" W	36.3	OVB	36.3	583.656	586.045	25.9-35.9	OVB

[a] Proposed well to be installed at the location of former monitoring well 271-RS2622; values in red are estimates from the former 271-RS2622 well installation. Actual values will be presented in the corrective measures completion report.

[b] Proposed wells; elevations, depth to bedrock and elevations are estimated based on site conditions

EFF - Effectiveness monitoring well.

ft amsl - Feet above mean sea level.

ft bgs - Feet below ground surface.

OVB - Overburden.

Table F-4

Groundwater Quality Monitoring Constituents
RSA-271
Redstone Arsenal, Madison County, Alabama

Unit	Hazardous Constituent
RSA-271	cis-1,2-Dichloroethene
	trans-1,2-Dichloroethene
	1,1-Dichloroethene
	Trichlorethene
	Vinyl chloride
	Perchlorate
	Manganese
	3-Nitrotoluene
	2-Nitrotoluene
	2,4,6-Trinitrotoluene
	1,3-Dinitrobenzene
	Nitrobenzene
	Nitroglycerin
	2-Amino-4,6-dinitrotoluene
	4-Amino-2,6-dinitrotoluene
	1-Methylnaphthalene
	Naphthalene
	2-Methlynaphthalene
	Benzo[a]anthracene
	Dibenz[a,h]anthracene
	Dibenzofuran

Table F-5

Groundwater Protection Standards
RSA-271
Redstone Arsenal, Madison County, Alabama

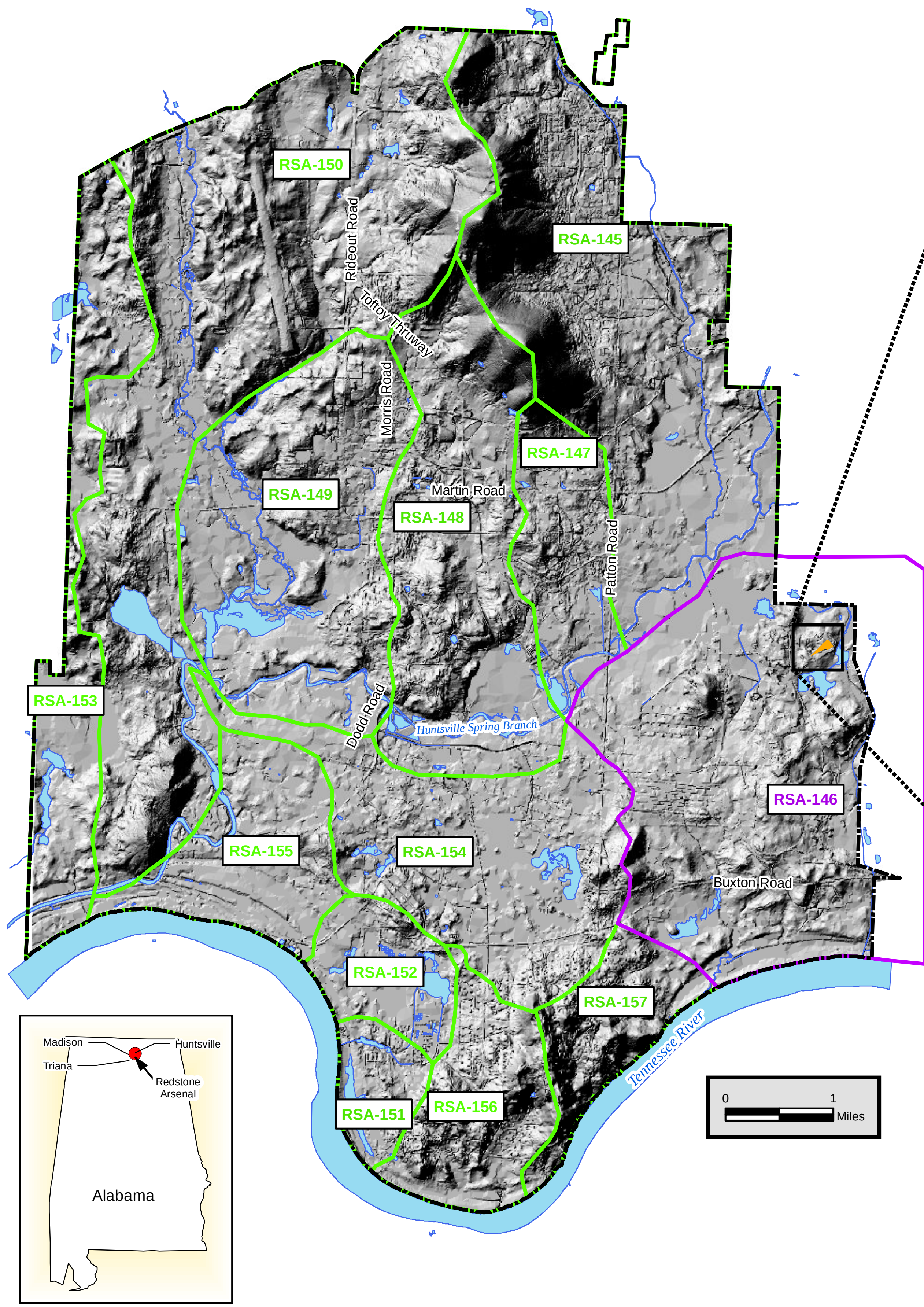
Unit	Hazardous Constituent	Cleanup Goal (µg/L)
RSA-271	Perchlorate	15
	2-Nitrotoluene	3.13
	Manganese	433
	1-Methylnaphthalene	10.1
	Trichloroethene	5

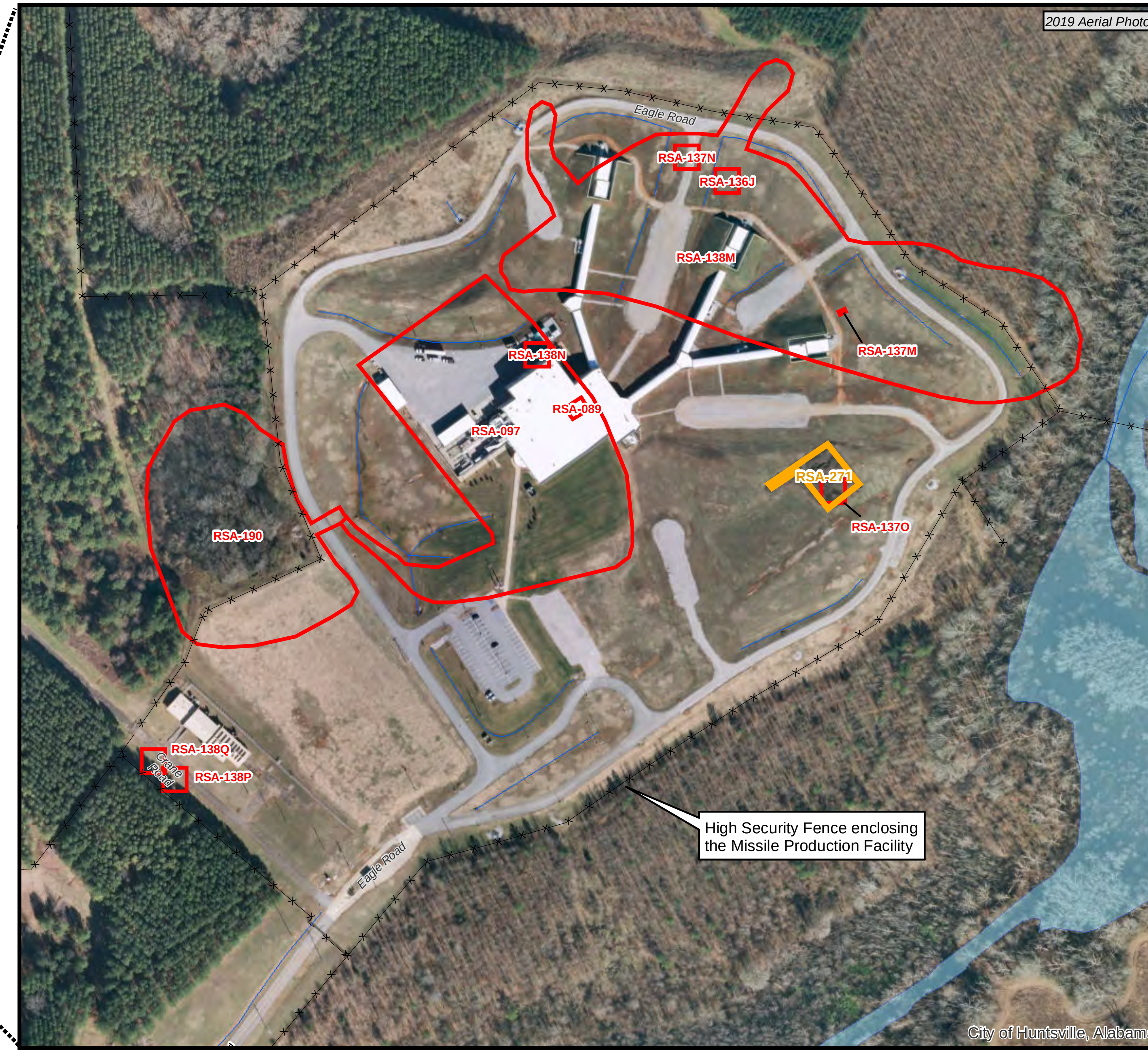
Unit	Monitoring Parameter	MAG (µg/L) [1]
RSA-271	1,1-Dichloroethene[2]	7
	cis-1,2-Dichloroethene[2]	70
	trans-1,2-Dichloroethene[2]	100
	Vinyl chloride[2]	2
	Benzo(a)anthracene	RSL
	Dibenz(a,h)anthracene	RSL
	Dibenzofuran	RSL
	1,3-Dinitrobenzene	RSL
	2-Methlynaphthalene	RSL
	Naphthalene	RSL
	Nitrobenzene	RSL
	Nitroglycerin	RSL
	3-Nitrotoluene	RSL
	2-Amino-4,6-dinitrotoluene	RSL
	4-Amino-2,6-dinitrotoluene	RSL
	2,4,6-Trinitrotoluene	RSL

Notes:
EPA - U.S. Environmental Protection Agency.
µg/L - Micrograms per liter.
MAG - Monitoring acceptance goal.
MCL - Maximum contaminant level.
RSL - Regional Screening Level.

[1] The MCL was selected as the MAG, if available. The most recent RSL for tap water (hazard quotient of 0.1) will be selected as the MAG for chemicals with no MCL.
[2] Constituent is a degradation product for trichloroethene.

FIGURES





Legend

- RSA-271 Site Boundary
- No Further Action (NFA) for Surface Media Site Boundary
- RSA-146 Groundwater Unit Boudary
- Groundwater Unit Boudary
- RSA Installation Boundary
- Water Bodies
- Surface Drainage Features (Some Ephemeral)
- Fence

Figure F-1

RSA-271
Site Location Map

Redstone Arsenal
Madison County, Alabama

1 inch = 300 feet

0 150 300 600 Feet

NAD 1983 State Plane Alabama East Feet

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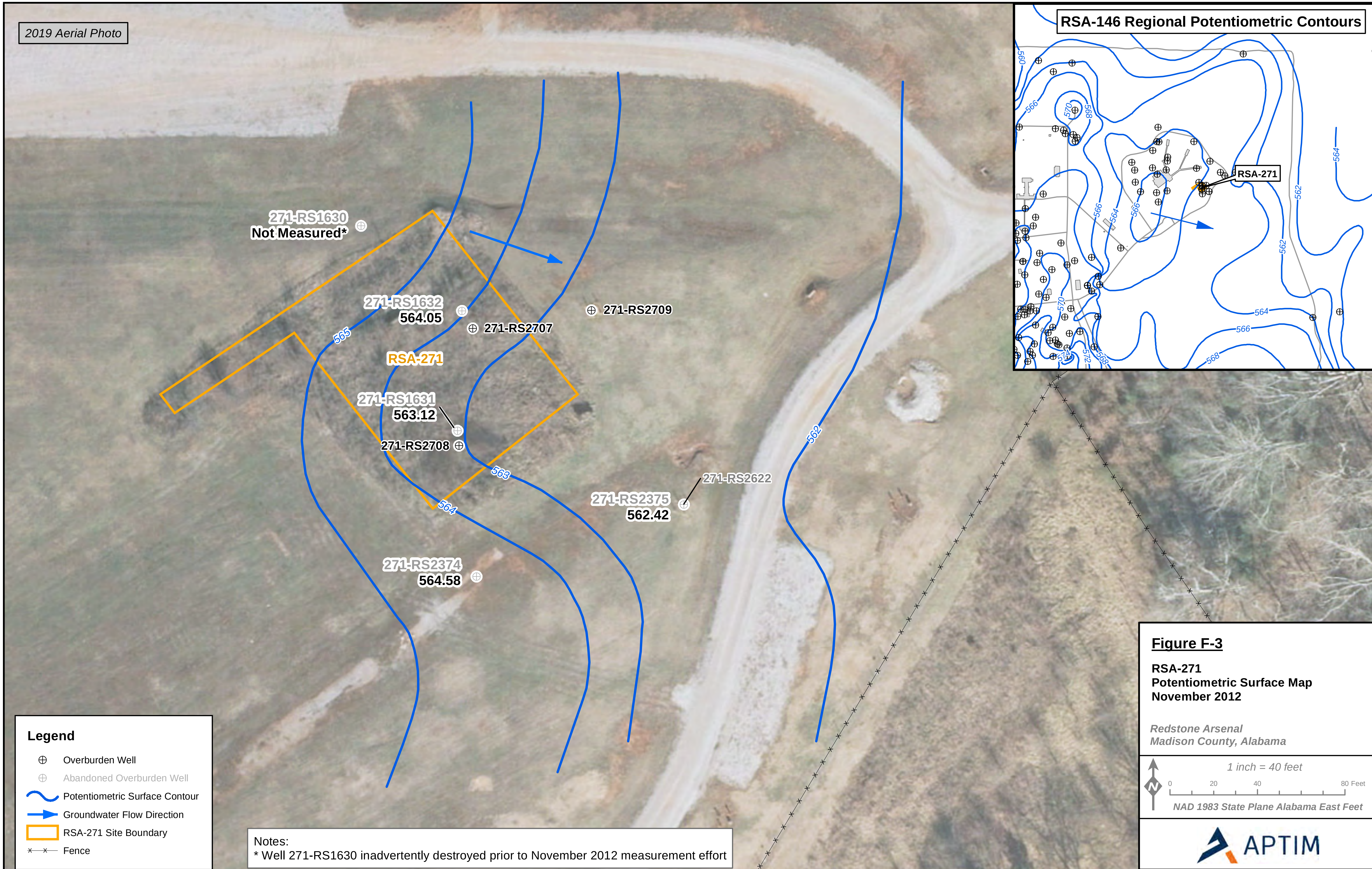

Figure F-3

RSA-271
Potentiometric Surface Map
November 2012

Redstone Arsenal
Madison County, Alabama

1 inch = 40 feet

NAD 1983 State Plane Alabama East Feet

Notes:
* Well 271-RS1630 inadvertently destroyed prior to November 2012 measurement effort

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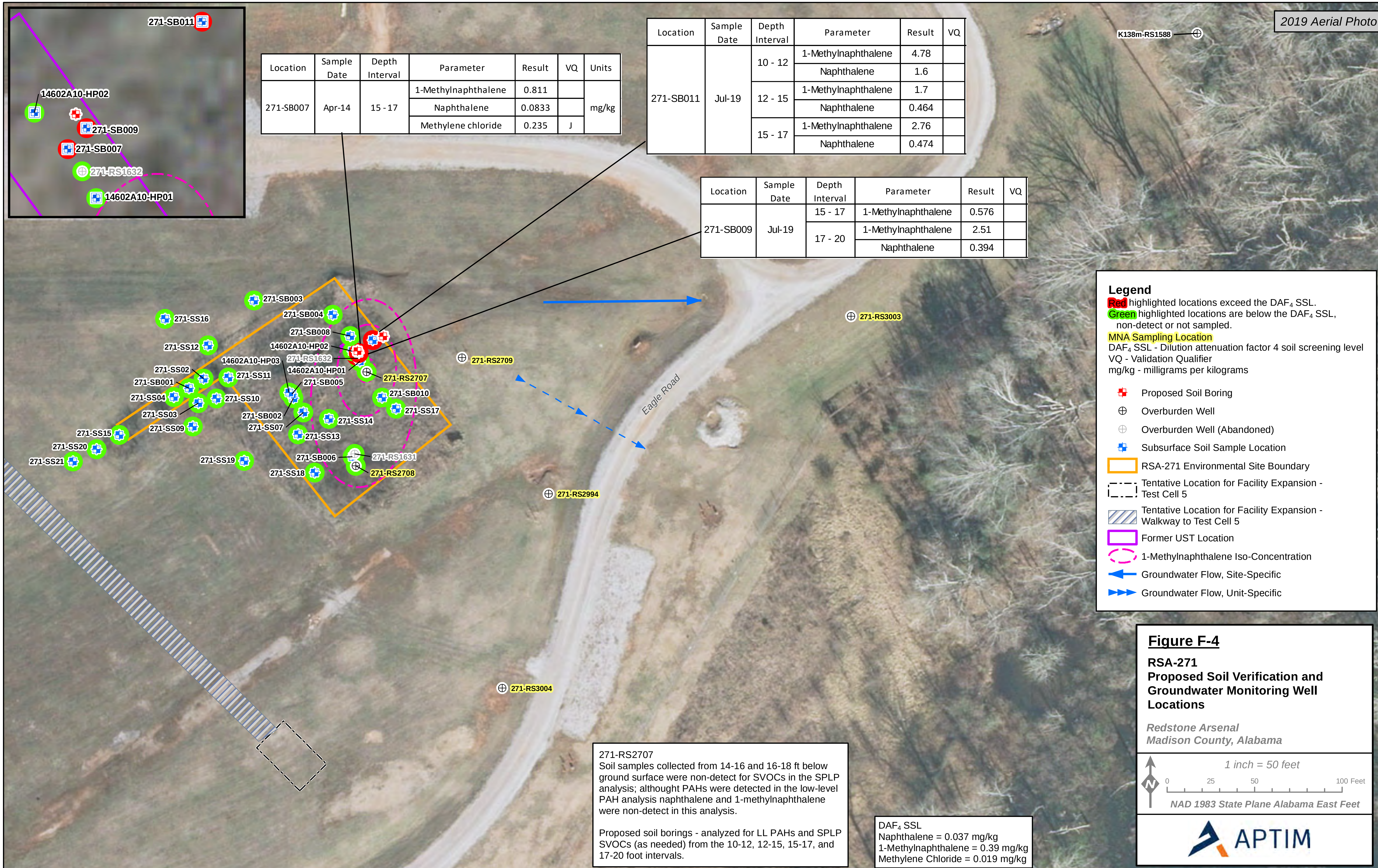

Location	Sample Date	Depth Interval	Parameter	Result	VQ	Units
271-SB007	Apr-14	15 - 17	1-Methylnaphthalene	0.811		mg/kg
			Naphthalene	0.0833		
			Methylene chloride	0.235	J	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB011	Jul-19	10 - 12	1-Methylnaphthalene	4.78	
			Naphthalene	1.6	
		12 - 15	1-Methylnaphthalene	1.7	
			Naphthalene	0.464	
		15 - 17	1-Methylnaphthalene	2.76	
			Naphthalene	0.474	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB009	Jul-19	15 - 17	1-Methylnaphthalene	0.576	
		17 - 20	1-Methylnaphthalene	2.51	
			Naphthalene	0.394	

Legend

Red highlighted locations exceed the DAF_4 SSL.
Green highlighted locations are below the DAF_4 SSL, non-detect or not sampled.
MNA Sampling Location
DAF_4 SSL - Dilution attenuation factor 4 soil screening level
VQ - Validation Qualifier
mg/kg - milligrams per kilograms

- Proposed Soil Boring
- Overburden Well
- Overburden Well (Abandoned)
- Subsurface Soil Sample Location
- RSA-271 Environmental Site Boundary
- Tentative Location for Facility Expansion - Test Cell 5
- Tentative Location for Facility Expansion - Walkway to Test Cell 5
- Former UST Location
- 1-Methylnaphthalene Iso-Concentration
- Groundwater Flow, Site-Specific
- Groundwater Flow, Unit-Specific

271-RS2707
Soil samples collected from 14-16 and 16-18 ft below ground surface were non-detect for SVOCs in the SPLP analysis; althought PAHs were detected in the low-level PAH analysis naphthalene and 1-methylnaphthalene were non-detect in this analysis.

Proposed soil borings - analyzed for LL PAHs and SPLP SVOCs (as needed) from the 10-12, 12-15, 15-17, and 17-20 foot intervals.

DAF_4 SSL
Naphthalene = 0.037 mg/kg
1-Methylnaphthalene = 0.39 mg/kg
Methylene Chloride = 0.019 mg/kg

Figure F-4

RSA-271
Proposed Soil Verification and Groundwater Monitoring Well Locations

Redstone Arsenal
Madison County, Alabama

APTIM

F:\Projects\Redstone_ERMA\GIS_Documents\Project_Maps\RSA_271\RSA_271_CMIP_Jan2020\RSA_271_Prop_Design_Opt_Boring_MNA.mxd

APPENDIX G

ALABAMA RISK-BASED CORRECTIVE ACTION FATE AND TRANSPORT MODELING

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Attachment 1 Soil and groundwater results compared to May 2021 ADEM RSLs

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G1.0 Introduction

An RSA-271-site-specific fate and transport model was developed for naphthalene and 1-methylnaphthalene for groundwater resource protection using Alabama Department of Environmental Management (ADEM) Alabama Risk-Based Corrective Action (ARBCA) computational software (ADEM, 2010). This ARBCA model software was developed to be consistent with ADEM guidance (ADEM, 2008; 2017b) for groundwater resource protection as discussed in Sections 6.9, and 9.3.9 of ADEM's ARBCA manual. This software package uses site-specific parameters for soil and groundwater which were integrated with updates to the default exposure factors, physical parameters, and toxicity values within the model to develop a site-specific leaching factor which includes the dilution attenuation factors (DAF) for mixing with groundwater in the mixing zone. A second DAF is calculated in the software package using the Domenico Model for horizontal transport to the assigned point of exposure (POE). Using these factors, the ARBCA model calculates source area soil concentrations that are protective of groundwater at the POE. These risk-based threshold levels (RBTL) will be used as the cleanup goals (CG) for soils. In addition, the horizontal DAFs for these chemicals will be used to calculate the cleanup goals for soil leachate obtained from the include synthetic precipitation leaching procedures (SPLP) samples of design optimization sampling.

The following sections provide information on the exposure factors, physical parameters and toxicity values used to develop site-specific soil risk-based threshold levels (RBTL) for naphthalene and 1-methylnaphthalene in soil to ensure groundwater resource protection. These RBTLs can be used as cleanup goals for soil.

As discussed in Chapter 4, soil results will be confirmed through design optimization sampling to include synthetic precipitation leaching procedure (SPLP) testing during corrective measures. RBTLs have been calculated for SPLP leachate using the results of the groundwater resource protection modeling. These RBTLs can be used as a confirmation of threats risks posed by soil contamination to groundwater.

To ensure clarity regarding data used in this process, Attachment 1 provides the summary of the RFI soil and groundwater results compared to May 2021 ADEM RSLs for soils and groundwater. Surface and subsurface soil results are presented on Figure 2-1 and 2-2 respectively compared to residential soil RSLs. Figure G-1 presents soil results compared to the RSA facility-wide DAF soil screening levels (SSL).

G2.0 Input Parameters

Input parameters used in the ADEM ARBCA computational software (ADEM, 2010) are discussed in the following section.

User-Specified Chemicals of Concern (COC) and Properties - Physical and Chemical Properties

The U.S. Environmental Protection Agency (EPA) has developed updates to physical and chemical properties as well as to toxicity factors for naphthalene and 1-methylnaphthalene since 2008. These factors are available in EPA regional screening level (RSL) tables. Unless otherwise noted, values shown on Table G-1 were taken from EPA (2020).

Exposure Factors

As shown in Table G-2, the ARBCA model default values were used for many exposure factors as a conservative approach. Receptor specific factors reflect the values that have been agreed to for use on Redstone Arsenal (RSA) sites or that have been updated based on more recent EPA exposure factor guidance.

Fate and Transport Parameters

This section explains the fate and transport parameters used to model the site-specific RBTL for naphthalene and 1-methylnaphthalene that is protective of groundwater at RSA-271. These factors and their parameter values are presented in Table G-3.

Length of groundwater source area parallel to groundwater flow. Width and length of groundwater source are perpendicular to groundwater flow direction. The source of naphthalene and 1-methylnaphthalene elevated above the RBTL is very localized and was therefore considered to be a small source area. The model default value of 1500 centimeters was selected for this parameter.

Depth to subsurface soil sources. The average depth of the results that exceed the naphthalene and 1-methylnaphthalene DAF_4 SSLs of 0.037 and 0.39 milligram per kilogram (mg/kg), respectively, was used as the depth to subsurface soil sources. The following table provides the sample locations, depths of the samples, and results for naphthalene and 1-methylnaphthalene that exceed their respective DAF_4 SSLs.

Naphthalene and 1-Methylnaphthalene Results Greater than the RSA DAF_4 SSL		
Locations	Sample Depth (feet below ground surface)	Result (mg/kg)
1-Methylnaphthalene (RSA DAF_4 SSL = 0.39 mg/kg)		
271-SB007	15 – 17	0.811
271-SB009	15 – 17	0.576
271-SB009	17 – 20	2.51
271-SB011	12 – 15	1.7
271-SB011	15 – 17	2.76
271-SB011	10 – 12	4.78
Naphthalene (RSA DAF_4 SSL = 0.037 mg/kg)		
271-SB007	15 – 17	0.0833
K271-USTSB01	12 – 15	0.0985
271-SB009	17 – 20	0.394
271-SB011	12 – 15	0.464
271-SB011	15 – 17	0.474
271-SB011	10 – 12	1.6

Based on these results, the average depth of source area was assumed to be 14.75 feet below ground surface or 449.6 centimeters. The maximum concentration of naphthalene and 1-methylnaphthlene greater than the respective DAF_4 SSLs was identified in sample 271-SB011 (10 to 12 feet depth). The estimated extent of the source area is shown on Figure G-1.

Total soil porosity, volumetric water content, dry soil bulk density, and fractional organic carbon content. The values used are the standard parameters from the RSA DAF_4 SSL development white paper (Shaw Environmental, Inc., 2011). As recommended in ADEM (2017), the same parameter values were used for the saturated and unsaturated soil zones.

Capillary fringe thickness. As recommended by ADEM (2017), the value of this parameter is based on literature values. A good summary of the thickness of the capillary fringe zone for various soil types can be found in Liu et al. (2014). The value for a clay soil was rounded down to 100 centimeters as a conservative approach.

Protection of Groundwater Use Parameters. As shown in Table G-4, the point of exposure (POE) for the maximum detected concentration (MDC) sample location for naphthalene and 1-methylnaphthalene (271-SB011) was assumed to be the distance to the nearest off-site well from the source area boundary well (Monitoring Well 271-RS2707) in the downgradient direction of groundwater flow (well 271-RS2622). These locations are shown on Figure G-1.

COC	Source Area Boundary Well	POE Well	Distance from MDC to POE (feet)
Naphthalene and 1-Methylnaphthalene	271-RS2707	271-RS2622	126.21

The point of compliance (POC) was considered to be the closest distance from the source area boundary well (Monitoring Well 271-RS2707) to the site boundary in the downgradient direction (Figure G-1). The POC and the distance used as inputs into the model are as follows:

COC	Source Area Boundary Well	POC	Distance from MDC to POC (feet)
Naphthalene and 1-Methylnaphthalene	271-RS2707	Site boundary	56.69

Using these parameters will result in soil RBTLs that are protective of groundwater within the core of the existing plume area. ADEM RSLs for naphthalene and 1-methylnaphthalene are based on the EPA RSLs of 0.17 and 1.1 milligrams per liter, respectively. These values are considered to be conservative for two reasons:

1. Potable use of groundwater is currently prohibited in accordance with RSA's site access control program, which implements RSA's installation-wide groundwater interim record of decision.

2. Risks from exposure to groundwater contamination in groundwater unit RSA-146, which is the groundwater unit below RSA-271, are unacceptable, and therefore, groundwater use in the future will be prohibited at this site until corrective measures for the groundwater unit have been completed.

G3.0 Results—Protection of Groundwater Use RBLTs for Soil and SPLP Leachate

Table G-5 presents the soil RBTLs developed for Groundwater Resource Protection at all locations beyond the plume core associated with RSA-271. This evaluation assumed that no biodegradation is occurring for naphthalene and 1-methylnaphthalene at this site. The site-specific soil RBTLs developed for naphthalene and 1-methylnaphthalene at RSA-271 are as follows:

COC	RBTL (mg/kg)
Naphthalene	2.17E+00
1-Methylnaphthlene	2.11E+01

As shown on Table G-5, the groundwater resource protection results include a horizontal DAF which is noted as the DAF at the point of exposure. This DAF equals 1.95 for both 1-methynaphthalene and naphthalene. Coupled with the RSA Facility-Wide DAF of 4 for leachate mixing into the groundwater mixing zone, an RTBL for SPLP soil leachate can be calculated such that soil concentrations of naphthalene and 1-methylnaphtalene are protective at the point of exposure. The SPLP RBTL is calculated as follows:

SPLP RBTL = Groundwater CG x Vertical DAF x Horizontal DAF

Where:

Groundwater CG = groundwater cleanup goals in Table 3-2
Vertical DAF = RSA Facility-Wide Dilution Attenuation Factor of 4 (Shaw, 2011).
Horizontal DAF = From ARBCA Groundwater Resource Protection DAF at point of exposure (see Table G-5)

As shown on Table G-6, the SPLP RBTLs are summarized as follows:

COC	SPLP RBTL (µg/L)
Naphthalene	1.33E+00
1-Methylnaphthlene	7.87E+01

If SPLP results are found to be less than these RBTLs then there is little likelihood that concentrations of these COCs in groundwater pose a threat from the soil to groundwater migration pathway.

G4.0 Discussion

The site-specific ARBCA-derived RBTLs at RSA-271 ensure that the groundwater concentrations downgradient of the naphthalene and 1-methylnaphthalene source area do not exceed the groundwater RSLs for these COCs. The resulting site-specific RBTLs for RSA-271 for these chemicals compared to the maximum site concentrations in soil indicate that there based on current results no source material posing a threat to groundwater at the most likely conservative point of exposure. Note that these values are less than the residential soil RSLs for 1-methylnaphthalene (18 milligrams per kilogram) and naphthalene (3.8 milligrams per kilogram). However, the full extent of contamination to the DAF4 SSLs has not been established. Therefore, a soil action including a design optimization sampling program, is planned for this site. This design optimization sampling program will include SPLP testing of soil samples to be collected to determine the extent of source material that may pose a threat to groundwater beyond the point of exposure. If future soil sampling results including results from SPLP leachate testing are below the RBTLs, then there is little likelihood that concentrations of these COCs in groundwater pose a threat from the soil to groundwater migration pathway.

G5.0 References

Alabama Department of Environmental Management (ADEM), 2017, ***Alabama Risk-Based Corrective Action Guidance Manual,*** Revision 3.0, February.

Alabama Department of Environmental Management (ADEM), 2010, ***ARBCA Computational Software, Version 2.1-R***, December.

Alabama Department of Environmental Management (ADEM), 2008, ***Alabama Risk-Based Corrective Action Guidance Manual, Revision 2.0***, April.

Liu, Q. Yasufuku, N., Miao, J, Ren J., 2014, ***An Approach For Quick Estimation Of Maximum Height Of Capillary Rise***, Japanese Geotechnical Society, Soils and Foundations, December.

Shaw Environmental, Inc., 2011, ***Development of a Facility-Wide Dilution Attenuation Factor and Process for Evaluating Migration from Soil to Groundwater, Redstone Arsenal, Huntsville, Alabama***, U.S. Army Garrison-Redstone, Madison County, Alabama, February.

U.S. Environmental Protection Agency (EPA), 2020, ***Regional Screening Levels for Chemical Contaminants at Superfund Sites***, May.

TABLES

Table G-1

User-Specified Chemicals of Concern and Properties
RSA-271
Redstone Arsenal, Madison County, Alabama

PHYSICAL AND CHEMICAL PROPERTIES

Chemicals	CAS #	Groundwater Cleanup Goal [mg/L]	Source	Molecular Weight (MW) [g/g-mol]	Water Solubility (S) [mg/L]	Henry's Law Constant (H) [L-water/L-air]	Org. Carbon Adsorption Coeff. (K_{oc}) [cm^3/g]	Soil-Water Partition Coefficient (K_d) [cm^3/g]	Molecular Diffusion Coefficient in air (D^a) [cm^2/s]	Molecular Diffusion Coefficient in water (D^w) [cm^2/s]
1-Methylnaphthalene	90-12-0	1.01E-02	Risk - c	1.42E+02	2.58E+01	2.11E-02	2.53E+03	NA	5.30E-02	7.80E-06
Naphthalene	91-20-3	1.70E-03	RSL, HI = 1.0	1.28E+02	3.10E+01	1.80E-02	1.54E+03	NA	6.05E-02	8.38E-06

TOXICOLOGICAL PROPERTIES

Chemicals	Cancer Group	Slope Factor Oral (SF_o) [kg-day/mg]	Slope Factor Inh. (SF_i) [kg-day/mg]	Reference Dose Oral (RfD_o) [mg/kg-day]	Reference Dose Inh. (RfD_i) [mg/kg-day]	Absorption Factor Dermal (RAF_d) [--]	Absorption Factor Oral (RAF_o) [--]	Bioconcentration Factor in Fish (BCF) [L/kg]
1-Methylnaphthalene	Suggestive Evidence	2.90E-02	ND	ND	ND	0.13	1	NA
Naphthalene	C	ND	1.20E-01	2.00E-02	8.60E-04	0.13	1	NA

Risk - c - Risk to lifetime residential receptor.
Risk - nc - Risk to child residential receptor based on target hazard index of 0.771 to account for target organ contribution of an HI = 0.229 from nickel.
NA - Not applicable. `
ND - No data.

Table G-2

Exposure Factors
RSA-271
Redstone Arsenal, Madison County, Alabama

Parameter	Symbol	Unit	Default Value	Value Used	Comment
Averaging Time for Carcinogen	AT_c	year	70	70	Default Value
Averaging Time for Non-Carcinogen	AT_n	year	=ED	=ED	Default Value
Body Weight:					
Resident Child	BW	kg	15	15	Default Value
Resident Adult	BW	kg	70	80	Site-Specific Value
Trespasser	BW	kg	45	45	Default Value
Commercial Worker	BW	kg	70	80	Site-Specific Value
Construction Worker	BW	kg	70	80	Site-Specific Value
Exposure Duration:					
Resident Child	ED	year	6	6	Default Value
Resident Adult	ED	year	30	26	Site-Specific Value
Trespasser	ED	year	10	10	Default Value
Commercial Worker	ED	year	25	25	Default Value
Construction Worker	ED	year	1	1	Default Value
Exposure Frequency:					
Resident Child	EF	day/year	350	350	Default Value
Resident Adult	EF	day/year	350	350	Default Value
Trespasser	EF	day/year	350	52	Site-Specific Value
Commercial Worker	EF	day/year	250	225	Site-Specific Value
Construction Worker	EF	day/year	250	250	Default Value
Soil Ingestion Rate:					
Resident Child	IRS	mg/day	200	200	Default Value
Resident Adult	IRS	mg/day	100	100	Default Value
Trespasser	IRS	mg/day	100	100	Default Value
Commercial Worker	IRS	mg/day	75	100	Site-Specific Value
Construction Worker	IRS	mg/day	177	177	Site-Specific Value
Water Ingestion Rate:					
Resident Child	IRW	L/day	1	1	Site-Specific Value
Resident Adult	IRW	L/day	2	3	Site-Specific Value
Hourly Indoor Inhalation Rate:					
Resident Child	IR_{ai}	m^3/hr	0.5	0.500	Default Value
Resident Adult	IR_{ai}	m^3/hr	0.833	0.833	Default Value
Trespasser	IR_{ai}	m^3/hr	1.5	1.500	Default Value
Commercial Worker	IR_{ai}	m^3/hr	1.5	1.500	Default Value
Construction Worker	IR_{ai}	m^3/hr	1.5	1.500	Default Value
Exposure Time for Indoor Inhalation:					
Resident Child	ET_{in}	hr/day	24	24	Default Value
Resident Adult	ET_{in}	hr/day	24	24	Default Value
Trespasser	ET_{in}	hr/day	24	24	Default Value
Commercial Worker	ET_{in}	hr/day	10	8	Site-Specific Value
Construction Worker	ET_{in}	hr/day	10	10	Default Value
Daily Indoor Inhalation Rate:					
Resident Child	IR_{ai_d}	m^3/day	12.0	12.0	Calculated
Resident Adult	IR_{ai_d}	m^3/day	20.0	20.0	Calculated
Trespasser	IR_{ai_d}	m^3/day	36.0	36.0	Calculated
Commercial Worker	IR_{ai_d}	m^3/day	15.0	12.0	Calculated
Construction Worker	IR_{ai_d}	m^3/day	15.0	15.0	Calculated

Table G-2

Exposure Factors
RSA-271
Redstone Arsenal, Madison County, Alabama

Parameter	Symbol	Unit	Default Value	Value Used	Comment
Hourly Outdoor Inhalation Rate:					
Resident Child	IR_{ao}	m^3/hr	0.5	0.625	Site-Specific Value
Resident Adult	IR_{ao}	m^3/hr	0.833	0.833	Default Value
Trespasser	IR_{ao}	m^3/hr	1.5	1.900	Site-Specific Value
Commercial Worker	IR_{ao}	m^3/hr	1.5	2.500	Site-Specific Value
Construction Worker	IR_{ao}	m^3/hr	1.5	2.500	Site-Specific Value
Exposure Time for Outdoor Inhalation:					
Resident Child	ET_{out}	hr/day	10	10	Default Value
Resident Adult	ET_{out}	hr/day	10	10	Default Value
Trespasser	ET_{out}	hr/day	10	6	Site-Specific Value
Commercial Worker	ET_{out}	hr/day	10	8	Site-Specific Value
Construction Worker	ET_{out}	hr/day	10	8	Site-Specific Value
Daily Outdoor Inhalation Rate:					
Resident Child	IR_{ao_d}	m^3/day	5.0	6.3	Calculated
Resident Adult	IR_{ao_d}	m^3/day	8.3	8.3	Calculated
Trespasser	IR_{ao_d}	m^3/day	15.0	11.4	Calculated
Commercial Worker	IR_{ao_d}	m^3/day	15.0	20.0	Calculated
Construction Worker	IR_{ao_d}	m^3/day	15.0	20.0	Calculated
Soil to Skin Adherence Factor:					
Resident Child	M	mg/cm^2	0.2	0.2	Default Value
Resident Adult	M	mg/cm^2	0.07	0.07	Default Value
Trespasser	M	mg/cm^2	0.2	0.04	Site-Specific Value
Commercial Worker	M	mg/cm^3	0.2	0.1	Site-Specific Value
Construction Worker	M	mg/cm^2	0.2	0.1	Site-Specific Value
Skin Surface Area for Dermal Contact:					
Resident Child	SA	cm^2/day	2800	2373	Site-Specific Value
Resident Adult	SA	cm^2/day	5700	6032	Site-Specific Value
Trespasser	SA	cm^2/day	5700	3700	Site-Specific Value
Commercial Worker	SA	cm^2/day	5700	3527	Site-Specific Value
Construction Worker	SA	cm^2/day	5700	3527	Site-Specific Value

The values in red are calculated.

The values in green are model default values.

Table G-3

Fate and Transport Parameters
RSA-271
Redstone Arsenal, Madison Countym Alabama

(Page 1 of 2)

Parameter	Symbol	Unit	Default Value	Value Used	Comment
SOIL PARAMETERS:					
Length of soil source area parallel to wind direction	W_a	cm	**	1500	Model default for small source area. See ** footnote.
Depth to subsurface soil sources	L_s	cm	30.48	449.6	Average depth of source area = 14.75 feet bgs
Lower depth of surficial soil zone	d	cm	30.48	30.48	ARBCA model Default Value
Depth to soil vapor measurement	d_{sv}	cm	30.48	30.48	ARBCA model Default Value
VADOSE ZONE:					
Total soil porosity	q_T	cm^3/cm^3-soil	0.30	0.41	Site-Specific Value
Volumetric water content	q_{ws}	cm^3/cm^3	0.10	0.08	Site-Specific Value
Volumetric air content	q_{as}	cm^3/cm^3	0.20	0.33	Calculated
Thickness	h_v	cm	295	136.67	Calculated
Dry soil bulk density	r_s	g/cm^3	1.8	1.59	Site-Specific Value
Fractional organic carbon content	f_{oc}	g-C/g-soil	0.002	0.035	Site-Specific Value
FOUNDATION/WALL CRACKS:					
Total soil porosity	q_{Tcrack}	cm^3/cm^3-soil	0.30	0.41	Site-Specific Value
Volumetric water content	q_{wcrack}	cm^3/cm^3	0.10	0.08	Site-Specific Value
Volumetric air content	q_{acrack}	cm^3/cm^3	0.20	0.33	Calculated
CAPILLARY FRINGE:					
Total soil porosity	q_{Tcap}	cm^3/cm^3-soil	0.30	0.41	Site-Specific Value
Volumetric water content	q_{wcap}	cm^3/cm^3	0.27	0.37	Calculated
Volumetric air content	q_{acap}	cm^3/cm^3	0.03	0.04	Calculated
Thickness	h_{cap}	cm	5	100	ARBCA (2017), Liu, et al. (2014)
GROUNDWATER PARAMETERS:					
Depth to groundwater	L_{gw}	cm	300	579.2	Site-Specific Value using two wells at tank pit
Width of GW source perpendicular to GW flow direct	Y	cm	**	1500	Model default for small source area. See ** footnote.
Length of GW source parallel to GW flow direction	W	cm	**	1219.2	Model default for small source area. See ** footnote.
Total soil porosity in the saturated zone	q_{TS}	cm^3/cm^3	0.30	0.41	Shaw (2011)
Dry soil bulk density in the saturated zone	r_{ss}	g/cm^3	1.8	1.59	Shaw (2011)
Fractional organic carbon content in the saturated zo	f_{ocs}	g-C/g-soil	0.002	0.035	Shaw (2011)
Groundwater mixing zone thickness	d_{gw}	cm	200	710	Shaw (2011)
Hydraulic conductivity in the saturated zone	K	cm/year	31536	18200	Shaw (2011)
Hydraulic gradient in the saturated zone	i	cm/cm	0.005	0.02	Shaw (2011)
Groundwater darcy velocity	U_{gw}	cm/year	364.00	364.00	Calculated
Infiltration rate	I	cm/year	14.8	19	Shaw (2011)

Table G-3

Fate and Transport Parameters
RSA-271
Redstone Arsenal, Madison Countym Alabama

(Page 2 of 2)

Parameter	Symbol	Unit	Default Value	Value Used	Comment
AMBIENT AIR PARAMETERS:					
Breathing zone height	d_a	cm	200	200	Default Value
Wind speed within the breathing zone	Ua	cm/s	225	225	Default Value
ENCLOSED SPACE PARAMETERS:					
Enclosed Space Air Exchange Rate:					
Residential	ER	1/sec	0.00014	0.00014	ARBCA model Default Value
Trespasser	ER	1/sec	0.00014	0.00014	ARBCA model Default Value
Commercial/construction worker	ER	1/sec	0.00023	0.00023	ARBCA model Default Value
Enclosed Space Volume/Infiltration Area Ratio:					
Residential	L_B	cm	200	200	ARBCA model Default Value
Trespasser	L_B	cm	200	200	ARBCA model Default Value
Commercial/construction worker	L_B	cm	300	300	ARBCA model Default Value
Enclosed Space Foundation or Wall Thickness:					
Residential	L_{crack}	cm	15	15	ARBCA model Default Value
Trespasser	L_{crack}	cm	15	15	ARBCA model Default Value
Commercial/construction worker	L_{crack}	cm	15	15	ARBCA model Default Value
Area Fraction of Cracks in Foundation/Walls:					
Residential	h	cm^2/cm^2	0.01	0.01	ARBCA model Default Value
Trespasser	h	cm^2/cm^2	0.01	0.01	ARBCA model Default Value
Commercial/construction worker	h	cm^2/cm^2	0.01	0.01	ARBCA model Default Value
PARTICULATE EMISSION RATE:					
Residential and commercial	P_e	g/cm^2sec	6.9E-14	6.90E-14	ARBCA model Default Value
Trespasser	P_e	g/cm^2sec	6.9E-09	6.90E-09	ARBCA model Default Value
Construction worker	P_e	g/cm^2sec	6.9E-09	6.90E-09	ARBCA model Default Value
AVERAGING TIME FOR VAPOR FLUX:					
Resident child	t	sec	1.89E+08	1.89E+08	Calculated
Resident adult	t	sec	9.46E+08	8.20E+08	Calculated
Trespasser	t	sec	3.15E+08	3.15E+08	Calculated
Commercial worker	t	sec	7.88E+08	7.88E+08	Calculated
Construction worker	t	sec	3.15E+07	3.15E+07	Calculated

****:** The source area (assumed to be square) should be classified as either (i) small (270 yd^2) = (1500 cm X 1500 cm), (ii) medium (1/2 acre) = (4,498 cm X 4,498 cm), or (iii) large (1 acre) = (6,362 cm X 6,362 cm).

The values in green are model default values.

The values in red are calculated values.

Table G-4

Points of Exposure and Points of Compliance
RSA-271
Redstone Arsenal, Madison County, Alabama

Parameter	Symbol	Unit	Default Value	Value Used	Comment
Distance from the Downgradient Edge of the Groundwater Source to the Point of Exposure	X_{poe}	ft	variable	126.21	Site-specific- Distance to the nearest offsite well from the source area in the downgradient direction
Longitudinal Dispersivity	a_x	ft	variable	12.621	Calculated
Transverse Dispersivity	a_y	ft	variable	4.207	Calculated
Vertical Dispersivity	a_z	ft	variable	0.631	Calculated
Distance from the Downgradient Edge of the Groundwater Source to the Point of Compliance	X_{poc}	ft	variable	56.69	Site-specific- Closest distance from the source area to the site boundary in the downgradient direction
Longitudinal Dispersivity	a_x	ft	variable	5.669	Calculated
Transverse Dispersivity	a_y	ft	variable	1.890	Calculated
Vertical Dispersivity	a_z	ft	variable	0.283	Calculated

Enter additional chemical-specific values on the "Chemical-Specific Inputs for Other Exposure Pathways" table.

The values in red are calculated. For exclusive use by Shaw E&I, Inc. (Knoxville, TN office)

ft - Feet.

Table G-5

Model Results - Protection of Groundwater Use - Without Biodegradation
RSA-271
Redstone Arsenal, Madison County, Alabama

CHEMICALS OF CONCERN	DILUTION ATTENTUATION FACTORS AT			ALLOWABLE CONCENTRATION AT				
	Unsaturated Zone [--]	Point of Compliance (Sentry Well) [--]	Point of Exposure [--]	Soil Source [mg/kg]	Groundwater Source [mg/L]	Point of Compliance (Sentry Well) [mg/L]	Point of Exposure [mg/L]	
1-Methylnaphthalene	1.00E+00	1.10E+00	1.95E+00	2.11E+01	1.96E-02	1.78E-02	1.01E-02	GW CG
Naphthalene	1.00E+00	1.10E+00	1.95E+00	2.17E+00	3.31E-03	3.00E-03	1.70E-03	GW CG

Notes:
GW CG - Groundwater cleanup goal.

Table G-6

Risk-Based Threshold Levels for SPLP Leachate
RSA-271
Redstone Arsenal, Madison County, Alabama

Parameter	Groundwater Cleanup Goals [a] (µg/L)	Vertical DAF [b] (unitless)	Horizontal DAF [c] (unitless)	SPLP RBTL [d] (µg/L)
Naphthalene	0.17	4	1.95	1.33E+00
1-Methylnaphthalene	10.1	4	1.95	7.87E+01

[a] See Table 3-2 in the main text.

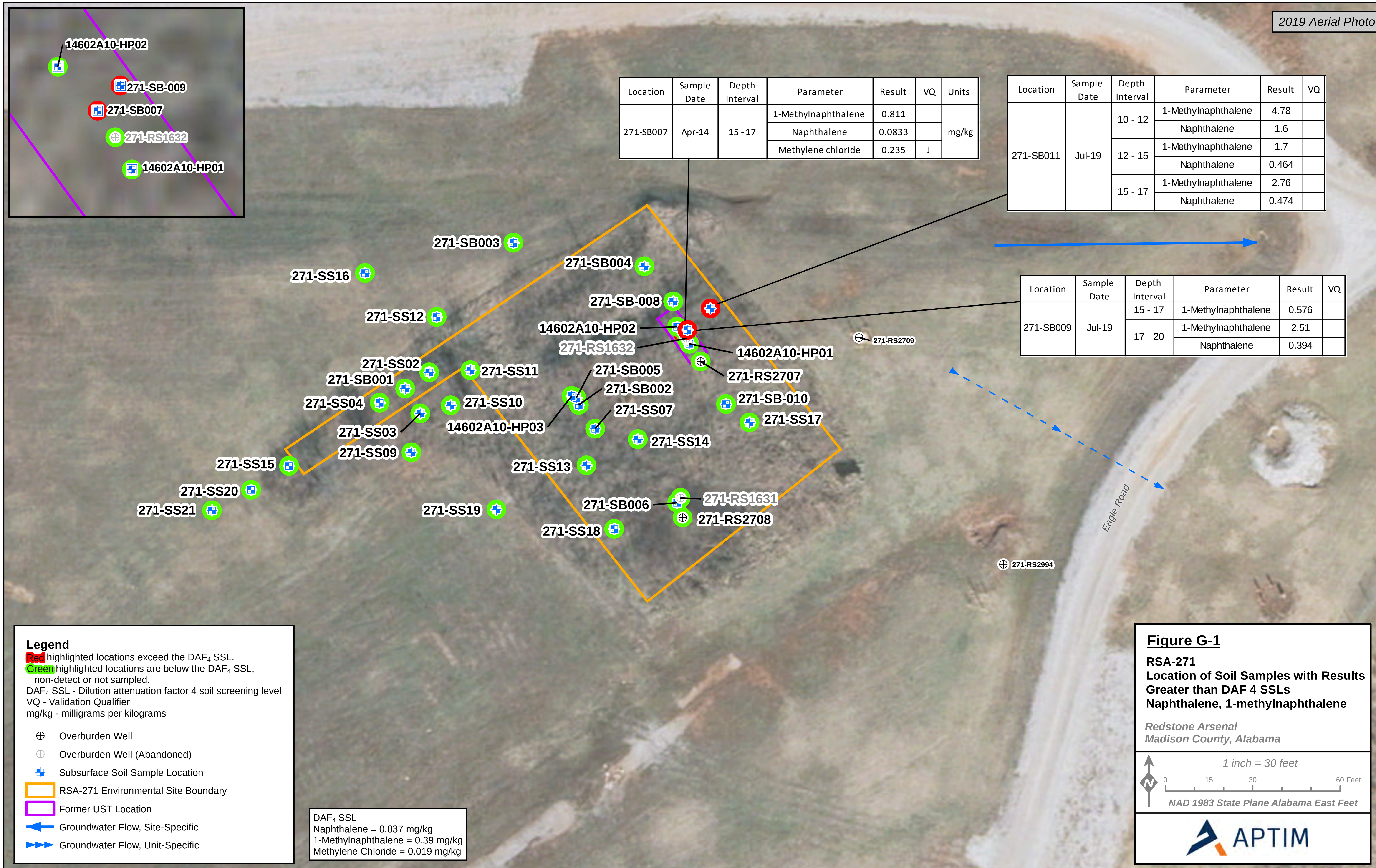
[b] Development of Redstone DAF4 SSLs is presented in Shaw Environmental, Inc. (Shaw), 2011, Development of a Facility-Wide Dilution Attenuation Migration from Soil to Groundwater, Redstone Arsenal, Huntsville, Alabama, U.S. Army Garrison-Redstone, Madison County, Alabama, February.

[c] See DAF at - point of exposure in Table G-5.

[d] SPLP RBTL is equal to the product of the groundwater CG x Vertical DAF x Horizontal DAF.

CG - Cleanup goal.
DAF - Dilution attenuation factor.
RBTL - Risk-based target level.
SPLP - Synthetic precipitation leaching procedure.
µg/L - Microgram per liter.

FIGURES



Location	Sample Date	Depth Interval	Parameter	Result	VQ	Units
271-SB007	Apr-14	15 - 17	1-Methylnaphthalene	0.811		mg/kg
			Naphthalene	0.0833		
			Methylene chloride	0.235	J	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB011	Jul-19	10 - 12	1-Methylnaphthalene	4.78	
			Naphthalene	1.6	
		12 - 15	1-Methylnaphthalene	1.7	
			Naphthalene	0.464	
		15 - 17	1-Methylnaphthalene	2.76	
			Naphthalene	0.474	

Location	Sample Date	Depth Interval	Parameter	Result	VQ
271-SB009	Jul-19	15 - 17	1-Methylnaphthalene	0.576	
		17 - 20	1-Methylnaphthalene	2.51	
			Naphthalene	0.394	

Legend

Red highlighted locations exceed the DAF_4 SSL.
Green highlighted locations are below the DAF_4 SSL, non-detect or not sampled.
DAF_4 SSL - Dilution attenuation factor 4 soil screening level
VQ - Validation Qualifier
mg/kg - milligrams per kilograms

- Overburden Well
- Overburden Well (Abandoned)
- Subsurface Soil Sample Location
- RSA-271 Environmental Site Boundary
- Former UST Location
- Groundwater Flow, Site-Specific
- Groundwater Flow, Unit-Specific

DAF_4 SSL
Naphthalene = 0.037 mg/kg
1-Methylnaphthalene = 0.39 mg/kg
Methylene Chloride = 0.019 mg/kg

Figure G-1

RSA-271
Location of Soil Samples with Results Greater than DAF 4 SSLs
Naphthalene, 1-methylnaphthalene

Redstone Arsenal
Madison County, Alabama

1 inch = 30 feet
0 15 30 60 Feet
NAD 1983 State Plane Alabama East Feet

APTIM

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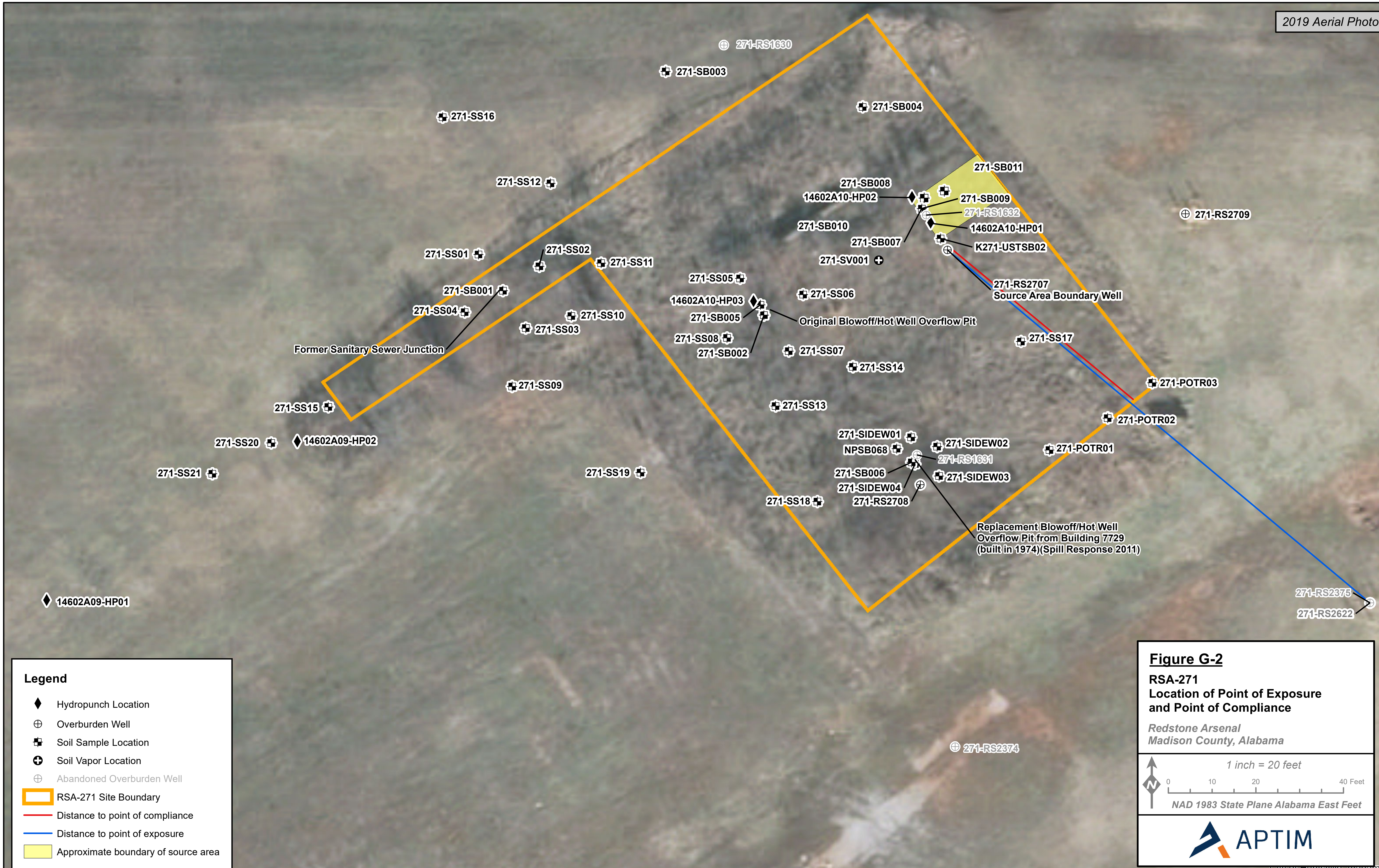

Figure G-2

RSA-271
Location of Point of Exposure and Point of Compliance

Redstone Arsenal
Madison County, Alabama

APTIM

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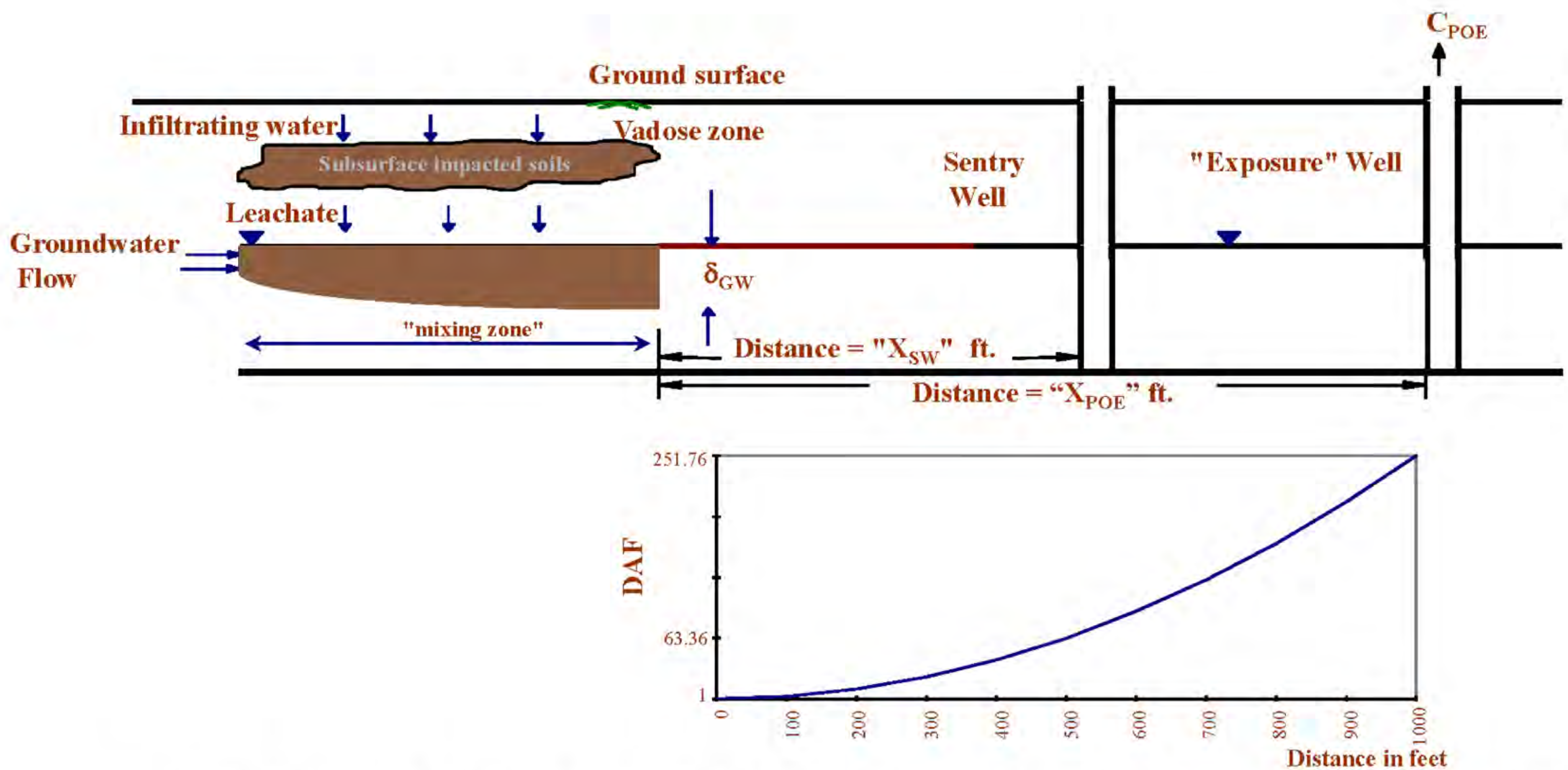

Allowable soil concentration at the source protective of a POE located at a distance X_{POE} from the source = C_{POE} x DAF_{POE}/LF_{SW}

C - Concentration
C_{POE} - Concentration at the POE
DAF - Horizontal dilution attenuation factor
POE - Point of exposure
X_{POE} - Distance from groundwater source to POE

Note:
Based on Figure B-1. Calculation of Groundwater Resource Protection Target Levels
ADEM, 2017 ARBCA (Revision 3)

Figure G-3

RSA-271
Conceptual Diagram of Groundwater Resource Protection for Determining Allowable Source Soil Concentration Based on the Point of Exposure

Redstone Arsenal
Madison County, Alabama

1 inch = 20 feet

0 10 20 40 Feet

NAD 1983 State Plane Alabama East Feet

APTIM

ATTACHMENT 1

SOIL AND GROUNDWATER RESULTS COMPARED TO MAY 2021 ADEM RSLS

Attachment 1, Table G-1

Summary of Data Screening Process for Surface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF_4[c] SSL	Min Value	Max Value	2016 PSV[d]
METALS-INCLUDES TWO SAMPLES ANALYZED FOR LEAD ONLY																				
Aluminum	mg/kg	39	16	16	16500	26900	-	40673	-	-	16	7700	7700	16500	26900	-	NA	-	-	7700
Antimony	mg/kg	39	16	1	1.58	1.58	-	9	-	-	-	3.1	3.1	-	-	1	1.08	1.58	1.58	3.1
Arsenic	mg/kg	39	16	16	7.56	11.5	-	15	-	-	16	0.67	0.68	7.56	11.5	16	1.13	7.56	11.5	0.68
Barium	mg/kg	39	16	16	34.6	176	1	174	176	176	-	1500	1500	-	-	-	289.7	-	-	1500
Beryllium	mg/kg	39	16	16	0.286	1.36	8	1	1.04	1.36	-	16	16	-	-	-	3.36	-	-	16
Cadmium	mg/kg	39	16	5	0.252	0.532	-	1	-	-	-	7	7.1	-	-	-	0.964	-	-	7.1
Calcium	mg/kg	39	16	16	1520	12500	8	4659	4660	12500	-	NA	NA	-	-	-	NA	-	-	NA
Chromium	mg/kg	39	16	16	29	92.3	-	97	-	-	16	0.3	0.3	29	92.3	16	8.48	29	92.3	0.3
Cobalt	mg/kg	39	16	16	2.04	19.6	3	17	17.7	19.6	15	2.3	2.3	2.84	19.6	-	91.2	-	-	2.3
Copper	mg/kg	39	16	16	7.72	44.1	3	21	23.1	44.1	-	310	310	-	-	-	1717	-	-	310
Iron	mg/kg	39	16	16	24000	46500	-	58199	-	-	16	5500	5500	24000	46500	-	NA	-	-	5500
Lead	mg/kg	39	18	18	15.7	59.9	2	48	54.9	59.9	-	400	400	-	-	-	400	-	-	400
Magnesium	mg/kg	39	16	16	352	1620	-	1620	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Manganese	mg/kg	39	16	16	407	2950	1	1934	2950	2950	16	180	180	407	2950	-	17200	-	-	180
Mercury	mg/kg	39	16	15	0.0361	0.115	-	0.14	-	-	-	2.3	2.3	-	-	-	0.13	-	-	2.3
Nickel	mg/kg	39	16	16	5.72	14.8	-	21	-	-	-	150	150	-	-	-	18.9	-	-	150
Potassium	mg/kg	39	16	16	418	842	-	1510	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Selenium	mg/kg	39	16	1	0.814	0.814	-	1	-	-	-	39	39	-	-	-	1.34	-	-	39
Silver	mg/kg	39	16	2	0.258	0.295	-	2	-	-	-	39	39	-	-	-	1.36	-	-	39
Sodium	mg/kg	39	16	0	-	-	-	716	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Thallium	mg/kg	39	16	10	0.783	4	4	2	2.09	4	10	0.078	0.078	0.783	4	10	0.514	0.783	4	0.078
Vanadium	mg/kg	39	16	16	55.7	110	-	131	-	-	16	39	39	55.7	110	-	344	-	-	39
Zinc	mg/kg	39	16	16	41.6	130	2	123	127	130	-	2300	2300	-	-	-	1133	-	-	2300
PAH-ANALYZED AND REPORTED FOR LOW LEVEL DETECTION LIMITS ONLY																				
1-Methylnaphthalene	mg/kg	39	28	4	0.00207	0.00515	-	NA	-	-	-	17	18	-	-	-	0.39	-	-	18
2-Methylnaphthalene	mg/kg	39	28	4	0.00407	0.00613	-	NA	-	-	-	23	24	-	-	-	12.5	-	-	24
Acenaphthene	mg/kg	39	28	1	0.00386	0.00386	-	NA	-	-	-	350	360	-	-	-	373	-	-	360
Acenaphthylene	mg/kg	39	28	9	0.00182	0.062	-	NA	-	-	-	350	180	-	-	-	366	-	-	360
Anthracene	mg/kg	39	28	7	0.00195	0.118	-	NA	-	-	-	1700	1800	-	-	-	4124	-	-	1800
Benzo(a)anthracene[e]	mg/kg	39	28	17	0.0019	0.44	-	NA	-	-	-	1.1	1.1	-	-	-	0.74	-	-	1.1
Benzo(a)pyrene[e]	mg/kg	39	28	19	0.0019	0.39	-	NA	-	-	3	0.12	0.11	0.248	0.39	-	16.4	-	-	0.12
Benzo(b)fluoranthene[e]	mg/kg	39	28	21	0.0024	0.6	-	NA	-	-	-	1.2	1.1	-	-	-	21	-	-	1.2
Benzo(ghi)perylene	mg/kg	39	28	20	0.0023	0.3	-	NA	-	-	-	170	180	-	-	-	163884	-	-	180
Benzo(k)fluoranthene[e]	mg/kg	39	28	19	0.0019	0.24	-	NA	-	-	-	12	11	-	-	-	206	-	-	12
Chrysene[e]	mg/kg	39	28	18	0.00286	0.43	-	NA	-	-	-	115	110	-	-	-	632	-	-	115
Dibenz(a,h)anthracene[e]	mg/kg	39	28	10	0.0026	0.091	-	NA	-	-	-	0.12	0.11	-	-	-	6.7	-	-	0.12
Fluoranthene	mg/kg	39	28	19	0.00252	0.95	-	NA	-	-	-	230	240	-	-	-	6211	-	-	240
Fluorene	mg/kg	39	28	2	0.0032	0.00476	-	NA	-	-	-	230	240	-	-	-	372	-	-	240
Indeno(1,2,3-cd)pyrene[e]	mg/kg	39	28	20	0.0023	0.284	-	NA	-	-	-	1.2	1.1	-	-	-	68	-	-	1.2
Naphthalene	mg/kg	39	28	2	0.00423	0.00487	-	NA	-	-	-	3.8	2	-	-	-	0.037	-	-	3.8
Phenanthrene	mg/kg	39	28	17	0.00228	0.43	-	NA	-	-	-	170	180	-	-	-	421	-	-	180
Pyrene	mg/kg	39	28	19	0.0022	0.74	-	NA	-	-	-	170	180	-	-	-	913	-	-	180
SEMIVOLATILES-INCLUDES FIVE SAMPLES ANALYZED FOR FULL SVOC AND SIX LOW LEVEL PAH ONLY SAMPLES REPORTED AS SVOC																				
1-Methylnaphthalene	mg/kg	39	11	3	0.00388	0.00894	-	NA	-	-	-	17	18	-	-	-	0.39	-	-	18
2,4,5-Trichlorophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	620	630	-	-	-	299	-	-	630
2,4,6-Trichlorophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	6.2	6.3	-	-	-	0.998	-	-	6.3
2,4-Dichlorophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	18	19	-	-	-	3.21	-	-	19
2,4-Dimethylphenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	120	130	-	-	-	25.1	-	-	130
2,4-Dinitrophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	12	13	-	-	-	2.55	-	-	13
2,4-Dinitrotoluene	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.78	1.7	-	-	-	0.0195	-	-	0.8

Attachment 1, Table G-1

Summary of Data Screening Process for Surface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF_4[c] SSL	Min Value	Max Value	2016 PSV[d]
2,6-Dinitrotoluene	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.78	0.36	-	-	-	0.004	-	-	0.8
2-Chloronaphthalene	mg/kg	39	5	0	-	-	-	NA	-	-	-	630	480	-	-	-	261	-	-	480
2-Chlorophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	39	39	-	-	-	3.98	-	-	39
2-Methylnaphthalene	mg/kg	39	11	0	-	-	-	NA	-	-	-	23	24	-	-	-	12.5	-	-	24
2-Methylphenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	310	320	-	-	-	40.7	-	-	320
2-Nitroaniline	mg/kg	39	5	0	-	-	-	NA	-	-	-	61	63	-	-	-	3.12	-	-	63
2-Nitrophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
3,3'-Dichlorobenzidine	mg/kg	39	5	0	-	-	-	NA	-	-	-	1.2	1.2	-	-	-	0.054	-	-	1.2
3-Nitroaniline	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4,6-Dinitro-2-methylphenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.49	0.51	-	-	-	0.16	-	-	0.51
4-Bromophenyl phenyl ether	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4-Chloro-3-methylphenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	620	630	-	-	-	97.6	-	-	630
4-Chloroaniline	mg/kg	39	5	0	-	-	-	NA	-	-	-	2.7	2.7	-	-	-	0.006	-	-	2.7
4-Chlorophenyl phenyl ether	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4-Methylphenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	620	630	-	-	-	81.5	-	-	630
4-Nitroaniline	mg/kg	39	5	0	-	-	-	NA	-	-	-	25	25	-	-	-	0.061	-	-	25
4-Nitrophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	3.864	-	-	NA
Acenaphthene	mg/kg	39	11	0	-	-	-	NA	-	-	-	350	360	-	-	-	373	-	-	360
Acenaphthylene	mg/kg	39	11	5	0.0023	0.0056	-	NA	-	-	-	350	180	-	-	-	366	-	-	360
Anthracene	mg/kg	39	11	2	0.0016	0.002	-	NA	-	-	-	1700	1800	-	-	-	4124	-	-	1800
Benzo(a)anthracene[e]	mg/kg	39	11	8	0.0023	0.012	-	NA	-	-	-	1.1	1.1	-	-	-	0.74	-	-	1.1
Benzo(a)pyrene[e]	mg/kg	39	11	8	0.00299	0.033	-	NA	-	-	-	0.12	0.11	-	-	-	16.4	-	-	0.12
Benzo(b)fluoranthene[e]	mg/kg	39	11	8	0.0032	0.04	-	NA	-	-	-	1.2	1.1	-	-	-	21	-	-	1.2
Benzo(ghi)perylene	mg/kg	39	11	8	0.00269	0.032	-	NA	-	-	-	170	180	-	-	-	163884	-	-	180
Benzo(k)fluoranthene[e]	mg/kg	39	11	8	0.00251	0.023	-	NA	-	-	-	12	11	-	-	-	206	-	-	12
bis(2-Chloroethoxy)methane	mg/kg	39	5	0	-	-	-	NA	-	-	-	18	19	-	-	-	0.168	-	-	19
bis(2-Chloroethyl)ether	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.23	0.23	-	-	-	0.0000748	-	-	0.23
bis(2-Chloroisopropyl)ether	mg/kg	39	5	0	-	-	-	NA	-	-	-	4.9	310	-	-	-	0.004	-	-	310
bis(2-Ethylhexyl)phthalate	mg/kg	39	5	2	0.118	0.135	-	NA	-	-	-	38	39	-	-	-	100.5	-	-	39
Butyl benzyl phthalate	mg/kg	39	5	0	-	-	-	NA	-	-	-	280	290	-	-	-	16	-	-	290
Carbazole	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Chrysene[e]	mg/kg	39	11	8	0.00244	0.018	-	NA	-	-	-	115	110	-	-	-	206	-	-	115
Dibenz(a,h)anthracene[e]	mg/kg	39	11	1	0.00277	0.00277	-	NA	-	-	-	0.12	0.11	-	-	-	6.7	-	-	0.12
Dibenzofuran	mg/kg	39	5	0	-	-	-	NA	-	-	-	7.2	7.8	-	-	-	10.1	-	-	7.3
Diethyl phthalate	mg/kg	39	5	0	-	-	-	NA	-	-	-	4900	5100	-	-	-	233	-	-	5100
Dimethyl phthalate	mg/kg	39	5	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	619.89	-	-	NA
Di-n-butyl phthalate	mg/kg	39	5	0	-	-	-	NA	-	-	-	620	630	-	-	-	147	-	-	630
Di-n-octyl phthalate	mg/kg	39	5	0	-	-	-	NA	-	-	-	62	63	-	-	-	3943	-	-	63
Fluoranthene	mg/kg	39	11	8	0.00254	0.017	-	NA	-	-	-	230	240	-	-	-	6211	-	-	240
Fluorene	mg/kg	39	11	0	-	-	-	NA	-	-	-	230	240	-	-	-	372	-	-	240
Hexachlorobenzene	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.33	0.21	-	-	-	0.868	-	-	0.21
Hexachlorobutadiene	mg/kg	39	5	0	-	-	-	NA	-	-	-	6.2	1.2	-	-	-	0.036	-	-	1.2
Hexachlorocyclopentadiene	mg/kg	39	5	0	-	-	-	NA	-	-	-	37	0.18	-	-	-	9.88	-	-	0.18
Hexachloroethane	mg/kg	39	5	0	-	-	-	NA	-	-	-	4.3	1.8	-	-	-	0.026	-	-	1.8
Indeno(1,2,3-cd)pyrene[e]	mg/kg	39	11	8	0.00288	0.031	-	NA	-	-	-	1.2	1.1	-	-	-	68	-	-	1.2
Isophorone	mg/kg	39	5	0	-	-	-	NA	-	-	-	560	570	-	-	-	0.776	-	-	570
Naphthalene	mg/kg	39	11	1	0.00478	0.00478	-	NA	-	-	-	3.8	2	-	-	-	0.037	-	-	3.8
Nitrobenzene	mg/kg	39	5	0	-	-	-	NA	-	-	-	5.1	5.1	-	-	-	0.005	-	-	5.1
n-Nitroso-di-n-propylamine	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.076	0.078	-	-	-	0.0004	-	-	0.078
n-Nitrosodiphenylamine	mg/kg	39	5	0	-	-	-	NA	-	-	-	110	110	-	-	-	4.43	-	-	110
Pentachlorophenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	0.99	1	-	-	-	0.695	-	-	1

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Summary of Data Screening Process for Surface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF_4[c] SSL	Min Value	Max Value	2016 PSV[d]
Phenanthrene	mg/kg	39	11	5	0.0019	0.00349	-	NA	-	-	-	170	180	-	-	-	421	-	-	180
Phenol	mg/kg	39	5	0	-	-	-	NA	-	-	-	1800	1900	-	-	-	157	-	-	1900
Pyrene	mg/kg	39	11	8	0.00267	0.016	-	NA	-	-	-	170	180	-	-	-	913	-	-	180
VOLATILES-INCLUDES TWO SAMPLES ANALYZED FOR BTEX ONLY																				
1,1,1-Trichloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	810	810	-	-	-	1.42	-	-	810
1,1,2,2-Tetrachloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.6	0.6	-	-	-	0.001	-	-	0.6
1,1,2-Trichloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.15	0.15	-	-	-	0.047	-	-	0.15
1,1-Dichloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	3.6	3.6	-	-	-	0.014	-	-	3.6
1,1-Dichloroethene	mg/kg	39	18	0	-	-	-	NA	-	-	-	23	23	-	-	-	0.038	-	-	23
1,2,4-Trichlorobenzene	mg/kg	39	18	0	-	-	-	NA	-	-	-	5.8	5.8	-	-	-	13.3	-	-	5.8
1,2-Dichlorobenzene	mg/kg	39	18	0	-	-	-	NA	-	-	-	180	180	-	-	-	32.7	-	-	180
1,2-Dichloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.46	0.46	-	-	-	0.032	-	-	0.46
1,2-Dichloropropane	mg/kg	39	18	0	-	-	-	NA	-	-	-	1	1.6	-	-	-	0.047	-	-	1
1,3-Dichlorobenzene	mg/kg	39	18	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	15.7	-	-	NA
1,4-Dichlorobenzene	mg/kg	39	18	0	-	-	-	NA	-	-	-	2.6	2.6	-	-	-	4	-	-	2.6
2-Butanone	mg/kg	39	18	17	0.00545	0.0928	-	NA	-	-	-	2700	2700	-	-	-	8.19	-	-	2700
2-Hexanone	mg/kg	39	18	0	-	-	-	NA	-	-	-	20	20	-	-	-	0.111	-	-	20
4-Methyl-2-pentanone	mg/kg	39	18	0	-	-	-	NA	-	-	-	530	3300	-	-	-	3.11	-	-	3300
Acetone	mg/kg	39	18	18	0.0354	0.867	-	NA	-	-	-	6100	6100	-	-	-	16.3	-	-	6100
Benzene	mg/kg	39	20	0	-	-	-	NA	-	-	-	1.2	1.2	-	-	-	0.106	-	-	1.2
Bromodichloromethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.29	0.29	-	-	-	0.424	-	-	0.29
Bromoform	mg/kg	39	18	0	-	-	-	NA	-	-	-	67	19	-	-	-	0.423	-	-	19
Bromomethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.68	0.68	-	-	-	0.021	-	-	0.68
Carbon disulfide	mg/kg	39	18	2	0.00203	0.00769	-	NA	-	-	-	77	77	-	-	-	3.23	-	-	77
Carbon tetrachloride	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.65	0.65	-	-	-	0.036	-	-	0.65
Chlorobenzene	mg/kg	39	18	0	-	-	-	NA	-	-	-	28	28	-	-	-	3.36	-	-	28
Chloroethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	1400	1400	-	-	-	83.2	-	-	1400
Chloroform	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.32	0.32	-	-	-	0.425	-	-	0.32
Chloromethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	11	11	-	-	-	0.523	-	-	11
cis-1,2-Dichloroethene	mg/kg	39	18	0	-	-	-	NA	-	-	-	16	16	-	-	-	0.449	-	-	16
cis-1,3-Dichloropropene	mg/kg	39	18	0	-	-	-	NA	-	-	-	1.8	1.8	-	-	-	0.005	-	-	1.8
Dibromochloromethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.73	8.3	-	-	-	0.423	-	-	8.3
Dichlorodifluoromethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	8.7	8.7	-	-	-	1.96	-	-	8.7
Ethylbenzene	mg/kg	39	20	0	-	-	-	NA	-	-	-	5.8	5.8	-	-	-	44.3	-	-	5.8
Freon 113	mg/kg	39	18	0	-	-	-	NA	-	-	-	4000	670	-	-	-	1799	-	-	4000
Methyl tert-butyl ether	mg/kg	39	18	0	-	-	-	NA	-	-	-	47	47	-	-	-	0.034	-	-	47
Methylene chloride	mg/kg	39	18	5	0.004	0.011	-	NA	-	-	-	35	35	-	-	-	0.019	-	-	35
Styrene	mg/kg	39	18	0	-	-	-	NA	-	-	-	600	600	-	-	-	6.33	-	-	600
Tetrachloroethene	mg/kg	39	18	0	-	-	-	NA	-	-	-	8.1	8.1	-	-	-	0.071	-	-	8.1
Toluene	mg/kg	39	20	0	-	-	-	NA	-	-	-	490	490	-	-	-	33.6	-	-	490
trans-1,2-Dichloroethene	mg/kg	39	18	0	-	-	-	NA	-	-	-	160	7	-	-	-	0.641	-	-	160
trans-1,3-Dichloropropene	mg/kg	39	18	0	-	-	-	NA	-	-	-	1.8	1.8	-	-	-	0.005	-	-	1.8
Trichloroethene	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.41	0.41	-	-	-	0.047	-	-	0.41
Trichlorofluoromethane	mg/kg	39	18	0	-	-	-	NA	-	-	-	73	2300	-	-	-	8.55	-	-	2300
Vinyl chloride	mg/kg	39	18	0	-	-	-	NA	-	-	-	0.059	0.059	-	-	-	0.008	-	-	0.059
Xylene, Total	mg/kg	39	20	0	-	-	-	NA	-	-	-	58	58	-	-	-	545	-	-	58

Attachment 1, Table G-1

Summary of Data Screening Process for Surface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

The number of detections excludes data with a "UB" qualifier as UB-qualified results are considered nondetect.
"-" Denotes the parameters were not detected.
BTEX - Benzene, toluene, ethylbenzene, and xylenes
mg/kg - Milligrams per kilogram.
NA - Screening value not available; value not applicable; or not analyzed for parameter.
PAH - Polynuclear aromatic hydrocarbons.
RFI - RCRA facility investigation.
SVOC - Semivolatile organic compounds.

[a] Background screening values (BSV) for inorganic constituents are based on 2 times the mean of the surface soil background data set (Gannett Fleming, Inc. and Shaw Environmental, Inc., 2010, *Final Supplemental Installation-Wide Background Soil Study, Redstone Arsenal, Madison County, Alabama,* Prepared for the U.S. Army Corps of Engineers, Savannah District, September).

[b] Residential soil preliminary screening values (PSV).
The EPA regional screening levels (RSL) for residential soil are adopted as the Redstone-specific PSVs and are adjusted, if necessary, to reflect an incremental lifetime cancer risk of 1E-6 or a hazard index of 0.1 (EPA, 2021, *Regional Screening Levels for Chemical Contaminants at Superfund Sites,* Mid-Atlantic Risk Assessment, May).

[c] Redstone-specific dilution-attenuation factor 4 soil screening levels (DAF_4 SSL).
Shaw Environmental, Inc. (Shaw), 2011, *Development of a Facility-Wide Dilution Attenuation Factor and Process for Evaluating Migration from Soil to Groundwater, Redstone Arsenal, Huntsville, Alabama,* U.S. Army Garrison-Redstone, Madison County, Alabama, February, as updated using current EPA (2018) maximum contaminant levels (if available) , the EPA May 2021 tap water RSLs.
References:
1) Maximum Contaminant Level (EPA, 2018 Edition of the Drinking Water Standards and Health Advisories, EPA 822-F-18-001, Office of Water, U.S. Environmental Protection Agency, Washington, District of Columbia., March.
2) Tapwater regional screening levels to reflect an incremental lifetime cancer risk of 1E-6 or a hazard index of 1 (EPA, 2021, *Regional Screening Levels for Chemical Contaminants at Superfund Sites,* Mid-Atlantic Risk Assessment, May).

[d] Residential soil PSVs.
The EPA RSLs for residential soil are adopted as the Redstone-specific PSVs and are adjusted, if necessary, to reflect an incremental lifetime cancer risk of 1E-6 or a hazard index of 0.1 (EPA, 2016, *Regional Screening Levels for Chemical Contaminants at Superfund Sites,* May.

Attachment 1, Table G-2

Summary of Data Screening Process for Subsurface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF4[c]	Min Value	Max Value	2016 PSV[d]
METALS-INCLUDES TWO SAMPLES ANALYZED FOR LEAD ONLY																				
Aluminum	mg/kg	62	32	32	11700	32000	-	44794	-	-	32	7700	7700	11700	32000	-	NA	-	-	7700
Antimony	mg/kg	62	32	15	1.3	3.94	-	9	-	-	3	3.1	3.1	3.27	3.94	15	1.08	1.3	3.94	3.1
Arsenic	mg/kg	62	32	32	6.07	15.2	-	18	-	-	32	0.67	0.68	6.07	15.2	32	1.13	6.07	15.2	0.68
Barium	mg/kg	62	32	32	9.48	117	1	115	117	117	-	1500	1500	-	-	-	289.7	-	-	1500
Beryllium	mg/kg	62	32	28	0.261	1.14	4	1	1.02	1.14	-	16	16	-	-	-	3.36	-	-	16
Cadmium	mg/kg	62	32	2	0.285	0.549	-	1	-	-	-	7	7.1	-	-	-	0.964	-	-	7.1
Calcium	mg/kg	62	32	28	281	4370	1	3513	4370	4370	-	NA	NA	-	-	-	NA	-	-	NA
Chromium	mg/kg	62	32	32	51	258	12	147	150	258	32	0.3	0.3	51	258	32	8.48	51	258	0.3
Cobalt	mg/kg	62	32	10	1.26	11.9	-	14	-	-	6	2.3	2.3	2.5	11.9	-	91.2	-	-	2.3
Copper	mg/kg	62	32	32	6.5	18.7	-	21	-	-	-	310	310	-	-	-	1717	-	-	310
Iron	mg/kg	62	32	32	24200	72700	-	75078	-	-	32	5500	5500	24200	72700	-	NA	-	-	5500
Lead	mg/kg	62	34	34	6.29	28.2	-	36	-	-	-	400	400	-	-	-	400	-	-	400
Magnesium	mg/kg	62	32	27	268	984	-	1581	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Manganese	mg/kg	62	32	32	32.4	1670	1	1254	1670	1670	21	180	180	192	1670	-	17200	-	-	180
Mercury	mg/kg	62	32	32	0.0348	0.117	-	0.13	-	-	-	2.3	2.3	-	-	-	0.13	-	-	2.3
Nickel	mg/kg	62	32	32	2.05	17.9	-	24	-	-	-	150	150	-	-	-	18.9	-	-	150
Potassium	mg/kg	62	32	30	271	1030	-	1643	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Selenium	mg/kg	62	32	1	0.749	0.749	-	1	-	-	-	39	39	-	-	-	1.34	-	-	39
Silver	mg/kg	62	32	3	0.344	0.634	-	2	-	-	-	39	39	-	-	-	1.36	-	-	39
Sodium	mg/kg	62	32	4	273	465	-	786	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Thallium	mg/kg	62	32	1	2.25	2.25	1	2	2.25	2.25	1	0.078	0.078	2.25	2.25	1	0.514	2.25	2.25	0.078
Vanadium	mg/kg	62	32	32	78.2	201	2	173	181	201	32	39	39	78.2	201	-	344	-	-	39
Zinc	mg/kg	62	32	32	16.6	1110	3	148	156	1110	-	2300	2300	-	-	-	1133	-	-	2300
PAH-ANALYZED AT LOW LEVEL DETECTION LIMITS ONLY																				
1-Methylnaphthalene	mg/kg	62	32	4	0.004	0.0252	-	NA	-	-	-	17	18	-	-	-	0.39	-	-	18
2-Methylnaphthalene	mg/kg	62	32	5	0.00306	0.913	-	NA	-	-	-	23	24	-	-	-	12.5	-	-	24
Acenaphthene	mg/kg	62	32	0	-	-	-	NA	-	-	-	350	360	-	-	-	373	-	-	360
Acenaphthylene	mg/kg	62	32	0	-	-	-	NA	-	-	-	350	180	-	-	-	366	-	-	360
Anthracene	mg/kg	62	32	0	-	-	-	NA	-	-	-	1700	1800	-	-	-	4124	-	-	1800
Benzo(a)anthracene[e]	mg/kg	62	32	1	0.0167	0.0167	-	NA	-	-	-	1.1	1.1	-	-	-	0.74	-	-	1.1
Benzo(a)pyrene[e]	mg/kg	62	32	1	0.022	0.022	-	NA	-	-	-	0.12	0.11	-	-	-	16.4	-	-	0.12
Benzo(b)fluoranthene[e]	mg/kg	62	32	2	0.00439	0.0292	-	NA	-	-	-	1.2	1.1	-	-	-	21	-	-	1.2
Benzo(ghi)perylene	mg/kg	62	32	1	0.0219	0.0219	-	NA	-	-	-	170	180	-	-	-	163884	-	-	180
Benzo(k)fluoranthene[e]	mg/kg	62	32	1	0.0186	0.0186	-	NA	-	-	-	12	11	-	-	-	206	-	-	12
Chrysene[e]	mg/kg	62	32	1	0.0187	0.0187	-	NA	-	-	-	115	110	-	-	-	632	-	-	115
Dibenz(a,h)anthracene[e]	mg/kg	62	32	1	0.00597	0.00597	-	NA	-	-	-	0.12	0.11	-	-	-	6.7	-	-	0.12
Fluoranthene	mg/kg	62	32	3	0.00234	0.0233	-	NA	-	-	-	230	240	-	-	-	6211	-	-	240
Fluorene	mg/kg	62	32	2	0.189	0.378	-	NA	-	-	-	230	240	-	-	-	372	-	-	240
Indeno(1,2,3-cd)pyrene[e]	mg/kg	62	32	1	0.0183	0.0183	-	NA	-	-	-	1.2	1.1	-	-	-	68	-	-	1.2
Naphthalene	mg/kg	62	32	3	0.00322	0.0985	-	NA	-	-	-	3.8	2	-	-	1	0.037	0.0985	0.0985	3.8
Phenanthrene	mg/kg	62	32	4	0.00288	0.441	-	NA	-	-	-	170	180	-	-	-	421	-	-	180
Pyrene	mg/kg	62	32	5	0.0057	0.0921	-	NA	-	-	-	170	180	-	-	-	913	-	-	180
SEMIVOLATILES-INCLUDES 7 RFI SAMPLES FOR LOW LEVEL PAH AND REPORTED AS SVOC,11 RFI SAMPLES ANALYZED FOR SVOC, AND 6 HISTORICAL SAMPLES ANALYZED FOR SVOC																				
1,2,4-Trichlorobenzene	mg/kg	62	6	0	-	-	-	NA	-	-	-	5.8	5.8	-	-	-	13.3	-	-	5.8
1,2-Dichlorobenzene	mg/kg	62	6	0	-	-	-	NA	-	-	-	180	180	-	-	-	32.7	-	-	180
1,3-Dichlorobenzene	mg/kg	62	6	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	15.7	-	-	NA
1,4-Dichlorobenzene	mg/kg	62	6	0	-	-	-	NA	-	-	-	2.6	2.6	-	-	-	4	-	-	2.6
1-Methylnaphthalene	mg/kg	62	18	3	0.00391	0.811	-	NA	-	-	-	17	18	-	-	1	0.39	0.811	0.811	18
2,4,5-Trichlorophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	620	630	-	-	-	299	-	-	630
2,4,6-Trichlorophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	6.2	6.3	-	-	-	0.998	-	-	6.3
2,4-Dichlorophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	18	19	-	-	-	3.21	-	-	19
2,4-Dimethylphenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	120	130	-	-	-	25.1	-	-	130
2,4-Dinitrophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	12	13	-	-	-	2.55	-	-	13

Attachment 1, Table G-2

Summary of Data Screening Process for Subsurface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF4[c]	Min Value	Max Value	2016 PSV[d]
2,4-Dinitrotoluene	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.78	1.7	-	-	-	0.0195	-	-	0.8
2,6-Dinitrotoluene	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.78	0.36	-	-	-	0.004	-	-	0.8
2-Chloronaphthalene	mg/kg	62	17	0	-	-	-	NA	-	-	-	630	480	-	-	-	261	-	-	480
2-Chlorophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	39	39	-	-	-	3.98	-	-	39
2-Methylnaphthalene	mg/kg	62	24	3	0.00298	0.0494	-	NA	-	-	-	23	24	-	-	-	12.5	-	-	24
2-Methylphenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	310	320	-	-	-	40.7	-	-	320
2-Nitroaniline	mg/kg	62	17	0	-	-	-	NA	-	-	-	61	63	-	-	-	3.12	-	-	63
2-Nitrophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
3,3'-Dichlorobenzidine	mg/kg	62	17	0	-	-	-	NA	-	-	-	1.2	1.2	-	-	-	0.054	-	-	1.2
3-Nitroaniline	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4,6-Dinitro-2-methylphenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.49	0.51	-	-	-	0.16	-	-	0.51
4-Bromophenyl phenyl ether	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4-Chloro-3-methylphenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	620	630	-	-	-	97.6	-	-	630
4-Chloroaniline	mg/kg	62	17	0	-	-	-	NA	-	-	-	2.7	2.7	-	-	-	0.006	-	-	2.7
4-Chlorophenyl phenyl ether	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
4-Methylphenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	620	630	-	-	-	81.5	-	-	630
4-Nitroaniline	mg/kg	62	17	0	-	-	-	NA	-	-	-	25	25	-	-	-	0.061	-	-	25
4-Nitrophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	3.864	-	-	NA
Acenaphthene	mg/kg	62	24	1	0.157	0.157	-	NA	-	-	-	350	360	-	-	-	373	-	-	360
Acenaphthylene	mg/kg	62	24	3	0.0019	0.0027	-	NA	-	-	-	350	180	-	-	-	366	-	-	360
Anthracene	mg/kg	62	24	1	4	4	-	NA	-	-	-	1700	1800	-	-	-	4124	-	-	1800
Benzo(a)anthracene[e]	mg/kg	62	24	9	0.0015	0.0087	-	NA	-	-	-	1.1	1.1	-	-	-	0.74	-	-	1.1
Benzo(a)pyrene[e]	mg/kg	62	24	6	0.0091	0.024	-	NA	-	-	-	0.12	0.11	-	-	-	16.4	-	-	0.12
Benzo(b)fluoranthene[e]	mg/kg	62	24	6	0.0015	0.021	-	NA	-	-	-	1.2	1.1	-	-	-	21	-	-	1.2
Benzo(ghi)perylene	mg/kg	62	24	7	0.00256	0.024	-	NA	-	-	-	170	180	-	-	-	163884	-	-	180
Benzo(k)fluoranthene[e]	mg/kg	62	24	7	0.00214	0.018	-	NA	-	-	-	12	11	-	-	-	206	-	-	12
bis(2-Chloroethoxy)methane	mg/kg	62	17	0	-	-	-	NA	-	-	-	18	19	-	-	-	0.168	-	-	19
bis(2-Chloroethyl)ether	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.23	0.23	-	-	-	0.0000748	-	-	0.23
bis(2-Chloroisopropyl)ether	mg/kg	62	17	0	-	-	-	NA	-	-	-	4.9	310	-	-	-	0.004	-	-	310
bis(2-Ethylhexyl)phthalate	mg/kg	62	17	6	0.105	0.161	-	NA	-	-	-	38	39	-	-	-	100.5	-	-	39
Butyl benzyl phthalate	mg/kg	62	17	0	-	-	-	NA	-	-	-	280	290	-	-	-	16	-	-	290
Carbazole	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	NA	-	-	NA
Chrysene[e]	mg/kg	62	24	6	0.0025	0.0094	-	NA	-	-	-	115	110	-	-	-	632	-	-	115
Dibenz(a,h)anthracene[e]	mg/kg	62	24	1	0.0016	0.0016	-	NA	-	-	-	0.12	0.11	-	-	-	6.7	-	-	0.12
Dibenzofuran	mg/kg	62	17	0	-	-	-	NA	-	-	-	7.2	7.8	-	-	-	10.1	-	-	7.3
Diethyl phthalate	mg/kg	62	17	0	-	-	-	NA	-	-	-	4900	5100	-	-	-	233	-	-	5100
Dimethyl phthalate	mg/kg	62	17	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	619.89	-	-	NA
Di-n-butyl phthalate	mg/kg	62	17	0	-	-	-	NA	-	-	-	620	630	-	-	-	147	-	-	630
Di-n-octyl phthalate	mg/kg	62	17	0	-	-	-	NA	-	-	-	62	63	-	-	-	3943	-	-	63
Fluoranthene	mg/kg	62	24	8	0.0023	0.015	-	NA	-	-	-	230	240	-	-	-	6211	-	-	240
Fluorene	mg/kg	62	24	1	0.405	0.405	-	NA	-	-	-	230	240	-	-	-	372	-	-	240
Hexachlorobenzene	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.33	0.21	-	-	-	0.868	-	-	0.21
Hexachlorobutadiene	mg/kg	62	17	0	-	-	-	NA	-	-	-	6.2	1.2	-	-	-	0.036	-	-	1.2
Hexachlorocyclopentadiene	mg/kg	62	17	0	-	-	-	NA	-	-	-	37	0.18	-	-	-	9.88	-	-	0.18

Attachment 1, Table G-2

Summary of Data Screening Process for Subsurface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	Detections Above Criteria	2014 DAF4[c]	Min Value	Max Value	2016 PSV[d]
Hexachloroethane	mg/kg	62	17	0	-	-	-	NA	-	-	-	4.3	1.8	-	-	-	0.026	-	-	1.8
Indeno(1,2,3-cd)pyrene[e]	mg/kg	62	24	6	0.0067	0.024	-	NA	-	-	-	1.2	1.1	-	-	-	68	-	-	1.2
Isophorone	mg/kg	62	17	0	-	-	-	NA	-	-	-	560	570	-	-	-	0.776	-	-	570
Naphthalene	mg/kg	62	24	2	0.00716	0.0833	-	NA	-	-	-	3.8	2	-	-	1	0.037	0.0833	0.0833	3.8
Nitrobenzene	mg/kg	62	17	0	-	-	-	NA	-	-	-	5.1	5.1	-	-	-	0.005	-	-	5.1
n-Nitroso-di-n-propylamine	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.076	0.078	-	-	-	0.0004	-	-	0.078
n-Nitrosodiphenylamine	mg/kg	62	17	0	-	-	-	NA	-	-	-	110	110	-	-	-	4.43	-	-	110
Pentachlorophenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	0.99	1	-	-	-	0.695	-	-	1
Phenanthrene	mg/kg	62	24	5	0.00287	0.55	-	NA	-	-	-	170	180	-	-	-	421	-	-	180
Phenol	mg/kg	62	17	0	-	-	-	NA	-	-	-	1800	1900	-	-	-	157	-	-	1900
Pyrene	mg/kg	62	24	8	0.0019	0.0566	-	NA	-	-	-	170	180	-	-	-	913	-	-	180
VOLATILES-INCLUDES TWO SAMPLES ANALYZED FOR BTEX ONLY AND THREE SAMPLES ANALYZED FOR METHYLENE CHLORIDE ONLY																				
1,1,1-Trichloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	810	810	-	-	-	1.42	-	-	810
1,1,2,2-Tetrachloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.6	0.6	-	-	-	0.001	-	-	0.6
1,1,2-Trichloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.15	0.15	-	-	-	0.047	-	-	0.15
1,1-Dichloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	3.6	3.6	-	-	-	0.014	-	-	3.6
1,1-Dichloroethene	mg/kg	62	31	0	-	-	-	NA	-	-	-	23	23	-	-	-	0.038	-	-	23
1,2,4-Trichlorobenzene	mg/kg	62	31	0	-	-	-	NA	-	-	-	5.8	5.8	-	-	-	13.3	-	-	5.8
1,2-Dichlorobenzene	mg/kg	62	31	0	-	-	-	NA	-	-	-	180	180	-	-	-	32.7	-	-	180
1,2-Dichloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.46	0.46	-	-	-	0.032	-	-	0.46
1,2-Dichloropropane	mg/kg	62	31	0	-	-	-	NA	-	-	-	1	1.6	-	-	-	0.047	-	-	1
1,3-Dichlorobenzene	mg/kg	62	31	0	-	-	-	NA	-	-	-	NA	NA	-	-	-	15.7	-	-	NA
1,4-Dichlorobenzene	mg/kg	62	31	0	-	-	-	NA	-	-	-	2.6	2.6	-	-	-	4	-	-	2.6
2-Butanone	mg/kg	62	31	7	0.00315	0.0358	-	NA	-	-	-	2700	2700	-	-	-	8.19	-	-	2700
2-Hexanone	mg/kg	62	31	0	-	-	-	NA	-	-	-	20	20	-	-	-	0.111	-	-	20
4-Methyl-2-pentanone	mg/kg	62	31	0	-	-	-	NA	-	-	-	530	3300	-	-	-	3.11	-	-	3300
Acetone	mg/kg	62	31	24	0.0114	0.203	-	NA	-	-	-	6100	6100	-	-	-	16.3	-	-	6100
Benzene	mg/kg	62	33	0	-	-	-	NA	-	-	-	1.2	1.2	-	-	-	0.106	-	-	1.2
Bromodichloromethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.29	0.29	-	-	-	0.424	-	-	0.29
Bromoform	mg/kg	62	31	0	-	-	-	NA	-	-	-	67	19	-	-	-	0.423	-	-	19
Bromomethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.68	0.68	-	-	-	0.021	-	-	0.68
Carbon disulfide	mg/kg	62	31	1	0.00252	0.00252	-	NA	-	-	-	77	77	-	-	-	3.23	-	-	77
Carbon tetrachloride	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.65	0.65	-	-	-	0.036	-	-	0.65
Chlorobenzene	mg/kg	62	31	0	-	-	-	NA	-	-	-	28	28	-	-	-	3.36	-	-	28
Chloroethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	1400	1400	-	-	-	83.2	-	-	1400
Chloroform	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.32	0.32	-	-	-	0.425	-	-	0.32
Chloromethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	11	11	-	-	-	0.523	-	-	11
cis-1,2-Dichloroethene	mg/kg	62	31	0	-	-	-	NA	-	-	-	16	16	-	-	-	0.449	-	-	16
cis-1,3-Dichloropropene	mg/kg	62	31	0	-	-	-	NA	-	-	-	1.8	1.8	-	-	-	0.005	-	-	1.8
Dibromochloromethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.73	8.3	-	-	-	0.423	-	-	8.3
Dichlorodifluoromethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	8.7	8.7	-	-	-	1.96	-	-	8.7
Ethylbenzene	mg/kg	62	33	0	-	-	-	NA	-	-	-	5.8	5.8	-	-	-	44.3	-	-	5.8
Freon 113	mg/kg	62	31	0	-	-	-	NA	-	-	-	4000	670	-	-	-	1799	-	-	4000
Methyl tert-butyl ether	mg/kg	62	31	0	-	-	-	NA	-	-	-	47	47	-	-	-	0.034	-	-	47
Methylene chloride	mg/kg	62	34	7	0.00319	0.235	-	NA	-	-	-	35	35	-	-	1	0.019	0.235	0.235	35
Styrene	mg/kg	62	31	0	-	-	-	NA	-	-	-	600	600	-	-	-	6.33	-	-	600
Tetrachloroethene	mg/kg	62	31	0	-	-	-	NA	-	-	-	8.1	8.1	-	-	-	0.071	-	-	8.1
Toluene	mg/kg	62	33	0	-	-	-	NA	-	-	-	490	490	-	-	-	33.6	-	-	490
trans-1,2-Dichloroethene	mg/kg	62	31	0	-	-	-	NA	-	-	-	160	7	-	-	-	0.641	-	-	160
trans-1,3-Dichloropropene	mg/kg	62	31	0	-	-	-	NA	-	-	-	1.8	1.8	-	-	-	0.005	-	-	1.8
Trichloroethene	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.41	0.41	-	-	-	0.047	-	-	0.41
Trichlorofluoromethane	mg/kg	62	31	0	-	-	-	NA	-	-	-	73	2300	-	-	-	8.55	-	-	2300
Vinyl chloride	mg/kg	62	31	0	-	-	-	NA	-	-	-	0.059	0.059	-	-	-	0.008	-	-	0.059
Xylene, Total	mg/kg	62	33	0	-	-	-	NA	-	-	-	58	58	-	-	-	545	-	-	58

Attachment 1, Table G-2

Summary of Data Screening Process for Subsurface Soil
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

The number of detections excludes data with a "UB" qualifier as UB-qualified results are considered nondetect
"-" Denotes the parameters were not detected.
BTEX - Benzene, toluene, ethylbenzene, and xylenes
mg/kg - Milligrams per kilogram.
NA - Screening value not available; value not applicable; or not analyzed for parameter
PAH - Polynuclear aromatic hydrocarbons.
RFI - RCRA facility investigation.
SVOC - Semivolatile organic compounds.

[a] Background screening values (BSV) for inorganic constituents are based on 2 times the mean of the subsurface soil background data set (Gannett Fleming, Inc. and Shaw Environmental, Inc., 2010, *Final Supplemental Installation-Wide Background Soil Study Redstone Arsenal, Madison County, Alabama,* Prepared for the U.S. Army Corps of Engineers, Savannah District, September)

[b] Residential soil preliminary screening values (PSV).
The EPA regional screening levels (RSL) for residential soil are adopted as the Redstone-specific PSVs and are adjusted, if necessary, to reflect an incremental lifetim cancer risk of 1E-6 or a hazard index of 0.1 (EPA, 2021, *Regional Screening Levels for Chemical Contaminants at Superfund Sites* Mid-Atlantic Risk Assessment, May).

[c] Redstone-specific dilution attenuation factor 4 soil screening levels (DAF_4 SSL).
Shaw Environmental, Inc. (Shaw), 2011, *Development of a Facility-Wide Dilution Attenuation Factor and Process for Evaluating Migration from Soil to Groundwater, Redstone Arsenal, Huntsville, Alabama* U.S. Army Garrison-Redstone, Madison County, Alabama, February, as updated using current EPA (2018) maximum contaminant levels (if available) , the EPA May 2021 tap water RSLs
References:
1) Maximum Contaminant Level (EPA, 2018 Edition of the Drinking Water Standards and Health Advisories, EPA 822-F-18-001, Office of Water, U.S. Environmental Protection Agency, Washington, District of Columbia, April).
2) Tapwater regional screening levels to reflect an incremental lifetime cancer risk of 1E-6 or a hazard index of 1 (EPA, 2021, *Regional Screening Levels for Chemical Contaminants at Superfund Sites* Mid-Atlantic Risk Assessment, May).

[d] Residential soil PSVs.
The EPA RSLs for residential soil are adopted as the Redstone-specific PSVs and are adjusted, if necessary, to reflect an incremental lifetim cancer risk of 1E-6 or a hazard index of 0.1 (EPA, 2016, *Regional Screening Levels for Chemical Contaminants at Superfund Sites* May.

Attachment 1, Table G-3

Summary of Data Screening Process for Groundwater
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above 2021 Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	2016 PSV[c]
METALS																
Aluminum	µg/L	11	7	6	64.9	1870	-	9434	-	-	-	2000	2000	-	-	2000
Antimony	µg/L	11	7	0	-	-	-	17	-	-	-	6	6	-	-	6
Arsenic	µg/L	11	7	2	5.82	7.39	2	5.1	5.82	7.39	-	10	10	-	-	10
Barium	µg/L	11	7	7	26.5	264	2	156	262	264	-	2000	2000	-	-	2000
Beryllium	µg/L	11	7	0	-	-	-	5	-	-	-	4	4	-	-	4
Cadmium	µg/L	11	7	2	0.57	2.05	-	5	-	-	-	5	5	-	-	5
Calcium	µg/L	11	7	7	19700	86300	-	144000	-	-	-	NA	NA	-	-	NA
Chromium	µg/L	11	7	2	3.71	9.16	-	16	-	-	-	100	100	-	-	100
Cobalt	µg/L	11	7	2	48	56.2	1	50	56.2	56.2	2	0.6	0.6	48	56.2	0.6
Copper	µg/L	11	7	3	2.11	3.49	-	25	-	-	-	1300	1300	-	-	1300
Iron	µg/L	11	7	5	40.9	13900	1	12100	13900	13900	2	1400	1400	5760	13900	1400
Lead	µg/L	11	7	3	5.52	12.1	3	5.2	5.52	12.1	-	15	15	-	-	15
Magnesium	µg/L	11	7	7	1910	6940	-	19414	-	-	-	NA	NA	-	-	NA
Manganese	µg/L	11	7	7	12	9610	2	3220	9090	9610	6	43	43	77.8	9610	43
Mercury	µg/L	11	7	0	-	-	-	0.2	-	-	-	2	2	-	-	2
Nickel	µg/L	11	7	2	62.3	90	2	40	62.3	90	2	100	39	-	-	100
Potassium	µg/L	11	7	3	433	1260	-	5810	-	-	-	NA	NA	-	-	NA
Selenium	µg/L	11	7	1	7.05	7.05	1	5	7.05	7.05	-	50	50	-	-	50
Silver	µg/L	11	7	0	-	-	-	10	-	-	-	9.4	9.4	-	-	9.4
Sodium	µg/L	11	7	7	7890	30000	-	65600	-	-	-	NA	NA	-	-	NA
Thallium	µg/L	11	7	1	3.6	3.6	-	5.7	-	-	1	2	2	3.6	3.6	2
Vanadium	µg/L	11	7	1	12.7	12.7	-	50	-	-	1	8.6	8.6	12.7	12.7	8.6
Zinc	µg/L	11	7	7	6.06	195	-	211	-	-	-	600	600	-	-	600
EXPLOSIVES																
1,3,5-Trinitrobenzene	µg/L	11	7	2	0.181	0.698	-	NA	-	-	-	59	59	-	-	59
1,3-Dinitrobenzene	µg/L	11	7	1	0.389	0.389	-	NA	-	-	1	0.2	0.2	0.389	0.389	0.2
2,4,6-Trinitrotoluene	µg/L	11	7	2	1.61	2.09	-	NA	-	-	2	0.98	0.98	1.61	2.09	0.98
2,4-Dinitrotoluene	µg/L	11	7	0	-	-	-	NA	-	-	-	0.11	0.24	-	-	0.11
2,6-Dinitrotoluene	µg/L	11	7	0	-	-	-	NA	-	-	-	0.11	0.049	-	-	0.11
2-Amino-4,6-dinitrotoluene	µg/L	11	7	1	0.333	0.333	-	NA	0.333	0.333	1	3.9	0.19	-	-	3.9
2-Nitrotoluene	µg/L	11	7	3	0.088	0.319	-	NA	-	-	1	0.31	0.31	0.319	0.319	0.31
3-Nitrotoluene	µg/L	11	7	2	0.352	1.06	-	NA	-	-	2	0.17	0.17	0.352	1.06	0.17
4-Amino-2,6-dinitrotoluene	µg/L	11	7	2	1.37	1.65	-	NA	1.37	1.65	2	3.9	0.19	-	-	3.9
HMX	µg/L	11	7	0	-	-	-	NA	-	-	-	100	100	-	-	100
Nitrobenzene	µg/L	11	7	1	1.21	1.21	-	NA	-	-	1	0.14	0.14	1.21	1.21	0.14
Nitroglycerin	µg/L	11	7	1	1	1	-	NA	-	-	1	0.2	0.2	1	1	0.2
PETN	µg/L	11	7	1	1.35	1.35	-	NA	-	-	-	3.9	3.9	-	-	3.9
p-Nitrotoluene	µg/L	11	7	1	0.139	0.139	-	NA	-	-	-	4.2	4.3	-	-	4.3
RDX	µg/L	11	7	0	-	-	-	NA	-	-	-	0.7	0.97	-	-	0.7
Tetryl	µg/L	11	7	1	0.416	0.416	-	NA	-	-	-	3.9	3.9	-	-	3.9
PAH-ANALYZED AS LOW-LEVEL PAH ONLY																
1-Methylnaphthalene	µg/L	11	4	2	3.81	22.1	-	NA	-	-	2	1.1	1.1	3.81	22.1	1.1
2-Methylnaphthalene	µg/L	11	4	2	0.997	9.4	-	NA	-	-	1	3.6	3.6	9.4	9.4	3.6
Acenaphthene	µg/L	11	4	2	0.783	1.17	-	NA	-	-	-	53	53	-	-	53
Acenaphthylene	µg/L	11	4	2	0.0972	0.352	-	NA	-	-	-	52	12	-	-	47
Anthracene	µg/L	11	4	2	0.0931	0.156	-	NA	-	-	-	180	180	-	-	180
Benzo(a)anthracene[d]	µg/L	11	4	2	0.025	0.0603	-	NA	-	-	1	0.030	0.030	0.0603	0.0603	0.030
Benzo(a)pyrene[d]	µg/L	11	4	0	-	-	-	NA	-	-	-	0.2	0.2	-	-	0.2
Benzo(b)fluoranthene[d]	µg/L	11	4	1	0.0563	0.0563	-	NA	-	-	-	0.25	0.25	-	-	0.25
Benzo(ghi)perylene	µg/L	11	4	0	-	-	-	NA	-	-	-	60	12	-	-	60

Attachment 1, Table G-3

Summary of Data Screening Process for Groundwater
RSA-271, RCRA Facility Investigation
Redstone Arsenal, Madison County, Alabama

Parameter	Unit	Total Samples Collected	Total Samples Analyzed	Detections	Min Value	Max Value	Detections Above Criteria	BSV[a]	Min Value	Max Value	Detections Above 2021 Criteria	2014 PSV[b]	2021 PSV[b]	Min Value	Max Value	2016 PSV[c]
Benzo(k)fluoranthene[d]	µg/L	11	4	0	-	-	-	NA	-	-	-	2.5	2.5	-	-	2.5
Chrysene[d]	µg/L	11	4	0	-	-	-	NA	-	-	-	25	25	-	-	25
Dibenz(a,h)anthracene[d]	µg/L	11	4	1	0.0272	0.0272	-	NA	-	-	1	0.025	0.025	0.0272	0.0272	0.025
Fluoranthene	µg/L	11	4	1	0.0858	0.0858	-	NA	-	-	-	80	80	-	-	80
Fluorene	µg/L	11	4	2	1.04	2.15	-	NA	-	-	-	29	29	-	-	29
Indeno(1,2,3-cd)pyrene[d]	µg/L	11	4	1	0.0382	0.0382	-	NA	-	-	-	0.25	0.25	-	-	0.25
Naphthalene	µg/L	11	4	2	1.04	7.31	-	NA	1.04	7.31	2	0.17	0.12	1.04	7.31	0.17
Phenanthrene	µg/L	11	4	2	0.128	1.68	-	NA	-	-	-	18	12	-	-	18
Pyrene	µg/L	11	4	2	0.0812	0.0837	-	NA	-	-	-	12	12	-	-	12
PERCHLORATE																
Perchlorate	µg/L	11	4	2	2.6	24.1	-	NA	24.1	24.1	1	15	15	24.1	24.1	15
SEMIVOLATILES WHICH INCLUDES LOW-LEVEL PAH ANALYSIS																
1-Methylnaphthalene	µg/L	11	7	4	8.9	21.6	-	NA	8.9	21.6	4	1.1	1.1	8.9	21.6	1.1
2,4,5-Trichlorophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	120	120	-	-	120
2,4,6-Trichlorophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	1.2	1.2	-	-	1.2
2,4-Dichlorophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	4.6	4.6	-	-	4.6
2,4-Dimethylphenol	µg/L	11	7	0	-	-	-	NA	-	-	-	36	36	-	-	36
2,4-Dinitrophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	3.9	3.9	-	-	3.9
2,4-Dinitrotoluene	µg/L	11	7	0	-	-	-	NA	-	-	-	0.11	0.11	-	-	0.11
2,6-Dinitrotoluene	µg/L	11	7	0	-	-	-	NA	-	-	-	0.11	0.11	-	-	0.11
2-Chloronaphthalene	µg/L	11	7	0	-	-	-	NA	-	-	-	75	75	-	-	75
2-Chlorophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	9.1	9.1	-	-	9.1
2-Methylnaphthalene	µg/L	11	7	4	1.77	18.2	-	NA	6.6	18.2	2	3.6	3.6	6.6	18.2	3.6
2-Methylphenol	µg/L	11	7	0	-	-	-	NA	-	-	-	93	93	-	-	93
2-Nitroaniline	µg/L	11	7	0	-	-	-	NA	-	-	-	19	19	-	-	19
2-Nitrophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	NA	NA	-	-	NA
3,3'-Dichlorobenzidine	µg/L	11	7	0	-	-	-	NA	-	-	-	0.12	0.13	-	-	0.13
3-Methylphenol and 4-Methylphenol	µg/L	11	3	0	-	-	-	NA	-	-	-	NA	93	-	-	NA
3-Nitroaniline	µg/L	11	7	0	-	-	-	NA	-	-	-	NA	NA	-	-	NA
4,6-Dinitro-2-methylphenol	µg/L	11	7	0	-	-	-	NA	-	-	-	0.15	0.15	-	-	0.15
4-Bromophenyl phenyl ether	µg/L	11	7	0	-	-	-	NA	-	-	-	NA	NA	-	-	NA
4-Chloro-3-methylphenol	µg/L	11	7	0	-	-	-	NA	-	-	-	140	140	-	-	140
4-Chloroaniline	µg/L	11	7	0	-	-	-	NA	-	-	-	0.36	0.37	-	-	0.37
4-Chlorophenyl phenyl ether	µg/L	11	7	0	-	-	-	NA	-	-	-	NA	NA	-	-	NA
4-Methylphenol	µg/L	11	4	0	-	-	-	NA	-	-	-	190	190	-	-	190
4-Nitroaniline	µg/L	11	7	0	-	-	-	NA	-	-	-	3.8	3.8	-	-	3.8
4-Nitrophenol	µg/L	11	7	0	-	-	-	NA	-	-	-	NA	NA	-	-	NA
Acenaphthene	µg/L	11	7	3	1.2	1.61	-	NA	-	-	-	53	53	-	-	53
Acenaphthylene	µg/L	11	7	0	-	-	-	NA	-	-	-	52	12	-	-	47
Anthracene	µg/L	11	7	1	0.13	0.13	-	NA	-	-	-	180	180	-	-	180
Benzo(a)anthracene[d]	µg/L	11	7	1	0.0955	0.0955	-	NA	0.0955	0.0955	1	0.030	0.030	0.0955	0.0955	0.030
Benzo(a)pyrene[d]	µg/L	11	7	1	0.0872	0.0872	-	NA	-	-	-	0.2	0.2	-	-	0.2
Benzo(b)fluoranthene[d]	µg/L	11	7	1	0.0992	0.0992	-	NA	-	-	-	0.25	0.25	-	-	0.25
Benzo(ghi)perylene	µg/L	11	7	1	0.0903	0.0903	-	NA	-	-	-	60	12	-	-	60
Benzo(k)fluoranthene[d]	µg/L	11	7	1	0.0913	0.0913	-	NA	-	-	-	2.5	2.5	-	-	2.5
bis(2-Chloroethoxy)methane	µg/L	11	7	0	-	-	-	NA	-	-	-	5.9	5.9	-	-	5.9
bis(2-Chloroethyl)ether	µg/L	11	7	0	-	-	-	NA	-	-	-	0.014	0.014	-	-	0.014
bis(2-Chloroisopropyl)ether	µg/L	11	7	0	-	-	-	NA	-	-	-	0.36	71	-	-	71
bis(2-Ethylhexyl)phthalate	µg/L	11	7	0	-	-	-	NA	-	-	-	6	6	-	-	6
Butyl benzyl phthalate	µg/L	11	7	0	-	-	-	NA	-	-	-	16	16	-	-	16
Carbazole	µg/L	11	7	1	1.69	1.69	-	NA	-	-	-	NA	NA	-	-	NA