IOWA ARMY AMMUNITION PLANT

FINAL

Five-Year Review Report

for

Iowa Army Ammunition Plant

Middletown, Iowa

Defense Environmental Restoration Program

February 2016

Prepared by:

U.S. Army Corps of Engineers-Baltimore District

Environmental and Munitions Design Center

10 South Howard Street

Baltimore, MD 21201

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

MAR 1 4 2016

Mr. Jesse Kahler
IAAAP Project Manager
Iowa Army Ammunition Plant
17571 DMC Highway 79
Middletown, Iowa 52638-5000

Dear Mr. Kahler:

The U.S. Environmental Protection Agency has received the Final Five-Year Review Report for the Iowa Army Ammunition Plant Superfund Site, Middletown, Iowa.

The EPA has approved the document, and has enclosed a signed copy for your records. The final signed report and the supporting information will need to be added to the Administrative Records file, as well as, online at www.iaaap.adminrecord.com. In addition, please mail an electronic version with all signatures to the EPA and all appropriate stakeholders.

If you have questions or concerns, please contact me at (913) 551-7763.

Sincerely,

Sandeep Mehta, P.E.
Remedial Project Manager
Iowa/Nebraska Remedial Branch
Superfund Division

Enclosure

cc: Mr. Jesse Kahler, IAAAP Project Manager (via USPS)
Mr. Daniel Cook, Iowa Department of Natural Resources (via email only)
Ms. Angela Leek, Iowa Department of Public Health (via email only)
Ms. Aleshia Kenney, U.S. Fish and Wildlife (via email only)
Ms. Jennifer Busard, Pika Inc. (via email only)

PROTECTIVENESS SUMMARY

As required by CERCLA, the Army and EPA have completed the third Five-Year Review for the Iowa Army Ammunition Plant. This Five-Year Review is required because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unrestricted use/unrestricted exposure. This review evaluates the protectiveness of the OU-1, OU-3, and OU-4 remedies. It also documents the status of other Operable Units (OUs) for which remedies have not yet been initiated, and therefore do not require protectiveness determinations under CERCLA.

The remedial actions required at the sites in the OU-1 Records of Decision (ROD) and Explanations of Significant Difference (ESD) are complete and are protective of human health and the environment in the short term. Enacting and recording property restrictions to limit land use to industrial type is needed in order to have long term protectiveness. The remedial actions at OU-3 are in progress, and are currently protective of human health and the environment in the short term. To have long term protectiveness, health advisories reminding the local population about the risks of consuming contaminated groundwater need to be issued and a health and safety program should be established, as required by the ROD. Also, a restriction on the installing of new drinking water wells in the explosives-contaminated area needs to be implemented. The physical remedial actions at OU-4 are complete and are protective of human health and the environment in the short term. For long term protectiveness, restrictions need to be placed in property documents that will limit land use to industrial type, and that will prevent surface and subsurface disturbance of the three capped areas (i.e., Inert Landfill, Trench 6, and Cap Extension Area). Also, regular operation and maintenance activities for the capped areas need to be conducted and fully documented.

For the United States Army:

23FEB '16

Signature Date

Printed Name: Lt. Col. Aaron M. Wolfe
Commander
Iowa Army Ammunition Plant

For the United States Environmental Protection Agency:

Mary P. Peterson 3/10/2016

Signature Date

Printed Name: Mary P. Peterson
Director
Superfund Division
EPA, Region VII

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ACRONYMS

ABCDP	Ammunition Box Chipper Disposal Pit
ACM	Asbestos Containing Material
AEC	US Atomic Energy Commission
AET	Advanced Environmental Technology, Inc.
amsl	above mean sea level
AO	American Ordnance
ARARs	Applicable, Relevant and Appropriate Requirements
Army	U.S. Army
BEHP	bis(2-ethylhexyl)phthalate
BHHRA	Baseline Human Health Risk Assessment
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BLRA	Baseline Risk Assessment
CAMU	Corrective Action Management Unit
CDL	Construction Debris Landfill
CEA	Cap Extension Area
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
COEC	contaminant of ecological concern
COPC	Contaminants of Potential Concern
CTA	Central Test Area
CWWP	Comprehensive Watersheds Work Plan
cy	cubic yard

DA/DF	Deactivation Area/Deactivation Furnace
DCA	dichloroethane
DCE	dichloroethene
DCP	dichloropropane
DNT	dinitrotoluene
DoD	Department of Defense
DU	Decision Unit
DUr	Depleted Uranium
EBP	East Burn Pads
ECC	Environmental Chemical Corporation
ED	Enhanced degradation
EDA	Explosive Disposal Area
EE/CA	Engineering Evaluation/Cost Analysis
EM	Electromagnetometry
EMNA	Enhanced Monitored Natural Attenuation
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ESD	Explanation of Significant Differences
EWI	Explosive Waste Incinerator
FAWP	Old Fly Ash Waste Pile
FEMA	Federal Emergency Management Administration
FFA	Federal Facilities Agreement
FFS	Focused Feasibility Study
FFWTP	Fixed Facility Wastewater Treatment Plant
FRP	Facilities Reduction Program

FS	Feasibility Study
FSA	Firing Site Area
FTA	Fire Training Area
FTP	Fire Training Pit (also known as the Fire Training Area)
FUSRAP	Formerly Utilized Sites Remedial Action Program
FYR	Five Year Review
GAC	granular activated carbon
GC	Geocomposite
GCL	Geosynthetic Clay Liner
GM	Geomembrane
GPR	Ground-penetrating radar
GRA	General Response Action
GWS	gamma radiation walkover survey
HAL	health advisory level
HEAST	Health Effects Assessment Summary Tables
HFCS	High Fructose Corn Syrup
HMX	High Melt Explosive
HI	hazard index
HQ	hazard quotient
IAAAP	Iowa Army Ammunition Plant
IAC	Iowa Administrative Code
ICs	Institutional Controls
IDA	Inert Disposal Area
IDNR	Iowa Department of Natural Resources
ILCR	incremental lifetime cancer risk

ILF	Inert Landfill
InDA	Incendiary Disposal Area
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LAP	Load, Assemble, and Pack
LDR	Land Disposal Restriction
LTM	Long Term Monitoring
LTTD	Low Temperature Thermal Desorption
LUCs	Land Use Controls
LUCIP	Land Use Controls Implementation Plan
MACS	Modular Artillery Charge System
MC	munitions constituents
MD	munitions debris
MEC	munitions and explosives of concern
µg/g	Micrograms per gram, equal to mg/kg
µg/L	Micrograms per Liter
mg/kg	Milligrams per Kilogram
MKM	MKM Engineers, Inc.
MMRP	Military Munitions Response Program
MNA	Monitored Natural Attenuation
MPI	multiple point incremental
MRS	Munitions Response Sites
MRSPP	Munitions Response Sites Prioritization Protocol
MTBE	methyl-tert-butyl-ether
NBP	North Burn Pads

NBPLF	North Burn Pads Landfill
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
NPL	National Priorities List
NPDES	National Pollutant Discharge Elimination System
NTCRA	Non-Time Critical Removal Action
O&M	Operation and Maintenance
OU	Operable Unit
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picocuries per gram
PD	Protectiveness Determination
PDS	Possible Demolition Site
PHC	U.S. Army Public Health Command
PP	Proposed Plan
ppm	parts per million
PRG	preliminary remediation goal
RA	Remedial Action
RAB	Restoration Advisory Board
RACR	Remedial Action Completion Report
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design

RDX	Royal Demolition Explosive
RfC	Reference Concentration
RfD	Reference Dose
RG	Remediation Goal
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
Seddam	sediment dam, or sediment retention pond
SF	Slope Factor
SI	Site Investigation
SSL	soil screening level for protection of groundwater
SRI	Supplemental Remedial Investigation
SVOC	Semi-Volatile Organic Compound
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCLP	Toxicity Characteristics Leaching Procedure
TNT	Trinitrotoluene
TPH	total petroleum hydrocarbons
Tt	Tetra Tech, Inc.
USACE	US Army Corps of Engineers
USATHAMA	US Army Toxic and Hazardous Materials Agency (currently Army Environmental Command)
UST	Underground Storage Tank
UXO	unexploded ordnance

VOC	Volatile Organic Compound
WBPA	West Burn Pads Area
WBPLF	West Burn Pads Landfill

1.0 EXECUTIVE SUMMARY

This Five-Year Review was performed for the Iowa Army Ammunition Plant (IAAAP) Superfund Site, which has been divided into eight Operable Units (OUs), as listed in Table 1-1 at the end of this section. This Five-Year Review Report was prepared in accordance with the U.S. Environmental Protection Agency's *Comprehensive Five-Year Review Guidance* (USEPA, 2001).

The scope of this review includes the Records of Decision (RODs) for OUs 1, 3, and 4. OU-2 was originally established for soil removal actions, but was subsequently merged into OU-1. OUs 5 through 9 are also discussed in this review, but because none of these OUs has initiated the Remedial Action phase, complete Technical Assessments are only included for OUs 1, 3, and 4. Two former OU-1 areas, Line 1 and the West Burn Pads South of the Road [WBPS], were placed under the responsibility of the Formerly Utilized Sites Remedial Action Program (FUSRAP) through a Federal Facility Agreement in October 1996. These two areas are being excavated by the U.S. Army Corps of Engineers, St. Louis District, under FUSRAP using the OU-1 ROD Remediation Goals (RGs) and are not part of this Five-Year Review.

Section 2.3.4.3 of the report describes OUs 1, 3, and 4; a summary of the description follows.

OU-1

The soils operable unit, OU-1, intended to address the majority of the areas of contaminated soil at the IAAAP, consists of an Interim Action to excavate contaminated soils from across the installation and consolidate them at the Inert Disposal Area (IDA), and a Final Action to treat excavated soils, when required, and address ultimate disposal of the soil. The Interim Action ROD for OU-1 was signed on March 4, 1998, to address remedial actions (RAs) to be conducted at 15 areas throughout the IAAAP. The Final ROD for OU-1 was signed on September 29, 1998. Three sites were added to OU-1 in an Explanation of Significant Differences (ESD) dated May 15, 2008. Contaminated soils from the 18 Non-FUSRAP areas included in OU-1 have been excavated and transported to the IDA for disposal and/or treatment, and the treatment has been completed. The OU-1 Remedial Goals (RGs) are protective of industrial/commercial use, and the necessary land use restrictions are to be included in the Site-Wide OU (now OU-7) as per the terms of the OU-1 Final ROD. Such industrial restrictions are already effectively in place through the current property function as an Army Ammunition Plant with its associated security and property access restrictions. Therefore the remedy for these Non-FUSRAP OU-1 sites is complete.

The remedy at OU-1 is considered to be protective of human health and the environment in the short term. For the remedy to be protective in the long term, institutional controls need to be fully implemented. The institutional controls (ICs) will: restrict land use to industrial/commercial in appropriate property administration documents.

OU-3

The Offsite Groundwater Operable Unit, OU-3, is intended to address off-post groundwater contamination resulting from IAAAP sources. These IAAAP sources discharged waste explosives to a watercourse on IAAAP, named Brush Creek, which flows off of IAAAP near its southeast corner. Once Brush Creek left IAAAP, it entered an area of more-permeable substrate which allowed the explosives-contaminated water to migrate downward into the groundwater. OU-3 is comprised of the response for the off-post groundwater, and monitoring and any response for the off-post section of Brush Creek. Currently a removal and remedial response is underway for the groundwater; the off-post section of Brush Creek is in the investigation stage and monitoring is underway. This FYR addresses the ongoing response for the groundwater.

The Army and the EPA signed an OU-3 ROD, effective in August 2005, for an off-site groundwater remedial action (RA). The explosive RDX, is the sole contaminant of concern, and there are three remedial action objectives: (1) Enhanced Degradation (ED) by carbon amendment injection for groundwater exceeding 50 µg/L RDX, (2) Monitored Natural Attenuation for groundwater exceeding 2 µg/L RDX, and (3) controls to prevent public use of >2 µg/L groundwater through municipal water connections, restrictions on potable well installation, and community information releases. In August 2007, 11 injection wells and 8 monitoring wells were installed. Five injection events followed over the next 21 months, with a sixth occurring in early 2013. The latest annual report notes that, as of November 2014, only two monitoring wells in the historic plume core have RDX concentrations above the active-treatment goal of 50 µg/L, and the exceedances of that threshold are minimal, at 50.1 µg/L and 60.1 µg/L.

Approximately 600 acres still exceed the MNA goal of 2 µg/L RDX. The plume extent was relatively stable during this five-year review period. Only two wells (i.e., the two with RDX >50 µg/L) showed some increasing behavior. An additional injection was being planned to address this behavior at the time of this review.

Ten of the 21 injection/monitoring wells that were approved for the Enhanced Degradation (ED) portion of the remedy have become unavailable due to abandonment or damage. In addition, injection wells are currently being used as monitoring wells, which is not an accepted practice. Therefore, it is currently difficult to support conclusions about the actual extent and concentration of the ED portion of the plume.

In 1994 and 2001 municipal water connections were made available to residents within and near the 2 µg/L RDX plume of OU-3, and implemented for those who accepted. With the exception of one residence, it appears that all known private wells in the plume are connected to municipal water.

Institutional controls are listed in the ROD to consist of “locally issued advisories, a health and safety program, and other institutional controls as may be needed to ensure that the remedial action objective is met.” Installation personnel indicate that they are not issuing advisories nor is there a health and safety program in place for this ROD requirement. However, the Land Use Control (LUC) status was discussed as recently as the July 2013 Restoration Advisory Board (RAB), which is open to the public.

Work has been ongoing to implement an enforceable prohibition on new well installations in the RDX plume. The process involves two counties and the State of Iowa. Despite efforts made, it appears that a resident could install and use a well sited within the RDX plume.

An important change in land use on the eastern border of the plume is the purchase of property by the neighboring sand and gravel quarry which extends onto the >2 µg/L RDX plume. Quarrying operations indicate that they remove material below the water table. Depending upon the dewatering practices employed, this operation has the ability to change the direction of plume movement, and expose additional properties to contaminated groundwater.

The remedy at OU-3 is considered to be protective of human health and the environment in the short term. For the remedy to be protective in the long term, institutional controls need to be fully implemented. The ICs will: restrict well installations in the RDX plume, issue local advisories and implement a health and safety program detailing the hazards of the RDX contamination in the groundwater.

OU-4

OU-4 addresses the closure of the Inert Disposal Area (IDA), including Trench 6, Trench 7, the Cap Extension Area (CEA), the Inert Landfill (ILF), and associated sedimentation ponds. OU-4 was originally designated as the installation-wide OU. In October 2009, the previously unaddressed areas of soil contamination were moved from OU-4 to a new Miscellaneous Sites OU-7, resulting in OU-4 consisting only of the IDA.

The closure of the IDA has been addressed in accordance with the Interim Action ROD for OU-4 issued in 2008. The treatment of OU-1 soil occurred in Trenches 6 and 7 of OU-4, as specified in the OU-1 ROD. Excavated soils from OU-1 requiring treatment within the IDA/OU-4 have been treated to the RGs established in the OU-1 Final ROD.

The ILF and the CEA have been capped and all treated soil and material have been moved from Trench 7 to Trench 6 thereby clean-closing Trench 7. Treatment and capping at Trench 6 is also complete. As allowed by the general land use control (LUC) requirements of the OU-4 Interim Action ROD, a chain link fence is being installed around the IDA to physically restrict intrusive activities by personnel and equipment onto or near the cap/closure systems.

A Land Use Control Implementation Plan (LUCIP) was submitted to EPA in 2014. It appears comprehensive, but implementation of some features, like annual LUCIP summary reports and a GIS layer showing environmental restrictions, could not be verified. A draft O&M Plan was also in the project files, specifying requirements for annual inspections and monitoring, but production of the annual reports could not be verified.

The remedy at OU-4 is considered to be protective of human health and the environment in the short term. For the remedy to be protective in the long term, institutional controls need to be fully implemented. The ICs will: restrict land use to commercial/industrial and prevent disturbance of the surface/subsurface of the ILF, Trench 6, and the CEA through recording restrictions on appropriate property ownership documents.

Table 1-1: Listing of IAAAP Operable Units

Operable Unit	Description
1	Soils on the IAAAP, other than those contaminated by use or testing of military munitions, or by radiological constituents. The OU-1 Records of Decision, and their amendments, are addressed in Section 2 of this report.
2	No longer used. Formerly used for removal action sites that were since incorporated into OU-1.
3	Groundwater and Brush Creek surface water and sediments off of the IAAAP. The OU-3 ROD is addressed in section 3 of this report.
4	The Inert Disposal Area, consisting of the closed Inert Landfill, the closed Trench 6, the former (now clean-closed) Trench 7, the closed Cap Extension Area, and the former (now clean closed) sedimentation ponds that were associated with these disposal areas. Physically located within OU-4, but not part of it, is closed Trench 5, which is addressed under RCRA. The OU-4 ROD is addressed in section 4 of this report.
5	Military Munitions Response Program sites. OU-5 had not initiated remedial action early enough to require being included in this report's protectiveness assessment; the status of OU-5 is summarized in the appendices.
6	Groundwater on the IAAAP. OU-6 has not reached the ROD stage and hence is not included in this report's protectiveness assessment; the status of OU-6 is summarized in the appendices.
7	Miscellaneous sites on the IAAAP, that is, all soil sites not included in the other OUs. OU-7 has not reached the ROD stage and hence is not included in this report's protectiveness assessment; the status of OU-7 is summarized in the appendices.
8	Sites contaminated by radiological, and other, contaminants by former Atomic Energy Commission activities, and now being addressed by the U.S. Army Corps of Engineers Formerly Used Sites Remedial Action Program, or FUSRAP. OU-8 had not initiated remedial action early enough to require a Five-Year Review. The status of OU-8 is summarized in the appendices.
9	Construction debris disposal sites. OU-9 had not reached the ROD stage and hence is not included in this report's protectiveness assessment; the status of OU-9 is summarized in the appendices.

2.0 OPERABLE UNIT 1

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Iowa Army Ammunition Plant		
EPA ID: IA7213820445		
Region: 7	**State:** IA	**City/County:** Middletown / Des Moines Co.
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Army		
Author name (Federal or State Project Manager): Mr. Jesse Kahler		
Author affiliation: Restoration Manager, Iowa Army Ammunition Plant		
Review period: May 2015 – July 2015		
Date of site inspection: June 2-4, 2015		
Type of review: Statutory		
Review number: 3		
Triggering action date: April 5, 2011		
Due date *(five years after triggering action date)*: April 5, 2016		

Five-Year Review Summary Form (continued)

The table below is for the purpose of the summary form and associated data entry and does not replace the two tables required in Section VIII and IX by the FYR guidance. Instead, data entry in this section should match information in Section VII and IX of the FYR report.

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
None

Issues and Recommendations Identified in the Five-Year Review:

OU(s): 1	**Issue Category: Institutional Controls**			
	Issue: No record of institutional controls exists in land administration documents.			
	Recommendation: Determine and implement means of formally recording LUCs during Army ownership, such as in the Base Master Plan.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Dec 2017

OU(s): 1	**Issue Category: Monitoring**
	Issue: Persistent animal disturbance of certain soil areas

	Recommendation: Continue repairing, but investigate to verify IAAAP constituents are not present			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA	Dec 2015
OU(s): 1	**Issue Category: Remedy Performance**			
	Issue: Regulatory concern exists re: residual explosives in Line 800 lagoon excavation.			
	Recommendation: Provide data; determine extent of concern.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Dec 2015

OU(s): 1	**Issue Category: Remedy Performance**			
	Issue: Previous removal actions might not have properly reached the end of the remedial process			
	Recommendation: Check with USAEC as to whether site closeout was given, what is needed to reach site closeout.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Dec 2017

OU(s): 1	**Issue Category: Institutional Controls**

	Issue: No central database of LUC sites available to avoid development of these sites in future			
	Recommendation: Determine if an IAAAP or Army GIS can record all past remediation sites.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Dec 2017

OU(s): 1	**Issue Category: Remedy Performance**			
	Issue: Leaching-to-GW RG not entirely attained at some sites.			
	Recommendation: Update leaching to GW RG. Consider covering and/or sloping areas that may still exceed the leaching RG.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	Dec 2017

To add additional issues/recommendations here, copy and paste the above table as many times as necessary to document all issues/recommendations identified in the FYR report.

Protectiveness Statement(s)
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
1	Short-term Protective	Click here to enter date.

Protectiveness Statement:

The remedy at the OU-1 ROD sites is currently protective of human health and the environment in the short-term. In order for the remedy to be protective in the long-term, language that restricts land use to industrial/commercial needs to be recorded in appropriate property ownership documents.

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: Choose an item.	*Addendum Due Date (if applicable):* Click here to enter date.
Protectiveness Statement: Click here to enter text.	

2.1 INTRODUCTION

This section documents the methods, findings, and conclusions of a CERCLA Five-Year Review for Operable Unit 1 of the Iowa Army Ammunition Plant, Middletown, Iowa. The OU-1 decision documents address on-post soil contamination for eighteen sites. The remedy for these OU-1 sites has attained the remedial goals and is considered complete. The purpose of this Five-Year Review is to evaluate the implementation and performance of the remedy and determine whether the remedy at OU-1 is protective of human health and the environment. This report also identifies issues found during the review, and recommendations to address them.

IAAAP is on the CERCLA National Priorities List and has a Federal Facilities Agreement between the U.S. Army (the “lead” agency) and the U.S Environmental Protection Agency. Because IAAAP is on the NPL and because the Army is performing the environmental work under the Defense Environmental Restoration Program, Five-Year reviews are required to be performed consistent with CERCLA section 121 and with the National Contingency Plan (NCP). The NCP, at 40 CFR §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

The contaminants for OU-1 are primarily explosives, but also include metals and various organic compounds. The remedial goals selected for OU-1 were based on an industrial/commercial land use, which is consistent with the current use of IAAAP as an ammunition plant. Since remedial goals were not based on an unlimited use and unrestricted exposure scenario, this Five Year Review (FYR) is required.

The Baltimore District of the U.S. Army Corps of Engineers performed this FYR for the remedial actions selected for OU-1 in two Records of Decision and five ESDs. This review was conducted from May 2015 to July 2015. Acting for the IAAAP, the U.S. Army Environmental Command tasked the U.S. Army Corps of Engineers (USACE) with this FYR, and USACE directed that the Baltimore District perform the work.

This FYR is the third FYR for the IAAAP installation as a whole, and the third FYR for OU-1. The triggering action for this review is the date of the previous five-year review, March 2011, and the fact that contaminants remain in OU-1 at the ROD’s remedial goals that are based on industrial/commercial use.

At the same time as this OU-1 FYR, a FYR was also performed for all other sites and OUs at IAAAP which have initiated remedial action under the DERP FFA. These other FYRs are documented in other sections of this report. Also, in Appendices G through L a status is provided for all other sites being addressed under the DERP FFA, but which are not yet required to have a FYR.

2.2 SITE CHRONOLOGY

The site events for IAAAP, focusing on OU-1, are listed in Table 2-1.

Table 2-1: Chronology of OU-1 Site Events

Sitewide Events	**Date**
IAAAP used for munitions production	1941 – present
Resource Conservation and Recovery Act (RCRA) Assessment	1987
IAAAP placed on National Priorities List (NPL)	1990
FFA for CERCLA response actions at IAAAP	1990
Facility-wide Preliminary Assessment/Site Investigation (PA/SI)	1992
Facility-wide Remedial Investigation (RI)/Baseline Risk Assessment (BLRA)	1996
OU-1 Events	Date
RCRA closure of Building 6-68 at Line 6, contaminated soil excavated	1994
Pesticide Pit and explosive wastewater sumps excavated	1995
RCRA closure of Deactivation Area/Deactivation Furnace (DA/DF), contaminated soil excavated	1995
OU-1 Focused Feasibility Study (FFS), preliminary remediation goals (PRGs) developed	1996
Multiple Removal Actions: excavations at Line 1 Impoundment and Line 800 Pink Water Lagoon	1997
Inert Landfill capped	1997
OU-1 Interim Action ROD signed	March 4, 1998
OU-1 Final ROD signed	September 29, 1998
Fire Training Pit Excavations	1998
Phase 1 Remediation: excavations at East Burn Pads (EBP), West Burn Pads Area (WBPA), North Burn Pads (NBP), and North Burn Pads Landfill (NBPLF)	1998
Phase 2 Remediation: excavations at Line 1 North Sump, Lines 5A/5B, RDX Roundhouse Area	1999
Sump at Building 800-192 (Line 800) removed, along with contaminated soil	1999

Line 1 North Sump excavated	2000
Phase 3 remediation: soil treatment at Random Fill Area, Trench 6, and Trench 7 (stabilization for metals, biological for explosives)	2001 and 2002
OU-1 ROD Explanation of Significant Differences (ESD): changed primary remedy for explosives-contaminated soil from low temperature thermal desorption (LTTD) to bioremediation, and documented the increase in contaminated soils from WBPA	2003
Phase 4 Sites Supplemental Remedial Design Sampling (Lines 4A/4B, Line 8, Roundhouse Transformer Storage Area)	2003 and 2004
Phase 4 Remediation: excavation at Line 9	2004
Supplemental RI sampling at Line 2, Line 3, Line 3A, Line 6, Line 800, Central Test Area (CTA), Incendiary Disposal Area (InDA), and Possible Demolition Site (PDS)	2005
OU-1 Interim Action ROD ESD, deleted radionuclides	2005
Line 2, Line 3, Line 3A, Line 6, Line 800, CTA, PDS, InDA excavated	2006 and 2007
Soil treatability tests at Trench 7	2006
First IAAAP Five Year Review	2006
Excavations at DA/DF	2007
OU-1 Interim Action ROD ESD: transferred CTA, InDA, and PDA from OU-4, added ecological protectiveness to the remedy	2008
Bioremediation of contaminated soils in Trench 6 and Trench 7	2008
OU-1 ROD ESD: changed primary remedy from bioremediation to alkaline hydrolysis	2009
Alkaline Hydrolysis of contaminated soils in Trench 6 and Trench 7;	2009
Final OU-1 Remedial Action Completion Report (RACR) Phases 5 ,7, 8	September 2010
OU-1 ESD: Added RG for Barium and allowed offsite disposal	2011
2nd IAAAP Five Year Review	2011

2.3 BACKGROUND

2.3.1 Physical Characteristics

The IAAAP is a load, assemble, and pack (LAP) munitions facility located on approximately 19,000 acres in Middletown, a rural area of eastern Iowa, 10 miles west of Burlington in Des Moines County and approximately nine miles northwest of the Skunk and Mississippi Rivers (**Figure 1**). The northern area of the IAAAP consists of gently undulating terrain; the central portion is characterized by rolling terrain dissected by a shallow drainage system; and the southern area of the site contains drainage ways with steep slopes down to the creek beds. Elevations within the IAAAP range from 730 feet above mean sea level (amsl) in the north to 530 feet amsl in the south.

The IAAAP contains portions of five watersheds. The Brush Creek watershed comprises the central portion of the facility; Brush Creek exits at the southeastern boundary and flows into the Skunk River, which then flows into the Mississippi River. The Spring Creek watershed drains the eastern portion of the facility; Spring Creek exits at the southeastern corner and flows directly into the Mississippi River. The Long Creek watershed comprises the western portion of the IAAAP; Long Creek exits at the southwestern boundary and joins the Skunk River just south of the facility. Long Creek has been dammed near the center of the facility to create the 85-acre George H. Mathes Lake, which was used as a water source for the facility until January 1977. The Skunk River watershed comprises the southwest corner of the IAAAP; Skunk River borders the facility's perimeter on the southwest corner and provides year-round recreational use. The Little Flint Creek watershed comprises a small area in the north portion of the facility.

The eighteen OU-1 sites are located entirely on the IAAAP and are distributed throughout the central to eastern part as shown in **Figure 1**.

2.3.2 Land and Resource Use

The IAAAP produced munitions for World War II from the plant's inception in September 1941 until August 1945, and munitions for military activities in southeast Asia in the 1960s and early 1970s. Activities at the IAAAP continued at a reduced level during peacetime. The plant was operated by Day & Zimmerman Corporation from 1941 to 1946, by the U.S. Government from 1946 to 1951, and by the Mason & Hanger Corporation from 1951 to 1998. The former U.S. Atomic Energy Commission (AEC) operated at Line 1 from 1947 through mid-1975, at which time operation reverted to Army control. The IAAAP is currently an active U.S. Army Joint Munitions Command facility operated by the civilian contractor American Ordnance LLC (AO).

The IAAAP's current mission is to LAP ammunition items, including projectiles, mortar rounds, warheads, demolition charges, and munitions components such as fuzes, primers, and boosters. Because the installation is an active production plant, inactive lines are maintained on standby status or leased to contractors. Lines which will no longer be used by the Army have been placed in modified caretaker status.

Approximately 8,000 acres of the IAAAP are leased for agricultural use, 7,500 acres are forested, and the remaining areas are used for administrative and industrial operations. Hunting and fishing are regulated at the IAAAP through the use of permits. The anticipated future land use at the

IAAAP is commercial/industrial. Public access to the installation is restricted by perimeter fencing and the IAAAP installation security staff.

The land surrounding the IAAAP is characterized as rural, and expected to remain rural. The largest population centers are the towns of Burlington (population: 25,500), West Burlington (3,300), Middletown (500), and Danville (900) (U.S. Census Bureau, 2010). The rural area south (downgradient) of the IAAAP is sparsely populated.

IAAAP is in Des Moines County which is about 60 percent croplands, 10 percent urban, eight percent pasture, and 22 percent woodlands or idle land. Crops grown in the area consist mostly of corn and soybeans (United States Department of Agriculture, 1983).

2.3.3 History of Contamination

Contamination at the IAAAP is primarily attributable to past industrial and laboratory operating practices involving various explosives-laden sludges, wastewaters, and solids; lead-contaminated sludges; ashes from incineration and open burning of explosives; and waste solvents. Past operations also generated waste pesticides and incendiaries. The eighteen OU-1 sites are the main explosives loading sites and the sites where explosives waste was formerly rendered nonexplosive by burning. Explosives loading operations employ water such as in building washdowns to ensure that explosives do not accumulate enough to become a hazard, and also create other wastewater streams. Wastewater would be sent to sumps and lagoons, while washdown water would be directed out doorways. Consequently in normal operations such load lines developed soil contamination around the periphery of the buildings. Historically off-specification or otherwise unusable explosives would be destroyed onsite by burning them on the ground. Loaded munitions that were judged faulty would be destroyed onsite by detonation, either in a containment device, or in the open with adequate soil cover to constrain kick-outs. Although most of the explosives combust or detonate during these disposal activities, a small proportion of them may not, and consequently these disposal operations have been extensively documented to cause soil contamination. When environmental investigations began at IAAAP in the 1980s, these types of sites were included because they were well-known candidates for finding contamination.

The primary contaminants at the installation, and in OU-1, are the explosives Royal Demolition Explosive (RDX) and trinitrotoluene (TNT). Other contaminants such as pesticides, fuel products, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals are also present in some on-site areas. Most of the contamination is contained within the industrial areas of the installation. However, a groundwater plume of explosives-related contamination approximately 1.5 miles long by 1 mile wide has developed off-site near Brush Creek south of the IAAAP and is being addressed as OU-3.

2.3.4 Initial Response

2.3.4.1 Preliminary Assessment and Early Site Identification

Pursuant to the RCRA Hazardous and Solid Waste Amendments of 1984, the EPA completed an assessment of the facility in 1987 and reported that releases had occurred (Ecology and Environment, Inc., 1987). The IAAAP was subsequently placed on the NPL in August 1990 with a Hazard Ranking Score of 29.73.

The U.S. Department of Defense (DoD) has established the Defense Environmental Restoration Program (DERP) to address sites under CERCLA, as amended by the SARA, that are within the responsibility of the DoD. The Army and EPA negotiated a Federal Facility Agreement (FFA) for site cleanup, which became effective December 10, 1990 (EPA, 1990a). The FFA provides a framework for CERCLA response actions to be performed at the IAAAP, including the investigation and cleanup of contamination. The EPA oversees the cleanup activities conducted by the Army to ensure that requirements of CERCLA/SARA, the NCP, and the FFA between the Army and EPA have been met. The State of Iowa is not currently a party to the FFA; however, the State participates in Restoration Advisory Board (RAB) and public meetings.

In 1992, a facility-wide PA/SI of 44 sites with potential contamination was completed (JAYCOR, 1994). All of the OU-1 sites were included in this PA/SI.

In 1993, off-post contamination of private drinking water wells with explosives [RDX and 2,6-dinitrotoluene (DNT)] was confirmed. The IAAAP offered to connect residents south of the installation to the Rathbun Regional Water Supply. One hundred and fifty-four residences accepted the Army's offer.

In 1996, a facility-wide RI/BLRA was completed for 35 of the 44 sites (JAYCOR, 1996). Two of the sites had ongoing RIs and were not addressed; the remaining seven sites were recommended for no further action.

2.3.4.2 Soil Removals

Several soil removal actions and closures occurred prior to and just after the date of the first OU-1 ROD; these removal actions are soils actions and are referred to as part of the IAAAP soil response; although they generally have EE/CAs, action memoranda, and removal action reports, they have not been closed out by including them in the OU-1 ROD or other remedial documentation process. These are part of the early response at IAAAP, but are not pre-ROD actions for the sites actually listed in the OU-1 RODs. These are:

- 1994, RCRA closure of Building 6-68 at Line 6, contaminated soil excavated
- 1995, former Pesticide Pit excavated, and soil disposed offsite
- 1995, fifty-seven sumps in various load lines excavated, soil placed in the IDA for eventual treatment and disposal
- 1997, Line 1 Impoundment excavated, soil placed in the IDA for eventual treatment and disposal
- 1997, Line 800 lagoon excavated, soil placed in the IDA for eventual treatment and disposal
- 1998-1999, Fire Training Pit excavated, most soil treated onsite by Low Temperature Thermal Desorption, some soil disposed in the IDA

2.3.4.3 Initial Assignment of Operable Units

The IAAAP facility was originally divided into four operable units (OUs-1, -2, -3, and -4). OU-2, originally established for soil removal actions, was subsequently merged into OU-1. Several other changes have been made during the course of CERCLA activities at the IAAAP, including realignment and adding of OUs. There are currently seven OUs under the DERP and the FFA, and an eighth OU under the DOE/USACE FUSRAP Program, with a separate FUSRAP FFA.

OUs 1, 3, and 4 have reached the start of remedial action, thereby requiring FYRs. These three OUs comprise the scope of this report. The remaining OUs are summarized in the Appendices. OUs 1, 3, and 4 are described below:

OU-1 -- Soils. OU-1, intended to address the majority of the areas of contaminated soil at the IAAAP, consists of an Interim Action to excavate contaminated soils from 15 sites across the installation and consolidate them at the Inert Disposal Area (IDA), and a Final Action to treat excavated soils when required and to address ultimate disposal of the soil. The Interim Action ROD for OU-1 was signed on March 4, 1998(EPA, 1998a). The Final ROD for OU-1, signed on September 29, 1998, specified LTTD or biological treatment of explosives-contaminated soils stockpiled at the IDA pursuant to the Interim ROD (EPA, 1998b). The OU-1 RODs have been modified by 5 ESDs:

April 2003: ESD to the Final OU-1 ROD, to change treatment from LTTD to bioremediation, and add solidification for soils containing metals only

June 2006: ESD to the Interim OU-1 ROD to delete radiological contaminants. At this time responsibility for radiological contaminants was moved to another OU under the responsibility of the USACE FUSRAP

January 2008: ESD to the Interim OU-1 ROD to move three sites from OU-4 to OU-1, and to increase the excavation volumes for OU-1 to meet ecological RGs

September 2009: ESD to the Final OU-1 ROD to change treatment from bioremediation to alkaline hydrolysis

March 2011: ESD to both OU-1 RODs to add an RG for Barium and to allow offsite disposal of soil

OU-3 -- Off-site Groundwater. Originally, OU-3 was intended to address both on- and off-site groundwater contamination resulting from IAAAP sources. The Army and EPA signed an OU-3 ROD, effective in August 2005, for an Off-Site Groundwater Interim Action (URS, 2005). In 2009, OU-6 was created to address on-site groundwater. Off-site groundwater remains in OU-3. OU-3 is discussed separately in this FYR report.

OU-4 -- IDA Closure. OU-4 was originally designated as the installation-wide OU. The 1998 OU-1 Final ROD specified that the installation-wide OU would address the closure of the IDA, institutional controls, previously unaddressed areas of soil contamination, VOC-contaminated media, ecological risks, long-term monitoring requirements, and any other unacceptable risks identified and not addressed in either OU-1 or OU-3 (EPA, 1998b). In October 2009, the previously unaddressed areas of soil contamination were moved from OU-4 to the newly created OU-7 (Army, 2009). The closure of the Inert Disposal Area (IDA) was retained in OU-4 and is addressed in accordance with the OU-

4 Interim Action ROD issued in 2008 (EPA, 2008a). OU-4 is discussed separately in this FYR report.

2.3.4.4 Site By Site History of Contamination and Initial Response

The historical information in this section is taken primarily from the second FYR report (Tetra Tech, 2011h). The Army's Army Environmental Database (AEDB) number follows the name of each site. AEDB is used to track the progress of each site through the remedial process to eventual Site Closeout.

1. Line 1 (IAAP-001)

In 2006, Line 1 was transferred from OU-1 to OU-8 by the FUSRAP FFA. Any non-radiological contaminants remaining are to be remediated under the terms of the OU-1 RODs, as amended, but will be done so by FUSRAP under OU-8. Because prior to 2006 substantial soil remediation occurred as OU-1, Line 1 is discussed here.

Line 1, an ammunition production line in operation since 1941, occupies approximately 188 acres in the northeast part of IAAAP. Line 1 was split in 2000, creating an active area called Line 1A. The Line 1A portion contains approximately 15.9 acres and 151 buildings, and is in active operation. Line 1A has been fenced off and secured as a separate area. All other areas of Line 1 are inactive and surrounded by perimeter fencing. The majority of the contamination at Line 1 occurred as a result of building wash downs and sump failures.

The layout of Line 1 is shown in **Appendix E, Figure 1-1**.

The PA/SI completed by JAYCOR in 1991 indicated that there was a potential for contamination at Line 1 (JAYCOR, 1994). Further investigation was conducted in 1996 as part of the RI (JAYCOR, 1996).

As a removal action, eleven sumps and associated soils in Line 1 were removed in 1995.

2. Line 2 (IAAP-002)

Line 2, a production line, has been in operation since 1941, with a brief hiatus from 1947 to 1949. Line 2 occupies nearly 140 acres, including 31 buildings and covered walkways, and is used to LAP 120mm ammunition and blank ammunition. The buildings include equipment rooms, explosives magazines, and nine sump buildings. The highest volumes of wastes appear to have been produced at the melt buildings (2-05-1 and 2-05-2). Contamination from past munitions production has resulted from the practice of washing spilled explosives from floors and equipment and sump failures.

The layout of Line 2 is shown in **Appendix E, Figure 1-2**.

Line 2 was included in the PA/SI and RI. Low levels of metals were reported in all of the SI samples collected at Line 2, with the highest concentrations reported in soil west of Filter House 2-70-2, at the southeast corner of Filter House 2-70-1, and at an area adjacent to a support pillar northeast of Building 2-08-1. One sample, collected near Building 2-08-2, contained low levels of HMX and RDX. Several SVOCs and VOCs were reported in soil samples collected throughout

Line 2. According to the RI, contamination appeared to be limited to surficial soils (JAYCOR, 1996).

Seven wastewater sumps were removed at Line 2 in 1995 as part of the Miscellaneous Sumps removal action.

3. Line 3 (IAAP-003)

Line 3 is a production line that has been in operation since 1941, except for a short time between 1945 and 1949. This line fills and assembles artillery projectiles, occupies about 150 acres, and consists of 26 buildings and covered walkways. The buildings include equipment rooms, explosives magazines, and nine sump buildings for explosives waste processing. The two melt buildings (3-05-1 and 3-05-2) appear to be the areas where the highest volumes of wastes were produced during operations.

Contamination at Line 3 is from past munitions production. During the early years of production, wastewater was disposed at the Line 800 Pink Water Lagoon. Line 3 was upgraded to include self-contained Pinkwater Reroute Systems in July 1995 and September 1998.

From 1977 to 1984, metal cleaning operations were conducted at Line 3. This process consisted of several stainless steel dip tanks where ammunition casings were immersed in a sulfuric/hydrochloric acid bath, followed by a chromic acid rinse, then a water rinse.

The layout of Line 3 is shown in **Appendix E, Figure 1-3**.

Line 3 was included in the PA/SI and RI. During the RI, soils exhibiting the highest concentrations of explosives were located at wastewater sumps, foundations of buildings where wastewater is generated, and loading docks. Sampling indicated explosives were confined to surficial soils and did not extend beyond approximately 10 to 20 feet from the most impacted soils. Elevated metals concentrations were more widespread throughout the building areas at Line 3 and were not concentrated at a particular building. Lead is the primary contaminant, and to a lesser degree, chromium (near Building 3-01). Several SVOCs were reported in soil samples collected throughout Line 3, with only one sample reporting levels greater than 10 mg/kg (JAYCOR, 1996).

Three wastewater sumps were removed at Line 3 in 1995.

4. Line 3A (IAAP-004)

Line 3A was constructed in 1941, began operations in 1943, and encompasses 119 acres. The line was shut down from 1945 to 1949. Metal cleaning operations were conducted here from 1977 to 1985. The process included several stainless steel dip tanks where ammunition casings were immersed in a sulfuric/hydrochloric acid bath, followed by a chromic acid bath, and water rinse. Line 3A is an active LAP operation for 155mm artillery rounds. The melt buildings (3A-05-1 and 3A-05-2) appear to be the areas where the highest volumes of wastes were produced during operations. Line 3A was upgraded to include a self-contained Pinkwater Reroute System in December 1996.

The layout of Line 3A is shown in **Appendix E, Figure 1-4**.

Line 3A was included in the PA/SI and RI. During the RI, the majority of explosives were detected around Building 3A-05-1 and its associated buildings, with the highest concentrations reported for RDX and HMX. Other buildings reported lower levels of explosives contamination. The levels of detectable contaminants were observed to decrease with distance from the identified source areas such as sumps and loading areas. The areas with the highest metals concentrations are the Building 3A-05-1 area and the area northwest of Building 3A-05-2 (JAYCOR, 1996).

5. Line 4A and 4B (IAAP-005)

Lines 4A and 4B are located in the north-central portion of the plant and are approximately 1,000 feet apart. Line 4A encompasses 20 acres, and Line 4B encompasses 17 acres. Both lines were constructed in 1941 for component assembly.

Line 4A produced detonators and was in operation between 1942 and 1945; it was reopened in 1982. It is currently leased to a private corporation. There are 12 buildings in the area, including an assembly building, mixer buildings, lead azide magazine, detonator service magazine and change houses. Hazardous substances at Line 4A include lead azide, RDX, lead styphnate, tetracene, barium nitrate, TNT, HMX, and metals. Fourteen in-ground sumps (treatment tanks) underwent RCRA closure in 1995 (TN & Associates, Inc., 2003), a portion of which are being renovated for future detonator production.

Line 4B is an assembly facility for components manufactured elsewhere. Operations began in 1941 and ceased in 1945. Production resumed in 1962 and the line was used for missile assembly in the late 1960s. Line 4B consists of a fuze assembly and equipment building, detonator service magazine, rest houses and change houses. Hazardous substances of concern are TNT, RDX, Composition B, HMX, and LX-14. Previous materials included tetryl, booster pellets, and fuze ingredients.

The layouts of Lines 4A and 4B are shown in **Appendix E, Figures 1-5 and 1-6**.

Lines 4A and 4B were included in the PA/SI and RI. One wastewater sump was removed at Line 4A in 1995, as part of the Miscellaneous Sumps removal action.

6. Line 5A and 5B (IAAP-006)

Lines 5A and 5B were booster and grenade lines situated in the north-central portion of the installation. Line 5A is approximately 33 acres in size, and Line 5B is 41 acres. Both lines, component lines for pelletizing and assembly of explosive components, were constructed in 1941 and operated from 1942 to 1945. Production resumed in 1949 during the Korean War and intensified in 1961 during the Vietnam War. Principal explosives used at these lines were TNT, RDX, and tetryl.

Lines 5A and 5B are currently in a modified caretaker status, and are slated for demolition under the Facilities Reduction Program (FRP). Most of Line 5A was torn down in the Spring and Summer of 2010.

The layouts of Lines 5A and 5B are shown in **Appendix E, Figures 1-7 and 1-8**.

Lines 5A and 5B were included in the PA/SI and RI. Eighteen wastewater sumps were removed at Line 5A and 5B in 1995, as part of the Miscellaneous Sumps removal action.

7. <u>Line 6 (IAAP-007)</u>

Line 6 is a detonator production area encompassing 30 acres and located in the center of the installation. Constructed in 1941 and operating until 1981, this line is currently inactive. Line 6 consists of 34 buildings for the production, storage, and shipping of detonators, relays, and hand grenade fuzes.

The primary waste stream was related to the production of detonators and included lead azide, lead styphnate, tetracene, RDX, barium nitrate, and mercury fulminate.

The production of 40mm Prop Charges at Line 1 required the development of a 40mm test range in 2013, covering approximately 400 acres, including parts of Lines 6, 7, and 9.

The layout of Line 6 is shown in **Appendix E, Figure 1-9**.

Line 6 was included in the PA/SI and RI. Treatment of black powder was performed in Building 6-68 as a RCRA permitted unit. This unit underwent RCRA closure in 1994 and will no longer be maintained or used by the Army (modified caretaker status). As part of the RCRA closure, 800 CY of contaminated soil were removed in 1994 (OHM, 1994).

Three wastewater sumps were removed at Line 6 in 1995, as part of the Miscellaneous Sumps removal action.

8. <u>Line 8 (IAAP-009)</u>

Line 8, a production line constructed in 1941, was used during World War II to produce Amatol. The Emergency Export Co. used the ammonium nitrate crystallization equipment to produce fertilizer to support the Marshall Plan. Subsequent activities were fuze and rocket igniter LAP operations. Prior to closing of the production activities around 1950, Line 8 consisted of four process buildings, a gatehouse, and tank farm to store ammonium nitrate liquor. Ammunition inspection activities took place from 1976 to 1993. Only two buildings remain and will no longer be maintained or used by the Army (modified caretaker status).

Line 8 was included in the PA/SI and RI.

The layout of Line 8 is shown in **Appendix E, Figure 1-10**.

9. <u>Line 9 (IAAP-010)</u>

Line 9, approximately 9 acres in size and built in 1942 for use as a production facility, produced mine and mine fuzes during the Vietnam War. The site was later operated as a LAP facility, but is no longer in use. Wastes produced at this facility include sump scrap, acetone, xylenes, lacquer thinner, and 1,1,1-TCA. During Line 9 operations, waste solvents were generated at Buildings 9-59 and 9-60. Building 9-58 served as the 90-day waste solvent accumulation area for this line. Waste solvents were then taken to Building 600-86, where they may have stayed for nine months.

Line 9 is currently in modified caretaker status, and is slated for demolition under the FRP. Most of Line 9 was torn down in the spring and summer of 2010.

The production of 40mm Prop Charges at Line 1 required the development of a 40mm test range in 2013, covering approximately 400 acres, including parts of Lines 6, 7, and 9.

The layout of Line 9 is shown in **Appendix E, Figure 1-11**.

Line 9 was included in the PA/SI and RI. Five wastewater sumps were removed at Line 9 in 1995, along with approximately 70 CY of contaminated soil, as part of the Miscellaneous Sumps removal action.

10. <u>Line 800 (IAAP-011)</u>

Line 800 is nearly 18 acres in size and has been in operation intermittently since 1941. From 1943 to present, the primary function of the line was ammunition renovation, which involved washing the explosives filler from the projectiles and loading it with 75mm blank salute ammunition.

Wastes were generated by metal cleaning operations at Line 800, which were identical to the metal cleaning operations at Line 3. Waste sludge from the metal cleaning bath was disposed of at the former Blue Sludge Lagoon at the IDA from 1979 through 1980. Prior to the construction of the Line 3 Treatment Facility, untreated metal cleaning effluent was discharged to the ditches at Line 800.

The layout of Line 800 is shown in **Appendix E, Figure 1-12**.

Line 800 was included in the PA/SI and RI. Soil samples collected during the PA/SI indicated explosives concentrations exceeded cleanup criteria in the northwest corner of the site and the area adjacent to the east end of Building 800-04, and lead concentrations exceeded cleanup criteria along the west side of Building 800-191 (JAYCOR, 1994).

During the RI, explosives were detected at three sample locations west of Building 800-191 and four sample locations southeast of Building 800-192. Metals contamination was confined to depths of less than 2 feet bgs, except in three areas surrounding Buildings 800-61, 800-04, and 800-193, which have metals contamination up to 3 feet bgs immediately adjacent to the loading doors and sumps (JAYCOR, 1996).

In 1999, as part of the OU-1 Phase II RA, a sump at building 800-192 was removed along with 20 CY of contaminated soil (ECC, 2001b). The excavated soil was disposed at Trench 6. According to the Remedial Action Report, a sump at Building 800-188 could not be removed at that time because AO was still operating in the building. During the OU-1 site inspection of Line 800 in 2005, Tetra Tech visually verified that the sump had been removed and the sump excavation backfilled with gravel.

11. <u>East Burn Pads (IAAP-012)</u>

The EBP, located in the northeast corner of the IAAAP, consisted of eight raised earthen burning pads enclosed in a fenced area of approximately 12 acres. Activities included open burning of explosives-contaminated metals, propellant explosives, and pyrotechnic contaminated materials.

Each pad was bermed on three sides to restrict horizontal movement of metal projectiles. The pads were in operation from 1941 until 1982, when the Explosives Waste Incinerator (EWI) was built.

The layout of the EBP is shown in **Appendix E, Figure 1-13**.

The EBP was included in the PA/SI and RI. The two soil samples collected at the EBP during the PA/SI contained elevated concentrations of explosives, metals, and SVOCs. Samples collected during the RI confirmed the PA/SI findings.

12. Demolition Area/Deactivation Furnace (IAAP-021)

The Demolition Area (DA) encompasses 10 acres of land and consists of a fenced field with six shallow craters. Open detonation of rejected ammunition items at this site began in the 1940s on a regular basis, with extensive use from 1966 to 1970. Current practices are limited to an emergency-only basis. The Iowa Department of Natural Resources (IDNR) does allow open detonation of ammunition items that require an immediate method of disposition due to safety considerations such as ammunition rounds that become armed during the assembly process. The IDNR is required to be notified of an open detonation event.

In 1997, EPA approved a change in the RCRA Subpart X interim status. This change allowed for the movement of the open burning of propellant with faulty stabilizer (performed in pans) from the EBP to the Detonation Area. This accommodated the cleanup of former open burning pads at the EBP in 1998. In 1985, the IDNR allowed open burning of propellant determined by the Army to have a faulty stabilizer on a case-by-case basis with an expedited (within 48 hours) approval.

The Deactivation Furnace (DF), incorporated into this site due to its close proximity, was used from 1971 until RCRA closure in 1995. The DF consists of a feed area, furnace system and an air pollution control system. The feed area is housed within a building that provides access to a conveyor system. The furnace was used to destroy small explosive-loaded components such as detonators, primers, and fuzes. The furnace incinerated the explosive/ propellant content of the munitions and thermally treated the metal casings, which were recovered and sold as scrap metal. The ash from these operations was placed in drums and stored as hazardous waste. The DF underwent RCRA closure in 1994 and is now in a temporarily inactive status (PDC Technical Services, Inc., 1995).

The layout of the DA/DF is shown in **Appendix E, Figures 1-14 and 1-18**.

The DA/DF was included in the PA/SI and RI. During the RI, explosives in the soils were not considered to be a concern at the site. All soil samples reported detectable levels of arsenic, barium, chromium, and lead; and 12 samples reported detectable levels of mercury. In other locations, lead and chromium were the metals with the highest reported values, but high levels of antimony, cadmium, copper, silver, and zinc were also reported (JAYCOR, 1996).

13. Burn Cages, Burn Cage Landfill, West Burn Pads, West Burn Pads Landfill (IAAP-032)

Due to the complexity in defining site boundaries, sites IAAP-032 (Burn Cages), IAAP-033 (Burn Cage Landfill), IAAP-034 (West Burn Pads), and IAAP-035 (West Burn Pads Landfill) are managed as one site, the WBPA, by the Army.

The three burn cages were used from 1949 to 1982 for the incineration of inert and explosives-contaminated packaging. The flashing of metal parts also was performed here. The cages were removed in 1982. Metal parts, munitions casings, and staining on the ground surface were observed during the site inspection in 1991.

The West Burn Pads were used for metals flashing from 1949 to 1982. Ash from the Burn Cages and West Burn Pads were disposed of at the Burn Cage Landfill (1949 to 1982) and the West Burn Pads Landfill (WBPLF) (1950 to 1975). The WBPLF also received waste from the EBP as well as various sanitary and industrial solid wastes. The landfills were approximately three acres in size and heavily vegetated.

Historical documents indicate the WBPA was used concurrently by the AEC and the Army from 1949 to 1975.

The layout of the WBPA is shown in **Appendix E, Figure 1-15**.

The WBPA sites were included in the PA/SI and RI. The RI confirmed metals and explosives contamination and indicated low levels of SVOCs and VOCs. The depth of explosives, metals, SVOCs, and VOCs contamination during the RI appeared to be limited to 3 or 4 feet bgs (JAYCOR, 1996).

14. <u>North Burn Pads (IAAP-036)</u>

The NBP, operational from 1968 to 1972, consists of Pads 1-N and 2-N, each measuring about 20 feet by 50 feet. Lead azide and gunpowder were burned here. A 275-gallon diesel fuel station was located at the base of Pad 2-N. The station had an above-ground tank used to refuel equipment operating in the area.

Historical documents indicate that the AEC conducted activities at the NBP Area.

The layout of the NBP is shown in **Appendix E, Figure 1-16**.

The NBP was included in the PA/SI and RI. The RI found metals and small amounts of explosives contamination.

15. <u>Roundhouse Transformer Storage Area (IAAP-040)</u>

This area was used since the 1940s to store transformers pending use or disposal; this site is no longer used for PCB storage. The storage yard is a flat, graded area with crushed stone on a hard base. Transformers found to contain greater than 50 parts per million (ppm) PCBs were moved to Building L-37-34, the old storage site. Those transformers having less than 50 ppm PCBs were moved to an outside storage concrete pad at Yard L, between buildings L-3 and L-4, new storage site E-18.

The layout of the Roundhouse Transformer Storage Area is shown in **Appendix E, Figure 1-17**.

The Roundhouse Transformer Storage Area was included in the PA/SI and RI. The RI results indicated that PCBs were present in surface soils in the drainage ditch to the east of the yard and in the soils west and south of the yard, which are periodically disturbed during agricultural planting activities (JAYCOR, 1996).

16. <u>Central Test Area (IAAP-047)</u>

The CTA was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD.

The CTA was used to test-fire munitions. Very little historical documentation is available on this particular site, but layout drawings are dated as far back as 1943. It is not known exactly when this area was in operation.

The historical documentation that exists indicates that Building 600-84 was known as the Central Test Laboratory. In addition, detonations were performed in the field 800 feet northeast of the CTA. Steel fixtures still exist at this site.

Building 600-84 lies approximately 500 feet northwest of Line 4A and 1,200 feet south of Line 5B, but still within the fence line of Lines 5A/5B. The walled-in area northeast of the building was used as a test site for the inside charge of grenades. This charge was composed of lead styphnate, black powder, and tetryl booster. The outer charge was TNT and RDX. Advanced Environmental Technology, Inc. (AET) currently operates in Building 600-84.

The layout of the CTA is shown in **Appendix E, Figure 1-19**.

The CTA was included in the PA/SI and RI. The RI results indicated the presence of cadmium and iron at concentrations exceeding their respective RGs (JAYCOR, 1996).

17. <u>Possible Demolition Site (IAAP-018)</u>

The Possible Demolition Site (PDS), was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD.

The PDS, located near the southern border of the IAAAP, was used as a demolition area for ammunition items during the 1940s and possibly into the early 1950s. There are no site records other than a 1945 drawing to substantiate demolition activities or the kind of ammunition items disposed at the site. However, based on historical data, contaminants likely to be present include explosives, metals, and UXO.

The layout of the PDS is shown in **Appendix E, Figure 1-20**.

The PDS was included in the PA/SI. In 1991, JAYCOR collected three subsurface samples (1.5 feet bgs) from areas within suspected demolition pit areas between the scarred area and Long Creek. None of these samples contained contaminants at concentrations that exceeded RGs (JAYCOR, 1996).

18. Incendiary Disposal Area (IAAP-047)

The Incendiary Disposal Area (InDA) was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD.

The InDA, a fenced area in the southern portion of the IAAAP near the eastern boundary and south of the Maneuver Area, was used by a contractor from 1940 to 1946 for high explosives demolition and burial of unknown materials (USATHAMA, 1980). Originally, the size of the impacted area was believed to be approximately 40 feet by 60 feet, encompassing three depressions purported to be burial pits for incendiary materials approximately 175 feet west of Lower Augusta Road (JAYCOR, 1996). The total area has been expanded to include a cratered area west of the suspected InDA observed during a site walkover in 2000 (MKM, 2004). In the fall of 2004, MKM encountered pieces of munitions-related scrap metal in several of these craters on the slope facing the InDA tributary (MKM, 2005a).

The layout of the InDA is shown in **Appendix E, Figure 1-21**.

Tetra Tech performed further site reconnaissance at the InDA in the fall of 2005, also observing numerous detonation craters grouped together along the slope, uphill of the InDA tributary. All of the craters were less than 10 feet in diameter and no more than 4 feet deep. A significantly greater number of detonation craters were found to be located to the west of the fence than to the east (Tetra Tech, 2007).

In response to potential lead contamination concerns, in 2006, Tetra Tech collected 259 soil samples from 128 locations in and around the detonation craters. Ten samples contained lead at concentrations which exceeded the RG (Tetra Tech, 2007).

2.3.5 Basis for Taking Action

Hazardous substances have been detected at concentrations above health-based screening values in soil at the IAAAP. The soils affected are near surface, and the contaminants are primarily the explosives RDX and TNT, but also include metals, and PAHs. Exceedances of industrial/commercial direct contact exposure remedial goals exist for all of these contaminants. Also, a soil leaching remedial goal that was designed to protect groundwater to potable levels was calculated in the RI/FS process; this is the lowest value remedial goal of all those calculated for the explosives and was exceeded in OU-1 sites.

The population that could be affected by the contamination is, for soils, industrial workers at the IAAAP, and construction or utility workers who could disturb contaminated soil, resulting in exposure to contaminants in both surface and subsurface soils. For groundwater affected by the soils, potable well users outside of the IAAAP could be exposed. Groundwater is the main source of potable water outside of IAAAP.

The **remedial action objectives** (EPA, 1998a) are:

1. Prevent human contact with contaminants of concern in soils at levels posing a threat, and

2. Minimize potential impacts associated with contaminants leaching from soils to groundwater.

2.4 REMEDIAL ACTIONS

2.4.1 Remedy Selection

OU-1 has two Records of Decision and 5 ESDs, as described below.

2.4.1.1 OU-1 Interim Action ROD (Excavation, segregation, and stockpiling pending treatment)

The OU-1 Interim Action ROD was signed on March 4, 1998, to address the RAs to be taken at 15 areas within the IAAAP:

1. Line 1
2. Line 2
3. Line 3
4. Line 3A
5. Lines 4A/4B
6. Lines 5A/5B
7. Line 6
8. Line 8
9. Line 9
10. Line 800
11. EBP
12. DA/DF
13. Burn Cages/WBPA
14. NBP
15. Roundhouse Transformer Storage Area

The interim RA, chosen in accordance with CERCLA, as amended by SARA, and to the extent practicable, the NCP, consists of the following primary elements:

- Excavation of soils at 15 areas with concentrations exceeding RGs,
- Verification sampling to ensure RGs are met following excavation,
- Restoration of excavated areas to original conditions,
- Segregation of excavated soils according to contaminant type and concentration,
- Temporary storage of the most highly contaminated soils (risk>1E-05) in the on-site Corrective Action Management Unit (CAMU) (Trench 7),
- Permanent disposal without treatment of soils contaminated at lesser levels (1E-05>risk>1E-06) in the on-site Soil Repository (Trench 6) or in the on-site ILF,
- Solidification/stabilization of metals-contaminated soils with concentrations exceeding Land Disposal Restriction (LDR) criteria, and
- Permanent disposal of excavated soils in the on-site Soil Repository (Trench 6).

2.4.1.1.1 OU-1 Interim Action ROD Remediation Goals

RGs for the IAAAP were established based on risk considerations. These include criteria associated with ingestion of contaminated soils by the reasonably maximum exposed individual, as well as criteria to evaluate possible leaching of contaminants from soils to groundwater at unacceptable levels. For the IAAAP, RGs were established at a target carcinogenic risk of 10^{-6}, consistent with the NCP. Commercial/industrial land use is the current and reasonably anticipated future land use at the site upon which the RGs were based.

In addition to risk-based soil RGs for protection of human health, the impact to groundwater from residual soil contamination was evaluated. The Summers model was used to estimate the level at which contaminant concentrations in soils would produce groundwater contamination above acceptable concentrations for potable use. The model was not used for metals, as metals are relatively immobile in the clay soils found at the IAAAP. The Summers model was used to determine acceptable concentrations for the explosives RDX and 2,4,6-TNT in soil.

All of the RGs listed in the OU-1 Interim ROD, as amended by ESDs, are shown in **Table 2-2**.

2.4.1.1.2 Explanations of Significant Difference for the OU-1 Interim Action ROD

1. 2006 ESD

In 2005, a re-evaluation of background soil samples collected as part of the RI indicated that naturally occurring background levels for actinium 228, bismuth 214, and potassium 40 were higher than the soil RGs established in the OU-1 Interim Action ROD. The analytical results for radionuclides in soil samples from Lines 1 and 3, which had exceeded RGs, did not exceed background values. Therefore, on June 13, 2006, an ESD was signed, deleting radionuclides from the OU-1 Interim Action ROD (EPA, 2006).

2. 2008 ESD

On May 15, 2008, a second ESD for the Interim Action ROD was signed, adding environmental (ecological) protectiveness to the remedy, and transferring the soil RA at three sites – the InDA, PDS, and CTA – from OU-4 to OU-1 (EPA, 2008b). The OU-1 Interim Action and Final RODs did not specifically address ecological risks, although the OU-1 Interim Action ROD indicated that further evaluation of potential ecological risks would be conducted as part of future investigations. Therefore, the Baseline Ecological Risk Assessment (BERA) was conducted using data collected during facility-wide SIs, the RI, and supplemental investigations conducted specifically for the BERA (MWH, 2004). The initial results of the BERA indicated that there were no unacceptable risks to ecological populations at the IAAAP. However, the risk to the Indiana bat was evaluated further in the BERA because it is listed as a threatened and endangered species and is known to be present at the IAAAP.

Copper was identified as a contaminant of ecological concern (COEC) in soil at Line 3, Line 3A, and Line 800 (Section 8.2), resulting in ecologically based soil RAs at these sites. The ecological evaluation performed for the Indiana Bat was an iterative process based on procedures developed in Appendix M of the BERA (MWH, 2004) and the second ESD to the OU-1 Interim Action ROD (EPA, 2008b). No RG was listed for copper in that ESD, however a copper concentration of approximately 60 milligrams per kilogram (mg/kg) was used as an excavation goal because it was determined that this concentration would not cause an exceedance of the ecological criteria

3. <u>2011 ESD</u>

This ESD is titled for OU-1, however it affects only an OU-1 site (i.e., WBPSR) that was transferred to OU-8. It is mentioned here for completeness, but is not considered in this FYR.

2.4.1.2 OU-1 Final ROD (treatment of stockpiled soils)

The Remedial Action Objectives (RAOs) as presented in the OU-1 Final ROD, signed on September 29, 1998, were intended to provide for treatment of excavated soils that were stockpiled in Trench 7 and ultimate disposal of those treated soils in the permanent disposal area (Trench 6) or the ILF. These soils were managed based on the nature of the contamination: 1) explosives-contaminated soils; 2) explosives plus metals contaminated soils; and 3) SVOC-contaminated soils. The Final ROD changed a condition of the Interim ROD: soils with risk between 1E-05 and 1E-06 would not be placed in Trench 6, but instead would go to Trench 7 for treatment. Soils in that risk range that already had been placed in Trench 6 would be treated there to reduce risk below 1E-06.

The OU-1 ROD specified Low Temperature Thermal Desorption (LTTD) as the primary technology for treatment of explosives-contaminated soils and biological treatment as the contingent remedy. The major components of the remedy included:

1. <u>Explosives-Contaminated Soils:</u>

- Excavate explosives-contaminated soils from the CAMU and transport to a temporary treatment facility on-site.
- Screen, shred, and blend the soil to produce a uniform feed material.
- Process the blended soil through a mobile direct-fired LTTD unit or a temporary Biological Treatment Unit.
- Following confirmation sampling, dispose of treated soil according to the following criteria: 1) For soils with cumulative risks less that 1E-06, in compliance with LDRs, and exceeding Summers model RGs, dispose in the Soil Repository or under another synthetic landfill cap on-site; and 2) For soils with cumulative risks less than 1E-06, in compliance with LDRs, and satisfying Summers model RGs, dispose on IAAAP property in an appropriate manner protective of human health and the environment. For biotreated soils, treatment residuals must also be shown to be non-toxic or not bioavailable at levels posing a threat to human health or the environment.

2. <u>Explosives Plus Metals Contaminated Soils</u>

- Excavate explosives plus metals contaminated soil from the CAMU and transport to a temporary treatment facility on-site.
- Screen, shred and blend the soil to produce a uniform feed material.
- Process the blended soil through a temporary solidification/stabilization facility.
- Following sampling to confirm compliance with Toxicity Characteristics Leaching Procedure (TCLP) based RGs, dispose of treated soil on-site in the Soil Repository or under another synthetic landfill cap.

3. SVOC-Contaminated Soils

- Excavate SVOC-contaminated soil from the CAMU.
- Transport the soil to a commercial waste treatment and disposal facility off-site.

2.4.1.2.1 OU-1 Final ROD Remediation Goals

For the OU-1 Final ROD, the RGs are derived from a combination of individual and cumulative risk-based values, and Applicable or Relevant and Appropriate Requirements (ARARs).

1. Risk-Based—Individual Contaminant

As in the Interim ROD, the risk-based chemical-specific RGs were established for treatment of soils stockpiled in the IAAAP CAMU (Trench 7) and the permanent disposal area (Trench 6). The treatment goals are based on risk considerations and have been established at the 1E-06 risk level to the reasonably maximum exposed individual considering an industrial land use setting.

Also as in the Interim ROD, risk-based chemical-specific RGs were established for impacts to groundwater from residual soil contamination. The Summers model was used to estimate the point at which contaminant concentrations in the soils will produce groundwater contamination at concentrations above acceptable levels.

These goals are identical to those for the Interim ROD in **Table 2-2** except for minor changes for TNT and RDX. The risk-based RGs are presented in **Table 2-3.**

2. Risk-based—Cumulative

Besides meeting the individual contaminant RGs discussed above, the treatment of the soil had to achieve a cumulative cancer risk less than 1E-06.

Table 2-2: OU-1 Interim ROD Soil Remediation Goals

Chemical	RG Based on Ingestion for Soils (mg/kg)	RG Based on Protection of Groundwater For Potable Use (mg/kg)
Antimony	816	NR[2]
Arsenic	30	NR
Beryllium	5	NR
Cadmium	1,000	NR
Chromium VI	10,000	NR
Lead	1,000	NR
Thallium	143	NR
Benzo(a)anthracene	8.1	NR
Benzo(a)pyrene	0.81	NR
Benzo(b)fluoranthene	8.1	NR
Dibenz(a,b)anthracene	0.81	NR
Total PCBs	10	NR
1,3,5-Trinitrobenzene	102	NR
2,4-DNT	8.7	NR
2,4,6-TNT	196	47
RDX	53	1
HMX	51,000	NR
Radionuclides[3]	**PRG (pCi/g)[1]**	
Actinium 228	0.014	NR
Bismuth 214	0.008	NR
Potassium 40	0.74	NR

[1] picocuries per gram

[2]NR=Not required

[3]Radionuclides were removed from the OU-1 Interim ROD by ESD

3. ARAR-Based

The OU-1 Final ROD does not list the actual numerical values for this category, but it indicates the following goals will be met by treatment prior to disposing of the soils in the IDA:

- Soil concentrations less than Land Disposal Restrictions (LDR)
- Toxicity Characteristic Leaching Procedure (TCLP) results less than RCRA limits.
- TCLP results less than 100 times the Maximum Contaminant Level (MCL)
- TCLP results less than 100 times the Lifetime Health Advisory
- For carcinogens, TCLP results less than 100 times the concentration corresponding to a 1E-04 risk level based on residential water usage, and
- For noncarcinogens, TCLP results less than 100 times the concentration corresponding to a Hazard Index of 1 based on residential water usage.

2.4.1.3 Explanations of Significant Difference for the OU-1 Final ROD

1. 2003 ESD

An ESD signed on April 16, 2003, included solidification/stabilization as the remedy for soils contaminated with only metals, changed the primary remedy for explosives-contaminated soils from LTTD to bioremediation, and documented the increase in contaminated soils from the WBPA that required treatment (EPA, 2003a).

2. 2009 ESD

On September 11, 2009, a second ESD for the OU-1 ROD was signed, changing the selected remedy for treatment of explosives-contaminated soils from biodegradation to alkaline hydrolysis (EPA, 2009a). Biological treatment of explosives-contaminated soils at the IAAAP in 2008 and 2009 resulted in residual concentrations of TNT that exceed the RGs. It was determined that biological treatment of TNT-contaminated soils at the IAAAP could not be completed as efficiently as RDX-contaminated soils, nor could it be completed in a reasonable time-frame.

2.4.2 Remedy Implementation

A summary of OU-1 ROD implementation is given just below, to highlight the degree to which the remedy was accomplished, and the difficulties. Below that, the sites are discussed individually for the excavation portion (i.e., Interim ROD), and finally a detailed discussion of the treatment portion (i.e., Final ROD) is given.

2.4.2.1 Summary of OU-1 ROD Response Actions

1. Excavation and Stockpiling

Implementation of the Interim OU-1 ROD occurred in eight phases of excavation extending from the year 2000 to 2009. Implementation was in most cases preceded by remedial design sampling to define the areas requiring excavation. This post-ROD design site characterization was extensive, comprising several hundred samples for some of the larger sites. This is because the larger sites have multiple ammunition processing buildings on them, and contaminant release was a spotty process arising from washdown operations and wastewater disposal at each of the buildings. Consequently, the perimeters of most buildings were investigated, and excavations had to be performed at 106 locations distributed among the OU-1 ROD sites. Completion was documented in Remedial Action Completion Reports (RACR) for the various excavation phases; these contain the post-excavation verification sample results. The last RACR in the series (for Phases 5, 7, and 8; Tetra Tech, 2009e) summarizes all of the excavation work and concludes that the RGs had been achieved, with exceptions noted below.

As a check on these conclusions, in this FYR the verification data was compared against the RDX RG of 1 mg/kg, because this RG was the main determinant of excavation volume, evidently due to RDX's prevalence at this site, and mobility in soil. The data showed that this RG was met except where it could not be attained due to infrastructure blocking the excavations, as was noted in the RACRs.

The RACRs noted 13 excavation verification samples at 7 excavation sites that exceeded the OU-1 ROD RGs, and which were not followed up with additional excavation because IAAAP infrastructure blocked or endangered the excavations. **Table 2-4** summarizes information about these samples.

The results from these samples were compared against the OU-1 ROD RGs, and the current EPA RSLs for industrial direct exposure. The RSLs provide a current value that takes into account the latest toxicity information and EPA default exposure assumptions for industrial use. The exposure scenario at IAAAP is not known to differ from the standard industrial exposure scenario used by EPA. Hence the RSLs provide a valid lower-bound estimate of the RGs if they were to be recalculated today. **Table 2-4** also shows the original RGs and the RSLs.

Table 2-4 highlights several conclusions:

- the above-RG residual RDX concentrations are distributed among several sites at Line 2, Line 3, and Line 800
- the RDX concentrations are all well below the original direct contact RG and the current RSL, and they are generally only slightly above the leaching-based RG in most cases.
- the above-RG TNT concentrations occur only at Line 800. They are all below the current RSLs for HI=1 and cancer risk = 1E-05, and they are significantly greater than the leaching-based RG.

Table 2-3: OU-1 Final ROD Soil Remediation Goals

Chemical	RG Based on Ingestion for Soils (mg/kg)	RG Based on Protection of Groundwater For Potable Use (mg/kg)
Antimony	816	NR[1]
Arsenic	30	NR
Beryllium	5	NR
Cadmium	1,000	NR
Chromium VI	10,000	NR
Lead	1,000	NR
Thallium	143	NR
Benzo(a)anthracene	8.1	NR
Benzo(a)pyrene	0.81	NR
Benzo(b)fluoranthene	8.1	NR
Dibenz(a,b)anthracene	0.81	NR
Total PCBs	10	NR
1,3,5-Trinitrobenzene	102	NR
2,4-DNT	8.7	NR
2,4,6-TNT	196	47.6
RDX	53	1.3
HMX	51,000	NR

Note: Values are identical to those in **Table 2-2** except for TNT and RDX groundwater protection values.

Note: Copper was identified as a contaminant of ecological concern in soil at Line 3, Line 3A, and Line 800. A copper concentration of 60 mg/kg was used as an ecological protective excavation goal. Source: 2008 ESD (EPA, 2008b).

[1]Not required.

Overall, although 7 out of 106 excavation areas did not reach the RGs, this was made clear and justified in the RACRs, which were approved as final FFA documents by the FFA parties. The excavation part of the remedy has been considered complete before the previous FYR. It may be necessary for IAAAP to determine if additional decision documentation is needed to record this decision in the FFA project files.

As to protectiveness, the residual levels are protective for industrial direct contact, thereby attaining that portion of the RAOs. For the protection-of-groundwater RAO, although the RG is exceeded, the RAO is still being met because:

- the leaching RGs were very conservative for the excavation sites because the RGs are based on protecting the groundwater directly beneath the water-filled Line 800 lagoon having contaminated sediments. The infiltration rate estimated downward from the filled lagoon is greater than would be observed through the grass-covered soil excavation sites.
- the groundwater which is used by the public is off of IAAAP and just over 2 miles from the three sites where the above-RG residuals exist,
- information available from the onsite groundwater investigation shows that plumes with RDX greater than the potable OU-3 RG of 2 µg/L do not exist further than 1,000 feet from the boundaries of the three sites where above-RG residuals exist. Hence, despite having historically high concentrations in soil at these three sites, the RDX plume is very close to the source because migration of RDX in groundwater is considered to be very slow and groundwater concentrations are decreasing (Tetra Tech, 2012g).

Overall, nonpotable concentrations in groundwater have not moved far from these three sites, and are far from the offsite groundwater users who must be protected. Most of the source of leaching to groundwater was removed by the OU-1 remedy, and the small number of areas that still have concentrations above the leaching RGs are not expected to adversely affect protectiveness for groundwater.

2. Treatment

Soil treatment occurred under the terms of the OU-1 Final ROD, but it occurred in the physical area of OU-4. Treatment evolved in stages from a plan to perform LTTD (1998-2003), to implementation of stabilization of metals and biological treatment of explosives in 2001-2002, to pilot testing (2006) and implementation (2008-2009) of biological treatment for most of the soil, and finally to pilot testing (2008) and implementation (2009) of alkaline hydrolysis for the last amount of soil. Treatment after 2002 addressed only the organic contaminants; although some soil had been stockpiled for solidification of metals, no such solidification had to be implemented as the soil did not fail TCLP after it was stockpiled.

The full-scale treatment occurred in two main periods. The first was performed by CAPE Environmental in 2000-2001, and is documented in a Phase III Remedial Action Report (CAPE, 2002). This work included a Phase I in which metals-contaminated soils were treated by a generic stabilization, a Phase II in which explosives-contaminated soils were biologically treated with a proprietary additive from W.R. Grace called DARAMEND®, and a Phase II metals retreatment using a proprietary stabilization additive (Free Flow FF100®), for soils that did not reach the RGs during Phase I.

The second period of treatment was in 2006-2009 by Tetra Tech. Several reports document the testing and treatment activities, including several workplans, and technical memos reporting the results. The last and most comprehensive is the Volume 3: Soil Treatment Activities of the OU-4 Remedial Action Completion Report (Tetra Tech, 2011c). This is titled “OU-4” because the activities occurred there, but it is an OU-1 ROD activity, and is therefore discussed herein in the OU-1 section.

The 2011 RACR discusses all aspects of the treatment, and contains the verification data to show that the RGs have been met. In implementation, the RG list from the ROD was adjusted by:

- Retaining only RGs for explosives, as they were the only relevant contaminants, and specifying EPA SW-846 8330B as the analytical test method to be used.

- Adding degradation products of TNT and RDX which also were measured by method 8330B, and calculating 1E-06-based RGs for them using actual toxicity information if it was available, and if it was not, then using RDX, TNT, or another compound, as appropriate, as the surrogate for toxicity data

- Omitting the leaching-to-groundwater RGs, because the soil was to be disposed in the capped IDA.

- Omitting 2,4-DNT (no reason is stated in the text of the OU-4 RACR, however Appendix A of that document lists pre-treatment soil sampling data for the soils stockpiled in trenches 6 and 7, and the 2,4-DNT reported concentrations and reporting limits corresponded to a cancer risk of not more than 6E-08, indicating that 2,4-DNT did not cause the cumulative risk of the post-treatment soil to exceed the RG of 1E-06).

The list of contaminant concentrations corresponding to the 1E-06-based RGs in the OU-1 ROD, and the treatment remedial goal that was calculated using them, are in **Table 2-5**.

As noted in the table, these values were not required to be met by each contaminant, but rather the cumulative cancer risk for each sample had to be less than 1E-06. The results for all samples were reviewed and they met the remedial goal.

The report noted that metals in the stockpiled soils did not exceed the ROD RGs, hence no stabilization, as selected in the ROD, was required. No data was found in the report to corroborate the statement.

To provide a check on this statement, the soils Excel® database for IAAAP was searched. As noted above, the 2011 RACR indicated that post-treatment samples were not sampled for metals. Without post-treatment data, the next most relevant data to locate would be the so-called “disposition” samples which characterized the soil stockpiled in trenches 6 and 7 prior to treatment. These samples are mentioned in Appendix A of the RACR. No data for metals is shown in that appendix, however it contains comparison criteria for metals, such as Land Disposal Restrictions and TCLP data, that would be used to determine whether metals concentrations in the soil would require remediation. That is, the appendix implies that "disposition" data for metals was collected, but is not included in the Appendix A of the Draft RACR.

The Excel® database was searched for these samples; it does not contain them.

The significance of the metals levels is determined by comparing them to the TCLP and LDR limits; exceedances of these limits would require that the soils be stabilized prior to being permanently placed in Trench 6. As an alternative to locating "disposition" samples, the entire soils database was searched for analytical data for each of the metals of concern, in order to judge whether significant levels could have existed at IAAAP.

Antimony: There are no TCLP or LDR limits for Antimony, hence levels of Antimony could not have caused stockpiled soil to be treated.

Arsenic: The LDR is 5 mg/kg, and 20 times the TCLP limit is 100 mg/kg. Background is listed in the RACR as 15.37 mg/kg. In the Excel® database, there are 3585 exceedances of 5 mg/kg Arsenic out of 6804 Arsenic results in soil. It would not be reasonable to stabilize most of the stockpiled soil for Arsenic because doing so would be treating naturally occurring Arsenic. As to TCLP exceedances, only three samples out of 6804 exceed 100 mg/kg Arsenic, and the levels are not exceptionally high, at 117 mg/kg, 120 mg/kg, and 185 mg/kg. Even these levels do not guarantee an exceedance of the TCLP limit if the TCLP leachate test were run. Considering how few of the sampled locations at IAAAP could potentially have soil that might fail the TCLP test, it is highly unlikely that bulk stockpiled soil could have failed a TCLP test and been required to be stabilized.

Beryllium: There are no TCLP or LDR limits for Beryllium, hence levels of Beryllium could not have caused stockpiled soil to be treated.

Cadmium: The LDR is 1 mg/kg, and 20 times the TCLP limit is 20 mg/kg. Background is listed in the RACR as 0.97 mg/kg. There are 2077 samples exceeding 1 mg/kg Cadmium out of 6726 samples. It would not be reasonable to stabilize most of the stockpiled soil for Cadmium because doing so would be treating naturally occurring Cadmium. Regarding TCLP, 44 soil samples exceed 20 mg/kg cadmium out of 6726 soil samples. Assuming that the TCLP test captures 50% of the total metals, samples with greater than 40 mg/kg Cadmium would fail TCLP, and there are 18 samples out of 6726 that exceed 40 mg/kg.

With this small number of samples within the entire IAAAP, and considering the large volume of soil that was stockpiled in trenches 6 and 7, it is very unlikely that a representative, volume-average TCLP result for the stockpiled soil could have exceeded the TCLP limit and required stabilization.

Chromium: Twenty times the TCLP limit is 100 mg/kg, and there is no LDR listed in the RACR. No background is listed in the RACR, however the soil dataset includes 42 samples from 1992 labeled as background, and nearly all have results between 10 and 30 mg/kg Chromium; clearly background is well below 100 mg/kg Chromium. Out of 6738 soil samples, 174 exceeded 100 mg/kg Chromium. Argonne National Labs published a study of the leachability by TCLP of various metals (ANL, 1994). For Chromium, the average recovery by TCLP was 4 percent, and the largest recovery was 15%. If we assume 15% of the Chromium leaches from IAAAP soils using the TCLP method, then soil with total Chromium greater than 666 mg/kg would fail the

TCLP test. There are 19 samples that exceed 666 mg/kg Chromium in the Excel® database. Considering that 19 is a small number of areas on IAAAP that could fail TCLP, and compared to the large amount of excavated soil from large areas that was stockpiled in trenches 6 and 7, it is not likely that a representative sample of the stockpiled soil would have failed the TCLP test and required stabilization for Chromium.

Copper: Soils were excavated because copper was an ecological contaminant of concern. There are no TCLP or LDR limits for Copper, hence levels of Copper could not have caused stockpiled soil to be treated.

Lead: The LDR is 5 mg/kg, and 20 times the TCLP limit is 100 mg/kg Lead. Background is not listed in the RACR, however the Excel® database has 42 samples from 1992 labeled as "background", for which all of the results are between 10 and 30 mg/kg. Hence, background is clearly greater than the LDR value, and treating all soil with more than LDR value of Lead would entail treating all of the soil, due to naturally occurring Lead, which is not reasonable. As to possible TCLP exceedances, 1260 samples out of 7282 exceeded 100 mg/kg of Lead. Argonne National Lab (ANL, 1994) determined in one study that an average of 26% of the available Lead was extracted by the TCLP test. Using this value for IAAAP, then soil with greater than 384 mg/kg Lead might fail the TCLP test. There are 392 samples that exceed 384 mg/kg Lead. Many of these are from load lines 1, 2, 3, 3A, 6, and 8, and the Incendiary Disposal Area.

Considering the large number of characterization sample locations that could have failed the TCLP test, it seems possible that some representative samples from the stockpiled soils could have required stabilization for Lead.

Thallium: There are no TCLP or LDR limits for Thallium, hence levels of Thallium could not have caused stockpiled soil to be treated.

Similarly, excavations were noted in the ROD to be triggered by RG exceedances by PAHs. There was no mention of whether any soils were excavated or disposed because of PAHs.

As in the case of metals, no characterization data was present for PAHs or PCBs in the 2011 RACR. The RACR showed that post-treatment samples were not analyzed for PAHs and PCBs, pre-treatment samples may have been analyzed for these constituents, but the Appendix A data table rows for these constituents are empty of data. As was done just above for the metals, to draw conclusions about occurrence of PAHs and PCBs in the stockpiled soil, the Excel® soil database was used to show the pre-excavation characterization data and use it to infer concentrations in the stockpiled soil.

Following are the results of this analysis for the constituents that have remedial goals in the OU-1 ROD:

Benzo(a)anthracene: The LDR treatment goal is 3.4 mg/kg. The RACR mentions no background value. The Excel® soils database has 779 sample results for Benzo(a)anthracene; 711 of them are non-detects with an average reporting limit of 0.36 mg/kg. For the 68 detected results, the average value is 2.79 mg/kg, and only 7 samples exceed the LDR value, ranging well above it, from 10 to 80 mg/kg. Because so few locations on IAAAP exceeded the LDR treatment goal, and because the amount of stockpiled soil was so large and was sourced from a wide variety of locations on IAAAP, it is highly unlikely that a representative sample of the stockpiled soil could have exceeded the LDR goal for Benzo(a)anthracene.

Benzo(a)pyrene: The LDR treatment goal is 3.4 mg/kg. The RACR mentions no background value. The Excel® soils database has 778 sample results for Benzo(a)pyrene; 751 of them are non-detects with an average reporting limit of 0.47 mg/kg. For the 60 detected results, the average value is 3.9 mg/kg, and only 6 samples exceed the LDR value, ranging well above it, from 5 to 100 mg/kg. Because so few locations on IAAAP exceeded the LDR treatment goal, and because the amount of stockpiled soil was so large and was sourced from a wide variety of locations on IAAAP, it is highly unlikely that a representative sample of the stockpiled soil could have exceeded the LDR goal for Benzo(a)pyrene.

Benzo(b)fluoranthene: The LDR treatment goal is 6.8 mg/kg. The RACR mentions no background value. The Excel® soils database has 811 sample results for Benzo(b)fluoranthene; 723 of them are non-detects with an average reporting limit of 0.53 mg/kg. For the 55 detected results, the average value is 3.86 mg/kg, and only 8 samples exceed the LDR value, ranging well above it, from 10 to 100 mg/kg. Because so few locations on IAAAP exceeded the LDR treatment goal, and because the amount of stockpiled soil was so large and was sourced from a wide variety of locations on IAAAP, it is highly unlikely that a representative sample of the stockpiled soil could have exceeded the LDR goal for Benzo(b)fluoranthene.

Dibenz(a,b)anthracene: This compound is more commonly written as Dibenz(a,h)anthracene The LDR treatment goal is 8.2 mg/kg. The RACR mentions no background value. The Excel® soils database has 811 sample results for Dibenz(a,h)anthracene; 797 of them are non-detects with an average reporting limit of 0.46 mg/kg. For the 14 detected results, the average value is 1.23 mg/kg, and no samples exceed the LDR value. Because this compound was not detected on IAAAP at greater than the LDR treatment goal, it is exceptionally unlikely that a representative sample of the stockpiled soil could have exceeded the LDR goal for Dibenz(a,h)anthracene.

PCBs: There is no LDR treatment goal. PCB cleanup and disposal may be regulated under the Toxic Substances Control Act (TSCA) depending on a number of conditions including concentration of source of release, date of release, and concentration of the resulting waste. A full discussion and understanding of the TSCA regulations is beyond the scope of this report, but in general soil with >50 mg/kg of PCBs may qualify as PCB remediation waste under TSCA and require disposal in a permitted landfill, while soil with <50 mg/kg PCBs from unknown origin is not regulated. The Excel® soils database has 237 sample results for total PCBs; 207 of them are non-detects with an average reporting limit of 2.08 mg/kg, and only one sample had a reporting limit greater than 50 mg/kg. For the 30 detected results, the average value is 0.408 mg/kg, with detections ranging from 0.012 mg/kg to 4.6 mg/kg. The samples were collected primarily at OU-1 sites including load lines 1, 2, 3, 3A, 6, 7, and 800.

Since no soil locations at IAAAP exceeded 50 mg/kg total PCBs, the stockpiled soil did not require disposal as a bulk PCB remediation waste under TSCA. Additionally, since the soil was disposed onsite in a RCRA Subtitle C-equivalent landfill, the disposal met the substantive disposal requirements that would have applied had this soil been TSCA-regulated bulk PCB remediation waste.

Table 2-4: Post-Excavation Soil Verification Samples Exceeding RGs, Excavation Phases 5, 7, and 8

Site	Contam-inant	Sample Concen-tration (mg/kg)	Sample Safe for Industrial Direct Contact? (<RSLs?)	OU-1 Remedial Goals (mg/kg)		Current RSLs, Direct Contact, Industrial (mg/kg)		Sample Depth BGS (ft)	Reason for Ceasing Dig	Sample Location Within the Excavation
				Direct Contact (Indust-rial)	Leaching to Potable GW	Cancer 1E-06	HI=1			
L2-E10	RDX	2.04	Yes	53	1.37	28	3300	Unk	Below groundwater	Floor
L2-E10	RDX	2.3	Yes	53	1.37	28	3300	Unk	Below groundwater	Floor
L2-E13	RDX	4.55	Yes	53	1.37	28	3300	7.5	Below foundation	Sidewall
L3-E12	RDX	1.97	Yes	53	1.37	28	3300	2.5	Near utility	Sidewall
L3-E26	RDX	2.12	Yes	53	1.37	28	3300	3	Under Bldg 3-06-1	Sidewall
L3A-E03	RDX	44.8	Yes	53	1.37	28	3300	5	Under bldg	Sidewall
L3A-E09	RDX	6.1	Yes	53	1.37	28	3300	3	Under load platform	Sidewall
L800-E08	RDX	1.58	Yes	53	1.37	28	3300	6-8	Concentratns below are very low, indicating no downward migration; risk of undermining Line 800 lagoon	Sidewall
L800-E08	RDX	2.13	Yes	53	1.37	28	3300	8-10	Same as above	Sidewall
L800-E08	RDX	1.98	Yes	53	1.37	28	3300	12-14	Depth is below max construction worker depth of 10 ft; risk of undermining Line 800 lagoon	Sidewall
L800-E08	TNT	336	Yes	196	47.6	96	510	14-16	Same as above	Sidewall
L800-E08	TNT	289	Yes	196	47.6	96	510	16-18	Same as above	Sidewall
L800-E08	TNT	67.2	Yes	196	47.6	96	510	12-14	Same as above	Sidewall

Table 2-5: Treatment Remedial Goals

Chemical	**Concentration corresponding to Ingestion of Soils at 1E-06 risk (mg/kg)**
MNX	*53*
DNX	*53*
TNX	*53*
2Amino-4,6-Dinitrotoluene	*4088*
4Amino-2,6-Dinitrotoluene	*4088*
3,5-Dinitroaniline	*4088*
1,3,5-Trinitrobenzene	102
~~2,4-DNT~~	~~8.7~~
2,4,6-TNT	196
RDX	53
HMX	51,000
Treatment Remedial Goal	**1E-06 cumulative risk, calculated by dividing each measured concentration by the values above, summing the results, and multiplying by 1E-06.**

Note1: Compounds in italics were added for treatment verification.

Note2: Compounds struckout were not included in treatment verification.

2.4.2.2 Site By Site OU-1 Interim ROD (Excavation and Stockpiling) Implementation

1. Line 1 Remedial Actions

Line 1 was part of OU-1 from the 1998 ROD signing until 2006, when it was transferred to OU-8. Some remedial actions occurred prior to this transfer, and they are discussed below. After the transfer, any remaining remediation for nonradiological contaminants would be performed to meet the RGs in the OU-1 RODs.

The OU-1 Interim Action ROD required that contaminated soils be removed from Line 1, be taken to the IDA, and be sorted by contaminant level and type. The OU-1 Interim Action ROD estimated this would involve the removal of approximately 7,410 CY of contaminated soil (220 CY metals, 4,850 CY explosives, 1,480 CY explosives and metals, 590 CY VOCs, and 270 CY radionuclide).

In May 2000, 600 CY of material were removed from the Line 1 North Sump area, located at Building 1-05-2. All of this material was placed in the Trench 6 Soil Repository for final disposal. Confirmation sampling showed that all soils exceeding excavation criteria were removed. The excavated area was backfilled with clean soil and revegetated (ECC, 2001b).

An SRI was completed in 2002 to further characterize contamination from explosives, metals, VOCs, and SVOCs at Line 1. Both RDX and 2,4,6-TNT were detected at concentrations exceeding RGs. Explosives were also detected above RGs in the basements of Buildings 1-05-1 and 1-05-2. Arsenic and lead concentrations exceeded RGs; barium, silver, and indeno(1,2,3-cd)pyrene concentrations exceeded EPA Region 9 PRGs. The explosives, metals, and SVOC contaminants were detected at concentrations exceeding EPA Region 9 PRGs in drainage-ways and around the doorways of Line 1 buildings (TN & Associates, 2002).

2. Line 2 Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 1,950 CY of soil contaminated with metals and/or explosives.

In 2005, Tetra Tech collected 157 soil samples from 87 locations at Line 2. RDX concentrations exceeded the RG in 26 samples; 2,4,6-TNT concentrations exceeded the RG in 26 samples; and lead concentrations exceeded the RG in two samples. Arsenic, beryllium, and thallium exceeded their respective RGs in one sample each (Tetra Tech, 2007).

In 2006, approximately 3,200 CY of contaminated soil were removed from 23 excavation sites near Buildings 2-01, 2-05-1, 2-05-2, 2-10, 2-12, 2-15, and 2-50 and taken to Trench 6 for final disposition. Soils were treated or disposed at Trench 6 in accordance with the OU-1 Interim Action ROD (EPA, 1998a). All excavations were completed in September 2006, with the exception of excavation 10 (L2-10), where a total of five phases of excavation continued into November 2006. Excavation of explosives-contaminated (RDX) soil at L2-10 occurred from ground surface to below the water table. The excavation was terminated below the water table where confirmation soil samples indicated the presence of RDX at concentrations comparable to those in groundwater (Tetra Tech, 2010c). Onsite RDX groundwater contamination is in the process of being addressed under OU-6. Confirmation samples collected elsewhere at the Line 2 excavations indicated that all contamination had been removed, with one exception. Contaminated soil along the north wall of excavation L2-13, south of Building 2-05-1, could not be removed without undermining the foundation of a vacuum house, and the contamination was left in place until the concrete structure/floor of the vacuum house is removed (Tetra Tech, 2010c). Remediation under OU-1 was successfully completed at Line 2 and did not leave leachable contamination in place that could impact groundwater in the future.

3. Line 3 Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 3,500 CY of contaminated soil including 120 CY of soil formerly believed to contain radionuclides at unacceptable levels. The 2006 ESD deleted radionuclides from the Interim Action ROD (EPA, 2006).

In 2005, Tetra Tech collected 260 soil samples from 139 locations at Line 3. RDX concentrations exceeded the RG in 15 samples; 2,4,6-TNT concentrations exceeded the RG in 11 samples; and lead concentrations exceeded the RG in three samples (Tetra Tech, 2007).

In 2006, approximately 3,400 CY of contaminated soil were removed from 37 excavation sites near Buildings 3-01, 3-03, 3-05-1, 3-05-2, 3-06-1, 3-06-2, 3-08-1, 3-08-2, 3-51, 3-70-2, 3-70-3, 3-99-1, 3-99-2, 3-99-3, 3-140-4, 3-140-6 and taken to Trench 6 for disposal. A small amount of the soil (140 CY) was designated for treatment at Trench 6 prior to disposal in place. With two exceptions, all contaminated soil was removed during the 2006 excavations. Contaminated soil along the east wall of excavation 12 (L3-E12), located south of Building 3-05-1, could not be removed without destroying utilities. Therefore, the contaminated soil must remain in place until the utilities are removed. Contaminated soil along the west wall of excavation 26 (L3-E26), located south of Building 3-06-1, could not be removed without undermining the foundation of the building. Therefore, this contaminated soil must remain in place until the building is removed (Tetra Tech, 2010c).

4. Line 3A Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 2,040 CY of soil contaminated with explosives or metals and explosives, and transport of excavated soil to the IDA.

In 2005, Tetra Tech collected 152 soil samples from 83 locations at Line 3A. RDX concentrations exceeded the RG in nine samples (Tetra Tech, 2007).

In 2006, approximately 1,400 CY of contaminated soil were removed from 17 excavation sites near Buildings 3A-06, 3A-08-1, 3A-08-2, 3A-23, 3A-50-1, 3A-50-2, 3A-70-1 3A-99-8, 3A-140-1, 3A-140-5, and 3A-140-7. Approximately 450 CY were taken to Trench 7; and the remainder of the excavated soil was taken to Trench 6. With two exceptions, all contaminated soil was removed during the 2006 excavations. Contaminated soil along the south wall of excavation 3 (L3A-03), north of Building 3A-10-5, could not be removed without undermining the foundation of a vacuum house, and the contamination was left in place until the vacuum house is removed. Contaminated soil along the south wall of excavation 9 (L3A-09), north of Building 3A-08-1, could not be removed without undermining the foundation of a loading platform, and the contamination was left in place until the loading platform is removed (Tetra Tech, 2010c).

5. Lines 4A and 4B Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 153 CY of contaminated soil from Line 4A and none from Line 4B.

Remedial Design Sampling conducted at Lines 4A and 4B in 2003 and 2004 found no contaminant concentrations above RGs. Details regarding sample results and conclusions are provided in the USACE *Draft Final Data Summary Report, Supplemental Remedial Design, Phase 4 Soil Sites, OU-1* (Shaw, 2004). In the conclusion of this report, Lines 4A and 4B were recommended for no further RD/RA activities and for CERCLA closure.

6. Lines 5A and 5B Remedial Actions

In October 1999, approximately 1,065 CY of contaminated soil were removed from Lines 5A and 5B and placed in the IDA. Approximately 590 CY were excavated from seven locations near Buildings 5A-26, 5A-28, 5A-99-1, 5A-99-2, 5A-140-1, 5A-140-2, and 5A-140-3 at Line 5A, and 475 CY were excavated from three locations near Buildings 5B-26, 5B-28, and 5B-140-3 at Line 5B. Verification sampling showed that all contaminated soil had been removed. These areas were then backfilled and revegetated (ECC, 2001b).

7. Line 6 Remedial Actions

The OU-1 Interim Action ROD required the removal of approximately 445 CY of metals-contaminated soil that were not addressed under the RCRA closure.

In 2005, Tetra Tech collected 155 soil samples from 130 locations at Line 6. The RDX concentration in one sample exceeded the RG (Tetra Tech, 2007).

In 2006, approximately 58 CY of contaminated soil were removed from three excavation sites near Buildings 6-34-2, 6-96, and 6-98 and taken to Trench 6. Soil samples collected immediately following excavations confirmed that all contamination had been removed (Tetra Tech, 2010c).

8. Line 8 Remedial Actions

The OU-1 Interim Action ROD required the removal of approximately 476 CY of lead-contaminated soil.

Eight distinct buildings or building groups were evaluated at Line 8 as part of Remedial Design Sampling for Phase 4 Soil Sites occurred in 2003 and 2004. Soil samples were collected from 56 locations and analyzed for explosives, VOCs, SVOCs, PCBs, total metals, and mercury. Analytical results showed benzo(a)anthracene and benzo(a)pyrene concentrations above RGs in two locations at the Line 8 Tank Farm. Both of these locations were covered with degraded asphalt, a possible source for the benzo(a)anthracene and benzo(a)pyrene. Therefore, it was concluded that these elevated compound concentrations were due to the presence of asphalt and were not products of past processes conducted at Line 8. Details regarding sample results are provided in the USACE *Draft Final Data Summary Report, Supplemental Remedial Design, Phase 4 Soil Sites, OU-1* (Shaw, 2004). In the conclusion of this report, Line 8 was recommended for no further RD/RA activities and for CERCLA closure.

9. Line 9 Remedial Actions

As part of the Phase 4 Remedial Design Sampling, conducted in 2003 and 2004, samples were collected from 57 sample locations and analyzed for explosives, VOCs, SVOCs, PCBs, total metals, and mercury. Analytical results from the surface and subsurface soils showed contaminant concentrations above RGs at the Building 9-57 and 9-61 areas only. Details regarding sample results are provided in the USACE *Draft Final Data Summary Report, Supplemental Remedial Design, Phase 4 Soil Sites, OU-1* (Shaw, 2004). In the conclusion of this report, seven areas at Line 9 were recommended for no further RD/RA activities and for CERCLA closure.

In 2004, 120 CY of soil were removed from two sites near Buildings 9-57 and 9-61 and transported to Trench 6 for disposal. Verification samples confirmed that all contaminated soil was removed, and the excavation was backfilled with clean soil (Shaw, 2005).

10. <u>Line 800 Remedial Actions</u>

The OU-1 Interim Action ROD required the removal of 1,325 CY of contaminated soil at Line 800.

In 2005, Tetra Tech collected 217 soil samples from 84 locations at Line 800. RGs were exceeded in 17 samples for 2,4,6-TNT, three samples for 2,4-DNT, 11 samples for RDX, and one sample for arsenic (Tetra Tech, 2007).

In 2006 and 2007, approximately 5,200 CY of contaminated soil were removed from 12 excavation sites near the arsenic ditch, the Explosive Waste Line, the former lagoon, and Buildings 800-04, 800-61, 800-188, 800-191, 800-192. Approximately 760 CY from three excavations were taken to Trench 7 for treatment because explosives contamination was visible in the soil. The remainder of the excavated soil was taken to Trench 6. The majority of this soil (3,800 CY) was treated at Trench 6 and disposed in place, and the remainder (670 CY) was disposed without treatment. With the exception of excavation 8 (L800-E08), all contaminated soil was removed (Tetra Tech, 2010b).

L800-E08 is a 24-foot deep excavation situated between active railroad tracks to the north and the Line 800 Pinkwater Lagoon to the south. Verification samples following the first phase of excavation showed 2,4,6-TNT concentrations exceeding the RG in the 12- to 14-foot interval on the north wall of the excavation and in the 14- to 16- and 16- to 18-foot intervals on the south wall. Verification samples following the first phase of excavation also showed RDX and 2,4,6-TNT exceedances on the east wall of the excavation, leading to further (Phase 2) excavation to the east. Verification samples following the second phase of excavation showed no 2,4,6-TNT exceedances on the east wall and marginal RDX exceedances in the 6- to 8-foot and 8- to 10 foot intervals on the east wall of the excavation (Tetra Tech, 2010b).

All residual 2,4,6-TNT concentrations in the north wall and south wall were below the maximum construction worker exposure depth of 10 feet bgs and the ecological exposure depth of 1 foot bgs. Therefore, it was determined that allowing the residual 2,4,6-TNT to remain in place below 12 feet bgs was protective of human health and the environment. The residual RDX concentrations in the east wall are overlain and underlain by soils containing residual RDX concentration significantly below the RG, suggesting that the potential for vertical leaching of low residual RDX through the dense clay underlying and surrounding L800-E08 was unlikely. Based on these two observations, and the facts that further excavation to the north could compromise the soil beneath the active railroad tracks, and further excavation to the south could compromise the integrity of the lagoon berm, the decision was made to halt excavation and leave the remaining 2,4,6-TNT and RDX contamination in place (Tetra Tech, 2010c). Excavation L800-E08 was centered around residual Line 800 Lagoon waste north of the soil contamination removed during the 1997 removal action within the lagoon proper. The L800-E08 removal action was successful in removing residual RDX and TNT soil contamination that had been acting as a continuing source to groundwater. Groundwater monitoring as part of the OU-6 groundwater FS concluded that the combination of the OU-1 removal action and addition of carbon substrate in the excavation prior to backfilling reduced explosives concentrations to nondetect within less than 1 year (Tetra Tech, 2010c).

11. East Burn Pads Remedial Actions

The OU-1 Interim Action ROD required the removal of 24,000 CY of contaminated soil.

In 1998, ECC excavated approximately 12,700 CY of contaminated soil from the EBP area. Approximately 1,300 CY of excavated soil were taken to Trench 7, with the remaining 11,400 CY taken to Trench 6. The RDX concentration in 10 of the 26 confirmation samples exceeded the RDX RG of 1.3 mg/kg. AEC and EPA approved backfilling the excavations based on four factors:

- Contaminant concentration was low,
- Remaining contamination was deep in the soil profile and would be covered with clean soil,
- Human health and ecological risk would be minimal at the site, and
- Removal of additional soil considering the contaminant depth and low risk potential was not cost effective (ECC, 2000a).

12. Demolition Area/Deactivation Furnace Remedial Actions

The OU-1 Interim Action ROD requires the removal of 753 CY of lead-contaminated soil from the DF subsite.

Contaminated soils at the DA/DF were remediated under the Compliance-Related Cleanup Program in 2007 (Tetra Tech, 2008b). A total of 96 CY of contaminated soil were removed from seven excavation sites and transported to Trench 6 for treatment. Verification samples confirmed that all contaminated soil had been removed.

13. Burn Cages, Burn Cage Landfill, West Burn Pads, West Burn Pads Landfill Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 1,451 CY of contaminated soil to be taken to the IDA and sorted by contaminant level and type. However, during pre-design characterization of soils in 1998, significant barium contamination that was not previously known was located.

In 1998, ECC excavated contaminated soil from the WBPA. A larger than expected quantity of contaminated soil was excavated, a large fraction of which required treatment for metals contamination only due to high barium concentrations, and to a lesser degree, lead. This led to the first ESD to the OU-1 Final ROD (EPA, 2003a).

Approximately 46,496 CY of contaminated soil were removed from the WPBA (north of the road). The Trench 6 Soil Repository received 5,112 CY; 4,032 CY were temporarily stored at the CAMU, and 37,352 CY were used as Random Fill in the CEA. Several thousand CY of metals-contaminated soil were stabilized at the time of placement in the CEA and the Trench 6 Soil Repository. In addition, approximately 6,000 CY of the soil placed within Trench 6 and the CAMU were treated for metals and explosives and subsequently disposed in the Trench 6 Soil Repository. Treatment involved stabilization of metals followed by bioremediation of explosives.

Following the IRP remedial action in the area north of the road, an area of soil contamination was discovered south of the road.

Annual groundwater monitoring begun in 1994 did not show the expected decline in explosives concentrations downgradient of the site. Groundwater sampling results, historical records, and a site walk-over in 2001 indicated further soil investigation was warranted in an area across the road to the south of the soil removal area, and explosives chunks were found on the surface. The USACE notified AO for a safety review, and some explosives chunks were removed and sampled.

In 2006 the West Burn Pads Area South of the Road was moved to OU-8 by the FUSRAP FFA. Any remediation for nonradiological contaminants would be performed to meet the RGs in the OU-1 RODs.

14. North Burn Pads Remedial Actions

The OU-1 Interim Action ROD required the removal of an estimated 41 CY of metals contaminated soils from the NBP.

In 1998, 2,990 CY of contaminated soil were excavated from the NBP Area and taken to the Trench 6 Soil Repository. The RDX concentration in 1 of the 18 confirmation samples was 2.7 mg/kg, exceeding the RDX RG of 1.3 mg/kg. The Army and EPA approved backfilling the excavations based on four factors:

- Contaminant concentration was low,
- Remaining contamination was deep in the soil profile and would be covered with clean soil,
- Human health and ecological risk would be minimal at the site, and
- Removal of additional soil considering the contaminant depth and low risk potential was not cost effective (ECC, 2000a).

15. Roundhouse Transformer Storage Area Remedial Actions

The OU-1 Interim Action ROD estimated the removal of approximately 600 CY of PCB-contaminated soil.

In 2003 and 2004, as part of the Supplemental Remedial Design Sampling for Phase 4 Soil Sites, samples were collected from 50 locations at the Roundhouse Transformer Storage Area and analyzed for PCBs, total metals, and mercury. Analytical results showed no contaminant concentrations above RGs. Details regarding sample results are provided in the USACE *Draft Final Data Summary Report, Supplemental Remedial Design, Phase 4 Soil Sites, OU-1* (Shaw, 2004). No further RD/RA activities and CERCLA closure were recommended in the report for this area (Shaw, 2005).

16. Central Test Area Remedial Actions

The CTA was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD. By the terms of that ESD, the soils from the CTA were to be excavated, treated, and disposed according to the OU-1 1998 Interim and Final RODs, and the 2003 OU-1 ESD.

In October of 2000, AET collected six composite surface soil samples east and south of Building 600-84. None of the samples exceeded RGs for any contaminants (AET/AO, 2001).

A geophysical survey was conducted across the CTA by MKM in the fall of 2004 to determine the subsurface MEC densities at the site. The area surveyed was a rectangle running southwest-northeast, approximately 600 feet x 1,200 feet, with Building 600-84 at one end. Results of the geophysical survey were subsequently used by MKM to locate and collect 10 surface soil samples which were screened for explosive hazards. A total of 2,835 EM61-MK2 anomalies were picked from the MKM geophysical data, along with two large heavily saturated areas where individual target discrimination was not possible (MKM, 2005a).

In the Fall of 2005, Tetra Tech collected soil samples from 29 locations across the CTA site. Sample locations were determined using the previous soil sampling and geophysical survey results. Arsenic, cadmium, and 2,4,6-TNT each exceeded their respective RGs in one sample; iron exceeded the Region 9 PRG in one sample (Tetra Tech, 2007).

In 2006, approximately 239 CY of contaminated soil were removed from three excavation locations near the test pit, the walkway to the test pit, and Building 800-64 and transported to Trench 6. Because they exceeded the RG of 1E-06, approximately 170 CY were designated for treatment in Trench 6 followed by disposal in place in Trench 6, while the remainder of the excavated soils met the RG without treatment and were disposed directly in Trench 6. Soil samples collected immediately following excavations confirmed that all contamination had been removed.

The excavation of the CTA is described in the Remedial Action Completion Report for Phase 5, 7, and 8 sites (Tetra Tech, 2009e).

17. Possible Demolition Site Remedial Actions

The PDS was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD. By the terms of that ESD, the soils from the PDS were to be excavated, treated, and disposed according to the OU-1 1998 Interim and Final RODs, and the 2003 OU-1 ESD.

Site reconnaissance and UXO avoidance efforts performed by MKM in 2004 and by Tetra Tech in 2005 encountered several craters at various locations across the PDS. Magnetometer sweeps of the area identified several small pockets in the subsurface containing high metal and ferrous content (MKM, 2004). Most of these pockets were encountered in the northeastern portion of the site.

In 2004, MKM collected 45 soil samples at the PDS. One sample contained 2,4,6-TNT and lead at concentrations above RGs, and one sample contained mercury at a concentration above the RG (MKM, 2005b).

In 2005, Tetra Tech collected six soil samples from two locations at the PDS. Mercury was detected in one soil sample at a concentration above the RG (Tetra Tech, 2007).

In 2006 and 2007, approximately 4,000 CY of contaminated soil were removed from three excavation sites at the PDS and transported to Trench 6. Soil samples collected immediately following excavations confirmed that all contamination had been removed (Tetra Tech, 2010c).

The excavation of the PDS is described in the Remedial Action Completion Report for Phase 5, 7, and 8 sites (Tetra Tech, 2009d).

18. Incendiary Disposal Area Remedial Actions

The InDA was not included in the March 1998 Interim OU-1 ROD, but was added to OU-1 in the January 2008 ESD to that ROD. By the terms of that ESD, the soils from the InDA were to be excavated, treated, and disposed according to the OU-1 1998 Interim and Final RODs, and the 2003 OU-1 ESD.

In 2007, a total of 179 CY of contaminated soil were removed from 10 excavation locations at InDA and transported to Trench 6. Soil samples collected immediately following excavations confirmed that all contamination had been removed (Tetra Tech, 2010b).

In April 2007, an M1A1 antitank mine, projectile nose fuses, and 75 mm rounds were discovered. Army personnel were informed of the discovery, and Army Explosive Ordnance Disposal personnel were dispatched to destroy them. Additional UXO items are likely present at the site since a comprehensive UXO survey has not been performed. The Army has transferred UXO identification and future actions to the MMRP (OU-5).

The excavation of the InDA is described in the Remedial Action Completion Report for Phase 5, 7, and 8 sites (Tetra Tech, 2009e).

19. Evaluation of Ecological Risk at OU-1 ROD Sites

Ecological evaluations for the above sites, except the DA/DF, are included in the OU-1 RACR (Tetra Tech, 2009e) for OU-1 Phases 5, 7, and 8, and for the DA/DF the evaluation is included in the draft RA report for excavations at the DF (Tetra Tech, 2008b).

The ecological evaluations performed in 2007 as part of RAs for OU-1 Phases 5, 7, and 8 examined unacceptable ecological risk to the federally endangered Indiana Bat. The exposure pathway for this species is through consumption of insects that thrive in the soil with elevated levels of site contaminants. An ecological evaluation of historical data, using a food chain model for the bioaccumulation of contaminants by insects that are prey for the Indiana Bat, determined that at eight areas at Line 3, two areas at Line 3A, and three areas at Line 800, copper concentrations posed an ecological risk to the bat. These 13 areas were excavated to a minimum of 1 foot below ground surface (bgs), the zone where insects that are prey for the bat could potentially be exposed. The inclusion of environmental protectiveness in the remedy added approximately 1,350 CY of copper-contaminated soil from Line 3, Line 3A, and Line 800.

The ecological evaluation indicated that no unacceptable risk exists to the Indiana Bat from exposure to chemical concentrations remaining on these sites. A similar evaluation for the DA/DF indicated that no unacceptable risk to the Indiana Bat is present from exposure to chemical concentrations remaining at this site (Tetra Tech, 2008b).

On the basis of the ecological evaluations contained in the OU-1 Phases 5, 7, and 8 RACR and the DA/DF RA Report, all requirements of the OU-1 ROD and associated ESDs have been met, with the exception of Line 1 and the WBPA South of the Road, which were transferred to OU-8 through the FUSRAP FFA.

2.4.2.3 OU-1 Final ROD (Treatment) Implementation

1. <u>Treatment by CAPE Environmental (2000-2002)</u>

The Phase 3 soil excavation effort at the WBP site was coupled with a treatment effort for those soils. It occurred after the soils were segregated by contaminant and risk level, and stockpiled in the various areas of the IDA in accordance with the OU-1 Interim ROD. The treatment technologies used were consistent with the OU-1 Final ROD, i.e., stabilization for the metals-contaminated soils, and biological treatment for the explosives contaminated soils. At this time, biological treatment was the contingency remedy in the Final OU-1 ROD, and the Army had submitted an ESD to the EPA making biological treatment the primary remedy.

CAPE implemented the remedy in three steps:

1. Stabilization of metals-only soils in Trench 6 and the Random-Fill Area of the IDA for metals (primarily Barium) by mixing with gypsum and Portland cement. Approximately 18,600 CY were treated from Sept 2000 to Nov 2000.

2. Degradation of explosives in explosives/metals-contaminated soils in Trenches 6 and 7 using a proprietary commercial amendment (DARAMEND®) that accelerates biological breakdown of explosives. Approximately 6,500 CY were treated from July 2001 to Oct 2001.

3. Stabilization of the metals component of the explosives/metals-contaminated soils in Trenches 6 and 7 using a commercial proprietary amendment and process (Free Flow 100®). Soils were treated from Sept 2001 to Jan 2002. Quantity was not listed in the report copy that was available.

2. <u>Treatment by Tetra Tech</u>

OU-1 Interim ROD remedial actions, plus other removal actions (noted previously), resulted in the excavation of 170,000 CY of soil, 89,500 CY of which were taken to the ILF or the CEA for disposal. Of the remaining 81,500 CY, 62,000 CY were taken to Trench 6 and 19,500 CY were taken to Trench 7. Under the OU-1 Final ROD, all of the soils in Trench 7 and 3,880 CY in Trench 6 required treatment for explosives contamination. In 2008, 1,000 CY at Trench 7 and 500 CY at Trench 6 were effectively treated with bioremediation, using high fructose corn syrup (HFCS) as a carbon source. In 2009, the remaining 10,000 CY at Trench 7 and 3,300 CY at Trench 6 were treated by alkaline hydrolysis.

All soil in Trenches 6 and 7 that required treatment in accordance with the OU-1 Final ROD were successfully remediated by biological or alkaline hydrolysis processes to meet the cumulative excess cancer risk RG of 1E-06. All treated soil from Trench 7 was transported to Trench 6 for final disposal, while treated soil in Trench 6 remained in place. More details on the treatment follow.

Bioremediation Testing

During the Summer of 2006, Tetra Tech performed treatability tests on four plots of soil at Trench 7 to evaluate the effectiveness of the addition of an electron donor (carbon) to enhance bioremediation of explosives-contaminated soil. The primary objective of the tests was to determine the appropriate carbon source concentration which would remediate 2,4,6-TNT and RDX to concentrations below RGs.

For the in-situ bioremediation treatability tests, HFCS in varying percentages was used to supply a simple carbon source (sugar solution) to four 15-foot by 15-foot plots of soil at Trench 7. The two primary considerations used to determine treatment parameters were effectiveness and cost. Based on a comparative analysis of the pilot test results, a 2 percent HFCS concentration was the most effective and least costly, and was chosen for full-scale treatment. Bioremediation of soil in Trenches 6 and 7 was conducted in 2008 and 2009. This full scale implementation of soil bioremediation provided unsatisfactory results, prompting a change to a more aggressive treatment approach for explosives-impacted soils (EPA, 2009a).

Full-Scale Bioremediation of Soils Stockpiled in Trench 7

Prior to the initial phase of soil treatment, Trench 7 soils were shaped into three treatment rows elongated north to south. The treatment rows were further subdivided into eight decision units (DUs) of approximately 325 CY each. The total volume of soil amended for biological treatment at Trench 7 was approximately 2,090 CY. A tracked excavator was used to ensure that the contaminated soil in each treatment area was completely amended with electron donor solution.

DU 1 through 6 were successfully treated (i.e., explosives soil concentrations were below the cumulative cancer risk RG of 1E-06), and the upper 18 inches of treated soils were moved to the southern end of Trench 6 for final disposal in 2008 and 2009. DUs 7 and 8 remained to be treated after unsatisfactory results of the bioremediation treatment and were included in subsequent RAs. Their corresponding soils were combined with the soil remaining to be treated at Trench 7, and reshaped into new DUs, labeled DUs 9 through 41, to avoid confusion with the DUs used for the biological treatment.

Full-Scale Bioremediation of Soils Stockpiled in Trench 6

Soil at Trench 6 designated as piles 9, 23, 26, and 35, along with a portion of pile 24 and the upper 10 feet of pile 30, had a cumulative cancer risk greater than 1E-06 and, therefore, required treatment. Because of the small volume of soil in piles 9, 23, 26, and 35, and the placement of these four piles near the boundaries of Trench 6, these soils were added to pile 24 for treatment. The soils requiring treatment in piles 24 and 30 were then combined and flattened into one single treatment area, producing a visibly distinguishable four-foot high ridge of soils requiring remediation sitting atop soils not requiring remediation. This ridge of soil was divided into DUs 1 through 6. The upper two feet of soil in DUs 1 through 4 (approximately 1,195 CY of soil) were treated by bioremediation.

The soil in DUs 2 and 3 (approximately 540 CY) were effectively treated by bioremediation. The upper 18 inches of treated soils at Trench 6 DU 2 and 3 were moved in May 2009 to allow treatment of the underlying remaining 2.5 feet of soil. The soil in DUs 1, 4, 5 and 6 remained to be treated.

Alkaline Hydrolysis Testing

Due to the recalcitrance and high initial concentration of 2,4,6-TNT in certain soils at Trenches 6 and 7, the biological treatment was deemed too slow to meet Army milestones. Therefore, a more aggressive treatment approach, alkaline hydrolysis, was proposed to treat the 2,4,6-TNT contamination and ensure all soils met the cumulative RG in a timely fashion and at a reasonable cost. A pilot test of this alternative treatment at Trench 6 DU 5 in 2008 determined the feasibility and design parameters for full-scale implementation at Trenches 6 and 7 (Tetra Tech, 2009b).

The treatability tests were performed from November 6 through 14, 2008, on the 650 CY of soils in DU 5 at Trench 6. Sodium hydroxide pellets were spread onto the DU 5 soil and then mixed thoroughly using a tracked excavator. The application rate (approximately 1 percent by weight) was based on previous experience at similar sites and the expected stoichiometric increase in pH that is required for destruction of RDX and 2,4,6-TNT.

Full-Scale Alkaline Hydrolysis of Soils Stockpiled in Trench 7

All soils in Trench 7 were treated in three phases for explosives contamination. Prior to the first phase of treatment, residual treated soils from DUs 1 through 6 (the lower 0.5-foot zone remaining after the upper 1.5 feet had been removed) and underlying untreated soils, along with the soils at DUs 7 and 8 that failed to meet the cumulative RG after full-scale bioremediation treatment were reshaped into three treatment rows of 40 feet by 300 feet. DUs 9 through 23 were constructed, each 40 feet wide, 60 feet long, and 4 feet thick, yielding an average unit volume of 350 CY. DUs 9 through 22 were effectively treated in the first phase of treatment by alkaline hydrolysis. DU 23 was included in the second phase due to access restriction.

When the upper 3.5 feet of treated soil had been removed from DUs 9 through 22, the remaining six inches of treated soils were combined with other untreated soils and reshaped into treatment rows with new four-foot thick 40 feet by 60 feet DUs (DUs 24 through 38). These 15 DUs were treated, along with DU 23 during Phase 2. After reshaping of the remaining soil, this DU was included in the second phase of treatment, consisting of three treatment rows and a total of 16 DUs of approximately 350 CY of soil each. Again, the soil in all DUs was effectively treated and treated soils were moved to Trench 6 as in Phase 1.

The last phase consisted of DU 39 (340 CY), DU 40 (400 CY), and DU 41 (425 CY). All DUs exhibited cumulative risk results under individual and cumulative RGs and treated soils were moved to Trench 6.

Full-Scale Alkaline Hydrolysis of Soils Stockpiled in Trench 6

The remaining four feet of soil in DUs 1, 4, 5, and 6, and 2.5 feet of soils in DU 2 and 3, covering an area of 31,000 ft^2 and totaling approximately 3,375 CY, were effectively treated in-place for explosives contamination in a single phase. Treated soils in Trench 6 remained in place for final disposal.

2.4.3 System Operations/O&M

There is no O&M plan or O&M associated with the soil excavation portion of the OU-1 RODs. The numerous soil excavation areas in the 17 current OU-1 ROD sites are formally inspected during FYRs. The general area of the excavations is traversed periodically by IAAAP operations and security personnel, and a building inspection is performed periodically; both of these activities could notice an issue with the remedy if it were highly visible. However, there is no requirement for an organized plan to inspect these sites. There is no periodic sampling or monitoring.

Regarding the excavated and treated soil, this is contained within the closed disposal units of OU-4 and the soil is now part of OU-4. Any O&M is discussed in the OU-4 section of this report.

2.5 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This section describes the conclusion and the resolution of issues that were noted in the previous FYR report (Tetra Tech, 2011h).

2.5.1 Protectiveness statement from the previous FYR

"The remedial actions at all non-FUSRAP OU-l sites were completed in accordance with the OU-l Interim Action ROD and are protective of human health and the environment. Two FUSRAP sites (Line 1 and WBPA South of the Road) are being remediated under OU-l and are anticipated to be complete by 2012. In the interim, exposure pathways that could result in unacceptable risks are being controlled."

2.5.2 Issues from the previous FYR, and their resolution

The resolution of issues from the previous FYR is discussed in a FYR followup report (Tetra Tech, 2012b). The issues and resolution are shown in **Table 2-6**. The issues have all been resolved.

2.5.3 Overall results of implemented actions

The actions appear to have resolved the issues thoroughly. No remaining concerns were detected during the site visit, interviews, or review of project files..

2.5.4 Status of Any Other Prior Issues

None

Table 2-6: 2nd FYR OU-1 Issues and Resolution

Issue	Resolution
Line 3A: Red-colored water is ponding at the end of the Building 3A-05-1 slides after it rains.	Ponded water at this location was observed on 7 instances after rain events, and the observation could not be replicated. Issue resolved.
Line 800 Pink Water Lagoon: Potential erosion on the bank near the discharge point.	The location was inspected on 8 occasions where rainfall occurred within the previous 1 to 2 days. No erosion was noted. As a precaution, 60 mil plastic sheeting was installed at the discharge point. Issue resolved.
Line 800: Need to compare the Army's building inspections report to OU-1 excavation sites.	The inspection report contained no information relevant to the CERCLA excavations. Issue resolved.
NBP Landfill: Uncertain if VOCs were found in excavations.	The remedial action report was reviewed and VOCs were found at only very low concentrations in pre-excavation soil samples, and not detected in post-excavation soil samples. Issue resolved.

2.6 FIVE YEAR REVIEW PROCESS

2.6.1 Administrative Components of the Five-Year Review Process

2.6.1.1 Notification of Potentially Interested Parties of Start of Review

A Five-Year Review kickoff teleconference was held with Army stakeholders on May 6, 2015. The start of the FYR was discussed with the EPA at the monthly IAAAP project managers conference call on May 19, 2015. Both the EPA and the Iowa Department of Natural Resources (IDNR) were invited by IAAAP to the FYR site visit held on June 2-4, 2015.

2.6.1.2 Identification of Five-Year Review Team Members

Name	Office	Title
Mr. Jesse Kahler	IAAAP	Restoration Manager
Steve Bellrichard	IAAAP	Environmental Coordinator
Ms. Jen Busard	IAAAP (PIKA)	Office Support to IAAAP
Ms. Darlene Abbott	IAAAP (Aerostar)	Restoration Execution at IAAAP
Dr. Rick Arnseth	IAAAP(Tetra Tech)	Restoration Support to IAAAP
Sandeep Mehta	EPA Region 7	RPM
Dan Cook	IDNR	PM
Cyril Onewokae	JMC	Environmental PM
Ms. Bridget Lyons	AMC	Environmental PM
Ms. Zaynab Murray	USAEC	ESM
Ms. Stephanie Zigler	USAEC	FYR Manager
Ms. India Nicholson	USAEC	Attorney
Ms. Sue Errett	USACE, CX	FYR Manager
Mike Bailey	USACE, CX	FYR Technical Lead
Ms. Laura Percifield	USACE, Omaha	PM for IAAAP support
Dennis Powers	USACE, Baltimore	Remedial Investigation & Design Section Chief
Russ Marsh	USACE, Baltimore	PM for IAAAP FYR effort
Dr. Charles Lechner	USACE, Baltimore	Chemical Engineer, IAAAP FYR lead, OU1 lead author
Grant Anderson	USACE, Baltimore	Hydrogeologist, OU3 lead author
Richard Braun, PhD	USACE, Baltimore	Risk Assessor, Question B lead author

Name	Office	Title
Alan Warminski	USACE, Baltimore	Lead Chemist, OU4 lead author
Ms. Arlene Weiner	USACE, Baltimore	Independent technical reviewer
Mr. Greg Sauer	USACE, Baltimore	Graphics Preparation, Document Assembly and QC
Mr. Seth Keller	USACE, Baltimore	OUs 5-9 initial author

2.6.1.3 Components and Schedule of FYR

The following schedule was followed in the preparation of this Five-Year Review Report:

Date	**Activity**
May 6, 2015	Project Start, Kickoff Teleconference
May 2015	Document retrieval; visit planning
June 2-4, 2015	Site Inspection
June-August, 2015	Document review, Five-Year Review Report Development
July 25, 2015-August 17, 2015	Army Review of Internal Draft
September 16- December 2, 2015	EPA Review of Draft Five-Year Review
December-February, 2015	Resolution of EPA Comments to the Draft Five-Year Review Report
March 24, 2016	Finalization of Five-Year Review Report

2.6.2 Community Notification and Involvement

Community notification that a Five-Year Review is being conducted was accomplished by publishing notices in the Fort Madison Daily Democrat on 6/12/2015 and the Burlington Hawkeye on 6/11/2015 (**Appendix A**). A copy of the final version of this Five-Year Review Report will be placed in the administrative record/ information repository at the IAAAP following EPA approval and signature.

Notices announcing the public availability of this Five-Year Review report will be published in the Fort Madison Daily Democrat and the Burlington Hawkeye newspapers.

2.6.3 Document Review

For this review over 1300 documents were retrieved from

- the publicly accessible RAB/administrative record website (http://iaaap.adminrecord.com/)
- the password-restricted IAAAP project website (http://iaaap.maporigin.com/)
- the FUSRAP administrative record website (http://www.mvs.usace.army.mil/Missions/CentersofExpertise/FormerlyUtilizedSitesRemedialActionProgram/IowaFUSRAPAdministrativeRecord.aspx), and
- the Common Access Card-restricted Repository of Environmental Army Documents (READ), operated by the Army Environmental Command

Documents used in this report are listed in the References in **Appendix B**. The categories of documents used most frequently are:

- those published in 2011 and later, that is, those published after the previous Five-Year Review
- all Records of Decision, and Action Memoranda that could be located
- all Remedial Action Completion Reports
- all monitoring and O&M reports, and
- most remedial design plans.

The most important reference documents were the decision documents that contained the remedial action objectives (RAOs), the ARARs, and the RGs. These were:

For **OU1 soil excavation and temporary placement into onsite holding areas pending treatment:** the OU-1 Interim Action ROD (EPA, 1998a), which addresses 15 sites. This document contains the two RGs (RDX: 1 mg/kg; TNT: 47 mg/kg) that are the basis for most of the soil excavation performed pursuant to this ROD. This ROD was changed three times by ESDs. The first ESD removed radionuclides as COCs (EPA, 2006). The second ESD specified additional soil excavation for three of the sites to attain ecological remedial objectives, and added three new sites (EPA, 2008b). The last ESD that modified this Interim ROD added soil excavation volume for one of the sites, added a RG for barium, and added offsite disposal as the soil disposition method (EPA, 2011a).

For **OU1 soil treatment**: the OU-1 Final ROD (EPA, 1998b), which specifies low temperature thermal desorption to address the explosives in the soils temporarily stockpiled onsite. It was modified three times by ESDs. The first changed the low-temperature thermal method to biological treatment (EPA, 2003a). The second ESD changed the biological method for the explosives to alkaline hydrolysis (EPA, 2009a). The third ESD is the same as the third ESD noted for the OU-1 soils excavation, and it added offsite disposal as the soil disposal method (EPA, 2011a).

2.6.4 Data Review and Evaluation

The types of data that were reviewed are:

- Post-excavation verification soil sampling data.
- Post-treatment verification soil sampling data.

1. Excavation

Phases 1 through 4

The reports for excavation phases 1 through 4 (ECC, 2000a; 2001b; 2001c; Shaw, 2005) contain post-excavation verification samples for those phases. Not all of the verification data described briefly in the text of these documents could be found in the detailed data tables of the report copies that were available. However, all of the data that was present was summarized in a single table, **Table F-1** in **Appendix F**. In that table the exceedances of the Remedial Goals are highlighted. There are 26 instances of RG exceedances in 206 final verification samples. RDX accounts for 24 of them, having an average value in these samples of 2.4 mg/kg and a maximum of 17 mg/kg, compared to the RG of 1.3 mg/kg. Barium accounts for 2 exceedances of the RG, having an average value in these verification samples of 801 mg/kg and a maximum of 14,000 mg/kg compared to the RG of 4100 mg/kg. Arsenic has one RG exceedance, and an average value in these samples of 7.2 mg/kg, and a maximum value of 59 mg/kg, compared to the RG of 30 mg/kg.

We note that the excavation reports were reviewed by EPA and USACE, and in at least two cases the reports note that the exceedance of the RDX RG was clearly allowed to remain without further excavation, due to it occurring at depth in the soil and being fairly close to the RG.

Overall, while this information shows that the leaching-to-groundwater RG is still exceeded in some places, the RGs based on direct contact are NOT exceeded by the residual concentrations. All final RDX concentrations are below the ROD’s direct exposure RG of 53 mg/kg. A direct exposure RG for Barium was not calculated when RGs were first developed for Barium in the 2011 ESD. However, the current RSL for industrial exposure for Barium is 220,000 mg/kg which is not exceeded by the residual Barium concentrations. Finally, the maximum residual for arsenic is 59 mg/kg. This exceeds the direct contact RG of 30 mg/kg, but it falls in the acceptable risk range according to the current RSLs, corresponding to a industrial exposure cancer risk of 2E-05 and a hazard index well below 1. Hence, the “Phase 1 to 4” excavations completely achieve the RAO for direct contact, but they attain the RG for protection of groundwater at only 86% of the verification sampling points.

Phases 5 through 8

The remaining phases of excavation are described in the Final RACR for Phases 5, 7, and 8 (Tetra Tech, 2009e). In that document, Tables 6-2 through 6-115, comprising 182 pages, present the final excavation verification data and the RGs. These tables were reviewed and it was verified that all the displayed sample results are less than the RGs, with the exception of 13 samples where further excavation was prevented because it would damage IAAAP infrastructure, or was below the water table. This is discussed in the earlier Remedy Implementation section.

Table 2-4, presented earlier, summarizes the data that does not comply with the RGs. Since these residual contaminants are in soils, and since the explosives RDX and TNT tend to degrade slowly in soils, these concentrations are not expected to decrease in the near term.

The Deactivation Furnace excavation was described in a separate report (Tetra Tech, 2008b), which presented the post-excavation verification data. This data was reviewed and showed that the relevant OU-1 RGs for this site (i.e., Lead and Arsenic) were attained in every sample.

2. <u>Treatment</u>

Regarding the treatment aspect of OU-1, the two main reports documenting the treatment periods were reviewed. The first, by CAPE for the 2000-2001 work, clearly indicated that the RGs were met. Both of the proprietary treatment additives had performance guarantees and considerable scrutiny was being provided by the Army and CAPE for these technologies. The report has a detailed set of tables that clearly present the verification data. The tables were reviewed and no instances of a failed treatment were noted. All of the verification samples were less than the toxicity characteristic limits for all of the metals, and the cumulative risk for the explosives was less than 1E-06.

For the second major period of treatment, the Draft Treatment report (Tetra Tech, 2011c) was reviewed. A summary table of the post-treatment cumulative risk data, with comparison to the RG of 1E-06 cumulative risk, is in **Table F-2** of **Appendix F**. This report, and the summary table, show that 2 of the 43 “batches” of soil treatment, referred to as Decision Units, did not achieve a cumulative risk of less than 1E-06. These were DUs 7 and 8, treated by bioremediation in Trench 7. The treatment result was due to the bioremediation method not being very effective for soils with high levels of explosives. At the time of treatment the alternate technology of alkaline hydrolysis was being approved, and it was successful in treating other DUs with high explosives. Table 2-1 shows another treatment unit, DU 4 in Trench 6, with a final sample cumulative risk of 1.1E-06. Earlier sample results for this DU were less than 1E-06, and the DU is considered in compliance with the RG.

All of the treated soils were placed in the Subtitle C equivalent permanent disposal area at Trench 6 in the IDA, which has been closed. Since moisture will be controlled by the Subtitle C cap, explosives which were not treated to below the RGs are not likely to degrade, but they will be effectively isolated from the environment in the capped disposal area.

2.7 SITE INSPECTION

A site inspection was conducted at IAAAP on June 2-4, 2015. The purpose of the inspection was to visually assess the implementation and effectiveness of the completed or initiated remedies at

IAAAP (OU-1, OU-3, and OU-4). Those offices participating in the inspection included IAAAP, U.S. Army Corps of Engineers-Baltimore District, EPA support contractor, and Tetra Tech (IAAAP support contractor). The inspection consisted of a 3-day driving and walking tour of the individual sites, with the personnel leaving the vehicles to walk the sites for several minutes or more. The team recorded notes, and collected numerous photographs which were georeferenced using Google Earth when they returned to the Baltimore District office. While onsite they were guided by a Tetra Tech staff member with extensive site history and knowledge, and they carried site maps showing areas of soil excavation in OU-1, and site features and monitoring wells for OUs 3 and 4. The weather was excellent and conducive to good visibility.

The following lists the sites that were visited (with exceptions noted) and any field observations dealing with the effectiveness of the remedy. For OU-1, the primary feature to inspect was the condition of the excavation areas, which had been backfilled and revegetated from at least 5 years to 15 years earlier. Where no observations are listed, or unless noted otherwise, the field team concluded that the remediated areas appeared well-vegetated and had not subsided or slumped enough to collect water.

- Line 1
- Line 1 Impoundment (though not strictly an OU-1 ROD site)
- Line 2
- Line 3
- Line 3A
- Line 3A Pond Area (though not strictly an OU-1 ROD site)
- West Burn Pads Area, including the “area south of the road”: It was noted that several areas which were near to, but not on, the former excavations had been persistently disturbed by deer so as to expose the soil. The reason was unknown, but it was noted by the inspection guide that this issue also occurs in other areas of IAAAP and that IAAAP fills the disturbed areas with gravel to stop the behavior. This does not affect the protectiveness determination, but it merits monitoring to determine if the behavior always occurs in certain areas, as it could be an indicator of a site operations-related soil condition that is somehow attractive to wildlife.
- East Burn Pads Area
- Explosive Waste Incinerator (though not strictly an OU-1 ROD site)
- Central Test Area
- Lines 4A and 4B

- Lines 5A and 5B
- Line 6
- Line 8
- Line 9: Line 9 is downrange from the target area of the new 40mm Test Range. During the site visit, the inspection team noted a blue 40mm test round. They vacated the area after this observation, and installation support personnel were present to address it if needed. A photo of the item is included herein in **Appendix C**.
- PCB Roundhouse Area
- Line 800
- Line 800 Lagoon (though not strictly an OU-1 ROD site)
- Incendiary Disposal Area: The InDA was not physically inspected during the site visit on June 2-4, 2015 because the area is fenced due to the MEC that are present. The fence was verified to be present during the visit. The excavated areas are unobservable from the access road, which is 400 to 600 feet away through forest. In lieu of a physical inspection, the area of the excavations was inspected on Google Earth aerial photos dated 2011, 2012, 2013, and 2014, and there was no evidence of erosion or ponded areas. Forest vegetation over the backfilled areas is in good condition and was indistinguishable from the surrounding area on the aerial photos.
- Possible Demolition Site: The PDS was inspected from Plant Road K because access is prevented by a fence running along the road. The main area of excavation is only approximately 30 feet south of the road. The large excavated area showed no evidence of erosion or ponded areas, and vegetation over the backfilled area is in good condition. The excavated areas were also studied in Google Earth aerial photos dated 2011 and 2013 which provided enough detail to discern texture in the grassy areas, and individual large branches in brushpiles in the area. No areas of bare earth or ponded water were visible on the areas that were excavated and revegetated.
- Demolition Area/Deactivation Furnace: The DA/DF was not inspected during the site visit as the access gate was locked and insufficient time was available to have Security arrive and allow the team into and out of the DA/DF.
- North Burn Pads: The NBP Area was inspected by viewing Google Earth aerial photos from the years 2011, 2012, 2013, 2014, and 2015. Resolution was sufficient to distinguish single tire tracks, deer paths, and individual shrubs. In all cases, there was no evidence of erosion or ponded areas. Both pads are well-covered with grass; vegetation over the backfilled areas is in good condition. Natural shrubs are visible within 50 ft of the former burn pads and would be expected to grow on them eventually. Larger trees completely cover the 100 foot wide space between the two former burn pads.

Site inspection photos are included in **Appendix C**.

2.8 PERSONNEL INTERVIEWS

Interviews with key members of the environmental restoration program team at IAAAP were conducted in July 2015 by telephone. These included the Restoration Manager at IAAAP, the Regional Project Manager at EPA Region 7, and the environmental manager for the operating contractor at IAAAP. The purpose of the interviews was to obtain views regarding the implementation and performance of the remedies at IAAAP. Interviews are documented in **Appendix D**. The key issues noted for OU-1 are summarized below

No issue was brought up about the implementation of the OU-1 RODs and ESDs as written. Related to OU-1 was a comment that the Line 800 lagoon could have soil remaining that exceeds the OU-1 remedial goal. This is not an OU-1 ROD issue since the Line 800 lagoon was remediated as a Removal Action, and was not listed within the OU-1 ROD. The Line 800 lagoon is similar to OU-1 ROD sites in terms of the soils being excavated, the COCs, the RGs, and the final disposition of the excavated soils, but it was not remediated under OU-1 ROD authority. Also related to OU-1 was a comment that pink water can be seen ponded infrequently during rainfall events. One specific instance was noted at one of the OU-1 ROD sites, however the observation could not be replicated. If such observations occur and are substantiated, it could indicate that the OU-1 Interim ROD sites were not adequately characterized before remedy implementation.

2.9 TECHNICAL ASSESSMENT

2.9.1 <u>Question A: Is the Remedy functioning as intended by the Decision Documents?</u>

Yes

2.9.1.1 Remedial Action Performance

1. <u>Excavation</u>

Nearly all soil with contaminants of concern (COC) concentrations exceeding OU-1 RGs has been removed from the 17 current OU-1 ROD sites. It is estimated that at least 95% of the soil area requiring excavation has attained the RGs. In the places where this did not occur, the reasons were that IAAAP buildings and utilities blocked the excavation, or the excavation had encountered groundwater or bedrock. Several other instances were made known to project managers at the time of excavation, and were allowed to remain unexcavated due to being at depth. In most of the cases of RG exceedance, excavation had occurred at the location to some depth, and the RG exceedance is below ground surface, and has been covered with clean backfill and revegetated.

The RAO of preventing direct contact has been achieved by removing contaminated soil at the surface and generally at least one foot below the surface, and backfilling with clean soil. Such containment is expected to be effective since most of the excavated areas are flat, and the IAAAP location is temperate with substantial rainfall, thereby affording conditions for a well-vegetated non-eroding soil cover.

The RAO of minimizing the impact to groundwater has been achieved by removing nearly all of the contaminated soil which could adversely affect groundwater.

2. Treatment

At least an estimated 95% of the excavated soil has been treated to attain the RGs. Though some small part of the soil has not attained the RGs, it has been treated so as to reduce the original contaminant mass substantially. In addition to that, all of this soil has been disposed in a RCRA Subtitle C (Trench 6) or RCRA Subtitle D (CEA) equivalent soil storage facility, which provides permanent and complete isolation from contact, and substantial isolation from groundwater.

2.9.1.2 System Operations/O&M

There is no required O&M for the soil excavation areas of OU-1. However, since they exist on a secured Army facility with regular security inspections, any significant changes to the soil surface are likely to be noticed. Also, IAAAP is an operating facility, and issues noticed by the operating contractor, American Ordnance (AO), would be addressed as they arise. Finally, O&M of the excavated areas is not necessary since the soil and rainfall is conducive to a thick and long-lasting vegetative cover.

For the treated soil in the IDA, O&M is being performed consistent with maintaining a RCRA Hazardous waste disposal facility. These RCRA type requirements require a thorough and continuing series of maintenance activities.

The OU-1 ROD gives no O&M costs for the excavation portion of the remedy, but estimates O&M costs for the soil repositories. The repositories are in OU-4 and are addressed in section 4 of this report. Specifically, O&M is discussed in section 4.4.3.

2.9.1.3 Opportunities for Optimization

O&M for the excavation sites is already minimal; no optimization opportunities are currently envisioned.

2.9.1.4 Early Indicators of Potential Issues

The remediated soils comprise a large and disbursed set of locations within the complex of active and stand-by processing facilities at IAAAP. The count of excavated areas is well over 100. If processing facilities are changed in the future to allow mission changes at IAAAP, it will be important to be aware of the residual contaminants existing in many of the areas and either avoid disturbing them, or properly handle the contaminated soils when they have to be disturbed. There is currently no visual marker of the excavated areas, and it is not known if there is a central GIS-like system at IAAAP that tracks these areas. The CERCLA documentation does show excavation areas, but such information is distributed among at least 6 separate reports, these being the Phase 1, 2, 3, and 4 excavation reports, the DF remediation report, and the Phases 5, 6, and 8 remediation report. To avoid disturbing the wide patchwork of excavated sites in the future will require access to complete copies of these reports, and very good familiarity with them.

2.9.1.5 Implementation of Institutional Controls and Other Measures

Although the industrial land use on which the RGs were based has not yet been made permanent by administrative or legal means, the OU-1 Final ROD assigned responsibility for doing so to the site-wide OU, which is now OU-7. Until that is done, industrial land use is already effectively made nearly permanent by the presence of the IAAAP. In the interim, IAAAP procedures are in place for maintaining site controls at the IAAAP to protect plant workers, contractors, and other site visitors from site contaminants. Currently, coordination of digging permits, utility repairs, maintenance, or other site work is accomplished through internal coordination between AO and the IAAAP staff to ensure that workers are aware of and protected from potential environmental hazards. Hunting and fishing are allowed on the IAAAP only in designated areas and are controlled through an in-place permit system. Hunters must attend a hunter safety briefing prior to each year's hunting season.

2.9.2 Question B: Are the exposure assumptions, toxicity data, clean-up levels and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Yes.

There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. The land use that is being protected by the RAOs is industrial on the IAAAP, and residential off of the IAAAP with potable groundwater use. These land uses are still current and are still reasonably anticipated to continue in the future, and the RAOs, and the RGs based on them, are still valid.

2.9.2.1 Changes in Standards and To-Be-Considered Information

The cleanup levels (RGs) for OU-1 soil were not based on chemical-specific ARARs. There are no known changes in ARARs that impact the protectiveness of the OU-1 remedies. There are also no known newly promulgated standards that call into question the protectiveness of the remedy. TBCs were not used in developing cleanup levels for OU-1 and any changes to TBCs would not affect the protectiveness of the remedy. Chemical-specific Remediation Goals (RGs) were developed based on human health risks to an industrial worker exposed to OU-1 soils and also the potential for 2,4,6-TNT and RDX to leach to groundwater.

2.9.2.2 Changes in Exposure Pathways

All exposure assumptions remain valid and are protective. New guidance in human health risk assessment for the dermal and inhalation pathways was published by the EPA in 2004 and 2009. The 1996 risk assessment did not evaluate the construction worker exposure pathway for OU-1 sites and the 1998 OU-1 ROD established RGs for soil removal and treatment based on industrial soil exposure and leaching to groundwater.

Following the establishment of remedial goals in the OU-1 ROD and the ensuing RAs, as part of the overall environmental program at IAAAP additional sites were identified for which little or no data existed to assess potential risks. These sites were assigned to the base-wide OU (OU-7). OU-7 sites are distributed across the installation and have constituents of potential concern and exposure pathways representative of those in OU-1. A baseline human health risk assessment (BHHRA) was conducted in 2009 as part of the OU-7 Supplemental RI and the construction worker exposure pathway and industrial worker exposure pathway were evaluated. Risk assessment results are presented in the final OU-7 Supplemental RI (Tetra Tech, 2011a). No estimated risks for the construction worker exceeded acceptable limits [hazard index (HI) of 1.0 or incremental lifetime cancer risk (ILCR) of 1E-06] for exposure to soils up to 20 feet bgs.

Based on extrapolation of the OU-7 Baseline Human Health Risk Assessment (BHHRA) results, it is concluded that the construction worker is adequately protected at OU-1 sites. Additionally, OU-1 RAs were most often driven by RDX and TNT at concentrations exceeding their leaching criteria. Since protectiveness of groundwater from leaching of RDX and TNT are driven by limits significantly lower than those for human health and since leaching criteria were applied to all soil, regardless of depth, the OU-1 remedies are considered protective of the construction worker, who may be exposed to subsurface soil to a depth of 10 feet.

Table 2-7 shows a comparison of existing OU-1 RGs based on ingestion by a potential industrial worker and leaching to groundwater to EPA RSLs which are based on an industrial worker potentially exposed through ingestion, dermal contact, and inhalation of contaminants. The EPA Industrial soil RSLs (November 2015) were developed with current toxicity information and the current risk assessment methodology by which ingestion, dermal contact, and inhalation are considered. Background concentrations are identified for metals. For RSLs based on a cancer risk of 1E-06 the last column presents COPC concentrations within the acceptable cancer risk range of 1E-06 to 1E-04.

If RGs had been based on dermal and inhalation exposure, those for cadmium and HMX would have been affected.

Cadmium. The cadmium RG is 1000 mg/kg. There are no cadmium concentrations above the RSL of 980 mg/kg in OU-1 post-excavation soil. The highest detection was 162 mg/kg in a sidewall sample of an OU-1 RA excavation at the CTA. This indicates that the remedy is protective because the levels of cadmium found across the post-excavation exposure areas are lower than the OU-1 RG (1000 mg/kg); as well as the November 2015 RSL for Industrial Soil of 980 mg/kg (for ingestion, dermal, and inhalation exposure).

Table 2-7: Comparison of RGs to EPA RSLs (November 2015), Background Concentrations and Protective Risk Range

Chemical of Potential Concern	EPA RSLs Industrial Soil (November 2015) (mg/kg) (c) = Cancer Risk of 1E-06 (nc) = Hazard Quotient of 1	Existing OU-1 RG (mg/kg)	Background (Maximum Concentration) (mg/kg)	Cancer Risk Range (1E-06 to 1E-04) (EPA RSL Table, November 2015)
RDX	28(c)	**1.3**[a]	--	28-2800
2,4,6-TNT	96 (c)	**47.6**[a]	--	96-9600
2,6-DNT	1.5 (c)		--	1.5-150
2,4-DNT	7.4 (c)	**8.7**	--	7.4-740
2-amino-4,6-DNT	2,300 (nc)		--	
4-amino-2,6-DNT	2,300 (nc)		--	
1,3,5-TNB	32,000 (nc)	**102**	--	
3,5-Dinitroaniline	No RSL		--	
HMX	57,000 (nc)	**51000**[b]	--	
1,3-Dinitrobenzene	82 (nc)		--	
Nitrobenzene	22 (c)		--	22-2200
o-Nitrotoluene	15 (c)		--	15-1500
m-Nitrotoluene	82 (nc)		--	
p-Nitrotoluene	140 (c)		--	140-14000
Antimony	470 (nc)	**816**	122	
Arsenic	3.0 (c)	**30**	30	3-300
Beryllium	2,300 (nc)	**1.4**	2.1	
Cadmium	980 (nc)	**1,000**	1.49	
Chromium III	1,800,000 (nc)	**10000**[c]	74.2[c]	
Chromium VI	6.3 (c)			6.3-630
Lead	800 (ALM)[d]	**1000**	53	
Thallium	12 (nc)	**143**	34.3	
Mercury	350 (nc)		0.50	
Vanadium	5,800 (nc)		74	
Aluminum	1,100,000 (nc)		22,100	
Cobalt	350 (nc)		58	
Dibenzofuran	1000 (nc)		--	
Iron	820,000 (nc)		72,000	

Chemical of Potential Concern	EPA RSLs Industrial Soil (November 2015) (mg/kg) (c) = Cancer Risk of 1E-06 (nc) = Hazard Quotient of 1	Existing OU-1 RG (mg/kg)	Background (Maximum Concentration) (mg/kg)	Cancer Risk Range (1E-06 to 1E-04) (EPA RSL Table, November 2015)
Benzo(a)anthracene	2.9 (c)	8.1	--	2.9-290
Benzo(a)pyrene	0.29 (c)	0.81	--	0.29-29
Benzo(b)fluorathene	2.9 (c)	8.1	--	2.9-290
Dibenz(a,h)anthracene[f]	0.29 (c)	0.81	--	0.29-29
Aroclor 1260 (PCBs)	1 (c)	**10**[e]	--	1-100
Tetryl	2,300 (nc)		--	

Notes:

Red values denote OU-1 soil RG which is based on:

1) it is already an OU-1 RG; 2) updated toxicity; 3) maximum background.

a.) RDX and TNT RGs are based on leaching to groundwater.

b.) HMX RG is lower than the RSL due to difference in ingestion rate.

c.) RG and background for chromium are based on total chromium.

d.) RG based on blood lead model for industrial worker.

e.) RG based on PCB ARAR for restricted use.

f.) Listed in OU-1 ROD as Dibenz(a,b)anthracene; correct name used in Nov 2015 RSL tables is as listed here

HMX. The HMX RG is 51,000 mg/kg. The HMX RSL is 57,000 mg/kg. There were no detections of HMX in soil above 51,000 mg/kg. The highest HMX detection is 1200 mg/kg in one surface soil sample (0-1 ft) at Line 2. This indicates that the remedy remains protective because HMX was not detected at concentrations greater than either the RG (51,000 mg/kg), or the November 2015 RSL of 57,000 mg/kg.

2.9.2.3 Changes to Toxicity, and other Contaminant Characteristics

2.9.2.3.1 Contaminants of Concern with Toxicity Information at the Time of the ROD

Besides there being updates to exposure assumptions and pathways, several soil COCs have had changes in toxicity information since the ROD. A comparison of toxicity values used to develop RGs in the ROD (EPA, 1998a; 1998b) to current EPA IRIS (or CalEPA) toxicity values is shown in **Table 2-8**. A discussion of the significance of those changes follows, including evaluation of how the changes in toxicity would affect the soil remediation levels.

Table 2-8: Toxicity Values Comparison

Contaminant	Media	Toxicity Value	Standard		Citation/Year
Arsenic	Soil	Oral Cancer Slope Factor	ROD	$1.8 \times 10^{+0}$ (mg/kg/day)$^{-1}$	OU-1 ROD (Aug. 1998)
			Current	$1.5 \times 10^{+0}$ (mg/kg/day)$^{-1}$	EPA IRIS (Aug 2015)
Beryllium	Soil	Oral Reference Dose (RfD)	ROD	5.0×10^{-3} (mg/kg/day)	OU-1 ROD (Aug. 1998)
			Current	2.0×10^{-3} (mg/kg/day)	EPA IRIS (Aug 2015)
Beryllium	Soil	Oral Cancer Slope Factor	ROD	$4.3 \times 10^{+0}$ (mg/kg/day)$^{-1}$	OU-1 ROD (Aug. 1998)
			Current	Removed from IRIS	EPA IRIS (Aug 2015)
Thallium	Soil	Oral Reference Dose (RfD)	ROD	7.0×10^{-5} (mg/kg/day)	OU-1 ROD (Aug. 1998)
			Current	2.0×10^{-5} (mg/kg/day)	EPA (2012)
Chromium VI	Soil	Oral Reference Dose (RfD)	ROD	5.0×10^{-3} (mg/kg/day)	OU-1 ROD (Aug. 1998)
			Current	3.0×10^{-3} (mg/kg/day)	EPA IRIS (Dec. 2015)
Chromium VI	Soil	Oral Cancer Slope Factor	ROD	None	None
			Current	5.0×10^{-1} (mg/kg/day)$^{-1}$	New Jersey DEP (2009, 2010)
Total PCBs, Aroclor 1254, Aroclor 1260	Soil	Oral Cancer Slope Factor	ROD	7.7 (mg/kg/day)$^{-1}$	OU-1 ROD (Aug. 1998)
			Current	2.0 (mg/kg/day)$^{-1}$	EPA IRIS (Aug 2015)
1,3,5-Trinitrobenzene	Soil	Oral Reference Dose (RfD)	ROD	5.0×10^{-5} (mg/kg/day)	OU-1 ROD (Aug. 1998)
			Current	3.0×10^{-2} (mg/kg/day)	EPA IRIS (Aug 2015)
2,4-Dinitrotoluene	Soil	Oral Cancer Slope Factor	ROD	6.8×10^{-1} (mg/kg/day)$^{-1}$ [Mixture]	OU-1 ROD (Aug. 1998)
			Current	3.1×10^{-1} (mg/kg/day)$^{-1}$	Cal OEHHA (2009)

Discussion of changes in toxicity values for individual CoCs:

Arsenic. Based on the cancer endpoint, the RG for arsenic was calculated in the BLRA as 3.4 mg/kg. The soil RG, however, was set at 30 mg/kg, the maximum value observed in background soil samples. The oral SF (SF_o) for arsenic was revised on April 10, 1998. Using the revised SF_o, the PRG calculates to 4.1 mg/kg, compared to the original PRG of 3.4 mg/kg. The current RG is 30 mg/kg, representing a human health risk of approximately 1E-05. Since this risk is within the acceptable risk range of 1E-06 to 1E-04, the current RG and resultant OU-1 cleanups are still considered health protective.

Beryllium. The soil RG for beryllium was set at 5 mg/kg in the OU-1 ROD (1998). The oral RfD, and carcinogenicity assessment in IRIS were revised on April 3, 1998. IRIS reduced the oral RfD_o and the oral SF_o was removed from IRIS. The EPA November 2015 noncancer RSL for industrial soil is 2.3E+03 mg/kg; thus, the OU-1 RG of 5 mg/kg remains health protective.

Chromium VI. An RG was established at 10,000 mg/kg in the 1998 OU-1 ROD for total chromium. No RG, however, was established for any particular valence state of chromium (e.g. III, VI, etc.). Based on a July 2008 study, the New Jersey Department of Environmental Protection (NJDEP) derived an oral SF for chromium VI, the most toxic valence state (**Table 2-8**). The New Jersey chromium VI cancer slope factor qualifies as a Tier 3 toxicity value for use in Superfund risk assessments (EPA, 2003b). The soil cleanup level suggested by the NJDEP SF yields a PRG of 6.75 mg/kg using OU-1 exposure parameters and a 6.3 mg/kg RSL (EPA, Nov. 2015). The newly derived chromium VI PRG and RSL are below the IAAAP-specific background value for total chromium of 74.2 (maximum concentration) and the approximated 95UCL concentration of 35.2 mg/kg (calculated as the average plus two standard deviations).

To assess the potential impact of a chromium VI toxicity value on the protectiveness of the OU-1 remedy, a review of the analytical data from OU-1 sites was performed as part of this five year review. A worst-case scenario was assessed whereby all chromium detections were assumed to be in the more toxic chromium VI valence state. This conservative assessment was endorsed by the EPA and was necessary because IAAAP soil data represent the total chromium concentration, with speciation of chromium III and chromium VI not having been performed. There are 1375 detections of total chromium in surface soil (0-2 ft) and 324 detections in subsurface soil (2-10 ft). If the total chromium data from OU-1 soils is conservatively assumed to solely exist in the chromium VI valence state, every chromium sample (1699 samples) would contain chromium greater than the 2015 RSL calculated at a 1E-06 risk. Of the 1375 surface soil samples (0-2 ft depth range), only four isolated soil samples contain chromium concentrations which would individually exceed a 1E-04 PRG of 675 mg/kg. The four samples were collected at three separate sites. None of the 324 subsurface soils (2-10 ft depth range) contained chromium concentrations greater than 675 mg/kg. Because the exposure area of the target receptor (i.e the industrial worker) includes all of OU-1 and its 1699 samples, the risk to the industrial worker would be significantly less than the exposure to any individual sample concentration and would be within the protective range of 1E-06 to 1E-04. Therefore, even when considering the highly conservative assumption that all chromium is of the more toxic chromium VI state, the OU-1 remedy remains protective. (Tetra Tech, 2011h)

Thallium. The OU-1 RG for Thallium was developed using the Oral RfD of 7.0E-05 (**Table 2-8**), which was decreased to 2.0E-05 (EPA 2012). The new Oral RfD would cause the RG to be reduced from 143 mg/kg to 41 mg/kg. The reduced soil RG of 41 mg/kg should remain health protective at OU-1, since as shown in the OU-7 BHHRA, Appdx K of the 2011 Final SRI Report (briefly introduced at the beginning of this section), the soil samples analyzed for thallium were almost all NDs with the few detects less than background concentrations (which for OU-7 soil is 19.05 mg/kg). OU-7 thallium soil data were reported for several locations, including Central Test Area (Table 10-2); Construction Debris Landfill, Soil Ash (Table 8.2); Line 3A Pond (Table 9-2b); Line 3A Pond (Table 9-5); Incendiary Disposal Area (Table 4-2b); Possible Demolition Site (Tables 6-2b and 6-5) (note: table references are to the OU-7 BHHRA). All of these results show that the analytical detection limits were capable of identifying potential levels of concern, as follows:

- For the Central Test Area (Table 10-2), 71 soil samples were collected; all 71 were ND for Thallium with detection limits from 0.42 to 5.2 mg/kg.
- For the Construction Debris Landfill, Soil Ash (Table 8.2), 22 soil samples were collected; 21 were ND for Thallium with the maximum detection limit of 34.3 mg/kg, and one detection of 1.1 mg/kg.
- For the Line 3A Pond (Table 9-2b), 15 soil samples were collected; all were ND for Thallium with detection limits from 0.5 to 34.3 mg/kg.
- For the Line 3A Pond (Table 9-5), 4 sediment samples were collected; all were ND for Thallium with maximum detection limit of 6.62 mg/kg.
- For the Incendiary Disposal Area (Table 4-2b), 33 soil samples were collected; all were ND for Thallium with detection limits ranging from 4.2 to 34.3 mg/kg.
- For the Possible Demolition Site (Table 6-2b), 9 soil samples were collected; all were ND for Thallium with detection limits ranging from 4.2 to 34.3 mg/kg.
- For the Possible Demolition Site (Table 6-5), 4 sediment samples were collected; all were ND for Thallium with detection limits ranging from 0.51 to 6.62 mg/kg.

PCBs. As noted in **Table 2-8**, the Oral Cancer Slope Factor (SFo) for PCBs has been reduced from 7.7 $(mg/kg/day)^{-1}$ to 2.0 $(mg/kg/day)^{-1}$. Since the soil RG for Total PCBs (10 mg/kg) was based on OSWER 9355.4-01, Guidance on Remedial Actions for Superfund Sites with PCB Contamination (EPA, 1990b), the change in SF_o toxicity value does not affect the protectiveness of the remedy for PCBs.

1,3,5-Trinitrobenzene. The oral RfD for 1,3,5-trinitrobenzene was revised in IRIS on October 1, 1997. Using the revised RfD_o, the RG would calculate to 61,224 mg/kg, compared to the RG of 102 mg/kg in the ROD. Therefore, the remedy for 1,3,5-TNB remains health protective.

2,4-Dinitrotoluene. The Oral Cancer Slope Factor (SFo) used to develop the RG for 2,4-dinitrotoluene was 6.8E-01 $(mg/kg/day)^{-1}$, which was for the Dinitrotoluene mixture of 2,4- and 2,6-. EPA has since adopted the use of the Cal OEHHA (2009) SFo of 3.1E-01 $(mg/kg/day)^{-1}$, which is slightly less than half the SFo for the mixture (less toxic). This results in the November

2015 RSL of 7.4 mg/kg compared to the RG of 8.7 mg/kg. This means the RG for 2,4 DNT remains health protective.

2.9.2.3.2 <u>COCs Without Toxicity Information at the Time of the ROD</u>

The OU-1 ROD indicates that six COCs (i.e., aluminum, cobalt, dibenzofuran, iron, lead, and sulfate) did not have toxicity information at the time the OU-1 ROD was developed in 1998. It indicates that an RG was developed at that time for Lead using EPA's blood lead model for an industrial worker. However, RGs were not developed for the other COCs. Toxicity data are now available for aluminum, cobalt, dibenzofuran, and iron. The November 2015 EPA Industrial Soil RSLs for these four chemicals are as follows:

Table 2-9: PRGs Previously Not Calculated

COC	EPA RSL(mg/kg)
Aluminum	1,100,000 (nc[1])
Cobalt	350 (nc)
Dibenzofuran	1000 (nc)
Iron	820,000 (nc)

[1]nc = noncarcinogenic

The Excel® soils database was used to compare all the existing sample data to these RSLs. Out of 2052 sample results for aluminum, the maximum detected value was 107,000 mg/kg. Of these samples, 173 were non-detects, where the maximum detection limit was 0.63 mg/kg. For Cobalt, out of 1748 sample results, the maximum detected value was 98.7 mg/kg. Of these samples, 19 were non-detects, where the maximum detection limit was 14 mg/kg. For Dibenzofuran, out of 770 sample results, the maximum detected value was 30 mg/kg. Of these samples, 757 were non-detects, where the maximum detection limit was 35 mg/kg. For Iron, out of 1757 sample results, the maximum detected value was 220,000 mg/kg. As might be expected, there were no non-detects.

Hence, there were no detections of aluminum, cobalt, dibenzofuran, or iron above the November 2015 industrial soil RSL.

2.9.2.3.3 <u>Byproducts of RDX and TNT Degradation</u>

The following is taken primarily from the previous FYR report (Tetra Tech, 2011h):

<u>RDX Breakdown Products</u>

MNX, DNX, and TNX may form as degradation products of RDX in the environment. Their toxicity is unknown. They are produced most frequently as biodegradation products under mildly anaerobic environments and are typically produced at much lower concentrations than their parent compound, RDX. Since near surface soils would likely be aerobic, creation of these RDX degradation products in significant amounts is unlikely. Recent research indicates that there are additional RDX degradation pathways in reducing and oxidizing environments that do not produce MNX, DNX, and TNX. MNX, DNX, and TNX also tend to be transitory degradation products that do not accumulate for long periods in the environment. Given their unknown toxicity, transitory nature, the unlikely conducive environment for their production, MNX, DNX, and TNX are not anticipated to compromise the protectiveness of the OU-1 remedy.

TNT Breakdown Products

The amino-dinitrotoluenes can be produced in the environment as the primary biologically produced breakdown products of TNT. Much like the RDX degradation products, TNT degradation products are produced under mildly anaerobic conditions. Since conditions in near surface soils are not expected to be conducive to the production of amino-dinitrotoluenes, they would not be anticipated to compromise the protectiveness of the OU-1 remedy.

As a check on this, it was noted that both amino-dinitrotoluene isomers (i.e., 2A4,6-DNT and 4A2,6-DNT) have November 2015 industrial soil RSLs of 2300 mg/kg (HQ = 1). The amino-dinitrotoluenes can be analyzed with the same laboratory method used to measure TNT and RDX. The Excel® soils database was searched for these compounds, and there are 3,410 sample results for 2A4,6-DNT, with 385 detections with a maximum value of 190 mg/kg. For 4A2,6-DNT, there are 3,414 sample results with 339 detections and a maximum value of 450 mg/kg. The maximum detections of these two compounds in IAAAP soils are well below their industrial RSLs.

TNT-related compounds

Both isomers of DNT (2,4 and 2,6) are routinely analyzed in combination with RDX and TNT. 2,4-DNT was already remediated using an RG that was shown in section 2.9.2.3.1 of this report to be protective. However, 2,6-DNT had no RG in the OU-1 ROD. As a check on protectiveness for 2,6-DNT, data for that compound was located in the Excel® soils database and compared to the 2015 soil industrial RSL, which is 1.5 mg/kg. There were 7218 sample results for 2,6-DNT, where 85 were detections, with a maximum value of 11.6 mg/kg, and 15 samples exceeding 1.5 mg/kg. Although 15 samples exceed the RSL, the RSL is based on a cancer risk of 1E-06. The corresponding value for a risk of 1E-05 is 15 mg/kg, which is not exceeded by any IAAAP 2,6-DNT detections. The sample with the highest concentration would have a risk of 8E-06. The 4 samples with the next highest concentration would have a risk of 4E-06, and the remaining 10 detections would have a risk no greater than 2.5E-06. All other detections are less than the 1E-06 RSL.

Since DNT is a parent explosive component produced during the manufacturing of TNT and not a degradation product of TNT or other explosives, they would not increase in concentration over time from environmental degradation processes.

2.9.2.3.4 Clean-up Levels and Remedial Action Objectives (RAOs)

The clean-up levels and remedial action objectives remain valid and achieve continued protection of the environment, ecological receptors, and potentially exposed human receptors.

The Indiana Bat, a Federal Endangered Species, is a known inhabitant of OU-1. Copper was identified as a contaminant of ecological concern (COEC) in soil at Line 3, Line 3A, and Line 800, resulting in ecologically based soil RAs at these sites. No RG was established for copper. The ecological evaluation performed for the Indiana Bat was an iterative process based on procedures developed in Appendix M of the BERA (MWH, 2004) and the second ESD to the OU-1 Interim Action ROD (EPA, 2008b). A copper concentration of approximately 60 milligrams per kilogram (mg/kg) was applied as an excavation goal, to a minimum of 1 foot below ground surface, because it was determined that this concentration (and depth) would not cause an exceedance of the ecological criteria.

2.9.2.4 Changes in Risk Assessment Methods

Risk assessment methodologies have not changed in a way that could affect the protectiveness of the remedy. Related to this topic is the specific use of the Summers leaching model to calculate remedial goals for RDX and TNT in the OU-1 ROD. Because they were lower than other RGs and because of the prevalence of RDX and TNT at IAAAP, the extent of nearly all the soil excavations was driven by the need to attain these values. It is thereby important to verify that they are still protective.

Protectiveness of Remediation Goals Based on Leaching to Groundwater

As shown in **Tables 2-2 and 2-3**, the OU-1 Interim and Final RODs used remediation goals for RDX and TNT that had been developed for protection of groundwater due to leaching from soils. These goals were lower than the goals for direct exposure to soils, and became the main remediation goals for OU-1. They were developed in 1995 during planning for removal actions at the Line 1 Impoundment, Line 800 Lagoon, and Miscellaneous Sumps (CDM, 1995c), using the Summers leaching model. They were designed to protect potable groundwater by achieving groundwater concentrations less than 2 µg/L for RDX, and less than 9.5 µg/L for TNT.

As noted in the protectiveness discussion for OU-3 later in this report, the value of 2 µg/L in groundwater for RDX is still protective because it corresponds to an acceptable risk under CERCLA.

TNT is not discussed in OU-3, as it is not a CoC, however, the current EPA RSL table lists a tapwater screening value for TNT of 2.5 µg/L based on 1E-06 cancer risk, and a value of 9.8 µg/L based on noncancer effects. The value of 9.5 µg/L used as the groundwater goal for TNT in the Summers model is less than the current noncancer threshold value, and corresponds to a cancer risk between 1E-05 and 1E-06. Hence the TNT goal of the Summers model remains protective.

As to the protectiveness of the Summers model itself, it is noted that a ROD was finalized for IAAAP OU-5 in November 2014 (EPA, 2014b) using the same soil remediation goals for RDX and TNT as the OU-1 Interim ROD, and referencing the OU-1 Interim ROD as the source of the goals. Also, in April 2011 a Feasibility Study (USACE, 2011b) was finalized for IAAAP OU-8 which (1) indicates that the OU-1 RGs for explosives are exceeded in one of the OU-8 sites, and (2) contains an appendix that calculates the risk due to leaching to groundwater, and finds it acceptable. The subsequent ROD (USACE, 2011d) requires no remediation for explosives in soils. Based on this information, it is concluded that the OU-1 ROD's RGs based on leaching to groundwater are still protective and still considered the default choice for RGs at IAAAP.

2.9.2.5 Expected Progress Towards Meeting RAOs

The RAOs are (EPA, 1998a):

1. Prevent human contact with contaminants of concern in soils at levels posing a threat, and
2. Minimize potential impacts associated with contaminants leaching from soils to groundwater.

The first RAO has been met. Human contact with contaminated soil posing an industrial-type exposure risk has been eliminated at the OU-1 ROD sites. Soils with concentrations greater than industrial exposure remediation goals have been removed, the areas backfilled with clean soil and revegetated, and the excavated soils have been treated and isolated in Subtitle C or Subtitle D equivalent soil repositories.

The objective to minimize potential impacts to groundwater has been met to a very great degree by removing an estimated 95% of soil posing a risk, treating that soil to remove leachable contaminants, and isolating that soil in Subtitle C or Subtitle D soil repositories. Affected groundwater that was historically contaminated by releases from OU-1 ROD sites remains close to those sites, and far from off-IAAAP groundwater that is used for drinking.

2.9.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No.

No new exposure risks, either human or ecological, have come to light. No major climate issues or natural disasters or land use changes have occurred or been identified that would affect the OU-1 sites. No other information is known that could call into question the protectiveness of the OU-1 remedy.

2.9.4 Technical assessment summary

The Remedy for OU-1 is functioning as intended by the OU-1 RODs and ESDs. There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy. The land use associated with OU-1 remains industrial. OU-1 exposure assumptions remain valid and are protective. The clean-up levels and remedial action objectives remain valid and achieve continued protection of the environment, ecological receptors, and potentially exposed human receptors. No other information is known that could call into question the protectiveness of the remedy.

2.10 ISSUES

The issues in **Table 2-10** were identified during the site June 2015 site inspection or personnel interviews.

2.11 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Table 2-11 has actions that are recommended to address issues identified during the June 2015 site inspection and personnel interviews.

2.12 PROTECTIVENESS STATEMENT

The remedy at the OU-1 ROD sites is currently protective of human health and the environment in the short-term. In order for the remedy to be protective in the long-term, language that restricts land use to industrial/commercial needs to be recorded in appropriate property ownership documents.

Table 2-10: OU-1 Issues from FYR

Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
1. A restriction limiting land use to industrial/commercial is not in place in the available land recording documents.	N	Y
2. Small disturbed areas were seen in the WBP area, explained as areas that are persistently pawed, possibly licked, by deer. These could be an indication of some type of constituent in the soil.	N	N
3. Some residual explosives concentrations at Line 800 adjacent to the lagoon did not attain the RGs. This was addressed in this report, and is not considered a major issue, but it was identified as a regulatory concern and needs to be addressed.	N	N
4. Several areas considered as OU-1 soils sites are not listed in the OU-1 RODs as part of the overall remedy (e.g., FTP, Line 1 Impoundment, Line 800 Lagoon, Miscellaneous Sumps, North Burn Pads Landfill, Pesticide Pit). These sites have undergone removal actions similar to the OU-1 remedial actions. It is not clear that these sites have completed the remedial process.	N	N
5. The numerous remediation areas of OU-1 ROD might not be readily visible either physically or administratively and could accidentally be disturbed in future land development associated with changes in IAAAP mission.	N	N
6. A small number of remediation areas did not achieve the leaching-to-groundwater remedial goal.	N	Y

2.13 NEXT FIVE-YEAR REVIEW

The next Five-Year Review is scheduled for completion no later than five years from the signature date of this report and is anticipated to be March 2021.

Table 2-11: OU-1 Recommendations

Issue	Recommendations and Follow-Up Actions	Party Responsible	Oversight Agency	Recommended Schedule	Affects Protectiveness? (Y/N)	
					Current	Future
1. Land use restrictions not recorded in available property administration documents.	Determine where land use restrictions can be recorded in official Army property administration documents, such as the Base Master Plan,and do so, in order that such restrictions can be transferred to land deed restrictions if the property were ever transferred out of U.S. Gov't ownership.	Army	EPA	December 2017	N	Y
2. WBP: Several small disturbed soil areas	Continue to fill them with gravel. Consider sampling to determine if IAAAP-related constituents are present.	Army	EPA	Complete by December 2015	N	N
3. Residual explosives at Line 800.	Discuss at a project meeting with relevant data. And try to alleviate concerns that not all OU-1 contamination was removed.	Army	EPA	Complete by December 2015	N	N
4. Sites that underwent soil removal actions have not reached the end of the remedial process.	Check with USAEC as to whether these sites reached site closeout; if not, carry them through remedial process with closeout investigation, NFA PP, and NFA ROD.	Army	EPA	Complete by December 2017	N	N
5. The numerous excavations are evidently not delineated in one easily	Determine if a local (i.e., IAAAP) or central (i.e., Army Mapper) GIS system contains locations of all areas where land use is restricted due to	Army	EPA	Complete by December 2016.	N	N

Issue	Recommendations and Follow-Up Actions	Party Responsible	Oversight Agency	Recommended Schedule	Affects Protectiveness? (Y/N)	
					Current	Future
accessible location.	remedial actions and contamination. Ensure operating contractor has appropriate level of access.					
6. Leaching-to-GW RG not entirely attained.	Update leaching RG; if changed, document in ESD. Sample as needed to define the soil volume that exceeds the RG. In near-term, mark areas >RG and establish SOP to keep them vegetated and sloped, especially not slumped, to facilitate runoff.	Army	EPA	Complete by December 2017	N	Y

3.0 OPERABLE UNIT 3

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Iowa Army Ammunition Plant		
EPA ID: IA7213820445		
Region: 7	**State:** IA	**City/County:** Middletown / Des Moines Co.
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Army		
Author name (Federal or State Project Manager): Mr. Jesse Kahler		
Author affiliation: Restoration Manager, Iowa Army Ammunition Plant		
Review period: May 2015 – July 2015		
Date of site inspection: June 2-4, 2015		
Type of review: Statutory		
Review number: 3		
Triggering action date: April 5, 2011		
Due date *(five years after triggering action date)*: April 5, 2016		

Five-Year Review Summary Form (continued)

The table below is for the purpose of the summary form and associated data entry and does not replace the two tables required in Section VIII and IX by the FYR guidance. Instead, data entry in this section should match information in Section VII and IX of the FYR report.

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Click here to enter text.

Issues and Recommendations Identified in the Five-Year Review:

OU(s): OU-3 Off-Site Groundwater	**Issue Category: Institutional Controls**			
	Issue: ICs have not been fully implemented. Enforceable restrictions on well installation in the RDX plume do not exist. A locally issued advisory and a health and safety program have not been enacted as stipulated in the ROD (Section 1.4.1). Currently this function is being conducted through the RAB which is considered an imperfect method of reaching the public.			
	Recommendation: Continue working with the State and Counties to enact LUCs. Document the status of enacting LUCs in the annual OU-3 monitoring reports. Institute a locally issued advisory and health and safety program, separate from what is reported at the RAB.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	State	Federal Facility	2017

To add additional issues/recommendations here, copy and paste the above table as many times as necessary to document all issues/recommendations identified in the FYR report.

Protectiveness Statement(s)
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
OU-3 Off-Site Groundwater	Short-term Protective	Click here to enter date.

Protectiveness Statement:

The remedy at OU-3 currently protects human health and the environment because city water has been offered to all affected residents in the current footprint of the RDX plume. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

1) Institute the ICs. This includes a locally issued advisory and a health and safety program to educate the public about the risks of consuming water from the RDX plume. Monitor progress of the State in instituting well drilling restrictions in the area of the plume.
2) Repair/replace the sentinel well network so that growth or expansion of the plume does not affect those residents not connected to city water.

Sitewide Protectiveness Statement (if applicable)

For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: Choose an item.	*Addendum Due Date (if applicable):* Click here to enter date.
Protectiveness Statement: Click here to enter text.	

3.1 INTRODUCTION

Section 3 of this report documents the methods, findings, and conclusions of a CERCLA Five-Year Review for Operable Unit 3 of the Iowa Army Ammunition Plant, Middletown, Iowa. OU-3 addresses off-post[1] contamination resulting from IAAAP sources. These IAAAP sources discharged waste explosives to a watercourse on IAAAP, named Brush Creek, which flows off of IAAAP near its southeast corner. Once Brush Creek left IAAAP, it entered an area of more-permeable substrate which allowed the explosives-contaminated water to migrate downward into the groundwater. OU-3 is comprised of the response for the off-post groundwater, and monitoring and any response for the off-post section of Brush Creek. Currently a remedial response is underway for the groundwater under the OU-3 ROD. The decision summary of that ROD notes that it is an "interim" remedy for OU-3, because the groundwater remedy cannot be successful until the presumed continuing contaminant source of Brush Creek is also remediated. The off-post section of Brush Creek is in the investigation stage and monitoring is underway; no remedial decisions have been reached for that area. Because remedial action for the OU-3 groundwater has been ongoing for at least five years, this review addresses the response for the groundwater.

The groundwater remedy at OU-3 has been initiated, but has not yet attained the remedial goals. The purpose of this Five-Year Review is to evaluate the implementation and performance of the remedy and determine whether the remedy at OU-3 is protective of human health and the environment. This report also identifies issues found during the review, and recommendations to address them.

IAAAP is on the CERCLA National Priorities List and has a Federal Facilities Agreement between the U.S. Army (the "lead" agency) and the U.S Environmental Protection Agency. Because IAAAP is on the NPL and because the Army is performing the environmental work under the Defense Environmental Restoration Program, Five-Year reviews are required to be performed consistent with CERCLA section 121 and with the National Contingency Plan (NCP). The NCP, at 40 CFR §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

[1] The NCP defines the term *on-site* to mean the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (40 CFR 300.5). This usage contrasts with that of the numerous IAAAP project documents, which use *on-site* and *off-site* to mean the area inside and outside the IAAAP boundary, respectively. This FYR report uses the term *site* as the NCP intends for *on-site*, the term *off-post* to refer to the area outside the IAAAP, and the term *off-site* when quoting an IAAAP document title or IAAAP document text which uses that term. In short, in this document the two terms, *off-post* and *off-site,* mean the same thing.

The only contaminant for this OU is the explosive compound RDX. RDX remains in ground water in OU-3 at concentrations greater than the remedial goal which was based on unlimited use, hence this Five-Year review was required at OU-3.

The Baltimore District of the U.S. Army Corps of Engineers performed this FYR for the remedial actions selected for OU-3 in the Record of Decision dated August 8, 2005. This review was conducted from May 2015 to July 2015. Acting for the IAAAP, the U.S. Army Environmental Command tasked the U.S. Army Corps of Engineers (USACE) with this FYR, and USACE requested that the Baltimore District perform the work.

While this is the third FYR for the IAAAP installation as a whole, this is the second FYR required for OU-3. The triggering action for this review is the date of the previous five-year review, March 2011, and the fact that contaminants remain in OU-3 above the ROD's remedial goal that is based on unlimited use and unrestricted exposure.

At the same time as this OU-3 FYR, a FYR was also performed for all other sites and OUs at IAAAP which have initiated remedial action under the DERP FFA. These other FYRs are documented in other sections of this report. Also, in Appendices G through L a status is provided for all other sites being addressed under the DERP FFA, but which are not yet required to have a FYR.

3.2 SITE CHRONOLOGY

The site events for IAAAP, focusing on OU-3, are listed in Table 3-1.

Table 3-1: Chronology of OU-3 Site Events

Sitewide	Date
IAAAP used for munitions production	1941 - present
Resource Conservation and Recovery Act (RCRA) Assessment	1987
IAAAP placed on National Priorities List (NPL)	1990
FFA for CERCLA response actions at IAAAP	1990
Facility-wide Preliminary Assessment/Site Investigation (PA/SI)	1992
Facility-wide Remedial Investigation (RI)/Baseline Risk Assessment (BLRA)	1996
OU-3 (Off-Post Groundwater)	**Date**
Local concern arises about discharge of IAAAP wastewaters into streams leaving the installation. Sampling of off-post wells occurs.	1985
RDX detected in off-post groundwater; Removal Action to connect approximately 150 homes, affected and unaffected by contamination, to municipal water	1993

Removal Action to connect approximately 40 homes to municipal water	2001
OU-3 RI	2003
OU-3 Feasibility Study (FS)	2004
OU-3 Treatability Studies	2004
OU-3 ROD (There are no ESDs or amendments.)	2005
First IAAAP Five Year Review	2006
OU-3 RD/RAWP	2007
2nd IAAAP Five Year Review	
OU-3 Groundwater Injections (6 separate events)	2007-2013
OU-3 Semi-Annual (2007-2009) and Annual (2009-2015) Monitoring Reports	2007-2015
OU-3 Draft Interim Remedial Action Completion Report	2014
Quarterly Brush Creek Sampling at 3 locations downstream from IAAAP	2007-2015

3.3 BACKGROUND

3.3.1 Physical Characteristics

The IAAAP is a load, assemble, and pack (LAP) munitions facility located on approximately 19,000 acres in Middletown, a rural area of eastern Iowa, 10 miles west of Burlington in Des Moines County and approximately nine miles northwest of the Skunk and Mississippi Rivers. The northern area of the IAAAP consists of gently undulating terrain; the central portion is characterized by rolling terrain dissected by a shallow drainage system; and the southern area of the site contains drainage ways with steep slopes down to the creek beds. Elevations within the IAAAP range from 730 feet above mean sea level (amsl) in the north to 530 feet amsl in the south.

The IAAAP contains portions of five watersheds. The Brush Creek watershed comprises the central portion of the facility; Brush Creek exits at the southeastern boundary and flows into the Skunk River, which then flows into the Mississippi River. The Spring Creek watershed drains the eastern portion of the facility; Spring Creek exits at the southeastern corner and flows directly into the Mississippi River. The Long Creek watershed comprises the western portion of the IAAAP; Long Creek exits at the southwestern boundary and joins the Skunk River just south of the facility. Long Creek has been dammed near the center of the facility to create the 85-acre George H. Mathes Lake, which was used as a water source for the facility until January 1977. The Skunk River watershed comprises the southwest corner of the IAAAP; Skunk River borders the facility's perimeter on the southwest corner and provides year-round recreational use. The Little Flint Creek watershed comprises a small area in the north portion of the facility.

The OU-3 groundwater plume is located entirely off of the IAAAP, approximately 2 miles southeast of the southeast corner of IAAAP. It is an approximately 600-acre area between U.S. Highway 61 on the north and the Skunk River on the south (see **Figure 1**). Nearly the entire extent of OU-3 lies within the watershed and flood plain of the Skunk River. The soil horizon is composed of mixed fluvial deposits, mostly sand. This differs from the glacial till deposits on the IAAAP site proper.

Average groundwater depth in OU-3 ranges from 4 to 30 feet below ground surface.

3.3.2 Land and Resource Use

The IAAAP produced munitions for World War II from the plant's inception in September 1941 until August 1945, and munitions for military activities in southeast Asia in the 1960s and early 1970s. Activities at the IAAAP continued at a reduced level during peacetime. The plant was operated by Day & Zimmerman Corporation from 1941 to 1946, by the U.S. Government from 1946 to 1951, and by the Mason & Hanger Corporation from 1951 to 1998. The former U.S. Atomic Energy Commission (AEC) operated at Line 1 from 1947 through mid-1975, at which time operation reverted to Army control. The IAAAP is currently an active U.S. Army Joint Munitions Command facility operated by the civilian contractor American Ordnance LLC (AO).

The IAAAP's current mission is to LAP ammunition items, including projectiles, mortar rounds, warheads, demolition charges, and munitions components such as fuzes, primers, and boosters. Because the installation is an active production plant, inactive lines are maintained on standby status or leased to contractors. Lines which will no longer be used by the Army have been placed in modified caretaker status.

Approximately 8,000 acres of the IAAAP are leased for agricultural use, 7,500 acres are forested, and the remaining areas are used for administrative and industrial operations. Hunting and fishing are regulated at the IAAAP through the use of permits. The anticipated future land use at the IAAAP is commercial/industrial. Public access to the installation is restricted by perimeter fencing and the IAAAP installation security staff.

The land surrounding the IAAAP is characterized as rural, and expected to remain rural. The largest population centers are the towns of Burlington (population: 25,500), West Burlington (3,300), Middletown (500), and Danville (900) (U.S. Census Bureau, 2010). The rural area south (downgradient) of the IAAAP is sparsely populated.

Des Moines County is about 60 percent croplands, 10 percent urban, eight percent pasture, and 22 percent woodlands or idle land. Crops grown in the area consist mostly of corn and soybeans (United States Department of Agriculture, 1983).

In OU-3 land use is predominantly rural residential and agricultural, mostly corn and soybean production. Some of the farm land is reclaimed floodplain, meaning it has been elevated with drain tiles to control the water table. Some of the floodplain is separated via levee structures to provide overland flood control. Some of the floodplain is owned by a commercial sand and gravel quarry which has recently expanded their land holdings into the RDX plume extent. Other than the extension westward of the quarry, no significant change in future land use is known or anticipated.

Groundwater is used for residential potable supply except where connections to the Rathbun Regional Water Supply have been made.

3.3.3 History of Contamination

Contamination at the IAAAP is primarily attributable to past industrial and laboratory operating practices involving various explosives-laden sludges, wastewaters, and solids; lead-contaminated sludges; ashes from incineration and open burning of explosives; and waste solvents. Past operations also generated waste pesticides and incendiaries.

The primary contaminants at the installation are royal demolition explosive (RDX) and trinitrotoluene (TNT). Other contaminants such as pesticides, fuel products, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals are also present in some on-site areas. Most of the contamination is contained within the industrial areas of the installation.

Operation of the LAP lines included water washdowns to ensure that explosives did not build up to unsafe levels in the buildings. Consequently explosives-contaminated wastewaters were generated and historically, prior to the start of clean water regulations, these waters were discharged to the nearest stream. Load lines 1, 2, 3, and 800 are located along Brush Creek, which received the wastewaters from these lines. Brush Creek flows off-post at the southeast corner of IAAAP, passing through off-post farmland, crossing US Highway 61, flowing through more farmland, and then entering the Skunk River.

The conceptual site model for OU-3 contamination indicates that north of US Highway 61 Brush Creek is in an area of soil comprised of fine-grained glacial till, which prevents leakage of water from the creek. However, at US Highway 61 the creek enters the floodplain of the Skunk River, which is an area of sandy soil that allows leakage of explosives-contaminated water from Brush Creek into the underlying groundwater.

Historically the explosives concentrations in Brush Creek were high, reportedly over one hundred parts per million. More recently a limit of 2 µg/L of RDX has applied to the discharge of IAAAP wastewater to the on-post streams. Average RDX concentrations in Brush Creek leaving IAAAP have decreased to approximately 10 µg/L from 2007 to the present, while the range of maximum values measured in locations downstream of IAAAP was 29.3 µg/L to 133 µg/L for that same time period.

Project files indicate that off-post groundwater became an issue in 1985 when a local family requested information about IAAAP waste disposal practices. The request received attention from the EPA and one of Iowa's U.S. senators. Off-post wells were sampled in 1985 by the Army Environmental Hygiene Agency (now PHC) with oversight from the State of Iowa. IAAAP was placed on the NPL in 1990. Off-post wells were sampled again in 1992, and two wells exceeded the RDX Health Advisory level of 2 µg/L. Because this level was exceeded in residential wells, immediate action was needed to prevent exposure. The response is described in the following section.

3.3.4 Initial Response

Pursuant to the RCRA Hazardous and Solid Waste Amendments of 1984, the EPA completed an assessment of the facility in 1987 and reported that releases had occurred (Ecology and Environment, Inc., 1987). The IAAAP was subsequently placed on the NPL in August 1990 with a Hazard Ranking Score of 29.73.

The U.S. Department of Defense (DoD) has established the Defense Environmental Restoration Program (DERP) to address sites under CERCLA, as amended by the SARA, that are within the responsibility of the DoD. The Army and EPA negotiated a Federal Facility Agreement (FFA) for site cleanup, which became effective December 10, 1990 (EPA, 1990a). The FFA provides a framework for CERCLA response actions to be performed at the IAAAP, including the investigation and cleanup of contamination. The EPA oversees the cleanup activities conducted by the Army to ensure that requirements of CERCLA/SARA, the NCP, and the FFA between the Army and EPA have been met. The State of Iowa is not currently a party to the FFA; however, the State participates in Restoration Advisory Board (RAB) and public meetings.

In 1992, a facility-wide PA/SI of 44 sites with potential contamination was completed (JAYCOR, 1994). In 1993, off-post contamination of private drinking water wells with explosives [RDX and 2,6-dinitrotoluene (DNT)] was confirmed. The IAAAP offered to connect residents south of the installation to the Rathbun Regional Water Supply. One hundred and fifty-four residences accepted the Army's offer. This number far exceeded the wells with confirmed contamination, however the Army reasoned that connecting all potentially affected wells was a better option than having to continue monitoring residential wells.

In 1996, a facility-wide RI/BLRA was completed for 35 of the 44 sites (JAYCOR, 1996). Two of the sites had ongoing RIs and were not addressed; the remaining seven sites were recommended for no further action.

The IAAAP facility was originally divided into four operable units (OUs-1, -2, -3, and -4). OU-2, originally established for soil removal actions, was subsequently merged into OU-1. Several other changes have been made during the course of CERCLA activities at the IAAAP, including realignment and adding of OUs. There are currently seven OUs under the DERP and the FFA, and an eighth OU under the DOE/USACE FUSRAP Program, with a separate FUSRAP FFS.

OUs 1, 3, and 4 have reached the start of remedial action, thereby requiring FYRs. These three OUs comprise the scope of this report. The remaining OUs are summarized in the Appendices. OUs 1, 3, and 4 are described below:

OU-1 -- Soils. OU-1, intended to address the majority of the areas of contaminated soil at the IAAAP, consists of an Interim Action to excavate contaminated soils from across the installation and consolidate them at the Inert Disposal Area (IDA) on-post, and a Final Action to treat excavated soils when required and to address ultimate disposal of the soil. The Interim Action ROD for OU-1 was signed on March 4, 1998, to address the remedial action (RA) to be taken at 15 areas throughout the IAAAP (EPA, 1998a). The Final ROD for OU-1, signed on September 29, 1998, specified LTTD or biological treatment of explosives-contaminated soils (EPA, 1998b). Two Explanations of Significant Difference (ESDs) have been issued for the OU-1 Interim Action ROD, two ESDs have been issued for the OU-1 Final ROD, and one ESD was issued that affects both OU-1 RODs.

OU-3 -- Off-post Groundwater. Originally, OU-3 was intended to address both on- and off-post groundwater contamination resulting from IAAAP sources. The Army and EPA signed an OU-3

ROD, effective in August 2005, for an Off-Site Groundwater Interim Action (URS, 2005). In 2009, OU-6 was created to address on-post groundwater. Off-post groundwater remains in OU-3.

OU-4 -- IDA Closure. OU-4 was originally designated as the installation-wide OU. The 1998 OU-1 Final ROD specified that the installation-wide OU would address the closure of the IDA, institutional controls, previously unaddressed areas of soil contamination, VOC-contaminated media, ecological risks, long-term monitoring requirements, and any other unacceptable risks identified and not addressed in either OU-1 or OU-3 (EPA, 1998b). In October 2009, the previously unaddressed areas of soil contamination were moved from OU-4 to the newly created OU-7 (Army, 2009). The closure of the Inert Disposal Area (IDA) was retained in OU-4 and is addressed in accordance with the OU-4 Interim Action ROD issued in 2008 (EPA, 2008a).

3.3.5 Basis for Taking Action

Hazardous substances have been detected at concentrations above health-based screening values in soil and groundwater at the IAAAP. For OU-3, RDX was the only compound detected in off-post groundwater at concentrations above its health risk-based level (lifetime health advisory guidance level of 2 µg/L RDX in drinking water; EPA, 2012). The RDX RG was established based on risk. These include criteria associated with ingestion of and dermal contact with contaminated ground and surface water by the reasonably maximum exposed individual.

The area with RDX contamination is rural residential, with between 5 and 10 residences in the area of the plume itself. Shallow groundwater is used for drinking water in this area. Because of the exceedance of the SDWA Health Advisory in actual and potential potable wells, the OU-3 remedy includes actions to prevent exposure and to restore the groundwater to potable use condition.

3.4 REMEDIAL ACTIONS

3.4.1 Remedy Selection

The scope of the OU-3 ROD is the currently contaminated groundwater off-post. It does not include potential source contamination in Brush Creek off-post. Brush Creek is being investigated, and a separate ROD will be written for any remedy of Brush Creek that may be needed.

The OU-3 response selection is documented in three places: (1) a Removal Action Memorandum, dated August 2, 1993, to connect residences to municipal water (Army, 1993), (2) an addendum to the Removal Action Memorandum, dated July 27, 2001, to connect additional residences to municipal water (IAAAP, 2001), and (3) a Record of Decision signed August 8, 2005 ((EPA, 2005). There are no ESDs or amendments to the OU-3 ROD.

The Remedial Action Objective (RAO) listed in the OU-3 ROD is “to prevent residential human exposure to RDX above 2 µg/L in Off-Site Groundwater”.

The remedy in the OU-3 *Off-Site Groundwater Record of Decision* consists of the following components:

- Enhanced degradation (ED) of highly contaminated groundwater (greater than 50 µg/L RDX) using sodium acetate as the carbon donor.

- Monitored Natural Attenuation (MNA) in all remaining areas of the plume to reduce concentrations of RDX to less than 2 µg/L.
- Institutional and engineering controls to prevent potential future exposure to RDX-contaminated groundwater with concentrations above 2 µg/L.

3.4.2 Remedy Implementation

In 1993, the presence of RDX in off-post groundwater at concentrations which exceeded 2 µg/L was confirmed after a round of private drinking water well sampling completed by the Army. The IAAAP connected private residences located south of the IAAAP to the regional water supply in 1994 and in 2001, as part of a removal action. This removal action was designed to eliminate the risk of exposure to contaminated drinking water until a remedial action could be completed.

Using data from previous groundwater sampling events in the off-post area, an RI was conducted in 2003 (URS, 2003). The RI defined the extent of RDX contamination in off-post groundwater and assessed the potential risks to human exposure to the RDX under a variety of exposure scenarios.

The exceedance of the target risk range and hazard index by off-post RDX groundwater concentrations triggered the development and evaluation of remedial alternatives in a FS, which was completed in March 2004 (URS, 2004).

The draft-final Proposed Plan was issued to the public in July 2004, identifying in-situ biodegradation in combination with MNA and institutional/land-use controls as the preferred remedial alternative. The preferred alternative was intended to be protective of potential exposures to RDX in groundwater to a level of 2 µg/L. The Proposed Plan also concluded that a field-scale treatability study evaluating in-situ biodegradation should be conducted to determine the most effective means to implement this technology.

The *OU-3 ROD for the Off-Site Groundwater* was signed by the Army and EPA in July and August 2005. The ROD listed two remedies: MNA for RDX concentrations less than 50 µg/L, and a proactive carbon donor injection (ED process, using sodium acetate as the donor) for plume areas with RDX concentrations greater than 50 µg/L.

In November 2004, a *Treatability Study Test Plan for In Situ Biodegradation of RDX in Off-Site Groundwater* was submitted for EPA review (Tetra Tech, 2004). The treatability study provided data useful for designing the in-situ biotreatment component of the remedy.

In 2007, the RD/RAWP was submitted for approval and implemented. In August 2007, 11 injection wells were installed approximately 70 feet apart along a transect line approximately 60 feet upgradient of Highway 61 and perpendicular to the groundwater flow. Five injection events followed over the next 21 months, as shown in Table 3-2.

In addition to the 11 injection wells, eight performance monitoring wells were installed at varying distances downgradient of the injection well transect to monitor changes in plume characteristics

Table 3-2: Off-post Groundwater Sodium Acetate Injections

Injection Well	Gallons of Sodium Acetate Injected					
	Event 1 Oct 2007	Event 2 Jan/Feb 2008	Event 3 Mar 2008	Event 4 Aug 2008	Event 5 Apr 2009	Event 6 Mar 2013
SMW-1	500	500				
SMW-2	500	500				
SMW-3	500	500				
SMW-4	500	500	250			
SMW-5	500	500	250	450		
SMW-6	500	500	250	450	625	
SMW-7	500	500	250	450	675	
SMW-8	500	500	250	450	450	450
SMW-9	500	500	250		475	
SMW-10	500	500			475	
SMW-11	500	500				

following injection. As of the last Five-Year Review in 2011, a total of 50 monitoring wells were installed throughout the plume footprint to monitor changes in the lateral and vertical extent of the plume. Presently, a significant number of these monitoring wells have become unusable due to the sale of land, abandonment, and/or disrepair. Along with groundwater level measurements, groundwater geochemical, chemical, and biological sampling data were collected from these monitoring points prior to injection and periodically since injections began to monitor the effectiveness of enhanced biodegradation of RDX.

A LUC implementation plan (LUCIP) is being developed with state and county stakeholders to prevent future use of groundwater with RDX concentrations greater than 2 µg/L.

3.4.1 System Operations/Operation and Maintenance (O&M)

The costs listed in the OU-3 ROD for the selected ED plus MNA alternative are:

Estimated Capital Cost: $1,233,000

Total O&M Cost: $1,050,000

Total Periodic Cost: $966,000

Total Cost: $3,248,000

Total Present Value: $2,441,000

The actual costs have not been quantified in the reports issued since the ROD. Like most sites in the Army's IRP, remediation services are being supplied to IAAAP in a long-term IAAAP-wide single-fixed-price contract under which the contractor is required to deliver all the necessary services, but is not required to report its costs. Appropriate costs are negotiated with the contractor during contract award, but once awarded, the contractor's obligation is to deliver the services; payment to the contractor is not based on the costs they incur, but only on the awarded fixed-price of the contract, hence they are not required to report their costs.

Most of the O&M effort is performed by the remediation contractor, though some amount is performed by Army staff. Army staff does not generally track its effort by individual task and subtask. For these reasons, a separate tally of the O&M efforts for OU-3 to compare with the ROD estimate has not been published, and is not readily available. A brief description of the O&M activities follows.

Engineering Controls: There are no Army O&M costs for the regional water supply. The cost for the water usage itself is paid by the individual users.

Institutional Controls: There is a small cost associated with holding RAB meetings to discuss OU-3 progress. The cost is primarily labor for developing slides and attending the meetings. Newspaper notices to advertise the meetings are less than $100 per year. Newspaper reports on these meetings are published as news for which there is no cost. There is also labor cost, which is unquantified, for coordinating with the State of Iowa and Des Moines and Lee counties to develop a regulatory prohibition on new well installation. That effort has not been completed, but is ongoing.

Active Remediation: There is a cost to conduct periodic groundwater injections of the sodium acetate amendment to accelerate biological degradation of the RDX. These are performed as part of the IAAAP-wide remediation contract. The last injection was in 2013, and another injection was being planned as this FYR was conducted.

Passive Remediation/Monitoring: Annual monitoring is being performed at most of the monitoring wells in the RDX plume. This work is also part of the IAAAP-wide contract and the costs are not separately quantified. Periodic maintenance of the monitoring well network occurs, as for instance several wells (discussed elsewhere herein) had to be abandoned due to their being located in an area that periodically floods. An assessment of all IAAAP monitoring wells was ongoing during this FYR, with a purpose of determining the type of monitoring well maintenance that is needed. This monitoring well maintenance is also performed as part of the IAAAP-wide remediation services contract and the actual costs are not required to be quantified to the Army.

3.5 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This section describes the conclusion and the resolution of issues that were noted in the previous FYR report (Tetra Tech, 2011h).

3.5.1 Protectiveness statement from the 2011 Five-Year Review

"The remedial actions at OU-3, implemented in accordance with the OU-3 ROD, are not yet complete, and are expected to be protective of human health and the environment upon completion. In the interim, exposure pathways that could result in unacceptable risks are being controlled by use of public water, rather than wells, and LUCs."

3.5.2 Status of Issues/ Recommendations from the Last FYR

These Issues/Recommendations which were included in the last Five-Year Review did not affect protectiveness, as is reflected in the Protectiveness Statement shown above. As such, they should not have been listed as "Issues" in the Technical Assessment. However, follow-up actions are discussed below.

1) The groundwater monitoring plan needs to be updated.

- **a.** Implemented actions: The groundwater monitoring plan was updated, and approved by EPA in October, 2011

2) Wells EMW-5, EMW-6, and EMW-7 need to be abandoned.

- **a.** Implemented actions: These wells were abandoned February 9, 2012 at EPA request because they were located in a storm water infiltration basin, and they went under water during storm events and could not be regularly sampled. No replacements to these monitoring points have been installed. These three wells were located from 90 feet to 230 feet south of the south-most extent of the >50 µg/L section of the RDX plume, and the extent of the >50 µg/l plume is now in question.

3) The groundwater model needs to be updated.

- **a.** Implemented actions: Groundwater model was updated for the purpose of re-estimating cleanup times for the MNA remedy. Results were reported in the Follow Up Report to the Five-Year Review (Tetra Tech, 2012b)

4) The groundwater report needs to be updated.

- **a.** Implemented actions: The update requested by the EPA was finalized in July 2012 after EPA review and approval. Annual groundwater monitoring reports have been issued every year since the last Five-Year Review.

3.5.3 Actions Taken Since the Previous FYR

3.5.3.1 Engineering controls

The health departments of Des Moines and Lee counties have permitting authority for new well installations. Contact was made with those departments in 2015, resulting in verification that no new wells had been permitted in the area of the RDX plume since the previous county contact that was made in 2010 (Aerostar, 2015). No contact was made with landowners in the plume area to verify the status of municipal water connections. The Army is working with the State of Iowa to enact a Groundwater Protection Zone on the RDX plume, which would restrict new well installation.

Examination of the private well survey forms (IAAAP, 1992) shows that at least two of the residential wells were installed by the homeowners themselves. When the soil is sandy and the water table is shallow, installing a well via jetting is an easy process, and would not require the homeowner to obtain a well permit. This suggests that there may be present or future wells that would not show up in the well permit records of the counties.

3.5.3.2 Institutional Controls

A RAB meeting was held in 2013 to discuss the status of the OU-3 remedy. No news releases, news articles, or community notices giving the status of the OU-3 remedy were found in searches of project files and the internet.

3.5.3.3 Active Treatment

One injection of 450 gallons of sodium acetate solution occurred in SMW-08 in 2013. During the 2012 groundwater sampling, only this well had an RDX concentration greater than the ROD's active remediation threshold of 50 µg/L, at 150 µg/L of RDX.

3.5.3.4 Passive Treatment, Monitoring, and O&M

Natural attenuation processes continued. Monitoring of most of the Army's wells in the plume area continued annually, generally in the Fall. Annual reports were prepared combining the results for the previous year's sampling, and the plan for the next year's sampling. These reports were finalized in mid-2011, mid-2012, mid-2013, mid-2014, and the 2015 report was in draft stage during the conduct of this FYR. The 2013 report is an Interim Remedial Action Report and it summarizes the previous GW sampling results, and also discusses the status of implementing all aspects of the ROD. For O&M of the monitoring network, three wells (EMW-05, -06, and -07) were abandoned because they were in an area often flooded, and could not be reliably sampled. Also, the sand and gravel company to the east of the RDX plume purchased property that extends onto the east edge of the plume. Two important wells that define the plume edge, MW-136 and MW-408, are located on this property. The company ceased allowing sampling access to these wells on their property after 2011.

3.5.4 Status of Any Other Prior Issues

None

3.6 FIVE-YEAR REVIEW PROCESS

3.6.1 Administrative Components of the Five-Year Review Process

3.6.1.1 Notification of Potentially Interested Parties of Start of Review

A Five-Year Review kickoff teleconference was held with Army stakeholders on May 6, 2015. The start of the FYR was discussed with the EPA at the monthly IAAAP project managers conference call on May 19, 2015. Both the EPA and the Iowa Department of Natural Resources (IDNR) were invited by IAAAP to the FYR site visit held on June 2-4, 2015.

3.6.1.2 Identification of Five-Year Review Team Members

Name	Office	Title
Mr. Jesse Kahler	IAAAP	Restoration Manager
Steve Bellrichard	IAAAP	Environmental Coordinator
Ms. Jen Busard	IAAAP (PIKA)	Office Support to IAAAP
Ms. Darlene Abbott	IAAAP (Aerostar)	Restoration Execution at IAAAP
Dr. Rick Arnseth	IAAAP(Tetra Tech)	Restoration Support to IAAAP
Sandeep Mehta	EPA Region 7	RPM
Dan Cook	IDNR	PM
Cyril Onewokae	JMC	Environmental PM
Ms. Bridget Lyons	AMC	Environmental PM
Ms. Zaynab Murray	USAEC	ESM
Ms. Stephanie Zigler	USAEC	FYR Manager
Ms. India Nicholson	USAEC	Attorney
Ms. Sue Errett	USACE, CX	FYR Manager
Mike Bailey	USACE, CX	FYR Technical Lead
Ms. Laura Percifield	USACE, Omaha	PM for IAAAP support
Dennis Powers	USACE, Baltimore	Remedial Investigation & Design Section Chief

Name	Office	Title
Russ Marsh	USACE, Baltimore	PM for IAAAP FYR effort
Dr. Charles Lechner	USACE, Baltimore	Chemical Engineer, IAAAP FYR lead, OU1 lead author
Grant Anderson	USACE, Baltimore	Hydrogeologist, OU3 lead author
Richard Braun, PhD	USACE, Baltimore	Risk Assessor, Question B lead author
Alan Warminski	USACE, Baltimore	Lead Chemist, OU4 lead author
Ms. Arlene Weiner	USACE, Baltimore	Independent technical reviewer
Mr. Greg Sauer	USACE, Baltimore	Graphics Preparation, Document Assembly and QC
Mr. Seth Keller	USACE, Baltimore	OUs 5-9 initial author

3.6.1.3 Components and Schedule of FYR

The following schedule was followed in the preparation of this Five-Year Review Report:

Date	**Activity**
May 6, 2015	Project Start, Kickoff Teleconference
May 2015	Document retrieval; visit planning
June 2-4, 2015	Site Inspection
June-August, 2015	Document review, Five-Year Review Report Development
July 25, 2015-August 17, 2015	Army Review of Internal Draft
September 16- December 2, 2015	EPA Review of Draft Five-Year Review
December-February, 2015	Resolution of EPA Comments to the Draft Five-Year Review Report
March 24, 2016	Finalization of Five-Year Review Report

3.6.2 Community Notification and Involvement

Community notification that a Five-Year Review is being conducted was accomplished by publishing notices in the Fort Madison Daily Democrat on 6/12/2015 and the Burlington Hawkeye on 6/11/2015 (**Appendix A**). A copy of the final version of this Five-Year Review Report will be placed in the administrative record/ information repository at the IAAAP following EPA approval and signature. Notices announcing the public availability of this Five-Year Review report will be published in the Fort Madison Daily Democrat and the Burlington Hawkeye newspapers.

3.6.3 Document Review

For this review over 1300 documents were retrieved from

- the publicly accessible RAB/administrative record website (http://iaaap.adminrecord.com/
- the password-restricted IAAAP project website (http://iaaap.maporigin.com/)
- the FUSRAP administrative record website (http://www.mvs.usace.army.mil/Missions/CentersofExpertise/FormerlyUtilizedSitesRemedialActionProgram/IowaFUSRAPAdministrativeRecord.aspx), and
- the Common Access Card-restricted Repository of Environmental Army Documents (READ), operated by the Army Environmental Command

Documents used in this report are listed in the References in **Appendix B**. The categories of documents used most frequently are:

- those published in 2011 and later, that is, those published after the previous Five-Year Review
- all Records of Decision, and Action Memoranda that could be located
- all Remedial Action Completion Reports
- all monitoring and O&M reports, and
- most remedial design plans.

The most important reference documents were the decision documents that contained the remedial action objectives (RAOs), the ARARs, and the RGs. For OU-3, these were:

- Action Memorandum for Permanent Potable Water Supply (Army, 1993)Action Memorandum Addendum for Permanent Potable Water Supply (IAAAP, 2001)
- OU3, offsite groundwater remediation: the Offsite Groundwater ROD (EPA, 2005). This ROD has not been modified.

3.6.4 Data Review

3.6.4.1 Data That Was Reviewed

The electronically tabulated groundwater sampling data for the OU-3 monitoring wells, was evaluated and approximately the last five years of OU-3 monitoring well data was plotted in order to discern trends in RDX, and is discussed in section 4.6.4.5. These plots are included as **Figures 3-4a through 3-4au of Appendix E**. The measured parameters that indicate conditions for RDX degradation, especially oxidation reduction potential (ORP) and dissolved oxygen, were also reviewed.

3.6.4.2 Enhanced Degradation Area Review

In total, 10 out of the 21 injection/monitoring wells are unusable due to damage or abandonment. These wells can be seen in **Figure 3-1** in **Appendix E**, indicated by the fact that they have no analytical result associated with their label. In 2007, sodium acetate was injected into 11 injection points. See Table 3-2 for the six different injection event details. For the last injection event in 2013, only one injection well was used (SMW-08). Unfortunately, this injection well is now also being used as a compliance point. This violates standard engineering practice because injection displaces groundwater and creates a “reaction halo” around the well. It does not measure the effectiveness of the remedy. Ironically, this well represents the highest remaining RDX levels which have been measured (61 µg/l). This practice should be discontinued.

At the present state of the well network: a) the extent of the >50 µg/l plume cannot be accurately determined, b) the effectiveness of the remedial action cannot be determined, and c) the groundwater flow directions cannot be determined. Some maps show the groundwater flow direction to the west, some show it to the south. It is possible that there are extreme changes in flow directions due to the storm water infiltration pond which lies in the middle of the Enhanced Degradation area.

In short, too much of the monitoring network has become unavailable; however, the Army is currently establishing a plan to expand the existing monitoring well network. Because of these factors, it is impossible to determine if the remedy is functioning as intended.

Besides the inadequacy of the monitoring network for detecting the RDX extent and trends, the aquifer parameters were reviewed to determine if they correspond to the conditions that cause the intended Enhanced Degradation. This applies to the area that exceeds 50 µg/L RDX, as ED was selected in the OU-3 ROD for that region. ED is facilitated by an anaerobic environment. The injection of a degradable water-soluble carbon source was intended to create anaerobic conditions. The most recent OU-3 groundwater monitoring report indicates that ORP is generally positive and dissolved oxygen levels are high enough to indicate generally aerobic conditions. In the area of the plume core, (i.e., near wells SMW-08. SMW-09, MW-309, EMW-02, and EMW-04), the ORP was at least 100 mv, and DO was at least 4.5 mg/L, indicating aerobic conditions that are not conducive to RDX degradation.

The anaerobic degradation process has to operate over a timeframe of years, with the appropriate conditions being maintained, in order to achieve the RGs. To sample only once per year, and have that sample show ineffective aerobic conditions, indicates that consistent anaerobic conditions, as were intended by the ROD, are not being maintained. A more frequent sampling schedule, and a more frequent and more spatially distributed injection program, should be considered for implementation.

3.6.4.3 Monitored Natural Attenuation (MNA) Area Review

Approximately 600 acres still exceed the MNA goal of 2 µg/L RDX, beginning at U.S. Highway 61 in the north and extending south to just beyond the Skunk River (see **Figure 3-3**). The extent of the RDX plumes in 2007, 2011, and 2014 are shown in **Appendix E** in **Figures 3-3, 3-2, and 3-1,** respectively. Overall, it appears the plume extent was relatively stable during the 5-year period preceding this FYR.

3.6.4.4 Land Use Controls (LUC) Review

The ROD (section 1.4.1) states, "Institutional controls will include locally issued advisories, and a health and safety program, and other institutional controls as may be needed to ensure that the remedial action objective is met." Certain documents (Tetra Tech, 2012e) (Tetra Tech, 2014b) state that these planned land use controls were designed with the goal of educating the local population through posting signs, locally issued advisories and a health and safety program. However, installation personnel indicated that no advisories or health and safety programs have been initiated. Instead, these institutional controls are being communicated through RAB meetings. RAB meetings are not considered to be the best means of educating the local population about the dangers of consuming RDX-contaminated water.

Section 1.4.1 of the ROD also intends for the Army to enforce Land Use Controls which control the use of new or existing water wells. Unfortunately, enforceable restrictions on well installation in the RDX plume do not currently exist. Installation personnel indicate that the State of Iowa is working with the local counties to initiate restrictions on new water well installation. Inspections of the county records indicate that no new wells have been installed.

3.6.4.5 Data Trends

Trends in the annual sampling results were determined visually by inspecting plots of the RDX concentrations versus time from all the monitoring wells for which data exists.
These concentration trend graphs for OU-3 are shown in **Appendix E**, **Figures 3-4a through 3-4au**. In addition to measured concentrations, dates of injection events are shown. According to the ROD, active injections must continue in the Enhanced Degradation area until RDX levels are reduced to less than 50 µg/L of RDX. This value is annotated as the Remedial Action Trigger value on the graphs. The Remedial Goal for RDX in groundwater is 2 µg/L, also shown on the trend figures.

Off-post groundwater was sampled and analysis continued yearly from 2011 to 2014. Indicator wells in the center and outer parts of the plume are generally showing slightly decreasing RDX concentrations, with the exception of wells MW-509 and MW-511, located just north of the Skunk River, with data shown in **Figures 3-4ag and 3-4aj** . For these the trend since the previous FYR appears to be slightly increasing. Yearly sampling studies within the groundwater plume show areal extent reducing more than 70% from the 2007 baseline area as visualized in **Figures 3-1 and**

3-3 in **Appendix E** (Aerostar, 2015a). However, concentrations of RDX in MW-309 and SMW-08 rebounded to greater than 50 µg/L in the November 2014 sampling event following the injection of sodium acetate in SMW-08 in March of 2013, meaning further active remediation will need to occur. In addition to these two wells, seven of the wells nearest to them also showed increasing trends for RDX since the last injection in 2013. These are EMW-02 (**Figure 3-4a**), EMW-04 (**Figure 3-4b**), MW-117 (**Figure 3-4n**), SMW-07 (**Figure 3-4aq**), SMW-09 (**Figure 3-4as**), SMW-10 (**Figure 3-4at**), and SMW-11 (**Figure 3-4au**). Though the RDX level in these wells is below the active remediation trigger of 50 µg/L, it is well above the RG of 2 µg/L, and the increasing trend indicates that conditions in this particular area are not consistently suitable for MNA.

In addition to analysis of RDX concentration trends, a second tool was developed to compare time changes in the mass of RDX as the key indicator of remedial effectiveness. This metric is quantified on a well-by-well basis by calculating the mass in the well itself during each sampling event. In 2011, the RDX mass of indicator wells decreased overall, with 16 exhibiting an overall downward trend, five exhibiting an upward trend and two are stable (Tetra Tech, 2012d). In 2012 indicator well sampling yielded similar results with 15 decreasing, two increasing and five stable (Tetra Tech, 2013b). Year 2014 sampling showed similar trends to the previous years, with two of the three plume-core indicator wells displaying an increasing trend, likely reflecting RDX mass transfer and transport following active treatment (Aerostar, 2015a). Complete historical data for OU-3 is presented in **Appendix F**.

3.6.4.6 Additional Findings

An interim remedial action report was drafted in 2014 (Tetra Tech, 2014a). This report suggests that the remedy for OU-3 has been constructed, is in place, and is operating successfully in accordance with established remedial action objectives, the OU-3 Record of Decision, and the approved OU-3 *Final Remedial Design/Remedial Action Work Plan for Off-Site Groundwater* (Tetra Tech, 2009g), though the active remediation is not yet complete. Because so many of the injection and monitoring wells have become unavailable (and this includes the sentinel wells on both the east and west sides of the plume), these findings may currently be difficult to substantiate.

In 2014 a technical memorandum was produced to document the long-term analytical results obtained during off-post Brush Creek surface water sampling from 1999 through March 2014. These data are important to understanding the long-term relationship between RDX concentrations in the off-post influent (i.e. water losing) stretch of Brush Creek and the OU-3 RDX plume. It was concluded that Brush Creek is not contributing sufficient RDX mass to cause RDX concentrations in groundwater to remain above 2 µg/L (Tetra Tech, 2014c). However, average RDX concentrations in Brush Creek remain between 6.1 µg/L and 9.4 µg/L, depending upon sampling location (Aerostar, 2015b).

3.6.5 Site Inspection

A site inspection was conducted at IAAAP on June 2-4, 2015. The purpose of the inspection was to visually assess the protectiveness of the completed or initiated remedies at IAAAP (OU-1, OU-3, and OU-4). Those offices participating in the inspection included IAAAP, U.S. Army Corps of Engineers-Baltimore District, EPA support contractor, and Tetra Tech (IAAAP support contractor). The inspection consisted of a 3-day driving and walking tour of the individual sites, with the personnel leaving the vehicles to walk the sites for several minutes or more. The team recorded notes, and collected numerous photographs which were georeferenced using Google Earth when they returned to the Baltimore District office. While onsite they were guided by a Tetra Tech staff member with extensive site history and knowledge, and they carried site maps showing areas of soil excavation in OU-1, and site features and monitoring wells for OUs 3 and 4. The weather was excellent and conducive for good visibility.

Off-site wells and the area of the OU-3 RDX plume were inspected during this visit. It was observed that a number of the wells had cracked concrete pads, missing locks, and damaged protective casings. Some of the wells were completely destroyed by farm equipment. Installation staff noted that a complete inventory and condition survey of all IAAAP wells is in progress. It was also noted that wells EMW-5, EMW-6, and EMW-7 had been abandoned due to ponding in their locations.

Site inspection photos are included in **Appendix C**.

3.6.6 Personnel Interviews

Interviews with key members of the environmental restoration program team at IAAAP were conducted in July 2015 by telephone. These included the Restoration Manager at IAAAP, the Regional Project Manager at EPA Region 7, and the environmental manager for the operating contractor at IAAAP. The purpose of the interviews was to obtain views regarding the implementation and performance of the remedies at IAAAP. Interviews are documented in **Appendix D**, and key issues noted for OU-3 are summarized below

OU-3: No concerns were given about the effectiveness of the remedy in reducing contaminant concentrations. However, concerns were raised about the lack of an enforceable potable well restriction in the RDX plume, though clearly the Army is working toward establishing such a restriction. Concerns were also raised that the Army does not have current verification that every one of the residential units in the RDX plume is using the clean municipal water that was previously offered to them by the Army.

3.7 TECHNICAL ASSESSMENT

3.7.1 *Question A*: Is the remedy functioning as intended by the decision documents?

No. The institutional controls called for in the ROD, to include preventing “potential future residential exposures to RDX-contaminated groundwater above 2 µg/L,” as well as the requirement for “locally issued advisories, and a health and safety program” are not yet in place. In addition, because many of the injection/monitoring/sentinel wells have been unavailable for sampling due to abandonment and damage, it is currently difficult to support conclusions about the actual extent and concentration of the plume.

3.7.2 ***Question B:*** **Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?**

Yes. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection are still valid.

The only COC at OU-3 is RDX. The EPA health advisory level (HAL) of 2 µg/L was selected as the RG for RDX (EPA, 2012). No standards identified in the ROD related to this EPA HAL are known to have been changed to call into question the protectiveness of this RG. We are unaware of any newly promulgated standards that call into question the protectiveness of the remedy. Finally TBCs were not used to establish cleanup levels for RDX in groundwater which might be used as tap water.

3.7.2.1 Changes in Exposure Pathways

The land associated with OU-3 includes residential and agricultural uses, and this land use is expected to continue. As described in sections 4.3.2 and 4.7.3, the local sand and gravel quarry has expanded on the east side of the plume and future quarry operations may impact the plume and expose new nearby property areas and receptors to RDX.

3.7.2.2 Changes in Contaminant Toxicity

RDX is the only COC in off-site groundwater as identified in the OU-3 ROD. The oral cancer slope factor of 1.1E-01 $(mg/kg\text{-}day)^{-1}$ for RDX has not changed since the remedy was selected, and it remains the basis for EPA's tap water screening level of 0.70 µg/L (EPA, 2015). The cleanup goal for RDX in OU-3 is 2 µg/L and is within the EPA's protective cancer risk range of 1E-06 to 1E-04 and noncancer hazard index less than one.

3.7.2.3 Changes in Risk Assessment Methods

In February 2014 EPA issued the Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (EPA, 2014a). The default exposure factors included minor changes in residential exposure duration, drinking water ingestion rate, skin surface area, and body weight, which were used in the calculation of the current Tapwater RSL (EPA, 2015).

EPA's RSLs were most recently updated in June 2015 and incorporate EPA's most recent risk assessment methodology, exposure factors (2014), and toxicity values. The RDX tap water screening level of 0.70 µg/L is based on an excess ILCR of 1E-06. The RDX cleanup level of 2 µg/L represents an excess ILCR of 3E-06, which falls within the target cancer risk range of 1E-06 to 1E-04, and noncancer hazard index less than one, as specified by the NCP. Further, the interim action in which residents with RDX concentrations higher than 2 µg/L in their private wells were connected to the regional water supply eliminates exposure, which is protective of human health.

3.7.3 ***Question C*: Has any other information come to light that could call into question the protectiveness of the remedy?**

Yes. The sand and gravel quarry has acquired the land on the eastern side of the plume. Portions of the plume extend onto this property. Quarry operations (dewatering) may have the ability to change the direction of plume movement, expose new areas to RDX contamination, and change the estimated time to meet the RAOs.

3.7.3.1 Technical Assessment Summary

Because the LUCs have not been fully enacted, and because it is easy for landowners to install their own wells without permits or concurrence from the county, it is determined that the remedy is not functioning as intended. Because many of the injection/monitoring/sentinel wells have been unavailable due to abandonment and damage, it is impossible to determine if the active remedy (sodium acetate injection) is working as intended. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection are still valid. Although the remedy is deemed to be short-term protective, due to the expansion of the neighboring quarry to the east, and the fact that landowners can install their own wells without a driller, future protectiveness is not ensured.

Although concerns about the plume extent and trends are significant, and are listed as formal issues in the next section, they are not thought to affect significantly protectiveness because the availability of municipal water extends over the entire plume area.

3.8 ISSUES

Table 3-3: Issues

Issues Affecting Protectiveness	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
1. Enforceable restrictions on well installation in the RDX plume do not exist. A locally issued advisory and health and safety program has not been enacted as stipulated in the ROD (Section 1.4.1). Currently this function is being conducted through the RAB which is considered an imperfect method of reaching the public.	N	Y
Issues Not Affecting Protectiveness	**Currently Affects Protectiveness (Y/N)**	**Affects Future Protectiveness (Y/N)**
1. Sentinel wells on the east and west of the plume are in need of repair, or inaccessible.	N	N
2. Nearly half (10 out of 21) injection/monitoring wells in the Enhanced Degradation part of the plume (i.e., >50 µg/L RDX) have been abandoned or damaged. Groundwater flow directions have not been seasonally established, and seem to vary within 90° between monitoring events.	N	N
3. Consistent and extensive RDX-degrading conditions are not being shown in the annual groundwater report.	N	N

3.9 Recommendations and Follow-up Actions

Table 3-4: Recommendations and Follow-up Actions

Issue	Recommendations and Follow-Up Actions	Party Responsible	Oversight Agency	Recommended Schedule	Affects Protectiveness? (Y/N)	
					Current	Future
1.	Continue working with the State and Counties to enact LUCs. Document the status of enacting LUCs in the annual OU-3 monitoring reports.	Army	EPA	By the annual report published in 2016	N	Y
Issue Not Affecting Protective-ness	**Recommendations and Follow-Up Actions, not affecting protectiveness**	**Party Responsible**	**Oversight Agency**	**Recommended Schedule**	**Affects Protectiveness? (Y/N)**	
					Current	**Future**
1.	Sentinel wells on the east and west of the plume need to be maintained and replaced in sufficient number to be able to delineate the east and west extent of the plume.	Army	EPA	Complete by August 2016	N	N
2.	Abandoned injection and monitoring wells near the Enhanced Degradation part of the plume (i.e., >50 µg/L) need to be replaced to be able to define progress on the Enhanced Degradation portion of the remedy. This includes establishing seasonal groundwater flow directions.	Army	EPA	Complete by August 2016	N	N
3.	For parameters essential to ED, such as DO and ORP, a more frequent sampling schedule, and a more frequent and spatially extensive amendment injection program should be considered, and if not adopted, then rationale should be provided in OU-3 reports.	Army	EPA	By the annual report published in 2016	N	N

3.10 PROTECTIVENESS STATEMENT

OU-3: Short-Term Protective

The remedy at OU-3 currently protects human health and the environment because city water has been offered to all affected residents in the current footprint of the RDX plume. However, in order for the remedy to be protective in the long-term, the following actions need to be taken to ensure protectiveness:

1. Institute a locally issued advisory and a health and safety program to educate the public about the risks of consuming water from the RDX plume.

2. Repair/replace the sentinel well network so that growth or expansion of the plume does not affect those residents not connected to city water.

3.11 NEXT FIVE-YEAR REVIEW

The next Five-Year Review is scheduled for completion no later than five years from the signature date of this report and is anticipated to be March 2021.

4.0 OPERABLE UNIT 4

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Iowa Army Ammunition Plant		
EPA ID: IA7213820445		
Region: 7	**State:** IA	**City/County:** Middletown / Des Moines Co.
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Army		
Author name (Federal or State Project Manager): Mr. Jesse Kahler		
Author affiliation: Restoration Manager, Iowa Army Ammunition Plant		
Review period: May 2015 – July 2015		
Date of site inspection: June 2-4, 2015		
Type of review: Statutory		
Review number: 3		
Triggering action date: April 5, 2011		
Due date *(five years after triggering action date)*: April 5, 2016		

Five-Year Review Summary Form (continued)

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Click here to enter text.

Issues and Recommendations Identified in the Five-Year Review:

OU(s): OU-4 Inert Disposal Area	**Issue Category: Institutional Controls**			
	Issue: Restrict Land Use to commercial/industrial			
	Recommendation: Determine and implement means of formally recording LUCs during Army ownership, such as in the Base Master Plan.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	December 2017

OU(s): OU-4 Inert Disposal Area	**Issue Category: Operations and Maintenance**
	Issue: Vegetative layer on soil cover was not mowed at time of site inspection.
	Recommendation: Insure required schedule of mowing of grass is followed.

Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA	April 2016

<table>
<tr><td rowspan="3">OU(s): OU-4 Inert Disposal Area</td><td colspan="4">Issue Category: Operations and Maintenance</td></tr>
<tr><td colspan="4">Issue: Cracked well pads were observed at numerous wells during the site inspection.</td></tr>
<tr><td colspan="4">Recommendation: Perform sufficient inspection of wells to identify and repair issues such as cracked well pads as part of normal O&M activities.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA</td><td>December 2016</td></tr>
</table>

<table>
<tr><td rowspan="3">OU(s): OU-4 Inert Disposal Area</td><td colspan="4">Issue Category: Operations and Maintenance</td></tr>
<tr><td colspan="4">Issue: Documentation of performance of O&M activities</td></tr>
<tr><td colspan="4">Recommendation: As indicated in the Remedial Action Completion Report, annual reports are to be completed which document numerous O&M activities. Prepare annual reports to document the performance of required O&M activities.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA</td><td>December 2016</td></tr>
</table>

OU(s): OU-4 Inert Disposal Area	**Issue Category: Remedy Performance**			
	Issue: No available closure documentation for Inactive Landfill			
	Recommendation: Locate closure report for Inactive Landfill, with as-built drawings of cap.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA	December 2016

OU(s): OU-4 Inert Disposal Area	**Issue Category: Operations and Maintenance**			
	Issue: Some O&M records might only exist in Tetra Tech files			
	Recommendation: Obtain copies of any original O&M records from Tetra Tech and incorporate into the IAAAP files, and furnish to EPA in OU-4 submittals.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA	December 2016

Protectiveness Statement(s)
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
OU-4 Inert Disposal Area	Short-term Protective	Click here to enter date.

Protectiveness Statement:

The remedy at OU-4 is currently protective of human health and the environment in the short term because nearly all soil has been treated to attain the industrial/commercial remedial goals, and all treated soil is contained in closed RCRA Subtitle C or Subtitle D disposal units. For the remedy to be protective in the long term, language that restricts land use to industrial/commercial, and permanently prevents surface and subsurface disturbance of the ILF, Trench 6, and the CEA should be recorded in appropriate property ownership documents.

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: Choose an item.	*Addendum Due Date (if applicable):* Click here to enter date.
Protectiveness Statement: Click here to enter text.	

4.1 INTRODUCTION

This section documents the methods, findings, and conclusions of a CERCLA Five-Year Review for Operable Unit 4, the Inert Disposal Area (IDA), at the Iowa Army Ammunition Plant, Middletown, Iowa. The IDA is made up of a temporary storage and treatment unit, and 3 permanent soil disposal units. The contents of these units are soils from OU-1 which have met the industrial/commercial RGs of OU-1. The OU-4 Record of Decision addresses the closure of these four units. The remedy for OU-4 has physically attained the remedial goals and is considered complete. The purpose of this Five-Year Review is to determine whether the remedy at OU-4 is

protective of human health and the environment. This report also identifies issues found during the review, and recommendations to address them.
IAAAP is on the CERCLA National Priorities List and has a Federal Facilities Agreement between the U.S. Army (the "lead" agency) and the U.S Environmental Protection Agency. Because IAAAP is on the NPL and because the Army is performing the environmental work under the Defense Environmental Restoration Program, Five-Year reviews are required to be performed consistent with CERCLA section 121 and with the National Contingency Plan (NCP). The NCP, at 40 CFR §300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

The contaminants for OU-4 are primarily explosives, but also include metals and various organic compounds. The remedial goals selected for OU-1 were based on an industrial/commercial land use, which is consistent with the current use of IAAAP as an ammunition plant. Since remedial goals were not based on an unlimited use and unrestricted exposure scenario, this FYR is required.

The Baltimore District of the U.S. Army Corps of Engineers performed this FYR for the remedial actions selected for OU-4 in its Record of Decision. This review was conducted from May 2015 to July 2015. Acting for the IAAAP, the U.S. Army Environmental Command tasked the U.S. Army Corps of Engineers (USACE) with this FYR, and USACE directed that the Baltimore District perform the work.

This FYR is the third FYR for the IAAAP installation as a whole, and the second FYR required for OU-4. The triggering action for this review is the date of the previous five-year review, March 2011, and the fact that the contaminated soils in OU-4 have attained remedial goals that are based on industrial/commercial use.

At the same time as this OU-4 FYR, a FYR was also performed for all other sites and OUs at IAAAP which have initiated remedial action under the DERP FFA. These other FYRs are documented in other sections of this report. Also, in Appendices G through L a status is provided for all other sites being addressed under the DERP FFA, but which are not yet required to have a FYR.

4.2 SITE CHRONOLOGY

The site events for IAAP OU-4 are listed in **Table 4-1**.

Table 4-1: Chronology of Site Events (OU-4)

Sitewide	**Date**
IAAAP used for munitions production	1941 - present
Resource Conservation and Recovery Act (RCRA) Assessment	1987
IAAAP placed on National Priorities List (NPL)	1990
FFA for CERCLA response actions at IAAAP	1990
Facility-wide Preliminary Assessment/Site Investigation (PA/SI)	1992
Facility-wide Remedial Investigation (RI)/Baseline Risk Assessment (BLRA)	1996
OU-4	**Date**
Inert Landfill receives waste	1940s-1980s
Trench 5 of ILF receives RCRA hazardous waste	1980-1983
Trench 5 closed under RCRA	1989
Unfilled Trench 6 and Trench 7 approved to be converted to Subtitle C-equivalent storage units to receive future excavated soils; EPA designates Trench 7 a Corrective Action Management Unit	1996
Inactive Landfill receives soil from removal action	1997
Random Fill Area (CEA) begins receiving lightly contaminated soil	1997
Trenches 6 and 7 outfitted with Subtitle C liners and receive soil from removal actions	1998
Inactive landfill closed with Subtitle D synthetic cover as removal action	1998
OU-4 created in the OU-1 Final ROD *as the base-wide OU, including the IDA*	1998
Trenches 6 and 7 receive soil excavated under OU-1 ROD	1998-2001

Stabilization and biotreatment occurs at Trenches 6 and 7 for WBP soil stockpiled there.	2000-2002
Soil excavated under OU-1 is stockpiled in Trenches 6 and 7	2004-2007
OU-1 Interim Action ROD ESD: transferred CTA, InDA, and PDA from OU-4	2008
OU-4 Interim Action ROD	2008
Bioremediation of contaminated soils in Trench 6 and Trench 7	2008
OU-1 ROD ESD: changed primary remedy from bioremediation to alkaline hydrolysis	2009
Alkaline Hydrolysis of contaminated soils in Trench 6 and Trench 7; Trench 7 treated contents and liner moved to Trench 6; Trench 7 removed	2009
OUs 6 and 7 created; various sites moved out of OU-4 to OU-7, *leaving OU-4 as the IDA closure*	2009
OU-4 Remedial Design/Remedial Action Work Plan (RD/RAWP) issued	September 2010
Cap Extension Area (CEA) capped	2010
Trench 6 capped with RCRA Subtitle C landfill cover	2011
Components of the OU-4 Remedial Action Report prepared	2011-2014

4.3 BACKGROUND

4.3.1 Physical Characteristics

The IAAAP is a load, assemble, and pack (LAP) munitions facility located on approximately 19,000 acres in Middletown, a rural area of eastern Iowa, 10 miles west of Burlington in Des Moines County and approximately nine miles northwest of the Skunk and Mississippi Rivers. The northern area of the IAAAP consists of gently undulating terrain; the central portion is characterized by rolling terrain dissected by a shallow drainage system; and the southern area of the site contains drainage ways with steep slopes down to the creek beds. Elevations within the IAAAP range from 730 feet above mean sea level (amsl) in the north to 530 feet amsl in the south.

The IAAAP contains portions of five watersheds. The Brush Creek watershed comprises the central portion of the facility; Brush Creek exits at the southeastern boundary and flows into the Skunk River, which then flows into the Mississippi River. The Spring Creek watershed drains the eastern portion of the facility; Spring Creek exits at the southeastern corner and flows directly into the Mississippi River. The Long Creek watershed comprises the western portion of the IAAAP; Long Creek exits at the southwestern boundary and joins the Skunk River just south of the facility. Long Creek has been dammed near the center of the facility to create the 85-acre George H. Mathes Lake, which was used as a water source for the facility until January 1977. The Skunk River watershed comprises the southwest corner of the IAAAP; Skunk River borders the facility's perimeter on the southwest corner and provides year-round recreational use. The Little Flint Creek watershed comprises a small area in the north portion of the facility.

OU-4 is located in the west-central part of IAAAP (see **Figure 1**).

4.3.2 Land And Resource Use

The IAAAP produced munitions for World War II from the plant's inception in September 1941 until August 1945, and munitions for military activities in southeast Asia in the 1960s and early 1970s. Activities at the IAAAP continued at a reduced level during peacetime. The plant was operated by Day & Zimmerman Corporation from 1941 to 1946, by the U.S. Government from 1946 to 1951, and by the Mason & Hanger Corporation from 1951 to 1998. The former U.S. Atomic Energy Commission (AEC) operated at Line 1 from 1947 through mid-1975, at which time operation reverted to Army control. The IAAAP is currently an active U.S. Army Joint Munitions Command facility operated by the civilian contractor American Ordnance LLC (AO).

The IAAAP's current mission is to LAP ammunition items, including projectiles, mortar rounds, warheads, demolition charges, and munitions components such as fuzes, primers, and boosters. Because the installation is an active production plant, inactive lines are maintained on standby status or leased to contractors. Lines which will no longer be used by the Army have been placed in modified caretaker status.

Approximately 8,000 acres of the IAAAP are leased for agricultural use, 7,500 acres are forested, and the remaining areas are used for administrative and industrial operations. Hunting and fishing are regulated at the IAAAP through the use of permits. The anticipated future land use at the

IAAAP is commercial/industrial. Public access to the installation is restricted by perimeter fencing and the IAAAP installation security staff.

The land surrounding the IAAAP is characterized as rural, and expected to remain rural. The largest population centers are the towns of Burlington (population: 25,500), West Burlington (3,300), Middletown (500), and Danville (900) (U.S. Census Bureau, 2010). The rural area south (downgradient) of the IAAAP is sparsely populated.

Des Moines County is about 60 percent croplands, 10 percent urban, eight percent pasture, and 22 percent woodlands or idle land. Crops grown in the area consist mostly of corn and soybeans (United States Department of Agriculture, 1983).

4.3.3 History Of Contamination

4.3.3.1 IAAAP

Contamination at the IAAAP is primarily attributable to past industrial and laboratory operating practices involving various explosives-laden sludges, wastewaters, and solids; lead-contaminated sludges; ashes from incineration and open burning of explosives; and waste solvents. Past operations also generated waste pesticides and incendiaries.

The primary contaminants at the installation are royal demolition explosive (RDX) and trinitrotoluene (TNT). Other contaminants such as pesticides, fuel products, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals are also present in some on-site areas. Most of the contamination is contained within the industrial areas of the installation. However, a groundwater plume of explosives-related contamination approximately 1.5 miles long by 1 mile wide has developed off-site near Brush Creek south of the IAAAP. RDX concentrations of up to approximately 200 micrograms per liter (µg/L) historically have been detected in the plume.

Surface water drainage is the primary off-site migration pathway for IAAAP contaminants from Brush Creek, Spring Creek, and Long Creek. The Brush Creek and Long Creek drainages are intercepted by the Skunk River, which flows east toward the Mississippi River. The Spring Creek drainage is intercepted by the Mississippi River. A small area in the northern part of the installation (Yard L) drains into the Little Flint Creek Watershed.

4.3.3.2 The IDA (Current OU-4)

The IDA is an area of approximately 20 acres that formerly included the ILF, and other waste handling activities such as a burning ground, a metal salvage operation, the Former Blue Sludge Lagoon, wastewater sludge drying bed, and an earthen holding area formerly used to store sludge. The ILF was in operation from 1941 to September 1992 and employed the trench and fill operation technique. Trenches 1 through 5 were filled primarily with sanitary landfill materials such as unsalvageable or unrecoverable materials (cafeteria and residential refuse and garbage, broken pallets, plastic, tin cans, scrap wood/lumber, paper, cardboard, and asbestos insulation in double-lined plastic bags). Ash from open burnings and incinerations was also placed in the landfill.

In 1980, a RCRA Part A Permit was received for the ILF and the Blue Sludge Lagoon. Interim status was granted that same year. The lagoon holding area was excavated, backfilled and closed in 1984 following the transfer of the blue sludge to a concrete-lined sludge drying bed, where it remained until January 1997.

The north end of Trench 5 contains “special waste” such as ash from the Contaminated Waste Processor (IAAP-024), EWI (IAAP-025), and open burning of explosives and explosives-contaminated wastes. This area was capped, and the RCRA closure plan was completed in April 1988; this plan was amended in February 1997 to address sampling issues. Radionuclide concentrations in 1997 groundwater samples were determined to be "within normal background levels for IAAAP" and within safe limits.

To provide a facility for handling contaminated soil onsite, the EPA designated "Trench 7" as a CAMU on March 8, 1996 (EPA, 1996). A removal action was taken to cover the ILF Area (CDM, 1997) and to create Trench 6 and Trench 7 at the IDA. From conception, it was planned that Trench 6 would become a permanent soil repository, and Trench 7 would be used for temporary storage and treatment, and after which it would be completely removed and disposed in Trench 6.

Removal actions for soils that were performed in 1996-1998 placed soils into the IDA pending treatment. These included removals at the Line 800 lagoon, the Line 1 impoundment, and a set of 57 sumps at the various load lines. Also, the IDA is a component of the OU-1 Interim Action ROD, for soil excavations at 15 sites. That ROD specifies that excavated soils will be stockpiled in the IDA pending treatment. The IDA/OU-4 is also related to the Final OU-1 Soils ROD, which specifies the treatment method for the soils stockpiled in the IDA.

Soils were segregated by risk before being placed in the IDA. Soils classified as a high health risk were placed in the CAMU (Trench 7) to be held for treatment. Those classified as a medium health risk are placed in Trench 6 and soils that were classified as low health risk were placed in the CEA/Random Fill Area.

"Low-level" contaminated soils, primarily from the Line 1 Impoundment and the Line 800 Pinkwater Lagoon soil removal actions in 1996 and 1997, were used as "random fill" in covering Trenches 1-5 of the ILF prior to placement of the synthetic cap in 1997 (approximately 17 acres).

Approximately 170,000 CY of soil were taken to the IDA for treatment and disposal. Two percent has undergone biological treatment for explosives, eight percent has undergone alkaline hydrolysis treatment for explosives, and five percent has undergone stabilization for metals. The remainder did not require treatment and was simply disposed at the IDA.

As of the 2nd Five-Year Review in 2011, all soil in Trenches 6 and 7 had been treated. The last treatments included, in 2008, 1000 CY at Trench 7 and 500 CY at Trench 6 which were effectively treated with bioremediation, using HFCS as a carbon source, and in 2009, the remaining 10,000 CY at Trench 7 and 3,300 CY at Trench 6 which were treated by alkaline hydrolysis. All treated soil from Trench 7 has been moved to Trench 6 for disposal, along with the Trench 7 liner and all components of leak detection and leachate collection systems.

In 2010, the CEA was capped in accordance with the *Draft Final Remedial Action Work Plan for the Closure of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown Iowa* (Tetra Tech, 2009d). Also in 2010, the water from all three Sediment Ponds was pumped to the Fixed Facility Wastewater Treatment Plant (FFWTP), treated, and discharged

Contamination was not discovered by investigation at OU-4 (IDA), rather OU-4 was constructed in 1996 to handle contamination discovered elsewhere on IAAAP. From the 1940s to the early 1990s IAAAP had disposed of wastes in its Inert Landfill, comprised of 5 disposal trenches. The new soil handling area was sited adjacent to the ILF, and included new Trench 6 and new Trench 7 to the west, and the Cap Extension Area adjacent to the ILF to the south (see **Figure 4-1**). OU-4 then consisted of the ILF, Trenches 6 and 7, and the CEA.

The ammunition loading operations, and also the destruction of off-specification or faulty explosives that was historically conducted by open-burning, caused large areas of soil to be contaminated with explosives. As part of various removal actions and the OU-1 remedial action, these soils were excavated, and segregated into those requiring treatment followed by disposal on IAAAP, and those needing only permanent disposal on IAAAP. These two soil portions were stockpiled in the IDA (OU-4) pending treatment. Treatment occurred successfully in the IDA, and the soil-filled disposal cells were closured as OU-4.

4.3.4 <u>Initial Response</u>

4.3.4.1 Preliminary Assessment and Early Site Identification

Pursuant to the RCRA Hazardous and Solid Waste Amendments of 1984, the EPA completed an assessment of the facility in 1987 and reported that releases had occurred (Ecology and Environment, Inc., 1987). The IAAAP was subsequently placed on the NPL in August 1990 with a Hazard Ranking Score of 29.73.

The U.S. Department of Defense (DoD) has established the Defense Environmental Restoration Program (DERP) to address sites under CERCLA, as amended by the SARA, that are within the responsibility of the DoD. The Army and EPA negotiated a Federal Facility Agreement (FFA) for site cleanup, which became effective December 10, 1990 (EPA, 1990a). The FFA provides a framework for CERCLA response actions to be performed at the IAAAP, including the investigation and cleanup of contamination. The EPA oversees the cleanup activities conducted by the Army to ensure that requirements of CERCLA/SARA, the NCP, and the FFA between the Army and EPA have been met. The State of Iowa is not currently a party to the FFA; however, the State participates in Restoration Advisory Board (RAB) and public meetings.

In 1992, a facility-wide PA/SI of 44 sites with potential contamination was completed (JAYCOR, 1994). In 1993, off-post contamination of private drinking water wells with explosives [RDX and 2,6-dinitrotoluene (DNT)] was confirmed. The IAAAP offered to connect residents south of the installation to the Rathbun Regional Water Supply. One hundred and fifty-four residences accepted the Army's offer.

In 1996, a facility-wide RI/BLRA was completed for 35 of the 44 sites (JAYCOR, 1996). Two of the sites had ongoing RIs and were not addressed; the remaining seven sites were recommended for no further action.

The IAAAP facility was originally divided into four operable units (OUs-1, -2, -3, and -4). OU-2, originally established for soil removal actions, was subsequently merged into OU-1. Several other changes have been made during the course of CERCLA activities at the IAAAP, including realignment and adding of OUs. This section of the FYR report will address OU-4.

4.3.4.2 Removal Actions

The ILF was closed as a removal action in 1997, with an Action Memorandum (CDM, 1997). Closure was performed by covering the wastes with a RCRA Subtitle D-style cap (Tetra Tech, 2009d), constructed as:

- A contouring layer,
- A 0.305-m (1-ft) layer of compacted clay,
- A 1-mm (40-mil) low density polyethylene geomembrane,
- A geocomposite drainage layer,
- A 0.457-m (18-inch) layer of com
- A 0.15-m (6-inch) layer of topsoil, and
- A vegetative cover.

A completion or closeout report containing As-Built drawings was not found in the project online files. The planned "Plan" view and "Section" view of the ILF cover, from the Action Memorandum, are included as **Figure 4-2** and **Figure 4-3**, respectively.

4.3.5 Basis For Taking Action

The ROD notes that "Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Interim Record of Decision (IROD), may present an endangerment to the public health and welfare or the environment."

4.3.5.1 Soil

The primary contaminants in soil are RDX, 2,4,6-TNT, and metals. The soils have been treated to attain: (1) Land Disposal Restrictions, (2) TCLP toxicity limits, and a total risk less than 1E-06 based on an industrial/commercial exposure scenario.

4.3.5.2 Groundwater

OU-4 includes the closure and O&M of the soil disposal areas, and monitoring of groundwater as normal practice for a closed soil disposal facility. It does not include groundwater investigation or remedial response; instead they are included in OU-6. Hence groundwater at OU-4 will be addressed in a future ROD for OU-6.

4.4 REMEDIAL ACTIONS

4.4.1 Remedy selection

4.4.1.1 Scope and Role, and Source Documents

OU-4 addresses the closure of the IDA, which is documented in the Interim OU-4 ROD (EPA, 2008a). At the start of OU-4 closure, OU-4 contained soil that was brought and treated under the terms of the OU-1 ROD. OU-4 is then all the actions needed to create closed disposal units containing that soil.

In 1998, when it was first defined, OU-4 was a "miscellaneous" OU to address issues that were not fully evaluated in other OUs, and to ensure that all remaining necessary remedial actions at the IAAAP are carried out. The 1998 OU-1 Final ROD defined OU-4, specifying that the installation-wide OU would address the closure of the IDA, institutional controls, previously unaddressed areas of soil contamination, VOC-contaminated media, ecological risks, long-term monitoring requirements, and any other unacceptable risks identified and not addressed in either OU-1 or OU-3 (EPA, 1998b). In October 2009, the previously unaddressed areas of soil contamination were moved from OU-4 to OU-7, but the IDA was retained in OU-4.

There are no modifications to the Interim OU-4 ROD.

Figures of the IDA and related site activities are provided in **Figures 4-1 through 4-5 of Appendix E**.

4.4.1.2 Remedial Action Objectives

The OU-4 Interim Action ROD (EPA, 2008a) presents the selected Remedial Action Objectives for closure of Trench 6, Trench 7, and the CEA, and includes:

- Provide adequate cover/cap to protect human health from carcinogenic and non-carcinogenic risks associated with incidental ingestion of, inhalation of, and dermal contact with contaminated soil in excess of the RGs identified in the OU-1 ROD (EPA 1998a). These soil RGs for human health and leaching (i.e., for protection of groundwater) are presented in Table 4-2.

- Provide containment to prevent leaching of chemicals from soil that would result in groundwater concentrations that do not meet the groundwater and surface water standards identified in the Applicable, Relevant, and Appropriate Requirements (ARARs) listed in OU-1 RODs (EPA 1998a and 1998b).

- Provide a cover/cap to protect the environment from the COCs in soil that cause adverse ecological effects as described in the Baseline Ecological Risk Assessment (MWH, 2004).

Table 4-2: Remediation Goals Listed in OU-4 Interim ROD (Table 2-1)

Chemical (µg/g)	Soil Remedial Goal	
	Human Health PRG	Soil Leaching PRG
Antimony	816	NA
Arsenic	30	NA
Beryllium	5	NA
Cadmium	1000	NA
Chromium	10000	NA
Lead	1000	NA
Thallium	143	NA
Banzo(a)anthracene	8.1	NA
Benzo(a)pyrene	0.81	NA
Benzo(b)flouranthene	8.1	NA
Dibenz(a,b)anthracene	0.81	NA
Total PCBs	10	NA
1,3,5-Trinitrobenzene	102	NA
2,4-Dinitrotoluene (2,4-DNT)	8.7	NA
2,4,6-TNT	196	47.6
RDX	53	1.3
HMX	51000	NA

PRG - Preliminary Remediation Goal
NA - PRG value not available
Note: Values are from Table 2 of the OU-1 Interim Record of Decision.

For OU-4 the RAOs were achieved by the following remedy components:

- Removal all sediment in the CEA, Trench 6, and Trench 7 sedimentation ponds that exceed OU-1 ROD RGs or ecological risk criteria for the Indiana Bat, and transport of impacted sediment to Trench 7 for treatment, or Trench 6 for disposal, based on OU-1 ROD RGs.
- Transfer of treated soil, that originated from OU-1 remediation, from Trench 7 to either Trench 6 or the CEA, as appropriate, following criteria established in the OU-1 RODs (EPA, 1998a and EPA, 1998b).
- Removal of the liner, leak detection system components, and leachate collection system components from Trench 7 and disposal in Trench 6.
- Excavation of soil beneath the Trench 7 liner, if necessary, after sampling for clean closure, and dispose of soil in Trench 6 or the CEA, as appropriate. Soils exceeding OU-1 ROD criteria impacted by Trench 7 activities will be managed according to the OU-1 RODs (EPA, 1998a and EPA, 1998b).
- Grading of the excavated areas of Trench 7 for proper drainage and future use using fresh fill from the existing embankment, followed by the addition of topsoil and vegetation.
- Installation of RCRA Subtitle C covers at the CEA and Trench 6 as part of Presumptive Remedy containment.
- Groundwater monitoring to evaluate the performance of landfill cover systems.
- Implementation of site access and future usage restrictions.
- Routine cover inspection, repairs, and maintenance at the CEA.
- Monitoring of cover maintenance, leachate collection, and leak detection at Trench 6 and maintenance and repair of the landfill cover.
- Treatment of Trench 6 leachate in the FFWTP.
- Treatment (in the CEA treatment system or the FFWTP) of contact runoff prior to establishment of vegetative layers from the caps of Trench 6 and the CEA.
- Decommissioning and decontamination of the CEA treatment system once it is no longer needed.

4.4.2 Remedy Implementation At OU-4

All treatment of OU-1 soils stockpiled in OU-4 was completed in accordance with the OU-1 Final ROD and ESDs by 2009, thereby making it possible to proceed to close OU-4. OU-4 was closed in phases as described in the subsections below, and all closure was completed in November 2011.

Closeout documentation for OU-4 is contained in a multivolume RACR, with different dates for the individual volumes, ranging from 2011 to 2014. Two volumes, for the closure of the CEA, and for O&M and LUCs, are currently in the draft stage. It is understood that progress toward finalizing the entire document was delayed by the expiration of the restoration support contract in late 2014. A new contract has been awarded for post-decision restoration services, and it is expected to resume the progress toward completing the IDA documentation.

Post closure care for OU-4 is being implemented and/or continued. The post closure activities include development of land use controls, long term monitoring of groundwater, site inspections, and general maintenance of the road, landfill caps, stormwater control structures, groundwater monitoring wells, settlement monuments, passive gas vents, and benchmarks, and Five-Year Reviews. The most notable current Land Use Control effort is the ongoing construction of a fence surrounding the entirety of OU-4, which is necessary to restrict intrusive activities by personnel and equipment onto or near the cap/closure systems. A 42-inch chain-link fence is being installed to provide the required access restriction, and the planned location for this fence is illustrated in **Figure 4-1** in **Appendix E** (Tetra Tech, 2014f).

The remedy implementation at each of the 4 units of OU-4 is discussed below.

4.4.2.1 Inert Landfill

The ILF was closed in 1997 as a removal action, as discussed above in the section on removal actions. A plan drawing and section drawing of the planned Subtitle D-type configuration of the cap are shown in **Figures 4-2** and **4-3** in **Appendix E**, respectively.

4.4.2.2 Cap Extension Area

The CEA, located at the southeastern side of the ILF, was used to store materials considered to be "lightly contaminated." In 2010, the CEA was capped in accordance with the *Final Remedial Action Work Plan for the Closure of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown Iowa* (Tetra Tech, 2009d). Closure consisted of covering with a RCRA Subtitle C-style cap meeting 40 CFR 264 requirements, including

- Contouring layer,
- Geosynthetic clay liner,
- Geomembrane,
- Geocomposite drainage layer,
- Infiltration layer,
- Topsoil layer, and
- Vegetative layer.

Completion details for the CEA closure are in the February 2011 document *DRAFT OPERABLE UNIT 4 (OU-4) REMEDIAL ACTION COMPLETION REPORT, VOLUME 1, CAPPING OF THE CAP EXTENSION AREA (CEA)* (Tetra Tech, 2011d). This document includes the as-built plan view of the soil cover, included as **Figure 4-4** in **Appendix E**. **Figure 4-5** in **Appendix E** shows the planned section view for the CEA landfill cover layers, as provided in the workplan for the CEA closure (Tetra Tech, 2009d). Though an as-built is not available of the section view, the CEA closure report notes that the workplan was used in the construction of the landfill cover at the CEA.

In 2010, the water from the CEA Sediment Pond was pumped to the CEA treatment system housed in the IDA Site Office, treated, and discharged. The sediment was then sampled and sent to a laboratory for analysis, in accordance with the Sampling and Analysis Plan for the CEA Sediment Pond Characterization (RAWP Appendix B). The characterization data were then evaluated for human health and ecological risk. Because no contaminants were present at concentrations exceeding OU-1 RGs, the sediment was left in place as noted in the final completion report for the removal of the sediment ponds (Tetra Tech, 2013c).

4.4.2.3 Trench 7

The CAMU (Trench 7) was designed as a temporary storage area for highly contaminated soil from various sites within the IAAAP, waiting for treatment. The CAMU was intended to be the location where treatment would occur, and after all the soil in the CAMU was treated, it would be moved elsewhere in the IDA for permanent disposal, and Trench 7 itself would be completely removed and its components placed in the permanent soil repository of the IDA. The CAMU was designed per RCRA Stockpile Requirements, which are similar to “Subtitle C” (hazardous waste) Landfill Cell. The bottom liner system components, from bottom to top, include:

- Geosynthetic Clay Liner,
- 60 mil Geomembrane,
- Geonet,
- Cushion Geotextile (in the sump areas only),
- 60 mil Geomembrane,
- Geonet,
- Geotextile, and
- 12-inch Soil Cover.

When its treatment activities were completed, Trench 7 was not capped, but was closed by complete removal. In 2010, all treated soils were moved from Trench 7 to Trench 6 for disposal, along with the liner, leak detection system components, and leachate collection system components from Trench 7. Several inches of soil below the liner were also removed and taken to Trench 6 for disposal. The soil beneath this was sampled and determined to have no contaminants with concentrations exceeding OU-1 RGs.

Also in 2010, the water from the Trench 7 Sediment Pond was pumped to the FFWTP, treated, and discharged. The sediment was then sampled and sent to laboratory for analysis. The characterization data were evaluated for human health and ecological risk. Because no contaminants were present at concentrations exceeding OU-1 RGs, the sediment was left in place (Tetra Tech, 2013c).

4.4.2.4 Trench 6

The Trench 6 Soil Repository, located adjacent to the ILF, was designed for permanent storage of moderately contaminated soil from various sites within the IAAAP, without any further treatment to be performed. Trench 6 was designed to have a capacity of approximately 80,000 CY, with the capability for expansion. The bottom of the trench was lined to minimize releases of leachate generated from the storage of contaminated material in the soils repository. Trench 6 was designed per RCRA Stockpile Requirements, which are similar to "Subtitle C" (hazardous waste) Landfill Cell. The bottom liner system components, from top to bottom, include:

- A 12-inch Soil Cover (side slopes only)
- Geogrid (side slopes only)
- Double-sided Geocomposite Drainage Layer (side slopes only)
- Granular Filter Material Layer (trench bottom only)
- Open-graded drainage material (trench bottom only)
- Cushion Geotextile (trench bottom only)
- 60 mil Geomembrane
- Cushion Geotextile (trench bottom only)
- Open-graded drainage material (sump areas only)
- Double-sided Geocomposite Drainage Layer
- 60 mil Geomembrane
- GCL (trench bottom only)

This system incorporates sump areas for leachate collection, and a leak detection system. GAC units are established onsite to treat the collected leachate.

Trench 6 disposal rules changed during 1998, which resulted in some treatment being needed in Trench 6 itself during 2008-2009. The first OU-1 ROD (Interim) allowed soil with risk between 1E-05 and 1E-06 to be disposed in Trench 6. The Final OU-1 ROD changed this to allow only soil with risk less than 1E-06 to enter Trench 6 and all soil with risk >1E-06 was to go to Trench 7 for treatment. The result was that during 1997 to approximately 2000, soil requiring treatment was placed in Trench 6, until the changed disposal rule could be implemented.

As noted previously, all treatment was completed at OU-4 in 2009 in accordance with the OU-1 ROD. After treated soil from Trench 7, and the Trench 7 components themselves, were moved into Trench 6, it was closed in 2011. The capping of Trench 6 was performed in accordance with the *Remedial Design/Remedial Action Work Plan for Capping of Trench 6, the Removal of Trench 7, and the Emptying of Sedimentation Dams 6 and 7* (Tetra Tech, 2010e). It was completed in November 2011 as described in Volume 2 of the Final OU-4 Remedial Action Completion Report (Tetra Tech, 2012f). The cap met the requirements of 40 CFR 264 and consists of the following components, from bottom to top:

- Contouring layer,
- 6-inch select fill,
- Geosynthetic Clay Liner,
- Geomembrane,
- 40-mil low-density polyethylene
- Geocomposite drainage layer,
- 18-inch Infiltration layer,
- 6-inch Topsoil layer, and
- Vegetative layer.

The IDA Landfill Cap for Trench 6 was signed and certified on April 4, 2012 by a professional engineer licensed in the state of Iowa stating that the landfill cap project for Trench 6 has been completed in accordance with the plans and specification prepared by Tetra Tech for that purpose.

The cover system is designed to eliminate direct human and animal contact, contain waste materials in a controlled environment and allow management and safe release of gases generated by decaying organic matter. The cover for Trench 6 is expected to exceed State requirements found in IAC Division 567, Chapters 100-121.

In 2010, the water from the Trench 6 Sediment Pond was pumped to the FFWTP, treated, and discharged. The sediment was then sampled and sent to laboratory for analysis. The characterization data were evaluated for human health and ecological risk. Because no contaminants were present at concentrations exceeding OU-1 RGs, the sediment was left in place (Tetra Tech, 2013c).

Figures 4-6, 4-7, and 4-8 in **Appendix E** show the as-built plan view of the Trench 6 cap, the final cover cross-sections, and the cap details, respectively.

4.4.3 System Operation and Maintenance

4.4.3.1 IDA Contaminated Water Treatment

A water treatment building was constructed in 1999 near the south end of the Trench 6 Soil Repository. The building is equipped with sand filters and GAC units. It treated water generated on the IDA, including surface water runoff, leachate from Trench 6 and Trench 7, and groundwater pumped from the ILF gas vents/dewatering wells. It currently treats leachate from the collection system of closed Trench 6. GAC discharges are sampled after every seven days of use. Sample collection information and operational records are kept on file at the contractor's field office at the IDA. Analytical results are kept on file at the contractor's office in Oak Ridge, Tennessee.

4.4.3.2 Inert Landfill Cap

The operation and maintenance activities required for the project features of the ILF Cap include:

- Maintaining the project signs;
- Mowing of the grass on the cap and the perimeter three times during the growing season;
- Inspecting and repairing any cap surface erosion or settled areas;
- Maintaining the rock surfacing of the access roads;
- Survey the settlement markers twice a year;
- Maintaining surface drainage control features, including: diversion berms, ditches, culverts, and riprap protection;
- The gas vents/dewatering wells and the perimeter gas monitoring probes are to be tested for landfill gases twice a year. The probes and wells are to be monitored for lower explosive

limits, hydrogen sulfide, methane, organic vapor and air pressure;

- Inspecting the two seepage collection outlet pipes that drain the subgrade below the Trench 6 Soil Repository and Detail G of the ILF Cap (quarterly). If leachate is discharging through the pipes, the leachate is to be sampled for explosives (SW-846 8330);
- Maintaining the integrity and effectiveness of the chain link security fence.
- Routine maintenance and sampling of the monitoring wells by others in association with the quarterly monitoring requirements.

4.4.3.3 Actual O&M Costs Over the FYR Period

O&M costs include inspection + reporting (internal draft/draft/draft final/final docs), O&M plan update (internal draft/draft/draft final/final docs), RCRA and CERCLA GW sampling + reporting (internal draft/draft/draft final/final docs).

Based on this, annual operating costs for the last 5 years are shown in **Table 4-3**. Costs for system operation and O&M have been decreasing as caps were installed, due to the decrease in wastewater treatment volumes. Construction of the remedy was completed in November 2011. O&M costs decreased by $29,700 in 2012 to $151,400 with costs staying around that same level for 2013, 2014 and 2015.

The OU-4 ROD estimated O&M costs as $200,000 for years 1 through 3, $153,000 for years 4 to 6, and $143,000 for years 7 to 30. The actual costs are in reasonable agreement with these.

Table 4-3: Annual System Operations/O&M Costs

Dates		Total Cost rounded to nearest $1,000
From	**To**	
1/1/2011	12/31/2011	$181,000.00
1/1/2012	12/31/2012	$151,000.00
1/1/2013	12/31/2013	$157,000.00
1/1/2014	12/31/2014	$151,000.00
1/1/2015	12/31/2015	$148,000.00 (estimated)

4.5 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This section describes the conclusion and the resolution of issues that were noted in the previous FYR report (Tetra Tech, 2011h).

4.5.1 Previous Protectiveness Statement

The protectiveness statement from the March 2011 FYR report is:

"The remedial actions at OU-4, implemented in accordance with the OU-l ROD and the OU-4 Interim Action ROD, are not yet complete and are expected to be protective of human health and the environment upon completion. In the interim, exposure pathways that could result in unacceptable risks are being controlled."

4.5.2 Status of Recommendations and Followup Actions from the Last Review

Table 4-4: 2nd FYR OU-4 Issues and Resolution

Issue	Resolution
Seddam 6: Remove old pallet and hoses	The hoses and old pallet were removed from the Seddam 6 area in January 2012. This issue is considered resolved.
ILF: Remove barrel and flash contents according to Army protocol and applicable permits.	On March 28, 2011, the drum was transferred to American Ordnance (AO) for flashing and final disposition. This issue is considered resolved.
FFWTP: Remove phone system or note that it is not in use.	The paging phone system was removed from the FFWTP building in June 2011. This issue is considered resolved.
FFWTP: Investigate and repair siphoning issue with carbon columns	An electrician was utilized to remove any of the electric equipment that was not being used and repair the issue with the level alarms. By fixing the level alarms in the influent tank, the siphoning issue with the carbon columns and influent tank were also mitigated. Upon repair the system operates so that when the system finishes treating a tank of water and the pumps are shut off, the effluent valve closes. With the effluent valve closed, the siphoning issue is eliminated. This issue is considered resolved.
FFWTP: Investigate and repair issue with high level alarm in carbon column.	
FFWTP: Install check valve in gas vent line coming into FFWTP building.	The leachate collection and detection lines were replaced in August 2011, and now have a manual switch and check valve installed to prevent siphoning of water from the FFWTP. This issue is considered resolved.

4.5.3 Results of Implemented Actions

These issues were resolved. No comments about these issues were noted during the site visit or interviews.

4.6 FIVE-YEAR REVIEW PROCESS

4.6.1 Administrative Components of the Five-Year Review Process

4.6.1.1 Notification of Potentially Interested Parties of Start of Review

A Five-Year Review kickoff teleconference was held with Army stakeholders on May 6, 2015. The start of the FYR was discussed with the EPA at the monthly IAAAP project managers conference call on May 19, 2015. Both the EPA and the Iowa Department of Natural Resources (IDNR) were invited by IAAAP to the FYR site visit held on June 2-4, 2015.

4.6.1.2 Identification of Five-Year Review Team Members

Name	Office	Title
Mr. Jesse Kahler	IAAAP	Restoration Manager
Steve Bellrichard	IAAAP	Environmental Coordinator
Ms. Jen Busard	IAAAP (PIKA)	Office Support to IAAAP
Ms. Darlene Abbott	IAAAP (Aerostar)	Restoration Execution at IAAAP
Dr. Rick Arnseth	IAAAP(Tetra Tech)	Restoration Support to IAAAP
Sandeep Mehta	EPA Region 7	RPM
Dan Cook	IDNR	PM
Cyril Onewokae	JMC	Environmental PM
Ms. Bridget Lyons	AMC	Environmental PM
Ms. Zaynab Murray	USAEC	ESM
Ms. Stephanie Zigler	USAEC	FYR Manager
Ms. India Nicholson	USAEC	Attorney
Ms. Sue Errett	USACE, CX	FYR Manager
Mike Bailey	USACE, CX	FYR Technical Lead

Name	Office	Title
Ms. Laura Percifield	USACE, Omaha	PM for IAAAP support
Dennis Powers	USACE, Baltimore	Remedial Investigation & Design Section Chief
Russ Marsh	USACE, Baltimore	PM for IAAAP FYR effort
Dr. Charles Lechner	USACE, Baltimore	Chemical Engineer, IAAAP FYR lead, OU1 lead author
Grant Anderson	USACE, Baltimore	Hydrogeologist, OU3 lead author
Richard Braun, PhD	USACE, Baltimore	Risk Assessor, Question B lead author
Alan Warminski	USACE, Baltimore	Lead Chemist, OU4 lead author
Ms. Arlene Weiner	USACE, Baltimore	Independent technical reviewer
Mr. Greg Sauer	USACE, Baltimore	Graphics Preparation, Document Assembly and QC
Mr. Seth Keller	USACE, Baltimore	OUs 5-9 initial author

4.6.2 Schedule

The following schedule was followed in the preparation of this Five-Year Review Report:

Date	Activity
May 6, 2015	Project Start
May 2015	Document retrieval; visit planning
June 2-4, 2015	Site Inspection
June-July, 2015	Five-Year Review Report Development
September 16- December 2, 2015	EPA Review of Draft Five-Year Review
December-February, 2015	Resolution of EPA Comments to the Draft Five-Year Review Report

March 24, 2016 Finalization of Five-Year Review Report

4.6.3 Community Notification and Involvement

Community notification that a Five-Year Review is being conducted was accomplished by publishing notices in the Fort Madison Daily Democrat on 6/12/2015 and the Burlington Hawkeye on 6/11/2015 (**Appendix A**). A copy of the final version of this Five-Year Review Report will be placed in the administrative record/ information repository at the IAAAP following EPA approval and signature. Notices announcing the public availability of this Five-Year Review report will be published in the Fort Madison Daily Democrat and the Burlington Hawkeye newspapers.

4.6.4 Document Review

For this review over 1300 documents were retrieved from

- the publicly accessible RAB/administrative record website (http://iaaap.adminrecord.com/
- the password-enabled IAAAP project website (http://iaaap.maporigin.com/)
- the FUSRAP administrative record website (http://www.mvs.usace.army.mil/Missions/CentersofExpertise/FormerlyUtilizedSitesRemedialActionProgram/IowaFUSRAPAdministrativeRecord.aspx), and
- the Common Access Card-enabled Repository of Environmental Army Documents (READ), operated by the Army Environmental Command

Documents used in this report are listed in the References in **Appendix B**. The categories of documents used most frequently were:

- those published in 2011 and later, that is, those published after the previous Five-Year Review
- all Records of Decision, and Action Memoranda that could be located
- all Remedial Action Completion Reports
- all monitoring and O&M reports, and
- most remedial design plans.

4.6.5 Data Review

GAC discharges from the FFWTP are sampled after every seven days of use. Sample collection information and operational records are kept on file at the contractor's field office at the IDA. Analytical results are kept on file at the contractor's office in Oak Ridge, Tennessee.

4.6.6 Site Inspection

A site inspection was conducted at IAAAP on June 2-4, 2015. The purpose of the inspection was to visually assess the protectiveness of the completed or initiated remedies at IAAAP for OU-4, the integrity of the cap, including the presence of fencing to restrict access. Those offices participating in the inspection included IAAAP, U.S. Army Corps of Engineers-Baltimore District, EPA support contractor, and Tetra Tech (IAAAP support contractor).

The following locations were visited:

Inert Disposal Area – Inactive Landfill, Cap Extension Area, Trench 6, and Trench 7 along with their respective Seddams and the FFWTP. A team of three USACE staff drove the perimeter road that follows the south and east sides of the closed CEA, the east and north sides of the ILF, the north and south sides of closed Trench 6, and the north and west sides of removed Trench 7. They walked on the north side of the CEA cap, and along the north part of the swale that divides the CEA and the ILF. They walked on the north part of the Trench 6 cap, and the north part of the swale that divides Trench 6 and the ILF. They inspected the former Trench 7 sediment pond, the Fixed Facility Wastewater Treatment Plant, and drove the road that follows the southwest edge of Trench 6 and inspected the edge of the Trench 6 cap there. They walked the short roadway along the south edge of the Trench 6 cap. They viewed the south end of the swale that divides the CEA and the ILF, and the south edge of the ILF cap.

The landfill caps were found to be in very good condition, in terms of having a lush, unbroken vegetative cover in all the areas that could be viewed, and having an unbroken rip-rapped edge. The inspection was limited by the fact that the vegetation was high enough (i.e., knee high) that small areas of possible erosion or settlement would not have been visible.

Site inspection photos are included in **Appendix C**.

4.6.7 Personnel Interviews

Interviews with key members of the environmental restoration program at IAAAP were conducted in July 2015 by telephone. The purpose of the interviews was to obtain views regarding the implementation and performance of the remedies at IAAAP. Those participating in the interviews represented the Army, EPA, and AO. Interviews are documented in **Appendix D**.

4.7 TECHNICAL ASSESSMENT

4.7.1 Question A: Is the Remedy functioning as intended by the Decision Documents?

Yes. In 2010, the CEA was capped in accordance with the *Draft Final Remedial Action Work Plan for the Closure of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown Iowa* (Tetra Tech, 2009d). Also in 2010, the water from the all three Sediment Ponds was pumped to the FFWTP, treated, and discharged.

The IDA Landfill Cap for Trench 6 was signed and certified on April 4, 2012 by Mr. Bryan C. Bross, a professional engineer licensed in the state of Iowa stating that the landfill cap project for

Trench 6 has been completed in accordance with the plans and specification prepared by Tetra Tech for that purpose.

Maintenance procedures at OU-4, as discussed in Section 4.3.3, will maintain the effectiveness of the response actions. Potential remedy problems should be identified early through routine monitoring and maintenance activities.

Formalized LUCs will be addressed in the OU-7 ROD, which as of this Report has not been issued yet. In the interim, engineering controls (i.e., partial perimeter fence, locked gate on access road) and access protocols (i.e., badge required for access) are in place for maintaining restricted site access to only those staff involved in capping and maintenance activities. However the current IDA fence does not encompass the entire site boundaries of the IDA. The Installation is currently in the process of fencing the entire site. The IDA boundary fence will be a physical land-use control to restrict intrusive activities by personnel and equipment onto or near the cap/closure systems. A 42-inch chain link fence will provide the required access restriction. These restrictions are in addition to those in place for all of the IAAAP. These controls prevent plant workers, contractors, construction workers, and other site visitors from inadvertently being exposed to OU-4 site contaminants. Currently, coordination of digging permits, utility repairs, maintenance, or other site work is accomplished through internal coordination between AO and the IAAAP staff to ensure that workers are aware of and protected from potential environmental hazards. Hunting and fishing are allowed on the IAAAP only in designated areas and are controlled through an in-place permit system. Hunters must attend a hunter safety briefing prior to each year's hunting season.

4.7.2 Question B: Are the exposure assumptions, toxicity data, clean-up levels and RAOs used at the time of the remedy selection still valid?

Yes. The current land use of the site has been the same as during the previous five year review. Since OU-4 is only the IDA and has only served historically as a landfill, no changes in land use are anticipated.

All changes in the physical site conditions at the IDA are the result of the implementation of the OU-4 remedy.

There are no new exposures. Since OU-4 is a permanent waste repository/landfill and has been closed and capped, therein mitigating exposure to waste materials, changes in toxicity data and resultant RGs or RSLs are not relevant.

4.7.2.1 Changes in Standards and To Be Considered:

The primary standards affecting protectiveness at OU-4 are the EPA RCRA Subtitle C and Subtitle D landfill closure regulations. These regulations ensure that landfilled hazardous and solid wastes will remain immobile and not leach contaminants for a period of at least 30 years. Trench 7 has been clean closed, that is all waste and infrastructure have been removed to Trench 6. Trench 6 and the CEA have been closed using the Subtitle C specifications. The Inert Landfill has been closed using the Subtitle D, or Subtitle D equivalent, specifications. The Federal regulations for these two Subtitles were consulted and no changes have been made since the last Five-Year Review.

The State of Iowa does not have authorization to administer the Federal RCRA program for hazardous and solid waste landfills (EPA, 2014c), rather EPA Region VII administers the program.

There have been no changes in standards identified as ARARs in the ROD, newly promulgated standards, and/or changes in TBCs identified in the ROD, that could call into question the protectiveness of the remedy.

4.7.2.2 Changes in Exposure Pathways, Toxicity, and other Contaminant Characteristics:

No new human health or ecological exposure pathways or receptors have been identified. No new contaminants or contaminant sources have been identified. The OU-4 remedy includes the capping of contaminated soils in lined landfill cells (trenches) at the IDA. The caps over the ILF, Trench 6, and the CEA are complete, thereby removing exposure pathways to surface soil and subsurface soil at those areas.

4.7.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No. There is no new information, chemical data, ARARs, or toxicity information that indicates the remedy is not protective. All wastes are contained and have been capped, thereby mitigating exposure. There are no known land use changes at IAAAP being considered by officials.

Based on the most current online FEMA floodplain maps (effective 8/2/2011), the 100-year flood plain is estimated to cover small areas immediately adjacent to the creeks on the installation and near Skunk River. The floodplain maps were georeferenced and overlaid on georeferenced OU-4 figures using Google Earth, and it is concluded that OU-4 components are at least approximately 700 feet from the nearest section of 100-year floodplain.

4.8 ISSUES

An issue affecting protectiveness in the long term is that land use controls are not yet recorded in property documents.

4.9 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The following actions are recommended <u>based on observations noted</u> during the June 2015 site inspection or personnel interviews.

- During the June 2, 2015 site visit of the IDA, there was fully grown vegetative cover on each of the trenches and the CEA. Growth was rather tall; approximately knee height and was in need of mowing. The approved mowing schedule should be followed. Affect Protectiveness? NO

- Some of the well pads were cracked. It is understood that cracked well pads, or other monitoring well issues, are being addressed by a site-wide well maintenance contract task. Appropriate well inspections should be conducted and issues that affect data quality should be identified and addressed. Affect Protectiveness? NO

- Though O&M is occurring, such as the leachate collection and treatment that was observed on the site visit, no report documentation of O&M activities was found in the project files. The draft RACR for OU-4 indicates that annual reports will be generated covering issues like leachate collection and treatment, cover inspections and maintenance, drainage swale inspection and maintenance, roadway and fence maintenance, etc. In addition, during stakeholder interviews the EPA POC indicated such reports have not been sent to him. The RACR indicates that maintenance logs will be kept; hence it is likely that O&M information is being recorded. Annual reports to document O&M for the closed OU-4 IDA need to be generated. Past years without reports should have any existing O&M information collected and placed in report format as well in order to maintain the record that the Army has properly maintained the three IDA disposal areas. O&M is essential to the effectiveness of the OU-4 remedial action, and needs to be performed and documented. Affect Protectiveness? NO

- For closure of the ILF, a completion report with as-built drawings is needed for the project files. Affect Protectiveness? NO

- O&M records for which the only copies are stored at Tetra Tech offices should be copied and furnished to IAAAP for the project files, and incorporated into the appropriate FFA submissions to the EPA. Affect Protectiveness? NO

4.10 PROTECTIVENESS STATEMENT

The remedy at OU-4 is currently protective of human health and the environment in the short term because nearly all soil has been treated to attain the industrial/commercial remedial goals, and all treated soil is contained in closed RCRA Subtitle C or Subtitle D disposal units. For the remedy to be protective in the long term, language that restricts land use to industrial/commercial, and permanently prevents surface and subsurface disturbance of the ILF, Trench 6, and the CEA should be recorded in appropriate property ownership documents.

4.11 NEXT REVIEW

The next Five-Year Review is scheduled for completion no later than five years from the signature date of this report and is anticipated to be March 2021.

APPENDIX A: COMMUNITY NOTIFICATION

Third Five-Year Review for the Iowa Army Ammunition Plant

The U.S. Army is conducting the third Five-Year Review of the environmental remedial actions that have been implemented at the Iowa Army Ammunition Plant (IAAAP) located in Middletown, Iowa. The purpose of the Five-Year Review is to determine whether the remedial actions are protective of human health and the environment. In addition, the Five-Year Review report will identify issues, if any, found during the review and make recommendations to address them.

The Iowa Army Ammunition Plant environmental cleanup is divided for management purposes into eight operable units, or OUs. The Five-Year Review is required for those OUs that have progressed through the investigation stage, reached a cleanup decision, and begun cleanup. These OUs requiring the review are: OU1, contaminated soil cleanup on the ammunition plant; OU3, off-site contaminated groundwater cleanup southeast of the ammunition plant near Brush Creek and the Skunk River; and OU4, capping and closure of engineered landfill cells on the ammunition plant. The remedy for OU1 included excavation of contaminated soils, treatment of the most highly contaminated soils on the ammunition plant, and placement of the soils in an engineered disposal area near the center of the ammunition plant. The remedy for OU3 included connecting well users to the public water supply system, treating the most highly contaminated parts of the groundwater by injecting an agent that will degrade the contamination, and monitoring the groundwater to ensure the contaminant concentrations continue to decline. The remedy for OU4 was to cover the landfill cells with an engineered cover that minimizes the ability of the contamination to migrate, and to perform periodic monitoring of the water leaving the cells to ensure that contamination is not present.

The Army is conducting this Five-Year Review as required by the Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund, and the National Contingency Plan. The Army will conduct the review with oversight and support from the U.S. Environmental Protection Agency and the Iowa Department of Natural Resources.

The final Five-Year Review report will be available in April 2016 through the Information Repository located at IAAAP Administrative Building 100-101.

For more information regarding environmental activities at the Iowa Army Ammunition Plant, contact: Mrs. Murray at (319) 753-7705.

June 11, 2015_11

STATE OF IOWA

COUNTY OF DES MOINES } SS.

I, Steve Delaney, being first duly sworn, depose and say that I am the Editor/Publisher of The Hawk Eye Company, a corporation, printers and publishers of The Hawk Eye, a newspaper of general circulation published in said County, and that the attached notice was published once

in said newspaper on 6/11/2015.

The first publication being on the 11th day of June, 2015.

Sworn and subscribed before me, a Notary Public in and for said County, on the 11th day of June, 2015.

Joann Wiegard

Notary Public in and for Des Moines County

NOTARIAL SEAL IOWA
JOANN WIEGARD
Commission Number 781165
My Commission Expires
November 4, 2016

Affidavit of Publication in THE DAILY DEMOCRAT, Fort Madison, Iowa

THIRD FIVE-YEAR REVIEW FOR THE IOWA ARMY AMMUNITION PLANT

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The Iowa Army Ammunition Plant environmental cleanup is divided for management purposes into eight operable units, or OUs. The Five-Year Review is required for those OUs that have progressed through the investigation stage, reached a cleanup decision, and begun cleanup. These OUs requiring the review are: OU1, contaminated soil cleanup on the ammunition plant; OU3, off-site contaminated groundwater cleanup southeast of the ammunition plant near Brush Creek and the Skunk River; and OU4, capping and closure of engineered landfill cells on the ammunition plant. The remedy for OU1 included excavation of contaminated soils, treatment of the most highly contaminated soils on the ammunition plant, and placement of the soils in an engineered disposal area near the center of the ammunition plant. The remedy for OU3 included connecting well users to the public water supply system, treating the most highly contaminated parts of the groundwater by injecting an agent that will degrade the contamination, and monitoring the groundwater to ensure the contaminant concentrations continue to decline. The remedy for OU4 was to cover the landfill cells with an engineered cover that minimizes the ability of the contamination to migrate, and to perform periodic monitoring of the water leaving the cells to ensure that contamination is not present.

The Army is conducting this Five-Year Review as required by the Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund, and the National Contingency Plan. The Army will conduct the review with oversight and support from the U.S. Environmental Protection Agency and the Iowa Department of Natural Resources.

The final Five-Year Review report will be available in April 2016 through the Information Repository located at IAAAP Administrative Building 100-101.

For more information regarding environmental activities at the Iowa Army Ammunition Plant, please contact: Mrs. Zaynab Murray at (319) 753-7705.

Published June 12, 2015 in the Daily Democrat, Fort Madison, Iowa 52627_1t.

State of Iowa, Lee County, ss.

I, Mary Older

being duly sworn, depose and say that I am General Manager

of

The Daily Democrat

a daily newspaper published and circulated in said County, and that the notice, of which the annexed is a true copy, was published in said newspaper for the full period of times, to wit:

June 12, 2015

M Older

Subscribed and sworn to before me this 12th day of June 2015.

Deva Kay Ross

Printer's Fee, $ 32.41

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Prepared by the Daily Democrat • 319-372-6421 • P.O. Box 160 • Fort Madison, IA 52627

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[2] NOTE: The environmental point of contact has changed from Ms. Murray to Mr. Jesse Kahler, (319) 753-7339.

APPENDIX B: REFERENCES

REFERENCES

Aerostar, 2015a. *Draft OU-3 Off-site Annual Groundwater Monitoring Report and Sampling & Analysis Plan Environmental Remedial Action Services, Iowa Army Ammunition Plant Burlington, Iowa*. Prepared by Aerostar SES LLC, Oak Ridge, TN for USACE Omaha District, Omaha, NE, under contract No. W9128F-10-D-0099-0004. April.

Aerostar, 2015b. *Draft Annual Surface Water Monitoring Report for Brush Creek, Environmental Remedial Action Services, Iowa Army Ammunition Plant, Burlington, Iowa.* Prepared by Aerostar SES LLC, Oak Ridge, TN for U.S. Army Corps of Engineers Omaha District under contract No. W9128F-10-D-0099, Delivery Order No. 0004. August.

AET/AO (Advanced Environmental Technology, Inc. and American Ordnance), 2001. *Field Sampling Report for Building 600-84 at the IAAAP*. February.

Army, 1993. *ACTION MEMORANDUM, IOWA ARMY AMMUNITION PLANT, PERMANENT POTABLE WATER SUPPLY,* approved August 2, 1993 by Deputy Assistant Secretary of the Army (ESOH)

Army, 2006. *Operable Unit 4 Work Plan for Supplemental Remedial Investigation Statement of Dispute Resolution*. December 21.

Army, 2009. Letter from Rodger D. Allison to Matthew Jefferson, U.S. Environmental Protection Agency, restructuring Operable Units at the Iowa Army Ammunition Plant. October 7.

Army, 2010. Letter from Rodger D. Allison to Sandeep Mehta, U.S. Environmental Protection Agency, withdrawing the Draft Final Feasibility Study for Operable Unit 6 Sitewide Groundwater at the Iowa Army Ammunition Plant dated April 2010. December 8.

Army, 2011. *Field Modification for the Final Work Plan for Supplemental Remedial Investigation of Groundwater and Surface Water at Line 1, Iowa Army Ammunition Plant (IAAAP).* December.

Army, 2015. *Notice of Public Comment Period Proposed Plan for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002 Operable Unit Nine, Iowa Army Ammunition Plant Middletown, IA.* January.

CAPE, 2002. *Draft Final Remedial Action Report, Iowa Army Ammunition Plant, Focused Feasibility Soil Study Sites, Phase 3, Remedial Action - West Burn Pads Area, Middletown, IA.* Prepared by CAPE Environmental, Waukegan, IL for USACE-Omaha District under contract DACA45-97-0022 Delivery Order 0009. December.

CB&I, 2013a. *Engineering Evaluation/Cost Analysis, Historical Small Arms Range, Military Munitions Response Program, IOWA ARMY AMMUNITION PLANT, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers-Omaha District by CB&I, Belcamp, MD. Contract Number W9128F-10-D-0060, Delivery Order 002. April.

CB&I, 2013b. *Draft Final Action Memorandum, Historical Small Arms Range, Military Munitions Response Program, IOWA ARMY AMMUNITION PLANT, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers-Omaha District by CB&I, Belcamp, MD. Contract Number W9128F-10-D-0060, Delivery Order 002. October.

CB&I, 2014. *Final Record Of Decision Operable Unit 5, Military Munitions Response Program, Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by CB&I Federal Services, Belcamp, MD for U.S. Army Corps of Engineers, Omaha District under contract W9128F-10-D-0060. September.

CB&I, 2015. *Draft Final Removal Action Work Plan, Historical Small Arms Range, Iowa Army Ammunition Plan, Military Munitions Response Program*. Prepared by CB&I Federal Services, Belcamp, MD for U.S. Army Corps of Engineers, Omaha District under contract W9128F-10-D-0060. May.

CDM, 1994a. *Final Engineering Evaluation/Cost Analysis for the Pesticide Pit Removal* a*t the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. October.

CDM, 1994b. *Final Engineering Evaluation/Cost Analysis for the Explosive-Contaminated Sumps* a*t the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. October.

CDM, 1995a. *Final Action Memorandum for the Pesticide Pit* a*t the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. March.

CDM, 1995b. *Final Action Memorandum for the Explosive-Contaminated Sump Removal* a*t the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. November.

CDM, 1995c. *Draft Final Engineering Evaluation/Cost Analysis for Three Removal Actions, Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. May.

CDM, 1996. *Action Memorandum For The Line-800 Pinkwater Lagoon, Former Line 1 Impoundment at the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared for U.S. Army Corps of Engineers, Omaha District by CDM Federal Programs Corporation, Lenexa, KS under contract DACW45-93-D-0004/0012. October.

CDM, 1997. *Action Memorandum for the Inert Landfill at the Iowa Army Ammunition Plant, Middletown, Iowa,* September.

Dames and Moore, 1989. *Draft Final Feasibility Study Iowa Army Ammunition Plant: Former Line 1 Impoundment and Line 800 Pink Water Lagoon.* August.

Dames and Moore, 1989. *Draft Final Endangerment Assessment Iowa Army Ammunition Plant: Former Line 1 Impoundment and Line 800 Pink Water Lagoon.* July.

ECC, 1997. *Explanation of Significant Difference and Action Memorandum, Fire Training Pit, Iowa Army Ammunition Plant, Middletown, IA.* Prepared for U.S. Army Corps of Engineers, Omaha District by Environmental Chemical Corporation, Burlingame, CA. December.

ECC, 2000a. *Final Remedial Action Report, Focused Feasibility Study Sites, Remedial Action – Phase I, Iowa Army Ammunition Plant*. Prepared by Environmental Chemical Corporation, Denver, CO for U.S. Army Corps of Engineers, Omaha District. October.

ECC, 2000b. *Final Remedial Action Report, Iowa Army Ammunition Plant, Fire Training Pit.* Prepared for U.S. Army Corps of Engineers, Omaha District by Environmental Chemical Corporation, Denver, CO under contract DACA45-95-D-0026/0005. April.

ECC, 2001a. *Draft Remedial Action Report, Iowa Army Ammunition Plant, Multiple Removal Actions.* April.

ECC, 2001b. *Final Remedial Action Report, Iowa Army Ammunition Plant, Focused Feasibility Study Sites, Phase II.* April.

ECC, 2001c. *Draft Final Excavation Report, Iowa Army Ammunition Plant, Focused Feasibility Soil Study Sites, Phase 3, Remedial Action - West Burn Pads Area, Middletown, IA.* Prepared by Environmental Chemical Corporation for USACE-Omaha under contract DACA45-95-D-0026, Delivery Order 0008. November.

ECC, 2005. *Draft Addendum Remedial Action Report, Fire Training Pit, Iowa Army Ammunition Plant.* August.

Ecology and Environment, Inc., 1987. *RCRA Facility Assessment*, Final Report for the Iowa Army Ammunition Plant, Middletown, IA. June.

Engineered Efficiency, 1997. *Draft Final Soils Focused Feasibility Study, Vol. 1 of 1* (Document contains the notation on the first page "Per the Federal Facility Agreement for Iowa Army Ammunition Plant, Article X.B.1, the attached document is the final version of the submitted document.) Prepared for U.S. Army Environmental Center, APG, MD by Engineered Efficiency, Harrisonville, MO under contract DAAM01-96-M-0064. 08 May 1997.

EPA, 1990a. *Federal Facilities Agreement*, Administrative Docket Number VII-F-90-0029, September.

EPA, 1990b. *Guidance on Remedial Actions for Superfund Sites with PCB Contamination* OSWER 9355.4-01. August.

EPA, 1992. *Health Effects Assessment Summary Tables (HEAST).*

EPA, 1996. *Designation of Corrective Action Management Unit*. Iowa Army Ammunition Plant, Middletown, Iowa. March.

EPA, 1998a. *Interim Action Record of Decision. Soils Operable Unit*. Iowa Army Ammunition Plant, Middletown, Iowa. March 4.

EPA, 1998b. *EPA Superfund Record of Decision*. Iowa Army Ammunition Plant, Middletown, Iowa. EPA ID: IA7213820445. September 29.

EPA, 2001. *Comprehensive Five-Year Review Guidance*, EPA-540-R-01-007, OSWER No. 935.7-03B-P. June.

EPA, 2003a. *Draft Final Explanation of Significant Differences for the Final Record of Decision (ROD) for the Soils Operable Unit (OU-1). Iowa Army Ammunition Plant, Middletown, Iowa*. January.

EPA, 2003b. *Human Health Toxicity Values in Superfund Risk Assessments.* OSWER Directive 9285.7-53, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. December 5, 2003.

EPA, 2004. *Dispute Resolution, Iowa Army Ammunition Plant*. February.

EPA, 2005. *Off-site Groundwater Record of Decision, Iowa Army Ammunition Plant, Middletown, Iowa*. EPA/ROD/R07-05/047. August 8.

EPA, 2006. *Final Explanation of Significant Differences, Deletion of Radiological Contaminants from the OU-1 Interim Action Record of Decision (ROD) for the Soils Operable Unit (OU-1). Iowa Army Ammunition Plant, Middletown, Iowa.* June 13.

EPA, 2008a. *Final, Rev.1 Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area (IDA) in Soils Operable Unit 4 (OU-4) for Iowa Army Ammunition Plant,* September. (Document is titled Draft Final Rev. 1, and is indicated by an additional cover page to be the Final ROD)

EPA, 2008b. *Final Explanation of Significant Differences for the OU-1 Interim Action Record of Decision (ROD) for the Soils Operable Unit (OU-1), Addition of Environmental Protectiveness to the Remedy and Transfer of Sites From OU-4 to OU-1*. May 15.

EPA, 2009a. *Final Explanation of Significant Differences for the Final Record of Decision, Soils Operable Unit 1, Change of Primary Treatment Technology from Biological to Alkaline Hydrolysis Chemical Treatment, Iowa Army Ammunition Plant, Middletown, Iowa.* September.

EPA, 2009b. *Toxicological Review of Thallium and Compounds in Support of Summary Information on the Integrated Risk Information System (IRIS),* EPA/635/R-08/001F. September.

EPA, 2009c. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* November.

EPA, 2009d. *2009 Edition of the Drinking Water Standards and Health Advisories* EPA 822-R-09-011. October.

EPA, 2010. *Regional Screening Levels Table.* November.

EPA, 2011a. *Final Explanation Of Significant Differences For The Records Of Decision, Soils Operable Unit 1 (Ou-I), Addition Of Soil Volume, Site-Specific Remedial Goal For Barium, And Offsite Disposal Of Contaminated Soil For Iowa Army Ammunition Plant, Middletown, Iowa.* March.

EPA, 2011b. *Letter from U.S. EPA to Iowa AAP, Re: Initiation of Informal Dispute Resolution Process: September 8, 2011, Submittal of Draft Final Feasibility Study Report of the Operable Unit 7at Iowa Anny Ammunition Plant, Burlington, Iowa*. Prepared by U.S. Environmental Protection Agency. October 7.

EPA, 2012. *Letter from U.S. EPA to Iowa AAP, Re: EPA Comments on "Data Summaries, Operable Unit 7 Installation Wide" for the Iowa Army Ammunition Plant Superfund Site, Middletown, Iowa.* Prepared by U.S. Environmental Protection Agency. May 25.

EPA, 2013. USEPA to Army: Re: Resolution of informal Dispute initiation letter dated April 29, 2013 and, email dated May 9, 2013 regarding Draft Final Work Plan, Remedial Investigation of Construction Debris Sites CC-IAAP-001 and CC-IAAP-002, Operable Unit 9 at Iowa Army Ammunition Plant, Burlington, Iowa. May 21, 2013.

EPA, 2014a. *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.* OSWER Directive 9200.1-120. February 6.

EPA, 2014b. *Final Record Of Decision Operable Unit 5, Military Munitions Response Program, Iowa Army Ammunition Plant, Middletown, Iowa.* November.

EPA, 2014c. *State Authorization Tracking System Report for State of Iowa, June 30, 2014.* U.S. Environmental Protection Agency. Accessed online July 2015 at http://www.epa.gov/epawaste/laws-regs/state/stats/ia.pdf

EPA, 2015. *Regional Screening Level Summary Table.* June. (accessed online at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

FEMA, 2011. *Website: FEMA Flood Map Service Center.* Federal Emergency Management Agency. https://msc.fema.gov/portal.

HARZA, 1996. Engineering Evaluation/Cost Analysis Study, Iowa Army Ammunition Plant, Fire Training Pit, Middletown, Iowa. Prepared for U.S. Army Corps of Engineers-Omaha District by HARZA Environmental Services, Chicago, IL under contract DACW45-94-D-0044/0004. May.

IAAAP, 1992. *Fax communication, M. Schramm, IAAAP to D. Romitti, USATHAMA.* 8 pages total. Dated 9/24/1992. Including 6 “Water Quality Questionaires” with owner-completed well information for properties owned by J. Pleasant, J. Miller, M. Nixon, R. Kemp (2 wells), and G. Miller, in preparation for private well sampling. Accessed through READ document repository, USAEC.

IAAAP, 2001. *ACTION MEMORANDUM ADDENDUM, IOWA ARMY AMMUNITION PLANT, PERMANENT POTABLE WATER SUPPLY,* dated July 27, 2001, signed by Yolanda Dennis-Lowman, LTC, OD, Commanding IAAAP.

IAAAP, 2013. *Proposed Plan for Military Munitions Response Program Operable Unit Five, Iowa Army Ammunition Plant. Middletown, Iowa*. May.

IAAAP, 2015. *Iowa Army Ammunition Plant, Final Proposed Plan For Construction Debris Sites CC-IAAP-001 and CC-IAAP-002, Operable Unit Nine*. Iowa Army Ammunition Plant. January.

IDNR (Iowa Department of Natural Resources), 2004. *Certificate of No Further Action for the Former Fuel Station, Lust No. 7LTB70, Tank Registration No. 8606348, Iowa Army Ammunition Plant.* August.

JAYCOR, 1994. *Preliminary Assessments for the 43 Iowa Army Ammunition Sites,* October.

JAYCOR, 1996. *Remedial Investigation/Risk Assessment, Iowa Army Ammunition Plant, Middletown, Iowa.* May.

MJW CRS, 2015. *Public Meeting Minutes Proposed Plan for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002 Operable Unite Nine Iowa Army Ammunition Plant Middleton, IA.* Reported by M. Jane Weingart, MJW Court Reporting Services, Burlington, Iowa. February.

MKM (MKM Engineers, Inc.), 2004. *Draft Final Soil Data Collection Work Plan for The Incendiary Disposal Area, Fly Ash Waste Pile, Possible Demolition Area, Line 3A Pond, Explosive Waste Incinerator and Construction Debris Landfill, Iowa Army Ammunition Plant*, July.

MKM, 2005a. *Draft Final MEC Density Survey Report for Line 6 and the Central Test Area, Iowa Army Ammunition Plant*, May.

MKM, 2005b. *Draft Final Report for the Soil Data Collection at The Incendiary Disposal Area, Fly Ash Waste Pile, Possible Demolition Area, Line 3A Pond, Explosive Waste Incinerator and Construction Debris Landfill, Iowa Army Ammunition Plant*, May.

MWH, 2004. *Draft Final Baseline Ecological Risk Assessment, Iowa Army Ammunition Plant*, October.

NJDEP (New Jersey Department of Environmental Protection), 2009. *Derivation of Ingestion-Based Soil Remediation Criterion for* Cr^{+6} *Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate,* Division of Science, Research and Technology of the New

Jersey Department of Environmental Protection, for the Risk Assessment Subgroup of the NJDEP Chromium Workgroup, April 8, 2009 (accessed January 2016 at http://www.state.nj.us/dep/dsr/chromium/soil-cleanup-derivation.pdf).

NJDEP, 2010. *N.J.A.C. 7:26E Technical Requirements for Site Remediation.* April 19.

OHM (OHM Remediation Services, Inc.), 1994. *Draft-Final Report for Environmental Remediation Services at IAAAP, Line No. 6 Closure*. March 29.

OHM, 1996. *Draft-Final Report for Contract Number DACW-45-940-D-0005, Rapid Response, Omaha District, Iowa Army Ammunitions Plant, Removal Actions, Middletown, Iowa*. January 8.

PDC Technical Services, Inc., 1995. *RCRA Closure Report, Deactivation Furnace, Iowa Army Ammunition Plant, Middletown, Iowa*. May.

PIKA, 2013. *Remedial Investigation of Construction Debris Sites CC-IAAP-001 and CC-IAAP-002 Iowa Army Ammunition Plant Middleton, IA.* Prepared by PIKA International Inc., Stafford, TX, for U.S. Army Contracting Command, Rock Island, IL, under Contract No. W52P1J-12-C-0025. May.

PIKA, 2014. *Final Focused Feasibility Study Report for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002, Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by PIKA International Inc., Stafford, TX, for U.S. Army Contracting Command, Rock Island, IL, under Contract No. W52P1J-12-C-0025. August.

PIKA, 2015. *Draft Final Record of Decision Construction Debris Sites CC-IAAP-001 and CC-IAAP-002 Operable Unite Nine Iowa Army Ammunition Plant Middleton, IA.* Prepared by PIKA International Inc., Stafford, TX, for U.S. Army Contracting Command, Rock Island, IL April.

Plexus Scientific Corporation, 1995. *Evaluation of Treatment Alternatives, Line 1 Impoundment and Line 800 Pink Water Lagoon*. June 15.

Shaw, 2004. *Draft Final Data Summary Report Supplemental Remedial Design, Phase 4 Soil Sites Operable Unit 1*. May.

Shaw, 2005. *Draft (Revision 1) Remedial Action Report, Phase 4 Soil Sites, Operable Unit 1, Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared by Shaw Environmental, Inc., Centennial, CO, for USACE-Omaha District under contract DACA45-96-D-0007. August.

Terracon, 2000. *RCRA Closure Report, Iowa Army Ammunition Plant, Middletown, Iowa, Terracon Project No. 42997105*. November 16.

Tetra Tech, 2004. *Draft-Final Treatability Study Test Plan for In Situ Biodegradation of RDX in Off-Site Groundwater*, November.

Tetra Tech, 2005. *Draft Final TREATABILITY STUDY TEST PLAN FOR IN SITU BIODEGRADATION OF ON-POST GROUNDWATER For IOWA ARMY AMMUNITION PLANT, MIDDLETOWN, IOWA*. April.

Tetra Tech, 2006a. *Final Spring Creek, Long Creek, and Skunk River Watersheds Evaluation and Supplemental Data Collection Work Plan for Iowa Army Ammunition Plant*. December.

Tetra Tech, 2006b. *Draft-Final Revision 1 Brush Creek Surface Water and Sediment Investigation Work Plan Operable Unit 4 Iowa Army Ammunition Plant Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. February.

Tetra Tech, 2006c. *Draft Final Revision 2 Soil Treatability Test Plan for Bioremediation of Explosives in Trench 7 (CAMU) Iowa Army Ammunition Plant Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. March.

Tetra Tech, 2007. *Draft Excavation Plan for Remedial Action for Phases 5, 7, and 8 of Operable Unit 1, Iowa Army Ammunition Plant, Middletown, Iowa.* February.

Tetra Tech, 2008a. *Phase I Treatability Study Report For In-Situ Biodegradation Of On-Post Groundwater For Iowa Army Ammunition Plant, Middletown, Iowa.* April.

Tetra Tech, 2008b. *Draft Remedial Action Report for Excavations at the Deactivation Furnace, Iowa Army Ammunition Plant, Middletown, Iowa*. July.

Tetra Tech, 2009a. *Final OU-4 O&M Plan for the Inert Disposal Area, Line 1 Impoundment and Line 800 Lagoon, Iowa Army Ammunition Plant, Middletown, Iowa.* February.

Tetra Tech, 2009b. *Final Technical Memorandum Full-Scale Treatability Study for In Situ Biodegradation of On-Post Groundwater for Iowa Army Ammunition Plant, Middletown, Iowa.* February.

Tetra Tech, 2009c. *Draft Status Report for Soil Chemical Treatment Inert Disposal Area Iowa Army Ammunition Plant.*

Tetra Tech, 2009d. *Final Remedial Action Work Plan for the Closure of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown Iowa*, April.

Tetra Tech, 2009e. *Final Remedial Action Completion Report for Operable Unit 1 (OU-1) Soils Phase 5, 7, and 8 Sites and Installation-wide Ecological, Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by Tetra Tech, Inc. Oak Ridge, TN, for Iowa Army Ammunition Plant, Middletown, IA. August.

Tetra Tech, 2009f. *Final Technical Memorandum Soil Treatment Results for Alkaline Hydrolysis in Trench 6 Inert Disposal Area for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. November.

Tetra Tech, 2009g. *Final Remedial Design/ Remedial Action Work Plan For Off-Site Groundwater.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for the Iowa Army Ammunition Plant. March.

Tetra Tech, 2010a. *Draft Final Feasibility Study for Operable Unit 6 (OU-6) Sitewide Groundwater for Iowa Army Ammunition Plant, Middletown, Iowa*. May.

Tetra Tech, 2010b. *Draft Final (Rev. 3) Supplemental Remedial Investigation Operable Unit 7 for Iowa Army Ammunition Plant, Middletown, Iowa*. July.

Tetra Tech, 2010c. *Final Remedial Action Completion Report for Operable Unit 1 (OU-1) Soils, Phase 5, 7, and 8 Sites and Installation-Wide Ecological, Iowa Army Ammunition Plant, Middletown, Iowa*. September. (cited in prior FYR, but not located within project files during 3rd FYR; possible erroneous cite to Tetra Tech, 2009e))

Tetra Tech, 2010d. *Offsite Groundwater Remediation Progress Report Four (March 2009 – December 2009).*

Tetra Tech, 2010e. *Remedial Design/Remedial Action Work Plan for Capping of Trench 6, the Removal of Trench 7, and the Emptying of Sedimentation Dams 6 and 7*. September.

Tetra Tech, 2010f. *Final Inert Disposal Area Winterization Plan 2010.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA.

Tetra Tech, 2011a. *Final (Revision 3) Supplemental Remedial Investigation, Operable Unit 7 for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. August.

Tetra Tech, 2011b. *Draft Final Feasibility Study, Operable Unit 7 for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. September.

Tetra Tech, 2011c. *Draft Volume 3 – Soil Treatment Activities Operable Unit 4 Remedial Action Completion Report for Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. March.

Tetra Tech, 2011d. *Draft Operable Unit 4 (OU-4) Remedial Action Completion Report Volume 1 Capping of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. February.

Tetra Tech, 2011e. *Supplemental Remedial Investigation Final Rev. 3 Operable Unit 7 for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. August.

Tetra Tech, 2011f. *Feasibility Study for Operable Unit 7 (OU-7) for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. September.

Tetra Tech, 2011g. *Final Work Plan For Supplemental Remedial Investigation of Groundwater and Surface Water At Line 1 For Iowa Army Ammunition Plant, Middletown, Iowa.* May.

Tetra Tech, 2011h. *FINAL Five-Year Review Report for Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. March.

Tetra Tech, 2012a. *Draft Land Use Controls Plan for Operable Unit (OU-3) Off-Site Groundwater*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. October.

Tetra Tech, 2012b. *Follow-up Report to the Five-Year Review for Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by Tetra Tech. July.

Tetra Tech, 2012c. *Draft Final Technical Memorandum and Work Plan Addendum Line 1 Groundwater and Surface Water, Phase 1 Sampling Results and Phase 2 Work Plan Addendum for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. October.

Tetra Tech, 2012d. *Draft Final Operable Unit 3 (OU-3) Off-Site Groundwater Annual Report and Sampling and Analysis Plan for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, IA. July.

Tetra Tech, 2012e. *Internal Draft Land Use Controls Plan for Operable Unit 3 (OU-#) Off-Site Groundwater*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. August.

Tetra Tech, 2012f. *Final Operable Unit (OU-4) Remedial Action Completion Report Volume 2 Part 1 Of 3 Capping Of Trench 6, The Removal Of Trench 7 For Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. August.

Tetra Tech, 2012g. *DRAFT SUPPLEMENTAL REMEDIAL INVESTIGATION FOR ONSITE GROUNDWATER, OPERABLE UNIT 6 (OU-6), IOWA ARMY AMMUNITION PLANT, MIDDLETOWN, IA.* Prepared by Tetra Tech, Oak Ridge, TN under contract W911S0-04-F-0026. July.

Tetra Tech, 2013a. *Final Workplan for Feasibility Study, Supplemental Data Collection, Operable Unit 7 for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. September.

Tetra Tech, 2013b. *Draft Final Operable Unit 3 (OU-3) Off-Site Groundwater Annual Report and Sampling and Analysis Plan for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown IA. August.

Tetra Tech, 2013c. *Final Operable Unit 4 (OU-4) Remedial Action Completion Report, Volume 5: Removal of Sediment Ponds CEA, 6 and 7 for Iowa Army Ammunition Plant Middletown, IA.*

Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown IA. February.

Tetra Tech, 2014a. *Draft Final Operable Unit 3 (OU-3) Off-Site Groundwater Interim Remedial Action Report for Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. July.

Tetra Tech, 2014b. *Internal Draft Land Use Controls Implementation Plan for Operable Unit 3 (OU-3) Off-Site Groundwater*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. March.

Tetra Tech, 2014c. *Technical Memorandum Off-Site Brush Creek Surface Water Update Iowa Army Ammunition Plant Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. June.

Tetra Tech, 2014d. *Draft Final Operable Unit 4 (OU-4) Land Use Controls Implementation Plan for the Inert Disposal Area (IDA) Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. April.

Tetra Tech, 2014e. *Draft Revision 1 Operable Unit 4 (OU-4) Remedial Action Completion Report Volume 4 – Land Use Controls, Long Term Monitoring, and Operation and Maintenance Plan for the Inert Disposal Area (IDA) Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. June.

Tetra Tech, 2014f. *Draft (Rev. 1) Operable Unit (OU-4) Remedial Action Work Plan Inert Disposal Area (IDA) Boundary Fence Installation at the Iowa Army Ammunition Plant, Middletown, Iowa.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. May.

Tetra Tech, 2014g. *Draft Work Plan for Data Gaps Investigation Operable Unit 6 for Iowa Army Ammunition Plant, Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. January.

Tetra Tech, 2014h. *Draft Final Phase 2 Technical Memorandum and Phase 3 Work Plan Addendum, Line 1 Groundwater for Iowa Army Ammunition Plant Middletown, IA.* Prepared by Tetra Tech, Inc., Oak Ridge, TN for Iowa Army Ammunition Plant, Middletown, IA. May.

TN & Associates, Inc., 2002. *Draft-Final Line 1 and Firing Site Supplemental Remedial Investigation Report.* August.

TN & Associates, Inc., 2003. *Draft Final Work Plan for Supplemental Remedial Design (Including Historical Site Assessment) for Phase 4 Soil Sites, Iowa Army Ammunition Plant.* March.

Trileaf Corporation, 2002. *Report of Overexcavation, Former Fueling Station, Iowa Army Ammunition Plant,* August.

URS, 2003. *Draft Final Offsite Groundwater Remedial Investigation, Iowa Army Ammunition Plant, Middletown, Iowa*. April.

URS, 2004. *Draft Final Offsite Groundwater Feasibility Study, Iowa Army Ammunition Plant, Middletown, Iowa*. March. (This document is not available on the RAB website, but has a restriction notice as follows: "Due to the sensitive nature and security restrictions of the information in this document distribution is limited.")

URS, 2005. *Draft Final Off-Site Groundwater Record of Decision.* Iowa Army Ammunition Plant. Middletown, Iowa. June.

URS, 2011. *Remedial Investigation Report for Operable Unit 5 (OU-5) Iowa Army Ammunition Plant, Middletown, Iowa*. June.

USATHAMA, 1980. *Installation Assessment of Iowa Army Ammunition Plant, Report Number 127.* By U.S. Army Toxic and Hazardous Materials Agency (now U.S. Army Environmental Command). January.

USACE , 2006. *Summary of the Radiological Survey Findings for the Iowa Army Ammunition Plant Explosive Disposal Area, Inert Disposal Area, Demolition Area/Deactivation Furnace, and Line 1 Former Waste Water Impoundment Area.* June 6.

USACE, 2008. *Draft-Final Iowa Army Ammunition Plant FUSRAP Remedial Investigation Report For Firing Sites Area, Yards C, E, F, G, and L, Warehouse 3-01 And Area West Of Line 5B,* July 25.

USACE, 2011a. *Remedial Investigation Report. Military Munitions Response Program. Iowa Army Ammunition Plant Middletown, Iowa*. June.

USACE, 2011b. *FUSRAP Feasibility Study Report for the Iowa Army Ammunition Plant Middletown, IA*. Prepared by U.S. Army Corps of Engineers, St. Louis District Office with assistance from Science Applications International Corporation under Contract No. W912P9-06-D-0534-0006. April.

USACE , 2011c. *FUSRAP Proposed Plan for the Iowa Army Ammunition Plant Middletown, IA*. Prepared by U.S. Army Corps of Engineers, St. Louis District Office with assistance from Science Applications International Corporation under Contract No. W912P9-06-D-0534-0006. April.

USACE, 2011d. *FUSRAP Record of Decision for the Iowa Army Ammunition Plant Middletown, IA*. Prepared by U.S. Army Corps of Engineers, St. Louis District Office with assistance from Science Applications International Corporation under Contract No. W912P9-06-D-0534-0006. September.

USACE, 2012. *Final Feasibility Study Report Amendment Military Munitions Response Program Iowa Army Ammunition Plant Middletown, Iowa.* Prepared for the U.S. Army Corps of Engineers Omaha District. November.

USACE, 2013a. *Public Notice. Proposed Plan for Operable Unit 5*. April.

USACE, 2013b. *May 28, 2013 Operable Unit 5 Proposed Plan Historical Small Arms Range EE/CA Public Meeting Minutes Iowa Army Ammunition Plant. Middletown, Iowa*. Reported by M. Jane Weingart MJW Court Reporting Services, Burlington, Iowa. May.

U.S. Census Bureau, 2010. http://census.gov/. December 14.

USDA (U.S. Department of Agriculture), 1983. *Soil Survey of Des Moines County, Iowa*. May