RECORD OF DECISION FOR 600 HILL WASTE PIT (PICA-058/SITE 12 and PICA-013-R-01)

PICATINNY ARSENAL NEW JERSEY

Final **July 2019**

This page intentionally left blank.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	microgram(s) per liter
µg/m^3	microgram(s) per cubic meter
°F	degrees Fahrenheit
%	percent
AA	Area of Attainment
AECOM	AECOM Joint Venture
ANL	Argonne National Laboratory
AOC	Area of Concern
AOI	Area of Interest
ARAR	Applicable or Relevant and Appropriate Requirement
ARDEC	Armament Research, Development and Engineering Center
Army	United States Department of the Army
AWDF	Advanced Warhead Development Facility
bgs	below ground surface
CEA	Classification Exemption Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Identification System
CFR	Code of Federal Regulations
CN	chloroacetophenone
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CS	o-Chlorobenzylidenemalononitrile
cy	cubic yard
DCE	dichloroethene
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DMM	discarded military munition
DoD	Department of Defense
ECC	Environmental Chemical Corporation
EOD	Explosives Ordnance Disposal
ERA	Ecological Risk Assessment
ESP	Explosives Site Plan
ESS	Explosives Safety Submission
EVO	emulsified vegetable oil
FFA	Federal Facility Agreement

FS	Feasibility Study
ft	foot/feet
ft^2	square feet
GIS	Geographic Information System
GWSL	Groundwater Screening Level
GWQS	Groundwater Quality Standard
HA	Hazard Assessment
HHRA	Human Health Risk Assessment
HI	Hazard Index
ICFKE	ICF Kaiser Engineers, Inc.
IRP	Installation Restoration Program
ISCO	In-Situ Chemical Oxidation
IT	IT Corporation
J	Data qualifier, detected value is an estimate of the concentration
J&E Model	Johnson and Ettinger Vapor Intrusion Model
LOC	level of concern
LUC	Land use control
MC	munitions constituents
MD	munitions debris
MEC	munitions and explosives of concern
mg/kg	milligram(s) per kilogram
mm	millimeter(s)
MMRP	Military Munitions Response Program
MNA	Monitored Natural Attenuation
MRS	Munitions Response Site
msl	mean sea level
MTBE	methyl tertiary-butyl ether
NA	Not Available/Not Applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NPL	National Priorities List
NTCRA	Non-Time Critical Removal Action
O&M	Operation and maintenance
OSWER	Office of Solid Waste and Emergency Response

PAERAB	Picatinny Arsenal Environmental Restoration Advisory Board
PD	Point Detonating
Picatinny	Picatinny Arsenal
PID	photoionization detector
PP	Proposed Plan
ppm	part per million
PTW	Principal Threat Waste
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDX	Research Department Formula X (Cyclotrimethylenetrinitramine)
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SGSL	Soil Gas Screening Level
Shaw	Shaw Environmental, Inc.
SI	Site Investigation
SLERA	Screening-Level Ecological Risk Assessment
SRS	Soil Remediation Standard
SVOC	semivolatile organic compound
SWQC	surface water quality criteria
TBC	To-Be-Considered
TCE	trichloroethene
US	United States
USACE	U.S. Army Corps of Engineers
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
UU/UE	unlimited use/unrestricted exposure
UXO	unexploded ordnance
VI	Vapor Intrusion
VISL	Vapor Intrusion Screening Level
VOC	volatile organic compound
WES	Waterways Experiment Station
WESTON	Weston Solutions, Inc.
WRA	Well Restriction Area
WWI	World War I
WWII	World War II

This page intentionally left blank.

1.0 PART 1: DECLARATION

1.1 SITE NAME AND LOCATION

Picatinny Arsenal (Picatinny) formally designated as United States (US) Department of the Army (Army), Installation Management Command, Northeast Region, Garrison Office, is located in north central New Jersey in Morris County near the city of Dover (**Figure 1**). Picatinny was included on the National Priorities List (NPL) in March 1990 and assigned a Comprehensive Environmental Response, Compensation, and Liability Identification System (CERCLIS) number of NJ3210020704. The Army signed a Federal Facility Agreement (FFA) with the US Environmental Protection Agency (USEPA) in 1991.

This Record of Decision (ROD) addresses contaminated groundwater and the explosive hazards associated with the presence of Department of Defense (DoD) military munitions in the surface and subsurface soil at 600 Hill Waste Pit. The Site is the combined acreage of the 600 Area Groundwater Plume (PICA-058/Site 12) and the Inactive Munitions Waste Pit Munitions Response Site (MRS) (PICA-013-R-01), located in Dover, New Jersey (**Figure 1**). Generally, Picatinny sites have two numbers assigned to them. The "site" numbers are individual, unique identifiers for each site that were assigned during the Site Inspection (SI)/Remedial Investigation (RI) phase of work. The "PICA" numbers were assigned to individual sites or to groups of sites in order for the Army to track progress on environmental sites on a national basis in the Army Environmental Database. Picatinny sites geographic locations are also identified by their area.

To ensure that the areas with the greatest potential for environmental contamination were addressed first, the Army categorized the sixteen areas of the base into Areas, A (greatest potential) through P (least potential). These areas were delineated in the RI Concept Plan (Argonne National Laboratory [ANL], 1991). The Army further grouped these Areas into three phases, with Area A investigated separately. Phase I included Areas B though G, Phase II included Areas H through K, and Phase III included Areas L through P. Picatinny Arsenal RI Concept Plan Areas are shown on **Figure 1**.

The 600 Hill Waste Pit addressed in this ROD is comprised of the following two sites located in Area N, which are shown separately on **Figure 2**:

- The 600 Area Groundwater Plume (PICA-058), which covers the trichloroethene (TCE)-impacted groundwater in the vicinity of the Advanced Warhead Development Facility (AWDF). The plume encompasses approximately 28 acres. This site was investigated under the Army's Installation Restoration Program (IRP).
- The Inactive Munitions Waste Pit MRS (PICA-013-R-01), a 21-acre area that partially overlaps the area of the 600 Area Groundwater Plume (PICA-058) and determined to be the source of the TCE-impacted groundwater. The MRS encompasses the 0.24-acre Munitions Waste Pit (depicted on **Figure 2** as the extent of the waste material). This MRS was investigated under the Army's Military Munitions Response Program (MMRP).

The Site boundary for the 600 Hill Waste Pit is shown in **Figure 3** and the Site features are depicted in **Figure 4**.

1.2 STATEMENT OF BASIS AND PURPOSE

This ROD for 600 Hill Waste Pit presents the Selected Remedy for the site. The Selected Remedy was chosen by the Army, as the Lead Agency, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, Executive Order 12580, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as required by the Defense Environmental Restoration Program (DERP). The USEPA is the lead regulatory agency. The information supporting the decisions on the Selected Remedy presented in this ROD is contained in the Administrative Record for the site. The Administrative Record is available at the locations listed in **Section 2.3** of this ROD. The USEPA and New Jersey Department of Environmental Protection (NJDEP) concur with the Selected Remedy, as presented in the September 2018 Final Proposed Plan (PP) (Army, 2018). Copies of the concurrence letters are included in **Appendix A**.

1.3 ASSESSMENT OF THE SITE

The Selected Remedy presented in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment at 600 Hill Waste Pit. The Selected Remedy addresses contaminated groundwater and the explosive hazards associated with the presence of DoD military munitions, herein referred to as "*munitions*", (i.e., unexploded ordnance [UXO] and discarded military munitions [DMM]), evaluated by military explosive ordnance disposal (EOD) personnel or similarly qualified personnel and determined to pose an explosive hazard, are referred to as munitions and explosives of concern (MEC). The environmental media at 600 Hill Waste Pit was investigated under the Army's IRP and the munitions and munitions constituents (MC) were investigated under the Army's MMRP. The key findings of these investigations are summarized in this Section and presented in more detail in **Part 2** of this ROD.

Previous investigations at the 600 Hill Waste Pit (**Table 1**) indicate that TCE is present in groundwater and surface water at concentrations above the levels of concern (LOCs) at the 600 Hill Waste Pit. The configuration of the TCE-impacted groundwater plume (approximately 28 acres) is primarily centralized along the axis of a prominent bedrock fold within the 600 Area and follows the direction of the regional groundwater flow from the source area to the southeast (**Figure 4**). TCE concentrations in groundwater have been as high as 210 micrograms per liter (µg/L), exceeding the LOC (1 µg/L) between May 2005 and February 2011 southwest and downgradient of the source area of the munitions waste pit at monitoring well 13MW-2 (**Figure 5**). The TCE groundwater plume extends into the wetland areas along the northeast and southwest plume boundaries, where TCE is discharging to surface water (**Figure 6**). TCE concentrations in surface water have been detected as high as 14.0 µg/L in a sample (11SW-3) collected October 2007 within the wetland area located at the northeast plume boundary and has been historically reported at concentrations exceeding the LOC (1 µg/L).

The human health contaminants of potential concern (COPCs) were selected from the detected chemicals in groundwater and surface water that exceeded the appropriate LOC. These compounds were also screened using the results of the Human Health Risk Assessment (HHRA) and, where available, chemical-specific Applicable or Relevant and Appropriate Requirements

(ARARs). Based on this screening process, TCE was identified as the sole contaminant of concern (COC) for 600 Area groundwater (**Table 2**). No unacceptable human health or ecological risks were identified for exposure to 600 Area surface water, sediment, or soil.

The May 2012 trenching conducted within the source area (13TR1-1) for the 600 Hill Waste Pit reported TCE at a concentration of 23.9 milligrams per kilogram (mg/kg) in soil collected between 24 feet (ft) and 24.5 ft below ground surface (bgs), directly on top of bedrock (**Figure 7**). No constituents were reported in surface soil exceeding the LOCs and therefore surface soil is not identified as a media of concern. No HHRA was completed for sediment because the results of sediment sampling during the 1989 SI and in 2004 and 2006 identified no contaminants exceeding human health screening criteria, and therefore sediment is not a media of concern at the Site. One MEC item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), and munitions debris (MD) were encountered in subsurface soil during the source area investigations at the 600 Hill Waste Pit. The one MEC item, encountered at 4.5 ft bgs, was evaluated by EOD or similarly qualified personnel and determined to be MEC, and the majority of the MD was encountered between 10 and 20 ft bgs. Additional information on site characterization is provided in **Section 2.5** of this ROD.

1.4 DESCRIPTION OF THE SELECTED REMEDY

The Selected Remedy for TCE-impacted groundwater and the explosive hazards associated with munitions in the surface and subsurface soil at 600 Hill Waste Pit, pursuant to this ROD, is part of a comprehensive environmental investigation and remediation process currently being performed at Picatinny. Alternative 6 was selected over other remedial alternatives evaluated, because it provides the best combination of primary balancing criteria, is protective of human health and the environment, while meeting the CERCLA threshold criteria, as detailed in the Final Feasibility Study (FS) (ECC, 2017).

The Selected Remedy is **Alternative 6 – *Total Munitions Waste Pit Removal, TCE Source Material Removal, Monitored Natural Attenuation (MNA) Polishing, and Land Use Controls (LUCs)***. Alternative 6 consists of excavation and off-site disposal of the entire 0.24-acre Munitions Waste Pit, to include the TCE-contaminated source area soil, and the sidewall cutback area extending 50 feet from the limits of the excavation area (**Figure 8**) and land use controls (LUCs). The description of Alternative 6, as provided in this Section, describes the implementation of the Selected Remedy to achieve the Remedial Action Objectives (RAOs) based on the available site data and as was presented in the Final approved FS (ECC, 2017). The site-specific details of the Selected Remedy will be developed and presented in a Remedial Action Work Plan during the remedial design phase. All munitions and related MD encountered will be removed within the 0.24-acre excavation area. The remaining areas in Picatinny are being considered separately, and remedies for these areas are presented in separate documents.

1.4.1 Munitions Waste Pit and TCE Source Material Removal

The entire 0.24-acre Munitions Waste Pit, including the TCE-impacted soil will be excavated to an estimated depth of 20 to 25 ft bgs since it is acting as a source of groundwater contamination and incidental surface water impacts. Based on the source area investigations completed at the site, the volume of the material is expected to total approximately 9,526 cubic yards (cy),

including approximately 1,334 cy of TCE-contaminated soil. In addition, an estimated 16,200 cy of clean overburden, sidewall cutback soils, and stockpiled gravel and debris will need to be excavated and staged near the Site in order to facilitate the removal of TCE-contaminated soil. The total disturbed area is estimated to be approximately 42,000 square ft (ft^2), with an additional two acres needed for stockpiling, staging, and sorting munitions. During excavation of the waste pit, all material soil will be inspected for munitions and MD by qualified technicians in accordance with the inspection standards of the Department of Defense Explosives Safety Board (DDESB). It is assumed that the majority of munitions and MD will be located within the waste pit itself, at a depth of 20 to 25 ft within the disposal area, and not in the overlying or cutback material.

Following the excavation activities, post-excavation confirmatory soil samples will be collected from the sidewalls and bottom of the excavation. Confirmation sample locations will be biased toward locations and depths of the highest expected contamination, utilizing an organic vapor analyzer as a field indicator. The samples collected will be sent to an offsite laboratory for volatile organic compound (VOC) analysis. Sampling procedures outlined in the NJDEP *Technical Guidance for Site Investigation of Soil, Remedial Investigation of Soil, and Remedial Action Verification for Soil* (NJDEP, 2015) will be used for confirmation soil sampling. During the design phase, NJDEP Impact to Groundwater Guidance (NJDEP, 2008) will be used to determine the Impact to Groundwater Soil Remediation Standard (SRS) to be used during soil excavation for the protection of groundwater. The details regarding post-excavation confirmatory sampling will be included in the Remedial Action Work Plan and will be submitted for review and approval by the appropriate agencies prior to initiation of remedial activities.

Post-excavation confirmatory soil samples will be collected at a frequency of every 30 ft of sidewall and every 900 ft^2 of the excavation bottom, which is considered representative of post-excavation conditions. Bedrock is expected to be encountered at the base of the excavation in some areas, which will reduce the number of confirmation samples collected from the bottom of excavation. The excavation will be kept open while awaiting laboratory confirmatory results. If the results of one or more of the sidewall samples exceed the site-specific Impact to Groundwater SRS, additional soil will be excavated in the direction of the exceedance, and additional confirmatory samples subsequently collected until the analytical results are below the criteria. Details regarding the confirmatory sampling will be included in the Remedial Action Work Plan.

1.4.2 Soil Screening and Disposal

During the soil removal phase, a Spread and Scan Method will be used to screen and sort any MEC in the soil and excavated debris. This method generally includes the following:

a. UXO Technicians should sweep the surface and subsurface to a minimum of 6-inches prior to the first and subsequent 6-inch lifts. The UXO Technicians will then investigate all anomalies detected.
b. Upon completion of the UXO technician sweep and removal of surface and/or subsurface anomalies, the 6-inch lift is conducted.
c. Following the lift, the UXO technicians inspect the spoils removed during the 6-inch lift to confirm no additional MEC and/or MD has been collected in the spoils.

The cleared soil will then be removed by a loader and stockpiled for disposal. The process would repeat every six inches in depth until soil is excavated and cleared. The UXO Technicians will certify the screened soil is safe prior to being loaded into dump trucks and transported to off-site landfills (Resource Conservation and Recovery Act [RCRA] Subtitle C or D). The soil screening process will be detailed in the Remedial Action Work Plan and in the Explosives Safety Submission (ESS).

1.4.3 Munitions Inspection and Disposal

UXO Technicians will make every effort to identify the munitions encountered during the excavation through visual examination of items for markings and other identifying features such as shape, size, and external fittings. All MEC and MD identified at the site will be carefully cataloged and the location accurately recorded. Items will not be moved during the inspection/ identification until the nature and condition of the item can be ascertained. All MEC disposal activities will be performed in accordance with Engineer Manual-385-1-97 (USACE, 2008), in addition to Federal, State, and local regulations. All MEC will be subjected to demolition procedures, which will be conducted through blow-in-place operations or consolidated shots. If an item is safe to move, the item may be relocated for disposal due to safety concerns or to consolidate shots. Details regarding the confirmatory sampling will be included in the Remedial Action Work Plan.

1.4.4 Carbon Substrate Amendment Application

Following the excavation of the munitions waste pit, including the TCE-contaminated source area soil, a carbon substrate amendment will be added to the bottom of the open excavation to further enhance degradation of any residual TCE contamination within the saturated zone in the source area. The excavation will then be backfilled with clean fill from an approved off-post source, and clean overburden and sidewall cutback soil, to restore the area to the existing site contours. As was requested by NJDEP in their April 26, 2018 comment letter on the Preferred Alternative, the Army will obtain a NJDEP Discharge to Groundwater Permit-by-Rule Equivalent, through the CERCLA process documentation, such as the Remedial Action Work Plan, which will detail the discharge of the carbon substrate amendment to the groundwater within the open excavation, as required for the Selected Remedy (**Appendix A**).

1.4.5 Monitored Natural Attenuation Polishing

MNA of groundwater and surface water is included in the Selected Remedy as a polishing step, upon completion of the waste pit excavation and soil removal. MNA polishing will continue until the ARAR for TCE in groundwater (NJDEP Groundwater Quality Standards [GWQS] of 1 µg/L) is achieved and the comparison criteria for surface water will be based on the New Jersey Surface Water Quality Criteria (SWQC) of 1 µg/L for TCE. Surface water will be monitored until the groundwater achieves the cleanup goal for TCE. Although no RAOs were established for surface water, it is included in the Selected Remedy based on previous agreements reached between the USEPA and the Army regarding differing approaches to addressing contaminated groundwater and surface water at Mid-Valley Groundwater (PICA-204) (Army, 2012). In the Mid-Valley Dispute Resolution, the Army and USEPA agreed that the impact to surface water

was a secondary issue for which the Army agreed to monitor surface water as part of the remedy but did not recognize the surface water criteria as ARARs since there was no unacceptable risk from surface water (**Appendix B**). The groundwater Area of Attainment (AA) is the area throughout which the groundwater cleanup goal (1 µg/L for TCE) will be attained. The groundwater AA encompasses the TCE-impacted groundwater and surface water sampling area (**Figure 8).**

The MNA polishing will include the existing 20 on-site monitoring wells and the 10 surface water sampling locations (as shown in **Figures 5** and **6**). **Table 3** provides a summary of the well construction information of the on-site monitoring wells. Following the excavation, the on-site downgradient monitoring wells and surface water will be monitored. The length of time required for the groundwater and surface water monitoring may be modified once the remedy is implemented on the basis of the analytical results and in collaboration with the regulators. The MNA program will be detailed in the Remedial Action Work Plan for the 600 Hill Waste Pit and will be conducted in accordance with the NJDEP field sampling guidelines and protocol (NJDEP, 2005b).

1.4.6 Land Use Controls

The objective of the LUC component of the Selected Remedy is to safeguard human health. LUCs will achieve this objective by restricting access to hazards associated with munitions and to TCE in groundwater, surface water, and subsurface soil. **Figure 9** depicts the groundwater and munitions LUC boundaries. LUCs include restrictions on groundwater use and intrusive activities, and safety programs, some of which are currently in place at the 600 Hill Waste Pit and summarized in this section. LUCs also include annual inspections, as discussed in **Section 1.4.7.**

Picatinny also has internal Army measures in place as components of regular facility operations, which prevent unlimited use/unrestricted exposure (UU/UE). These internal measures include the following:

Site Clearance/Soil Management Procedures—Prior to all soil movement, the Picatinny Environmental Affairs Office must be notified and give approval.

UXO Clearance Procedures—Intrusive activities require a permit from the Picatinny Safety Office and are subject to Picatinny UXO Safety requirements. Construction support is required for any planned excavations. Identified UXO is handled in accordance with Picatinny UXO safety requirements.

Master Plan Regulations (Army Regulation 210-20)—Land use restrictions are memorialized in the Picatinny Arsenal Real Property Vision Plan (AECOM Joint Venture [AECOM], 2015).

Geographic Information System (GIS) Database—The GIS database contains a record of the Site location/boundaries, size, chemical analytical data (and screening criteria for the Site COCs), and any land use restrictions. The GIS database is used by the Environmental Affairs Office to administer procedures for site clearance and soil management.

Base Access Restrictions (Security)—The Base is surrounded by a fence and entrances are guarded 24 hours per day. The entire 600 Area lies entirely within the Robinson Enclosure, a secure part the Base, which has restricted access, a security system, and fence with a locked entrance gate.

Safety Programs—All contractors are required to attend safety training conducted by the Picatinny Safety Office.

Picatinny also has media-specific restrictions, including the base-wide New Jersey Department of Environmental Protection Classification Exception Area (CEA), which is an existing measure at Picatinny to guard against unauthorized use of groundwater. As part of the CEA, there is a Well Restriction Area (WRA), which establishes well installation and groundwater use restrictions with proper controls and authorization by the Army and NJDEP.

In addition, the Army has issued a Non-Time Critical Removal Action (NTCRA) Interim Land Use Control Plan, Picatinny Arsenal, specifically for the five MRSs, which include the Inactive Munitions Waste Pit (PICA-013-R-01) (Army, 2013). The interim Land Use Control Plan is currently in place and consists of interim measures for achieving the RAOs for explosive hazards and other risks from munitions.

The measures currently included in the NTCRA Interim LUC Plan will be incorporated into the final Selected Remedy and applied to the 21-acre Inactive Munitions Waste Pit MRS, which encompasses the 0.24-acre waste pit area (**Figure 8**). These LUCs include the following:

- Notification of intrusive activities and on-site UXO Clearance Procedures by UXO contractors for intrusive activities, per DoD 6055.09-M Volume 7.
- Safety program and UXO training prior to initiating any intrusive operations. All contractors are required to attend a safety and UXO briefing. Safety training also includes use of educational materials, such as a web-based UXO safety classes available to Arsenal personnel and UXO briefings, as applicable for site access. Educational programs will be tailored to the community needs and could include public meetings, distribution of fact sheets, exhibits, videos, and educational signage placed at the MRS (ECC, 2017; Army, 2013).

The Selected Remedy also includes the following additional LUC for vapor intrusion (VI) potential:

- Completion of an assessment for VI potential for any proposed future building construction at the Site.

The site-specific details of the VI assessments for future construction will be included in the Remedial Action Work Plan.

1.4.7 Land Use Control Inspections

Annual inspections are included in the Selected Remedy to ensure that LUCs remain in effect and are being properly implemented. The inspections will determine whether the fencing or

signage is uncompromised or in need of repair or replacement, whether the safety and UXO training programs are being properly implemented, and that the groundwater and surface water monitoring wells and sample areas within the AA are intact and accessible. In addition, the inspections will document whether erosion has exposed munitions to the surface (0 to 6 inches bgs). Following annual inspections and maintenance, one annual report will be completed describing the inspection results, needed maintenance or repairs, evaluation of erosion and potential migration of munitions, and assessment of the effectiveness of the administrative LUCs to prevent exposure and trespassing. The Army is responsible for implementing, maintaining, reporting on and enforcing LUCs.

1.5 STATUTORY DETERMINATIONS

The Selected Remedy for the 600 Hill Waste Pit site is protective of human health and the environment, complies with Federal and State requirements that are ARAR to the remedial action, is cost-effective, and uses permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The Army will remain responsible for ensuring that the Selected Remedy remains protective of human health and the environment. Because the Selected Remedy will result in hazardous substances, pollutants, or contaminants remaining on the site above levels that allow for UU/UE, the Army will conduct a statutory review within five years after initiation of the response action to ensure that the Selected Remedy is, or will be, protective of human health and the environment.

The Selected Remedy satisfies the chemical-specific cleanup levels and complies with the chemical-, action and location-specific ARARs as are presented in **Tables 4** through **6** in this ROD. The Selected Remedy will also meet the comparison criteria for surface water based on the New Jersey SWQC.

1.5.1 Five-Year Reviews

Alternative 6 will result in hazardous substances, pollutants or contaminants remaining on-site above levels that allow for UU/UE. Therefore, statutory reviews will be conducted every five years after the initiation of the remedial action, pursuant to CERCLA §121(c) and NCP §300.430(f)(5)(iii)(C). Five-year reviews will continue as long as contaminants remain onsite at concentrations greater than levels that allow for UU/UE.

In compliance with CERCLA and the NCP, Five-Year Reviews will be conducted as part of the Selected Remedy to evaluate the implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

1.6 DATA CERTIFICATION CHECKLIST

The following information is included in the Part 2: Decision Summary (**Section 2**) of this ROD. Additional information can be found in the Administrative Record for this site.

Criterion	Section/Table No.	Page No.
Contaminants of concern (COCs) and their respective concentrations	Section 2.5.2 and Table 2	2-6
Baseline risk represented by the contaminants of concern	Section 2.7/Table 9	2-13
Cleanup levels established for COCs and the basis for these levels	Section 2.7.4/Table 4	2-16
How source materials constituting principal threats will be addressed	Section 2.11	2-30
Current and reasonably anticipated future land use assumptions used in baseline risk assessment and Record of Decision (ROD)	Section 2.6	2-12
Potential land and groundwater use available as a result of the Selected Remedy	Section 2.12.3	2-32
Estimated capital, annual operation and maintenance (O&M) and total present worth costs, for the Selected Remedy	Section 2.12.2	2-32
Key factors leading to selection of Selected Remedy	Sections 2.10 and 2.12	2-26, 2-31

NA – Not Applicable

This page intentionally left blank.

1.7 AUTHORIZATION SIGNATURES

Isaac C. Manigault
Colonel, Commander
US Army Environmental Command

13 Sep 2019
Date

This page intentionally left blank.

10/31/19
Date

Pat Evangelista, Acting Director
Superfund and Emergency Management Division
United States Environmental Protection Agency, Region 2

This page intentionally left blank.

2.0 PART 2: DECISION SUMMARY

2.1 SITE NAME, LOCATION AND DESCRIPTION

The 600 Hill Waste Pit, (herein referred to as the "Site") is located on the grounds of Picatinny Arsenal in Rockaway Township, Morris County, New Jersey. Picatinny is an NPL site and is registered under CERCLIS number NJ3210020704.

The installation encompasses approximately 5,900-acres and is located about 40 miles west of New York City and four miles northeast of Dover, New Jersey. The Site location within Picatinny Arsenal is presented in **Figure 1**. The Site is a combination the following two areas (as shown in **Figure 2**):

- The 600 Area Groundwater Plume (PICA-058), which covers the TCE-impacted groundwater in the vicinity of AWDF. The plume area is approximately 28 acres.
- The Inactive Munitions Waste Pit MRS (PICA-013-R- 01), a 21-acre area that partially overlaps the area of the 600 Area Groundwater Plume (PICA-058) and identified as the source of the TCE-impacted groundwater in the 600 Area.

The total area of the 600 Hill Waste Pit site is approximately 44 acres (**Figure 3**).

2.2 SITE HISTORY

2.2.1 Picatinny Background

The US War Department established Picatinny in 1880 as a storage and powder depot. Later, the facility was expanded to assemble powder charges for cannons and to fill projectiles with maximite (a propellant). During World War I (WWI), Picatinny produced all sizes of projectiles. In the years following WWI, Picatinny began projectile melt-loading operations and began to manufacture pyrotechnic signals and flares on a production basis. During World War II (WWII), Picatinny produced artillery ammunition, bombs, high explosives, pyrotechnics, and other ordnance. After WWII, the installation's primary role became the research and engineering of new ordnance. However, during the Korean and Vietnam conflicts, Picatinny resumed the production and development of explosives, ammunition and mine systems.

In recent years, the mission of Picatinny Arsenal has shifted to conducting and managing research development, life-cycle engineering and support of other military weapons and weapon systems. The facility has responsibility for the research and development of armament items. The Base Realignment and Closure process in 2005 resulted in Picatinny being designated to remain open and to expand in mission.

The facility houses government-operated munitions research and development facilities, operational ranges for munitions testing, residential housing, and recreational facilities that include a golf course and water park. Picatinny will continue to be used for military research and development, industrial, residential housing and recreational activities (fishing, boating, hunting and golfing) in the foreseeable future. Picatinny is not closed to the public, but access is strictly controlled. Trespassing and unauthorized activities are illegal.

2.2.2 600 Area Background

The 600 Hill Waste Pit is located in the 600 Area, which has been investigated extensively under both the IRP and MMRP. The 600 Area is approximately 450 acres in size and lies on the northwest boundary of Picatinny in a remote portion of the Arsenal amidst several test ranges that are currently used by the military for research and development. The 600 Area is partially enclosed within the Robinson Enclosure, and access is restricted.

As shown in **Figure 3** the 600 Area overlaps into the northeastern portion of the Area of Interest (AOI) Code 300 Area (975 acres), which is an area once used as a former artillery firing and fragmentation pattern testing area for munitions as large as 155-millimeter (mm) projectiles. The 600 Area contains approximately 100 small structures associated with explosive testing activities that take place in this portion of Picatinny. Building 660 is the currently active AWDF located near the top of Green Pond Mountain. The AWDF was constructed in 1999 and became operational in 2000 to test experimental warheads in support of Armament Research, Development and Engineering Center's (ARDEC) research and development mission.

The Army has completed various studies in the 600 Area including the RI Concept Plan for Picatinny (U.S. Army Toxic and Hazardous Materials Agency [USATHAMA], 1991), which identified three RI sites in the 600 Area (**Figure 4**), as follows:

- Site 11 – Buildings 647, 649, and 650, Munitions Test Range
- Site 12 – Building 656, Munitions Waste Pit
- Site 13 – Building 640, Munitions/Pyrotechnics Test Area

Of these three sites identified, Site 12, the Munitions Waste Pit, identified as former investigation Area of Concern (AOC) 1 is the known source of the TCE plume (600 Hill Groundwater Plume [PICA-058]). Sites 11 and 13 are not part of the 600 Hill Waste Pit and are not discussed in this ROD. Both Site 11 and Site 13 were once part of the IRP back in the 1990s but were removed from the Program since they are ineligible as they are active ranges. The Munitions Waste Pit is approximately seven acres and is located approximately 700 ft north of the AWDF (Building 660) within the 600 Area. Previous investigations reported that steel armor plate, metal parts, and other metallic objects were disposed at Site 12 (Shaw Environmental, Inc. [Shaw], 2013). Interviews conducted of Picatinny personal during the ANL 1991 RI, reported that munitions testing was historically conducted at the Munitions Waste Pit. In 1989, Dames and Moore noted that static testing of explosives and propellants occurred at the Munitions Waste Pit (Site 12) (Dames and Moore, 1989).

Site investigations at the Munitions Waste Pit indicated that although no munitions or MD were observed, evidence of historical range activity was observed, and structures were observed such as a burn cage and gun turret (**Figure 4**). Additional investigations were recommended to determine whether munitions and/or MC-related contamination were present at the site (see **Section 2.2.3**).

Historically large amounts of blasted rock from the construction of Building 660 were deposited in the Munitions Waste Pit area beginning in the late-1990s. Based on review of aerial photographs, the more recent fill material was located immediately surrounding the burning cage

and to the south and west, where the drum and other debris are located (ECC, 2017). An inspection of the Site in 2005 encountered a partially buried drum and other canisters in the 1970-era filled areas, in addition to discarded light anti-tank weapon rocket tubes and 81- mm mortar shells. The maximum vertical extent of the late-1990s blasted rock fill exceeded 20 ft when it was in place. The blasted rock fill was removed between 2010 and 2011.

2.2.3 Site Investigations

Several investigations have been conducted within the 600 Hill Waste Pit and are listed in **Table 1**. The investigations were conducted within the 600 Area under IRP, as summarized in the *600 Area Data Report/Feasibility Study for 600 Area Groundwater Plume* (Shaw, 2013), and under the MMRP as summarized in the *Military Munitions Response Program Remedial Investigation for the Inactive Munitions Waste Pit MRS (PICA-013- R-01)* (Weston Solutions, Inc. [WESTON], 2014). The various investigations conducted under both Army programs are summarized in **Table 1**.

2.2.4 Enforcement Activities

No formal enforcement activities have been conducted for the 600 Hill Waste Pit site. Picatinny is working in cooperation with the USEPA and the NJDEP to apply an appropriate remedy to the 600 Hill Waste Pit site that will preclude the necessity of formalized enforcement actions, such as Notices of Violation.

2.3 COMMUNITY PARTICIPATION

The site addressed in this ROD has been the topic of presentations at the Picatinny Arsenal Environmental Restoration Advisory Board (PAERAB). PAERAB members have provided comments regarding the Selected Remedy. A copy of the *Final Proposed Plan for 600 Hill Waste Pit (600 Area Groundwater Plume [PICA-058/Site 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01])* (Army, 2018) was given to the PAERAB's co-chair, and a copy was offered to all PAERAB members. The Final 600 Hill Waste Pit PP was completed and released to the public on September 10, 2018 at the information repositories listed below:

Installation Restoration Program Office
Building 319
Picatinny Arsenal, New Jersey 07806

Morris County Library
30 East Hanover Avenue
Whippany, New Jersey 07981

Rockaway Township Library
61 Mount Hope Road
Rockaway Township, New Jersey 07866

An electronic version of the document has also been placed on the Picatinny Environmental Restoration web page at: ***https://www.pica.army.mil/envRestore/PublicNotice.aspx***

Multiple newspaper notifications were made to inform the public of the start of the PP comment period, to solicit comments from the public, and to announce the public meeting. The

notification was placed in *The Daily Record* (September 7, 2018), *The Star Ledger* (September 10, 2018) and *The Picatinny Voice* (September 14, 2018). Copies of the certificates of publication are provided in **Appendix C.** The Army held a public meeting on September 26, 2018 to inform the attendees of the remedial alternatives considered and the Preferred Alternative for the 600 Hill Waste Pit, and to seek comments on the remedy. At this meeting, representatives from the Army, NJDEP, USEPA, and the Army's contractor, ECC, were present to answer questions about the Site and the Preferred Alternative under consideration. Following the public meeting, a 30-day public comment period was held from September 26, 2018 to October 25, 2018 during which written comments were received from the public. Public comments and prepared responses from the public meeting are presented in **Section 3.0** of this ROD.

2.4 SCOPE AND ROLE OF SELECTED REMEDY

This ROD addresses the Selected Remedy for the TCE-impacted groundwater and the explosive hazards associated with munitions in the surface and subsurface soil at 600 Hill Waste Pit. The Selected Remedy addresses TCE in groundwater, which was identified as the COC during previous investigations conducted at the Site within the 600 Area (**Table 1**). The Selected Remedy (***Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing and LUCs***) is designed to provide protection to human health for both the current and reasonably anticipated future site uses (i.e., military/industrial and recreational) and to the environment. The COCs at the Site are discussed in detail in **Section 2.7.4**.

The Selected Remedy is a combination of actions that address the TCE in groundwater and surface water in the 600 Area, through the removal of the TCE-impacted soil in the source area. Confirmatory soil sampling will be completed of the limits of excavation and a carbon substrate amendment will be applied to the excavation to enhance degradation of any residual TCE-contamination in the source area, prior to back filling with clean fill material from a pre-approved location. To address the munitions with the 600 Hill Waste Pit, all munitions will be removed if encountered within the 0.24-acre Munitions Waste Pit. Soil screening will be conducted in areas where munitions and MD, or significant quantities of cultural debris (drums, vehicles, materials potentially presenting an explosives hazard, etc.) are encountered.

MNA of groundwater and surface water in the 600 Area is included in the Selected Remedy as a polishing step upon completion of the removal of the waste pit and the collocated TCE-contaminated source area soil and would continue until the TCE remediation goal for groundwater (NJDEP GWQS 1 µg/L) is achieved. Alternative 6 includes the implementation of LUCs for groundwater use with the groundwater AA and to address the explosive hazards and the risks from munitions within the MRS, as previous detailed in **Section 1.4.**

The Selected Remedy also involves performing any site maintenance required to maintain the protectiveness. The LUCs and any maintenance that will be implemented by the Army will be detailed in the Remedial Action Work Plan. The Army is the Lead Agency for this response action and has the primary responsibility for coordinating the implementation of the Selected Remedy under CERCLA.

2.5 SITE CHARACTERISTICS

2.5.1 Physical Characteristics

2.5.1.1 Size, Topography and Geology/Hydrogeology

Picatinny consists of approximately 5,900 acres of improved and unimproved property. Picatinny is located in an elongated, U-shaped valley between Green Pond Mountain and Copperas Mountain to the northwest and an unnamed hill to the southeast. Most of the buildings and other facilities at Picatinny are located on the valley floor or on the slopes along the southeast side of the property. Several firing and testing ranges are located on Green Pond Mountain.

Picatinny lies within Green Pond Valley, a glaciated river valley bounded by Green Pond Mountain to the northwest and Copperas Mountain to the southeast. Elevations at Picatinny range from approximately 1,000 ft above mean sea level (msl) to 700 ft above msl at Green Pond Brook at the southern boundary. Green Pond Valley is filled with a thin layer of soil and glacially derived sediments underlain by bedrock, which is a massive-bedded pebble conglomerate and sandstone known as the Green Pond Conglomerate. The bedrock is faulted by a series of steeply dipping northeast/southwest trending faults.

The principal source of groundwater in the Green Pond Valley is the glacial deposits filling the valley floor. The low-permeability and the steep slopes of Green Pond Mountain and Copperas Mountain restrict infiltration of precipitation in these mountains. As a result, most precipitation flows overland and into the permeable valley glacial fill deposits in the valley center. The small amount of precipitation that enters Green Pond and Copperas Mountains flows down through shallow fractures to the glacial sediments in the valley. Four separate aquifers have been identified beneath Picatinny. The aquifers include an unconfined glacial aquifer, an upper semi-confined glacial aquifer, a lower semi-confined glacial aquifer and a dolomitic bedrock aquifer (Dames and Moore, 1989, 1991 and 1998). Groundwater beneath Picatinny is classified as Class IIA, which is potable water or water potable after conventional treatment.

2.5.1.2 Surface Water

600 Area drainage features and wetlands are shown on **Figure 6**. Upland 600 Area drainage is toward the southwest, where surface runoff is captured by a string of northeast-southwest trending wetlands, ponds and drainages. Drainage features include a small spring fed pond located at Site 11 (near Building 650) in northeast portion of the 600 Area, which discharges to a culvert under the test range and into an unnamed stream. The unnamed stream flows southwest into a 0.46-acre wetland (located near Building 647), mapped by the US Army Corps of Engineers (USACE) Water Experiment Station (WES) in 1994. This wetland also receives runoff from a portion of the AWDF (Building 660) as well as seasonal spring(s) located to the northwest of the wetland. The unnamed stream gains substantial flow volume from its origin at the pond to the discharge structure under Bear Swamp Road. This perennial stream discharges to Picatinny Lake.

A second wetland area is mapped in Site 13 (located southwest of Building 660) and receives runoff via a culvert and drainage ditch from the western portion of the AWDF. This wetland is

at least seasonally spring fed, since the discharge stream flows during dry weather. The Site 13 wetland area totals 2.84 acres (WES, 1994), and is mapped as part man made (1.51 acres) and red maple (1.33 acres). Discharge from the wetland is seasonal, although water is retained year-round in a small wetland pond. The wetland stream discharges to a culvert under Bear Swamp Road, and into Picatinny Lake.

2.5.1.3 Climate

Northern New Jersey has a continental temperate climate controlled by weather patterns from the continental interior. Prevailing winds blow from the northwest from October to April and from the southwest from May to September. The average monthly temperature ranges from a high of about 72 degrees Fahrenheit (°F) in July to a low of about 27°F in January and February. The average date of the last freeze is May 2, and the average date of the first freeze is October 8. Average annual precipitation at the Boonton monitoring station located approximately five miles east of Picatinny is 48 inches and is evenly distributed throughout the year.

2.5.2 Summary of Site Information

The information presented in this section is presented in more detail in the Final FS (ECC, 2017) and the other investigations and studies conducted at the 600 Hill Waste Pit, as listed in **Table 1**.

2.5.2.1 600 Area Groundwater Plume Source Area

As discussed, **Section 2.2.2**, the source of TCE comprising the 600 Area Groundwater Plume in bedrock is the leaching of impacted soils/fill associated with the 1970s debris disposal activity in Munitions Waste Pit (i.e., Site 12). This finding is supported by the presence of crushed drums seen in the fill material during test pit excavations (at least one of which was labeled as containing TCE), soil gas results and the detection of TCE in monitoring well 13MW-1, immediately downgradient of the 1970s fill material. After its installation in 1994, initial sampling of the AWDF well (labeled in **Figure 4**) resulted in the detection of TCE at 1.3 µg/L. As a result, bottled water was provided for drinking and a water treatment system was installed for non-potable uses such as flushing toilets and fire suppression. The AWDF has since been connected to the base water supply system; therefore, the treatment system is no longer in use. The AWDF well is a 430 ft deep open borehole well and is retained for use only as a groundwater monitoring well.

Increases in TCE concentrations at the AWDF well were reported in 2000 (39 µg/L), 2002 (82 µg/L) and 2003 (110 µg/L). However, it was unclear whether the fluctuations in the elevated TCE concentrations detected after that time (ranging from 58 µg/L in October 2007 to 120 µg/L in March 2007) reflect the migration of an incipient TCE plume or capture of existing side gradient plumes(s) via pumping. The wide lateral extent and depth of the current plume indicate that TCE is dispersed within the bedrock aquifer and suggest that the plume would have migrated within a broad front toward the AWDF well (ECC, 2017).

Generally, the configuration of the TCE-impacted groundwater plume (approximately 28 acres) is centralized following the surface axis of a prominent bedrock fold, which is located along the length of the 600 Area (**Figure 4**). The plume discharges into the 0.46-acre wetland area located along the northeast plume boundary (near Building 647) and the larger wetland area located

southwest of Building 660, as shown in **Figure 4**. The groundwater TCE plume from the source follows the direction of the regional groundwater flow from the source area to the southeast, but upon encountering the bedrock fold, which trends northeast/southwest, the plume migrates along the preferential flow pathways, following the surface axis of the bedrock fold (ECC, 2017; Shaw, 2013).

2.5.2.2 Source Area Investigation Findings

Several investigations have been conducted in the 600 Area to investigate the groundwater contamination, as listed in **Table 1**. A source area investigation was conducted in the Munitions Waste Pit in June 2011 and May 2012 to further investigate the source for the 600 Area TCE groundwater plume (Shaw, 2013). Four objectives were established for the source area investigation: (1) determine if an active source of TCE is present (fill earth or containers); (2) determine the thickness of the 1970s fill; (3) determine the presence or absence of contamination other than VOCs; and (4) determine the size of the TCE source area (if identified). Test pit and trenching activities were conducted during this investigation within the former testing area at the center of the Munitions Waste Pit (Shaw, 2010b).

Two 10-ft by 10-ft test pits were completed at isolated detections of TCE in site soil gas, and two additional cross trenches were planned. However, while excavating the trench (TR2) in June 2011, UXO Technicians encountered a MEC item at a depth of approximately 4.5 ft bgs (Shaw, 2013). The item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), was identified as potentially explosive and excavation trenching activities ceased immediately. Numerous MD was also encountered including an expended M72 Rocket Launcher for 66-mm (light anti-tank weapon) rockets, chloroacetophenone/o-chlorobenzylidenemalononitrile (CN/CS) tear gas canisters (inert), expended 40-mm grenade cartridge cases, an exploded XM31 antitank landmine, 155-mm fragments, expended MK45 aircraft flare and expended Point Detonating (PD) fuzes (Shaw, 2013). **Figure 7** shows the locations of the one MEC item and the MD discovered during the source area investigation at the Munitions Waste Pit. The specific items encountered within the source area are listed in **Table 7.**

After completion of an Explosives Site Plan (ESP) in December 2011, the Army continued the source area investigation in May 2012, and additional trenching was completed throughout the source area (Army, 2011). Trenching continued and extended into clean native soil or top of bedrock, to a final depth of 24.5 ft bgs terminating at the bedrock interface (Shaw, 2013). During the investigation, multiple drums and significant quantities of MD were excavated from the 10-ft to 20-ft bgs interval within the source area of the Munitions Waste Pit. All of the drums were crushed, exhibited no photoionization detector (PID) response, and contained no free phase liquid. A label on one of the excavated drums clearly identified its former contents as TCE. Soil in the 20-ft to 24.5-ft bgs interval exhibited PID responses from 700 to 1,000 parts per million (ppm) total VOCs, with the highest PID reading from soil collected directly on top of bedrock. A soil sample was collected from the trench (13TR1-1) at a depth of 24-ft to 24.5 ft bgs and contained TCE at 23.9 mg/kg (**Figure 7**).

2.5.2.3 Summary of Environmental Media

Groundwater

Figure 5 shows historical sampling locations and the constituents reported in groundwater between April 2004 and February 2011 (Shaw, 2013). A total of four VOCs and one explosive compound (research department formula X, cyclotrimethylenetrinitramine [RDX]) have historically exceeded applicable LOCs. The constituents reported were further evaluated in the HHRA. The compounds reported in groundwater at concentrations exceeding their respective LOCs are as follows:

- 1,2-Dichloroethane
- Methyl tertiary-butyl ether (MTBE)
- RDX
- 1,1,2,2-Tetrachloroethane
- TCE

As shown in **Figure 5**, the highest TCE concentrations (up to 210 µg/L, exceeding the LOC of 1 µg/L) were detected between June 2006 and February 2011 at well 13MW-2 located southwest and downgradient of the source area of the munitions waste pit. The next highest TCE concentrations (up to 170 µg/L) were reported between May 2005 and May 2010 at well 13MW-1, just south of the munitions waste disposal area. The vertical extent of TCE contamination has been investigated through packer testing completed on the site wells, which indicated that the maximum TCE concentration (71.0 µg/L) at the AWDF bedrock well is at 140 to 160 ft bgs and declines with depth to 11.0 µg/L at 416 to 436 ft bgs (Shaw, 2013 and ECC, 2017).

RDX was detected in several groundwater samples at concentrations exceeding the NJDEP Interim GWQS (0.50 µg/L). An additional investigation was conducted to determine the potential source of RDX within the 600 Area in 2008. The results of the RDX investigation were presented in the *600 Area RDX Investigation Data Report* (Shaw, 2009), and No Further Action (NFA) was recommended. NJDEP and USEPA approved the *RDX Investigation Data Report* and agreed to the NFA recommendation for RDX in groundwater.

An MNA assessment of the TCE Plume was conducted during a previous investigation of the 600 Area Groundwater. As detailed in the Final FS for the 600 Hill Waste Pit, the MNA Assessment indicated evidence of degradation of TCE in the aquifer (Shaw, 2013; ECC, 2017). Overall, the groundwater results from samples collected between 2004 and 2011 in the 600 Area indicate low frequency of detections of daughter products cis-1,2-DCE, vinyl chloride, and ethane. The infrequent detection of cis-1,2-DCE and ethene in TCE-impacted wells indicates limited anaerobic degradation. The observed limited/incomplete degradation of TCE is consistent with the overall slightly reducing conditions in the aquifer (ECC, 2017). Groundwater modeling has been completed and included in the Final FS, which uses the hypothetical leaching rate of TCE to predict the length of time required for concentrations to reach the cleanup goal in groundwater through natural attenuation (ECC, 2017 [Appendix D]).

Surface Water

600 Area drainage features and wetlands are shown on **Figure 6** and discussed in **Section 2.5.1.2**. Surface water samples have been collected from the unnamed tributary, the two wetland areas, and surface water within the 600 Area and analyzed for VOCs, RDX and MTBE. TCE was detected at one sample location (11SW-3) on multiple occasions, at concentrations ranging from 2.8 µg/L (November 2006) to 14.0 µg/L (October 2007). TCE was also detected in a downgradient sample at 2.2 µg/L in 13SW-6 (January 2006). As shown in **Figure 6**, surface water data collected in January 2011 indicate the 600 Area TCE groundwater plume extends into the wetland areas adjacent to sample locations 11SW-3 (located along the northeast plume boundary) and 13SW-4 (located along the southwest plume boundary). Surface water samples collected from these locations between June 2005 and January 2011 indicate that the TCE plume is discharging to surface water in these wetland areas.

Sediment

As shown in **Figure 6**, two sediment samples were collected during the 1989 SI (Dames and Moore, 1989) at the Munitions Waste Pit. The two samples (SD12-1 and SD-12-2) were analyzed for propellants, metals, and explosives. There were no reported exceedances in one sample (SD12-2), and mercury was reported in the other sample (SD12-1) at a concentration of 0.266 mg/kg, which is slightly above the NJDEP criteria (0.15 mg/kg) and slightly above the background value of 0.246 mg/kg for sediment (IT Corporation [IT], 2002). No other VOCs were detected at concentrations exceeding LOCs; therefore, a risk assessment was not warranted for sediment.

Soil

As shown in **Figure 7,** four surface soil samples (0.5 to 1 ft bgs) were collected during the 1989 SI (Dames and Moore, 1989) at the Munitions Waste Pit (Site 12). The samples were analyzed for propellants, metals and explosives. Two surface soil samples (SS12-1 and SS12-2) were collected around the perimeter of the metal burn cage, used for former testing activities (**Figure 7**) and two samples (SS12-3 and SS12-4) were collected from other areas exhibiting evidence of testing activities. Nitroglycerine and other explosives were detected in three of the four surface soil samples (SS12-2, SS12-3 and SS12-4), with 2,4-dinitrotoluene and nitroglycerin reported in one sample (SS12-2) at concentrations slightly exceeding the NJDEP Non-Residential SRS. All other detections of explosives were below standards, and explosives in surface soil were therefore determined to be insignificant. Metals were detected in all four surface soil samples and were attributed to past activities conducted outside the metal burn cage, other testing activities, or the possible decay of metal debris present at the Site (Dames and Moore, 1989). However, all metals concentrations were below the NJDEP Non-Residential SRSs.

During the 2011 to 2012 source area investigation (Shaw, 2013), shallow subsurface soil samples were collected from the test pits (13TP-1 and 13TP-2) between 1 and 1.5 ft bgs and test trenches (13TR1-1 and 13TR2-1) between 1 and 1.5 ft bgs completed in the source area. These shallow subsurface soil samples were analyzed for VOCs as shown in **Figure 7**. Two samples 13TP-1 and 13TR2-1 were also analyzed for metals, explosives, and semivolatile organic compounds (SVOCs). Benzo(a)pyrene was detected in one test pit soil sample (13TP-1) at an estimated concentration of 0.601 J mg/kg, which at the time of the writing of the 2017 FS, slightly exceeded the NJDEP Non-Residential SRS and the USEPA Industrial Regional

Screening Level (RSL). However, in September 2017 the NJDEP SRS was updated from 0.2 mg/kg to 2.0 mg/kg and the USEPA RSL was updated in June 2017 from 0.21 mg/kg to 2.1 mg/kg. Therefore, the reported concentration of benzo(a)pyrene is shown on **Figure 7** only as reference for consistency with the FS, since the concentration no longer exceeds the applicable screening criteria.

Nine additional subsurface soil samples were collected during the June 2011 and May 2012 source area investigation, as shown on **Figure 7** (Shaw, 2013). All samples were analyzed for VOCs. Five samples were also analyzed for explosives, metals, and SVOCs. The results of the source area investigation within the Munitions Waste Pit boundaries are shown in **Figure 7**. TCE was reported in subsurface soil during the trenching investigation in the source area conducted in May 2012 (13TR1-1) between 24 ft and 24.5 ft bgs at a concentration of 23.9 mg/kg, which is above the NJDEP Non-Residential SRS and USEPA Industrial Soil RSL. There were no explosives detected in subsurface soils, and detected metals were at concentrations below the NJDEP Non-Residential SRS, USEPA RSLs and/or established background. Notably, as further discussed under **Section 2.7.1.1** of this ROD, although the reported concentrations of contaminants in soil at the Site did not trigger the need for a risk assessment, the TCE-impacted soil, reported between 24 ft and 24.5 ft bgs within the source area, presents a potential impact to groundwater due to the leaching through the waste pit. Therefore, contaminated soil beneath the waste pit is addressed in the Selected Remedy for this site.

Vapor Intrusion

As part of the source area investigations within the Munitions Waste Pit, a VI investigation was conducted in the spring of 2011. VI at the AWDF Building 660 was evaluated through the collection of near-slab soil gas samples and indoor air samples to investigate the potential for VI from the TCE groundwater plume (Shaw, 2010b). "Near-slab" soil gas samples were collected in lieu of "subslab" soil gas samples, based on the review of the as-built drawings for Building 660, which indicated a minimum concrete foundation thickness of 20 inches with many areas significantly in excess of that value, as well as presence of a vapor barrier surrounding the foundation. In addition, the building foundation was constructed directly on top of bedrock, minimizing the possibility of the presence of a vapor collection area facilitating sub-slab soil gas sampling (Shaw, 2011).

VI was determined to be a potential concern at Building 660, as the building footprint (covering approximately 23,000 ft^2) overlies the 600 Area TCE plume, between source area well 13MW-1 and the AWDF (Building 660) well. The potential for VI to enter into buildings was evaluated in accordance with the DoD, NJDEP and USEPA protocols (DoD, 2009; NJDEP, 2005a and USEPA, 2002). The findings of this VI investigation were summarized in the *Building 660 VI Investigation Report* (Shaw, 2011). However, since the USEPA VI Guidance was updated in 2015, (USEPA, 2015), the VI data was re-evaluated using the current criteria and was included in the Final FS (ECC, 2017). The results were as follows:

- *Near-slab Sampling Results*-TCE was detected in soil gas in only one of three near-slab soil gas samples at a concentration of 17 micrograms per cubic meter ($\mu g/m^3$), below both the NJDEP Non-Residential Soil Gas Screening Level (SGSL) of 27 $\mu g/m^3$ and the USEPA commercial Vapor Intrusion Screening Level (VISL) level of 100 $\mu g/m^3$. In addition, the TCE daughter product trans-1,2-dichloroethene (DCE) was detected at a

concentration of 8 $\mu g/m^3$, below the NJDEP Non-Residential SGSL of 5,100 $\mu g/m^3$. There is no USEPA VISL value for this compound. All other detected VOCs were below both the NJDEP and USEPA VISLs.

- *Indoor Air Sampling Results*- Neither TCE nor its daughter products (1,2-DCE [cis] or vinyl chloride) were detected in the four indoor air samples. Low-levels of other VOCs were detected at concentrations well below the applicable screening levels (NJDEP non-residential SGSL and USEPA commercial VISL values). Benzene was detected in one sample at 3 $\mu g/m^3$, exceeding both the NJDEP criteria of 2.0 $\mu g/m^3$ and the USEPA criteria of 1.6 $\mu g/m^3$. However, benzene is not associated with the 600 Area Groundwater Plume and is considered attributable to building operations.

The potential future risks and hazard from VI of VOCs in 600 Area groundwater is within acceptable risk range and VI is not a concern at AWDF Building 660. However, it was recommended in the 2011 VI Assessment that any future construction of buildings in the 600 Area should be assessed for VI concerns (Shaw, 2011).

2.5.2.4 Summary of Munitions and Explosive of Concern and Munition Constituents

An SI was completed at the 600 Hill Waste Pit (as the Inactive Munitions Waste Pit MRS) under the MMRP in July 2007 (Malcom Pirnie, Inc., 2008). As shown in **Figure 2**, the Inactive Munitions Waste Pit MRS was initially a circle; however, for the SI it was separated into on-post (PICA-013- R-01) and off-post (PICA-014-R-01) portions. Additionally, other portions of the PICA-013-R-01 MRS were deemed ineligible for the MMRP due to their use as operational range areas. These factors resulted in the current MRS boundary. Although no munitions or MD were observed during the SI fieldwork, evidence of historical range activity was observed, including structures such as a burn cage and gun turret (**Figure 4**). As a result, an RI/FS was recommended at the MRS to determine whether munitions and/or MC-related contamination were present at the site. The MMRP RI for 600 Hill Waste Pit was completed between 2012 and 2013 (WESTON, 2014).

During the RI in January 2012, the Army completed digital geophysical mapping (DGM) transect surveys over the central portion of the Inactive Munitions Waste Pit MRS to detect subsurface anomalies and determine lateral and vertical extent of the waste pit (**Figure 10**). Based on a total of 6,163 linear ft of DGM transects surveys, the munitions waste pit area is estimated to extend laterally over 0.24 acres (10,498 ft^2) and vertically from ground surface down to bedrock, at approximately 24.5 ft bgs. Assuming an even distribution of buried fill material, the approximate volume of the waste pit has been estimated at 9,526 cy of fill material with debris, containing at least one MEC item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), and numerous MD (WESTON, 2014). Although a small portion of the AOI Code 300 Area (**Figure 3**) overlaps the MRS, no 155-mm projectiles from testing at the 300 Area were identified within the 600 Area. MD was recovered at ground surface from the portion of the MRS that overlaps with the AOI Code 300 Area only (WESTON, 2014).

Based on findings of the RI, the bulk of buried debris containing munitions is located from 10 to 20 ft bgs, although one MEC item was encountered within the Munitions Waste Pit at 4.5 ft bgs and numerous MD was encountered, as listed in **Table** 7.

Munitions Constituents

As discussed above, soil samples were collected and analyzed for MC-related contamination during the trenching activities as part of the source area investigation. The soil samples (IMWP-002, IMWP-003 and IMWP-004) were collected from observed areas of contamination, such as below a drum containing MD and below leaking fluids (**Figure 10**). As part of the MMRP RI, these analytical soil sampling results were further evaluated (WESTON, 2014) to determine if any MC-related COPCs or contaminants of potential ecological concern (COPECs) were present and warranted a quantitative risk assessment. No COPCs or COPECs were identified in soil and no quantitative risk assessment was performed.

DoD Military Munitions Hazards

During the June 2011 intrusive source area investigation conducted under the Army's IRP, one MEC item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), and MD were encountered at the 600 Hill Waste Pit (**Table 7**).

The bulk source for munitions and MD was encountered approximately 10 to 20 ft bgs within the waste pit. However, MD was encountered within the waste pit and one MEC item was discovered at approximately 4.5 ft bgs within the 600 Hill Waste Pit. Surface MEC exposure pathways are not anticipated to be present to human receptors, given that MEC and MD was not detected above the frost line (3 ft bgs), where environmental factors (e.g., frost) may bring subsurface munitions to the surface. Impact and/or displacement through human activities (e.g., intrusive activities) are considered the only potential factor that could expose human receptors to explosive hazards (MEC) suspected to exist within the waste pit (WESTON, 2014; ECC, 2017).

2.6 CURRENT AND POTENTIAL FUTURE LAND USE

The Picatinny Arsenal Real Property Vision Plan (AECOM, 2015) designates future use of the area encompassing the 600 Hill Waste Pit (Area N) consistent with its current use as a secured military and industrial operations area, where access is restricted to on-site research workers, other authorized personnel and limited recreational users (hunters). At this time, the current and foreseeable future users are considered to consist of authorized Picatinny personnel, contractors, visitors (e.g., regulatory personnel) and occasional recreational users (hunters). Unauthorized trespassers are highly unlikely, given the controlled access to the site. The 600 Hill Waste Pit is a restricted access area, as it is fully fenced by the Robinson Enclosure and abuts operational range areas to the east, west, and south. The installation boundary forms the northwestern extent of the Site.

Internal Army measures include fencing, guarded access points, warning signage for explosive hazards, pre-authorization requirements for access and escorts for visitors in the restricted area. The current access restrictions are not anticipated to change in the future, and the 600 Hill Waste Pit is not currently included in any future overall redevelopment plans for Picatinny because of its proximity to operational range areas, although plans could change in the future. Future military housing is unlikely in the 600 Area due to long-term projected range operation. Initially the preferred remedy for the 600 Hill Waste Pit was LUCs; however, upon further discussions with Picatinny leadership, Alternative 6 was selected since the Site was identified as a prime building area and it was preferred that the area remain available for use in the future.

2.7 SUMMARY OF SITE RISKS

This section provides a summary of the risk and hazard assessments completed for the 600 Hill Waste Pit. The estimated human health risk and hazards from 600 area groundwater, surface water, and vapor intrusion from in-situ groundwater to Building 660 are summarized in **Table 8**. An ecological risk assessment (ERA) for surface water and a MEC Hazard Assessment (HA) for the 600 Area were also completed for the 600 Hill Waste Pit and are summarized in this section.

No HHRA was conducted for sediment because the results of sediment sampling at the 600 Area identified no contaminants exceeding human health screening criteria. No HHRA was completed under the IRP investigations for soil since no COPCs were identified in the surface or subsurface soil and the TCE reported in soil (23.9 mg/kg) at 24 ft bgs did not constitute a complete exposure pathway (Shaw, 2013; ECC, 2017). Likewise, no COPCs were identified in soil under the MMRP using all available site soil data and therefore no quantitative risk assessment was performed as part of the MMRP RI (WESTON, 2014). All MC-related contamination pathways to potential receptors at the Site were determined to be incomplete.

2.7.1 Human Health Risks

2.7.1.1 Groundwater

Risks to anticipated current and future receptors (industrial research worker and construction excavation worker) were evaluated for groundwater in the HHRA. A military residential scenario was not evaluated because the 600 Area is located in a secure part of Picatinny and is restricted to on-site research workers and construction excavation workers. Future military housing is unlikely in the 600 Area due to the long-term projected range operations. The estimated cancer risks and non-cancer hazards were quantified for exposure scenarios for on-site industrial research workers and on-site construction excavation workers. It was assumed these receptors would be exposed to untreated groundwater if it were hypothetically used as a drinking water supply. For these receptors, groundwater routes of exposure evaluated included ingestion and dermal contact, inhalation of VOCs during washroom use and volatilization of constituents from in-situ groundwater to indoor air followed by inhalation. However, these exposure scenarios should be considered future scenarios, except for the inhalation of VOCs from in-situ groundwater, since no workers currently use 600 Area Groundwater.

Based on the risk assessments performed for groundwater for the current and reasonably anticipated future exposure scenarios for 600 Area, the summary of human health risks is provided in **Table 8** and are as follows:

- The estimated total reasonable maximum exposure (RME) cancer risk of 1.1E-05 for the future industrial research worker scenario is based upon the following risks associated with the three exposure pathways evaluated and totaled: 9.8E-06 for ingestion, 5.8E-07 for inhalation and 1.8E-07 for dermal contact. The estimated RME risk for the future industrial research worker is within the USEPA's cancer risk range of 1E-04 to 1E-06. The cancer risk driver was TCE in groundwater.

- The estimated total RME cancer risk is 2.2E-08 for the future construction excavation worker scenario, which is based entirely on the evaluated dermal exposure pathway and is below the USEPA's acceptable risk range.
- The estimated total RME non-cancer hazard of 0.005 for the future industrial research worker scenario and the estimated total RME non-cancer hazard of 0.0001 for the future construction excavation worker scenario are both less than the USEPA's target non-cancer hazard index (HI) of 1.

2.7.1.2 Surface Water

For surface water, human routes of exposure were limited to dermal contact with surface water by future industrial research workers, since surface water is not currently used by on-site workers or any other human receptor populations. Based on the risk assessments performed for surface water for the current and reasonably anticipated future exposure scenarios, the summary of human health risks are provided in **Table 8** and are as follows:

- The estimated total RME cancer risk of 1.1E-09 for the current and future industrial research worker scenario is below the USEPA's target cancer risk range of 1E-04 to 1E-06.
- The estimated total surface water RME non-cancer hazard of 0.000009 for the current and future industrial research worker scenario is below the USEPA's target non-cancer HI of 1.
- No unacceptable human health risks have been identified associated with exposure to 600 Area surface water.

2.7.1.3 Vapor Intrusion

As discussed in **Section 2.5.2.2** of this ROD, the future risks and hazards from VI of the VOCs in 600 Area groundwater for the future industrial research worker receptor are within the acceptable risk range, and VI is not a concern at AWDF Building 660 (Shaw, 2011 and 2013). Since the USEPA VI Guidance was updated in 2015, (USEPA, 2015), the VI data from Building 660 was re-evaluated using the current USEPA criteria and included in the Final FS (ECC, 2017), which also indicated VI is not a concern at the AWDF Building 660.

The Johnson and Ettinger VI Model (J&E Model) was used to evaluate risks and hazards from the inhalation of organics that may migrate from in-situ groundwater to indoor air at Building 660. The results of the VI potential risk evaluation are summarized in **Table 8** and are as follows:

- The estimated cancer risk from the off-gassing of organics from in-situ groundwater to indoor air for the current and future industrial research worker of 6.3E-06 is within the USEPA's target cancer risk range of 1E-04 to 1E-06.
- The estimated non-cancer hazard of 0.002 is below the USEPA's target HI of 1.
- No unacceptable human health risks have been identified associated with VI exposure at Building 660. However, the 2011 VI Assessment recommended that any future building construction within the 600 Area should be assessed for VI concerns.

2.7.2 Ecological Risk

Ecological concerns for surface water were assessed using the surface water data collected at the Site between November 2004 and January 2011 (Shaw, 2013). Results were compared to the ecological screening criteria derived in the Phase II (ERA (IT, 2000) and in the Phase III Screening Level Ecological Risk Assessment (SLERA) (Shaw, 2005b). These screening values were compared to concentrations of COPECs in surface water to determine if there is any potential for an ecological impact. The risk to aquatic receptors (e.g., fish and macroinvertebrates), which may be exposed to COPECs from groundwater discharging into flowages via seeps or springs, was evaluated (Shaw, 2013). The chemicals reported in the surface water at concentrations exceeding their respective screening criteria included RDX, MTBE and TCE.

The ERA results indicated that the reported concentrations of contaminants, both within and downstream of the 600 Area, as well as in the groundwater-to-surface water discharge areas, were all below the screening values and are not expected to pose any adverse effects on aquatic life (Shaw, 2013 [Appendix M]).

2.7.3 Munitions and Explosives of Concern Hazards

As part of the MMRP RI, the Army completed a MEC HA to evaluate the explosive hazards associated with conventional munitions at the MRS (WESTON, 2014). The MEC HA was completed for the 600 Hill Waste Pit in accordance with the Interim MEC HA Methodology (USEPA, 2008). As discussed in **Section 2.5**, one MEC item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), was discovered in the subsurface of the 600 Hill Waste Pit during the June 2011 intrusive source area investigation, along with numerous MD.

As discussed in **Section 2.6**, the human receptors on the MRS include authorized Picatinny personnel, contractors, visitors (e.g., regulatory personnel) and recreational users. The MRS is in a restricted access area (fully fenced) within Picatinny that abuts operational ranges to the east and south and the installation boundary to the northwest. Therefore, site accessibility was rated as "limited" in the MEC HA scoring. The current access restrictions are not anticipated to change in the future. Potential contact hours are estimated to be between 10,000 and 99,999 receptor hours per year, and the migration potential was rated as unlikely (ECC, 2017). Based on these and other factors, the baseline MEC HA resulted in a hazard level of 3 (with a total score of 560) for the MRS, which is a moderate potential explosive hazard condition, as shown in the Table below:

Summary of the MEC HA Hazard Levels

Hazard Level	Maximum/Minimum MEC HA Score	Description
1	1000/840	Highest potential explosive hazard condition
2	835/725	High potential explosive hazard condition
3	720/530	Moderate potential explosive hazard condition
4	535/125	Low potential explosive hazard condition

Source: USEPA, 2008.

2.7.4 Basis for Taking Action

The Selected Remedy presented in this ROD for the 600 Hill Waste Pit, ***Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing and LUCs*** is necessary to protect the public health or welfare from actual or threatened releases of hazardous substances into the environment. Specifically, the presence of TCE in the groundwater and potential presence of MEC warrant further action based on the potential risks to current and future human receptors.

In July 2009, a resolution was reached between USEPA and the Army regarding the Selected Remedy for the Mid-Valley Groundwater. The Mid-Valley Dispute Agreement (**Appendix B**) involved the recognition of USEPA policy of returning groundwater to its beneficial use, where the Army agreed to recognize promulgated groundwater criteria as the ARAR even when sites have excess risk levels less than 1E-4 for exposure to groundwater. Surface water was considered a secondary issue, whereby the Army agreed to monitor surface water but not recognize surface water criteria as ARARs without an unacceptable risk. Based on the July 2009 Mid-Valley Groundwater Dispute Resolution, a remedial action was determined necessary for the 600 Area groundwater, and the agreed upon approach was applied to the Selected Remedy for the 600 Hill Waste Pit (Army, 2012; Shaw, 2013).

The information supporting the decisions on the Selected Remedy is contained in the administrative record file for the site.

2.8 REMEDIAL ACTION OBJECTIVES

RAOs are site-specific cleanup objectives that are established based on the nature and extent of contamination, potential for human and environmental exposure, and ARARs. RAOs specify the item/COCs, media of concern, exposure routes and receptors and an acceptable contaminant level or range of levels for each exposure route. The COC for the 600 Hill Waste Pit is TCE in groundwater. However, as detailed in **Section 2.7.1**, estimated cancer risks calculated in the HHRA for the future industrial research worker and the future construction excavation worker are below the USEPA's acceptable risk range. In addition, the estimated non-cancer hazards for both receptors are both less than the USEPA's target non-cancer HI of 1. Although there were no unacceptable human health or ecological risks identified for either groundwater or surface water, both medium are addressed in the Selected Remedy via MNA of groundwater and surface water as a polishing step, upon completion of the removal of the waste pit and the collocated TCE-contaminated source area soil. The evaluation of ARARs identified the most stringent cleanup level for TCE in groundwater is the NJDEP GWQS (1.0 µg/L), which is geared toward restoring groundwater to its beneficial use as a drinking water source.

The RAOs were developed based on criteria outlined in Section 300.430(e)(2) of the NCP and Section 121 of CERCLA. The following RAOs were developed for the 600 Hill Waste Pit to address both the TCE-impacted groundwater and the potential explosive hazards related to the occurrence of munitions at the site:

- Prevent exposure to TCE-contaminated groundwater (TCE greater than 1 µg/L) via ingestion, dermal contact or inhalation, that would cause unacceptable risk (greater than 1E-04) over the duration of the response action.

- Achieve the TCE New Jersey GWQS to restore groundwater to meet the GWQS cleanup goal for TCE (1 µg/L) in a reasonable timeframe (less than 50 years), thereby restoring groundwater to its beneficial use as a drinking water source. This estimated reasonable cleanup timeframe is site-specific and not applicable to other groundwater remediation projects.
- Prevent Picatinny personnel (military and civilian), contractors, visitors and recreational hunters from contact with munitions potentially present in the surface soil (0 to 6 inches bgs) and subsurface soil (greater than 6 inches bgs).

The RAO developed for munitions is based on the finding of the one MEC item, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines), within subsurface soil; no munitions were found in the surface soil. The RAO is, however, protective of the both surface and subsurface soil exposure pathways through the implementation of LUCs.

2.9 DESCRIPTION OF REMEDIAL ALTERNATIVES

This ROD provides a summary of the RAs that were considered for the 600 Hill Waste Pit in the FS conducted for the Site (ECC, 2017) in accordance with the CERCLA process.

The Army assembled the following alternatives to satisfy the RAOs:

- Alternative 1 – No Action
- Alternative 2 – MNA, and LUCs
- Alternative 3 – In-Situ Chemical Oxidation (ISCO), MNA Polishing and LUCs
- Alternative 4 – In-Situ Enhanced Anaerobic Bioremediation, MNA Polishing, and LUCs
- Alternative 5 – TCE Source Material Removal, MNA Polishing, and LUCs,
- Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing, and LUCs
- Alternative 7 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing, LUCs, and MEC Clearance of Entire MRS.

In accordance with Section 300.430(e) of the NCP, nine CERCLA criteria were used to evaluate the different Remedial Alternatives, as presented in the Final FS (ECC, 2017). The seven Remedial Alternatives evaluated in the Final FS are described below with their respective estimated capital costs, estimated cost for operation and maintenance (O&M) activities, and an estimate of the present worth costs for the each of the RAs. For the cost evaluation presented in the Final FS, a discount rate of 3.5 % was used to estimate the present value of the alternative costs. The selected remedy is *Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing and LUCs.*

The estimated costs for each of the Remedial Alternatives evaluated for 600 Hill Waste Pit are presented in **Table 9**. A cost comparison summary for each alternative evaluated in the FS is provided in **Appendix D** of this ROD.

2.9.1 Alternative 1 – No Action

Estimated Capital Cost: $0
Estimated O&M Cost Discounted Over 30 Years: $0
Estimated Present Worth Cost: $0

CERCLA and the NCP require that a No Action alternative be evaluated at every site to establish a baseline for comparison of other remedial alternatives. Under Alternative 1, no efforts would be undertaken to contain, remove, monitor or treat the TCE-contaminated groundwater or remove munitions contained within the Inactive Munitions Waste Pit MRS or potential hazards from munitions encountered within the remaining portions of the MRS. In addition, the LUCs implemented at the MRS as part of the *Non-Time Critical Removal Action Land Use Control Plan* (Army, 2013) would be allowed to expire. According to the NCP, the level of treatment achieved must be compared to the required expenditures of time and materials as an integral portion of the remedy selection process. The No Action alternative is intended to serve as a baseline by which to compare the risk reduction effectiveness of other potential alternatives. In this alternative, no remedial actions will be performed, and the Site will essentially be left as is with no additional actions taken. The MEC HA score associated with the implementation of Alternative 1 is 560, (no change from baseline) indicating a moderate explosive hazard with a hazard level of 3 since no action is included to address the hazards related to munitions (ECC, 2017 [Appendix E]).

2.9.2 Alternative 2 – MNA and LUCs

Estimated Capital Costs: $71,600
Estimated O&M Cost Discounted Over 30 Years: $602,905
Estimated Present Worth Cost: $674,505

Alternative 2 includes the following components:

- MNA, including groundwater and surface water sampling and the assessment of contaminant trends.
- LUCs, including groundwater and land use restrictions, safety program, annual inspections and assessment for VI potential during future building construction.
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosives safety.

Alternative 2 includes use of MNA to clean up groundwater and surface water within the 600 Area, and the continuous implementation of LUCs to prevent exposure to groundwater and munitions hazards. Note that the MNA program and groundwater LUCs detailed for Alternative 2 would be included in Alternative 3 through 7, which are presented in this Section. The groundwater AA, which is the area throughout which the groundwater cleanup goal (1 µg/L) will be attained, would include the area of the TCE-impacted groundwater plume. MNA would continue until the TCE ARAR for groundwater (NJDEP GWQS 1 µg/L) is achieved. LUCs related to groundwater use would be implemented within the groundwater AA boundary and

LUCs would be implemented within the MRS portion of the Site to achieve the munitions-related RAO (**Figure 9**).

Alternative 2 would include implementation of LUCs, in particular, notification of groundwater standards' exceedances and potential restrictions on well installations through the base-wide CEA/WRA, restrictions on intrusive activities, access control, fencing and signage requirements, safety programs, on-site Construction Support for intrusive activities, per DoD 6055.09-M Volume 7 and assessment for VI potential during future building construction. Warning signs are required to prohibit entrance to unauthorized personnel, warn of potential MEC hazards, and provide a telephone number to contact if potential MEC are observed. Existing signage and fencing (both the Garrison fencing and Robinson Enclosure) are considered adequate to prevent unauthorized access. The LUC areas for both groundwater and the MRS portion of the Site are shown in **Figure 9.** Annual inspections are included to ensure that LUCs remain in effect and are being properly implemented. The inspections will determine that the fencing or signage is uncompromised or in need of repair or replacement, and that erosion has not exposed munitions or that migration of munitions to the surface (0 to 6 inches bgs) has not occurred within the MRS. Any breaks in the fence will need to be repaired quickly to prevent unauthorized entry. Following annual inspections and maintenance, one annual report will be completed describing the inspection results, needed maintenance or repairs, evaluation of erosion and potential migration of MEC, and assessment of the effectiveness of the administrative LUCs to prevent exposure and trespassing. The LUCs and any maintenance that would be implemented by the Army would be detailed in the Remedial Action Work Plan. Five-Year Reviews would be conducted no less than every five years after initiation of the remedial action to evaluate the remedy implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

The MEC HA Hazard Level associated with the implementation of Alternative 2 is 3. The MEC HA score would remain at 560 (no change from baseline) since Site access is currently restricted. This score indicates a moderate hazard potential with a hazard level of 3 since no munitions clearance is included (ECC, 2017 [Appendix E]).

2.9.3 Alternative 3 – ISCO, MNA Polishing and LUCs

Estimated Capital Cost: $451,412
Estimated O&M Cost Discounted Over 30 Years: $1,018,902
Estimated Present Worth Cost: $1,470,313

Alternative 3 includes the following components:

- In situ treatment using chemical oxidants to reduce TCE concentrations in groundwater.
- MNA, including groundwater and surface water sampling, and assessment of contaminant trends.
- LUCs, including groundwater and land use restrictions, safety training, annual inspections and assessment for VI potential during future building construction.
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosives safety.

Alternative 3 includes in-situ treatment using chemical oxidants to reduce TCE concentrations in groundwater, followed by MNA of groundwater and surface water in the 600 Area as a polishing step after active remediation has reduced TCE contamination concentrations (**Figure 11**), as described in Alternative 2. This alternative would involve up to three injections (1 injection per year for a 3-year period) of a chemical oxidizer in six wells (three upgradient of the source area of the plume and three downgradient) for the in-situ treatment of TCE concentrations in groundwater, thereby decreasing contaminant discharge into downgradient well and wetland receptors.

Performance monitoring would be conducted at source injection wells and upgradient monitoring wells to evaluate the effectiveness of the remedy. Active treatment in the form of ISCO would be conducted over a three-year period, followed by MNA polishing for the remainder of the TCE-contaminated groundwater within the AA. MNA would continue until the TCE remediation goal for groundwater (NJDEP GWQS 1 µg/L) is achieved. Alternative 3 would include implementation of LUCs, as specified for Alternative 2. LUCs will involve performing any site maintenance required to maintain the protectiveness of the remedy. The LUCs and any maintenance that would be implemented by the Army would be detailed in the Remedial Action Work Plan. Five-Year Reviews would be conducted no less than every five years after initiation of the remedial action to evaluate the remedy implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

The MEC HA Hazard Level associated with the implementation of Alternative 3 is 3. The MEC HA score will remain at 560 (no change from baseline), indicating a moderate hazard potential with a hazard level of 3 because no munition clearance is included (ECC, 2017 [Appendix E]).

2.9.4 Alternative 4 – In-Situ Enhanced Anaerobic Bioremediation, MNA Polishing and LUCs

Estimated Capital Cost: $622,326
Estimated O&M Cost Discounted Over 30 Years: $985,682
Estimated Present Worth Cost: $1,608,008

Alternative 4 includes the following components:

- In situ treatment using carbon substrate amendment[1] to reduce TCE concentrations in groundwater;
- MNA, including groundwater and surface water sampling and assessment of contaminant trends.
- LUCs, including groundwater and land use restrictions, safety training, annual inspections and assessment for VI potential during future building construction.

[1] Note that the term carbon substrate indicates a generic type of amendment that is a carbon source (electron donor), which is injected into the groundwater to enhance bioremediation through reductive dechlorination of the TCE. The carbon substrate can be emulsified vegetable oil (EVO), molasses, or other carbon source. The type of carbon substrate would be identified during the design phase if this Alternative was selected.

- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosives safety.

Alternative 4 includes in-situ treatment using carbon substrate to reduce TCE concentrations in groundwater, followed by MNA polishing of groundwater and surface water in the 600 Area for the remainder of the TCE (**Figure 12**). This alternative would involve up to two applications of an organic carbon substrate amendment into the soil above the source area of the plume for the in-situ treatment of TCE-contaminated soil, which is the source of the groundwater contamination. Sufficient quantities of carbon substrate would be injected to saturate the vadose zone soils and fractured bedrock down to the water table. A second application of the carbon substrate would be included in the remedy as a contingency, depending on the contaminant trend and results of the performance groundwater monitoring. The organic carbon solution would be introduced into the source area through an infiltration gallery, which would be the same size as the source area (120 ft by 60 ft). An upgradient extraction well would be installed to provide a continual source of water to trickle over the infiltration gallery and further distribute the amendment through the vadose and saturated zones, after the initial amendment application in the source area.

Performance monitoring would be conducted at source area wells and select downgradient wells to evaluate the effectiveness of the remedy, and a source area bedrock well would be installed and included in the performance monitoring. After active treatment is complete, MNA polishing for the remainder of the TCE-contaminated groundwater would be performed within the AA. MNA would continue until the TCE remediation goal for groundwater (NJDEP GWQS 1 µg/L) is achieved. Alternative 4 would include implementation of LUCs, as specified for Alternative 2. LUCs would involve performing any site maintenance required to maintain the protectiveness of the remedy. The LUCs and any maintenance that would be implemented by the Army would be detailed in the Remedial Action Work Plan. Five-Year Reviews would be conducted no less than every five years after initiation of the remedial action to evaluate the remedy implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

The MEC HA Hazard Level associated with the implementation of Alternative 4 is 3. The MEC HA score would remain at 560 (no change from baseline), indicating a moderate hazard potential with a hazard level of 3 since there is no munitions clearance is included (ECC, 2017 [Appendix E]).

2.9.5 Alternative 5 – TCE Source Material Removal, MNA Polishing and LUCs

Estimated Capital Cost: $1,525,182
Estimated O&M Cost Discounted Over 30 Years: $602,129
Estimated Present Worth Cost: $2,127,311

Alternative 5 includes the following components:

- Excavation and off-site disposal of TCE-contaminated soil, carbon substrate amendment[1] and removal of MEC located within the limits of the excavation;

- MNA, including groundwater and surface water sampling and an assessment of contaminant trends;
- LUCs, including groundwater and land use restrictions, safety training, annual inspections and assessment for VI potential during future building construction.
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosive safety.

Alternative 5 includes excavation and off-site disposal of TCE-contaminated soil, carbon substrate application, and removal of munitions located within the limits of the source area (TCE-impacted soil) excavation (**Figure 13**). The area of excavation would be approximately 200 ft by 160 ft to include the sidewall cutback area extended from the source area excavation (120 ft by 60 ft), as shown in **Figure 13**. This alternative entails excavation of TCE-contaminated soil, which is estimated at approximately 1,334 cy. In addition, an estimated 5,334 cy of clean overburden and 11,539 cy of sidewall cutback soils will need to be excavated and staged near the Site in order to facilitate excavation of TCE-contaminated soil. The clean overburden volume was based on the same area estimate of 120 ft by 60 ft, with a 20-ft thickness (ECC, 2017).

This alternative would involve removal of munitions and MD that is encountered within the TCE-contaminated soil excavation. During the excavation, a UXO–qualified team would provide construction support. Soil screening would be conducted for material where munitions and MD, or significant quantities of cultural debris (drums, vehicles, materials potentially presenting an explosives hazard, etc.) are encountered. This alternative would include confirmatory soil sampling of the limits of excavation followed by backfilling with clean fill to restore existing site contours. During the design phase, NJDEP Impact to Groundwater Guidance (NJDEP, 2008) would be used to determine the Impact to Groundwater SRS to be used as the cleanup criteria during soil excavation for the protection of groundwater. The details regarding post-excavation confirmatory sampling would be included in the Remedial Action Work Plan and would be submitted for review and approval by the appropriate agencies prior to initiation of remedial activities. Following the excavation of collocated MEC/MD and TCE-contaminated source soil, a carbon substrate amendment (estimated at 3,500 gallons) would be added to the excavation to enhance degradation of any residual contamination in the source area. Subsequently, the excavation will be backfilled with clean fill to restore existing site contours.

MNA of groundwater and surface water in the 600 Area is included in this alternative as a polishing step upon completion of the source material removal and would continue until the TCE remediation goal for groundwater (NJDEP GWQS 1 µg/L) is achieved. Alternative 5 would include implementation of LUCs, as specified for Alternative 2. LUCs would involve performing any site maintenance required to maintain the protectiveness of the remedy. The LUCs and any maintenance that would be implemented by the Army would be detailed in the Remedial Action Work Plan. Five-Year Reviews would be conducted no less than every five years after initiation of the remedial action to evaluate the remedy implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

The MEC HA Hazard Level associated with implementation of Alternative 5 is 4 (a lower hazard than baseline). The MEC HA score would be at 365, a low hazard potential with a hazard level of 4. This alternative would have the lowest MEC HA score and would achieve the lowest MEC hazard potential due to the partial removal of subsurface MEC at the TCE source area only, combined with LUCs.

2.9.6 Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing and LUCs

Estimated Capital Cost: $2,708,303
Estimated O&M Cost Discounted Over 30 Years: $602,128
Estimated Present Worth Cost: $3,310,431

Alternative 6 is the Selected Remedy for the 600 Hill Waste Pit and includes the following components:

- Excavation and off-site disposal of the Munitions Waste Pit, including the TCE-contaminated soil, carbon substrate amendment[2] and MEC removal within the entire 0.24-acre Munitions Waste Pit;
- MNA, including groundwater and surface water sampling and an assessment of contaminant trends;
- LUCs, including groundwater and land use restrictions, safety training, annual inspections and assessment for VI potential during future building construction.
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosives safety.

Alternative 6 includes excavation and off-site disposal of the entire 0.24-acre Munitions Waste Pit (approximately 9,526 cy of material), including the TCE-contaminated soil (estimated at approximately 1,334 cy), and the sidewall cutback area extending from the Munitions Waste Pit (as shown in **Figure 8**). In addition, an estimated 16,200 cy of clean overburden, sidewall cutback soils and stockpiled gravel and debris will need to be excavated and staged near the Site in order to facilitate excavation of TCE-contaminated soil. During excavation, all soil would be assessed for MEC. It is assumed that the majority of MEC items would be located within the waste pit itself at a depth of 20 to 25 ft and not in the cutback material. Assuming MEC and other MD will account for approximately 30 percent (%) of the Munitions Waste Pit volume, approximately 2,857 cy of MEC and other debris are anticipated at the site. If encountered, all munitions and MD will be removed within the 0.24-acre munitions waste pit area. Munitions and MD may remain in the uncleared areas of the MRS portion of the Site area (20.76 acres). During the excavation, a UXO-qualified team will provide construction support. Soil screening will be conducted for material where munitions and MD, or significant quantities of cultural

[2] Note that the term carbon substrate indicates a generic type of amendment that is a carbon source (electron donor), which is injected into the groundwater to enhance bioremediation through reductive dechlorination of the TCE. The carbon substrate can be EVO, molasses, or other carbon source. The type of carbon substrate will be identified during the design phase for Alternative 6, which is the Selected Remedy for 600 Hill Waste Pit.

debris (drums, vehicles, materials potentially presenting an explosives hazard, etc.) are encountered.

This alternative includes confirmatory soil sampling of the limits of excavation and the application of carbon substrate to the excavation to enhance degradation of any residual TCE-contamination in the source area. The excavation will then be backfilled with clean fill from a designated pre-approved location to restore the Site to the existing conditions. During the design phase, NJDEP Impact to Groundwater Guidance (NJDEP, 2008) will be used to determine the Impact to Groundwater SRS to be used as the cleanup criteria during soil excavation for the protection of groundwater. The details regarding post-excavation confirmatory sampling will be included in the Remedial Action Work Plan and will be submitted for review and approval by the appropriate agencies prior to initiation of remedial activities.

MNA of groundwater and surface water in the 600 Area is included in this alternative as a polishing step upon completion of the removal of the munitions waste pit and TCE-contaminated soil and will continue until the remediation goal for TCE in groundwater (NJDEP GWQS 1 µg/L) is achieved. Surface water within the 600 Area will be monitored throughout the duration of groundwater monitoring as part of the MNA polishing component of the remedy until the groundwater cleanup goal for TCE (1 µg/L) is achieved.

Alternative 6 will include implementation of LUCs, as specified for Alternative 2. LUCs will involve performing any site maintenance required to maintain the protectiveness of the remedy. The LUCs and any maintenance that will be implemented by the Army will be detailed in the Remedial Action Work Plan. Five-Year Reviews will be conducted no less than every five years after initiation of the remedial action to evaluate the remedy implementation and performance in order to determine if the remedy continues to be protective of human health and the environment.

The MEC HA Hazard Level associated with the implementation of Alternative 6 is 4 (lower hazard than baseline). The MEC HA score is 365, indicating a low hazard potential (ECC, 2017 [Appendix E]). This alternative has the lowest score and achieves the lowest hazard potential since it includes the clearance of subsurface munitions within the 0.24-acre munitions waste pit down to the bedrock. Notably, the MEC HA score for Alternative 6 is the same as that for Alternative 5 since they both partially mitigate the hazards associated with MEC, as the entire Inactive Munitions Waste Pit MRS would not be addressed and LUCs would be implemented to reduce the hazards associated with the presence of MEC.

2.9.7 Alternative 7 – Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing, LUCs and Removal of DoD Military Munitions within the Entire MRS

Estimated Capital Cost: $3,787,256
Estimated O&M Cost Discounted Over 30 Years: $332,124
Estimated Present Worth Cost: $4,119,380

Alternative 7 includes the following components:

- Excavation and off-site disposal of TCE-contaminated soil, and MEC removal within the 0.24-acre Munitions Waste Pit.
- Surface and subsurface (up to 2 ft bgs) MEC removal from the entire MRS.
- MNA, including groundwater and surface water sampling and an assessment of contaminant trends.
- LUCs, including access control, groundwater and land use restrictions, fencing and signage, safety training and annual inspections and assessment for VI potential during future building construction.
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosive safety.

Alternative 7 includes excavation and off-site disposal of the entire 0.24-acre Munitions Waste Pit, including the transport and disposal of approximately 1,334 cy of TCE-contaminated soil, and the sidewall cutback area extending from the waste pit. If encountered, all munitions and MD would be removed within the limits of the 0.24-acre munitions waste pit area. Additionally, this alternative includes surface and subsurface clearance (to an average depth of 2 ft bgs) and removal of munitions in the remaining 20.76-acre Inactive Munitions Waste Pit MRS portion of the Site (**Figure 14**). However, anomalies would be removed to depth and may be discovered to extend deeper than 2 ft bgs in some areas.

This alternative would include confirmatory soil sampling of the limits of excavation followed by backfilling with clean fill to restore existing site contours. During the design phase, NJDEP Impact to Groundwater Guidance (NJDEP, 2008) would be used to determine the Impact to Groundwater SRS to be used as the cleanup criteria during soil excavation for the protection of groundwater. The details regarding post-excavation confirmatory sampling would be included in the Remedial Action Work Plan and would be submitted for review and approval by the appropriate agencies prior to initiation of remedial activities.

MNA of groundwater and surface water in the 600 Area is included in this alternative as a polishing step upon completion of the removal of the waste pit and the TCE-contaminated soil and would continue until the remediation goal for TCE in groundwater (NJDEP GWQS 1 µg/L) is achieved.

Alternative 7 would include implementation of temporary LUCs for groundwater until the TCE groundwater remediation goal for TCE (1 µg/L) is achieved. Alternative 7 would involve continuous implementation of LUCs, in particular, restrictions on groundwater use. The long-term groundwater monitoring program for this area would be used to determine whether subsequent actions were required and determine if MNA is progressing as anticipated following completion of the source remediation, if it is required. The MNA, LUCs, and CERCLA Five-Year Review components of this alternative are presented under Alternative 2. Because the entire MRS would be cleared of MEC to a level where the risk of encountering MEC is negligible, MEC-related LUCs would be included for ten years. Five-Year Reviews would be required as part of Alternative 7 to document the remedy's protectiveness for both groundwater and the explosive hazards at the Site. For groundwater, Five-Year Reviews are required until the remediation goal for TCE (1 µg/L) is achieved. Additionally, Five-Year Reviews would be

proposed for only two review periods to document that the remedy remains protective with regard to the explosive hazards. After the two five-year periods, the need for construction support, or LUCs associated with limiting exposure to MEC hazards, would be evaluated and would no longer be required. Implementation of Alternative 7 would achieve the UU/UE after a minimum of ten years, and once the TCE remediation goal in groundwater is achieved.

Alternative 7 would provide long-term effectiveness and permanence related to MEC explosive hazards because the MEC within the MRS would be removed. The MEC HA Hazard Level associated with the implementation of Alternative 7 is 4. The MEC HA score would be 430, indicating a low hazard potential with a hazard level of 4 (ECC, 2017 [Appendix E]). This alternative would achieve the lowest hazard potential. The Hazard Level for Alternative 7 is the same as for Alternatives 5 and 6, but the score is slightly higher, as long-term LUCs are not included in Alternative 7.

2.10 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section summarizes the comparative analysis of the expected performance of each remedial alternative to identify the respective advantages and disadvantages of each remedy, as was presented in detail in Section 7.2.2 of the Final FS. In accordance with Section 300.430(e) of the NCP, nine CERCLA criteria were used to evaluate the different Remedial Alternatives considered for the site (ECC, 2017). The nine CERCLA criteria are as follows:

1) Protection of human health and environment is used to determine whether an alternative eliminates, reduces, or controls threats to public health and the environment through LUCs, engineering controls, or treatment.
2) Compliance with ARARs is used to evaluate whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site(s), or whether a waiver is justified.
3) Long-term effectiveness and permanence is used to consider the ability of an alternative to maintain protection of human health and the environment over time.
4) Reduction of toxicity, mobility, or volume through treatment is used to evaluate an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
5) Short-term effectiveness is used to consider the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
6) Implementability is used to consider the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
7) Cost is used to evaluate the estimated capital and O&M costs, as well present-worth costs for the alternatives considered.
8) State acceptance is used to consider whether the State agrees with the analyses and recommendations and to assess that the State's key concerns related to the preferred alternative are addressed.

9) Community acceptance is used to consider whether the local community agrees with the analyses and the preferred alternative as presented in the Proposed Plan.

The nine CERCLA evaluation criteria are divided into threshold criteria, primary balancing criteria and modifying criteria. An overview of the comparative analysis of threshold and balancing criteria is provided in **Table 9.**

2.10.1 Threshold Criteria

These criteria are standards that an alternative must meet to be eligible for the Selected Remedy. There is little flexibility in meeting the threshold criteria, whereas the alternative must meet the criteria or it is unacceptable.

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

2.10.1.1 Protection of Human Health and the Environment

All alternatives except for Alternative 1 – No Action provide protection of human health and the environment. Alternative 2 provides an adequate protection of the human health and the environment through the implementation of LUCs and groundwater controls, primarily through groundwater use restrictions. Alternatives 2 through 7 meet this threshold criterion because they provide protection to human health and the environment through a combination of treatment or removal and LUCs. Alternatives 3 and 4 provide an active remedy to reduce TCE groundwater concentrations in the source area and over time, reduce TCE concentrations in the downgradient plume and receptor areas, and by the groundwater LUC. Alternatives 3 and 4 provide protection to human health for the potential explosive hazards related to MEC through the implementation of LUCs and by requiring construction support. Alternatives 5 through 7 provide an adequate protection of human health through removal of munitions and TCE-contaminated soil and provide protection from TCE-impacted groundwater and explosive hazards related to munitions through the implementation of groundwater LUCs, construction support, and through clearance of munitions within the entire Inactive Munitions Waste Pit MRS included in Alternative 7.

2.10.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

All alternatives except for Alternative 1 – No Action, will achieve the ARARs. Alternatives 2 through 7 will meet the chemical-specific ARARs for groundwater contaminants at the end of the remedial action, when contaminants levels fall below the NJDEP GWQS (1µg/L), the most stringent groundwater ARAR, and will comply with all location- and action-specific ARARs.

2.10.2 Primary Balancing Criteria

These criteria weigh the tradeoffs between alternatives and represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. In general, a high rating on one criterion can offset a low rating on another balancing criterion.

2.10.2.1 Long-term Effectiveness and Permanence

Alternative 2 is effective, as TCE concentrations will decrease over time through MNA; however, the residual risks in groundwater will remain unchanged. Alternatives 3 and 4 are effective, as upon completion of the application of the ISCO treatment (Alternative 3) or the organic carbon substrate amendment (Alternative 4), the groundwater is expected to show rapid decreases in TCE concentrations within the treatment area. Alternative 4 provides greater long-term effectiveness than Alternatives 2 and 3 through treatment of the Munitions Waste Pit source area resulting in the reduction of downgradient groundwater and surface water TCE concentrations. The long-term effectiveness and permanence of Alternative 3 is compromised by an active source in the Munitions Waste Pit and is limited due to the rebound effects of TCE concentrations in groundwater. The groundwater restoration timeframe for Alternatives 2 and 3 is 35 years; as Alternative 4 targets the TCE-impacted soil, the groundwater restoration timeframe is estimated at 14 years. Alternatives 5 and 6 are effective, as upon completion of the excavation, the groundwater is expected to show a gradual TCE concentration decrease within the AA. The TCE-impacted soil excavation (included in Alternatives 5, 6 and 7) will permanently remove TCE contamination likely resulting in a significantly reduced MNA time-period to cleanup. With Alternatives 6 and 7, the munitions would be permanently removed from within the limits of the excavation. The groundwater restoration timeframe for Alternatives 5, 6 and 7 to achieve the groundwater RAO is estimated to be within eight years, after the source area TCE-impacted soils are removed (ECC, 2017).

Alternative 7 provides the most long-term effectiveness and permanence related to munitions hazards because the MEC items discovered within the entire Inactive Munitions Waste Pit MRS would be removed.

2.10.2.2 Reduction in Toxicity, Mobility or Volume through Treatment

Alternatives 1 and 2 do not employ any treatment to contribute to the reduction in the toxicity, mobility, or volume of COCs in groundwater or munitions at the site. Alternative 3 should result in the rapid destruction of groundwater TCE within the treatment zone, reducing both toxicity and volume of TCE at the site. However, because the ISCO treatment targets the areas upgradient and downgradient of the source only, there is not a significant amount of reduction in the volume of TCE, because the majority of the source will remain untreated.

Alternative 4 provides effective reduction of toxicity, mobility, or volume of contamination within the treatment zone by reduction of groundwater TCE concentrations; however, Alternatives 2, 3, and 4 provide no actions that will reduce the hazards of munitions at the Site. Alternatives 5 and 6 effectively reduce the toxicity and mobility of TCE in groundwater through removal of the TCE-impacted soil, and the explosive hazards associated with MEC would be addressed within the excavation area of Munitions Waste Pit. However, Alternatives 5 and 6 will not address munitions in other portions of the MRS.

Alternative 7 would be most effective at reducing the volume of munitions through clearance and removal within the entire MRS, thereby eliminating the explosive hazards associated with MEC. Toxicity, mobility, and volume of TCE-contaminated soil in the source area would be reduced; however, the waste would be transferred from the Site to a disposal facility rather than eliminated.

2.10.2.3 Short-term Effectiveness

For Alternatives 2 and 3, modeling predictions estimate the time to achieve the groundwater RAO to be 35 years, and for Alternative 4, remediation of the downgradient TCE plume extending 1,100 ft downgradient is estimated to occur approximately 14 years after the treatment is initiated. Alternative 2 does not pose any additional risks to the surrounding community, the workers, or the environment that cannot be mitigated through LUCs or construction support; however, the short-term effectiveness of Alternative 2 is more favorable than for Alternatives 3, 4, 5, 6 and 7, which include an active remedy such as treatment or excavation.

For Alternatives 3 and 4, there is a risk that site workers may be exposed to contaminated groundwater; however, these risks would be minimized using proper personal protection equipment and field techniques. The short-term effectiveness of Alternatives 5, 6 and 7 are adequate, and the modeling predictions estimate the time to achieve the groundwater RAO to be eight years. Excavation activities included in Alternatives 5, 6 and 7 would require significant material handling, and could result in dust generation and potential volatilization of TCE, posing a risk that site workers may be exposed to contaminated soil; however, these potential risks would be minimized through the use of proper personal protection equipment, good construction practices and standard dust suppression techniques.

There is the potential to encounter munitions during the excavation activities included in Alternatives 5, 6 and 7, posing additional risks to site workers and the surrounding community. These risks would be minimized by proper site worker training in MEC safety procedures, construction support and following construction and MEC-safety protocols during excavation and transportation of munitions.

2.10.2.4 Implementability

Alternatives 1 and 2 are the most implementable. Alternatives 4, 5 and 6 are readily implementable. Implementability for Alternative 3 is compromised by the use of a chemical oxidant in an environment where there is a potential for munitions, which presents a potential safety hazard and risk. Additionally, large amounts of buried metal and potential munitions present additional challenges for the implementation of Alternative 3, and as a result the injection points for the chemical amendment must be installed outside the limits of the Munitions Waste Pit to avoid the potential explosive hazards, reducing the effectiveness of this alternative. Alternative 4 is more implementable due to the use of the infiltration gallery technology for the application of the organic substrate amendment to treat the source area and downgradient groundwater plume. Alternatives 5, 6, and 7 involve logistical considerations such as coordinating the construction activities with the active range operations, the potential to encounter munitions during excavation, the handling of contaminated soil, and dust generation. Alternative 7 implementability is limited due to the area required for the large volume of stockpiled materials and tree clearing (on steep terrain) to support the larger excavation and associated staging area. Additionally, access restrictions and work delays would be anticipated during munitions testing within the adjacent active range areas.

2.10.2.5 Cost

Alternative 1 is the least costly option, followed by Alternative 2. Alternative 3 is slightly less expensive than Alternative 4. Alternative 4 is less expensive than Alternatives 5, 6 and 7. Alternative 7 involves the highest cost including the greatest initial capital costs, followed by Alternatives 5 and 6. The costs associated with the removal of the entire munitions waste pit under Alternatives 6 and 7 are much higher than those for Alternative 5 due to the presence of stockpiled soil and debris above the larger excavation footprint and staging area. The total present worth cost for each alternative is provided in **Table 9** and a cost comparison summary for each alternative is provided in **Appendix D.**

2.10.3 Modifying Criteria

These are criteria that have been considered based on the public and regulator comments received during the public comment period.

2.10.3.1 State/Agency Acceptance

This document was prepared in partnership with USEPA and NJDEP representatives. The USEPA and NJDEP have expressed their support for Alternative 6.

2.10.3.2 Community Acceptance

During the public comment period (ending on October 25, 2018), the community generally expressed its support for the Selected Remedy and is in favor of Alternative 6 for the 600 Hill Waste Pit remedy.

2.11 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that USEPA will use treatment to address the principal threats posed by a site wherever practicable (NCP 300.430(a)(1)(iii)(A)). Identifying principal threat wastes (PTWs) combines concepts of both hazard and risk. In general, PTWs are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-PTWs are those source materials that generally can be reliably contained and would present only a low risk in the event of exposure. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied. For the 600 Hill Waste Pit, the principal threats are identified as TCE in source soils, because it is at high levels and is considered a continuing source to groundwater, and the explosive hazards related to munitions, (UXO or DMM) (ECC, 2017).

DMM or UXO, if any that remain present at the Site may constitute a principal threat to human health due to the potential for an explosive hazard if the material is moved, handled, or disturbed. If UXO or DMM are later encountered on surfaces in those areas originally addressed by the selected remedy, DoD explosive ordnance disposal personnel or similarly UXO-qualified personnel will evaluate the material to determine if it poses an explosive hazard. Such material that is determined to pose an explosive hazard, which may also be categorized as MEC, will

normally be treated on-site or removed for destruction per applicable DoD explosives safety standards and environmental laws and regulations. The Army and the USEPA will consult, in accordance with the terms of the March 1991 FFA, to make a determination as to whether the material encountered and determined to pose an explosive hazard should be classified as a PTW, as defined by CERCLA, the NCP and USEPA guidance. If the material is determined to be a PTW, the Army will take the necessary actions to ensure protectiveness of human health and the environment to address unacceptable risks posed by the material designated as a PTW.

2.12 SELECTED REMEDY

As a result of the comparative analysis, the Army selects: *Alternative 6 - Total Munitions Waste Pit Removal, TCE Source Material Removal, Monitored Natural Attenuation Polishing and LUCs* for the 600 Hill Waste Pit. This Selected Remedy was developed in accordance with CERCLA, as amended and consistent with the NCP, and includes the following components:

- Excavation and off-site disposal of TCE-contaminated soil, carbon substrate application[3] and MEC removal within the entire 0.24-acre Munitions Waste Pit;
- MNA, including groundwater and surface water sampling and an assessment of contaminant trends;
- LUCs, including access control, groundwater and land use restrictions, fencing and signage, safety training and annual inspections, and assessment for VI potential during future building construction; and
- Construction support, which requires the presence of UXO-qualified personnel during all intrusive activities for explosive safety

As presented in more detail in **Section 2.9.6**, Alternative 6 includes excavation and off-site disposal of the entire 0.24-acre Munitions Waste Pit, including the TCE-impacted soil. If encountered, all MEC and MD will be removed within the 0.24-acre munitions waste pit area. Munitions and MD may remain in the uncleared areas of the MRS portion of the Site area (20.76 acres). During the excavation, a UXO-qualified team will provide construction support. Soil screening will be conducted for material where munitions and MD, or significant quantities of cultural debris (drums, vehicles, etc.) are encountered.

This alternative includes confirmatory soil sampling of the limits of excavation and the application of carbon substrate to the excavation to enhance degradation of any residual TCE-contamination in the source area. During the design phase, the NJDEP Impact to Groundwater Guidance (NJDEP, 2008) will be used to determine the Impact to Groundwater SRS to be used as the cleanup criteria during soil excavation for the protection of groundwater. MNA of groundwater and surface water in the 600 Area is included in Alternative 6 as a polishing step

[3] Note that the term carbon substrate indicates a generic type of amendment that is a carbon source (electron donors), which is injected into the groundwater to enhance bioremediation through reductive dechlorination of the TCE. The carbon substrate can be EVO, molasses, or other carbon source. The type of carbon substrate will be identified during the design phase for Alternative 6 for the 600 Hill Waste Pit.

upon completion of the removal of the munitions waste pit and TCE-contaminated soil and will continue until the remediation goal for TCE in groundwater (NJDEP GWQS 1 µg/L) is achieved.

Alternative 6 will include implementation of LUCs, as specified for Alternative 2 in **Section 2.9.2**. LUCs will involve performing any site maintenance required to maintain the protectiveness of the remedy. The LUCs and any maintenance that will be implemented by the Army will be detailed in the Remedial Action Work Plan, which will include a Site Health and Safety Plan. An ESS will be prepared to describe the explosive safety considerations for the Selected Remedy, including construction support and handling, and disposal and demolition of any munitions encountered during the construction phase, in accordance with Engineer Manual 385-1-97 and DoD 6055.09M. The ESS will be submitted to and approved by the DDESB prior to beginning work.

2.12.1 Summary of the Rationale for the Selected Remedy

The Selected Remedy achieves the RAOs, meets the threshold criteria and provides the best balance of tradeoffs with respect to the balancing and modifying criteria, as detailed in Section 2.10. Alternative 6 is implementable, effective in meeting the RAOs and cost effective for addressing the TCE-impacted groundwater and the explosive hazards related to munitions (UXO and DMM) within the 0.24-acre Munitions Waste Pit. The Selected Remedy is consistent with CERCLA.

2.12.2 Summary of Estimated Costs for the Selected Remedy

The costs associated with Alternative 6 are provided in detailed cost tables provided in **Appendix D**, with the totals summarized below:

Estimated Capital Cost: $2,708,303
Estimated O&M Cost Discounted Over 30 Years: $602,128
Estimated Present Worth Cost: $3,310,431

2.12.3 Expected Outcomes of the Selected Remedy

It is expected that implementation of Alternative 6 will meet the RAOs for the 600 Hill Waste Pit developed to address the TCE-contaminated groundwater and the explosives hazards associated with munitions within the surface (0 to 6 inches bgs) and subsurface soil (greater than 6 inches bgs) and will provide protection to human health and the environment. The current access restrictions for the 600 Hill Waste Pit are not anticipated to change in the future, and the Site is not currently included in any future overall redevelopment plans, although plans could change in the future. As noted in **Section 2.6** of this ROD, the Site was identified as a prime building area and Alternative 6 was the Army's preferred alternative to enable the land to remain available for future use.

2.13 STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP, the lead agency must select remedies that are protective of human health and the environment and comply with ARARs (unless a statutory waiver is

justified), are cost effective and utilize permanent solutions and remedial action treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment and permanently and significantly reduce the volume, toxicity or mobility of hazardous wastes as a principal element and are biased against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

Alternative 6 provides an adequate protection of human health through removal of MEC and TCE-contaminated soil in the 0.24-acre Inactive Munitions Waste Pit, as well as the implementation of LUCs for groundwater and MEC through groundwater use restrictions and construction support, respectively; therefore, the Selected Remedy meets this criterion.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 6 meets this threshold criterion. The chemical-specific ARAR for groundwater will be met at the end of the remedial action, when the contaminant levels for TCE fall below the NJDEP GWQS (1 µg/L), which is the most stringent ARAR for TCE in groundwater (**Table 4**). During the Remedial Design phase of the Selected Remedy, a Site-Specific Impact to Groundwater standard will be established for use during the soil excavation for the protection of groundwater. Alternative 6 complies with the action- and location -specific ARARs (**Tables 5** and **6,** respectively). The action-specific ARARs are associated with the potential discharge of groundwater to surface water features during groundwater sampling; however, this ARAR will be complied with by disposing all contaminated purge water off-site. Other action-specific ARARs (**Table 5**) are associated with the requirements for general remediation, including confirmatory sampling, well installation (if determined to be required), as well as the management of any recovered munitions and hazardous waste generated as a result of the remedial action, and for the control and discharge of stormwater resulting from the remedial activities. The only location-specific ARAR (**Table 6**) is the wetland regulations within the Clean Water Act (Section 402), which regulates construction sites on an acre or greater of land discharging wastewater or stormwater directly from a point source into a surface water feature (such as a stream, waterbody or wetland or wetland transition zone). However, no impacts are anticipated to any wetland area within the 600 Area for the implementation of the Selected Remedy. Actions will be taken to avoid degradation or destruction of wetlands, and wetland transition zones, within the 600 Area during the remedial activities required for implementation of the Selected Remedy. These regulations will be complied with by best management practices to minimize any disturbance or impacts to wetlands or the wetland transition zones within the Site Boundary.

2.13.3 Cost Effectiveness

In the lead agency's judgment, the Selected Remedy is cost-effective and represents a reasonable value in the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP §300.430(f)(1)(ii)(D)). This determination was accomplished by evaluating the "overall

effectiveness" of those RAs that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing the five balancing criteria in combination (long-term effectiveness and permanence, reduction in toxicity, mobility and volume through treatment, short-term effectiveness, and implementability) and a comparison of the costs to the overall effectiveness was conducted to determine cost effectiveness. The relationship of the overall effectiveness of the Selected Remedy was determined to be proportional to its costs, and hence the Selected Remedy represents a reasonable value for the money to be spent.

The total estimated cost for Alternative 6 is $3,310,431, including $2,708,303 in capital costs and $602,128 in O&M costs. Detailed costs for Alternative 6 are provided in **Appendix D**. The Army believes that the Selected Remedy is cost-effective and is protective of human health and the environment.

2.13.4 Long-Term Effectiveness and Permanence

Upon completion of the excavation, the groundwater is expected to show a gradual TCE concentration decrease within the AA. The source material excavation will permanently remove TCE contamination from the site soil, likely resulting in a significantly reduced MNA time period to cleanup. MEC will also be permanently removed from within the limits of excavation. Long-term TCE groundwater concentrations are expected to decrease to the RAO within eight years. Long-term effectiveness will also be dictated by the success of LUCs implemented under the Selected Remedy until the TCE groundwater RAO is achieved. These LUCs are adequate to ensure that any exposure to receptors is within protective levels. LUCs include construction support for subsurface excavations, the base-wide CEA with corresponding WRA and groundwater use restrictions, as evaluated during the CERCLA Five-Year Review. Although the LUC aspects of Alternative 6 provide some long-term effectiveness, potential risk to explosive hazards will remain within the MRS. Alternative 6 meets the RAOs by minimizing unacceptable risks posed by exposure to MEC and supporting future military and limited recreational land use (military training and hunting). LUCs are an adequate and reliable control method to reduce long-term risk associated with potential exposure to MEC. Existing interim LUCs already implemented at Picatinny have demonstrated that they are capable of adequately addressing the long-term risk.

2.13.5 Preference for Treatment as a Principal Element

The PTWs for 600 Hill Waste Pit are identified as TCE in source soils and munitions. Alternative 6 satisfies the statutory requirement for treatment of a principal threat, since the remedy is expected to effectively reduce the volume of munitions and MD within the excavated soils through removal, destruction and disposal, thereby reducing the explosive hazards associated with MEC at the site. All encountered munitions will be treated. Alternative 6 includes treatment actions that will reduce the mobility or volume of munitions in the Munitions Waste Pit, but will not address potential munitions in other portions of the MRS.

Alternative 6 is expected to remove up to 95% of the volume of the TCE source soil, thereby reducing the toxicity and mobility of TCE in groundwater through removal of the TCE source. However, the toxicity and volume of soil removed from the Site will be transferred to the

disposal facility rather than eliminated. Alternative 6 does not employ any treatment that will directly reduce the toxicity, mobility or volume of TCE in groundwater; however, following source area excavation, MNA is expected to treat the remaining groundwater contamination to the TCE remediation goal (NJDEP GWQS 1 µg/L) within a 10-year period. The 10-year time period is based on the results of USEPA Bioscreen® simulations that indicate MNA will result in TCE groundwater concentrations below the RAO in approximately eight years, following TCE source removal, with two additional years of MNA monitoring to demonstrate complete restoration (ECC, 2017).

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES FROM SELECTED REMEDY FROM PROPOSED PLAN

The Selected Remedy in this ROD was presented as the Army's Preferred Remedy for the 600 Hill Waste Pit in the Final PP (Army, 2018). No significant changes have been made.

This page intentionally left blank.

3.0 PART 3: RESPONSIVENESS SUMMARY

The purpose of the Responsiveness Summary is to provide a summary of the stakeholders' comments, concerns and questions about the Selected Remedy for the 600 Hill Waste Pit and the Army's responses to these concerns.

The Army has fulfilled the public participation requirements identified in 40 CFR 300.430(f) and Title 10 United States Code 2705(b)(2), and maintains an administrative record, which is available for the public, in accordance with 40 CFR 300.800. The remedy for the 600 Hill Waste Pit has been the topic of presentations at the PAERAB. A copy of the *Final Proposed Plan for 600 Hill Waste Pit (600 Area Groundwater Plume [PICA-058/Site 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01])* (Army, 2018) was given to the PAERAB's co-chair, and a copy was offered to all PAERAB members. The Final 600 Hill Waste Pit PP was completed and released to the public on September 10, 2018 at the information repositories listed in Section 2.3.

The Army held a public meeting on September 26, 2018 to inform the attendees of the remedial alternatives considered and the Selected Remedy for the 600 Hill Waste Pit and to seek comments on the remedy. At this meeting, representatives from the Army, NJDEP, USEPA and the Army's contractor, ECC, were present to answer questions about the Site and the remedial action under consideration.

Following the public meeting, a 30-day public comment period was held from September 26, 2018 to October 25, 2018 during which written comments were received from the public. Comments and responses from the public meeting are presented in **Section 3.1** and the written comments received are provided in **Appendix E** of this ROD.

The Army and USEPA have considered all comments and concerns provided during the public comment period, summarized below, in selecting the final remedy for the Site. The Army and USEPA have made these decisions. Comments received from the NJDEP were considered in selecting the final Selected Remedy. NJDEP concurred with the Selected Remedy, and copies of the concurrence letters for site remedy are included in **Appendix A**.

3.1 PUBLIC ISSUES AND LEAD AGENCY RESPONSES

As of the date of this ROD, the Army, USEPA and NJDEP endorse the Selected Remedy for the 600 Hill Waste Pit included herein. Comments received during the public comment period on the PP are summarized below and the written comments received are provided in **Appendix E**. The comments are categorized by source.

3.1.1 Summary of Written Comments Received during the Public Comment Period

Comment No. 1, Mark Hiler, 64 Lyonsville Road, Rockaway Twp, Boonton, New Jersey. Letter emailed to Mr. Ted Gabel dated September 28, 2018 (**Appendix E**). *As a resident of Rockaway Township, and a member of the Township's Environmental Commission, I attended the presentation of the proposed plan for 600 Hill Waste Pit. It was a clear and concise overview of the environmental issues, and a complete evaluation of the Alternatives. I am in*

total agreement with the Army's recommended Alternative #6. I am always in favor of removal actions when they are possible. It seems lately there have been more Monitored Natural Attenuation and Land Use Controls solutions used, than removal actions. I understand it not always economically possible depending on the risk factors, but I favor "when in doubt dig it out".

I understand the complexity of the environmental cleanup, but it seems the process has slowed down in the last several years. I would like to encourage all stakeholders, Army, Contractors, Regulators, and the Public to think of ways to expedite the process of cleanup.

Army Response to Comment No. 1: No formal response required.

3.1.2 Summary of Comments Received during the Public Meeting

Comment No. 1, Doug Pocze, United States Environmental Protection Agency, Region II, New York, New York. *We support the release of the Proposed Plan for public comment. Final approval of the preferred alternative is given after the public comment period, after public comments are reviewed.*

Army Response to Comment No. 1: No formal response required.

Comment No. 2, Mark Hiler, 64 Lyonsville Road, Rockaway Twp, Boonton, New Jersey. *I'd just like to say as a resident of Rockaway Township and a member of the Restoration Advisory Board that we are always ecstatic when removals are proposed. I know removals are not always practical, but it seems like the last few years, there were more sites with monitored natural attenuation and land use controls.*

Army Response to Comment No. 2: No formal response required.

3.2 TECHNICAL AND LEGAL ISSUES

No technical or legal issues were raised on the Selected Remedy.

4.0 REFERENCES

AECOM Joint Venture (AECOM). 2015. *Picatinny Arsenal Real Property Vision Plan*, Picatinny Arsenal, New Jersey. U.S. Army Corps of Engineers, Sacramento District Contract No. W91238-11-D-0016. November.

Argonne National Laboratory (ANL). 1991. *Remedial Investigation Concept Plan for Picatinny Arsenal, New Jersey. Volume 2: Descriptions of and Sampling Plans for Remedial Investigation Sites*. March (Final Report). Picatinny Arsenal, New Jersey. Report No. CETHA-IR-CR-91018, prepared for U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), Aberdeen Proving Ground, Maryland.

Dames and Moore. 1989. *Site Investigation of Picatinny Arsenal, New Jersey*. Volume 1, Main Report and Appendices A through E. Prepared for U.S. Army Toxic and Materials Agency, Aberdeen Proving Ground, Maryland. February.

_____. 1991. *Remedial Investigation Concept Plan for Picatinny Arsenal, New Jersey*. Volume 1 Environmental Setting, Applicable Regulations, Summaries of Site Sampling Plans, Sampling Priorities and Supporting Appendices. Prepared for USACE Toxic and Hazardous Materials Agency. March.

_____. 1998. *Draft Final Phase l Remedial Investigation Report – Picatinny Arsenal, New Jersey*. Prepared for U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

Department of Defense (DoD). 1973. *Executive Order 11508 Picatinny Arsenal Survey Report*. Picatinny Arsenal, Dover, New Jersey.

_____. 2009. *DoD Vapor Intrusion Handbook*. Prepared by Tri-Service Environmental Risk Assessment Workgroup. January.

Environmental Chemical Corporation (ECC). 2017. *Final Feasibility Study For 600 Hill Waste Pit (600 Area Groundwater Plume [PICA-058] and Inactive Munitions Waste Pit [PICA-013-R-01]*). Picatinny Arsenal Cleanup Contract. Picatinny Arsenal, New Jersey. Prepared for Prepared for U.S. Army Corps of Engineers–Baltimore District. June.

IT Corporation (IT). 2000. *Draft Final Picatinny Arsenal Phase II Ecological Risk Assessment*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. February.

_____. 2001. *Phase III-1A Human Health Risk Assessment Approach (Final)*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers– Baltimore District. Contract No. DACA-31-95-D-0083. April.

_____. 2002. Picatinny Arsenal Facility-Wide Background Investigation, New Jersey. Prepared for the U.S. Army Corps of Engineers–Baltimore District, TERC Number DACA31-95-D-0083. May.

Malcolm Pirnie, Inc. 2008. *Final Site Inspection*, Picatinny Arsenal, New Jersey, Picatinny Arsenal, New Jersey. Prepared for the U.S. Army Corps of Engineers–Baltimore District April.

New Jersey Department of Environmental Protection (NJDEP). 2005a. *Vapor Intrusion Guidance*. Prepared by staff in the NJDEP Site Remediation and Waste Management Program and the Division of Science, Research and Technology. October.

_____. 2005b. Field Sampling Procedures Manual, Division of Remediation Support Bureau of Environmental Measurement and Site Assessment. August.

_____. 2008. *Introduction to Site-Specific Impact to Groundwater Soil Remediation Standards Guidance Document*. Site Remediation Program. December.

_____. 2015. *Technical Guidance for Site Investigation of Soil, Remediation Investigation of Soil, and Remedial Action Verification Sampling for Soil*. Site Remediation Program. March.

Shaw Environmental, Inc. (Shaw). 2004. *Final 600 Area Groundwater Remedial Investigation Work Plan*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31- 95-D-0083. April.

_____. 2005a. *600 Area Work Plan Addendum*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. December.

_____. 2005b. *Phase III & Phase I 2A/3A Sites Ecological Risk Assessment*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. December.

_____. 2005c. *600 Area Groundwater Investigation Data Report*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. July.

_____. 2005d. *Well Head Protection Plan (Final),* Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. March.

_____. 2006a. *600 Area Groundwater Investigation – Supplemental Investigation Work Plan*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. October.

_____. 2006b. *600 Area Groundwater Investigation – Update on Additional Work*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers –Baltimore District. Contract No. DACA-31-95-D-0083. October.

_____. 2007a. *600 Area Groundwater Investigation – Pump Test Work Plan*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D- 0083. March.

_____. 2007b. *600 Area Groundwater Investigation – Well Log and Isotope Data*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. DACA-31-95-D-0083. February.

_____. 2009. *Picatinny Arsenal Task Order 17 600 Area RDX Investigation Data Report*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. W912DR-04-R-0026. April.

_____. 2010a. *600 Area MTBE Groundwater Investigation Data Report*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. W912DR-04-R-0026. August.

_____. 2010b. *600 Area Work Plan for Vapor Intrusion and Source Area Investigation*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. W912DR-04-R-0025. December.

_____. 2011. *Building 660 Vapor Intrusion Investigation Report*, Picatinny Arsenal, New Jersey. Prepared for U.S. Army Corps of Engineers–Baltimore District. Contract No. W912DR-04-R-0025.

_____. 2013. *Final 600 Area Data Report and Feasibility Study*, 600 Area Groundwater Plume (PICA-058), Picatinny Arsenal, New Jersey. Revision 3, Volume I Report and Appendixes A through P. June.

U.S. Army (Army). 2009. Correspondence from United States Environmental Protection Agency Region 2 Office to U.S. Army Garrison Commander regarding the Mid-Valley Groundwater Feasibility Study Dispute Resolution. 6 July.

_____. 2011. Explosives Site Plan, Picatinny Arsenal (PTA), 600 Area, Picatinny Arsenal, New Jersey. Prepared for submission to Department of Defense Explosives Safety Board, DDESB-PE. 9 December.

_____. 2012. Final Record of Decision for Mid-Valley Groundwater (PICA 204), Picatinny Arsenal, New Jersey. September.

_____. 2013. *Final Non-Time Critical Removal Action Interim Land Use Control Plan Picatinny Arsenal for Military Munitions Response Program (1926 Explosion Radius [PICA-003-R-01], Green Pond Site [PICA-005-R-01], Former Operational Areas [PICA-006-R-01], Lakes Sites [PICA-008-R-01], Shell Burial Grounds [PICA-010-R-01], and Inactive Munitions Waste Pit [PICA-013-R-01])*, Picatinny Arsenal, New Jersey. January.

_____. 2018. *Proposed Plan for 600 Hill Waste Pit (600 Area Groundwater Plume [PICA-058/Site 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01])*, Picatinny Arsenal, New Jersey. Final. September.

U.S. Army Corp of Engineers (USACE). 2008. Safety and Health Requirements, Manual EM 385-1-1. Department of Army, Washington, D.C. September.

USACE Waterways Experiment Station (WES). 1994, Identification and Analysis of Wetlands, Floodplains, Threatened and Endangered Species, and Archeological Geomorphology at Picatinny Arsenal, New Jersey. United States Army Corps of Engineers.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1991. Remedial Investigation Concept Plan for Picatinny Arsenal, Vol. 1 and 2. USATHAMA Report No. CETHA-IR-CR-91018.

U.S. Environmental Protection Agency (USEPA). 2002. *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*. Office of Solid Waste and Emergency Response (OSWER), USEPA 530-D-02-004. November 2002.

_____. 2008. *Munitions and Explosives of Concern Hazard Assessment Methodology (Interim)*. Publication Number 505B08001. October.

_____. 2015. *Technical Guide For Assessing And Mitigating The Vapor Intrusion Pathway From Subsurface Vapor Sources To Indoor Air*. Office of Solid Waste and Emergency Response (OSWER), Publication 9200.2-154. June.

Weston Solutions, Inc. (WESTON). 2012. *Final Work Plan, Military Munitions Response Program Remedial Investigation*, Picatinny Arsenal, Morris County, New Jersey. Prepared for the U.S. Army Corps of Engineers–Baltimore District. March.

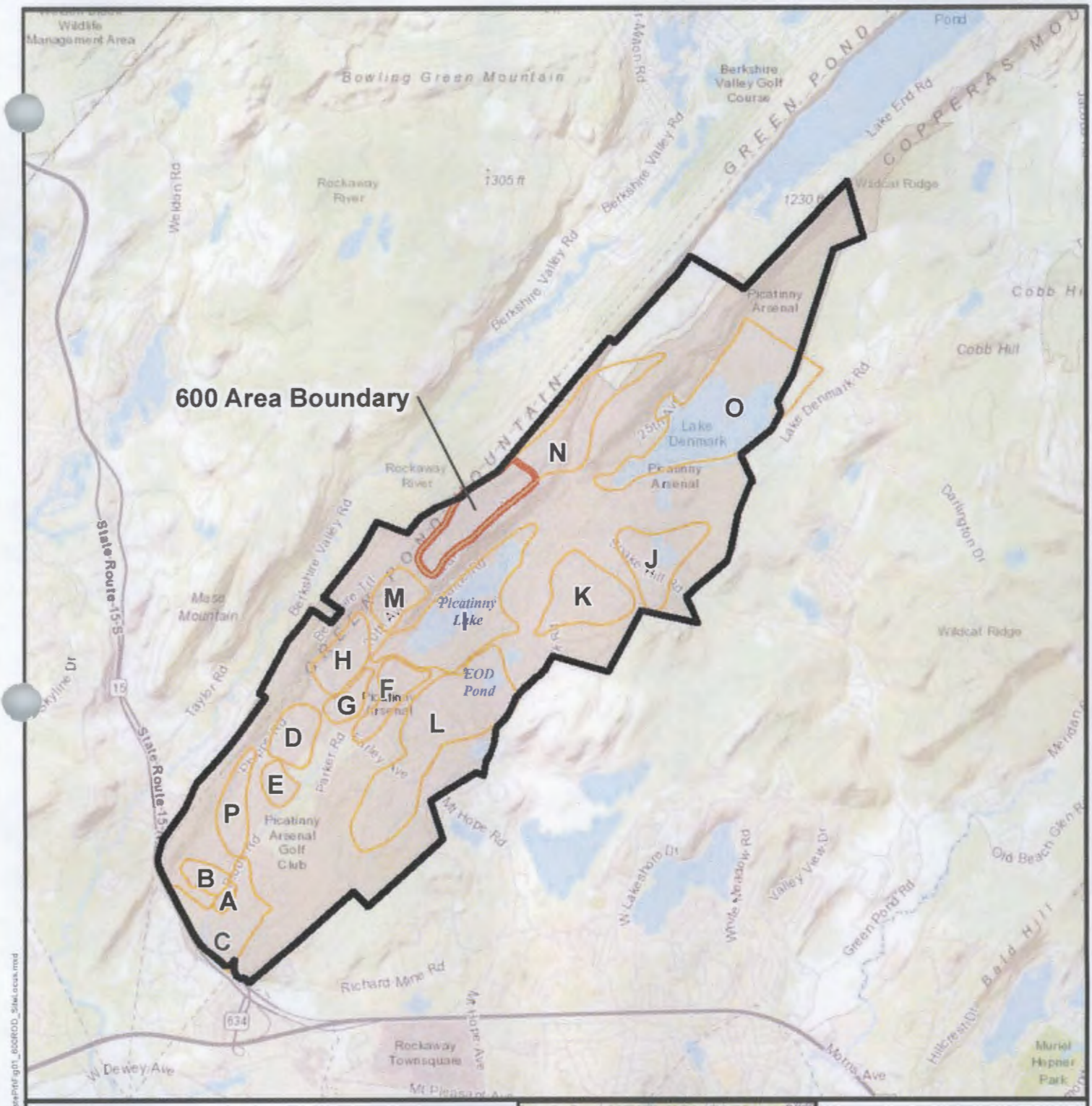
_____. 2014. *Final Remedial Investigation Report: Military Munitions Response Program Remedial Investigation*, Picatinny Arsenal, Morris County, New Jersey. Prepared for the U.S. Army Corps of Engineers–Baltimore District. September.

Figures

This page intentionally left blank

LIST OF FIGURES

This page intentionally left blank



Legend

- Picatinny Arsenal Boundary
- ANL RI Concept Plan Area
- 600 Area Boundary

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community
3. ANL RI = Argonne National Laboratory Remedial Investigation

N W E S

0 0.5 1 Miles

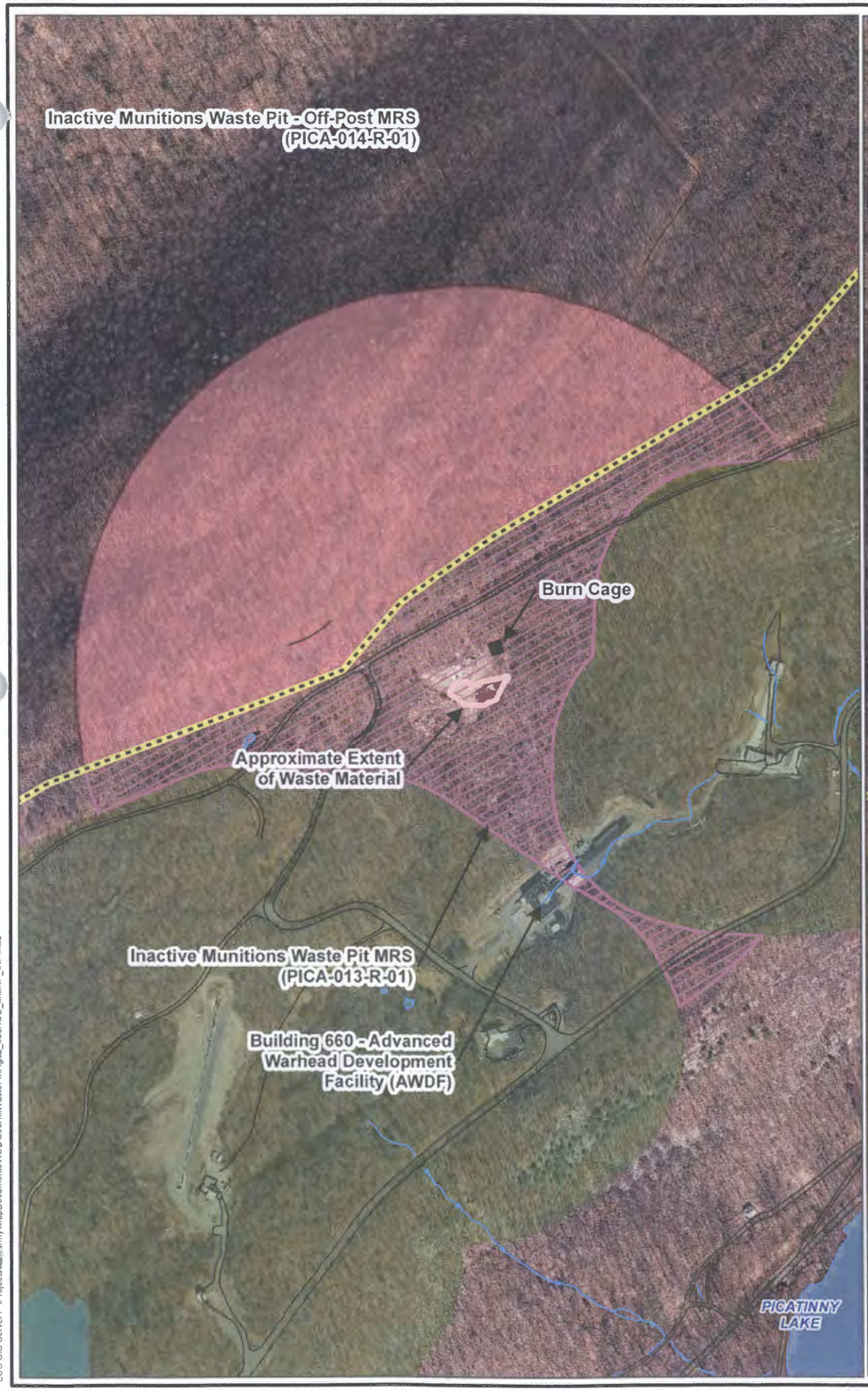
ECC

Figure 1
Picatinny Arsenal Location
Morris County, New Jersey

600 Hill Waste Pit
Record of Decision

ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\gd1_600ROD_SiteLocal.mxd

This page intentionally left blank



Legend

- Road
- Burn Cage
- 600 Hill Groundwater Plume (PICA-058) - 2007 TCE Plume Boundary
- Approximate Extent of Waste Material
- Operational Range Areas
- Picatinny Arsenal Boundary

Munitions Response Sites

- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- Inactive Munitions Waste Pit - Off-Post MRS (PICA-014-R-01)
- Water Body
- River/Stream

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. Service Layer Credits:
3. PICA = Picatinny Arsenal
4. MRS = Munitions Response Site
5. TCE = Trichloroethene

0 400 800
Feet

N W E S

Figure 2
Inactive Munitions Waste Pit Munitions Response Site (PICA-013-R-01) and
600 Area Groundwater Plume (PICA-058), 600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\...\MapDocuments\ROD\600HillWastePit\Fig02_600ROD_MMRP_IRP.mxd

600 Hill Waste Pit

600 Area Boundary

Code 300 Area

GREEN POND BROOK

BURNT MEADOW BROOK

PICATINNY LAKE

NORTH BASIN

SOUTH BASIN

EOD POND

BEAR SWAMP BROOK

Legend

- 600 Hill Groundwater Plume (PICA-058) - 2007 TCE Plume Boundary
- Site Boundary
- 600 Area Boundary
- Code 300 Area
- Picatinny Arsenal Boundary
- Operational Range Areas

Munitions Response Sites

- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- Inactive Munitions Waste Pit - Off-Post MRS (PICA-014-R-01)
- Water Body
- River/Stream

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
3. PICA = Picatinny Arsenal
4. MRS = Munitions Response Site
5. TCE = Trichloroethene

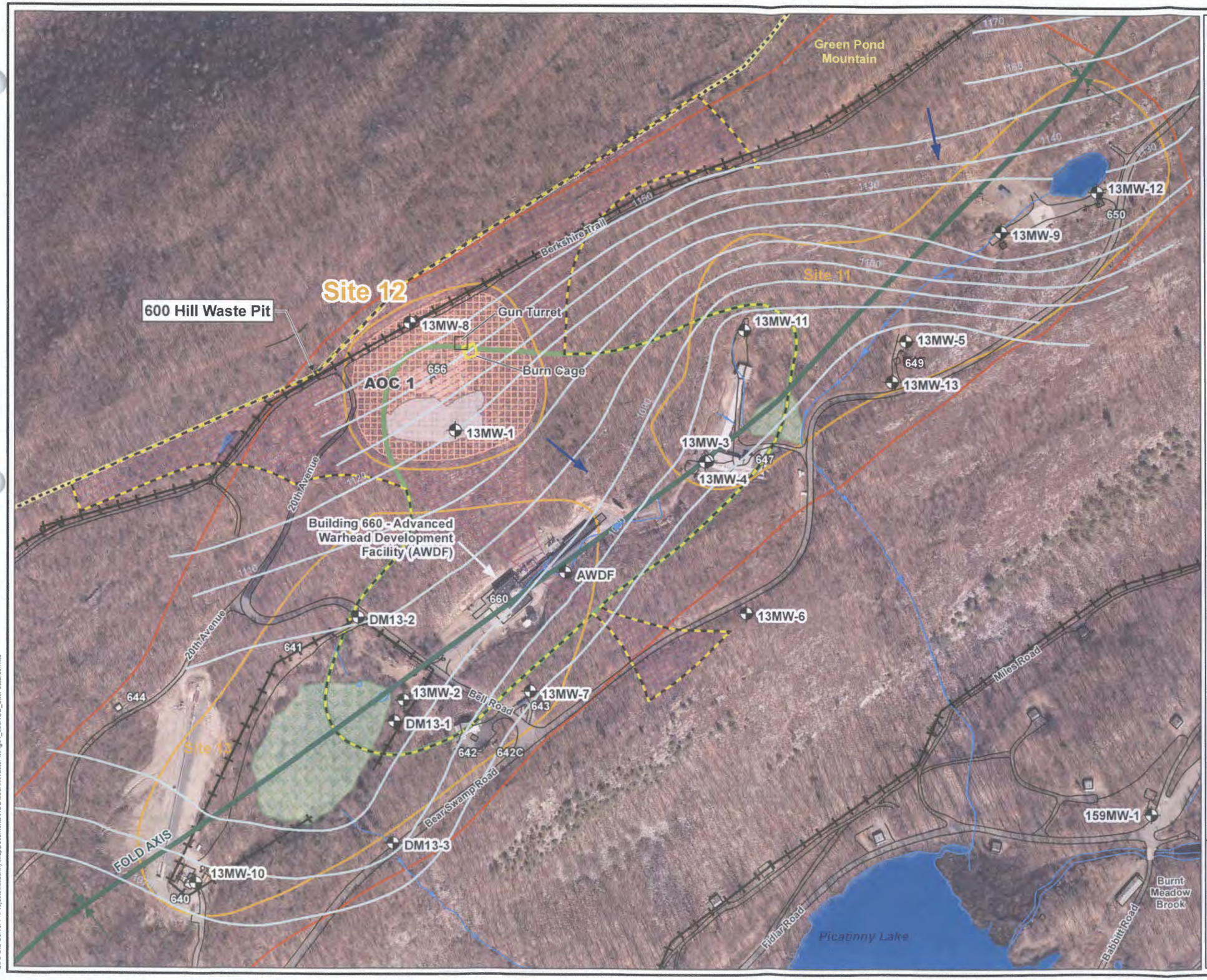
0 0.15 0.3
Miles

N W E S

Figure 3
600 Hill Waste Pit
Site Boundary
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECG GIS Server: F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePitFig03_600ROD_Code300Area.mxd



Legend

- Monitoring Well
- Groundwater Contour, June 2007
- Groundwater Flow Direction
- Bedrock Fold Axis
- Site Boundary
- 2007 TCE Plume Boundary
- Burn Cage
- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- 600 Area
- IRP Site
- Area of Concern
- Approximate Limits of Large Rock Debris
- 650 Existing Building
- 650 Former Building
- Picatinny Arsenal
- Water Body
- Stream
- Road
- Fence Line (Robinson Enclosure)
- Wetland

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. IRP = Installation Restoration Program
4. PICA = Picatinny Arsenal
5. AOC = Area of Concern
6. AWDF = Advanced Warhead Development Facility
7. TCE = Trichloroethene
8. Figure adapted from Figure 2-1 of the Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013). Bedrock geology features obtained from Figure 2-5 (Shaw, 2013).
9. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.
10. The regional groundwater flow direction is based on groundwater gauging data provided in the FS (Shaw, 2013).

0 150 300 600
Feet

N W E S

Figure 4
600 Hill Waste Pit
Site Features
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig04_600ROD_SiteFeatures.mxd

Sample ID - Depth (ft)	Compound	LOC	Date	Conc. (ug/L)
13MW14-128	TCE	1.0	1/13	ND
13MW14-270	TCE	1.0	1/13	ND
13MW14-325	TCE	1.0	1/13	ND

13MW-11 (Total Depth: 30, Screened Interval: 17.3-27.3) Conc. (ug/L)

Compound	LOC	3/07	6/07	10/07	6/08	4/10	2/11
TCE	1.0	7.9	29	31	19	24.7	9.9
RDX	0.5	ND	ND	ND	ND	NS	NS
Freon113	20,000	ND	0.81J	ND	NS	ND	ND

DM10-1 (Total Depth: 45, Screened Interval: 35-45) Conc. (ug/L)

Compound	LOC	3/99	6/08
RDX	0.5	ND	ND

DM10-2 (Total Depth: 33, Screened Interval: 25-35) Conc. (ug/L)

Compound	LOC	3/99	6/08
RDX	0.5	ND	ND

MW-2_N Conc. (ug/L)

Compound	LOC	3/99	6/08
RDX	0.5	ND	ND

13MW-8 (Total Depth: 103, Screened Interval: 78-103) Conc. (ug/L)

Compound	LOC	7/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	ND	ND	ND	ND	ND	ND	ND
RDX	0.5	NS	ND	ND	0.42	NS	NS	NS
Freon113	20,000	0.60J	1.0	0.49J	0.65J	NS	1.46	0.65
Toluene	600	1.S	1.1	0.29J	0.19J	ND	ND	ND

13MW-9 (Total Depth: 45, Screened Interval: 25-45) Conc. (ug/L)

Compound	LOC	7/06	11/06	3/07	6/07	10/07	6/08	4/10
TCE	1.0	ND	NS	ND	ND	ND	ND	ND
RDX	0.5	NS	ND	ND	ND	ND	ND	NS
Freon113	20,000	1.4	NS	0.3	8.9	81.0	NS	3.8

13MW-12 Conc. (ug/L)
(Total Depth: 33, Screened Interval: 23-33)

Compound	LOC	5/10
TCE	1.0	ND

13MW-1 (Total Depth: 253, Screened Interval: 228-253) Conc. (ug/L)

Compound	LOC	5/05	7/06	11/06	3/07	7/07	10/07	6/08	5/10	2/11
TCE	1.0	140	140	120	170	130	120	110	116	96
RDX	0.5	NS	NS	0.55	0.62	0.62	0.67	NS	NS	NS
Freon113	20,000	28	32	43	93	56	52	NS	72.7	66
1,2-DCA	2.0	ND	ND	ND	ND	ND	20	ND	ND	ND
1,1,2,2-TCA	1.0	ND	ND	ND	ND	ND	5.1	ND	ND	ND

AWDF (Total Depth: 430, Screened Interval: NA) Conc. (ug/L)

Compound	LOC	4/04	7/06	11/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	110	81	87	120	61	58	86	95.9	62
RDX	0.5	0.49	NS	0.11J	0.34J	0.23J	0.2J	NS	NS	NS
Freon113	20,000	33	15	ND	2.9	8.0	6.4	NS	15.4	10
MTBE	70	0.31	ND	ND	ND	ND	ND	0.28J	NS	ND

13MW-5 (Total Depth: 150, Screened Interval: 125-150) Conc. (ug/L)

Compound	LOC	7/06	11/06	3/07	6/07	10/07	6/08	4/10	2/11
TCE	1.0	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.5	1.1	0.38J	ND	0.13J	ND	ND	NS	NS
Freon113	20,000	730	490	190	170	100	10	107	56
MTBE	70	130	140	S1	35	21	NS	7.26	2.3

DM13-2 (Total Depth: 18, Screened Interval: 8-18) Conc. (ug/L)

Compound	LOC	4/04	5/05	7/06	11/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	15	5.2	8.6	0.77J	0.40J	2.6	NS	4.9	14.3	15
RDX	0.5	NS	NS	NS	ND	ND	ND	NS	NS	NS	NS
Freon113	20,000	12	6.5	10	1.2	1.4	3.8	NS	NS	11.1	11

13MW-13 Conc. (ug/L)
(Total Depth: 179, Screened Interval: 156-176)

Compound	LOC	5/10
TCE	1.0	ND

13MW-3 (Total Depth: 75, Screened Interval: 47-72) Conc. (ug/L)

Compound	LOC	5/05	7/06	11/06	3/07	6/07	10/07	6/08
TCE	1.0	9.5	6.6	10	24	17	21	18
RDX	0.5	NS	ND	0.12J	0.29J	0.26J	0.3J	0.36J
Freon113	20,000	4.7	2.4	2.8	9.0	5.5	7.4	NS
MTBE	70	3.8	2.9	3.6	2.3	1.1J	0.94J	0.55J

13MW-2 (Total Depth: 190, Screened Interval: 168-193) Conc. (ug/L)

Compound	LOC	5/05	7/06	11/06	3/07	6/07	10/07	6/08	5/10	2/11
TCE	1.0	42	130	81	110	130	110	130	171	210
RDX	0.5	NS	NS	0.18J	0.23J	0.2J	0.18J	NS	NS	NS
Freon113	20,000	14	60	31	45	52	41	NS	81.3	64
Toluene	600	31	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-DCE	70	ND	ND	ND	ND	2.0J	2.2	1.5	1.29	2

13MW-4 (Total Depth: 193, Screened Interval: 168-193) Conc. (ug/L)

Compound	LOC	5/05	7/06	11/06	3/07	6/07	10/07	6/08	4/10
TCE	1.0	39	15	19	34	33	40	35	8.64
RDX	0.5	NS	NS	ND	ND	0.11J	ND	ND	NS
Freon113	20,000	28	7.4	31	9.3	9.8	6.2	NS	3.01
MTBE	70	1	0.33	0.51J	0.567	0.54J	0.51J	0.48J	ND
VC	1	ND	0.245	ND	ND	ND	ND	ND	ND

13MW-6 (Total Depth: 147, Screened Interval: 122-147) Conc. (ug/L)

Compound	LOC	7/06	11/06	3/07	6/07	10/07	6/08	4/10	2/11
TCE	1.0	ND	ND	ND	ND	ND	NS	ND	ND
RDX	0.5	NS	ND	0.3	ND	ND	NS	NS	NS
Freon113	20,000	0.74J	ND	1.0	0.5	0.9J	NS	10.7	1.2
MTBE	70	ND	ND	ND	ND	ND	NS	ND	ND

13MW-7 (Total Depth: 105, Screened Interval: 80-105) Conc. (ug/L)

Compound	LOC	7/06	11/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	ND	ND	ND	ND	0.765	0.49	ND	ND
RDX	0.5	NS	0.44J	0.4	0.45J	0.485	NS	NS	NS
Freon113	20,000	470	540	1200	780	780	NS	875	740
MTBE	70	ND	ND	ND	ND	ND	ND	NS	ND

13MW-10 (Total Depth: 112.5, Screened Interval: 90-110) Conc. (ug/L)

Compound	LOC	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	0.33J	ND	ND	ND	ND	ND
RDX	0.5	ND	ND	ND	NS	NS	NS

DM13-3 (Total Depth: 27, Screened Interval: 17-27) Conc. (ug/L)

Compound	LOC	4/04	5/05	7/06	11/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	0.22	9.5	0.3J	ND	ND	ND	ND	ND	ND	ND
RDX	0.5	NS	NS	NS	ND	ND	ND	NS	NS	NS	NS
Freon113	20,000	2.3	4.7	1.2	1.7	1.9	ND	0.38J	ND	1.95	0.6
MTBE	70	ND	3.8	ND	ND	ND	ND	ND	ND	NS	ND

DM13-1 (Total Depth: 22, Screened Interval: 12-22) Conc. (ug/L)

Compound	LOC	4/04	5/05	7/06	11/06	3/07	6/07	10/07	6/08	5/10	2/11
TCE	1.0	33	17	22	20	20	16	8.5	12	11	13
RDX	0.5	NS	NS	NS	ND	ND	ND	ND	NS	NS	NS
Freon113	20,000	5.4	3.3	3.9	3.1	2.6	2.8	2.2	NS	1.68	1.7

600 Hill Waste Pit
Berkshire Trail
Building 660 - Advanced Warhead Development Facility (AWDF)
Bell Road
Bear Swamp Road
Miles Road
Picatinny Lake
13MW14
13MW-8
13MW-1
13MW-11
13MW-3
13MW-4
13MW-5
13MW-13
13MW-12
13MW-9
13MW-6
13MW-7
13MW-2
13MW-10
DM13-2
DM13-1
DM13-3
DM10-1
DM10-2
MW-2_N
159MW-1
AWDF
656
649
647
644
641
643
642
642C
640
639A
913
904
930
948
911
912
903
900
902
910
909
908
945

Legend

- Bedrock Monitoring Well
- Groundwater Flow Direction
- Approximate Extent of Waste Material
- Site Boundary
- 2007 TCE Plume Boundary
- 600 Area
- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- Existing Building
- Former Building
- Picatinny Arsenal
- Water Body
- Surface Contour (10 foot interval)
- Stream
- Wetland

NOTES AND SOURCES:
1. Map Coordinates: NAD83 State Plan New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. The groundwater comparison criteria shown in this figure are the Level of Concern (LOCs) developed for 600 Area Groundwater (Shaw, 2013).
4. Exceedances of LOCs are shown in red.
5. AWDF = Advanced Warhead Development Facility
6. AOC = Area of Concern; ND = non-detect
7. DCA = Dichloroethane; ft bgs = feet below ground surface
8. IRP = Installation Restoration Program; TCE = Trichloroethene
9. J = Detected concentration; value is an estimate
10. LOC = Level of Concern; MTBE = methyl tertiary-butyl ether
11. MRS = Munitions Response Site
12. NS = Not sampled; PICA = Picatinny Arsenal
13. RDX = Research Department Formula X (Cyclotrimethylenetrinitramine)
14. TCA = trichloroethane; DCE = dichloroethene
15. ug/L = microgram per liter; VC = vinyl chloride
16. Total well depth and screened interval in ft bgs.
17. The LOCs shown for Freon 113 (20,000 ug/L) and RDX (0.5 ug/L) are based on the most current NJDEP Interim GWQS last amended November 30, 2015.
18. This figure shows only the constituents detected in the groundwater samples collected from the site wells and does not include packer testing sampling results.
19. Figure adapted from Figure 4-1 of the Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
20. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.
21. The regional groundwater flow direction is based on groundwater gauging data provided in the FS (Shaw, 2013).

0 150 300 600
Feet

N W E S

Figure 5
Summary of Groundwater Sample Results
April 2004 - February 2011, 600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\PicatinnyMapDocuments\ROD\600HillWastePit\Fig05_600ROD_GWresults.mxd

11SW-2	Conc. (ug/L)								
Compound	LOC	6/05	8/06	11/06	3/07	6/07	10/07	6/08	4/10
TCE	1.0	ND	DRY	ND	ND	DRY	DRY	DRY	ND
RDX	0.5	NS	NS	3.7	0.86	DRY	DRY	DRY	NS

11SW-1	Conc. (ug/L)								
Compound	LOC	6/05	8/06	11/06	3/07	6/07	10/07	6/08	4/10
TCE	1.0	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.5	NS	NS	10	0.31J	ND	0.39J	ND	NS

11SW-3	Conc. (ug/L)									
Compound	LOC	6/05	8/06	11/06	3/07	6/07	10/07	6/08	4/10	1/11
TCE	1.0	7.6	ND	2.8	4.4	12.0	14	6.4	4.22	5.2
RDX	0.5	NS	NS	0.22J	0.26	0.22J	0.08	0.32	NS	NS

11SD-2 Conc. (mg/kg)				
Compound	LOC	11/04	1/06	6/08
TCE	1.6	ND	ND	NS
RDX	17	NS	NS	ND

11SD-1 Conc. (mg/kg)						
Compound	LOC	11/04	1/06	11/06	3/07	6/08
TCE	1.6	ND	ND	NS	NS	NS
RDX	17	NS	ND	ND	ND	ND
Toluene	0.05	0.12	0.071	NS	NS	NS

11SD-3 Conc. (mg/kg)				
Compound	LOC	11/04	1/06	6/08
TCE	1.6	ND	0.0048J	NS
RDX	17	NS	NS	ND

SD12-2
Sample Date: 1989
No Exceedances

600 Hill Waste Pit

SD12-1				
Sample Date: 1989				
Analyte	Bkgd[4]	NJDEP Criteria[3]	USEPA Criteria[2]	Conc (mg/kg)
Mercury	0.249	0.15	46	0.266

11SW-10 Conc. (ug/L)			
Compound	LOC	4/10	1/11
TCE	1.0	ND	ND

13SW-6	Conc. (ug/L)					
Compound	LOC	1/06	10/07	6/08	4/10	1/11
TCE	1.0	2.2	0.88J	0.74J	ND	3.4
RDX	0.5	NS	0.049J	ND	NS	NS
MTBE	2.6	3.9	0.39J	0.22J	ND	ND

13SD-6 Conc. (mg/kg)		
Compound	LOC	1/06
TCE	1.6	0.0026J

13SW-4	Conc. (ug/L)									
Compound	LOC	6/05	8/06	11/06	3/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	9.6	0.82J	5.0	0.97J	ND	ND	ND	ND	4.3
RDX	0.5	NS	NS	ND	ND	ND	ND	NS	NS	NS

13SD-4 Conc. (mg/kg)			
Compound	LOC	11/04	1/06
TCE	1.6	ND	ND

13SW-7 Conc. (ug/L)		
Compound	LOC	6/05
TCE	1.0	ND

13SD-7 Conc. (mg/kg)		
Compound	LOC	1/06
TCE	1.6	ND

13SW-5	Conc. (ug/L)									
Compound	LOC	6/05	8/06	11/06	2/07	6/07	10/07	6/08	5/10	1/11
TCE	1.0	0.82J	DRY	0.33J	ND	DRY	ND	ND	ND	ND
RDX	0.5	NS	NS	0.87J	ND	DRY	ND	NS	NS	NS

13SD-5 Conc. (mg/kg)			
Compound	LOC	11/04	1/06
TCE	1.6	ND	ND

13SW-8 Conc. (ug/L)		
Compound	LOC	6/05
TCE	1.0	ND

13SD-8 Conc. (mg/kg)		
Compound	LOC	1/06
TCE	1.6	ND
RDX	17	NS

13SW-9 Conc. (ug/L)		
Compound	LOC	6/05
TCE	1.0	ND

13SD-9 Conc. (mg/kg)		
Compound	LOC	1/06
TCE	1.6	ND

13MW-8, 13MW-11, 13MW-12, 13MW-9, 13MW-5, 13MW-13, 13MW-1, 13MW-3, 13MW-4, 13MW-6, 13MW-7, 13MW-2, 13MW-10, 159MW-1
SD12-1, SD12-2, DM13-1, DM13-2, DM13-3
11SW/SD-1, 11SW/SD-2, 11SW/SD-10, 11SW/SD-3, 13SW/SD-4, 13SW/SD-5, 13SW/SD-6, 13SW/SD-7, 13SW/SD-8, 13SW/SD-9
AWDF, Building 660 - Advanced Warhead Development Facility (AWDF)
Unnamed Stream, Bear Swamp Road, Bell Road, Miles Road, Fidler Road, Babbitt Road, Bott Road, Burnt Meadow Brook, Picatinny Lake

Legend

- 1989 Sediment Sample Location
- Surface Water/Sediment Sample Location
- MNA Monitoring and Compliance Well
- Site Boundary
- 2007 TCE Plume Boundary
- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- 600 Area
- Approximate Extent of Waste Material
- Existing Building
- Former Building
- Picatinny Arsenal
- Water Body
- Surface Contour (10 foot interval)
- Stream
- Wetland

NOTES AND SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. The surface water comparison criteria (LOCs) shown in this figure are based on NJDEP Surface Water Quality Standards (SWQS) last amended April 4, 2011 and the NJDEP Interim GWQS last updated November 30, 2015 (for RDX only). The sediment comparison criteria (LOCs) shown in this figure are based on the NJDEP Ecological Screening Criteria - Effects Range -Low (ER-Ls) effective March 2009. The comparison criteria for RDX in sediment (17 mg/kg) is based on the NJDEP Interim (Non-promulgated) Non-Residential Soil Remediation Standard. The comparison criteria for toluene in sediment (0.05 mg/kg) is based on the Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota – Oak Ridge National Laboratory (ORNL). November 1997. The screening criteria for MTBE (2.6 ug/L) in surface water is based on the USEPA Region III Tap Water Risk Based Criteria (RBC for Carcinogen 1x10-6).
4. Note the NJDEP SWQS for TCE has been updated in April 2011 from 1.09 ug/L to 1.0 ug/L which is shown in this figure.
5. The surface water LOC shown for RDX (0.5 ug/L) is based on the most current NJDEP Interim GWQS, last amended November 30, 2015.
6. Exceedances of LOCs are shown in red.
7. AWDF = Advanced Warhead Development Facility
8. ft bgs = feet below ground surface
9. J = Detected concentration; value is an estimate
10. LOC = Level of Concern; MTBE = methyl tertiary-butyl ether
11. MRS = Munitions Response Site; mg/kg = milligrams per kilogram
12. ND = Not detected; NS= Not sampled
13. PICA = Picatinny Arsenal; TCE = Trichloroethene
14. RDX = Research Department Formula X (Cyclotrimethylenetrinitramine)
15. ug/L = microgram per liter
16. This figure shows only the constituents detected in the surface water and sediment samples collected.
17. Boxes for surface water results are highlighted in purple and boxes for sediment sample results are highlighted in yellow.
18. Figure adapted from Figure 4-5 of the Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
19. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.

0 200 400 Feet

N W E S

Figure 6
Summary of Surface Water and Sediment Sampling Results
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\PicatinnyMapDocuments\ROD\600HillWastePit\Fig06_600ROD_SWSED.mxd

SOIL-GAS RESULTS

TCE [µg]

0.993
0.817
0.672
0.553
0.455
0.374
0.308
0.253
0.208
0.171
0.141
0.116
0.095
0.078
0.065
0.053
0.044
0.036
0.030
0.024
0.020

13TP-1			
Sample Date: 6/21/2011		Depth:	1-1.5 ft
Analyte	NJDEP Criteria	USEPA Criteria	Conc (mg/kg)
Benzo(a)pyrene*	2.0	2.1	0.601 J
Sample Date: 6/21/2011		Depth:	7-7.5 ft
No Exceedances			
Sample Date: 6/21/2011		Depth:	11.5-12 ft
No Exceedances			

13TP-1
(1-1.5)
(7-7.5)
(11.5-12)

SS12-2			
Sample Date: 1989		Depth:	0.5-1
Analyte	NJDEP Criteria[1]	USEPA Criteria[2]	Conc (mg/kg)
2,4-Dinitrotoluene	3.0	7.4	**11.7**
Nitroglycerin	NC	82	**97.0**

SS12-1			
Sample Date: 1989		Depth:	0.5-1
Analyte	NJDEP Criteria[1]	USEPA Criteria[2]	Conc (mg/kg)
Arsenic	19	3.0	**10[3]**

Burn Cage

SS12-3

SS12-3		
Sample Date: 1989	Depth:	0.5-1 ft
No Exceedances		

SS12-2

SS12-1

Munitions Waste Pit

SS12-4		
Sample Date: 1989	Depth:	0.5-1 ft
No Exceedances		

SS12-4

656

13TP-2		
Sample Date: 6/22/2011	Depth:	1-1.5 ft
No Exceedances		
Sample Date: 6/22/2011	Depth:	5-5.5 ft
No Exceedances		
Sample Date: 6/22/2011	Depth:	11.5-12 ft
No Exceedances		

13TP-2
(1-1.5)
(5-5.5)
(11.5-12)

13TR2-1		
Sample Date: 6/22/2011	Depth:	1.5-2 ft
No Exceedances		
Sample Date: 6/23/2011	Depth:	4.5-5 ft
No Exceedances		

13TR2-1
(1.5-2)
(4.5-5)*

13TR1-1			
Sample Date: 5/24/2012		Depth:	24-24.5 ft
Analyte	NJDEP Criteria	USEPA Criteria	Conc (mg/kg)
Trichloroethene	10	6.0	**23.9 D**

13TR1-1 (24-24.5)

13TR1-1		
Sample Date: 5/22/2012	Depth:	10.5-11 ft
No Exceedances		

13TR1-1 (10.5-11)

13TR1-1		
Sample Date: 5/23/2012	Depth:	19-20 ft
No Exceedances		

13TR1-1
(19-20)

13MW-1

13TR1-1		
Sample Date: 5/22/2012	Depth:	1-1.5 ft
No Exceedances		

13TR1-1 (1-1.5)

ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig07_600ROD_Site12TPloca.mxd

Legend

- 1989 Surface Soil Sample Location
- 2011/2014 Test Pit or Trench Soil Sample
- 2004 Soil-Gas Sample Location
- 2010/2011 Soil-Gas Sample Location
- Munitions Debris (MD) Encountered
- DoD Military Munitions Encountered +
- Montoring Well
- June 2011 Test Pit/Trench
- Former Building 656
- May 2012 Trench/Test Pit Excavation
- Extent of Large Gravel Piles During June 2011 Investigation
- Extent of Fill Material Deposited

References:
(1) New Jersey Department of Environmental Protection (NJDEP) Non-Residential Direct Contact Soil Remediation Standard (September 2017).
(2) United States Environmental Protection Agency (USEPA) Industrial Regional Screening Level (RSL) Summary Table (TR=1E-06, HQ=1), Industrial Screening Values (June 2017).
(3) An estimated value. Sample was not diluted and exceeded instrument calibration range (Dames and Moore, 1989).

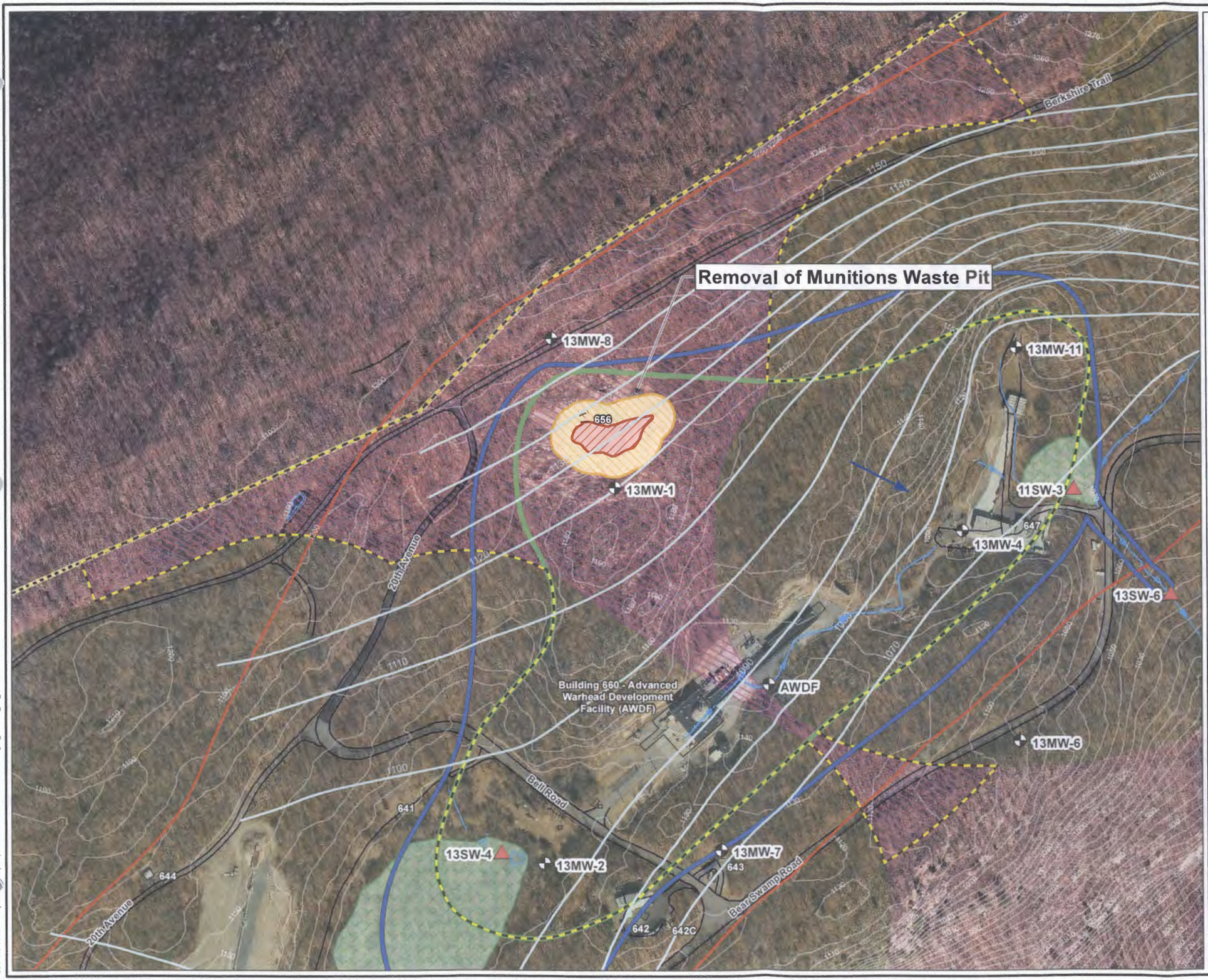
Notes:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. Soil sample intervals are in feet (ft) below ground surface.
4. 13TR2-1 (4.5-5)* - Two soil samples were collected from the same depth interval within approximately 2 ft, horizontally, of each other. The initial soil sample was located where the crushed drum was discovered and the second soil sample was located where the gravel mine canister was discovered.
5. All test pit/trench soil samples were analyzed for volatile organic compounds (VOCs). Yellow highlighted soil sample intervals (i.e., 19-20) were also analyzed for metals, explosives, and semi-volatile organic compounds (SVOCs) in addition to VOCs.
6. The shaded areas are the interpreted soil-gas trichloroethene (TCE) concentrations corresponding to the color-coded levels for micrograms (µg) of TCE in soil-gas.
7. Figure adapted from Figure 4-9 of the Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
8. The 1989 Site Investigation of Picatinny Arsenal (Dames and Moore, 1989) soil and sediment samples were analyzed for metals, explosives, and propellants.
9. D = sample was diluted; J = estimated value
10. Surficial soil sample result tables are highlighted in green.
11. Subsurface soil sample result tables are highlighted in orange.
12. Values shown in bold exceed one or both of the criteria shown.
13. * = Since the issuing of the Final Feasibility Study (FS) for 600 Hill Waste Pit (600 Hill Groundwater Plume [PICA-058] and Inactive Munitions Waste Pit [PICA-013-R-01]) (ECC, 2017), the screening criteria for both USEPA and NJDEP have been updated. The reported concentration of benzo(a)pyrene is no longer above the screening criteria and only shown on this figure for consistency with the Final FS.
14. + = The encountered DoD military munition was identified by the UXO-qualified Technicians to be munitions of explosive concern (MEC). The item identified as a CDU-10 [T-1]/B Canister with XM39E and XM44 [Gravel Mines]), was encountered at approximately 4.5 ft bgs at Test Trench 13TR2-1.

0 15 30 60
Feet

N W E S

Figure 7
Source Area Investigation Soil and Soil-Gas Sampling Results, 600 Hill Waste Pit
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey



ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig08_600ROD_RA_6.mxd

Legend

- Surface Water Monitoring Point
- MNA Monitoring and Compliance Well
- Groundwater Flow Direction
- Groundwater Contour, June 2007
- Groundwater Land Use Control Area/Area of Attainment

Proposed Remedial Alternatives

- Excavation Area/No UXO Related LUC/Construction Support Required *
- Cutback Area (50' Buffer of Excavation Area)
- Site Boundary
- 2007 TCE Plume Boundary
- DoD Military Munitions Land Use Controls/Construction Support
- 600 Area Boundary
- Existing Building
- Former Building
- Operational Range Areas
- Picatinny Arsenal Boundary
- Surface Contour (10 foot interval)
- Stream
- Wetland

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. * Excavation Area based on approximate location of munitions waste pit identified in the Military Munitions Response Program Remedial Investigation (Weston, 2014).
4. LUC = Land Use Controls
5. AWDF = Advanced Warhead Development Facility
6. PICA = Picatinny Arsenal
7. MNA = Monitored Natural Attenuation
8. UXO = Unexploded Ordnance
9. TCE = Trichloroethene
10. Figure adapted from Figure 10-4 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
11. The area where the TCE plume extent is within the Active Operation Range Area is not included in the Groundwater Land Use Control Area.
12. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.
13. The regional groundwater flow direction is based on groundwater gauging data provided in the FS (Shaw, 2013).
14. Alternative 6 includes the application of carbon substrate amendment to the excavation area in order to enhance the degradation of TCE in the groundwater. The carbon substrate can be emulsified vegetable oil (EVO), molasses, or other carbon source which will be identified during the Design Phase for Alternative 6.

0 125 250 500
Feet

N W E S

Figure 8
Remedial Alternative 6: Munitions Waste Pit Removal, Monitored Natural Attenuation Polishing, and Land Use Controls, 600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

600 Hill Waste Pit

DoD Military Munitions Land Use Controls

Berkshire Trail

20th Avenue

Bell Road

Bear Swamp Road

Miles Road

Fidlar Road

Building 660 - Advanced Warhead Development Facility (AWDF)

13MW-8
13MW-1
13MW-11
11SW-3
13MW-4
13SW-6
13MW-6
13SW-4
13MW-2
13MW-7
13SW-5
DM13-3

656
649
647
641
644
643
642
642C
904
911

Legend

- MNA Monitoring and Compliance Well
- Surface Water Monitoring Point
- Groundwater Land Use Control Area/Area of Attainment
- Site Boundary
- 2007 TCE Plume Boundary
- DoD Military Munitions Land Use Controls/ Construction Support
- 600 Area Boundary
- Approximate Extent of Waste Material
- Operational Range Areas
- Picatinny Arsenal Boundary
- Existing Building
- Former Building
- Water Body
- Surface Contour (10 foot interval)
- Stream
- Road
- Wetland

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. PICA = Picatinny Arsenal
4. AWDF = Advanced Warhead Development Facility
5. DoD = Department of Defense
6. MNA = Monitored Natural Attenuation
7. MRS = Munitions Response Site
8. TCE = Trichloroethene
9. Figure adapted from Figure 10-2 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
10. The area where the TCE plume extent is within the Active Operation Range Area is not included in the Groundwater Land Use Control Area.
11. The Groundwater Land Use Control Area is the same area as the Area of Attainment.

0 125 250 500
Feet

N W E S

Figure 9
Remedial Alternative 2: Groundwater and DoD Military Munitions Land Use Controls
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\PicatinnyMapDocuments\ROD\600HillWastePit\Fig09_600ROD_RA_2.mxd

13MW-8

Munitions Waste Pit

Rubble Piles

656

IMWP-004
(24-24.5)

IMWP-003
(19-20)

IMWP-002
(10-11)

Fill/Gravel Piles

13MW-1

Legend

- MC Sample Location (sample depth ft bgs)
- Monitoring Well
- Shaw Completed Test Pit Location
- Approximate 2012 Limit of Disturbance
- Approximate Extent of Waste Material
- Limit of Disturbance in 1963 Aerial
- Fill/Gravel or Rubble Piles
- May 2012 Trench/Test Pit Excavation
- Burn Cage Current Location
- Inactive Munitions Waste Pit MRS (PICA-013-R-01)
- Former Building
- Picatinny Arsenal Boundary

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. PICA = Picatinny Arsenal
4. MC = munitions constituents
5. ppm = parts per million
6. MRS = Munitions Response Site
7. Figure adapted from Figure 6-24 of the Final Remedial Investigation Report, Military Munitions Response Program Remedial Investigation (Weston, 2014).

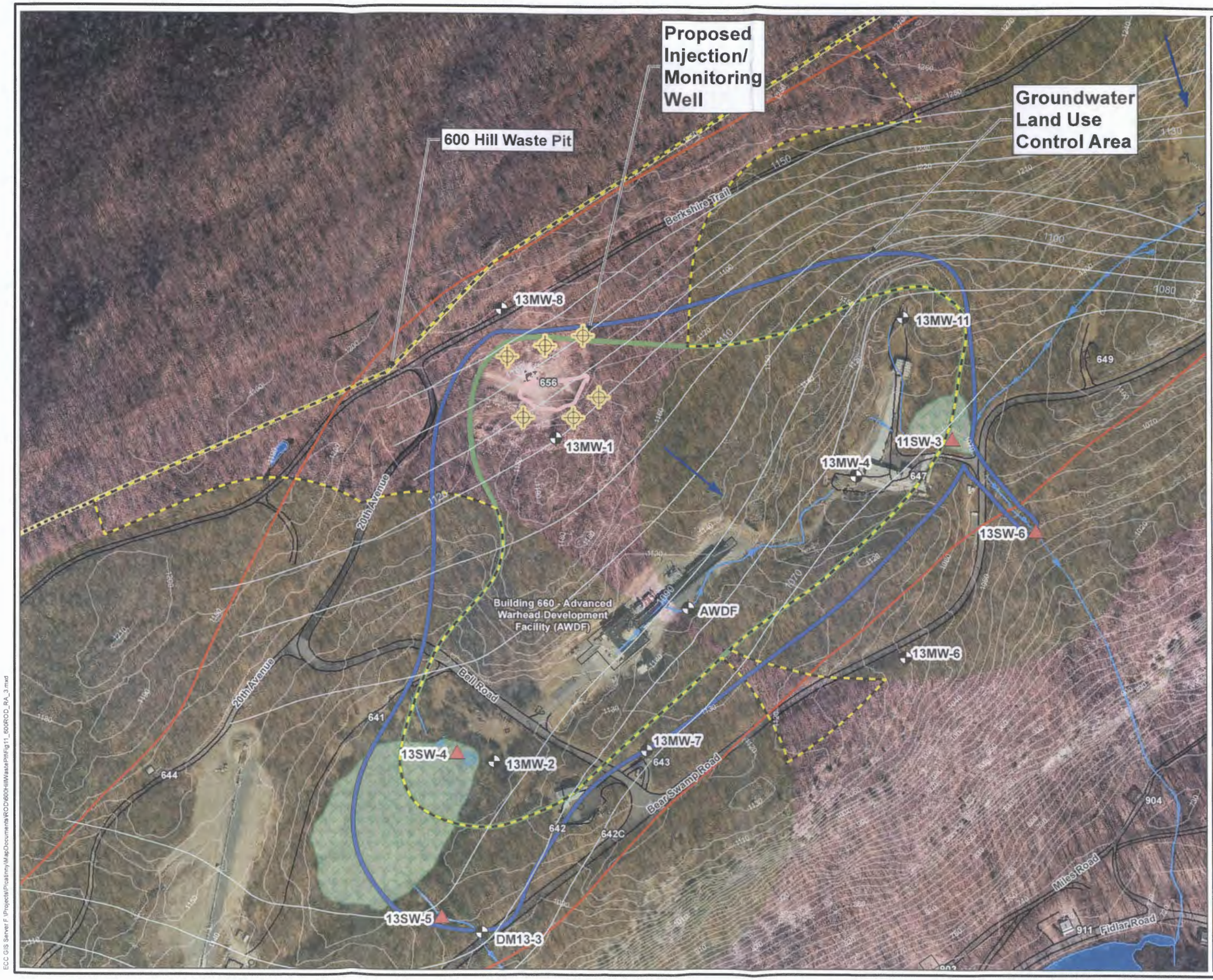
0 20 40 80
Feet

N
W E
S

Figure 10
Digital Geophysical Mapping (DGM) Results
Inactive Munitions Waste Pit
Munitions Response Site
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig10_600ROD_DGM.mxd



Legend

- Proposed Injection/Monitoring Well
- Surface Water Monitoring Point
- MNA Monitoring and Compliance Well
- Groundwater Flow Direction
- Groundwater Contour, June 2007
- Groundwater Land Use Control Area/Area of Attainment
- Site Boundary
- 2007 TCE Plume Boundary
- 600 Area Boundary
- Approximate Extent of Waste Material
- Existing Building
- Former Building
- Operational Range Areas
- Picatinny Arsenal Boundary
- Water Body
- Surface Contour (10 foot interval)
- Stream
- Wetland

NOTES & SOURCES:

1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. PICA = Picatinny Arsenal
4. AWDF = Advanced Warhead Development Facility
5. MNA = Monitored Natural Attenuation
6. TCE = Trichloroethene
7. Figure adapted from Figure 10-3 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
8. The area where the TCE plume extent is within the Active Operation Range Area is not included in the Groundwater Land Use Control Area.
9. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.
10. The regional groundwater flow direction is based on groundwater gauging data provided in the Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).

0 125 250 500

Feet

N W E S

Figure 11
Remedial Alternative 3:
In-Situ Treatment, Injection Points and
Monitored Natural Attenuation Sampling Locations
600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\PicatinnyMapDocuments\ROD\600HillWastePit\Fig11_600ROD_RA_3.mxd

Legend

- Proposed Monitoring Well Location
- Monitoring Well
- Infiltration Gallery (60' x 120')
- May 2012 Trench/Test Pit Excavation Area
- Site Boundary
- 2007 TCE Plume Boundary
- Burn Cage
- Extent of Fill Material - 1990's
- Extent of Fill Material Deposited - 1970's
- Former Building
- Picatinny Arsenal

NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. ' = feet
4. TCE = Trichloroethene
5. Figure adapted from Figure 10-4 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
6. See Alternative 3 (Figure 6-4) for monitored natural attenuation (MNA) sample locations and land use control (LUC) boundaries.

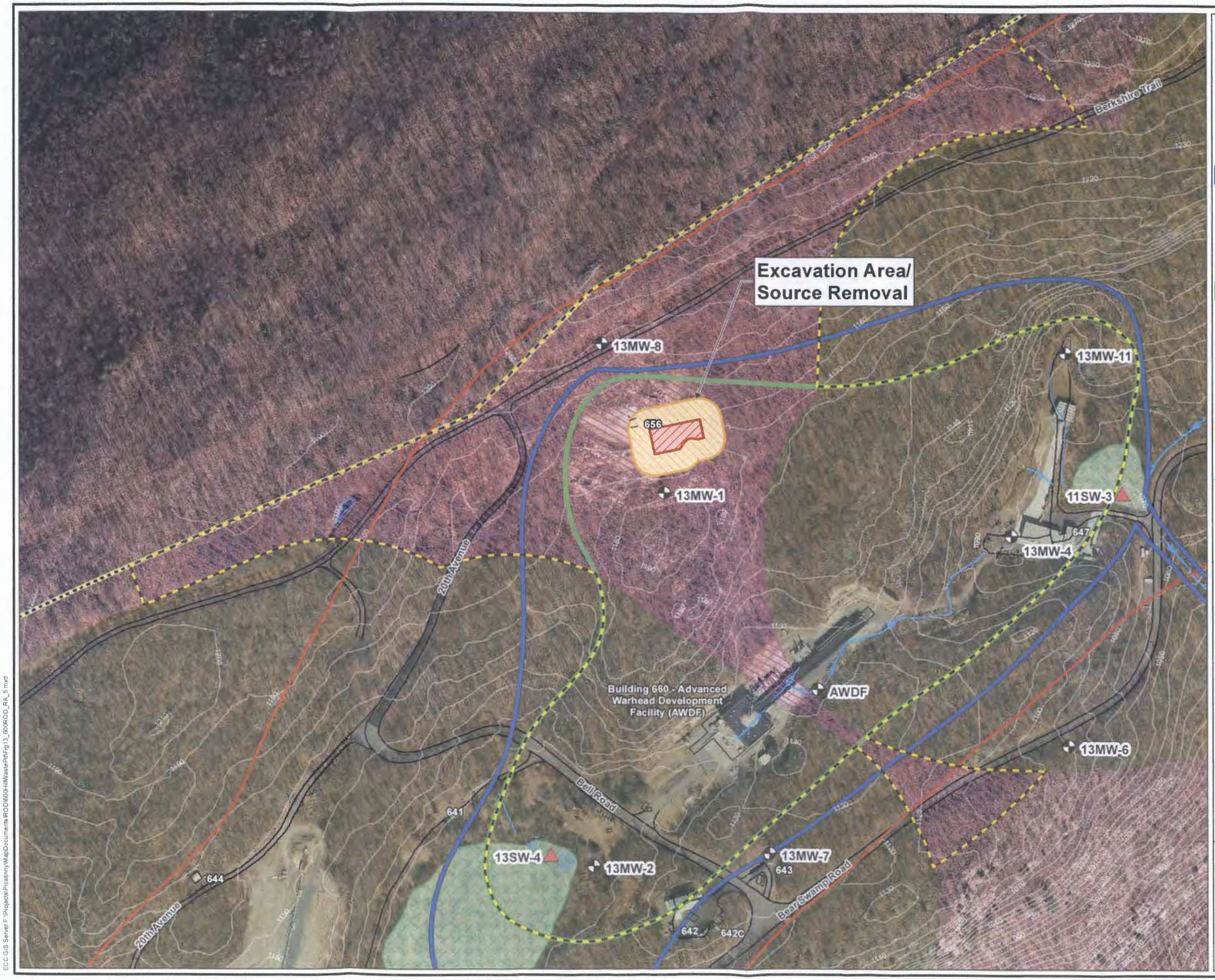
0 15 30 60
Feet

N
W E
S

Figure 12
Remedial Alternative 4: In Situ Enhanced Anaerobic Bioremediation and Monitored Natural Attenuation Polishing and Land Use Controls, 600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

ECC GIS Server F:\Projects\...\MapDocuments\ROD\600HillWaste\PM\Fig12_600ROD_RA_4.mxd



ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig13_600ROD_RA_5.mxd

ECC

Legend

- Surface Water Monitoring Point
- MNA Monitoring and Compliance Well
- Groundwater Land Use Control Area/Area of Attainment

Proposed Remedial Alternatives

- Excavation Area/No UXO Related LUC/Construction Support Required (~60' x 120') (6,326 sq ft)
- Side Wall Cutback Area (~160' x 200') (25,432 sq ft)
- Site Boundary
- 2007 TCE Plume Boundary
- DoD Military Munitions Land Use Controls/Construction Support
- 600 Area
- Existing Building
- Former Building
- Operational Range Areas
- Picatinny Arsenal Boundary
- Surface Contour (10 foot interval)
- Stream
- Wetland

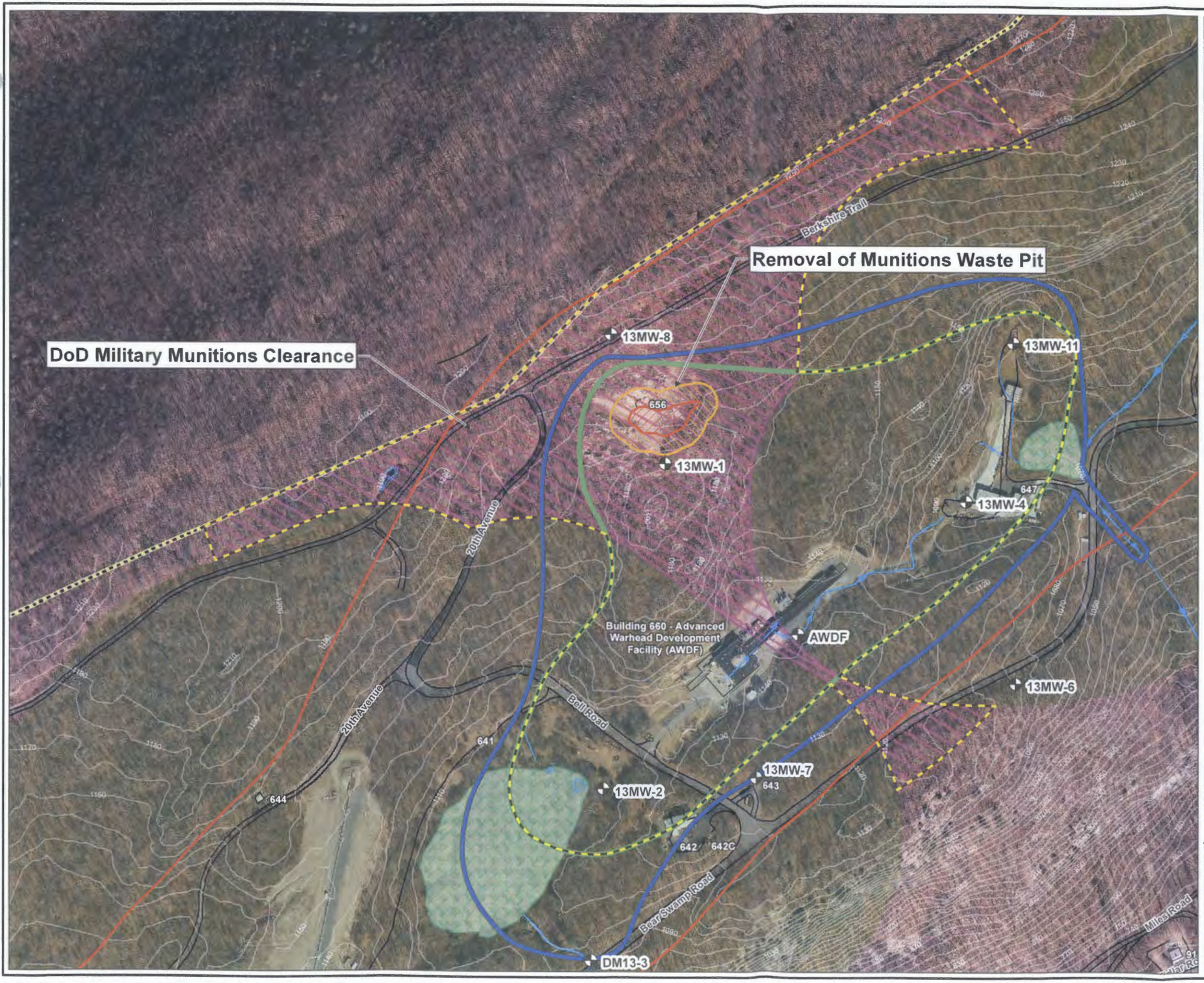
NOTES & SOURCES:
1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. AWDF = Advanced Warhead Development Facility
4. PICA = Picatinny Arsenal
5. MNA = Monitored Natural Attenuation
6. LUC = Land Use Controls
7. sq ft = Square Feet
8. TCE = Trichloroethene
9. UXO = Unexploded Ordnance
10. Figure adapted from Figure 10-4 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
11. The area where the TCE plume extent is within the Active Operation Range Area is not included in the Groundwater Land Use Control Area.
12. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.

0 125 250 500
Feet

N W E S

Figure 13
Remedial Alternative 5:
Source Removal, Monitored Natural Attenuation
Polishing and Land Use Controls, 600 Area

600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey



ECC GIS Server F:\Projects\Picatinny\MapDocuments\ROD\600HillWastePit\Fig14_600ROD_RA_7.mxd

Legend

- MNA Monitoring and Compliance Well
- Groundwater Land Use Control Area/Area of Attainment

Proposed Remedial Alternatives

- Excavation Area *
- Cutback Area (50' Buffer of Excavation Area)
- Site Boundary
- 2007 TCE Plume Boundary
- Surface and Subsurface Removal of DoD Military Munitions/Land Use Controls/Construction Support
- 600 Area
- Operational Range Areas
- Picatinny Arsenal
- Existing Building
- Former Building
- Surface Contour (10 foot interval)
- Stream
- Wetland

NOTES & SOURCES:

1. Map Coordinates: NAD83 State Plane New Jersey, US feet
2. 2016 aerial photograph provided by Picatinny Arsenal.
3. * Excavation Area based on approximate location of waste pit identified by Weston (2012).
4. ' = feet
5. AWDF = Advanced Warhead Development Facility
6. PICA = Picatinny Arsenal
7. MRS = Munitions Response Site
8. DoD = Department of Defense
9. TCE = Trichloroethene
10. Figure adapted from Figure 10-5 of the 600 Area Data Report and Feasibility Study 600 Area Groundwater Plume (PICA 58), Revision 3 (Shaw, 2013).
11. The area where the TCE plume extent is within the Active Operation Range Area is not included in the Groundwater Land Use Control Area.
12. The AWDF well is an open borehole well that was formally used as a non-potable well at Building 660; however, it is currently off-line and not in use.
13. DoD Military Munitions Land Use Controls/Construction Support are included in the remedy for two, five-year review periods to document that the remedy remains protective with regards to explosive hazards.
14. The subsurface clearance depth was assumed to extend to an average depth of 2 feet below ground surface; however, anomalies will be removed to depth and may be found to extend deeper than 2 feet in some areas.

0 125 250 500
Feet

N W E S

Figure 14
Remedial Alternative 7: Munitions Waste Pit Removal, Monitored Natural Attenuation Polishing, Land Use Controls and DoD Military Munitions Clearance of Entire Munitions Response Site, 600 Area
600 Hill Waste Pit Record of Decision
Picatinny Arsenal
Morris County, New Jersey

This page intentionally left blank

Tables

This page intentionally left blank

LIST OF TABLES

This page intentionally left blank

Table 1: Chronology of Investigations at the 600 Area, Picatinny Arsenal, New Jersey

ACTIVITY	REPORT AUTHOR	DATE
Facility-Wide		
Site Investigation of Picatinny Arsenal, New Jersey Volume 1, Main Report and Appendices A through E	Dames & Moore	1989
Remedial Investigation Concept Plan	Argonne National Laboratory	1991
Remedial Investigation Concept Plan for Picatinny Arsenal. Environmental Setting, Applicable Regulations, Summaries of Site Sampling Plans, Sampling Priorities, and Supporting Appendices, Volume 1	Dames & Moore	1991
Site Investigation of Picatinny Arsenal, New Jersey, Volumes 1 and II	Dames and Moore	1998
Draft Final Picatinny Arsenal Phase II Ecological Risk Assessment	IT Corporation	2000
Phase III-1A Human Health Risk Assessment Approach (Final)	IT Corporation	2001
Picatinny Arsenal Facility-Wide Background Investigation	IT Corporation	2002
600 Area Groundwater		
Final 600 Area Groundwater Remedial Investigation Work Plan	Shaw Environmental, Inc.	2004
600 Area Work Plan Addendum	Shaw Environmental, Inc.	2005a
Phase III and I 2A/3A Sites Ecological Risk Assessment	Shaw Environmental, Inc.	2005b
600 Area Groundwater Investigation Data Report	Shaw Environmental, Inc.	2005c
Well Head Protection Plan (Final)	Shaw Environmental, Inc.	2005d
600 Area Groundwater Investigation – Supplemental Investigation Work Plan	Shaw Environmental, Inc.	2006a
600 Area Groundwater Investigation – Update on Additional Work	Shaw Environmental, Inc.	2006b
600 Area Groundwater Investigation – Pump Test Work Plan	Shaw Environmental, Inc.	2007a
Facility-Wide		
600 Area Groundwater Investigation – Well Log and Isotope Data	Shaw Environmental, Inc.	2007b
600 Area Risk Assessment Revised Approach, email correspondence among Mr. William Roach, USEPA Project Manager, Charles Nance, U.S. Environmental Protection Agency Region 2 Toxicologist, and Mark Weisberg, Shaw Risk Assessor, through Mr. Ted Gabel, Picatinny Arsenal Project Manager for Installation Restoration, 30 June, 7 July, 24 July, and 13 August	Shaw Environmental, Inc.	2008
Picatinny Arsenal Task Order 17 600 Area RDX Investigation Data Report, April	Shaw Environmental, Inc.	2009
600 Area MTBE Groundwater Investigation Data Report	Shaw Environmental, Inc.	2010a
600 Area Work Plan for Vapor Intrusion and Source Area Investigation	Shaw Environmental, Inc.	2010b
Building 660 Vapor Intrusion Investigation Report	Shaw Environmental, Inc.	2011
Final 600 Area Data Report and Feasibility Study, 600 Area Groundwater Plume (PICA-058), Volume I Report and Appendixes A through P, Final Revision 3	Shaw Environmental, Inc.	2013
Inactive Munitions Waste Pit Munitions Response Site		
Executive Order 11508 Picatinny Arsenal Survey Report	Dept. of Defense	1973
Final Site Inspection	Malcolm Pirnie, Inc.	2008
Military Munitions Response Program Remedial Investigation	Weston Solutions, Inc.	2012
Final Remedial Investigation Report: Military Munitions Response Program Remedial Investigation	Weston Solutions, Inc.	2014

Source: Final Feasibility Study (ECC, 2017) and Final Proposed Plan (Army, 2018).

This page intentionally left blank

Table 2: Contaminant of Concern (COC) 600 Area Groundwater, Picatinny Arsenal, New Jersey

Chemical	Historical Maximum Observed Concentration 600 Area (µg/L)	ARAR (µg/L)	Frequency of ARAR Exceedances	COC Screening Criteria			COC
				Above ARAR?	Plume Distribution?	Risk Driver?	
Volatile Organic Compounds							
Trichloroethene	210	1	67 / 124	Yes	Yes	Yes	Yes

Notes:

µg/L = Microgram per liter

ARAR = Applicable or Relevant and Appropriate Requirement

COC = Contaminant of concern

Source: Modified Final FS (ECC, 2017).

Table 3: Existing Monitoring Well Construction Summary, 600 Hill Waste Pit, 600 Area Groundwater, Picatinny Arsenal, New Jersey

Well ID	Well Completion Date	Well Design	Media	Steel Outer Casing, Diameter (inches)	Casing Depth, (ft bgs)	Total Depth (ft)	PVC Screen Size (inches)	Screen length (feet)	Screen diameter (inches)	Screened Interval, (ft. bgs)
13MW-1	4/13/2005	Stick-up	Bedrock	8	26	253	0.020	25	4	228-253
13MW-2	4/13/2005	Stick-up	Bedrock	8	36	190	0.020	25	4	168-193
13MW-3	4/13/2005	Flush	Bedrock	6	19	75	0.020	25	2	47-72
13MW-4	4/13/2005	Flush	Bedrock	8	19	193	0.020	25	4	168-193
13MW-5	7/5/2006	Stick-up	Bedrock	8	20	150	0.010	25	4	125-150
13MW-6	7/18/2006	Stick-up	Bedrock	8	16.5	147	0.010	25	4	122-147
13MW-7	7/18/2006	Stick-up	Bedrock	8	17	105	0.010	25	4	80-105
13MW-8	7/18/2006	Stick-up	Bedrock	8	17	103	0.010	25	4	78-103
13MW-9	7/10/2006	Flush	Bedrock	6	20	45	0.010	25	2	25-45
13MW-10	2/26/2007	Flush	Bedrock	6	17	112.5	0.010	20	2	90-110
13MW-11	2/26/2007	Stick-up	Bedrock	6	14	30	0.010	10	2	17.3-27.3
13MW-12	2/26/2007	Stick-up	Bedrock	6	12	34	0.010	10	2	23-33
13MW-13	2/26/2007	Stick-up	Bedrock	6	17	180	0.010	10	2	156-176
AWDF	6/3/1994	Stick-up	Bedrock	6	40	430	Open	NA	NA	NA
MW-2_N	1/1/1981	Stick-up	Bedrock	6	20	48.5	0.010	10	2	38.5-48.5
DM13-1	3/7/1988	Stick-up	Bedrock	6	2.5	22	0.020	10	4	12-22
DM13-2	2/25/1988	Stick-up	Bedrock	6	2.5	18	0.020	10	4	8-18
DM13-3	2/26/1988	Stick-up	Bedrock	6	2.5	27	0.020	10	4	17-27
DM10-1	3/1/1988	Stick-up	Bedrock	8	2.5	45	0.020	10	4	35-45
DM10-2	2/26/1988	Stick-up	Bedrock	8	2.5	33	0.020	10	4	25-35
Source: 600 Area Data Report/Feasibility Study Picatinny, New Jersey (Shaw 2013) and the Picatinny Geographic Information System (GIS) Database. Final Document, Revision #3										

Notes
bgs – below ground surface
Ft – feet
NA – not applicable

Table 4: Chemical-Specific Groundwater Applicable or Relevant and Appropriate Requirements and To Be Considered, 600 Area Groundwater, Picatinny Arsenal, New Jersey

Media/Chemical	Requirement	Requirement Synopsis	Status
Groundwater/TCE (See **Table 2**)[1]	Safe Drinking Water Act Maximum Contaminant Levels, 40 CFR 141.61 through 141.62	Maximum Contaminant Levels have been promulgated and regulate contaminants in public drinking water.	ARAR
	New Jersey Safe Drinking Water Act State Maximum Contaminant Levels, N.J.A.C. 7:10-5.2 through 5.4	Maximum Contaminant Levels have been promulgated by the State and regulate contaminants in public drinking water.	ARAR
	New Jersey Groundwater Quality Standards, N.J.A.C. 7:9C-1.7 and Table 1	Groundwater quality standards have been promulgated and regulate contaminants in groundwater[1].	ARAR
	New Jersey Site Remediation Program. Introduction to Site-Specific Impact to Groundwater Soil Remediation Standards Guidance Document, December 2008	Guidance on developing site-specific soil standards for the protection of groundwater.	TBC
	Safe Drinking Water Act Maximum Contaminant Level Goals, 40 CFR 141.50 through 141.51	Promulgated health-based goals for drinking water sources.	ARAR
	New Jersey Administrative Code NJAC 7:8, Subchapter 5, 5.3 through 5.9	Design and performance standards for stormwater management measures	ARAR

Notes:

ARAR = Applicable or relevant and appropriate requirements
CFR = Code of Federal Regulations
N.J.A.C. = New Jersey Administrative Code
TCE = Trichloroethene
TBC = To Be Considered

1. Note that TCE is the only chemical in groundwater for which a chemical-specific ARAR (1 µg/L) has been established based on the NJDEP Groundwater Quality Standards.

Source: Modified from Final FS (ECC, 2017).

Table 5: Action-Specific Applicable or Relevant and Appropriate Requirements for 600 Hill Waste Pit, Picatinny Arsenal, New Jersey

Action	Requirement	Requirement Synopsis	Status
General Remediation and Institutional Controls	Technical Requirements for Site Remediation N.J.A.C. 7:26E-5.1(d)3	Specifies that remediation must not cause an uncontrolled discharge or transfer of contaminants to another media. Requirement is substantive because it specified a standard of control for onsite remedial action.	ARAR
	Technical Requirements for Site Remediation N.J.A.C. 7:26E-5.1(e)	Requires that remediation must remove free product and residual product to the extent practicable or contain free product and residual product when treatment or removal is not practicable. Requirement is substantive because it provides a standard of control related to protectiveness of the onsite action	ARAR
	Technical Requirements for Site Remediation N.J.A.C. 7:26E- 1.5 (h)	Excavated soil or drill cuttings may be returned to the original location provided neither free product nor residual product is present. Requirement is substantive because it provides a standard of control related to protectiveness of the onsite action.	ARAR
	Technical Requirements for Site Remediation N.J.A.C. 7:26E 5.2 (b) through (f)	Specifies the requirements for using alternative fill from an onsite or offsite source for backfilling excavations. Specifies the requirements for utilizing clean fill for backfill allowable ing excavations. Requirement is substantive because it dictates constituent levels for the fill material allowable for use as backfill.	ARAR
	Technical Requirements for Site Remediation N.J.A.C. 7:26E-4.2	Specifies requirements of soil excavation, confirmatory and quality assurance sampling and analysis at remediation sites.	ARAR
	Well Construction and Maintenance; Sealing of Abandoned Wells N.J.A.C 7:9D, Subchapters 2 and 3	Technical requirements for the installation and abandonment of monitoring wells.	ARAR
	New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Groundwater Technical Manual (June 2007)	Provides on guidance on discharge of groundwater into surface water features.	TBC
Management of Military Munitions	RCRA, Subpart M (Military Munitions Rule). 40 CFR 266 (203 through 206)	Provide relevant standards on the management of any recovered military munitions, including standards applicable for transportation of military munitions (40 CFR 266.203), emergency responses (40 CFR 266.205), storage (40 CFR 266.205) and treatment (40 CFR 266. 206), as applicable.	ARAR
Discharge of Aqueous Waste to Surface Water	Clean Water Act Effluent Guidelines 40 CFR 401. 13; 401.15; 401.16; and 401.17	Provides requirements for point source (a pipe, ditch, or channel) discharges of pollutants to surface water (or wetlands), where applicable. Requirement is substantive because it specifies the level or standard of control for potential discharge of stormwater resulting from the implementation of the selected remedy.	ARAR
Discharge of Aqueous Waste to Surface Water	New Jersey Pollutant Discharge Elimination System (NJPDES) (N.J.A.C. 7:14A- Subchapter 12)	Stormwater discharges into surface water from remediation sites is regulated via New Jersey Pollutant Discharge Elimination System requirements.	ARAR
Packaging, Labeling and Storage of Hazardous Waste	RCRA Hazardous Waste Generation 40 CFR 262, Subpart C (Subchapters §262.30 - §262.33)	Specifies standards applicable to generators of hazardous waste, including the pre-transport requirements (packaging, labeling, marking, and placarding).	ARAR

Table 5: Action-Specific Applicable or Relevant and Appropriate Requirements for 600 Hill Waste Pit, Picatinny Arsenal, New Jersey (continued)

Action	Requirement	Requirement Synopsis	Status
Hazardous Waste Disposal	RCRA Hazardous Waste Determination 40 CFR §262.11	Requires the determination of whether a generated solid waste is a hazardous waste and specifies citations for exclusions, lists of hazardous wastes, and testing for determination.	ARAR
Remedial excavation/ construction	Standards for Soil Erosion and Sediment Control in New Jersey (New Jersey Department of Agriculture, State Soil Conservation Committee January 2014)	Vegetative and engineering standards for control soil and sediment erosion applicable during excavation.	TBC
	Agriculture State Soil Conservation Committee Soil Erosion and Sediment Control Act Rules (N.J. A. C. 2:90-1.8) Clearing or grading of land.	Specifies management of soil erosion and sediment control for engaging in clearing or grading of more than 5,000 square feet of land, unless such land disturbance is for agricultural or horticultural purposes. Implemented by the Department of Agriculture (NJDA) and the state's soil conservation districts. These standards are applicable during the clearing and excavation activites.	TBC

Notes:
ARAR = Applicable or Relevant and Appropriate Requirement
CFR = Code of Federal Regulations
NESHAPS = National Emission Standards for Hazardous Air Pollutants
N.J.A.C. = New Jersey Administrative Code
NJDEP = New Jersey Department of Environmental Protection
NJPDES = New Jersey Pollutant Discharge Elimination System
RCRA = Resource Conservation and Recovery Act
Source: Modified from Final FS (ECC, 2017).

Table 6: Location-Specific Applicable or Relevant and Appropriate Requirements for 600 Hill Waste Pit, Picatinny Arsenal, New Jersey

Location	Requirement	Requirement Synopsis	Status
Wetlands	Clean Water Act, Section 402	Section 402 of the Clean Water Act which regulates construction sites on an acre or greater of land, as well as municipal, industrial and commercial facilities discharging wastewater or stormwater directly from a point source into a surface water feature (such as a stream, waterbody or wetland). No impacts are anticipated to any wetland area for the implementation of the selected remedy. Actions will be taken to avoid degradation or destruction of wetlands, and wetland transition zones, in the 600 Area during the remedial activities required for implementation of the selected remedy.	ARAR

Notes:
ARAR = Applicable or relevant and appropriate requirement.
Source: Modified from Final FS (ECC, 2017).

Table 7: Summary of DoD Military Munitions and Munitions Debris Identified in June 2011 Source Area Investigation, 600 Hill Waste Pit, Picatinny Arsenal, New Jersey

Description	Quantity	Test Pit/Trench Location	Comments
Munitions Debris			
Cartridge, Photoflash: practice, M121, Expended	1	TP-2, approximately 8 feet below ground surface	
M72 Rocket Launcher for 66-millimeter Rocket (light anti-tank weapon), Empty – no sights	13	TP-2, approximately 10-12 feet below ground surface	3 sights were discovered, collected, and tested by Picatinny Radiation Protection Office – not radiologically contaminated
XM31 Anti-Tank Land Mine, Expended	1	TP-2	Item recovered from within garbage can removed from TP-2
155-Millimeter Fragment (ogive)	1	TP-2	Item recovered from within garbage can removed from TP-2
Aircraft Flare, MK45, Expended	1	TR2*	
PD Fuze, Expended	1	TR2*	Photograph shows 2 pieces/ components of fuze
BLU 3/B plate, CDU-10 canister cover	1	TR2*	
BLU 39/B Skitters, CN/CS Tear Gas, Inert	3	TR2*	
40-Millimeter Grenade Cartridge Cases, Expended	7	TR2*	
Electric Blasting Cap, Expended	1	TR2*	
Fuzes M48, M51, M81 Series, M557 Series, and M572	12	TR2	Several fuzes recovered folded into the side of a crushed drum
Munitions and Explosives of Concern			
CDU-10 (T-1)/B Canister with XM39E and XM44	1	TR2, East End, approximately 4.5 feet below ground surface	Munitions and explosives of concern data sheet references approximately 680 XM40E5 and 48 XM44 mines per CDU-10/B

Notes:

No munitions debris discovered in TP1.

TR2 trench offset 8 feet to the south due to concentration of munitions debris encountered at initial location. Locations noted with an asterisk (TR2) refer to the location prior to the offset. Excavation of TR2 ceased upon encountering unexploded ordnance.

Source: Final FS (ECC, 2017) and Final PP (Army, 2018).

CN = Chloracetophenone

CS = o-Chlorobenzylidenemalononitrile

TP = Test Pit

TR = Test Trench

Table 8: Summary of Estimated Risk and Hazards from 600 Area Groundwater, Surface Water and Vapor Intrusion from In-Situ Groundwater to Building 660, Picatinny Arsenal, New Jersey

600 Area Groundwater			
Receptor (Future)	**Est. Total Cancer Risk (RME)**	**Cancer Risk Drivers**	**Pathway Contributing to Risk**
Industrial Research Worker	1.1E-05	TCE, PCE	Ingestion
Construction Excavation Worker	2.2E-08	None (Cancer Risk <1E-06)	Not Applicable
Receptor (Future)	**Est. Total Non-Cancer Hazard (RME)**	**Non-cancer Hazard Drivers**	
Industrial Research Worker	0.005	None (HI<1)	
Construction Excavation Worker	0.0001	None (HI<1)	
600 Area Surface Water			
Receptor (Current and Future)	**Est. Total Cancer Risk (RME)**	**Cancer Risk Drivers**	**Pathway Contributing to Risk**
Industrial Research Worker	1.1E-09	None (Cancer Risk <1E-06)	Not Applicable
Receptor (Current and Future)	**Est. Total Non-Cancer Hazard (RME)**	**Non-cancer Hazard Drivers**	
Industrial Research Worker	0.000009	None (HI<1)	
Vapor Intrusion from In-Situ Groundwater (Building 660)			
Receptor (Current and Future)	**Est. Total Cancer Risk (RME)**	**Cancer Risk Drivers**	**Pathway Contributing to Risk**
Industrial Research Worker	6.3E-06	TCE	Indoor Air (inhalation)
Receptor (Current and Future)	**Est. Total Non-Cancer Hazard (RME)**	**Non-cancer Hazard Drivers**	**Pathway Contributing to Risk**
Industrial Research Worker	0.002	None (HI<1)	Not Applicable

Source: Modified from Final FS (ECC, 2017) and Final PP (Army, 2018).

Notes:

HI = Hazard Index

TCE = Trichloroethene

PCE = Tetrachloroethene

RME = Reasonable Maximum Exposure

No Human Health Risk Assessment was conducted for soil or sediment since the sampling results indicated no contaminants of potential concern were identified and no contaminants exceeded the human health screening criteria.

Table 9: Comparative Analysis of Remedial Alternatives for 600 Hill Waste Pit, Picatinny Arsenal, New Jersey

Screening Criterion	Alternative 1 No Action	Alternative 2 MNA, LUCs,	Alternative 3 In-Situ Chemical Oxidation, MNA Polishing, LUCs	Alternative 4 In-Situ Enhanced Anaerobic Bioremediation, MNA Polishing, LUCs	Alternative 5 TCE Source Material Removal, MNA Polishing, LUCs	Alternative 6 Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing, LUCs	Alternative 7 Total Munitions Waste Pit Removal, TCE Source Material Removal, MNA Polishing, LUCs, MEC Clearance of Entire MRS (Achieving Unlimited Use/ Unrestricted Exposure Criteria)
Threshold Criteria							
Protection of human health and the environment	○	●	●	●	●	●	●
Compliance with ARARs	○	●	●	●	●	●	●
Balancing Criteria							
Long-term effectiveness and permanence	○	○	○	○	○	○	●
Reduction of toxicity, mobility or volume through treatment	○	○	○	○	○	○	●
Short-term effectiveness	○	○	○	○	○	○	○
Implementability	●	●	○	○	○	○	○
Costs[a]	$0	$674,505	$1,470,313	$1,608,008	$2,127,311	$3,310,431[b]	$4,119,380
Modifying Criteria [c]							
State Acceptance	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Notes:

● Favorable (Yes for threshold criteria)

○ Moderately Favorable.

○ Not Favorable (no for threshold criteria).

a. Costs (shown in this table as the total present worth costs) are detailed in Appendix C of Final FS (ECC, 2017).

b. The cost for **Alternative 6** in this Table was modified from the cost presented in the Final FS (ECC, 2017) by an additional $36,390 to include the addition of a carbon substrate amendment to the excavation. The cost was also presented in the Final PP (Army, 2018).

c. The Modifying criteria of regulator and community acceptance are To Be Determined following review and input from these parties.

Source: Modified from Final FS, Table 7-3 (ECC, 2017).

ARAR = Applicable or relevant and appropriate requirement
LUC = Land use control
MEC = Munitions and explosives of concern
MNA = Monitored natural attenuation
MRS = Munitions response site
TBD = To Be Determined
TCE = Trichloroethene

This page intentionally left blank.

Appendix A
NJDEP and USEPA Proposed Plan
Concurrence Letters

This page intentionally left blank.

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Site Remediation and Waste Management Program
401 E. State Street
PO Box 420, Mail Code 401-06
Trenton, New Jersey 08625
Tel: (609) 292-1250
Fax: (609) 777-1914

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

CATHERINE R. McCABE
Commissioner

Mr. Ted Gabel
U.S. Army Garrison-Picatinny Arsenal
ATTN: IMPI-PW-E/Building 319
Picatinny, NJ 07806-5000

July 9, 2018

RE: Picatinny Arsenal – 600 Hill Waste Pit Proposed Plan

Dear Mr. Gabel:

The New Jersey Department of Environmental Protection (Department) has completed its review of the Proposed Plan for the Picatinny Arsenal - 600 Hill Waste Pit (600 Hill Groundwater Plume [PICA-058/SITE 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01]) and concurs with the preferred alternative. The preferred alternative, which is Alternative 6 in the Proposed Plan, consists of the following:

- Total Munitions Waste Pit Removal, TCE Source Material Soils Removal, Monitored Natural Attenuation (MNA) Polishing, and Land Use Controls (LUCs).

- Military munitions and munitions debris (MD) will be removed in the 0.24-acre Munitions Waste Pit however, military munitions and MD may be potentially present in the remaining uncleared areas of the Munitions Response Site area (20.76 acres). LUCs will include fencing, signage and PICA safety and intrusive-activity programs.

The Department looks forward to working with the Army-PICA and EPA on the issuance of the Record of Decision and remediation of the Picatinny Arsenal – 600 Hill Waste Pit.

Sincerely,

Mark J. Pedersen
Assistant Commissioner

This page intentionally left blank.

Army Response to Follow-Up NJDEP Comment on Draft Proposed Plan

This page intentionally left blank.

Follow-up NJDEP Comment on Draft Proposed Plan for 600 Hill Waste Pit (600 HILL Groundwater Plume [PICA-058/Site 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01]) Picatinny Arsenal, New Jersey Submitted: February 6, 2018

Comment provided by Joe Marchesani, NJDEP on April 26, 2018 letter. Responses will be incorporated in the Final PP text in RLSO.

General Comment
A 6- inch diameter 430-foot-deep potable supply well was drilled in 1994 to provide water to the new building 660. Sampling of groundwater in the well indicated TCE contamination above NJDEP criteria. Subsequent investigations and sampling indicated MTBE and RDX contamination; however, it is not above applicable criteria. The source area for the TCE is identified as the inactive waste pit, containing at least one buried drum of TCE along with unexploded ordinance/ military munitions hazards.

The preferred remedy for the groundwater TCE contamination is ***Alternative 6- Total Munitions Waste Pit Removal, TCE source Material Removal, MNA polishing and Land Use Controls.*** The excavation would then be backfilled with clean fill. The remedial timeframe is listed as reasonable. Reasonable is explained in the report as less than 50 years.

Army Response: No response required.

NJDEP Specific Comment - The report is approvable. Picatinny should investigate modifying the clean backfill (if the water table is encountered) with amendments (to promote microbial degradation) across the water table which will help reduce the remedial timeframe. A permit by rule equivalent would be required to backfill with amendments with discharge to the water table.

Army Response: Following the excavation of the total munitions waste pit, including the TCE-contaminated source soil, a carbon substrate amendment will be added to the excavation to enhance degradation of any residual contamination in the source area and the excavation will then be backfilled with clean fill to restore existing site contours. The carbon substrate application language has been added to the PP under the description of Alternative 6, similar to the description under Alternative 5 in the SUMMARY OF REMEDIAL ALTERNATIVES section. The quantity of EVO will also be assumed to be the same as that for Alternative 5, and the cost in Table 10 for Alternative 6 has been updated to include the amendment application, with a note added to clarify this change from the FS cost. A discharge permit equivalent will be obtained, as noted in the comment.

This page intentionally left blank.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

AUG 13 2018

LTC Samuel W. Morgan III
Garrison Commander
U.S. Army TACOM-ARDEC
Picatinny, New Jersey 07806-5000

Re: Final Proposed Plan for 600 Hill Waste Pit (600 Hill Groundwater Plume [PICA-058/Site 12] and Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01])
Picatinny Arsenal, New Jersey

Dear LTC Morgan:

The purpose of this letter is to notify the Army that the U.S. Environmental Protection Agency (EPA) has reviewed the Proposed Remedial Action Plan (PRAP) dated July 2018, for the 600 Hill Groundwater Plume [PICA-058/Site 12] and the Inactive Munitions Waste Pit, Munitions Response Site [PICA-013-R-01], at Picatinny Arsenal, a federal facility listed on the National Priorities List. The PRAP proposes a response action pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. §9601 *et seq.*, and by this letter I am notifying the Army that EPA concurs with the release of the PRAP for public review and comment.

The proposed preferred remedial action for these sites is **Alternative 6 – Total Munitions Waste Pit Removal, TCE Source Material Removal, Monitored Natural Attenuation (MNA) Polishing, and Land Use Controls.** The proposed preferred remedial action includes the following measures:

- Excavation and off-site disposal of the entire 0.24-acre Munitions Waste Pit, including the TCE-contaminated source area soil (an estimated 9,526 cubic yards of material). The alternative would involve confirmatory soil sampling of the limits of excavation, followed by backfilling with clean fill.
- MNA of groundwater and surface water is included, and would continue until the TCE groundwater concentration is at or below the New Jersey Department of Environmental Protection Groundwater Quality Standard (GWQS) of 1 µg/L, with an expected timeframe of eight years to achieve this level.
- Removal of all military munitions and munitions debris (MD) from the 0.24-acre Munitions Waste Pit, to reduce explosive hazards at the site.
- Implementation of Land Use Controls (LUCs) to control access to the site, and completion of CERCLA Five Year Reviews to ensure the remedy remains protective.

This preferred alternative will protect human health and the environment, and achieve the Remedial Action Objectives developed for the site, by preventing exposure to TCE-contaminated groundwater, restoring groundwater to the cleanup goal through monitored natural attenuation, and addressing potential explosive hazards through removal of the Inactive Munitions Waste Pit and implementation of LUCs.

EPA understands that the Army will release the PRAP to the public and arrange for publication of a notice of availability of the PRAP for public comment as provided in Section 117 of CERCLA. EPA will make a final determination on the selection of the final remedy after the close of the public comment period, when we have completed our review of the comments, the response to the comments, and the draft Record of Decision.

If you have any questions regarding the subject of this letter, please contact me at 212-637-4380 or your staff may contact Sharon Hartzell, EPA Project Manager, at 212-637-4132.

Sincerely,

John Prince, Acting Director for
Emergency and Remedial Response Division

cc: M. Pedersen, New Jersey Department of Environmental Protection

Appendix B
Mid-Valley Groundwater Dispute Resolution Letter
(July 2009)

This page intentionally left blank.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

JUL - 6 2009

LTC John P. Stack
Garrison Commander
Bldg. 176, Buffington Road
Garrison Headquarters
Picatinny Arsenal, NJ 07806-5000

Dear LTC Stack,

EPA is pleased to inform the Army that the formal dispute raised by EPA over the Mid-Valley Groundwater Feasibility Study (FS) is over. EPA originally invoked dispute resolution over the FS due to our different approaches in addressing contaminated groundwater and surface water. Since the meeting of the Dispute Resolution Committee held on July 24, 2008 our respective staffs have worked on compromise language in the FS that would be satisfactory to both parties. Compromise language for the FS was approved by EPA in an April 15, 2009 e-mail from Ms. Carpenter, Chief, Special Projects Branch to Mr. Daniels, Chief of Cleanup Division of the Army Environmental Command and a revised FS containing those revisions was received by this office on May 12, 2009. That being the case, EPA approves the Mid-Valley Groundwater FS and looks forward to the implementation of the remedy.

I would like to thank our respective staffs for working diligently to resolve this dispute and would also call on them to work in such a cooperative fashion in the future. If you have any questions regarding this matter you may call me at (212) 637- 4405.

Sincerely yours,

John E. LaPadula

John LaPadula, Deputy Director
Emergency and Remedial Response Division

cc: I. Kropp, NJDEP

This page intentionally left blank.

Appendix C
Certificates of Publication for Public Notices

This page intentionally left blank.

Star Ledger

LEGAL AFFIDAVIT

AD#: 0008780750 Total $270.48

State of New Jersey,) ss
County of Middlesex)

MEDINAH JONES being duly sworn, deposes that he/she is principal clerk of NJ Advance Media; that Star Ledger is a public newspaper, with general circulation in Atlantic, Burlington, Cape May, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union, and Warren Counties, and this notice is an accurate and true copy of this notice as printed in said newspaper, was printed and published in the regular edition and issue of said newspaper on the following date(s):

Star Ledger 09/10/2018

Principal Clerk of the Publisher

Swom to and subscribed before me this 4th day of October 2018

CHERILYN A. ALSTON
Commission # 50002224
Notary Public, State of New Jersey
My Commission Expires
September 05, 2019

Notary Public

PUBLIC NOTICE

U.S. ARMY INVITES PUBLIC COMMENT ON PROPOSED PLAN FOR 600 HILL WASTE PIT

PROPOSED PLAN FOR 600 HILL WASTE PIT

The US Army's Environmental Program at Picatinny Arsenal invites public comment on a Proposed Plan for the 600 Hill Waste Pit which includes the 600 Hill Groundwater Plume, and the Inactive Munitions Waste Pit. The 600 Hill Groundwater Plume covers the approximately 26 acres of solvent-impacted groundwater in the vicinity of the Advanced Warhead Development Facility. The Inactive Munitions Waste Pit is a 21-acre area located between two operational ranges. Extensive environmental studies and sampling have been conducted at the 600 Hill sites.

The Army evaluated seven alternatives for addressing the sites including no action (as required by law), monitored natural attenuation and land use controls, in-situ chemical oxidation, in-situ enhanced anaerobic bioremediation, source material removal, and various combinations of these remedies. The Army's preferred response is: Total Munitions Waste Pit Removal, TCE (a solvent) Source Material Removal, Monitored Natural Attenuation Polishing, and Land Use Controls. The cost of the preferred response is $3,274,041

Proposed Plan Public Meeting

The Army invites the public to attend a meeting on Wednesday, September 26, 2018, 6:30 p.m., Homewood Suites, 2 Commerce Center Drive, Dover, NJ, 07801 (near the Rockaway Townsquare Mall). The meeting location is wheelchair accessible.

Written Comments

Copies of the Feasibility Study, Remedial Investigations, and the Proposed Plan for 600 Hill Waste Pit are available for public review at the Environmental Affairs Directorate at Picatinny by contacting Mr. Ted Gabel at (973) 724-6748 or ted.b.gabel.civ@mail.mil in advance. A copy of the Proposed Plan and the PDF version of the Feasibility Study for these sites is available for review at the Rockaway Township Library (61 Mount Hope Road) and Morris County Library (30 East Hanover Avenue, Whippany). In addition, you can have the Proposed Plan emailed to you by contacting Mr. Ted Gabel by email.

This page intentionally left blank.

AFFIDAVIT OF PUBLICATION

Publisher's Fee $47.30 Affidavit $35.00

State of New Jersey } **SS.**
Morris County

Personally appeared _____

Of the **Daily Record,** a newspaper printed in Freehold. New Jersey and published in Parsippany. in said County and State. and of general circulation in said county. who being duly sworn. deposeth and saith that the advertisement of which the annexed is a true copy, has been published in the said newspaper 1 times. once in each issue as follows:

09/07/18 **A.D 2018**

Notary Public of New Jersey

Ad Number: 0003142635

Ad Number: 0003142635 Run Dates: 09/07/18

OTHER HEADINGS

PUBLIC NOTICE

U.S. ARMY INVITES PUBLIC COMMENT ON PROPOSED PLAN FOR 600 HILL WASTE PIT

PROPOSED PLAN FOR 600 HILL WASTE PIT

The US Army's Environmental Program at Picatinny Arsenal invites public comment on a Proposed Plan for the 600 Hill Waste Pit which includes the 600 Hill Groundwater Plume, and the Inactive Munitions Waste Pit. The 600 Hill Groundwater Plume covers the approximately 26 acres of solvent-impacted groundwater in the vicinity of the Advanced Warhead Development Facility. The Inactive Munitions Waste Pit is a 21-acre area located between two operational ranges. Extensive environmental studies and sampling have been conducted at the 600 Hill sites.

The Army evaluated seven alternatives for addressing the sites including no action (as required by law), monitored natural attenuation and land use controls, in-situ chemical oxidation, in-situ enhanced anaerobic bioremediation, source material removal, and various combinations of these remedies. The Army's preferred response is: Total Munitions Waste Pit Removal, TCE (a solvent) Source Material Removal, Monitored Natural Attenuation Polishing, and Land Use Controls. The cost of the preferred response is $3,274,041

Proposed Plan Public Meeting

The Army invites the public to attend a meeting on Wednesday, September 26, 2018, 6:30 p.m., Homewood Suites, 2 Commerce Center Drive, Dover, NJ, 07801 (near the Rockaway Townsquare Mall). The meeting location is wheelchair accessible.

Written Comments

Copies of the Feasibility Study, Remedial Investigations, and the Proposed Plan for 600 Hill Waste Pit are available for public review at the Environmental Affairs Directorate at Picatinny by contacting Mr. Ted Gabel at (973) 724-6748 or ted.b.gabel.civ@mail.mil in advance. A copy of the Proposed Plan and the PDF version of the Feasibility Study for these sites is available for review at the Rockaway Township Library (61 Mount Hope Road) and Morris County Library (30 East Hanover Avenue, Whippany). In addition, you can have the Proposed Plan emailed to you by contacting Mr. Ted Gabel by email.

The public may submit written comments during the 30-day comment period (September 26 to October 25, 2018). Comments must be postmarked by October 25, 2018 and sent to Mr. Ted Gabel, U.S. Army Garrison, Picatinny Arsenal, IMPI-PWE, Building 319, Picatinny Arsenal, NJ, 07806-5000 or by email to ted.b.gabel.civ@mail.mil.
($47.30)

Public Notice placed September 14, 2018 in The Picatinny Voice

Civil War Soldiers interred at new Arlington National Cemetery addition

Army News Service

WASHINGTON

Two caissons from the 3rd U.S. Infantry Regiment (The Old Guard) Caisson Platoon, The U.S. Army Band 'Pershing's Own,' and Soldiers from The 3rd U.S. Infantry Regiment conduct military funeral honors with funeral escort for two unknown Civil War Union Soldiers in Section 81 of Arlington National Cemetery, Arlington, Virginia, on Sept. 6

MILLENNIUM ADDITION

CIVIL WAR SOLDIERS INTERRED

STREETS HONOR TWO HEROES

PUBLIC NOTICE

U.S. ARMY INVITES PUBLIC COMMENT ON PROPOSED PLAN FOR 600 HILL WASTE PIT

This page intentionally left blank.

Appendix D
Cost Comparison Summary for Remedial Alternatives Evaluated and Detailed Cost Tables
(Source: ECC, 2017 [Appendix C in Final FS])

This page intentionally left blank.

Table ES-1 Summary of Group 1 Alternatives Analysis

Alternative	Description	Capital Cost	Discounted O&M	Total Present Worth
600 Hill Waste Pit, 600 Area				
1	No Action	$0.00	$0.00	$0.00
2	Monitored Natural Attenuation and Land Use Controls	$71,600	$602,905	$674,505
3	In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing and Land Use Controls	$451,412	$1,018,902	$1,470,313
4	In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing and Land Use Controls	$622,326	$985,682	$1,608,008
5	Trichloroethene Source Removal, Monitored Natural Attenuation Polishing and Land Use Controls	$1,525,182	$602,129	$2,127,311
6	Total Munitions Waste Pit Removal, Trichloroethene Source Material Removal, Monitored Natural Attenuation Polishing and Land Use Controls	$2,708,303[a]	$602,128	$3,310,431[a]
7	Total Munitions Waste Pit Removal, Trichloroethene Source Material Removal, Monitored Natural Attenuation Polishing, Land Use Controls and Munitions and Explosives of Concern Clearance of Entire Munitions Response Site (to achieve the Unlimited Use/Unrestricted Exposure Criteria)	$3,787,256	$332,124	$4,119,380

Notes:

a. The cost for Alternative 6 has been modified from the cost presented in the Final FS (ECC, 2017) by an additional $36,390 to include the addition of a carbon substrate amendment to the excavation, as included for Alternative 5 in the Final FS.

This page intentionally left blank.

ALTERNATIVE 2
Monitored Natural Attenuation and Land Use Controls

Alternative 2 involves MNA and the maintenance and enforcement of ICs, in particular the restrictions of groundwater uses, intrusive activities and long-term groundwater monitoring for all parameters that exceeded the SCLs. It is assumed that ICs and the long-term groundwater monitoring would be performed for 50 years. The anticipated length of MNA will be reevaluated following review of the groundwater sampling results, and reevaluation of site-specific attenuation rates. This alternative also includes the requirement for UXO Construction Support, Annual Inspections, maintenance and reporting for monitoring of Land Use.

CAPITAL COSTS

1.0 Land Use Control Implementation Plan

2.0

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the 600 Area Sites and within the Inactive Munitions Waste Pit MRS. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plumes or exposed to MEC hazards.

Description	Unit Rate	Number of units	Cost
LCUP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning, Permitting and Reporting

Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$5,000	Lump Sum	5,000
Work Plan	$20,000	Lump Sum	20,000
Health and Safety Plan	$9,000	Lump Sum	9,000
FSP, QAPP, and DQOs	$17,000	Lump Sum	17,000
Closeout Report (Draft, Draft Final, Final)	$12,000	Lump Sum	12,000
Total Cost for Reporting			**$63,000**

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	$63,000
Total Capital Cost for Institutional Controls:	**$71,600**

ALTERNATIVE 2
Monitored Natural Attenuation and Land Use Controls

OPERATION AND MAINTENANCE (O&M) COSTS

3.0 Long-Term Groundwater and Surface Water Monitoring

The long-term groundwater monitoring would be designed to evaluate the extent to which natural attenuation of the COCs is occurring, ensure that the plume characteristics are not changing in an unexpected manner, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of all of the contaminants of concern and daughter products in addition to dissolved oxygen, ORP, nitrate, iron (II), sulfate, and methane. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$55.00 /hr/person
Number of People:	2 people
Hours worked per day:	8 hrs
Anticipated time to collect GW samples per location:	3.0 hrs
Number of Wells to Sample for the long-term monitoring:	12 wells
Number of Surface Water Samples Collected Per Event:	5 locations
Anticipated time to collect SW samples per location:	1.5 hrs
Data Management cost per sampling event:	$3,000.00 per event

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$55.00 /hr/person	44 hrs	$4,840
Equipment (vehicle, pumps, water quality meter, etc.)	$1000.00 /event	1 event	$1,000
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$50.00	21 samples	$1,050
alkalinity	$15.00	21 samples	$315
Iron (II)	$10.00	21 samples	$210
Sulfate	$20.00	21 samples	$420
Methane, Ethane, Ethene	$85.00	21 samples	$1,785
TOTAL CHEMICAL ANALYSIS COST:			**$3,780**
Data Management and Annual Monitoring Reporting	$5,000.00 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$14,620**

ALTERNATIVE 2
Monitored Natural Attenuation and Land Use Controls

It is assumed that following the first 10 years of the LTM program that the total number of wells to be sampled would be reduced from 12 to 8.

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$55.00 /hr/person	32 hrs	$3,520
Equipment (vehicle, pumps, water quality	$1000.00 /event	1 event	$1,000
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$50.00	16 samples	$800
alkalinity	$15.00	16 samples	$240
Iron (II)	$10.00	16 samples	$160
Sulfate	$20.00	16 samples	$320
Methane, Ethane, Ethene	$85.00	16 samples	$1,360
TOTAL CHEMICAL ANALYSIS COST:			**$2,880**
Data Management and Annual Monitoring Report	$5,000.00 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$12,400**

ALTERNATIVE 2
Monitored Natural Attenuation and Land Use Controls

DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE

Description	Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-10	$14,600 /event	2 events	$29,240
Using a discount rate of 3.5%	**for a period of**	**10 years**	**$243,200**

Description	Unit Rate	Number of units	Cost
Annual Cost for Years 11-20 (annual sampling for 10 years)	$12,400 /event	1 events	$12,400
Using a discount rate of 3.5%	**for a period of**	**10 years**	**$73,100**

Description	Unit Rate	Number of units	Cost
Cost for Years 21-35 (sampled once every five years for 15 years)	$12,400 /event	1 events	$12,400
Using a discount rate of 3.5%	**for a period of**	**15 years**	**$13,400**

Total Discounted Sampling Cost:

Years 1-10	**$243,200**
Years 11-20	**$73,100**
Years 21-60	**$13,400**
Total	**$329,700**

4.0 Well Construction, Abandonment, and Maintenance

Since natural attenuation monitoring will occur over an anticipated period of 50 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Discounted Cost
Well inspection and maintenance	$2,158 /year	35 years	$43,180
Future Well abandonment	$2,425 /well	25 wells	$10,871
Well Replacement Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five years for the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Well replacement	$16,865 / 5 year	35 years	$62,900
Total Discounted Well Construction, Abandonment, and Maintenance Cost			**$116,951**

Discount Rate = 3.5%

ALTERNATIVE 2
Monitored Natural Attenuation and Land Use Controls

5.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 50 years.

Description		Unit Rate	Number of units	Cost
5-Year Review (including draft, draft final, and final reports)		$15,000	lump sum	$15,000
Using a discount rate of	**3.5%**	**for a period of**	**50 years**	**$73,771**

6.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support

Description		Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)		$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs		$5,575/year	lump sum	$5.575
Using a discount rate of	**3.5%**	**for a period of**	**50 years**	**$242,104**

Discounted O&M Cost:

50-Year Sampling Cost	**$329,700**
Well Construction, Abandonment, and Maintenance	**$116,951**
5-Year Reviews	**$73,771**
Total	**$520,422**

TOTAL CAPITAL COST:		**$71,600**
DISCOUNTED O&M COST:		**$520,422**
Contingency of Scope:	**5%**	**$27,494**
Contingency of Bid:	**10%**	**$54,989**
TOTAL DISCOUNTED O&M COST:		**$602,905**
TOTAL PRESENT WORTH VALUE:		**$674,505**

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

Alternative 3 would involve: 1) injection of a chemical oxidant (permanganate is generally the preferred oxidant for TCE remediation) within the source area of the contaminant concentrations, 2) monitored natural attenuation of the remainder of the TCE plume; 3) maintenance and enforcement of ICs for as long as groundwater concentrations remain above SCLs, and 4) Annual Inspections for land use controls and construction support for intrusive operations. Under Alternative 3, TCE concentrations in the source area of the plume would be chemically degraded, thereby decreasing contaminant discharge into downgradient receptors to below ARAR levels. Performance monitoring of selected source area wells would be performed monthly for the first 6 months to be followed by quarterly monitoring until one year after the final permanganate injection. Monitoring of downgradient wells and surface water would be performed semiannually during the performance monitoring period. MNA polishing of residual groundwater TCE concentrations in the aquifer once active treatment (to protect downgradient receptors) is complete. LUCs and construction support would be required due to the potential for MEC hazards.

Following the performance monitoring period, long term monitoring would consist of both source area and downgradient wells and surface water sampled semiannually to year 10 (from implementation of the remedy), annually to year 20 , and once every 5 years to year 50.

GENERAL ASSUMPTIONS

1) The costs are adopted from, previous work conducted by ECC and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule, unless otherwise noted.
4) Work is to be conducted under a safety level D condition.
5) A two person UXO team will be used for all clearing, grubbing, and ground intrusive activities.
6) Dimensions of the Areas of Concern:

AAs	GW Plume		Surface Area
	Area (SF)	Volume (Gal.)	Area (SF)*
AA_{1GW-1}	48,000	2,692,800	52,800

* Groundwater plume area multiplied by 1.1

CAPITAL COSTS

1.0 Institutional Controls/Planning

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the 600 Area Sites and within the Inactive Munitions Waste Pit MRS. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plumes or exposed to MEC hazards.

Description	Unit Rate	Number of units	Cost
LCUP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning,Permitting and Reporting

Permit equivalents required for this alternative will include drilling for injection wells and any additional groundwater monitoring wells (including replacement wells which may be necessary during the timeframe of the project). Deliverables will include a work plan, design drawings and specifications, a health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$5,300	Lump Sum	5,300
Design documents (drawings, specifications, design basis) - draft, draft final, and final	$27,700	Lump Sum	27,700
Pilot Tests (Oxidant Injections, ROI)	$41,500	Lump Sum	41,500
Work Plan	$20,000	Lump Sum	20,000
Health and Safety Plan	$9,000	Lump Sum	9,000
FSP, QAPP, and DQOs	$17,400	Lump Sum	17,400
Closeout Report (Draft, Draft Final, Final)	$11,600	Lump Sum	11,600
Total Cost for Reporting			**$132,500**

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	$132,500
Total Cost for Institutional Controls:	**$141,100**

3.0 Site Preparations

3.1 Clearing

Negligible clearing will be required to allow drill rig access for the installation of injection wells.

3.2 Erosion Control (Silt Fence Construction and Maintenance):

Prior to start of work, silt fence will be erected along the perimeter of the work areas.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence: 350 LF

Description	Unit Rate	Number of units	Duration (days)	Cost
Silt fencing, polypropylene, adverse conditions, 3' high	$3.39 /lf	350 lf	1	$1,187
UXO Avoidance (2 person team) Professional	$1,800 /day		1	$2,400
	10%			**$2,969**
Total Erosion Control Cost				

Estimated time required for Silt Fence Construction = 1 days

3.3 Layout and Construction Survey

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place . The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

Assumptions:

1) Survey crew used to perform the construction layout survey will require a two person crew.

Description	Unit Rate	Number of units	Cost
Surveying Crew, 2 person survey	$1,250/day	5 days	$6,250
Total Surveying Cost			**$6,250**

Estimated Number of days required = 5 days

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

4.0 Injections of Permanganate and Construction of Monitoring Wells

Injections of permanganate would involve: (1) installation of 6 injection wells and 2 monitoring wells; and (2) injection of approximately The initial stage would consist of installing approximately 8 wells, 6 injection wells and 2 monitoring wells, followed by a pilot test. UXO clearance is required for well installation.

Description	Unit Rate	Number of units	Cost
Well Installation			
Injection/Monitoring Well Installation	$10,015 /well	8 wells	$80,120
UXO Avoidance (2 person team)	$1,560 /day	16 days	$24,960
Permanganate Injection	$826 /day	22 days	$18,172
Field Scientist/Superintendent	$7,808	lump sum	$7,808
Equipment (vehicle, poly tank, pump)	$2.18 /lb	6,700 lbs	$14,606
Sodium Permanganate			
Total Cost for MW Installation and Lactate Injection			**$145,646**
Total Cost with H&S markup 10%			**$160,210**

Estimated construction time for the sodium permanganate injections: 22 days

4.1 Performance Monitoring Following First Injection of Oxidizer

Performance monitoring for alternative 3 will consist of sampling selected source area monitoring wells. Samples will be collected

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58 /hr/person
Number of People:	2 people
Anticipated time to collect samples per location:	3.0 hrs
Number of Wells to Sample for performance monitoring:	3 wells

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	8 hrs	$928
Equipment (vehicle, pumps, water quality meter,	$1,752.00 /event	1 event	$1,752
Chemical Analysis Cost and validation			
VOCs (including TCE, DCE, VC)	$50	4 samples	$200
Methane, ethane, ethene	$85	4 samples	$340
Total Sampling and Analysis Cost per event			*$3,220*
TOTAL CHEMICAL ANALYSIS COST:	**$3,220.00 /month**	**6 months**	**$19,320**
Monitoring Report Cost and Data Management	$8,995.00	Lump Sum	$8,995
Total Performance Monitoring Cost			**$28,315**

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the site.

Mobilization is calculated as 10% of the direct capital costs, including site preparations and remedial system installations.

Mobilization/Demobilization	**10% of capital**	**$32,528**

6.0 Construction and Technical Oversight

Enhanced anaerobic degradation will require technical oversight during the planning and design stages and during the

Estimated total construction time frame:	Site preparations:	4	days
	Substrate Inject.	22	days
	Mob/Demob	2	days

Description	Unit Rate	Number of units	Cost
Data Review	$1,000.00	lump sum	$1,000
Site Visit and Meeting	$5,000.00	lump sum	$5,000
Field Engineer	$3,787.00 /week	6 weeks	$22,700
H&S Engineer	$5,020.00 /week	1.2 weeks	$6,040
Total Cost for Construction and Oversight			**$34,724**

All work associated with Remedial Alternative GW-3 to be done using local workforce.

SUMMARY OF CAPITAL COSTS:

1) Land Use Restrictions & Institutional Controls		**$8,600**
2) Permits and Reports Writing		**$132,500**
3) Site Preparation		**$9,219**
4) Installation of Injection Points and Sodium Permanganate Injection		**$174,961**
5) Mobilization/Demobilization		**$32528**
6) Construction Oversight		**$34,724**
Contingency of Scope	**10%**	**$39,253**
Contingency of Bid	**5%**	**$19,626**
TOTAL CAPITAL COST		**$451,412**

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

OPERATION AND MAINTENANCE COSTS

O&M activities required under this alternative would include additional permanganate injections as necessary to ensure contaminant reduction in groundwater.

7.0 Additional Injections of Sodium Permanganate

Additional injections of permanganate would be performed as necessary to protect downgradient receptors. The objective of additional Injection of permanganate would be performed by site personnel, using the existing injection/monitoring wells and therefore would not require additional well installation.

Description	Unit Rate	Number of units	Cost
Field Scientist (2)	$826 /day	22 days	$18,172
Equipment (vehicle, poly tank, pump)	$7,808	lump sum	$7,808
Sodium Permanganate	$2.18 /lb	6,700 lbs	$14,628
Total Cost for Additional Lactate Injections			**$40,608**
Total Cost with H&S markup of:	**10%**		**$44,668**

Estimated construction time for the ISCO injections: 22 days

For the purpose of this cost estimate it is assumed that additional injections would be performed yearly for a period of three years.

Description	Unit Rate	Number of units	Cost
Annual Costs for Additional Permanganate Injections	$44,668 /event	1 events	$44,668
Using a discount rate of 3.5%	**for a period of**	**2 years**	**$84,855**

8.0 Long-Term Groundwater Monitoring

The long-term groundwater monitoring would be designed to monitor the RA performance and ensure that the plume characteristics are meeting restoration goals.

The analytical program for the long-term groundwater monitoring program will consist of three parts:

- Source area monitoring following permanganate injections
- Downgradient monitoring during ISCO Injection period
- Long-term monitoring following completion of ISCO treatment

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58 /hr/person
Number of People:	2 people
Hours worked per day:	10 hrs
Anticipated time to collect samples per monitoring well:	3.0 hrs
Anticipated time to collect SW samples per location	1.5 hrs
Data Management/Monitoring Report per sampling event:	$5,000 per event

8.1 Source Area Monitoring Following Additional Permanganate Injections

Number of Wells to Sample for performance monitoring program: 4 wells

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58. /hr/person	12 hrs	$1,392
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC)	$50	5 samples	$250
Methane, ethane, ethene	$850	5 samples	$425
TOTAL CHEMICAL ANALYSIS COST:			**$3,819**
Monitoring Report Cost and Data Management	$5,000.00	Lump sum	$5,000
Total Source Area Monitoring Cost Per Event			**$8,819**

Description	Unit Rate	Number of units	Cost
Annual Cost for Quarterly Sampling Years 1-3	$8,819.00 /event	4 events	$35,276
Using a discount rate of 3.5%	**for a period of**	**3 years**	**$98,831**

8.2 Downgradient Monitoring During the ISCO Injection Period

Number of Wells to Sample for downgradient monitoring: 11 wells
Number of surface water samples collected per event 5 locations

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	40.5 hrs	$4,698
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC, ethene)	$135	20 samples	$2,700
TOTAL CHEMICAL ANALYSIS COST:			**$2,700**
Monitoring Report Costs and Data Management per Year	$5,000 per event	1 event	$5,000
Total Downgradient Sampling and Reporting Costs per Sampling Event			**$14,150**

Description	Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-3 (3 years	$14,150 /event	2 events	$28,300
Using a discount rate of 3.5%	**for a period of**	**3 years**	**$79,286**

8.3 Long-Term Monitoring Following Completion of ISCO Treatment

It is assumed that the total number of monitoring wells to be sampled for the LTM program would be reduced from the performance

Number of Wells to Sample for the long-term monitoring program: 9 wells
Number of surface water samples collected per event 5 locations

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	34.5 hrs	$4,002
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC, ethene)	$135	17 samples	$2,295
TOTAL CHEMICAL ANALYSIS COST:			**$2,295**
Monitoring Report and Data Management Costs per	$5,000 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$13,049**

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

DESCRIPTION OF COSTS PER PHASE

Description		Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 4-10		$13,049 /event	2 events	$26,098
Using a discount rate of	**3.5%**	**for a period of**	**7 years**	**$143,929**

Description		Unit Rate	Number of units	Cost
Annual Sampling Costs for Year 11-20 (10 years)		$13,049.00 /event	1 events	$13,049
Using a discount rate of	**3.5%**	**for a period of**	**10 years**	**$42,955**

Description		Unit Rate	Number of units	Cost
Sampling Costs for Years 21-35 (15 years)		$13,049.00 /event	1 events	$13,049
Using a discount rate of	**3.5%**	**for a period of**	**15 years**	**$14,085**

Total Discounted LTM Sampling Cost:

Years 1-6	**$178,116.95**
Years 7-10	**$143,929.64**
Years 11-20	**$42,955.78**
Years 21-60	**$14,085.12**
Total	**$379,087.49**

9.0 Well Abandonment, Replacement, and Maintenance

Since the long-term monitoring would occur over a period of 50 years, the groundwater monitoring wells will require maintenance to allow to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Cost
Well inspection and maintenance	$2,158 /year	35 years	$43,180
Future Well abandonment	$2,425 /well	31 wells	$18,213
Well Replacement			
Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five yearsfor the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Description	**Unit Rate**	**Number of units**	**Cost**
Well replacement	$16,865 / 5 year	35 years	$62,905
Total Well Abandonment, Replacement, and Maintenance Cost			**$106,085**

Discount Rate = 3.5%

10.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these remedies.

Description	Unit Rate	Number of units	Cost
5-Year Review (including draft, draft final, and final reports)	$15,000	lump sum	$15,000
Using a discount rate of 3.5%	**for a period of**	**50 years $73,771.49**	

11.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support.

ALTERNATIVE 3
In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

Description	Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)	$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs	$5,575/year	lump sum	$5.575
Using a discount rate of 3.5% for a period of 50 years $242,104.08			

Discounted O&M Cost:

7.0 Additional Injections of Permanganate	**$84,855**
8.0 Long Term Monitoring Program	**$379,087**
9.0 Well Abandonment, Replacement, and Maintenance	**$106,085**
10.0 5-Year Reviews	**$73,771**
11.0 – LUCs/construction Support	**$242,204**
Total	**$886,002**

ALTERNATIVE 3

In Situ Chemical Oxidation, Monitored Natural Attenuation Polishing, and Land Use Controls

TOTAL CAPITAL COST:		**$451,411**
DISCOUNTED O&M COST:		**$886,002**
Contingency of Scope:	10%	$88,600
Contingency of Bid:	5%	$44,300
TOTAL DISCOUNTED O&M COST:		**$1,018,902**
TOTAL PRESENT WORTH VALUE:		**$1,470,313**

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

Alternative 4 would involve: 1) Construction of an infiltration gallery to apply a microbial growth substrate (for the purpose of this estimating costs it is assumed to be emulsified vegetable oil within the source area of the contaminant concentrations, 2) Installation of nested source area monitoring wells and an extraction well to use for infiltration 3) MNA of the remainder of the TCE plume; 4) maintenance and enforcement of ICs for as long as groundwater concentrations remain above SCLs, and 4) Annual Inspections for land use controls and construction support for intrusive operations. Under Alternative 4, TCE concentrations in the source area of the plume would be reduced, thereby decreasing contaminant discharge into downgradient receptors to below ARAR levels. Performance monitoring of selected source area wells would be performed monthly for the first 6 months to be followed by quarterly monitoring until one year after the final substrate injection. Monitoring of downgradient wells and surface water would be performed semiannually during the performance monitoring period. MNA polishing of residual groundwater TCE and daughter product concentrations in the aquifer once active treatment (to protect downgradient receptors) is complete.

Following the performance monitoring period, LTM would consist of both source area and downgradient wells and surface water sampled semiannually to year 10 (from implementation of the remedy), and annually to year 14. LUCs and construction support would be required due to the potential for MEC hazards.

Note: Injection of nano-scale zero-valent iron (ZVI) would be evaluated along with potential microbial growth substrates as part of the pilot study. Although abiotic, ZVI injection would involve nearly identical logistic requirements and result in reductive degradation of TCE (and its reductive daughter products). Sodium Lactate, the lowest cost (and most likely applied) substrate, is costed in this alternative.

GENERAL ASSUMPTIONS

1) The costs are adopted from, previous work conducted by ECC and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule, unless otherwise noted.
4) Work is to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition, where appropriate.
5) A two person UXO team will be used for all clearing, grubbing, and ground intrusive activities.
6) treatment area is assumed to be 120' x 60' x 52' =374,400 ft^3

CAPITAL COSTS

1.0 Land Use Control Implementation Plan

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the groundwater plume and within the Inactive Munitions Waste Pit MRS. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plume or exposed to MEC hazards.

Description	Unit Rate	Number of units	Cost
LUCP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning, Permitting and Reporting

Permit equivalents required for this alternative will include drilling replacement wells which may be necessary during the timeframe of the project. Deliverables will include a work plan, design drawings and specifications, a health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$5,300	Lump Sum	$5,300
Design documents (drawings, specifications, design basis) - draft, draft final, and final	$27,700	Lump Sum	$27,700
Work Plan	$20,000	Lump Sum	$20,000
Health and Safety Plan	$9,000	Lump Sum	$9,000
FSP, QAPP, and DQOs	$17,400	Lump Sum	$17,400
Closeout Report (Draft, Draft Final, Final)	$11,600	Lump Sum	$11,600
Total Cost for Reporting			**$91,000**

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	**$91,000**
Total Cost for Institutional Controls:	**$99,600**

3.0 Site Preparations

3.1 Clearing

Negligible clearing will be required to allow drill rig access for the installation of injection wells.

3.2 Erosion Control (Silt Fence Construction and Maintenance):

Prior to start of work, silt fence will be erected along the perimeter of the work areas.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence: 350 LF

Description	Unit Rate	Number of units	Duration (days)	Cost
Silt fencing, polypropylene, adverse conditions, 3' high	$3.39 /lf	350 lf	1	$1,187
UXO Avoidance (2 person team) Professional	$1,800 /day		1	$2,400
	10%			**$2,969**
Total Erosion Control Cost				

Estimated time required for Silt Fence Construction = 1 days

3.3 Layout and Construction Survey

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place . The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

Assumptions:

1) Survey crew used to perform the construction layout survey will require a two person crew.

Description	Unit Rate	Number of units	Cost
Surveying Crew, 2 person survey	$1,250 /day	5 days	$6,250
Total Surveying Cost			**$6,250**

Estimated Number of days required = 5 days

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

4.0 Construction of an Infiltration Gallery, application of emulsified vegetable oil (EVO) and nested source monitoring we and extraction well.

Application of EVO would involve: (1) construction of a nested source monitoring well and on extraction well (2) application of approximately 55,900 lbs of sodium lactate diluted to yield 173,300 gallons of solution

UXO support would be required for well installation and construction of the infiltration gallery for avoidance. Injection of EVO would be performed by site personnel and therefore would not require subsequent mobilization. EVO requirement is based on a 374,400 ft^3 source area.

Description	Unit Rate	Number of units	Cost
Well Installation			
Source Well	$10,485 /well	2 wells	$20,965
Extraction Well with pump and solar panel	$45,168/well	1 well	$45,168
UXO Avoidance (2 person team)	$1,560.00 /day	16 days	$24,960
Geologist	$1,025/day	16 days	$16,410
Infiltration Gallery Installation			
Construction of a 120 x 60 x 3 x gallery (PVC piping and stone) and connect piping to extraction well.	$45,645 each	1	$45,645
Sodium Lactate Injection			
Engineer and Superintendent	$2,271.00/day	40 days	$90,840
Equipment (vehicle, poly tank, pump)	$20,533	lump sum	$20,533
Emulsified vegetable oil	$9.79/gal	7300 gal	$71,467
Total Cost for MW Installation and Lactate Injection			**$335,988**
Total Cost with H&S markup of:	**10%**		**$369,587**

Estimated construction time for the emulsified vegetable oil injections: 40 days

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

4.1 Performance Monitoring Following Substrate Injection

Performance monitoring for alternative 4 will consist of sampling selected source area monitoring wells. Samples will be collected monthly for a period of 6-months and quarterly for the remainder of the year following evo application. Samples will be analyzed for VOCs, TOC, nitrate alkalinity, soluble iron, methane, ethane, and ethene in addition to measured geochemical parameters measured during sampling. Quality control samples (field duplicates, rinse blanks, trip blanks) are assumed to be an additional 20% of the total number of samples collected.

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58.00 /hr/person
Number of People:	2 people
Anticipated time to collect samples per location:	3.0 hrs
Number of Wells to Sample for the long-term monitoring program:	3 wells

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	8 hrs	$928
Equipment (vehicle, pumps, water quality meter,	$1,7520 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC)	$50	4 samples	$200
TOC	$26	4 samples	$104
alkalinity	$15	4 samples	$60
Iron (II)	$10	4 samples	$40
Sulfate	$20	4 samples	$80
Methane, ethane, ethene	$85	4 samples	$340
Total Sampling and Analysis Cost per event			*$3,504*
TOTAL CHEMICAL ANALYSIS COST:	**$3,504 /month**	**6 months**	**$21,024**
Monitoring Report and Data Management Cost	$5,000	Lump sum	$5,000
Total Performance Monitoring Cost			**$26,024**

5.0 Mobilization/Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the site. In addition, providing all required utilities is also included with mobilization.

Mobilization is calculated as 10% of the direct capital costs, including site preparations and remedial system installations.

Mobilization/Demobilization	**10% of capital**	**$32,528**

6.0 Construction and Technical Oversight

Enhanced anaerobic degradation will require technical oversight during the planning and design stages and during the implementation.

Estimated total construction time frame:	Site preparations:	6	days
	Substrate Inject.	8	days
	Mob/Demob	2	days

Description	Unit Rate	Number of units	Cost
Data Review	$1,000	lump sum	$1,000
Site Visit and Meeting	$5,000	lump sum	$5,000
Field Engineer	$3,787 /week	8 weeks	$30,296
H&S Engineer	$5,020 /week	0.8 weeks	$4,016
Total Cost for Construction and Oversight			**$40,312**

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

All work associated with Remedial Alternative 4 to be done using local workforce.

SUMMARY OF CAPITAL COSTS:

1) Land Use Restrictions & Institutional Controls		**$8,600**
2) Permits and Reports Writing		**$99.600**
3) Site Preparation		**$9,219**
4) Installation of Injection Points and Sodium Lactate Injection		**$369,587**
5) Mobilization/Demobilization		**$32,528.**
6) Construction Oversight		**$40,312**
Contingency of Scope	**10%**	**$41,885**
Contingency of Bid	**5%**	**$20,595**
TOTAL CAPITAL COST		**$622,326**

OPERATION AND MAINTENANCE COSTS

O&M activities required under this alternative would include additional substrate injections as necessary to ensure contaminant concentrations do not rebound to the extent which continues to impact downgradient receptors, and long-term monitoring of groundwater to measure the performance of the remediation.

7.0 Additional Injections of EVO

Additional injections of EVO (or other microbial growth substrate) would be performed as necessary to protect downgradient receptors. The objective of additional application is to prevent a rebound in contaminant concentrations to above the modeled concentration demonstrated to be protective of downgradient receptors.

Application of EVO would be performed by site personnel, using the existing infiltration gallery and therefore would not require subsequent driller mobilization. EVO requirement is based on required mass to achieve a concentration of 500 mg/L within the targeted region, although the final substrate quantity would be adjusted based on the results of previous injections and pilot testing.

Description	Unit Rate	Number of units	Cost
Field Engineer/Super (2)	$2271/day	20 days	$45,420
Equipment (vehicle, poly tank, pump)	$20,533	Lump sum	$20,533
EOS	$9.79/gal	3650 gal	$35,744
Total Cost for MW Installation and Lactate Injection			**$101,697**
Total Cost with H&S markup of:	**10%**		**$111,867**

Estimated construction time for the sodium lactate injections: **20** days

8.0 Long-Term Groundwater Monitoring

The long-term groundwater monitoring would be designed to monitor the RA performance and ensure that the plume characteristics are not changing, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted. Quality control samples (field duplicates, rinse blanks, trip blanks) are assumed to be an additional 20% of the total numbers of samples collected.

The analytical program for long term monitoring will consist of 3 parts:

- Source area monitoring following EVO injections
- Downgradient monitoring during EVO infiltration period
- Long-term monitoring following completion of treatment

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58.00 /hr/person
Number of People:	2 people
Hours worked per day:	10 hrs
Anticipated time to collect samples per monitoring well:	3.0 hrs
Anticipated time to collect SW samples per location	1.5 hrs
Monitoring Report per sampling event:	$5,000.00 per event

8.1 Source Area Monitoring Following Additional Substrate Injections:

Number of wells to sample for performance monitoring program: 3 wells

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	10 hrs	$1,160
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$600
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC, ethene)	$50	4 samples	$200
TOC	$26	4 samples	$104
alkalinity	$15	4 samples	$60
Iron (II)	$10	4 samples	$40
Sulfate	$20	4 samples	$80
Methane, ethane, ethene	$85	4 samples	$340
TOTAL CHEMICAL ANALYSIS COST:			**$2,584**
Monitoring Report Costs	$5,000 per event	1 event	$5,000
Total Source Area Monitoring Cost Per Event			**$7,584**

Description		Unit Rate	Number of units	Cost
Annual Cost for Quarterly Sampling Years 1-3 (3 years)		$7,584 /event	4 events	$30,336
Using a discount rate of	**3.5%**	**for a period of**	**3 years**	**$84,990**

8.2 Downgradient Monitoring During the EVO Infiltration Period

Number of wells to sample for performance monitoring program: 11 wells
Number of surface water samples collected per event: 5 locations

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	40.5 hrs	$2,349
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC, ethene)	$135	20 samples	$2,700
TOTAL CHEMICAL ANALYSIS COST:			**$6,801**
Monitoring Report Costs	$5,000 per event	1 event	$5,000
Total Source Area Monitoring Cost Per Event			**$11,8010**

Description		Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-3 (3 years)		$11,801 /event	2 events	$23,602
Using a discount rate of	**3.5%**	**for a period of**	**3 years**	**$66,124**

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

8.3 Long-Term Monitoring Following EVO Treatment

It is assumed that the total number of monitoring wells to be sampled for the LTM program would be reduced from the performance monitoring sampling. Two of the 4 source area monitoring wells (those with the highest historic concentrations) would be selected as representative of the source area, and an additional 4 wells would be eliminated from the downgradient wells.

Number of wells to sample for performance monitoring program: 9 wells
Number of surface water samples collected per event: 5 locations

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	34.5 hrs	$4,002
Equipment (vehicle, pumps, water quality meter,	$1752 /event	1 event	$1752
Chemical Analysis Cost			
VOCs (including TCE, DCE, VC, ethene)	$135	17 samples	$2,295
TOTAL CHEMICAL ANALYSIS COST:			**$8,049**
Monitoring Report Costs	$5,000 per event	1 event	$5,000
Total Source Area Monitoring Cost Per Event			**$13,049**

DESCRIPTION OF COSTS PER PHASE

Description		Unit Rate	Number of units	Cost
Annual Costs for Semiannual Sampling Years 4-10 (4 years)		$13,049 /event	2 events	$26,098
Using a discount rate of	**3.5%**	**for a period of**	**7 years**	**$65,947**

Description		Unit Rate	Number of units	Cost
Annual Costs for Annual Sampling Years 11-14 (10 years)		$13,049 /event	1 events	$13,049
Using a discount rate of	**3.5%**	**for a period of**	**4 years**	**$33,978**

Total Discounted Sampling Cost:

Years 1-3	**$151,114**
Years 4-10	**$65,947**
Years 11-14	**$76,934**
Total	**$293,995**

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

9.0 Well Abandonment, Replacement, and Maintenance

Since the long-term monitoring would occur over a period of 50 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Cost
Well inspection and maintenance	$2,158 /year	50 years	$50,636
Future Well abandonment	$2,425 /well	31 wells	$10,871
Well Replacement			
Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every five yearsfor the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Description	**Unit Rate**	**Number of units**	**Cost**
Well replacement	$16,865 / 5 year	50 years	$73,771
Total Well Abandonment, Replacement, and Maintenance Cost			**$135,279**

Discount Rate = 3.5%

10.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 50 years.

Description	Unit Rate	Number of units	Cost
5-Year Review (including draft, draft final, and final reports)	$15,000	1 reviews	$15,000
Using a discount rate of 3.5%	**for a period of**	**50 years**	**$73,771**

11.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support.

Description	Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)	$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs	$5,575/year	lump sum	$5.575
Using a discount rate of 3.5% for a period of 50 years $242,104.08			

Discounted O&M Cost:

7.0 Additional Injections of Sodium Lactate	**$111,867**
8.0 Long Term Monitoring Program	**$293,995**
9.0 Well Abandonment, Replacement, and Maintenance	**$135,279**
10.0 5-Year Reviews	**$73,771**
11.0 LUC/Construction Support	**242,204**
Total	**$857,116**

ALTERNATIVE 4
In Situ Enhanced Anaerobic Bioremediation, Monitored Natural Attenuation Polishing, and Land Use Controls

TOTAL CAPITAL COST:		**$622,326**
DISCOUNTED O&M COST:		**$857,116**
Contingency of Scope:	10%	$85,711
Contingency of Bid:	5%	$42,855
TOTAL DISCOUNTED O&M COST:		**$985,682**
TOTAL PRESENT WORTH VALUE:		**$1,608,008**

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

Alternative 5 involves excavation of the assumed source of the plume in the soil overburden; LTM; and the maintenance and enforcement of ICs, in particular the restrictions of groundwater uses and long-term groundwater monitoring for all parameters that exceeded the SCLs., and the requirement for construction support in the uncleared areas of the MRS. It is assumed that groundwater-related ICs and the long-term groundwater monitoring would be performed for 10 years, and that MEC related LUCs and construction support will be required for 50 years. The anticipated length of LTM will be reevaluated following review of the groundwater sampling results, and evaluation of site-specific attenuation rates.

GENERAL ASSUMPTIONS

1) The costs are adopted from R.S. Means 2007 Cost works - Site Work, previous work conducted by Shaw Environmental at PTA, and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey

3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule, unless otherwise noted.
4) Work is to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition when appropriate..

5) For activities requiring construction support, the team will consist of: 1 truck driver, 2 laborers, 1 Tech 3,1 Tech 2, and 2 Operators (Tech 2).

6) For activities requiring MEC screening, the team will consist of: 1 truck driver, 2 laborers, SUXOS, UXOSO/QCS, 1 Tech 3, 2 Tech 2, 2 Tech 2, and 3 Operators (Tech 2).

7) The source area is assumed to be located under 20' of clean overburden, with an area 60' x 120' and a thickness of 5'. Total excavated volume: 18,087 CY. Volume of source area (60' x 120' x5'): 1334 CY, volume of clean overburden (60'x120'x20'): 5334 CY, volume of excavation sidewall cutback (1:2 slope): 11,419 CY

CAPITAL COSTS

1.0 Institutional Controls/Planning

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the 600 Area Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plumes.

Description	Unit Rate	Number of units	Cost
LCUP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning, Permitting and Reporting

Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$2,000	Lump Sum	5,300
Design documents (drawings, specifications, design basis) - draft, draft final, and final	$27,700	Lump Sum	27,700
Work Plan	$20,000	Lump Sum	20,000
Explosive Safety Submission	$6,700	Lump Sum	6,700
Health and Safety Plan	$9,000	Lump Sum	9,000
FSP, QAPP, and DQOs	$17,400	Lump Sum	17,400
Closeout Report (Draft, Draft Final, Final)	$11,600	Lump Sum	11,600
Total Cost for Reporting			**$97,700**

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	$97,700
Total Capital Cost for Institutional Controls:	**$106,300**

3.0 Site Preparation

3.1 Erosion Control

Prior to start of work, silt fence will be erected along the perimeter of the work areas. In addition to the assumed 60' x 120' source area, a 1:2 slope will be required for side wall stabilization. For an overall depth of 25' bgs, the resulting cutback is 50', yeilding a 160' x 220' work area.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence (110% of work area perimeter): 836 LF

Description	Cost Code	Unit Rate	Number of units	Duration	Cost
Silt fencing, polypropylene,		$3.39 /lf	836 lf	1	$2834
MEC Support (2 person team)		$1,800 /day		1	$1,800
Total Erosion Control Cost					**$4,634**

Estimated time required for Silt Fence Construction = 1 days

3.2 Layout and Construction Survey

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place . The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

Assumptions:
1) Survey crew used to perform the construction layout survey will require a two person crew.

Description	Cost Code	Unit Rate	Number of units	Cost
Surveying Crew, 2 person survey		$1,250 /day	5 days	$6,250
Total Cost for Survey Crew T				**$6,250**

Estimated Number of days required = 5 days

3.3 Site Setup/ Vehicle and Personnel Decontamination Area

The 4,000 sf decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the ground surface. Sand will be used to smooth the existing terrain. Assumes no site trailer or utility hookups required, due to short duration of field work.

Description	Unit Rate	Number of units	Duration (days)	Cost
Material and Installation costs for Decon Pad	$8,700	Lump Sum		$8,700
Vehicle and Personnel Decon Area Cost	**Total**			**$8,700**

Estimated time required for Decon Area Construction = 6 days

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

4.0 Excavation and Disposal of Source Material

4.1 Excavation of Material Requiring Construction Support

Assumptions:

Soil will be excavated using an excavator that will load directly into end dump trucks or staging area. The excavation rate and unit cost have been selected based on ECC experience and professional judgment to account for difficult terrain, site accessibility, and anticipated MEC clearance activities. In areas where the MEC/MD is not likely (i.e., clean overburden), construction support activities will be required. This will consist of having two UXO technicians visually observing the excavation. Excavation will proceed in six inch lifts such that debris will be observed if present. One UXO team member will be located to the rear and upwind of the excavation equipment and will visually observe excavation. Assume 5,334 CY of clean overburden and 11,419 CY of cutback soil require construction support. Assume 700 CY/day during construction support activities.

Clean overburden and sidewall cutback spoils will be staged and used as backfill following confirmation sampling.

Volume of source area requiring construction support:	0	CY
Volume of clean overburden requiring construction support:	5334	CY
Volume of excavation sidewall cutback requiring construction support:	11419	CY
Total excavated volume requiring construction support:	16753	CY

Description	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314 /day	23 days		$7,222
Two - Truck, 6X4,10-wheel End Dump, 12-14 CY, 70,000-lb. GVW, Diesel	$410.00/day	23 days		$9,430
Misc Equipment/fuel	$540 /day	23 days		$12,420
Carbon substrate application	9.79/gal	3650 gal		$36,390
Construction Support Team	$4,198 /day	23 days		$95,554
Total Cost for Source Material Excavation				**$161,016**

Estimated time required for Excavation = 23 days

4.2 Excavation of Material Requiring Screening of Excavated Soil for MEC/MD

Assumptions:

TCE contaminated soil will require screening for MEC/MD and certification as safe prior to disposal. In addition, 914 CY of the excavated cutback will also require screening to remove MEC/MD. It is assumed that the screening process will involve laying out soil to be screened in 6-inch lifts and visually inspected (aided by the use of a Schonstedt) by a team of UXO Technicians. MEC/MD screening will take place simultaneously with the excavation. Assume 150 CY/day during construction support activities.

Volume of source area:	1334	CY
Volume of overburden expected to contain MEC/MD:	0	CY
Volume of excavation sidewall cutback expected to contain MEC/MD:	914	CY
Total excavated volume requiring MEC/MD screening:	2248	CY

Description Cost Code	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314/day	15 days		$4,710
Two -Truck, 6X4,10-wheel End Dump, 12-14 CY,	$410/day	15 days		$6,150
Loader, Articulating, 3.00 CY, (Rental) John Deere	$215 /day	15 days		$3,225
Dozer, Standard Crawler, 90-99 HP, (Rental) John Deere 650J, Cat D5 Komatsu D39P	$200 /day	15 days		$3,000
Misc Equipment/fuel	$719 /day	15 days		$10,787
MEC and Construction Support Team	$7,995 /day	15 days		$119,925
Additional H & S Markup of	**10%**			**$14,779**
Total Cost for MEC/MD screening				**$162,576**

Estimated time required for Excavation = 15 days

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

4.3 MEC Destruction

Assumptions:

Since a subsurface investigation has not been performed over the entire excavation area, the number of MEC items anticipated remains unknown. Assume 1 BIP per 20 CY of MEC/MD/OD

Description	Unit Rate	Number of units	Cost
Explosives	$76.70 /BIP	34 BIPS	$2,608
Total Cost for MEC Destruction			**$260.80**
Total Cost with H & S Markup of	**10%**		**$2,869**

4.4 Transportation and Off-Site Disposal of Contaminated Soil

Note: Based on previous investigations, it is assumed that the TCE-contaminated soil will have to be disposed as hazardous.

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$165.00 /ton	2,602 tons	$429,330
Total Cost for Transportation and Off-Site Disposal			**$429,330**
Total Cost with H & S Markup of	**10%**		**$472,263**

4.5 Transportation and Off-Site Disposal of Non-Hazardous Debris

Note: Based on previous investigations, it is assumed that the majority of MD/OD identified will be non-hazardous and will be recycled at no cost to contractor. Assume 675 CY of scrap metal.

Subtitle D Landfill with transportation:	$0.00	/ton
Estimated volume of non-hazardous waste:	675	CY
Estimated unit weight of non-hazardous waste:	0.375	ton/CY
Tonnage of non-hazardous waste:	254	ton

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$0.00 /ton	254 tons	$0.00
Total Cost for Transportation and Off-Site Disposal			**$0.00**
Total Cost with H & S Markup of	**10%**		**$0.00**

4.6 Confirmation Sampling, Soil Profiling for Disposal, and Decon Water Profiling

Waste Characterization Samples:	4
1 sample for 1st 100cy + 1ea per add'l 200cy	
Post excavation samples (1 sample per 30 ft of sidewall and 1 sample per 900 sf of excavation bottom)	10
Decon water:	1
Total Number of Samples:	15

Note: Hazardous waste characterization sampling required under RCRA for disposal includes: TCLP VOCs, TCLP SVOCs, TCLP pesticides/herbicides, TCLP metals, reactivity, corrosivity, and ignitability.

Description	Unit Rate	Number of units	Cost
Post Excavation Sampling Analysis (VOCs only)	$50 /sample	10 samples	$500
Decon Water Waste Characterization	$420 /sample	1 samples	$420
Hazardous Waste Characterization	$982 /sample	4 samples	3,840
Field samplers and misc sample equipment	$125/sample	15 Samples	$1,875
Total Cost for Confirmation/Profiling Sampling			**$6,635**
Total Cost with H & S Markup of	**10%**		**$7,298**

4

4.7 Site Restoration

Site Restoration activities include backfilling the area with clean overburden, sidewall cutback spoils and certified clean fill; compaction; and slope stabilization.

Estimated volume of certified clean fill required:	1,334 CY
Including 30% swelling factor	1,734 CY
Total backfill volume:	18,087 CY

Description	Unit Rate	Number of units	Duration (days)	Cost
Backfill and compaction	$6.62 cy	18,087 CY	24	$119.736
Certified Clean Fill (delivered)	$14.39/ ton	1,734 tons		$24,935
Compaction testing tech and equipment	$75/hr		192 hrs	$14,400
Hydromulching	$1,874 /acre	18,087 CY		$1,874.00
Total Cost for Site Restoration				**$160,975**
Total Cost with H & S Markup of	**10%**			**$177,0723**

Estimated time required for Site Restoration: 24 days

5.0 Mobilization / Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the site. In addition, providing all required utilities is also included with mobilization.

Mobilization is calculated as 10% of the direct capital costs, including site preparations and remedial system installations.

Mobilization/Demobilization	**10% of capital**	**$117,145**

6.0 Construction and Technical Oversight

Field construction oversight will be required for the duration of the project. The duration of the project will include time to construct and remove support facilities (i.e. decon pad, erosion controls), excavation, and site restoration. An H&S Engineer is estimated to provide additional oversight at a rate of 1 day/wk. Due to the site location in an active range area, an additional 10% is applied to the work duration to account for anticipated work restrictions and delays. A similar cost is applied to UXO support for Characterization Sampling, Site Prep, and Excavation; however as base UXO support costs have already been applied in the preceding sections, only the additional 10% is applied here.

Estimated total construction time frame:

Site preparations:	8	days
Excavation/Restoration:	62	days
Mob/Demob:	2	days
Duration (including 10% standby):	79	days

Description	Unit Rate	Number of units	Cost
Data Review	$1,000	lump sum	$1,000
Site Visit and Meeting	$5,000	lump sum	$5,000
Field Engineer	$3,790 /week	16 weeks	$60,640
H&S Engineer	$5,020 /week	3.2 weeks	$16,064
Total Cost for Construction and Oversight			**$82,704**

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

All work associated with Remedial Alternative GW-5 to be done using local workforce.

SUMMARY OF CAPITAL COSTS:

1) Institutional Controls/Planning		**$8,600**
2) Planning, Permitting and Reporting		**$106,300**
3) Site Preparation		**$19,584**
4) Excavation of Source Material		**$996,658**
5) Mobilization/Demobilization		**$117,145**
6) Construction and Technical Oversight		**$82,704**
Contingency of Scope	**10%**	**$129,460**
Contingency of Bid	**5%**	**$64,730**
TOTAL CAPITAL COST		**$1,525,182**

OPERATION AND MAINTENANCE (O&M) COSTS

7.0 Long-Term Groundwater and Surface Water Monitoring

The long-term groundwater monitoring would be designed to ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of all of the contaminants of concern in addition to field parameters including dissolved oxygen, pH, Conductivity, Temperature, Turbidity, and ORP. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58.00 /hr/person
Number of People:	2 people
Hours worked per day:	10 hrs
Anticipated time to collect GW samples per location:	3.0 hrs
Number of Wells to Sample for the long-term monitoring:	12 wells
Number of Surface Water Samples Collected Per Event:	5 locations
Anticipated time to collect SW samples per location:	1.5 hrs
Data Management cost per sampling event:	$3,000.00 per event

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	44 hrs	$5,104
Equipment (vehicle, pumps, water quality meter, etc.)	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135	21 samples	$2,835
TOTAL CHEMICAL ANALYSIS COST:			**$2,835**
Data Management and Reporting cost	$5,000 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$14,691**

ALTERNATIVE 5

Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

It is assumed that following the first 5 years of the LTM program that the total number of wells to be sampled would be reduced from 12 to 8.

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	32 hrs	$3,712
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135	16 samples	$2,160
TOTAL CHEMICAL ANALYSIS COST:			**$2,160**
Data Management and Reporting cost	$5,000 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$12,084**

DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE

Description		Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-5		$14,691 /event	2 events	$29,382
Using a discount rate of	**3.5%**	**for a period of**	**5 years**	**$82,318**

Description		Unit Rate	Number of units	Cost
Annual Cost for Years 6-10 (annual sampling for 5 years)		$12,084 /event	1 events	$12,084
Using a discount rate of	**3.5%**	**for a period of**	**5 years**	**$45,938**

Total Discounted Sampling Cost:

Years 1-5	**$82,317.00**
Years 6-10	**$45,937.97**
Total	**$128,254.97**

8.0 Well Construction, Abandonment, and Maintenance

Since LTM will occur over an anticipated period of 10 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Discounted Cost
Well inspection and maintenance	$2,158.00 /year	10 years	$11,901
Future Well abandonment	$2,425.00 /well	23 wells	$39,539
Well Replacement Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every 5 years for the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Description	**Unit Rate**	**Number of units**	**Discounted Cost**
Well replacement	$16,865 / 5 year	10 years	$28,081
Total Discounted Well Construction, Abandonment, and Maintenance Cost			**$79,460**

Discount Rate = 3.5%

ALTERNATIVE 5
Trichloroethene Source Removal, Monitored Natural Attenuation Polishing, and Land Use Controls

10.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support.

Description	Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)	$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs	$5,575/year	lump sum	$5.575
Using a discount rate of 3.5% for a period of 50 years $242,104.08			

11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 10 years.

Description	Unit Rate	Number of units	Cost
5-Year Review (including draft, draft final, and final reports)	$15,000	lump sum	$15,000
Using a discount rate of 3.5% for a period of		**10 years**	**$73,771**

Discounted O&M Cost:

10-Year Sampling Cost	**$$128,255**
Well Construction, Abandonment, and Maintenance	**$79,460**
LUC Inspection/Construction Support	**$242,1048**
5-Year Reviews	**$73,771**
Total	**$523,590**

TOTAL CAPITAL COST:		**$1,525,182**
DISCOUNTED O&M COST:		**$523,590**
Contingency of Scope:	**5%**	**$26,179**
Contingency of Bid:	**10%**	**$52,359**
TOTAL DISCOUNTED O&M COST:		**$602,128**
TOTAL PRESENT WORTH VALUE:		**$2,127,311**

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

Alternative 6 involves excavation of the entire Munitions Waste Pit, including the assumed source of the plume in the soil overburden; LTM; and the maintenance and enforcement of ICs, in particular the restrictions of groundwater uses and long-term groundwater monitoring for all parameters that exceeded the SCLs, and the requirement for construction support in the uncleared areas of the MRS. It is assumed that ICs and the long- term groundwater monitoring would be performed for 10 years. The anticipated length of LTM will be reevaluated following review of the groundwater sampling results, and evaluation of site-specific attenuation rates.

GENERAL ASSUMPTIONS

1) The costs are adopted from previous work conducted by ECC and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule, unless otherwise noted.
4) Work is to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition, where appropriate

5) For activities requiring construction support, the team will consist of: 1 truck driver, 2 laborers, 1 Tech 3,1 Tech 2, and 2 Operators (Tech 2).
6) For activities requiring MEC screening, the team will consist of: 1 truck driver, 2 laborers, SUXOS, UXOSO/QCS, 1 Tech 3, 2 Tech 2, 2 Tech 2, and 3 Operators (Tech 2).
7) Preliminary estimate of the entire waste pit area is approximately 10,500 SF with a total depth of approximately 25 ft bgs. Volume of landfill: 9,723 CY, Volume of clean overburden and cutback: 26,852 CY

CAPITAL COSTS

1.0 Institutional Controls/Planning

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the 600 Area Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plumes.

Description	Unit Rate	Number of units	Cost
LCUP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning, Permitting and Reporting

Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$2,000	Lump Sum	5,300
Design documents (drawings, specifications, design basis) - draft, draft final, and final	$27,700	Lump Sum	27,700
Work Plan	$20,000	Lump Sum	20,000
Explosive Safety Submission	$6,700	Lump Sum	6,700
Health and Safety Plan	$9,000	Lump Sum	9,000
FSP, QAPP, and DQOs	$17,400	Lump Sum	17,400
Closeout Report (Draft, Draft Final, Final)	$11,600	Lump Sum	11,600
Total Cost for Reporting			**$97,700**

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	$97,700
Total Capital Cost for Institutional Controls:	**$106,300**

3.0 Site Preparation

3.1 Erosion Control

Prior to start of work, silt fence will be erected along the perimeter of the work areas. In addition to the assumed 60' x 120' source area, a 1:2 slope will be required for side wall stabilization. For an overall depth of 25' bgs. the resulting cutback is 50', yielding a 160' x 220' work area.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence (110% of work area perimeter): 1,276 LF

Description	Unit Rate	Number of units	Duration	Cost
Silt fencing, polypropylene,	$3.39 /lf	1,276 lf	2	$4,325
MEC Support (2 person team)	$1,800.00 /day		2	$3,600.00
Total Erosion Control Cost				**$7,925**

Estimated time required for Silt Fence Construction = 2 days

3.2 Layout and Construction Survey

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place . The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

Assumptions:
1) Survey crew used to perform the construction layout survey will require a two person crew.

Description Cost Code	Unit Rate	Number of units	Cost
Surveying Crew, 2 person survey	$1,250 /day	5 days	$6,250
Total Cost for Survey Crew			**$6,250**

Estimated Number of days required = 5 days

3.3 Site Setup/ Vehicle and Personnel Decontamination Area

The 4,000 sf decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the ground surface. Sand will be used to smooth the existing terrain. Assumes no site trailer or utility hookups required, due to short duration of field work.

Description	Unit Rate	Number of units	Duration (days)	Cost
Material and Installation costs for Decon Pad	$8,700	Lump Sum		$8,700
	Total			**$8,700**
Vehicle and Personnel Decon Area Cost				

Estimated time required for Decon Area Construction = 6 days

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

4.0 Excavation and Disposal of Source Material
4.1 Excavation of Material Requiring Construction Support

Assumptions:

Soil will be excavated using an excavator that will load directly into end dump trucks or staging area. The excavation rate and unit cost have been selected based on ECC experience and professional judgment to account for difficult terrain, site accessibility, and anticipated MEC clearance activities. In areas where the MEC/MD is not likely (i.e., clean overburden and sidewall cutback), construction support activities will be required. This will consist of having two UXO technicians visually observing the excavation. Excavation will proceed in six inch lifts such that debris will be observed if present. One UXO team member will be located to the rear and upwind of the excavation equipment and will visually observe excavation. Assume 22,136 CY of clean overburden, sidewall cutback soil and existing stockpiled material require construction support. Assume 580 CY/day during construction support activities.
Clean overburden and sidewall cutback spoils will be staged and used as backfill following confirmation sampling.
Total excavated volume requiring construction support: 22136 CY

Description	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314 /day	38 days		$11,932
Two - Truck, 6X4,10-wheel End Dump, 12-14 CY, 70,000-lb. GVW, Diesel	$410/day	38 days		$15,580
Misc Equipment/fuel	$540.00 /day	38 days		$20,520
Construction Support Team	$4,198 /day	38 days		$159,524
Total Cost for Source Material Excavation				**$20,755** **$228,312**

4.2 Excavation of Material Requiring Screening of Excavated Soil for MEC/MD

Assumptions:

Excavation of the entire Inactive Munitions Waste Pit landfill (approximately 9,526 CY), including transport and disposal of approximately 1,334 cubic yards (CY) of TCE contaminated soil will require screening for MEC/MD and certification as safe prior to disposal. It is assumed that the screening process will involve laying out soil to be screened in 6-inch lifts and visually inspected (aided by the use of a Schonstedt) by a team of UXO Technicians. MEC/MD screening will take place simultaneously with the excavation. Assume 150 CY/day during construction support activities.

Total excavated volume requiring MEC/MD screening: 9526 CY

Description Cost Code	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314/day	65 days		$20,410
Two -Truck, 6X4,10-wheel End Dump, 12-14 CY, 70,000-	$410/day	65 days		$26,650
Loader, Articulating, 3.00 CY, (Rental) John Deere 544J,	$215 /day	65 days		$13,975
Dozer, Standard Crawler, 90-99 HP, (Rental) John Deere 650J, Cat D5 Komatsu D39P	$200 /day	65 days		$13,000
Misc Equipment/fuel	$719 /day	65 days		$46,746
MEC and Construction Support Team	$7,995 /day	65 days		$519,675
Additional H & S Markup of Cost for MEC/MD screening	**10% Total**			**$64,045** **$704,502**

Estimated time required for Excavation = 65 days

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

4.3 MEC Destruction

Assumptions:

Since a subsurface investigation has not been performed over the entire excavation area, the number of MEC items anticipated remains unknown. Assume 1 BIP per 20 CY of MEC/MD/OD

Description	Unit Rate	Number of units	Cost
Explosives	$67.70 /BIP	146 BIPS	$9,882
Additional H & S Markup of	**10%**		**$982**
Total Cost for MEC Destruction			**$10,880**

4.4 Transportation and Off-Site Disposal of Contaminated Soil

Note: Based on previous investigations, it is assumed that the TCE contaminated soil will have to be disposed as hazardous.

Subtitle C Landfill with transportation:			$200.00	/ton
Estimated unit weight of contaminated soil:			1.5	ton/CY
Tonnage of Subtitle C soil, including	30%	swelling factor:	2,602	ton

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$165 /ton	2,602 tons	$420,330
Additional H & S Markup of	**10%**		**$42,933**
Total Cost for MEC/MD screening			**$463,263**

4.5 Transportation and Off-Site Disposal of Non-Hazardous Debris

Note: Based on previous investigations, it is assumed that the majority of MD/OD identified will be non-hazardous and will be recycled at no cost to contractor. Assume 2917 CY of scrap metal.

Subtitle D Landfill with transportation:	$0.00	/ton
Estimated volume of non-hazardous waste:	2917	CY
Estimated unit weight of non-hazardous waste:	0.375	ton/CY
Tonnage of non-hazardous waste:	1,094	ton

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$0.00 /ton	1,094 tons	$0.00
Total Cost for Transportation and Off-Site Disposal			**$0.00**
Total Cost with H & S Markup of	**10%**		**$0.00**

4.6 Confirmation Sampling, Soil Profiling for Disposal, and Decon Water Profiling

Waste Characterization Samples:	48
1 sample for 1st 100cy + 1ea per add'l 200cy	
Post excavation samples (1 sample per 30 ft of sidewall and 1 sample per 900 sf of excavation bottom)	10
Decon water:	1
Total Number of Samples:	59

Note: Hazardous waste characterization sampling required under RCRA for disposal includes: TCLP VOCs, TCLP SVOCs, TCLP pesticides/herbicides, TCLP metals, reactivity, corrosivity, and ignitability.

Description	Unit Rate	Number of units	Cost
Post Excavation Sampling Analysis (VOCs only)	$50.00 /sample	10 samples	$500
Decon Water Waste Characterization	$420.00 /sample	1 samples	$730
Hazardous Waste Characterization	$982.00 /sample	48 samples	$47,136
Field samplers and misc sample equipment	$125/sample	60 Samples	$7,500
Total Cost for Confirmation/Profiling Sampling			**$55,966**
Total Cost with H & S Markup of	**10%**		**$61,453**

4.7 Site Restoration

Site Restoration activities include backfilling the area with clean overburden, sidewall cutback spoils and certified clean fill; compaction; and slope stabilization.

Estimated volume of certified clean fill required:	1,334 CY
Including 30% swelling factor	1,734 CY
Total backfill volume:	36,575 CY

Description	Unit Rate	Number of units	Duration (days)	Cost
Backfill and compaction	$6.62 cy	36,575 CY	48	$242,126
Certified Clean Fill (delivered)	$14.39/ ton	1,734 tons		$24,952
Compaction testing tech and equipment	75.00/hr		384 hrs	$28,800
Hydromulching	$1,874 /acre	1 acre		$1,874
Total Cost for Site Restoration				**$295,879**
Total Cost with H & S Markup of	**10%**			**$325,466**

Estimated time required for Site Restoration: 48 days

5.0 Mobilization / Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the site. In addition, providing all required utilities is also included with mobilization.

Mobilization is calculated as 5% of the direct capital costs, including site preparations and remedial system installations.

Mobilization/Demobilization	**10% of capital**	**$157,448**

6.0 Construction and Technical Oversight

Field construction oversight will be required for the duration of the project. The duration of the project will include time to construct and remove support facilities (i.e. decon pad, erosion controls), excavation,MEC Clearance, and site restoration. An H&S Engineer is estimated to provide additional oversight at a rate of 1 day/wk. Due to the site location in an active range area, an additional 10% is applied to the work duration to account for anticipated work restrictions and delays. A similar cost is applied to UXO support for Characterization Sampling, Site Prep, and Excavation; however as base UXO support costs have already been applied in the preceding sections, only the additional 10% is applied here.

Estimated total construction time frame:

Site preparations:	9	days
Excavation/Restoration:	151	days
Mob/Demob:	2	days
Duration (including 10% standby):	179	days

Description	Unit Rate	Number of units	Cost
Data Review	$1,000	lump sum	$1,000
Site Visit and Meeting	$5,000	lump sum	$5,000
Field Engineer	$3,790/week	36 weeks	$136,440
H&S Engineer	$5,020 /week	7.2 weeks	$36,144
Total Cost for Construction and Oversight			**$178,584**

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

All work associated with Remedial Alternative 6 to be done using local workforce.

SUMMARY OF CAPITAL COSTS:

1) Institutional Controls/Planning		$86000
2) Planning, Permitting and Reporting		$97,700
3) Site Preparation		$22,875
4) Excavation of Source Material		$1,793,877
5) Mobilization/Demobilization		$165,425
6) Construction and Technical Oversight		$157,448
Contingency of Scope	10%	$232,392
Contingency of Bid	5%	$116,196
TOTAL CAPITAL COST		**$2,671,913**

OPERATION AND MAINTENANCE (O&M) COSTS

7.0 Long-Term Groundwater and Surface Water Monitoring

The long-term groundwater monitoring would be designed to ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of all of the contaminants of concern in addition to field parameters including dissolved oxygen, pH, Conductivity, Temperature, Turbidity, and ORP. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58.00 /hr/person
Number of People:	2 people
Hours worked per day:	10 hrs
Anticipated time to collect GW samples per location:	3.0 hrs
Number of Wells to Sample for the long-term monitoring:	12 wells
Number of Surface Water Samples Collected Per Event:	5 locations
Anticipated time to collect SW samples per location:	1.5 hrs
Data Management cost per sampling event:	$5,000.00 per event

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	44 hrs	$5,104
Equipment (vehicle, pumps, water quality meter, etc.)	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135	21 samples	$2,835
TOTAL CHEMICAL ANALYSIS COST:			**$2,835**
Data Management and Reporting cost	$5,000.00 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$14,691**

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

It is assumed that following the first 5 years of the LTM program that the total number of wells to be sampled would be reduced from 12 to 8.

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	32 hrs	$3,712
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135.00	16 samples	$2,160
TOTAL CHEMICAL ANALYSIS COST:			**$2,160**
Data Management and Reporting cost	$5,000 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$12,084**

DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE

Description	Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-5	$14,691 /event	2 events	$29,382
Using a discount rate of 3.5%	**for a period of**	**5 years**	**$82,318**

Description	Unit Rate	Number of units	Cost
Annual Cost for Years 6-10 (annual sampling for 5 years)	$12,084 /event	1 events	$12,084
Using a discount rate of 3.5%	**for a period of**	**5 years**	**$45,938**

Total Discounted Sampling Cost:

Years 1-5	**$82,318**
Years 6-10	**$45,938**
Total	**$128,255**

8.0 Well Construction, Abandonment, and Maintenance

Since LTM will occur over an anticipated period of 10 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Discounted Cost
Well inspection and maintenance	$2,158 /year	10 years	$11,901
Future Well abandonment	$2,425 /well	23 wells	$39,539
Well Replacement			
Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every 5 years for the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Description	**Unit Rate**	**Number of units**	**Discounted Cost**
Well replacement	$16,865 / 5 year	10 years	$28,081
Total Discounted Well Construction, Abandonment, and Maintenance Cost			**$79,460**

Discount Rate = 3.5%

ALTERNATIVE 6
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, AND LAND USE CONTROLS

10.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support.

Description	Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)	$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs	$5,575/year	lump sum	$5,575
Using a discount rate of 3.5% for a period of 50 years $242,105			

11.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 10 years.

Description	Unit Rate	Number of	C
5-Year Review (including draft, draft final, and final reports)	$15,000	lump sum	$15,000
Using a discount rate of 3.5% for a period of			

Discounted O&M Cost:

10-Year Sampling Cost	**$128,255**
Well Construction, Abandonment, and Maintenance	**$79,460**
LUC Inspection/Construction Support	**$242,105**
5-Year Reviews	**$73,772**
Total	**$523,590**

TOTAL CAPITAL COST:		**$2,671,913**
DISCOUNTED O&M COST:		**$523,590**
Contingency of Scope:	**5%**	**$26,179**
Contingency of Bid:	**10%**	**$52,359**
TOTAL DISCOUNTED O&M COST:		**$602,128**
TOTAL PRESENT WORTH VALUE:		**$3,274,041**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

Alternative 7 involves excavation of the entire Munitions Waste Pit, including the assumed source of the plume in the soil overburden; LTM; and the maintenance and enforcement of ICs, in particular the restrictions of groundwater uses and long-term groundwater monitoring for all parameters that exceeded the SCLs. It is assumed that ICs and the long- term groundwater monitoring would be performed for 10 years. The anticipated length of LTM will be reevaluated following review of the groundwater sampling results, and evaluation of site-specific attenuation rates.

GENERAL ASSUMPTIONS

1) The costs are adopted from previous work conducted by ECC and professional judgment.
2) The costs are adjusted with a location factor for Dover, New Jersey
3) The costs and duration of the construction activities are based on an 8-hour 5-day per week working schedule, unless otherwise noted.
4) Work is to be conducted under a safety level D condition. However, a general health and safety markup of **10%** will be used to account for modification of safety level condition, where appropriate

5) For activities requiring construction support, the team will consist of: 1 truck driver, 2 laborers, 1 Tech 3,1 Tech 2, and 2 Operators (Tech 2).
6) For activities requiring MEC screening, the team will consist of: 1 truck driver, 2 laborers, SUXOS, UXOSO/QCS, 1 Tech 3, 2 Tech 2, 2 Tech 2, and 3 Operators (Tech 2).
7) Preliminary estimate of the entire waste pit area is approximately 10,500 SF with a total depth of approximately 25 ft bgs. Volume of landfill: 9,723 CY, Volume of clean overburden and cutback: 26,852 CY

CAPITAL COSTS

1.0 Institutional Controls/Planning

Land Use Restrictions: A site-specific Land Use Control Implementation Plan (LUCIP) will need to be written in order to place restrictions on activities that can be performed in areas of the plumes at the 600 Area Sites. These restrictions can be enforced through existing institutional controls and by restricting future land use. The land use restrictions will ensure that potential receptors are not exposed to contaminated groundwater from the 600 Area plumes.

Description	Unit Rate	Number of units	Cost
LCUP Preparation	$8,600	Lump Sum	$8,600
Total Cost For the Land Use Control Implementation Plan:			**$8,600**

2.0 Planning, Permitting and Reporting

Deliverables will include work plan, health and safety plan and a closure report. In addition, the substantive requirements for a Classification Exemption Area submittal will need to be made.

Description	Unit Rate	Number of Units	Cost
Permit equivalents	$2,000	Lump Sum	5,300
Design documents (drawings, specifications, design basis) - draft, draft final, and final	$27,700	Lump Sum	27,700
Work Plan	$20,000	Lump Sum	20,000
Explosive Safety Submission	$6,700	Lump Sum	6,700
Health and Safety Plan	$9,000	Lump Sum	9,000
FSP, QAPP, and DQOs	$17,400	Lump Sum	17,400
Closeout Report (Draft, Draft Final, Final)	$11,600	Lump Sum	11,600
Total Cost for Reporting			**$97,700**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

Summary of Institutional Control/Planning Costs

Description	Cost
Total Cost For Institutional Controls Plan Amendments:	$8,600
Total Cost For Planning, Permitting, and Reporting	$97,700
Total Capital Cost for Institutional Controls:	**$106,300**

3.0 Site Preparation

3.1 Erosion Control

Prior to start of work, silt fence will be erected along the perimeter of the work areas. In addition to the assumed 60' x 120' source area, a 1:2 slope will be required for side wall stabilization. For an overall depth of 25' bgs, the resulting cutback is 50', yeilding a 160' x 220' work area.
Silt fence will be maintained in an erect position and cleaned as required to ensure efficiency.

Required length of silt fence (110% of work area perimeter): 1,276 LF

Description	Unit Rate	Number of units	Duration	Cost
Silt fencing, polypropylene,	$3.39 /lf	1,276 lf	2	$4,325
MEC Support (2 person team)	$1,800.00 /day		2	$3,600.00
Total Erosion Control Cost				**$7,925**

Estimated time required for Silt Fence Construction = 2 days

3.2 Layout and Construction Survey

The purpose of a layout/construction survey is to assure that the proper amount of cover materials are in place . The work will consist of furnishing, placing, and maintaining the construction layout controls (stakes) necessary.

Assumptions:
1) Survey crew used to perform the construction layout survey will require a two person crew.

Description	Cost Code	Unit Rate	Number of units	Cost
Surveying Crew, 2 person survey		$1,250 /day	5 days	$6,250
Total Cost for Survey Crew				**$6,250**

Estimated Number of days required = 5 days

3.3 Site Setup/ Vehicle and Personnel Decontamination Area

The 4,000 sf decontamination facility will be constructed using a geomembrane liner to contain liquids generated during the decontamination activities. The liner will be placed directly on the ground surface. Sand will be used to smooth the existing terrain. Assumes no site trailer or utility hookups required, due to short duration of field work.

Description	Unit Rate	Number of units	Duration (days)	Cost
Material and Installation costs for Decon Pad	$8,700	Lump Sum		$8,700
	Total			**$8,700**
Vehicle and Personnel Decon Area Cost				

Estimated time required for Decon Area Construction = 6 days

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

4.0 Excavation and Disposal of Source Material
4.1 Excavation of Material Requiring Construction Support

Assumptions:

Soil will be excavated using an excavator that will load directly into end dump trucks or staging area. The excavation rate and unit cost have been selected based on ECC experience and professional judgment to account for difficult terrain, site accessibility, and anticipated MEC clearance activities. In areas where the MEC/MD is not likely (i.e., clean overburden and sidewall cutback), construction support activities will be required. This will consist of having two UXO technicians visually observing the excavation. Excavation will proceed in six inch lifts such that debris will be observed if present. One UXO team member will be located to the rear and upwind of the excavation equipment and will visually observe excavation. Assume 22,136 CY of clean overburden, sidewall cutback and stockpiled soil require construction support. Assume 580 CY/day during construction support activities.
Clean overburden and sidewall cutback spoils will be staged and used as backfill following confirmation sampling.
Total excavated volume requiring construction support: 22136 CY

Description	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314 /day	38 days		$11,932
Two - Truck, 6X4,10-wheel End Dump, 12-14 CY, 70,000-lb. GVW, Diesel	$410/day	38 days		$15,580
Misc Equipment/fuel	$540.00 /day	38 days		$20,520
Construction Support Team	$4,198 /day	38 days		$159,524
Total Cost for Source Material Excavation				**$20,755** **$228,312**

4.2 Excavation of Material Requiring Screening of Excavated Soil for MEC/MD

Assumptions:

Excavation of the entire Inactive Munitions Waste Pit landfill (approximately 9,625 CY), including transport and disposal of approximately 1,334 cubic yards (CY) of TCE contaminated soil will require screening for MEC/MD and certification as safe prior to disposal. It is assumed that the screening process will involve laying out soil to be screened in 6-inch lifts and visually inspected (aided by the use of a Schonstedt) by a team of UXO Technicians. MEC/MD screening will take place simultaneously with the excavation. Assume 150 CY/day during construction support activities.

Total excavated volume requiring MEC/MD screening: 9526 CY

Description Cost Code	Unit Rate	Duration		Cost
Excavator, Track, 19 to 21 Metric Tons, JDeere 200CLC/Komstsu PC200	$314/day	65 days		$20,410
Two -Truck, 6X4,10-wheel End Dump, 12-14 CY, 70,000-	$410/day	65 days		$26,650
Loader, Articulating, 3.00 CY, (Rental) John Deere 544J,	$215 /day	65 days		$13,975
Dozer, Standard Crawler, 90-99 HP, (Rental) John Deere 650J, Cat D5 Komatsu D39P	$200 /day	65 days		$13,000
Misc Equipment/fuel	$719 /day	65 days		$46,746
MEC and Construction Support Team	$7,995 /day	65 days		$519,675
Additional H & S Markup of Cost for MEC/MD screening	**10% Total**			**$64,045** **$704,502**

Estimated time required for Excavation = 65 days

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

4.3 MEC Destruction

Assumptions:

Since a subsurface investigation has not been performed over the entire excavation area, the number of MEC items anticipated remains unknown. Assume 1 BIP per 20 CY of MEC/MD/OD

Description	Unit Rate	Number of units	Cost
Explosives	$67.70 /BIP	146 BIPS	$9,882
Additional H & S Markup of	**10%**		**$982**
Total Cost for MEC Destruction			**$10,880**

4.4 Transportation and Off-Site Disposal of Contaminated Soil

Note: Based on previous investigations, it is assumed that the TCE contaminated soil will have to be disposed as hazardous.

Subtitle C Landfill with transportation:			$200.00	/ton
Estimated unit weight of contaminated soil:			1.5	ton/CY
Tonnage of Subtitle C soil, including	30%	swelling factor:	2,602	ton

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$165 /ton	2,602 tons	$420,330
Additional H & S Markup of	**10%**		**$42,933**
Total Cost for MEC/MD screening			**$463,263**

4.5 Transportation and Off-Site Disposal of Non-Hazardous Debris

Note: Based on previous investigations, it is assumed that the majority of MD/OD identified will be non-hazardous and will be recycled at no cost to contractor. Assume 2917 CY of scrap metal.

Subtitle D Landfill with transportation:	$0.00	/ton
Estimated volume of non-hazardous waste:	2917	CY
Estimated unit weight of non-hazardous waste:	0.375	ton/CY
Tonnage of non-hazardous waste:	1,094	ton

Description	Unit Rate	Number of units	Cost
Transportation and Disposal	$0.00 /ton	1,094 tons	$0.00
Total Cost for Transportation and Off-Site Disposal			**$0.00**
Total Cost with H & S Markup of	**10%**		**$0.00**

4.6 Confirmation Sampling, Soil Profiling for Disposal, and Decon Water Profiling

Waste Characterization Samples:	48
1 sample for 1st 100cy + 1ea per add'l 200cy	
Post excavation samples (1 sample per 30 ft of sidewall and 1 sample per 900 sf of excavation bottom)	10
Decon water:	1
Total Number of Samples:	59

Note: Hazardous waste characterization sampling required under RCRA for disposal includes: TCLP VOCs, TCLP SVOCs, TCLP pesticides/herbicides, TCLP metals, reactivity, corrosivity, and ignitability.

Description	Unit Rate	Number of units	Cost
Post Excavation Sampling Analysis (VOCs only)	$50.00 /sample	10 samples	$500
Decon Water Waste Characterization	$420.00 /sample	1 samples	$730
Hazardous Waste Characterization	$982.00 /sample	48 samples	$47,136
Field samplers and misc sample equipment	$125/sample	60 Samples	$7,500
Total Cost for Confirmation/Profiling Sampling			**$55,966**
Total Cost with H & S Markup of	**10%**		**$61,453**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

4.7 Site Restoration

Site Restoration activities include backfilling the area with clean overburden, sidewall cutback spoils and certified clean fill; compaction; and slope stabilization.

Estimated volume of certified clean fill required:	1,334 CY
Including 30% swelling factor	1,734 CY
Total backfill volume:	36,575 CY

Description	Unit Rate	Number of units	Duration (days)	Cost
Backfill and compaction	$6.62 cy	36,575 CY	48	$242,126
Certified Clean Fill (delivered)	$14.39/ ton	1,734 tons		$24,952
Compaction testing tech and equipment	75.00/hr		384 hrs	$28,800
Hydromulching	$1,874 /acre	1 acre		$1,874
Total Cost for Site Restoration				**$295,879**
Total Cost with H & S Markup of	**10%**			**$325,466**

Estimated time required for Site Restoration: 48 days

5.0 MEC/MD clearance of Remaining MRS
5.1 Transect Layout

The purpose of a layout is to assure that the MRS has 100 % coverage during subsequent MEC removal activities. The work will consist of furnishing, placing, and maintaining the MEC clearance layout controls (stakes) necessary.

Assumptions:
1) a UXO Survey crew used to perform the construction layout survey will require a two person crew.

Description Cost Code	Unit Rate	Number of units	Cost
UXO Surveying Crew, 2 person survey	$1,250 /day	20 days	$25,000
Total Cost for Survey Crew			**$25,000**

Estimated Number of days required = 20 days

5.1 Vegetation Clearance

Description	Unit Rate	Duration		Cost
UXO team clearance team	$7,400.00 /day	5 days		$37,000
Subcontractor - Clearing crew	19,150	5 days		$95,750
Equipment/supplies	$1,219/day	5 days		$6,069
Misc Equipment/fuel	$719.18 /day	5 days		$3,596
Additional H & S Markup of	**10% Total**			**$14,241**
Cost for MEC/MD screening				**$156,656**

Estimated time required for Excavation = 5 days

5.2 MEC Clearance

Assumptions:

Clearance of the remaining 20 acres of the Inactive Waste pit MRS will involve clearance to a depth of two feet below ground surface. It is assumed that the clearance process will use a mag and dig technique using Schonstedts, by a team of UXO Technicians (1 tech II, 3 Tech IIs and 3 Tech 1s) , including one SUXO and one UXO QC/safety.

Description	Unit Rate	Duration		Cost

UXO team clearance team	$7,000.00 /day	80	days		$560,000
Equipment/supplies	$1219.00 /day	80	days		$97,520
Misc Equipment/fuel	$719.18 /day	80	days		$57,534
Additional H & S Markup of Cost for MEC/MD screening	**10% Total**				**$71,505 $786,559**

Estimated time required for Excavation = 80 days

5.3 MEC Destruction

Assumptions:

Since a subsurface investigation has not been performed over the entire excavation area, the number of MEC items anticipated remains unknown. Assume 1 BIP per acre.

Description	Unit Rate	Number of units	Cost
Explosives	$76.70 /BIP	20 BIPS	$1,534
Additional H & S Markup of Total Cost for MEC Destruction	**10%**		**$153 $1,687**

5.0 Mobilization / Demobilization

Mobilization and demobilization consists of providing and removing all required equipment and materials to and from the site. In addition, providing all required utilities is also included with mobilization.

Mobilization is calculated as 5% of the direct capital costs, including site preparations and remedial system installations.

Mobilization/Demobilization	**10% of capital**	**$157,448**

6.0 Construction and Technical Oversight

Field construction oversight will be required for the duration of the project. The duration of the project will include time to construct and remove support facilities (i.e. decon pad, erosion controls), excavation,MEC Clearance, and site restoration. An H&S Engineer is estimated to provide additional oversight at a rate of 1 day/wk. Due to the site location in an active range area, an additional 10% is applied to the work duration to account for anticipated work restrictions and delays. A similar cost is applied to UXO support for Characterization Sampling, Site Prep, and Excavation; however as base UXO support costs have already been applied in the preceding sections, only the additional 10% is applied here.

Estimated total construction time frame:

Site preparations:	9	days
Excavation/Restoration:	151	days
Mob/Demob:	2	days
Duration (including 10% standby):	179	days

Description	Unit Rate	Number of units	Cost
Data Review	$1,000	lump sum	$1,000
Site Visit and Meeting	$5,000	lump sum	$5,000
Field Engineer	$3,790/week	36 weeks	$136,440
H&S Engineer	$5,020 /week	7.2 weeks	$36,144
Total Cost for Construction and Oversight			**$178,584**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

All work associated with Remedial Alternative GW-5 to be done using local workforce.

SUMMARY OF CAPITAL COSTS:

1) Institutional Controls/Planning		$86000
2) Planning, Permitting and Reporting		$97,700
3) Site Preparation		$22,875
4) Excavation of Source Material		$1,793,877
5) MEC Clearance of remaining MRS		$969,942
6) Mobilization/Demobilization		$165,425
7) Construction and Technical Oversight		$157,448
Contingency of Scope	10%	$329,326
Contingency of Bid	5%	$164,663
TOTAL CAPITAL COST		**$3,787,256**

OPERATION AND MAINTENANCE (O&M) COSTS

7.0 Long-Term Groundwater and Surface Water Monitoring

The long-term groundwater monitoring would be designed to ensure that the plume characteristics are not changing in an unexpected manor, no new source areas are apparent, regulatory levels are being met, and the plume as a whole is acting as predicted.

The analytical program for the long-term groundwater monitoring program will consist of all of the contaminants of concern in addition to field parameters including dissolved oxygen, pH, Conductivity, Temperature, Turbidity, and ORP. These parameters ensure monitoring of the plume for regulatory compliance as wells as monitoring for changing geochemical and oxidation reduction state. All quality control sample analysis (field duplicates, rinse blanks, trip blanks) are assumed to be 20% of the total number of samples collection (20% of analytical costs).

For each sampling event, the following unit costs and level of efforts (LOEs) will apply:

Field Sampler:	$58.00 /hr/person
Number of People:	2 people
Hours worked per day:	10 hrs
Anticipated time to collect GW samples per location:	3.0 hrs
Number of Wells to Sample for the long-term monitoring:	12 wells
Number of Surface Water Samples Collected Per Event:	5 locations
Anticipated time to collect SW samples per location:	1.5 hrs
Data Management cost per sampling event:	$5,000.00 per event

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	44 hrs	$5,104
Equipment (vehicle, pumps, water quality meter, etc.)	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135	21 samples	$2,835
TOTAL CHEMICAL ANALYSIS COST:			**$2,835**
Data Management and Reporting cost	$5,000.00 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$14,691**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

It is assumed that following the first 5 years of the LTM program that the total number of wells to be sampled would be reduced from 12 to 8.

Description	Unit Rate	Number of units	Cost
COSTS PER SAMPLING EVENT			
Labor for chemical sampling	$58 /hr/person	32 hrs	$3,712
Equipment (vehicle, pumps, water quality meter,	$1,752 /event	1 event	$1,752
Chemical Analysis Cost			
VOCs (Including TCE, DCE, VC)	$135.00	16 samples	$2,160
TOTAL CHEMICAL ANALYSIS COST:			**$2,160**
Data Management and Reporting cost	$5,000 per event	1 event	$5,000
Total Sampling and Reporting Costs per Sampling Event			**$12,084**

DESCRIPTION OF COSTS PER PHASE ADJUSTED TO PRESENT VALUE

Description		Unit Rate	Number of units	Cost
Annual Cost for Semiannual Sampling Years 1-5		$14,691 /event	2 events	$29,382
Using a discount rate of	**3.5%**	**for a period of**	**5 years**	**$82,318**

Description		Unit Rate	Number of units	Cost
Annual Cost for Years 6-10 (annual sampling for 5 years)		$12,084 /event	1 events	$12,084
Using a discount rate of	**3.5%**	**for a period of**	**5 years**	**$45,938**

Total Discounted Sampling Cost:

Years 1-5	**$82,318**
Years 6-10	**$45,938**
Total	**$128,255**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

8.0 Well Construction, Abandonment, and Maintenance

Since LTM will occur over an anticipated period of 10 years, the groundwater monitoring wells will require maintenance to allow for accurate sampling of the aquifer. This will include inspections yearly with maintenance as needed.

Description	Unit Rate	Number of units	Discounted Cost
Well inspection and maintenance	$2,158 /year	10 years	$11,901
Future Well abandonment	$2,425 /well	23 wells	$39,539
Well Replacement Well replacement will be performed periodically as needed. For the purpose of this FS, the well replacement is assumed to occur every 5 years for the entire duration of the project. UXO support will be required for each well, assumed to take 2 days to complete.			
Description	**Unit Rate**	**Number of units**	**Discounted Cost**
Well replacement	$16,865 / 5 year	10 years	$28,081
Total Discounted Well Construction, Abandonment, and Maintenance Cost			**$79,460**

Discount Rate = 3.5%

9.0 Land Use Control Inspections/Sign Repairs/ Construction Support

Construction Support will be required during all intrusive operations (sign replacement, utility repairs, etc). Assumes 40 hours/year of Construction support.

Description	Unit Rate	Number of units	Cost
UXO Construction Support – (Tech III)	$4,750/year	lump sum	$4,750
Land Use Control Inspection/Sign Repairs	$5,575/year	lump sum	$5,575
Using a discount rate of 3.5% for a period of 10 years $7,317.31			

10.0 5-Year Review

Five-year reviews will be performed to assess the effectiveness of the remedy. For the purpose of this FS, the duration for these activities is assumed to be 10 years.

Description	Unit Rate	Number of	C
5-Year Review (including draft, draft final, and final reports)	$15,000	lump sum	$15,000
Using a discount rate of 3.5% for a period of			

Discounted O&M Cost:

10-Year Sampling Cost	**$128,255**
Well Construction, Abandonment, and Maintenance	**$79,460**
Land Use Control Inspections/Sign Repairs/ Construction	**$ 7,317**
5-Year Reviews	**$73,772**
Total	**$288,804**
Discounted O&M	**$288,804**

ALTERNATIVE 7
TOTAL MUNITIONS WASTE PIT REMOVAL, TRICHLOROETHENE SOURCE MATERIAL REMOVAL, MONITORED NATURAL ATTENUATION POLISHING, LAND USE CONTROLS, AND MUNITIONS AND EXPLOSIVES OF CONCERN CLEARANCE OF ENTIRE MUNITIONS RESPONSE SITE

TOTAL CAPITAL COST:		$3,787,256
DISCOUNTED O&M COST:		$288,804
Contingency of Scope:	5%	$14,440
Contingency of Bid:	10%	$28,880
TOTAL DISCOUNTED O&M COST:		$332,124
TOTAL PRESENT WORTH VALUE:		$4,119,380

This page intentionally left blank.

Appendix E
Public Comment Letters Received

This page intentionally left blank.

From: Mark Hiler [mailto:dbear12@optonline.net]
Sent: Friday, September 28, 2018 4:04 PM
To: Gabel, Ted B CIV USARMY ID-SUSTAINMENT (US) <ted.b.gabel.civ@mail.mil>
Subject: [Non-DoD Source] Comments on the 600 Hill Waste Pit Proposed Plan

Dear Mr. Gabel

As a resident of Rockaway Township, and a member of the Township's Environmental Commission, I attended the presentation of the proposed plan for 600 Hill Waste Pit. It was a clear and concise overview of the environmental issues, and a complete evaluation of the Alternatives. I am in total agreement with the Army's recommended Alternative #6. I am always in favor of removal actions when they are possible. It seems lately there have been more Monitored Natural Attenuation and Land Use Controls solutions used than removal actions. I understand it not always economically possible depending on the risk factors, but I favor "when in doubt dig it out".

I understand the complexity of the environmental clean-up, but it seems the process has slowed down in the last several years. I would like to encourage all stakeholders, Army, Contractors, Regulators, and the Public to think of ways to expedite the process of cleanup.

Respectfully
Mark Hiler
64 Lyonsville Road
Rockaway Twp.
(Boonton 07005 mailing address)

This page intentionally left blank.