IOWA ARMY AMMUNITION PLANT

FINAL

EXPLANATION OF SIGNIFICANT DIFFERENCES FOR THE RECORDS OF DECISION SOILS OPERABLE UNIT 1 (OU-1)

ADDITION OF SOIL VOLUME, SITE-SPECIFIC REMEDIAL GOAL FOR BARIUM, AND OFFSITE DISPOSAL OF CONTAMINATED SOIL FOR IOWA ARMY AMMUNITION PLANT MIDDLETOWN, IOWA

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LIST OF ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminants of Concern
COPC	Contaminants of Potential Concern
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FFA	Federal Facilities Agreement
FUSRAP	Formerly Utilized Sites Remedial Action Program
IAAAP	Iowa Army Ammunition Plant
IDA	Inert Disposal Area
IROD	Interim Record of Decision
LAP	Load, Assemble, and Pack
LDR	Land Disposal Restrictions
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OU	Operable Unit
RI	Remedial Investigation
ROD	Record of Decision
SVOC	Semi-volatile Organic Compound
TCLP	Toxicity Characteristic Leaching Procedure
USACE	U.S. Army Corps of Engineers

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1.0 INTRODUCTION

This Explanation of Significant Differences (ESD) presents the site-specific rationale for modifying the selected remedy identified in the Interim Action Record of Decision (IROD) for the Soils Operable Unit (OU1), dated March 1998, and the Final Record of Decision (Final ROD) for the Soils Operable Unit (OU1), dated September 1998, at the Iowa Army Ammunition Plant (IAAAP) in Middletown, Iowa (EPA ID: IA7213820445). Except as noted herein, the U.S. Army (Army) serves as the lead agency with support from the U.S. Environmental Protection Agency (EPA) for executing the remedy selected in the Interim ROD and Final ROD, referred to as the IAAAP Soils RODs hereinafter.

Particular areas of concern at the IAAAP are being addressed by the U.S. Army Corps of Engineers (USACE) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). These areas are identified in the Federal Facilities Agreement (FFA) executed between the EPA, USACE, U.S. Department of Energy, and the State of Iowa (Administrative Docket Number: CERCLA-07-2005-0378 (FUSRAP FFA)). The scope as defined in the FUSRAP FFA covers response actions at seven areas associated with historic Atomic Energy Commission (AEC) activity, including Line 1 and the West Burn Pads Area (South of the Road). The USACE is the lead agency for implementing environmental restoration activities in areas within the scope of the FUSRAP FFA. To the extent the remedy selected in the IAAAP Soils RODs is appropriate for areas identified for FUSRAP response, the USACE is implementing the selected remedy. FUSRAP response actions at Line 1 and the West Burn Pads Area (South of the Road) are being executed pursuant to the IAAAP Soils RODs. The remaining FUSRAP areas are being addressed under separate Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) actions and are outside the scope of this document.

This ESD was prepared in accordance with Section 117(c) of CERCLA 42 U.S.C. 9601 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986, and Sections 300.435(c)(2)(i) and 300.825(a)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Section 117(c) of CERCLA provides, in relevant part, that "After adoption of a final remedial action plan…if any remedial action is taken…or if any settlement or consent decree under Section 9606 of this title…is entered into, and if such action, settlement or decree differs in any significant respect from the final plan, the President…shall publish an explanation of the significant differences and the reasons such changes were made."

The purpose of this ESD is to provide information in support of the significant site-specific modifications to portions of the selected remedy described in the IAAAP Soils RODs for FUSRAP response actions at Line 1 and the West Burn Pads Area (South of the Road). In addition, the ESD will summarize the information that led to the making of the changes to the remedy and affirm that the remedy will still comply with the statutory requirements of CERCLA § 121. The three site-specific changes to the selected remedy, presented in greater detail herein, include the following:

1. Derivation of a site-specific remedial goal for barium at the West Burn Pads Area (South of the Road);

2. Increased volume of contaminated soil excavated from the West Burn Pads Area (South of the Road) from that which was estimated in the Interim ROD to be at the West Burn Pads; and

3. Change from on-site treatment and disposal to offsite treatment and disposal for contaminated soil excavated at Line 1 and West Burn Pads Area (South of the Road).

These proposed changes do not fundamentally alter the overall remedy for the site and are appropriately addressed in this ESD.

This ESD will become part of the Administrative Record file pursuant to Section 300.825(a)(2) of the NCP. The Administrative Record for IAAAP is available online at the following address:

www.iaaap.adminrecord.com

2.0 SITE HISTORY, CONTAMINATION AND SELECTED REMEDY

2.1 SITE HISTORY

The IAAAP is a government-owned, contractor-operated facility under the command of the U.S. Army Joint Munitions Command, Rock Island, Illinois. The current operating contractor is American Ordnance. IAAAP occupies approximately 19,000 acres in the town of Middletown in Des Moines County, Iowa, and is bordered by U.S. Highway 34 to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south. Approximately one-third of the IAAAP property is occupied by active or formerly active production or storage facilities. The property includes production lines, former surface impoundments, landfills and disposal areas, burn pads, demolition areas, and fire training areas. The remaining land is either woodlands or property leased for agricultural use.

Production of munitions began in 1941. Production activities at IAAAP include loading, assembling, and packaging (LAP) of munitions, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, and anti-personnel mines. The LAP operations use explosives-containing materials and lead-based initiating compounds. The AEC operated at some facilities at the IAAAP from 1947 to 1975 assembling components of nuclear weapons.

2.2 SITE CONTAMINATION

The primary source of contamination at the site is attributable to past operating practices in which explosives-contaminated waste waters and sludges were discharged to uncontrolled, on-site lagoons and impoundments. Additional sources of contamination include open burning of explosives materials and munitions, and landfilling of waste materials.

EPA added IAAAP to the National Priorities List in 1990. Numerous investigations have been conducted at the site from 1975 until present to investigate soil and groundwater contamination.

2.3 SELECTED REMEDY IN THE IAAAP SOILS RODS

The IAAAP Soils RODs were jointly executed by Army and EPA in 1998 and documented the selected remedy for soils contaminated primarily with metals and explosives. Significant changes to the selected remedy were documented in ESDs executed in 2003, 2006, 2008 and 2009. Collectively, the Interim ROD, the Final ROD, the 2003 ESD, the 2006 ESD, the 2008 ESD and the 2009 ESD present the final remedy for contaminated OU-1 soils, which is to excavate and manage the soils based on the nature of contamination. Four different types of soil contamination were established:

- Explosives-contaminated soils
- Explosives-plus-metals-contaminated soils
- Metals-contaminated soils
- Semi-volatile organic compound (SVOC)-contaminated soils

The main components of the selected remedy established in the Interim ROD include:

- Excavation of soils contaminated at levels exceeding the soil remediation goals for the remediation areas.
- Verification sampling to ensure that remedial goals are met in the remediation areas.
- Segregation of excavated soils according to contaminant type and concentration.
- Temporary storage of the most highly contaminated soils in the on-site Corrective Action Management Unit and treatment of those soils in accordance with the specification of the Final ROD for the soils.
- Permanent disposal of soils contaminated at lesser levels in the on-site Soil Repository or in the on-site Inert Landfill;
- Solidification/stabilization of metals-contaminated soils containing metals at levels exceeding land disposal restriction (LDR) criteria, and permanent disposal in the on-site Soil Repository.

The major components of the selected remedy for the four types of contamination requiring treatment are summarized below:

Explosives-Contaminated Soil

- Excavate explosives-contaminated soil and transport to a temporary treatment facility on-site.
- Process the soil using chemical treatment (alkaline hydrolysis).
- Following confirmation sampling, dispose treated soil according to the following criteria:

  A. For soils with cumulative risks less than 10^{-6}, which are in compliance with LDRs, and which exceed groundwater protection remediation goals, dispose the soil in an on-site engineered landfill cell such as the "Trench 6" Soil Repository, located at the Inert Disposal Area (IDA), or another EPA-approved on-site landfill.

  B. For soils with cumulative risks less than 10^{-6}, which are in compliance with LDRs and which satisfy groundwater protection model remediation goals, dispose on IAAAP property in an appropriate manner protective of human health and the environment. The treatment residuals must also be shown to be non-toxic or not bio-available at levels posing a threat to human health or the environment.

Explosive-Plus-Metals-Contaminated Soils

- Excavate explosives-plus-metals-contaminated soil and transport to a temporary treatment facility on-site.

- Process the soil through a two-step treatment process: chemical treatment (alkaline hydrolysis) for explosives contaminants and solidification/stabilization for metals contaminants.

- Sample to confirm successful treatment for both explosives and metals.

- Following sampling to confirm compliance with Toxicity Characteristic Leaching Procedures (TCLP) based on remediation goals, dispose of the soil in an on-site engineered landfill cell such as the "Trench 6" Soil Repository, located at the IDA, or another EPA-approved on-site landfill.

Metals-Contaminated Soil

- Excavate metals-contaminated soil and transport to a temporary treatment facility on-site.

- Process the soil through solidification/stabilization step for metals contaminants.

- Following sampling to confirm compliance with TCLP-based remediation goals, dispose the soil in an on-site engineered landfill cell such as the "Trench 6" Soil Repository, located at the IDA, or another EPA-Approved on-site Landfill.

SVOC-Contaminated Soil

- Excavate SVOC-contaminated soil.

- Transport the soil to a commercial waste treatment and disposal facility off-site.

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3.0 BASIS FOR THIS ESD

This ESD is documenting three separate, but related, changes to the selected remedy as stated in the IAAAP Soils RODs for contaminated soils at the Line 1 and West Burn Pads Area (South of the Road). The ESD is limited in scope to response actions taken under FUSRAP at Line 1 and the West Burn Pads Area (South of the Road) pursuant to the IAAAP Soil RODs. Each change will be discussed individually, as presented below.

3.1 DEVELOPMENT OF A REMEDIAL GOAL FOR BARIUM FOR WEST BURN PADS AREA (SOUTH OF THE ROAD)

As part of the analysis in preparation for selecting a final remedy to address contaminated soils at IAAAP, the Army conducted a multiphase remedial investigation (RI) culminating in the preparation of the *Remedial Investigation Report/Risk Assessment, Iowa Army Ammunition Plant, Middletown, Iowa,* Revised Draft-Final (May 1996). The RI Report indicated the presence of widespread metals and explosives contamination in surficial soils and drainage ways. Initially, 88 radiological and non-radiological contaminants of potential concern (COPCs) were identified at the IAAAP. Chemical constituents were eliminated from consideration in the baseline risk assessment if they were detected infrequently (typically less than 5%) or if they were essential nutrients and were nontoxic in the levels encountered at IAAAP. The 88 COPCs, which included barium, were then quantitatively evaluated for risk in the risk assessment. The results of the risk assessment indicated no risks (i.e., risks less than 10^{-6}) due to barium at the West Burn Pads Area for the evaluated receptor (site visitor). Of the 88 COPCs evaluated in the risk assessment, remediation goals were established for 17 chemicals in the Interim ROD, which did not include barium. Later, during a Focused Feasibility Study conducted in 2003, barium was found to be present a the West Burn Pads Area at concentrations that exceeded Land Disposal Restrictions, which were used as screening criteria (based on the 20X TCLP rule for metals).

The USACE developed a remedial design to implement the selected remedy for soils at Line 1 and West Burn Pads Area (South of the Road) at IAAAP. The design was based on sample data obtained during the Army RI and additional investigation conducted by USACE under FUSRAP. Excavation boundaries were developed to satisfy the soil remediation goals based on human health and leaching as identified in the Tables 2 and 3 of the Interim ROD and the Tables 13 and 14 of the Final ROD, which do not state remediation goals for barium. During excavation, however, USACE encountered soil with barium as the only contaminant.

The IAAAP Soils RODs note that remediation goals for additional constituents that may be detected at levels of concern subsequent to the RI and not specified in the RODs should be determined using similar criteria. The Interim ROD states that soil remediation goals are established based upon risk considerations. These include criteria associated with ingestion and dermal contact with 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. Soil remediation goals for the protection of human health were established at a target carcinogenic risk of 10^{-6} using a commercial/industrial scenario consistent with the current and reasonably anticipated future land uses at the site. In addition to risk-based soil

remediation goals for protection of human health, impact to groundwater from residual soil contamination was evaluated. The Summers model was used to estimate the point at which contaminant concentrations in the soil will produce groundwater contamination at concentrations above acceptable levels. The Summers model is a model adopted by EPA, which estimates leaching of a chemical from soil directly to the underlying ground water, while applying simple, yet site-specific inputs for vertical volumetric water flow through the soil column, along with the horizontal volumetric flow rate of ground water in the subject aquifer. Generally, the Summers model can be used to determine soil concentrations that are protective of a groundwater concentration assumed to be equivalent to an EPA Maximum Contaminant Level, Maximum Contaminant Level Goal, Health Advisory Level or some risk-based concentration directly beneath the source soil. At the IAAAP, the resultant soil concentration was then used as a remediation goal for guiding horizontal and vertical excavation boundaries**.**

At EPA's direction, USACE developed a site-specific remediation goal for barium only contaminated soil at the West Burn Pads Area (South of the Road), based on groundwater protection, using the methodology set forth in the Interim ROD. USACE developed a site-specific remediation goal for barium based on soil leaching using the Summers model adjusted for the limited barium mobility through the soil. USACE derived a site-specific remediation goal to ensure that residual barium concentrations do not result in groundwater concentrations that exceed EPA's maximum contaminant levels directly beneath the West Burn Pads Area (South of the Road). The technical approach for the development of the barium remediation goal is set forth in Appendix A to this ESD. In general, however, the development followed a two step process. First, USACE calculated a site-specific partition coefficient for the West Burn Pads Area (South of the Road) based on an analysis of TCLP data for the West Burn Pads Area included in the *Draft–Final Excavation Report, Iowa Army Ammunition Plant Focused Feasibility Soil Study Sites, Phase 3, Remedial Action West Burn Pads Area, Middletown, Iowa*, (Nov. 2001) in Appendix H. Next, a barium remediation goal based on soil leaching was calculated using the Summers model.

USACE utilized existing samples, data, test results, and site-specific Summers model inputs (e.g., area of the site, width of the site perpendicular to the aquifer flow directions, Darcy velocity in the aquifer, and thickness of the mixing zone of the aquifer) to promptly develop the site-specific remediation goal for barium at West Burn Pads Area (South of the Road). Due to the imminent closure of the on-site land disposal facility and the need to quickly determine which soils exceeded the barium remediation goal and would, therefore, require treatment and disposal, USACE calculated a conservative barium remediation goal using existing TCLP data instead of calculating a remediation goal using water leaching test data. The existing TCLP data resulted in a more conservative remediation goal by at least an order of magnitude because the data is based on acid leaching instead of water leaching. The resulting site-specific soil remediation goal for the West Burn Pads Area South of the Road is 4100 milligrams of barium per kilogram of soil. The calculation is set forth in Appendix B to this ESD.[1]

[1] Data taken during the remediation of the barium-only soil indicates, however, that barium is not leached appreciably by groundwater and that the proper interpretation of the RODs statement, "The model was not used for metals, as metals are relatively immobile in the clay soils found at the IAAAP", is that no remediation goals for metals are necessary for the protection of groundwater.

No human health-based remediation goal was derived for barium at the West Burn Pads Area (South of the Road) for the following reasons: 1) the 1996 risk assessment estimated no exceedances of EPA target risk criteria for cancer or non-cancer risks due to barium exposures to a site visitor at the West Burn Pads Area; and 2) EPA's most recent (November 2010) Regional Screening Levels Table presents an industrial risk-based soil screening level of 190,000 mg/kg, derived assuming ingestion, dermal and inhalation exposures. The groundwater protection value of 4,100 mg/kg derived using the Summers model (per Appendix A) is a more stringent value that is driving soil remediation at WBPS. Additionally, based on ecological risk information provided in the *Iowa Army Ammunition Plant FUSRAP Remedial Investigation Report for Firing Sites Area, Yard C, E, F, G, and L, Warehouse 3-01 and Area West of Line 5B*, an ecological remediation goal of 18,000 mg/kg would be applicable to West Burn Pads Area for protection of the primary ecological receptor of concern, the Indiana bat *(Myotis sodalist).* This remediation goal applies the same food chain model, exposure assumptions, and area use considerations described in the aforementioned FUSRAP Remedial Investigation Report, and that are consistent with EPA's (1997) Ecological Risk Assessment Guidance. As was the case for the human health, the groundwater protection value of 4,100 mg/kg derived using the Summers model (per Appendix A) is a more stringent value that is driving soil remediation at West Burn Pads Area (South of the Road). Therefore, no human health direct contact-based or ecological risk-based remediation goals are being applied to the West Burn Pads Area (South of the Road).

3.2 INCREASED VOLUME OF EXCAVATED SOIL

As documented in the FUSRAP FFA, USACE is responsible for conducting response actions at the West Burn Pads Area (South of the Road). The RI which led to the development of the IAAAP Soil RODs, however, was completed prior to the identification of areas subject to USACE response under the FUSRAP. The estimates of contaminated soil provided in the RI and Table 1 of the Interim ROD do not identify volumes specifically for West Burn Pads Area (South of the Road), but instead focus on the larger West Burn Pads Area. The soils estimated in the Interim ROD for the Burn Cages/West Burn Pads Area are as follows: 423 cubic yards metals contaminated soil, 339 cubic yards explosives contaminated soil, 689 cubic yards metals and explosives contaminated soil, and 1451 cubic yards total contaminated soil.

An ESD to the Final ROD for OU1 issued in January 2003 documented three changes to the selected remedy, including an increase in volume of excavated soil at the West Burn Pads Area. The ESD notes that between September 2000 and January 2002, 45,000 cubic yards of soil were excavated from the West Burn Pads Area by Army during its response activities. This volume does not include soil from West Burn Pads Area (South of the Road).

USACE began excavation at the West Burn Pads Area (South of the Road) pursuant to the Interim ROD in October 2008 and continued through September 2010. USACE response activities resulted in the excavation and disposal of approximately 15,800 *in situ* cubic yards of contaminated soil from the West Burn Pads Area (South of the Road).

3.3 OFFSITE TREATMENT AND DISPOSAL

The Final ROD specified on-site disposal for explosives contaminated soils exceeding the Summers model remediation goals and all explosives plus metals contaminated soil in the Soils Repository or under another synthetic covered landfill at IAAAP. In accordance with the IAAAP Soils RODs, contaminated soils were excavated, treated as necessary, and disposed in the on-site Soils Repository, also known as the IDA. In June 2009, however, the IDA began approaching its maximum capacity and was essentially no longer available as a disposal site for any soils excavated from West Burn Pads Area (South of the Road) or Line 1 under FUSRAP. At about the same time, Trench 7 was no longer available for treatment of contaminated soil excavated under FUSRAP at Line 1 and West Burn Pads Area (South of the Road) because of plans to excavate Trench 7 and place associated wastes in the IDA prior to closure.

Ongoing remedial activities at West Burn Pads Area (South of the Road) and Line 1 required the identification of alternate treatment and disposal facilities. In evaluating on-site and offsite treatment and disposal options, several factors were considered, including: the estimated volume of soil requiring excavation, treatment as necessary, and disposal; the costs involved for offsite treatment and disposal; the costs involved in constructing another on-site treatment and disposal facility; the amount of time required to site, design, and construct another on-site treatment and disposal facility; the limited construction season at IAAAP due to weather; and the impact delay associated with establishing another on-site treatment and disposal facility would have on the remedial activities. The following key facts support the conclusion that offsite treatment and disposal was necessary: 1) a significant amount of time would have been required to establish an on-site disposal cell and construction could not begin until Army completed the Trench 7 excavation and disposal if the cell were located at the former Trench 7 site; 2) during this time, water controls for open excavations would have been required; and 3) the establishment of a new on-site disposal facility would have also required the development and implementation of long-term maintenance control. Based on these considerations, the identification of offsite treatment and disposal facilities is more efficient and cost effective than constructing new treatment and disposal facilities on-site at IAAAP.

3.4 DESCRIPTION OF SIGNIFICANT DIFFERENCES

The following text summarizes the three changes to the selected remedy as documented in the IAAAP Soils Rods for contaminated soils at the Line 1 and West Burn Pads Area (South of the Road) locations.

3.4.1 Development of a Remedial Goal for Barium for West Burn Pads Area (South of the Road)

This ESD revised the remedy under the IAAAP Soils RODs to specify a site-specific soil remediation goal for barium at the West Burn Pads Area (South of the Road). The site-specific barium remediation goal is 4100 milligrams of barium per kilogram of soil.

As a result of identifying a site-specific remediation goal for barium at the West Burn Pads Area (South of the Road), barium-only contaminated soils exceeding the site- specific barium

remediation goal requires excavation, treatment to satisfy land disposal restrictions, and disposal. Approximately 600-1200 *in situ* cubic yards of barium-only contaminated soils were excavated, treated, and disposed from the West Burn Pads Area (South of the Road).

3.4.2 Increased Volume of Excavated Soil

This ESD acknowledges the increased volume of soil that required excavation, treatment as necessary, and disposal from the West Burn Pads Area due to the soils excavated from the West Burn Pads Area (South of the Road). Response activities at the West Burn Pads Area (South of the Road) resulted in approximately 15,800 *in situ* cubic yards of contaminated soils excavated in addition to the soils estimated in the Interim ROD and documented in the January 2003 ESD.

3.4.3 Offsite Treatment and Disposal

This ESD revised the remedy under the Final RODs to specify offsite treatment and disposal for explosives contaminated soils and explosives plus metals contaminated soil. The choice of offsite disposal depends on the type of contamination:

- Soils contaminated with explosives below 500 ppm and meeting LDRs will be transported to an EPA approved offsite landfill;

- Soils requiring treatment for metals contamination or treatment for explosives contamination greater than 500 ppm in soil will be transported to a Class C landfill for offsite treatment and disposal.

It is expected that response costs will increase due to the need to transport contaminated soil to offsite treatment and disposal facilities. Increased costs may range from $64 to $144 per cubic yard of soil not requiring treatment. Cost for treatment and disposal at a Class C landfill would be higher.

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4.0 STATUTORY DETERMINATIONS

The derivation of a remediation goal for barium, the increase in volume of excavated soils, and the change to offsite treatment and disposal do not change the scope of the remedy or adversely affect the ability of the remedy to comply with the statutory requirements of CERCLA §121 as required by the NCP §300.430(f)(5)(ii). Specifically, the remedy:

- remains protective of human health and the environment;
- complies with federal and state requirements that were identified as applicable or relevant and appropriate requirements at the time the original Interim and Final RODs for OU 1 were signed;
- is cost effective; and
- utilizes permanent solutions or alternate treatment technologies to the maximum extent practicable.

Further, as provided in the IAAAP Soils RODs, reviews will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. The next Five-Year Review is scheduled to be completed in March 2011.

In summary, the revised remedy satisfies the statutory requirements of CERCLA §121.

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5.0 PUBLIC PARTICIPATION

In accordance with the public participation requirements set forth in NCP §300.435(c)(2)(i), a notice of this ESD will be placed in the Burlington *"Hawk Eye"* newspaper. This ESD will also be made available to the public by placing it in the Administrative Record file available at www.iaaap.adminrecord.com. In addition, the USACE provided information briefings regarding soil excavation, treatment and disposal at Line 1 and West Burn Pads to the Restoration Advisory Board during multiple public meetings during calendar years 2008 through 2010.

The point of contact for public inquiries is:

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6.0 DECLARATION

For the foregoing reasons, by my signature below, EPA is issuing this ESD to the IAAAP Soils RODs for the OU1 at the Iowa Army Ammunition Plant in Middletown, Iowa.

3/9/11
Date

Cecilia Tapia
Director, Superfund Division
U. S. Environmental Protection Agency
Region VII

8 Mar 2011
Date

Lt. Col. Tommie Hewitt
Commander
Iowa Army Ammunition Plant

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APPENDIX A

CALCULATION APPROACH FOR BARIUM SOIL REMEDIATION

Appendix A
Calculation Approach for Barium Soil Remediation Goal
West Burn Pads South of the Road
Iowa Army Ammunition Plant, Middletown, Iowa

During soil sampling investigations conducted at the West Burn Pads Site South of the Road (WBPS) at the Iowa Army Ammunition Plant (IAAAP), barium was measured at elevated concentrations that could be cause for possible concern. Barium had been used historically at the IAAAP as an ingredient in explosives production, the chemical form of which is expected to be mobile in the environment.

Because the potential exists for barium to mobilize from soil to the underlying ground water, USACE, St. Louis District (USACE-St. Louis) has developed a site-specific soil remediation goal (RG) of 4,100 milligrams of barium per kilogram of soil (mg/kg). As described in the following paragraphs, the RG was derived using site-specific leachability data, along with U.S. EPA's Summers model. The Summers model is a simple and conservative environmental fate and transport model that was used by the U.S. Army to derive RGs for the explosives RDX and TNT, as described in the August 1998 Final *Record of Decision (ROD) (Revision 1) for Operable Unit #1 Soil*. Although no RG was previously developed and presented for barium in the ROD, the ROD does allow for the derivation of RGs for additional chemicals of concern (COC), as necessary. This is demonstrated by the following statement, which appears directly after Table 13 ("Soil Remediation Goals") of the ROD: *"Remediation Goals for other constituents which may be detected at the site and which are not specified in this table will be established using similar criteria."*

The Summers model, which was used to derive the recommended barium RG of 4,100 mg/kg, estimates leaching of a chemical from soil directly to the underlying ground water, while applying simple, yet site-specific inputs for vertical volumetric water flow through the soil column, along with the horizontal volumetric flow rate of ground water in the subject aquifer. Actual leaching of barium from WBPS soil is represented in the model by a site-specific, soil-to-water partitioning factor (Kd) of 84 liters of water per kilogram of soil (L/kg). The Kd value is defined as the ratio of a chemical's sorbed concentration (mg/kg) to its dissolved concentration (mg/L) at equilibrium. The Kd value for barium was calculated by USACE from existing leachability data obtained from analyses of total barium in soil and barium in leachate, with the latter having been performed using U.S. EPA's Toxicity Characteristic Leaching Procedure (TCLP). The site-specific Kd was determined as the average value estimated for a dataset consisting of 283 samples analyzed for both total barium and TCLP barium. Additional model inputs were obtained as being the best site-specific data available, as presented in the *Revised Draft Final Remedial Investigation/Risk Assessment Report, Iowa Army Ammunition Plant, Middletown, Iowa, Volume 3* (JAYCOR, May 21, 1996).

Calculation of the soil RG using the Summers model was designed to be protective of U.S. EPA's Safe Drinking Water Act Maximum Contaminant Level (MCL) in the aquifer, i.e., so that the MCL is not exceeded in ground water as a result of leachate infiltration from the overlying soil. During remediation activities of the WBPS, USACE will be operationally sampling and analyzing for total barium in soil and TCLP barium. However, based on site-specific leachability information, total barium measured in soil at concentrations of less than 4,100 mg/kg will be considered as not only being protective of the MCL, but as having met U.S. EPA's TCLP criterion.

Patrick B. Moroney

Senior Risk Assessment Specialist

Science Applications International Corporation

APPENDIX B

SUMMERS MODEL CALCULATION - BARIUM IN WBPS SOIL

Appendix B
Summers Model Calculation - Barium in WBPS Soil

Parameter Descriptions/Formulas			Value	Sources/Assumptions
Summers Model: $C_p = \frac{C_{gw}(Q_p + Q_A) - (Q_a C_A)}{Q_p}$				
C_p	Concentration in the infiltration at the unsaturated-saturated zone interface (ug/L)		Unknown	Calculated Value
C_{gw}	Target concentration in groundwater (ug/L)		2,000	USEPA Safe Drinking Water Act Maximum Contaminant Level. No lifetime health advisory level available.
Q_p	Volumetric flow rate of infiltrations into the aquifer (ft^3/day)	**$= V_{dz} * A_p$**		
A_p =	Contaminated Surface Area of site (ft^2)		426,888	Approximate area of WBPS.
V_{dz} =	Darcy Velocity downward (ft/day)		$5.27x10^{-5}$	Vertical hydraulic conductivity ($1.86x10^{-8}$ cm/sec) of the upper aquifer (till) determined by laboratory analysis of sample from monitoring well JAW-68 (located at the West Burn Pads). Section Section 6.24 of JAYCOR (1996).
Q_p	**$= 5.27x10^{-5}$ ft/day * 426888 ft^2 = 22.5 ft^3/day**			
Q_A	Volumetric flow rate of groundwater (ft^3/day)	**$= V_d * hw$**	Unknown	Calculated Value
V_d =	Darcy Velocity in aquifer (ft/year)		11	JAYCOR (1996)
h =	Thickness of zone of mixing in aquifer (ft)		35	Based on Soil Boring Logs for nearby monitoring wells (JAW-68, JAW-25) Reference: Fence Diagram for West Burn Pads (JAYCOR 1996).
w =	Width of site perpendicular to aquifer flow direction (ft)		492	Width of WBPS determined along 200 ft topographic contour presented in attached Figure 1.
Q_A	**= 11 ft/yr * 1 yr/365 days * 35 ft (depth) * 492 ft (width) = 519 ft^3/day**			
C_A	Initial or background concentration in aquifer (ug/L)		0	Assumed to be non-detect.

Calculation of Barium Remediation Goal Protective of MCL:

$$C_p = \frac{2{,}000 \text{ ug/L} * (22.5 \text{ ft}^3\text{/day} + 519 \text{ ft}^3\text{/day})}{22.5 \text{ ft}^3\text{/day}} = 48{,}133 \text{ ug/L} = 48.1 \text{ mg/L}$$

C_{gw} (ug/L)	Q_p (ft^3/day)	Q_A (ft^3/day)
2,000	22.5	519

$C_s = C_p K_d$

Where: C_s = Soil concentration protective of groundwater = recommended remediation goal (mg/kg)

K_d = Soil/Water Adsorption Coefficient (mL/g)

= 83.9 (Provided by USACE, St. Louis District)

C_s = 4038.4

References:

JAYCOR. 1996. *Revised Draft Final Remedial Investigation/Risk Assessment, Iowa Army Ammuntion Plant, Middletown, Iowa.*

USACE. 2007. *Final Remedial Investigation Work Plan for Line 1, Firing Sites Area, Yards C, G, and L, Warehouse 3-01 and the West Burn Pads Area South of the Road, Middletown, Iowa.* St. Louis District. June.

Summers, K., S. Gherini, and C. Chen. 1980. *Methodology to Evaluate the Potential for Ground Water Contamination from Geothermal Fluid Releases.* EPA-600/7-80-117, U.S. EPA/IERL, Cincinnati, OH.