FMC Idaho LLC, Pocatello, Idaho

Volume 1 - Report

Supplemental Feasibility Study Report for the FMC Plant Operable Unit

July 2010

MWH

FMC Corporation
1735 Market Street
Philadelphia PA 19103

215.299.6000 phone
215.299.6947 fax

www.fmc.com

FMC Corporation

Via Federal Express

July 30, 2010

Ms. Kira Lynch, MS ECL-113
US Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Re: Administrative Order on Consent (AOC) for Supplemental Remedial Investigation/Feasibility Study for the FMC Plant Operable Unit (U.S. EPA Docket No. CERCLA 10-2004-0010):
Final Supplemental Feasibility Study Report – Volumes 1 & 2

Dear Ms. Lynch:

Enclosed please find two copies the *Final Supplemental Feasibility Study Report – Volumes 1 and 2 - for the FMC Plant OU (SFS Report*) prepared pursuant to the above referenced AOC. FMC has revised this report to reflect the changes agreed upon in response to agency comments, as detailed in Appendix I. Additionally, as we discussed, the Remedial Action Objective (RAO) for phosphine has been revised slightly to conform to the language for the RAO for elemental phosphorus.

As you are aware, FMC is currently implementing Supplemental Remedial Investigation (*SRI) Field Modification #15* to perform the site-wide gas assessment, approved by EPA on July 9, 2010. EPA directed FMC to develop this study for the following purpose:

> *To get a site-wide snapshot understanding of phosphine gas generation associated with RCRA ponds and CERCLA RUs that are known to contain elemental phosphorus waste. The characterization effort is focused on phosphine gas because phosphine is the primary gas of concern that can be used to evaluate the extent of the gas generation problem. This event is not intended to replace the long term gas monitoring that will be required under both the RCRA and CERCLA monitoring plans. In addition, this effort is not intended to replace the need for full characterization of the nature and extent of the phosphine gas generation in the CERCLA RUs if it is determined that the current CSM presented in the SRI and the SFS is incorrect and significant quantities of phosphine gas are found being generated within the soil column.*

If the results of this gas assessment were to indicate that the CSM should be modified, i.e., that quantities of PH3 (or other gases of concern) are fluxing from the soil to the ambient air at levels that pose a threat to human health and/or the environment from the FMC Plant OU Remediation Areas (RAs) identified for remedial action to meet the elemental phosphorus and phosphine

RAOs, then further evaluation of cap designs and/or contingencies will be warranted in the remedial design.

As requested by EPA, FMC has modified the distribution list to include shipment of two (2) of the four (4) EPA copies directly to Sue Skinner (EPA-Pocatello), with the other two (2) EPA copies to EPA-Seattle. Sue Skinner will also get six (6) electronic copies of the document. The modified distribution list is attached.

Please call me with any questions, or to discuss further.

Sincerely,

Barbara E. Ritchie
Associate Director, Environment
FMC Corporation

cc:

Sue Skinner (2 copies + 6 extra CDs)
U.S. EPA, Region 10
c/o Idaho State University
Dept. of Biology, Rm 406
921 S. 8th Ave, Stop 8007
Pocatello, ID 83209

Marianne E. Walsh (1 copy)
US Army ERDC/CRREL
72 Lyme Road
Hanover, NH 03755-1290

Doug Tanner (1 copy)
Waste & Remediation Manager
Idaho Department of Environmental Quality
444 Hospital Way #300
Pocatello, ID 83201

Kelly Wright (1 copy)
RCRA/CERCLA Program Manager
Shoshone-Bannock Tribes
Pima Drive
Fort Hall, ID 83203

Steve Rock (1 copy)
U.S. EPA
5995 Center Hill Ave.
Cincinnati, OH 45224

Randall Ross (2 copies)
USEPA
919 Kerr Research Dr.
Ada, OK 74820

David Reisman (1 copy + 1 extra CD)
26 W Martin Luther King Drive
MS 190
USEPA-NRMRL-ETSC
Cincinnati, OH 45224

Susan Hanson (1 copy)
11458 Philbin Road
Pocatello, ID 83202

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ACRONYMS/ABBREVIATIONS

A/C	asphalt/concrete
AFC	alternative final cover
AOC	Area of Contamination
ARAR	applicable or relevant and appropriate requirement
As	arsenic
bgs	below ground surface
CAA	Clean Air Act
CAAA	Crane Army Ammunition Activity
CAR	comparative analysis report
CDC	Center For Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO	carbon monoxide
COC	constituent of concern and chain of custody
COPC	constituent of potential concern
CRREL	Cold Regions Research Engineering Laboratory
CSM	Conceptual Site Model
CV	comparative value
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DOT	Department of Transportation
DPSRA	development and preliminary screening of remedial alternatives
EMF	Eastern Michaud Flats
EPA	Environmental Protection Agency
ESD	Explanation of Significant Difference
ET	evapotranspiration
FeP	ferrophos
FS	feasibility study
ft/day	feet per day
GRA	general response action
GWCCR	Groundwater Current Conditions Report
HHRA	Human Health and Risk Assessment
HSAD	high speed air dispersion
HQ	hazard quotient
IDEQ	Idaho Department of Environmental Quality
IRIS	Integrated Risk Information System
ISTD	In-Situ Thermal Desorption

ACRONYMS/ABBREVIATIONS

LDR	land disposal restriction
LLTSM	low level threat source material
LNAPL	light non-aqueous phase liquid
LOAEL	lowest observed adverse effect level
LTM	long term monitoring
MCL	maximum contaminant level
NCP	National Contingency Plan
NAREL	National Air and Radiation Environmental Laboratory
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net present value
O&M	operation and maintenance
OU	operable unit
P2O5	phosphorus pentoxide
P4	elemental phosphorus
PH3	phosphine
POTW	publicly owned treatment works
PPE	personal protective equipment
PRB	permeable reactive barrier
PRG	preliminary remediation goal
PSCS	preliminary site characterization study
PTSM	principal threat source material
RA	remediation area
RAO	remedial action objective
RAWP	remedial action work plan
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	remedial investigation
RIR	receptor-initiated remediation
RO	reverse osmosis
ROC	radionuclides of concern
ROD	record of decision
ROPC	radionuclides of potential concern
RU	remediation unit
SFS	Supplemental Feasibility Study
SOW	Statement of Work
SRI	Supplemental Remedial Investigation
S/S	solidification/stabilization
SSL	soil screening level

ACRONYMS/ABBREVIATIONS

SUA	Southern Undeveloped Area
SVE	soil vapor extraction
SWMU	solid waste management unit
TCE	trichloroethene
TVA	Tennessee Valley Authority
TCLP	toxicity characteristic leaching procedure
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	United States Army Corp of Engineers
USC	United States Code
WP	work plan
WUA	Western Undeveloped Area
WWT	waste water treatment

Section 1
INTRODUCTION

1.1 PURPOSE AND BACKGROUND OF THE SUPPLEMENTAL FEASIBILITY STUDY

The FMC Plant Operable Unit (OU) is located in southeastern Idaho, approximately 2.5 miles northwest of Pocatello, Idaho, and is a part of the larger Eastern Michaud Flats Superfund site (EMF Site) which was listed on the National Priorities List (NPL) on August 30, 1990. The EMF Site includes two adjacent production facilities, the former FMC Corporation elemental phosphorus (P4) processing plant that ceased operation in 2001 and the phosphate fertilizer processing facility currently operated by the J.R. Simplot Company. The FMC Plant OU, consisting of the FMC Plant Site and other FMC-owned properties at the EMF Site (except the Tesco property), is on privately-owned fee land, most of which is located within the exterior boundaries of the Fort Hall Indian Reservation. As used throughout this *Supplemental Feasibility Study Report for the FMC Plant Operable Unit* (*SFS Report*), the FMC Plant Site is the former operating facility located south of Highway 30, but excluding the Southern and Western Undeveloped Areas (SUA and WUA) that are described in the *Supplemental Remedial Investigation Addendum Report for the FMC Plant Operable Unit* (*SRI Addendum Report,* MWH, 2010a). The easternmost portions of the FMC Plant OU as well as the Simplot OU are located outside the reservation boundary. The EMF Site is shown on Figure 1-1 and encompasses both the FMC and Simplot plants and surrounding areas affected by releases from these facilities. FMC, Simplot and EPA entered into a *CERCLA Administrative Order on Consent (1991 AOC)* in May 1991 under which the companies agreed to conduct a remedial investigation/ feasibility study (RI/FS) for the EMF Site. EPA issued its June 1998 *Record of Decision of the Eastern Michaud Flats Superfund Site, Pocatello, Idaho (1998 ROD*, EPA, 1998).

This *SFS Report* has been prepared to augment the original EMF feasibility study (EMF FS) that was prepared for the FMC Plant Subarea in 1997 entitled *Feasibility Study Report for the FMC Subarea* (*1997 FMC Subarea FS;* BEI, 1997). The FMC Subarea was renamed the FMC Plant OU after the 1998 ROD was issued. This *SFS Report*, as in the *1997 FMC Subarea FS,* screens remedial technologies for each environmental medium against the identified contaminants of concern (COCs), assembles remedial alternatives, and presents the detailed and comparative analyses of remedial alternatives for the FMC Plant OU. This *SFS Report* encompasses all property within the FMC Plant OU and takes into account the Supplemental RI and risk assessment work that has been conducted for the FMC Plant OU after the EMF FS was issued in 1997. The remainder of this subsection summarizes the efforts undertaken between the 1997 FMC Subarea FS and this current Supplemental FS for the FMC Plant OU. These major activities included the performance of a Supplemental Remedial Investigation (SRI), a Groundwater Update for the FMC Plant OU and development of a *Supplemental Feasibility Study Work Plan for the FMC Plant Operable Unit* (*SFS Work Plan,* MWH, 2010b).

1.1.1 Supplemental Remedial Investigation (SRI)

FMC ceased production of P4 from phosphate ore at its Pocatello facility in December 2001. From 2002 to 2006, the facility process operations were decommissioned and the facility infrastructure was demolished to ground level. The cessation of operations led EPA and FMC to enter into an *Administrative Order on Consent* (*2003 AOC*) in October 2003 for a Supplemental Remedial Investigation and Feasibility Study (SRI/SFS) at the FMC Plant OU, whose primary focus was the former operating areas at the facility that the 1998 ROD had assumed would remain in active operation. In accordance with the *2003 AOC,* FMC prepared a document entitled *Supplemental Remedial Investigation and Supplemental Feasibility Study for the FMC Plant Operable Unit - Scoping and Planning Memorandum (Scoping and Planning Memo;* BEI, 2004a*).* Following the *Scoping and Planning Memo*, FMC developed a *Remedial Investigation Update Memorandum for the FMC Plant Operable Unit* (*RI Update Memo*; BEI, 2004b) to summarize data gaps at the FMC Plant OU. These documents were the basis for the *Supplemental Remedial Investigation Work Plan (SRI Work Plan*; MWH, 2007a) that FMC developed as required under the *2003 AOC* to describe the data collection activities and document the rationale, methods, quality criteria and data uses for the SRI.

Consistent with the *2003 AOC*, FMC conducted the SRI at the FMC Plant OU and targeted those areas at the Plant Site that were not investigated during the EMF RI because of ongoing plant production. The FMC Plant OU was sub-divided into 23 preliminary Remediation Units (RUs) to facilitate scoping and planning of the SRI/SFS consistent with the *Scoping and Planning Memo*. RU boundaries were drawn to encompass one or more Solid Waste Management Units (SWMUs) with similar processes or characteristics, including types of constituents of potential concern. A SWMU was identified as a former manufacturing process or solid waste management unit that may have impacted soil or groundwater, consistent with Resource Conservation and Recovery Act (RCRA) criteria. SWMUs were grouped based on their operational similarity and/or geographic proximity to facilitate efficient remedial investigation and evaluation of potential remedial alternatives. In many cases, an RU boundary was easily defined because it was bounded by roads, structures, or other features. An RU was added (RU 24) during development of the SRI Work Plan to capture all other areas within the FMC Plant Site that had been impacted by plant operations but were not otherwise within an existing RU boundary.

EPA approved the *SRI Work Plan* in May 2007 and FMC commenced the SRI field work that year. The SRI findings, including risk assessment updates and an updated conceptual site model, are presented in the final *Supplemental Remedial Investigation Report for the FMC Plant Operable Unit* (*SRI Report*; MWH, 2009a). Figure 1-2 depicts the FMC Plant OU area and shows the remediation units (RUs) that were investigated during the SRI. The *SRI Report* was approved by EPA in June 2009.

During EPA, Idaho Department of Environmental Quality (IDEQ) and Shoshone-Bannock Tribes (Tribes) review of the SRI report drafts, it was agreed that the collection of additional surface soil samples was appropriate at the Southern and Western Undeveloped Areas (SUA and WUA as shown in Figure 1-3) at the FMC Plant Site, and at FMC-owned properties north of Highway 30 (see Figure 1-4) to further evaluate, in addition to the investigative work performed during the EMF RI, potential impacts to these areas from windblown contaminants released from FMC and Simplot sources. These areas had not otherwise been impacted because FMC never used these areas for production operations. In the Fall of 2008, surface soil samples were collected from these areas, and from 10 locations in the greater Pocatello area to update background concentrations for metals and radionuclides. The locations for these background sampling activities are shown in Figure 1-5. The findings of these later investigations, including updated ecological and human risk assessment, are presented in an addendum to the *SRI Report* entitled *SRI Addendum Report*. The final *SRI Addendum Report* was submitted to EPA in November 2009 with copies transmitted to the Idaho Department of Environmental Quality (IDEQ) and the Shoshone Bannock Tribes (Tribes) as specified in the *2003 AOC*. The *SRI Addendum Report* was approved by EPA in December 2009. The data presented in the *SRI Report*, the *SRI Addendum Report*, and the *EMF Remedial Investigation Report* (*EMF RI Report*, BEI, 1996), form the basis for the evaluations presented in this *SFS Report* of soil remedial alternatives at the FMC Plant OU.

1.1.2 Groundwater Update for the FMC Plant OU

To fully document the nature and extent of environmental conditions at the FMC Plant OU, FMC prepared a report that sets forth and evaluates the groundwater data collected after the 1996 EMF RI through FMC's May 2008 groundwater sampling event. This report is entitled the *Groundwater Current Conditions Report for the FMC Plant Operable Unit* (*GWCCR*, MWH 2009b). FMC submitted the final version of this report to EPA in June 2009 with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*. EPA approved this report in July 2009. This report forms the basis for the SFS evaluations of groundwater remedial alternatives at the FMC Plant OU.

1.1.3 Supplemental Feasibility Study Work Plan (SFS Work Plan)

As prescribed by the *2003 AOC*, FMC prepared a *SFS Work Plan*. FMC submitted that to EPA in June 2008, with copies transmitted to IDEQ and the SBT as specified in the *2003 AOC*. After EPA, IDEQ and Tribes review and comment, FMC submitted the final *SFS Work Plan* in January 2010. EPA approved the SFS Work Plan on February16, 2010. The *SFS Work Plan* presents updated applicable or Relevant and Appropriate Requirements (ARARs), Remedial Action Objectives (RAOs), and general response actions (GRAs) for the FMC Plant OU based on the findings presented in the *SRI Report*, *SRI Addendum Report*, and *GWCCR*. The *SFS Work Plan* also provides descriptions and rationale of the work to be performed during this SFS, consistent with the protocol presented in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* (*EPA RI/FS Guidance*; EPA, 1988).

1.2 REGULATORY BACKGROUND

As required under the 1991 *Eastern Michaud Flats Administrative Order on Consent* (*1991 AOC*), FMC and Simplot developed a number of EMF Site studies and reports. These included the *Preliminary Site Characterization Summary* (*EMF PSCS*: BEI, 1994*)* and the *EMF RI Report.* EPA reviewed and approved these reports. EPA conducted the baseline ecological and human health risk assessments concurrently with the companies' RI/FS work and issued the draft and final reports for those risk assessments in July 1995 and July 1996, respectively. The conclusions of those risk assessments were incorporated into the *1997 FMC Subarea FS Report* and the *1998 ROD*.

1.2.1 Key 1998 ROD Elements - FMC Plant Subarea

The *1998 ROD* addressed all three Subareas at the EMF Site (the FMC, Simplot and Off-Plant Subareas). The following were the major remedial action components it prescribed for the FMC Subarea:

- Cap the Old Phossy Waste Ponds (identified in the SRI as RU 22b) and the Calciner Solids Storage area (RU 16), and line the Railroad Swale (RU 22c) to reduce or eliminate infiltration of rainwater and prevent incidental exposure to contaminants.

- Monitor ground water and implement legally enforceable controls that will run with the land to prevent use of contaminated ground water for drinking purposes under current and future ownership. Ground water monitoring and enforceable controls will continue until site contaminants of concern (COCs) in ground water decline to below the Maximum Contaminant Levels (MCLs) or risk-based concentrations (RBCs) for those substances.

- Implement legally binding land use controls that will run with the land to prevent potential future residential use and control potential worker exposures under future ownership.

- Implement a contingent ground water extraction/treatment system if contaminated groundwater migrates beyond Company-owned property and into adjoining springs or the Portneuf River. Containment of contamination shall be achieved via hydrodynamic controls such as long-term ground water gradient control provided by low level pumping. Extracted ground water will be treated and recycled within the plant to replace unaffected ground water that would have been extracted and used in plant operations.

- Conduct operation and maintenance at areas capped to meet CERCLA requirements and, if implemented, at the groundwater extraction system.

The IDEQ concurred with the selected remedies. The Tribes sent EPA comments that were supportive of the following elements of the proposed plan (that were also incorporated into the *1998 ROD*): monitoring of fluoride emissions off-site, monitoring ground water to insure no increases in the contamination, and capping of historical pond areas. However, the Tribes did not fully concur with the ROD. Due to the fact that EPA had received only relatively minor comments regarding the proposed Remedial Design/Remedial Action (RD/RA) at the Simplot Subarea, the United States proceeded with entry of an RD/RA consent decree only with Simplot and only with respect to its plant site and its other owned properties, re-designated at that time as the Simplot Plant OU. The consent decree for the Simplot Plant OU was entered in May 2002. Although a RD/RA consent decree was never entered to implement the 1998 ROD remedies for the FMC Plant OU, FMC has undertaken actions consistent with elements of the ROD including:

- FMC has continued to voluntarily monitor groundwater at numerous CERCLA wells at the FMC Plant OU. Pursuant to an EPA-approved reduction in CERCLA groundwater monitoring in 1994, routine groundwater monitoring of CERCLA wells has continued for the following constituents: arsenic, selenium, potassium, chloride, fluoride, ammonia/ammonium as nitrogen, nitrate as nitrogen (NO3-N), orthophosphate, sulfate, pH, specific conductivity, temperature and turbidity (from 1995 to the present). As of the second quarter 2009, FMC samples sixteen monitoring wells semi-annually under its voluntary CERCLA groundwater monitoring program. In addition, FMC samples 36 wells quarterly under its RCRA groundwater monitoring program and 7 wells semi-annually under its Calciner Ponds Remedial Action groundwater monitoring program (conducted under Idaho Department of Environmental Quality (IDEQ) oversight).

- FMC has also performed periodic supplemental groundwater investigation/monitoring programs or events as requested by EPA or IDEQ. The routine groundwater monitoring programs and special investigation/monitoring events are described in detail and the groundwater data from those programs and special events through the second quarter 2008 are presented in the *GWCCR*.

- In 1995, FMC placed deed restrictions that prohibited any future residential use of the FMC Plant Site and all the other properties at the EMF Site it owned at the time. FMC acquired the Batiste Springs property in 1995 (this parcel includes both the "Spring at Batiste Road" [aka Swanson Road Spring] and Batiste Springs). FMC is in the process of placing similar restrictions at the Batiste Springs parcel prohibiting its development for residential use or operation of child-care or schooling facilities.

The remaining *1998 ROD* items have not been implemented at the FMC Plant OU due to the fact that a RD/RA consent decree was never entered and given the continued SRI/SFS evaluations of its environmental conditions and remedial alternatives.

1.2.2 2003 Administrative Order on Consent Requirements - FMC Plant OU

As discussed above, the *2003 AOC* incorporated a *Statement of Work* (*2003 AOC SOW*, EPA, 2003) that required the following deliverables and actions:

1. Submit a Supplemental RI/FS Scoping and Planning Memorandum. The final version of this deliverable, *Scoping and Planning Memo*, was dated February 2004 and approved by EPA in a letter dated February 20, 2004.

2. Submit a Remedial Investigation Update Memorandum to 1) update the Conceptual Site Model (CSM) and identify former working areas at the plant that had been excluded from the 1998 ROD; 2) compile data regarding the nature and extent of contamination for pathways and former working areas not previously evaluated in the RI/FS; 3) develop an RBC for elemental phosphorus; and 4) update the RI Report. FMC submitted the final version of this document, the *RI Update Memo*, in December 2004. It was approved by EPA in a letter dated May 26, 2005.

3. Submit a Work Plan for the SRI, including a SRI Sampling and Analysis Plan and SRI Health and Safety Plan. The final version of this deliverable, the *SRI Work Plan*, was dated May 2007. EPA approved it on May 14, 2007.

4. Perform a Supplemental Remedial Investigation as prescribed by the EPA-approved SRI Work Plan. FMC conducted the SRI field work between May and December 2007. The SRI Report discusses the findings of that investigative work. This draft document was submitted to EPA for review and approval on June 16, 2008. This draft report was revised based on EPA, IDEQ and Tribes comments and FMC submitted the final SRI Report to EPA on May 14, 2009. EPA approved the final SRI Report on May 26, 2009. FMC also performed additional investigations and studies outside the original scope of the SRI that are companions to the SRI Report. As described in Section 1.1.1, the *SRI Addendum Report* was approved by EPA in December 2009, and, as described in Section 1.1.2, the *GWCCR* was approved by EPA in July 2009.

5. Submit a Work Plan for a Supplemental Feasibility Study of remedial alternatives at the FMC Plant OU. FMC submitted the draft *SFS Work Plan* to EPA on July 15, 2008 with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*. EPA responded with a letter dated July 21, 2009 that directed FMC to finalize the draft *SFS Work Plan* in accordance with FMC's responses to EPA, IDEQ and Tribes comments FMC submitted a draft final version of the SFS Work Plan to EPA with copies transmitted to IDEQ and the Tribes electronically on August 18, 2009. Following EPA review and approval of that document, FMC submitted a final SFS WP on January 22, 2010 to fulfill this requirement of the 2003 AOC. EPA approved the final *SFS Work Plan* on February16, 2010.

6. Submit a Supplemental Feasibility Study Report that evaluates remedial alternatives for the FMC Plant OU and proposes a selected remedy for adoption in the Proposed Plan and Amended ROD. This *SFS Report* is submitted to fulfill this requirement.

Following EPA approval of the *SFS Report*, FMC will have met all the requirements of the *2003 AOC* for the SRI/SFS.

1.2.3 SFS Process

The information generated during the SRI allows EPA to ensure that cleanup requirements at the FMC Plant OU are appropriate for current conditions and compatible with its potential future commercial/industrial use. The SFS will ensure that the FMC Plant OU ARARs, RAOs, general response actions, remedial technologies, remedial alternatives, and proposed remedial actions are re-evaluated specifically in light of the SRI and other post-RI data and the updated CSM.

The SFS for the FMC Plant OU focuses on the potential for exposure to soils and solids under a future commercial or industrial land use scenario, as well as the potential for migration of constituents from soils and solids through the subsurface to groundwater and the transport of constituents in groundwater to discharge into surface water at the Portneuf River. The air and groundwater pathways were evaluated on a site-wide basis in the *FMC Subarea FS Report.* This SFS updates those pathway evaluations consistent with the final *SFS Work Plan*. It is anticipated that after the SRI/SFS is completed, EPA will issue an Amended ROD specifying the FMC Plant OU remedial action requirements.

1.3 SFS SCHEDULE

The *2003 AOC* provides that this *SFS Report* will be submitted 60 days following EPA approval of the SFS Work Plan. FMC submitted the draft *SFS Work Plan* on July 15, 2008. The EPA provided comments on the draft *SFS Work Plan* on September 30, 2008. FMC provided responses to these comments on November 14, 2008 and has met with the EPA, IDEQ and Tribes regarding the SFS on several occasions to finalize the *SFS Work Plan*.

Following EPA approval of FMC's responses to comments on the *draft SFS Work Plan*, FMC prepared a draft final *SFS Work Plan* and submitted that electronically on August 18, 2009 for EPA approval. Following final EPA approval of the draft final document, FMC submitted a final hard-copy version of SFS Work Plan on January 22, 2010. FMC received EPA's approval of the draft final SFS Work Plan on February 16, 2010. This *SFS Report* is being submitted within 60 days of receiving EPA approval of the *SFS Work Plan*.

1.3.1 Supplemental Documents that Augment the *SFS Report*/Effect SFS Schedule

Several key supplemental documents were prepared by FMC during the SFS process and submitted to EPA (with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*) that are not specifically discussed in the *2003 AOC*. Understanding the nature and sequence of these documents is critical to understanding the overall schedule under which this *SFS Report* has been prepared, the information sources on which it is based, and the EPA oversight in accordance with the *EPA RI/FS Guidance* with respect to FMC's scoping and development of these documents. These supplemental documents are discussed below.

Soil and Groundwater Technology Screening Tables for the FMC Plant OU. The first interim deliverables submitted on January 16, 2009 were the technology screening tables for soil and groundwater. These tables present the technologies that were considered for remediation of the COCs and conditions found at the FMC Plant OU and screen them against the criteria of effectiveness, implementability, and cost (in that order of priority). The groundwater technology screening table was revised to add technologies and process options pursuant to EPA's direction during meetings on February 25 and 26, 2009. The revised groundwater technology screening table was provided to the EPA, IDEQ and the Tribes during a subsequent May 21, 2009 meeting. The technologies that remained following this screening were used in assembling the FMC Plant OU preliminary remedial alternatives.

Identification and Evaluation of P4 Treatment Technologies. FMC submitted a document entitled *Identification and Evaluation of P4 Treatment Technologies* (*P4 Treatment Technologies*, MWH, 2009c) to EPA on January 16, 2009 (with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*) to facilitate review of the alternatives screening tables for soils and groundwater in which technologies for P4 treatment are listed and then screened based on effectiveness, implementability, and cost. This document presents an in-depth analysis of the treatment technologies that exist for P4 including the description of each treatment process, engineering challenges and issues associated with the technology, treatment performance and limitations, by-products and residuals, and the history of use for each process. The document also evaluates, for each treatment technology, the ancillary process options and issues associated with feed preparation, the health and safety risks to site workers and the public during P4 removal and treatment, and potential environmental impacts. This document is provided in Appendix A. A meeting between FMC and-EPA, IDEQ and Tribes to discuss the technology screening tables and the supplemental P4 document was held on February 26, 2009.

Buried Railcar Evaluations for the FMC Plant OU. Following questions and discussions resulting from the above-referenced February 2009 meeting and in preparation for a second meeting in which FMC presented assembled remedial alternatives to EPA, FMC prepared several additional documents and submitted those to EPA in May 2009 (with copies transmitted to IDEQ and the Tribes as specified in the

2003 AOC). FMC developed these documents to provide additional information regarding the assembled alternatives for soil remediation and to answer questions that came out of the February 2009 meeting. These documents included a technical memorandum entitled *Buried Railcar Evaluations for the FMC Plant OU* (*Buried Railcar Evaluations*, MWH, 2009d). That paper presented a summary of the evaluation and preliminary screening of the removal/treatment options and technologies for addressing the railcars (RU 19c) that were buried in the Slag Pile (RU 19) in 1981. A copy of this document is provided in Appendix B.

Assembled Soil Alternatives for the FMC Plant OU. FMC developed a document entitled Interim Deliverable - *Assembled Soil Alternatives for the FMC Plant OU* (MWH, 2009e) to present soil remediation technologies and individual process options that had passed the initial screening and that FMC assembled into five preliminary soil alternatives. This document discussed the elements in common to the five alternatives (e.g., cap integration, soil management plans, etc.); the proposed cover system (or cap) designs for gamma, evapotranspiration (ET), and multi-layered caps; combining RUs into larger remediation areas (RAs) for the purpose of efficient and effective site remediation; and detailed descriptions of the alternatives. A copy of this document is provided in Appendix C.

In addition, prior to a meeting between FMC and EPA, IDEQ and the Tribes in Seattle on May 20 and 21, 2009, the five alternatives (six including the No Action Alternative) presented in this document were screened in a table entitled "Assembled Soil Remediation Alternatives, Initial Screening, and Selection." In this table, the alternatives were screened in accordance with the *EPA RI/FS Guidance* against the criteria of implementability, effectiveness, and cost. However, the final column entitled "selection (yes/no)," in which alternatives normally would be listed as either retained or eliminated based on these screening criteria, was intentionally left blank to stimulate discussion at these late May 2009 meetings.

Comparison of Conventional and Alternative Cover Systems for Use at the FMC Plant OU. Following the May 20 and 21, 2009 meetings, FMC prepared a further document entitled *Comparison of Conventional and Alternative Cover Systems for Use at the FMC Plant OU* (*Capping Memo*, MWH, 2009f). This document presented a comparison between conventional (multi-layer) and alternative (ET) capping systems and responded to questions raised in the May 2009 meetings regarding the effectiveness of the various capping systems with respect to, for example, preventing exposure to P4, reducing infiltration through the capped wastes, handling the gases emitted from the wastes that would be covered, and the long-term durability of each cap design.   FMC submitted the *Capping Memo* to EPA electronically on June 16, 2009 (with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*). FMC held a follow-up teleconference on July 2, 2009 in which Steve Rock, EPA, National Risk Management Research Laboratory (NRMRL), stated that he agreed with the conclusions of the *Capping Memo* and that ET caps would be acceptable for capping areas underlain by P4 as well as areas underlain by other site COCs. Mr. Rock further noted that it would be necessary to monitor the soil chemistry should off-gassing occur from FMC Plant OU wastes covered by ET caps. A copy of this document is provided in Appendix D.

Assembled Soil Alternatives Table for the FMC Plant OU. At EPA's request, FMC also prepared a table following the May 20 and 21, 2009 meetings that identified the potentially available process options for soil remediation at each Remediation Area (RA). This process resulted in a total of five assembled alternatives (by RA), similar to those presented in the previously-submitted *Assembled Soil Alternatives for the FMC Plant OU*, but organized differently based upon requests from EPA and the Tribes. These assembled alternatives are screened as described in Section 7 of this Report.

Groundwater Flow and Transport Modeling Report for the FMC Plant OU. During the May 21, 2009 meeting, FMC committed to proceed with development of a groundwater flow and transport model as a tool to support the Supplemental Feasibility Study and compare the remedial alternatives for the FMC Plant OU discussed during that meeting. FMC held a series of meetings with EPA, IDEQ and the Tribes during development of the groundwater model, The *Groundwater Modeling Report for the FMC Plant OU- March 2009* (*Modeling Report*, MWH 2010c) is attached to this *SFS Report* as Appendix E.

1.4 DOCUMENT ORGANIZATION

This SFS has been organized to accomplish the objectives discussed in Section 1.1 above and to meet the criteria set forth in the *EPA RI/FS Guidance*. Figure 4-1 of the *EPA RI/FS Guidance* document presents a summary of the RI/FS process. This figure has been re-created here as Figure 1-6, referencing the sections of this report that correspond to the specified steps of the RI/FS process. A description of each section of this report is presented below.

Section 2.0 – Site background information is summarized in this section. This includes a brief summary of the site physical characteristics and a description of the plant site and its operational history, including a description of the wastes generated by the manufacturing process.

Section 3.0 – Investigation and risk assessment findings and an updated conceptual site model based on the SRI, 2008 SRI field work, and the *GWCCR* are summarized in this section.

Section 4.0 – This section summarizes remedial action objectives, ARARs, and general response actions as presented in the final *SFS Work Plan*.

Section 5.0 – A wide range of potentially usable technologies and process options for remediation of soil and groundwater are identified and screened in this section with respect to on-site technical implementability.

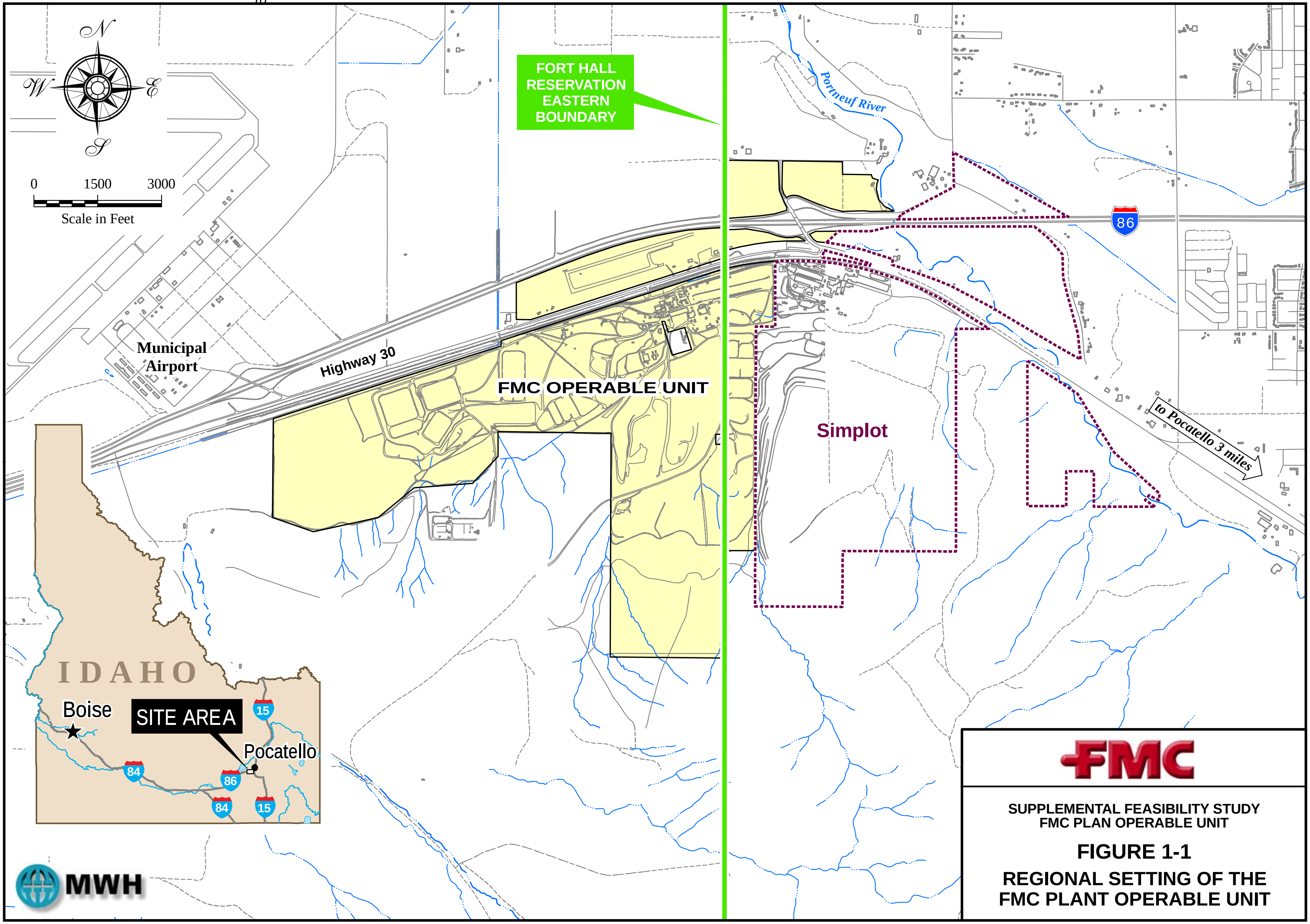
Section 6.0 – Soil and groundwater remedial technologies are screened against the criteria of effectiveness, implementability, and cost to eliminate marginal technologies and identify potentially viable technologies for the FMC Plant OU remediation.

Section 7.0 – Soil alternatives are assembled by RA and then screened against the criteria of effectiveness, implementability, and cost to eliminate marginal alternatives and identify alternatives that warrant rigorous detailed analysis. Groundwater alternatives for the entire FMC Plant OU also are assembled and screened in this section against the three criteria listed above.

Section 8.0 – A detailed analysis of each soil and groundwater remedial alternative that passed the screening process is conducted in this section using the threshold and balancing criteria specified in the National Contingency Plan and EPA guidance. A total of seven individual criteria are used in the detailed analysis, in the first instance the two *threshold criteria* of overall protection of human health and the environment and compliance with ARARs. The five *balancing criteria* of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume, short-term effectiveness, implementability, and cost are also evaluated. EPA will perform an evaluation of the two *modifying criteria* of state and community acceptance during / following the Proposed Plan comment period.

Section 9.0 – This section presents the comparative analysis of the soil and groundwater alternatives that have undergone detailed evaluation, to select the most appropriate alternatives for soil and groundwater remediation at the FMC Plant OU.

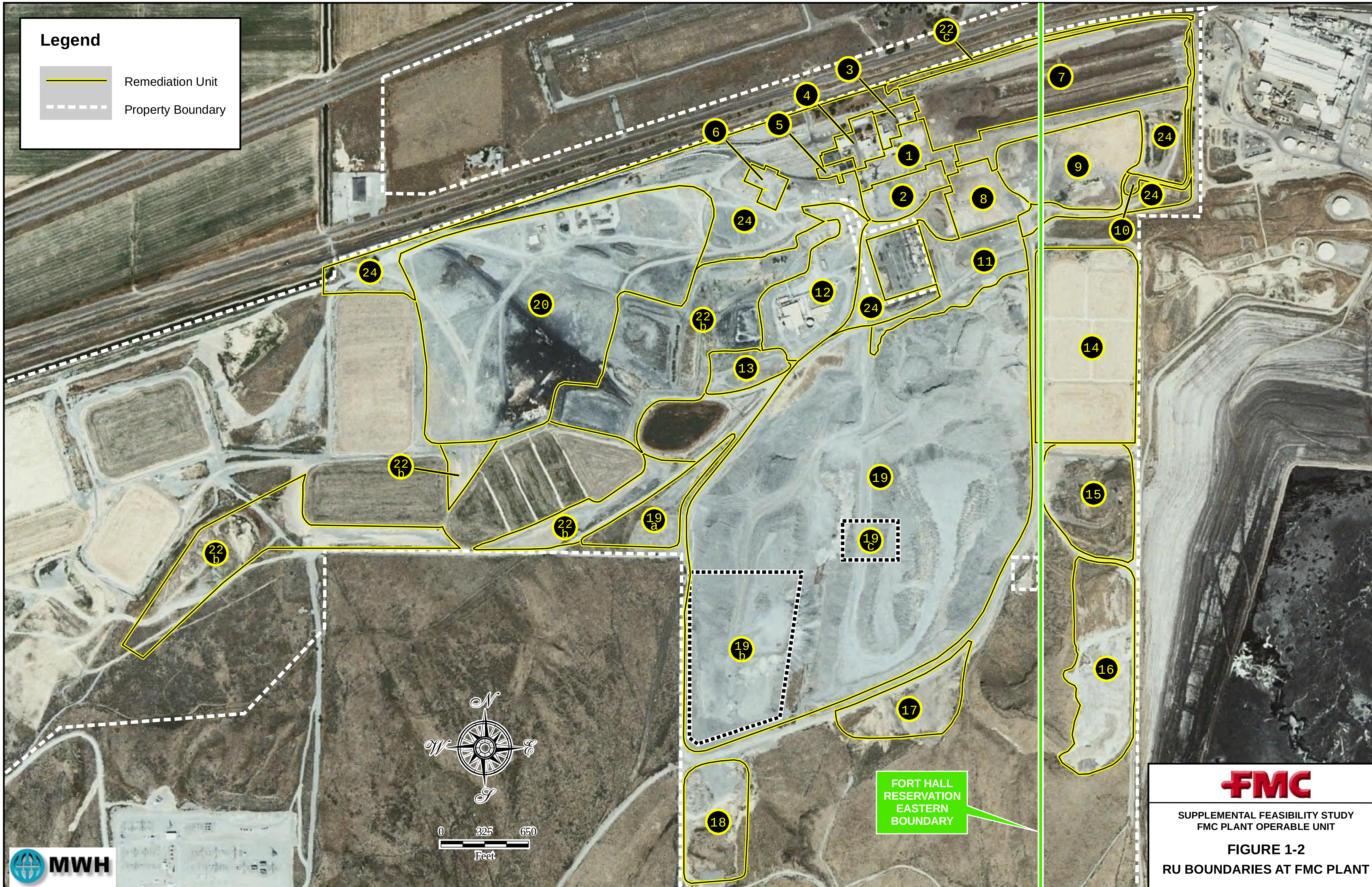
FILE Fig 1-01 Regional Setting_1009.mxd 10 /11/09



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLAN OPERABLE UNIT

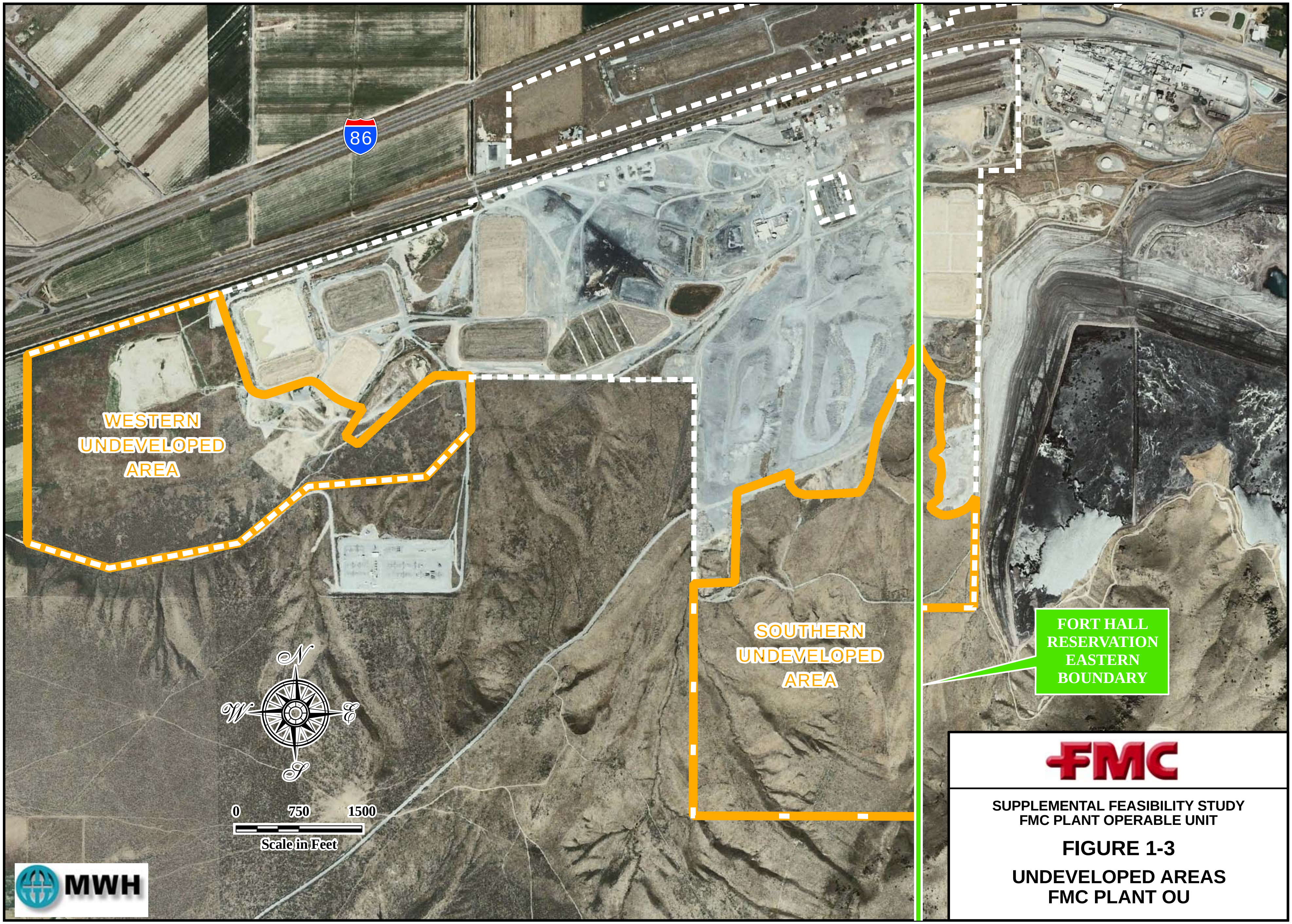
FIGURE 1-1

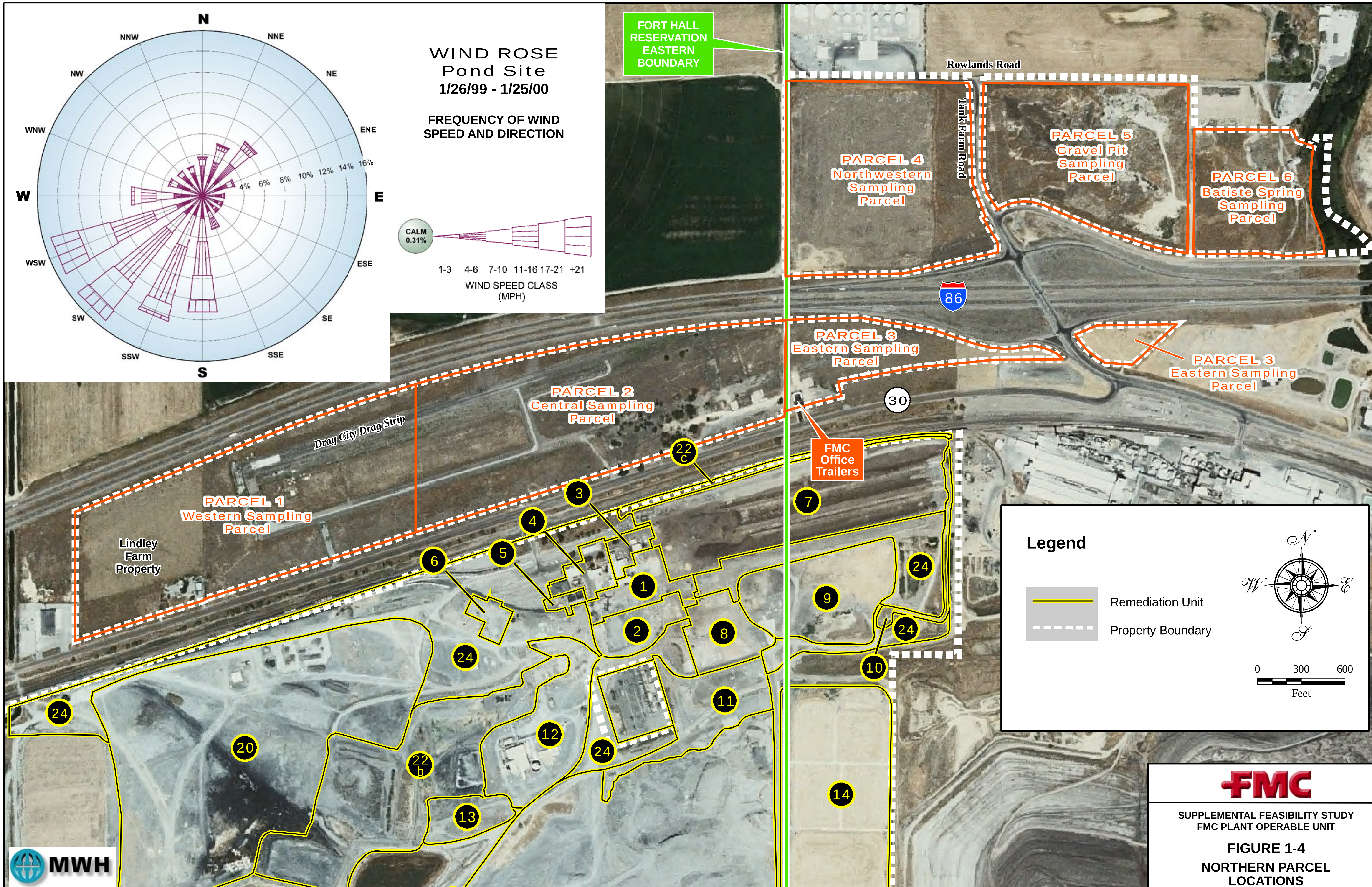
REGIONAL SETTING OF THE FMC PLANT OPERABLE UNIT



FILE Fig 1-02_RU Bndries at FMC Plant_0310.mxd 3/01/10

FILE *Fig 1-03_Undev Areas_1009.mxd* *10/11/09*



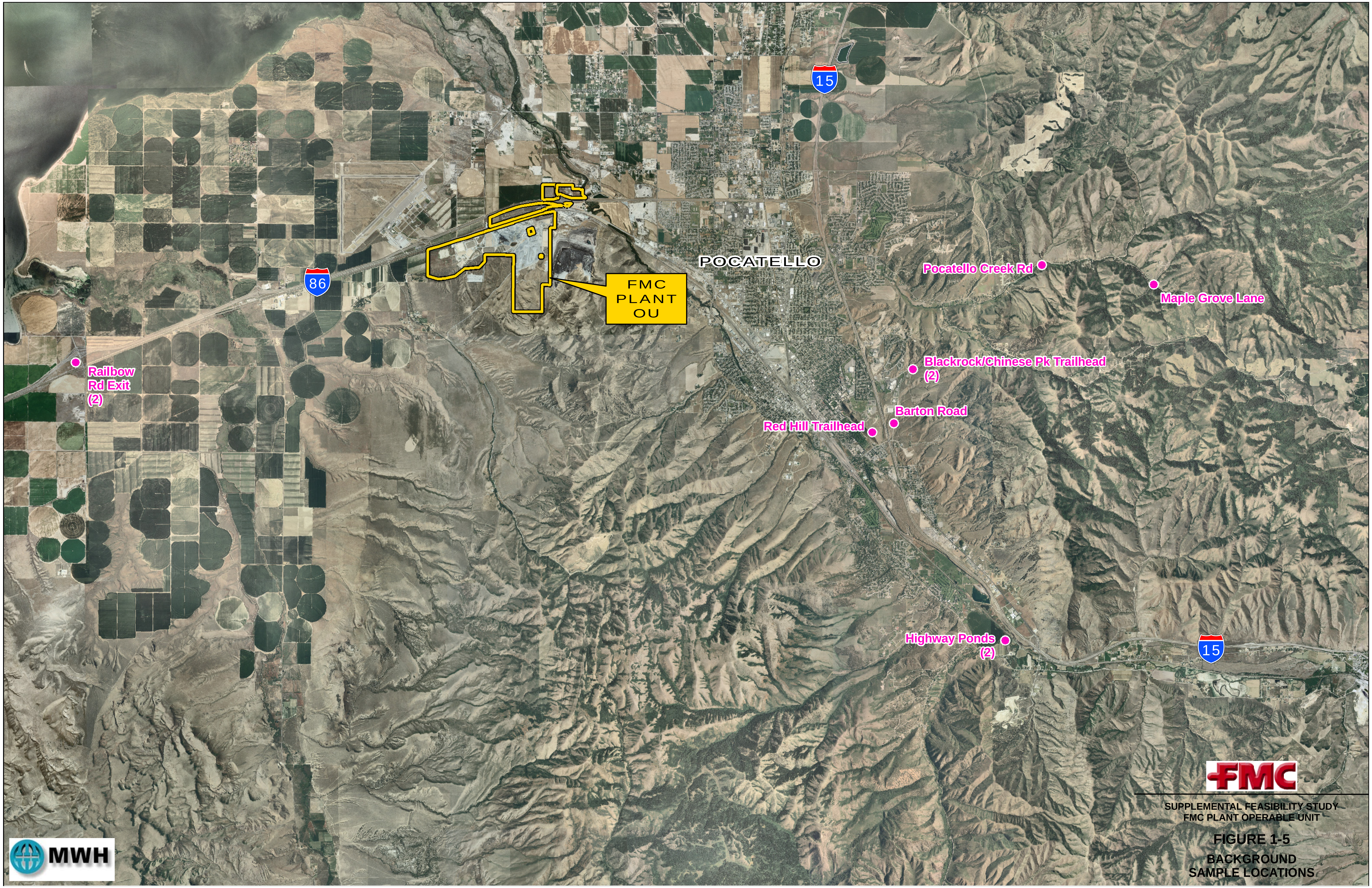


FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 1-4
NORTHERN PARCEL LOCATIONS

FILE Fig 1-04_Northern Parcel Locations_1009.mxd 10/11/09



FILE Fig 1-05_Background Sampling Locs_1009.mxd 10/11/09

FILE Fig 5-01_Alternative Development_modified_909.ai 9/13/09

WH

SOURCE
Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988)

SUPPLEMENTAL FEASIBILITY STUDY
FMC POCATELLO

FIGURE 1-6

SFS PROCESS AND ALTERNATIVE DEVELOPMENT

Section 2
SITE BACKGROUND – FMC PLANT OU

2.1 INTRODUCTION

This section summarizes the site background information including a brief description of the site physical characteristics, the plant manufacturing process, and the scope and findings of previous investigations that are relevant to the SFS.

The FMC Plant OU is located approximately 2.5 miles northwest of Pocatello, Idaho, and 1 mile southwest of the Portneuf River, a tributary of the Snake River. The FMC Plant Site lies south of Highway 30, covers approximately 1,150 acres, and was the location of all of the process operations used for the production of P4. The FMC Plant Site adjoins the western boundary of the Simplot Don Plant, as shown on Figure 1-1. There are an additional 212 acres owned by FMC located north of Highway 30 (excluding the Tesco property) that are also part of the FMC Plant OU. Figure 1-1 also shows where the FMC Plant OU, which encompasses the FMC Plant Site, is located in the State of Idaho and in relationship to the city of Pocatello.

The FMC Plant OU is on privately-owned fee land, most of which is located within the exterior boundaries of the Fort Hall Indian Reservation. The easternmost portion of the FMC Plant OU is located outside the reservation boundary. The FMC Plant OU consists of all the property that FMC owns at the EMF Site, and includes the FMC Plant Site located south of Highway 30 and all the properties that FMC owns north of that highway with exception of the Tesco property. The Tesco property, located immediately west of the FMC-owned properties north of Highway 30, was purchased by FMC after the 1998 ROD and therefore is not included in the FMC Plant OU.

2.2 SUMMARY OF PHYSICAL CHARACTERISTICS

This section describes the physical characteristics of the region and the FMC Plant OU, including the geology, hydrogeology, surface water hydrology, area soils, climate, demography, land use and ecology. The physical characteristics described in this section are summaries of the observations made during the EMF RI and SRI as presented in the reports for those investigations (i.e., *EMF RI Report* and *SRI Report*), the *1997 FMC Subarea FS*, and Section 2 of the *GWCCR*.

2.2.1 Geologic Setting

Regional Geology. As described in Section 3.1.1 of the *EMF RI Report*, the FMC Plant OU and surrounding area are located at the juncture between the Basin and Range physiographic province to the south and the Snake River Plain to the north (Dohrenwend, 1987). The FMC Plant OU is located at the northern base of the Bannock Range where it merges with the Michaud Flats. The Bannock Range is part of the Basin and Range Province and the Michaud Flats is part of the Snake River Plain. The southern undeveloped area of the FMC Plant OU is located at the northern end of the Bannock

Range and the former operational areas of the FMC P4 production facility are located primarily on the Michaud Flats. The FMC Plant OU is underlain by a sequence of Starlight Formation volcanics and sediments, and is overlain by the interfingered American Falls Lake Beds-Sunbeam Formation. These are overlain by Michaud Gravel and Aberdeen Terrace deposits. Finally, a mantling of loess is present at higher elevations and a veneer of alluvium covers lower areas. Loess deposits are much thicker in portions of drainages where they have been reworked and redeposited. The regional geology, including at the FMC Plant OU area, is shown on Figure 2-1 as mapped by K.L Othberg in an unpublished report by the Idaho Geological Survey in April 1997.

Site Geology. A detailed description of site geology is presented in the *EMF RI Report* Section 3.1.2 and was based on the RI drilling and geologic logging program. A hydrogeologic cross section based on drilling completed by Bechtel during the RI is shown on Figure 2-2. The cross section (C – C') extends from the southeast near the slag pile across the FMC Plant OU to the northwest and ends near Highway 30.

The stratigraphy of the FMC Plant OU generally can be described as discontinuous layers of unconsolidated sediments deposited on an erosional surface that was incised in volcanic bedrock. The sedimentary units immediately above the bedrock are gravels derived from volcanic rocks. The stratigraphy at the FMC Plant OU includes, in ascending order, volcanic bedrock units (rhyolite, tuff, and some basalt), coarse volcanic and quartzitic gravels, fine-grained sediments of the American Falls Lake Bed, Michaud gravels, Aberdeen alluvial terrace deposits (locally) and loess deposits of calcareous silts and clays. Loess is present at both higher elevations and lower elevations of the site in varying thicknesses. Loess deposits are much thicker in portions of drainages where they have been reworked and redeposited. During RI and SRI drilling, loess was described as fine sandy silt in texture with some localized areas of thinly bedded alluvial gravels.

Fill material encountered during drilling and excavating consisted of reworked native soil, imported soil and other materials generated during the facility operations. The materials were stored and/or placed around the FMC Plant Site during the operation of the facility. The fill material types and thickness are discussed in detail in Section 4.0 of the *SRI Report* for each RU. Fill and other source material at the FMC Plant Site observed during SRI drilling included reworked native soils (loess, sand, and gravel), slag, ore (including calcined ore and bull rock), ferrophos, concrete, asphalt, silica, calciner pond solids, phossy solids, precipitator solids, and coke (and coke fines). Table 2-1 lists the fill materials encountered at the surface and in the subsurface at each RU. Also included in this table are potential incidental fill materials and maximum/minimum depths of fill across each RU.

Native soil types encountered during SRI drilling include loess, gravels and clays. Material up to boulder size and possibly larger was encountered beneath the site during the drilling at RU 1 at depths below 60 feet below ground surface (bgs). Bedrock was encountered during the drilling in RU 15 and 16 and included basalt, rhyolite, and tuffs.

2.2.2 Hydrology

Regional Hydrology and River Morphology. Major surface water features of the region near the FMC Plant OU include the Snake River, Portneuf River, and the American Falls Reservoir as shown on Figure 2-3 and described in greater detail in Section 3.2.1 of the *EMF RI Report*. The American Falls Reservoir is an impoundment of the Snake and Portneuf rivers and other smaller creeks near the FMC Plant OU that discharge into the reservoir at its eastern end.

The Portneuf River drainage area is approximately 1,250 square miles. Predominantly fine-grained deposits collected from point bars, chute bars, and the local floodplain of the river were sampled during the RI field investigation. Upstream of the FMC Plant OU, the Portneuf River flows in a relatively steep valley between the Pocatello and Bannock ranges. East of the FMC Plant OU, the river emerges onto the Michaud Flats along the base of the Bannock Range. The river runs across the flats incised in a shallow, flat-bottomed valley that widens from about 0.5 mile (0.8 km) at the Bannock Range to over 1.5 miles (2.4 km) near the reservoir, and the river course is sinuous. At the reservoir, the broad flat-bottomed area is called the Fort Hall Bottoms.

The American Falls Reservoir covers 88 square miles (22,800 hectares), and has a capacity of 1.7 million acre-feet (2,097 million cubic meters). The reservoir level fluctuates seasonally, with high levels occurring during peak runoff in spring. During high water levels, the reservoir floods much of the Fort Hall Bottoms, as evidenced by stressed trees along the banks (Fenwick, 1993a). Sediments deposited in the American Falls Reservoir likely originate from a large number of watersheds and reflect anthropogenic activities throughout the area.

Site Hydrology and Drainage. There are no naturally-occurring perennial surface water systems within the FMC Plant OU. The nearest major surface water feature is the Portneuf River, located at the northeastern boundary of the FMC Plant OU as shown on Figure 2-3. Natural drainages within the FMC Plant OU primarily consist of small ephemeral streams that channel flow from the Bannock Range to the Michaud Flats. Within the FMC Plant Site these natural drainages have been significantly modified by plant operations.

Surface runoff within the FMC Plant Site is infrequent and is contained within boundaries of the Plant Site. When storm runoff occurs it does not run outside the FMC Plant Site but is contained in the storm drainage ditches and depressions, and eventually evaporates or infiltrates. Modeling of storm runoff within the FMC Plant Site for the maximum 24-hour storm of record (1.82 inches) indicated that runoff would be completely contained within the plant site area (BEI, 1996).

The EMF RI investigation found no channels by which stormwater would discharge from the FMC Plant Site, other than the former NPDES-permitted IWW ditch outfall from the FMC Plant Site to the Portneuf River, which was eliminated and the piping plugged in

2002. The FMC Plant Site is separated from the Portneuf River by the Union Pacific Railroad, Highway 30, and Interstate 86. The bed of the railroad and highway grades are raised above the adjacent terrain and form multiple barriers separating the FMC Plant Site from the river.

2.2.3 Hydrogeologic Setting

Regional Hydrogeology. The Eastern Snake River Plain is underlain by basalt and gravel aquifers that are recharged mostly by underflow from surrounding mountain ranges. Some recharge occurs as irrigation return and deep percolation from precipitation. Several rivers flow onto the Snake River Plain, infiltrate underground, and the water ultimately discharges to the Snake River. Groundwater flow through the basalts of the Snake River Plain occurs primarily in thin interflow zones: thin gravel and fracture zones between basalt flows and in the fracture of the basalts (some of the basalts are columnar basalts, with a large interconnected fracture network). Regionally, the Snake River defines the base level for other smaller rivers such as the Blackfoot and Portneuf rivers.

The Michaud Flats are underlain by the same prolific basalt and gravel aquifers. These aquifers are recharged by underflow from the adjoining Bannock and Pocatello mountain ranges and from significant downvalley underflow from the Pocatello Valley aquifer. Smaller drainages also provide underflow to the aquifers. Direct infiltration from precipitation and irrigation return is another recharge source. Within the mountainous areas, there are no regionally continuous hydrostratigraphic units. Groundwater flows through undifferentiated volcanic and sedimentary rock units, with flow focused to sediment-filled valleys incised into the mountains. At the transition between mountainous areas and flatlands, there are alluvial fan deposits where groundwater flow occurs primarily within sand and gravel lenses.

Groundwater that flows into the regional aquifer system discharges to the Portneuf River (via springs and base flow contribution), American Falls Reservoir, or to one of the numerous springs and seeps in the Fort Hall Bottoms. Groundwater discharges to the Portneuf River along the reach from I-86 downstream to the American Falls Reservoir. The river gains approximately 200 cubic feet per second (cfs) flow along this reach as groundwater discharges through the riverbed and springs.

Site Hydrogeology. There are three distinct hydrogeologic areas underlying the FMC Plant OU, each with characteristic stratigraphic, hydrologic, and geochemical features. These have been designated the Michaud Flats, Bannock Range, and Portneuf River Valley hydrogeologic areas.

The Michaud Flats groundwater enters the FMC Plant OU from the southwest and west and occupies the northwestern part of the site. It has higher sodium chloride content than other groundwater in the area. Hydraulic conductivities are relatively high (30 to 100 feet per day [ft/day]). The stratigraphy of the Michaud Flats can generally be described as discontinuous layers of unconsolidated sediments (including the Michaud Gravel) overlying fine-grained silts, clays, and sands (American Falls Lake Bed deposits) that form a discontinuous, semi-confining unit. Deeper alluvial and colluvial silt, sand and gravels are typically volcanic (Sunbeam Formation), especially where the Michaud Flats area merges with the Bannock Range. These alluvial / colluvial sediments overlie an erosional surface incised in volcanic bedrock.

Bannock Range groundwater enters the FMC Plant OU from the south where it primarily occupies the southern undeveloped area. Water can be described primarily as calcium-bicarbonate rich. This area has relatively lower hydraulic conductivity values (0.03 to 28 ft/day), steep hydraulic gradients, and typically thinner saturated thicknesses of volcanic gravels or resides within volcanic bedrock.

Portneuf River Valley groundwater is found at the northeastern extent of the FMC Plant OU north of Highway 30 near the Portneuf River. This groundwater is similar to the Bannock Range groundwater, but is more alkaline. The geology in this area generally consists of relatively thick deposits of highly permeable Michaud Gravel and the American Fall Lake Bed deposits are not present having been scoured out during deposition of the Bonneville flood gravels. Hydraulic conductivities are relatively high (28 to 4,800 ft/day) as there appear to be very few if any fine-grained units within the gravels.

Groundwater level depths range from more than 150 feet bgs in the southern portion of the FMC Plant OU (northern edge of the Bannock Range) to about 45 feet in the northwestern area of the FMC Plant Site. In the northern portion of the FMC Plant OU (north of Highway 30), groundwater generally is about 60 feet bgs. At the FMC Plant Site, the SRI sampling encountered groundwater at depths typically greater than 90 feet bgs. These groundwater depths were observed in both the unconsolidated sediments and bedrock.

In the western portion of the FMC Plant OU, Michaud Flats groundwater in the shallow aquifer moves from the southwest and west to the east toward the Portneuf River. Across the southern boundary of the FMC Plant OU, groundwater flows north from the Bannock Range. Michaud Flats and Bannock Range groundwater systems mix together within the FMC Plant OU and the surrounding area. In the northeastern corner of the FMC Plant OU and surrounding area, Bannock Range, Michaud and Portneuf River Valley groundwater mix together (BEI, 1996).

As shown on Figure 2-4, groundwater beneath the FMC Plant Site (south of Highway 30) generally flows to the north from the Bannock Range and then to an east-northeasterly flow as the Bannock Range groundwater merges with the Michaud groundwater system.

2.2.4 Area Soils

Surface soils at the FMC Plant OU originated from deposition by fluvial erosion and deposition (alluvium), collection at the base of slopes (colluvium), weathering in place (residuum), and deposition by wind (loess). As described in Section 1.2 of the *EMF RI Report* and in Section 2.2.2 from the *1997 FMC Subarea FS*,, the area where the FMC Plant OU is located is underlain to some depth by soils consisting of calcareous silts and clays (loess). These silts and clays have an average pH greater than 8 and, because of their calcareous nature, a high buffering capacity. The high pH will act to neutralize acidic materials, precipitate cations that form carbonate solutions, and provide for numerous cation exchange opportunities for trace elements. The silts are of greatest thickness in the western and central portions of the FMC Plant Site and extend to the south beyond the FMC Plant OU boundary (BEI, 1997).

2.2.5 Climate

The FMC Plant OU is located in a region where the climate is semi-arid, characterized by a wide range of temperatures. The warmest temperatures generally occur from June through August (daily mean maximum temperature 86.8 ºF), and the coldest temperatures occur from December through February (daily mean minimum temperature 15.1ºF). The highest and lowest temperatures recorded at the Pocatello Municipal Airport were 104 ºF in August 1969 and minus 33 ºF in February 1985 (NOAA, 2007). The mean evaporation during the summer is 29.76 inches (762 mm) for the 3-month period, and 3.36 inches (86 mm) for the winter months.

The average annual precipitation for the region is 11.53 inches per year, with the greatest amount of precipitation occurring during the spring months. The areal and seasonal distribution of precipitation also influences hydrogeologic characteristics. Precipitation patterns in the region are strongly linked to topography, with larger amounts of snow and overall precipitation falling at higher elevations in the Bannock Range to the south of the site. The higher elevations of the Bannock Range serve as recharge areas for aquifers in the valleys.

Regional air movement is generally from the west/southwest, with local wind flow patterns controlled by the rugged topography. Pocatello Airport data show a prevailing wind direction from the south-southwest, with a strong predominance of wind from the entire southwest quadrangle. Mean annual wind is 10 mph. In the summer months, moisture-laden air from the Gulf of Mexico and Caribbean regions produce thunderstorms.

2.3 FMC PLANT PROCESS DESCRIPTION

The FMC Plant process is described below as well as the products and by-products produced from the manufacturing process and the RUs where these by-products are found. Areas where P4 is anticipated are intentionally highlighted because they pose unique challenges in evaluating remedial alternatives.

2.3.1 Historic FMC Plant Process Description

The FMC Plant Site produced P4 from phosphate-bearing shale ore mined regionally. Figure 1-2 shows the location of process areas of the site and the RUs identified for evaluation during the SRI. Ore was shipped to FMC via the Union Pacific Railroad during the summer months and stockpiled (in RU 7). The ore was crushed, screened, and formed into briquettes prior to heat treatment (known as calcining). The calcining process (located within RU 8) involved heating the ore briquettes to a sintering temperature of approximately 1,200°F to form nodules. Carbon monoxide (CO), a by-product of the phosphorus furnace reaction, was used as fuel to fire the calciners. The nodules were blended with coke and quartzite (known as silica) to make the phosphorus furnace feed. This mix of nodules, coke and silica was fed into four electric arc furnaces (located within RU 1). The furnace reaction primarily yielded gaseous P4, CO gas, slag, and ferrophos (FeP). The P4 gas was subsequently condensed to a liquid state and stored in sumps and tanks in the furnace building and phos dock prior to shipment off-site as product.

P4 will burn upon contact with air. Therefore, to prevent oxidation, the condensed phosphorus product was kept covered with water from the time it was produced through loading and transport off-site. All of the P4 product manufacturing and handling processes were located within RU 1, with the exception of long-term phosphorus storage tanks located in RU 6.

Process water (known as phossy water) was used to isolate P4 from contact with air and to slurry precipitator dust (a furnace by-product). Phossy water and precipitator slurry were typically managed separately in a series of surface impoundments located to the west of the P4 furnaces. A number of these surface impoundments (Ponds 8S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18A, 8E, and 9E) were closed and capped under EPA-approved RCRA closure plans and are not subject to evaluation in the SRI/SFS (designated as RU 22a). Numerous other surface impoundments were historically dewatered and/or covered. These ponds, which had ceased receiving wastes prior to the narrowing of the Bevill exemption and thus were not subject to RCRA, are located within RU 22b. The railroad swale (designated as RU 22c) was designed as a stormwater retention area but also received phossy water (and therefore P4) from process spills in the furnace building and phos loading dock.

More detailed information regarding the ore processing, by-product handling, and waste management operations at the FMC Plant Site is provided in Sections 1.1.2 through 1.1.3 of the *EMF RI Report*.

2.3.2 Description of FMC Plant Site P4 Product and P4-Containing By-Products

The following subsections provide a brief description of P4 and other materials (precipitator solids, phossy solids, and native soil) that could be expected to be encountered along with P4 at the FMC Plant Site, and thus are important in evaluating treatment technologies for P4 and other site COCs (including radionuclides and metals) during the SFS. It should be noted that slag and ore from the P4 manufacturing process would also be expected to be encountered with P4. A description of these materials can be found in Sections 1.3.3.1 and 1.3.3.2 of the *SRI Report*, respectively.

2.3.2.1 Description of P4

The primary product from the FMC facility was white (or yellow) phosphorus. Elemental phosphorus exists in three distinct configurations called allotropes, all with the same molecular weight, but each differing significantly from the other allotropes in physical and chemical characteristics. The chemical formula for all allotropes of elemental phosphorus is P4; however, they have different names according to their respective colors, including black, red, violet, and white (sometimes called yellow due to impurities). While some transformation of white (or yellow) P4 may have occurred at the FMC Plant Site at very insignificant rates, by far the predominant allotrope expected to be encountered on site is white (or yellow). Therefore, the SFS technology screening will be limited to white P4.

<u>Physical & Chemical Characteristics:</u> White P4 is a waxy solid that may be colorless, white, or yellow, and has a garlic-like odor. Table 2-2 provides a summary of some of the physical properties of P4, which shows that it is relatively insoluble in water, with a solubility of 3 mg/L at 15°C.

The primary processes for chemical transformation of P4 are oxidation and hydrolysis. In a solid phase such as in soil, P4 oxidizes spontaneously with oxygen in air to form phosphorus pentoxide (P_4O_{10}, commonly expressed as P_2O_5), which exists as a particulate at ambient conditions. Phosphorus pentoxide has a strong affinity for water and will react with water (hydrolyze), including moisture from the atmosphere, to form various phosphorus acids, primarily orthophosphoric acid (H_3PO_4). In water, dissolved P4 is oxidized by dissolved oxygen (DO) to form various forms of soluble phosphorus acids, including $H_2PO_4^{-}$, HPO_4^{-2}, and PO_4^{-3}. In water with other dissolved ions, and depending on environmental conditions such as pH and Eh, these acids may be further converted to a solid metal phosphate compound such as calcium phosphate. The rate of phosphorus oxidation in water is governed by the form of the phosphorus (dissolved or suspended), DO concentration, salt concentration, metal ion concentration, pH, and temperature.

To a lesser degree, P4 also is hydrolyzed in water to form phosphine (PH3) and lesser amounts of phosphorus acids. PH3 is a toxic gas that has a low solubility, and thus is expected to migrate from the water to the air; the portion of phosphine that dissolves is generally oxidized to form the above-referenced forms of phosphorus acids. The rate of hydrolysis of P4 is enhanced by an increase in the pH of the water reacting with the white phosphorus (WP). (USACE, 1996)

P4-impacted soils are known (or suspected) to be present in the following areas of the FMC Plant Site:

- RU 1 – Furnace building, secondary condenser, and phos loading dock due to leaks and spills from production processes and waste management;
- RU 2 – Slag pit due to leaks and spills from production processes and waste management;
- RU 13 – Pond 8S recovery process area and metal scrap preparation area due to management of waste materials in the adjacent old pond area;
- RU 19c – Railcars containing P4 sludge buried in the slag pile (RU 19).
- RU 22b – Old pond area due to management and disposal of P4 containing wastes;
- RU 22c – Railroad swale, due to phossy water spills entering stormwater sewers and discharging to the stormwater retention pond; and
- Areas containing underground piping or sewer lines that carried phossy water, precipitator slurry, or CO gas, and therefore potentially could contain residual P4, or which may have leaked P4 (RUs 1, 2, 3, 8, 12, 13, 22b, and 24).

P4-impacted groundwater has been identified immediately downgradient (flowing to the northeast) of RUs 1 and 2. As a result of this groundwater impact, P4 has been identified in the capillary fringe soils immediately above groundwater in RUs 3 and 7.

Section 2.3.3 below provides a description of each of these areas, including the types of materials encountered with the P4, particle sizing, P4 concentrations, and depth of P4 contamination. The physical setting in which the P4 is found and the nature of the P4 are important factors in screening and evaluating potential remedial options.

2.3.2.2 Description of Precipitator Solids

Precipitator solids (otherwise referred to as precipitator slurry, precipitator dust, and/or fluid bed dryer slurry/prills) were produced in the electrostatic precipitators immediately downstream of the phosphorus furnaces. The precipitator solids consisted of furnace feed dust and condensed constituents that had boiled off in the high temperatures of the furnace (including metals, radionuclides, and P4). Prior to 1955 precipitator solids were handled dry. After 1955, a slurry system was installed for all the precipitators with the resulting slurry being pumped to a series of ponds located in RU 22b. When possible (e.g., phosphorus content was not too high), precipitator slurry was allowed to air dry in these ponds. Dried precipitator slurry (precipitator solids) was reclaimed from these ponds and sold as a fertilizer additive due to its high zinc content.

Precipitator dust contained in any of the historical ponds is assumed to have some level of P4 remaining in the sediment matrix at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that the discharge of phossy water or precipitator slurry into ponds during operation is known to have locally concentrated P4 to much higher concentrations (e.g., liquid P4 was known to have accumulated at the discharge area of piping into the ponds, resulting in a large frozen mass of highly concentrated [50% or higher] P4).

Physical, Radiological and Chemical Characteristics: Precipitator solids are typically described as "fine-grained, dark-gray-to-black material." While the particle size of precipitator dust is relatively uniform, cover materials such as slag and ore placed on historical ponds certainly would impact particle size distribution of materials in these ponds.

A summary of radiological sampling results for precipitator solids is presented in Table 1-3 of the *SRI Report.* These sampling activities also are described in Table F-1 of the *RI Update Memo*. Elevated levels of lead-210 and polonium-210 are associated with precipitator solids (labeled "Precipitator Slurry/Phossy Wastes" in Table 1-3 of the *SRI Report*). In addition, precipitator solids were sampled as part of the SRI fill characterization study and analyzed for gross alpha, gross beta, radium-226, uranium-238, potassium-40, lead-210, and polonium-210. The radionuclide sample results from the SRI are discussed in Section 4.27 of the *SRI Report.*

Table 1-4 of the *SRI Report* presents total metals and fluoride concentrations in historical precipitator solids samples. In addition, precipitator solids were sampled as part of the SRI fill characterization study and analyzed for fluoride and metals. The fluoride and metal sample results from the SRI are presented in Section 4.27 of the *SRI Report*.

In addition to ponds in RU 22b, precipitator solids were known to be present (or have been identified through sampling) in the following areas:

- RU 1 – Precipitator dust and slurry was generated within the furnace building.

- RU 2 – Releases of precipitator slurry were at times washed from the furnace building into the slag pit.

- RU 10 – During the SRI, solids containing precipitator slurry were identified in the sediment in the non-contact water cooling pond. These solids were likely from spills of precipitator slurry within the furnace building that became co-mingled with non-contact cooling water.

- RU 12 – During the RI, solids identified as precipitator solids were identified within the western edge of RU 12. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids may have been stockpiled or spilled in this area during precipitator dust recovery.

- RU 13 – During the SRI, solids containing precipitator solids (identified as a red fill) were identified within RU 13. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids (or soils impacted by pond leaching) may have been stockpiled or used as fill in this area.
- Areas containing underground piping or sewer lines that carried precipitator slurry (and therefore potentially could contain P4) are located in RUs 1, 2, 12, 13, 22b, and 24.

2.3.2.3 Description of Phossy Solids

Phossy solids, otherwise referred to as phossy water solids, oxidized phossy solids, and/or phossy slurry, were produced throughout the phosphorus manufacturing process and were typically solids (consisting of ore dust, coke, dust, silica dust, slag dust and/or precipitator dust) containing phosphorus within a phossy water stream. The phossy solids accumulated within the water stream as a result of contact with phosphorus-containing process streams (e.g., phosphorus product and phosphorus sludge). These various phossy water streams were accumulated within sumps/drains/tanks and pumped to slurry ponds located to the west of the furnace building (in RU 22b), where the phossy solids were allowed to settle and accumulate. These ponds were maintained with a water cover to prevent oxidation of phosphorus with air. Early phossy water ponds, i.e., those that ceased operation before RCRA management requirements became applicable, were eventually "closed" by dewatering and being covered with other fill materials such as precipitator dust, slag, and/or native soils. These pre-RCRA historic ponds are located in RU 22b.

Phossy solids contained in any of the historical ponds or the railroad swale are assumed to have some level of P4 remaining in the sediment matrix, at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that the discharge of phossy water or precipitator slurry into ponds during operation is known to have locally concentrated P4 to much higher concentrations (e.g., liquid P4 was known to have accumulated at the discharge area of piping into the ponds, resulting in a large frozen mass of highly concentrated [50% or higher] P4).

<u>Physical, Radiological and Chemical Characteristics:</u> Phossy solids that were allowed to dry typically resulted in oxidation of the phosphorus, leaving gray to dark-gray or black sediments. However, the appearance of phossy solids can vary depending on the other types of solids with which they are found (i.e., ore, coke, slag, silica or precipitator dust). While the particle size of phossy solids is relatively uniform, cover materials such as slag and ore certainly would impact the particle size distribution of materials in historical ponds.

A summary of radiological sampling results for phossy solids is presented in Table 1-3 of the *SRI Report*. These sampling activities also are described in Table F-1 of the *RI Update Memo*. An additional phossy solids sample was collected as part of the SRI fill characterization study and analyzed for gross alpha, gross beta, radium-226, uranium-238, potassium-40, lead-210, and polonium-210. All the SRI radionuclide sample results are discussed by RU in Section 4.27 of the *SRI Report*.

Table 1-4 of the *SRI Report* presents total metals and fluoride concentrations in historical phossy solid samples. In addition, a phossy solids sample was collected as part of the SRI fill characterization study and analyzed for fluoride and metals. The fluoride and metal sample results from the SRI are presented in Section 4.27 of the *SRI Report*.

In addition to ponds in RU 22b, phossy water and phossy solids were known to be present, or have been identified through sampling, in the following areas:

- RU 1 - Most phossy water was generated within the furnace building, phos dock and secondary condenser where P4 was produced, stored, and recovered.

- RU 2 – Releases of phossy water were at times washed from the furnace building into the slag pit.

- RU 12 – During the RI, solids identified as precipitator solids were identified within the western edge of RU 12. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids may have been stockpiled or spilled in this area during precipitator dust recovery.

- RU 13 – During the SRI, solids containing precipitator solids (identified as a red fill) were identified within RU 13. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids (or soils impacted by pond leaching) may have been stockpiled or used as fill in this area.

- RU 22c - Phossy water spills to the surface in the furnace building or phos dock were often captured in the storm sewer system, which discharged to the railroad swale (stormwater retention pond).

- Areas containing underground piping or sewer lines that carried phossy water (and therefore potentially could contain P4) are located in RUs 1, 2, 3, 12, 13, 22b, and 24.

2.3.2.4 Description of Native Soils

The native soils and underlying sedimentary package found at the FMC Plant OU consist of alluvium, colluvium, loess, etc. and are described in detailed in Sections 2.2.1 and 2.2.4. The distribution and thickness of these native soils are important factors because these soils will be used as a source of clean borrow material for capping systems and other earthwork that might be necessary for the FMC Plant OU remediation.

2.3.3 Description of Areas (RUs) Where P4-Impacted Soils Are Expected

Because of the differing process operations within the FMC Plant Site that managed P4 product and P4-containing waste, different areas of the site that are known or suspected to contain P4-impacted soils have varying physical settings in which P4 is or may be encountered in the subsurface. Deposited P4 is typically associated with varying amounts of slag, ore, precipitator solids, phossy solids, and native soils. In order to effectively screen and evaluate P4 treatment technologies and, as discussed in this section, the ancillary processes necessary to implement a treatment technology, it is critical to understand the following physical properties in each differing area of the site:

- Relative P4 concentrations and the variability of P4 concentrations across the area;
- Depth of P4 deposition;
- Total volume of P4 and impacted fill that must be handled and processed;
- Particle size distribution, not only of the frozen P4 particles, but also of other fill materials and soils associated with the P4-impacted matrix; and
- Other fill materials (and associated COCs) included in the P4-impacted matrix that must also be treated or handled.

A summary of these physical characteristics for the areas of P4-impacted soils is included on Table 2-1. These physical characteristics for each of the areas of P4-impacted soils are further described in the following subsections.

2.3.3.1 Furnace Building, Phos Dock & Secondary Condenser (RU 1) and Slag Pit (RU 2)

<u>RU Description:</u> RU 1 is 4.1 acres in size and encompasses the locations of the former furnace building, secondary condenser, and phos dock. These were the primary P4 product production, storage, and handling areas within the FMC Plant Site. The furnace building contained electric arc furnaces, primary condensers, P4 sumps, and various tanks. The secondary condenser was downstream of the furnaces and provided final recovery of P4 product, collecting that in a single sump. P4 from the furnace sumps and the secondary condenser sump was pumped to the phos dock for storage and loading onto rail cars for shipment. Because of the pyrophoric nature of the P4, the P4 product was contained within a closed system, consisting of piping, pumps and tanks, and was always covered with water to prevent the P4 from contacting air. Water that came into contact with P4 was known as phossy water and typically contained small particles of P4, ore dust, coke dust, silica dust, and P4 reaction products. This phossy water was pumped via underground and aboveground piping to ponds in RU 22b.

Furnace offgas, containing primarily CO and P4 gases, passed through an electrostatic precipitator in which particulate was removed to clean the offgas stream. The dust collected in the electrostatic precipitator, known as precipitator dust, was then slurried with recycled water and pumped via underground and aboveground piping to ponds in RU 22b and RU22a (RCRA Ponds).

RU 2 is 3.7 acres in size and encompasses the former slag pit located immediately south of the furnace building (RU 1). It is an area where molten slag from the furnaces was poured, cooled, broken, and loaded onto slag haul trucks to be placed on the slag pile (RU 19). In 1999-2000, FMC converted to slag ladling, where the molten slag was poured from the furnaces into ladles. The ladles were truck mounted, allowing for the molten slag to be transported to the slag pile where it was poured down the face of the slag pile and allowed to cool and solidify. Prior to implementing slag ladling, the soils beneath RUs 1 and 2 (down to groundwater) were heated by the molten and cooling slag to above the 44°C melting point of P4.

The heated column of soil located beneath the furnace building and slag pit respectively at RUs 1 and 2 would allow the P4 from surface and subsurface spills, such as spills or releases from product sumps, underground piping, and slag pit catch basins, to remain as a liquid and thus move downward to groundwater (to a depth of approximately 85 feet). This heated soil column, as determined using a thermal model, is depicted as the area within the 44°C isotherm on Figure 2-5. The phos dock and secondary condenser are positioned well outside the 44°C isotherm; thus, there is limited potential for migration of P4 downward to the groundwater in these areas.

P4 likely exists in soils and fill materials to a depth of 10 feet throughout RUs 1 and 2 at concentrations varying from 0 to 50%, with the highest concentrations being immediately under P4 product sumps. Within the 44°C isotherm, P4 likely exists throughout the soil column to groundwater. As liquid P4 likely filled the void spaces between soil particles in the vadose zone, concentrations up to 30% may be possible.

<u>Fill Materials:</u> As summarized on Table 2-1, the surface of RU 1 and RU 2 is made of up of slag, concrete foundations, asphalt with slag aggregate, and silica. The subsurface fill materials around the perimeters of RUs 1 and 2 consist primarily of slag, concrete foundations, and reworked native soils and slag. Although not visually identified, process knowledge has identified precipitator solids as an incidental fill material in RUs 1 and 2. The native soil interface around the perimeters of the RUs ranges between 1.5 and 20 feet bgs. With a predominance of slag on the surface, particle size distribution down to 20 feet bgs would range from very fine to plus 6-inch. The concrete slabs within RU 1 range from 2 feet to 10 feet in thickness and are steel reinforced.

Below 20 feet bgs and within the 44°C isotherm, the P4 is likely to be within native soils, consisting of gravelly silts and sands in the upper three to nine feet, followed by 20 to 30 feet of silt to sandy silt, 40 to 50 feet of coarse sands, gravels, and cobbles, and finally 10 feet of silts and sandy silts at the capillary fringe.

As discussed in Section 4.2 of the *SRI Report*, groundwater is encountered at a typical depth of 85 feet bgs. P4 was encountered (as evidenced by slight smoking) at the capillary fringe in 2 borings in RU 3 and at 1 boring in RU 7, both immediately downgradient to the northeast of RU 1. Based upon the 2-foot split spoon interval that was sampled and observed, the P4 was limited to a 2-foot interval immediately above the groundwater. Based upon the amount of smoking observed in the capillary fringe samples, it is estimated that the P4 concentration was at least 1,000 ppm but well below 10,000 ppm.

As discussed in Section 4.2.4 of the *SRI Report*, the P4 estimated to be present within RUs 1 and 2 combined is 580 to 5,470 tons. RUs 1 and 2 contain total estimated fill volumes of 56,580 yd^3 and 20,485 yd^3, respectively.

<u>Summary of Pertinent SFS Information for RUs 1 and 2:</u>

- P4 concentrations vary from 0 to 50% across the RUs at depths down to 10 feet, 0 to 30% in soils down to the capillary fringe at 80 feet bgs (within the 44°C isotherm), and 1,000 to less than 10,000 ppm within the 2-foot capillary fringe encountered at about 83 feet bgs;

- Total estimated mass of P4 is 580 to 5,470 tons and total estimated volume of fill is 77,065 yd^3;

- Particle size distribution for fill materials would range from minus ¼-inch to plus 6-inch, (with crushed slag amassing to form monolithic particles several feet in diameter in some areas) with a similar range for native soils; and

- Other fill materials include slag, concrete, asphalt, silica, phossy solids, precipitator solids, and underground piping.

2.3.3.2 Historical Surface Impoundment Area (RUs 13 and 22b)

<u>RU Description:</u> RU 13 is 3.6 acres in size and is located in the south-central portion of the FMC Plant Site, as shown on Figure 1-2. It is immediately southwest of RU 12 and is adjacent to several old ponds. RU 13 is north of a portion of RU 22b (old phossy water ponds). Because RUs 13 and 22b share a common boundary and have similar fill materials, this report evaluates them together. Although RU 13 was never documented to have been used directly in the P4 production process operation, in the mid-1980s a process was developed, built, and tested on the northern side of Pond 8S to recover P4 from Pond 8S. This process (the Pond 8S recovery process) was located within the RU 13 boundaries. The Pond 8S recovery process was shut down, closed and removed in 1993. Pond solids may have been stockpiled or used in RU 13 as fill material prior to construction of the Pond 8S recovery process.

RU 22b is 37.7 acres in size and consists of four separate parcels in the western portion of the FMC Plant Site as shown on Figure 1-2. As described above, waste streams that contained P4 (i.e., phossy water and precipitator slurry) were slurried and pumped to a series of ponds at RU 22b. The hydraulic head at the old ponds was removed through solar evaporation.

In 1954, the initial ponds in RU 22b were created and began receiving phossy water. In 1955, a slurry system was installed for all the precipitators with the resulting slurry similarly being pumped to ponds within RU 22b. When possible (e.g., phosphorus content was not too high), precipitator slurry was allowed to air dry in these ponds. Dried precipitator slurry (precipitator solids) was reclaimed from these ponds and sold as a fertilizer additive due to its high zinc content. All of the ponds located in RU 22b (with the exception of Pond 10S) were closed during a period from 1972 through 1976 by being covered with various materials, including native soil, dried precipitator dust and prills, ore, and slag.

Precipitator solids and phossy solids contained in any of the historical ponds is assumed to have P4 remaining in the sediment matrix at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that addition of precipitator slurry to historical ponds may have concentrated P4 to much higher levels. For example, low concentrations of liquid P4 within heated phossy water/precipitator slurry will accumulate in the surface impoundment at the pipe discharge. This P4 tended to immediately freeze upon entering the surface impoundment and create a large frozen mass of highly concentrated P4 (50% or higher). During operation of the ponds, the piping discharge point was periodically moved to prevent "islands" of sediments from extending above the water line. Therefore, areas of highly concentrated P4 associated with the pipe discharge are variably distributed throughout the pond sediments.

<u>Fill Materials:</u> As summarized on Table 2-1, the fill materials within RUs 13 and 22b consist of slag, concrete foundations, asphalt with slag aggregate, precipitator solids, phossy solids, ferrophos, underground piping and reworked native soils (i.e., native soils that have been mechanically mixed with other fill materials). Fill depth within RU 13 ranges from 1 to 25 feet. Fill depth within RU 22b ranges from 0 to 44 feet.

As discussed in Section 4.13.4 of the *SRI Report*, the mass range of P4 estimated for RU 13 is 25 to 60 tons. The total volume of all fill materials at RU 13 is 66,630 yd^3. As discussed in Section 4.18.4 of the SRI Report, the mass range of P4 estimated for RU 22b is 4,440 to 10,800 tons. The total volume of all fill materials for RU 22b is 595,820 yd^3.

<u>Summary of Pertinent SFS Information for RUs 13 and 22b:</u>

- P4 concentrations vary from 0 to 50% across the RUs;
- Depth of P4 contamination extends to 44 feet bgs (maximum depth of former ponds / fill material);

- Total estimated mass of P4 is 4,465 to 10,860 tons and total estimated volume of fill is 662,450 yd^3;
- Particle size distribution for fill materials would range from minus ¼-inch to plus 6-inch (with crushed slag often becoming compacted in-place to form monolithic layers up to several feet in thickness in some areas, as observed during the SRI trenching conducted at RU22c); and
- Other fill materials include slag, concrete, asphalt, ore materials, phossy solids, precipitator solids, ferrophos, and underground piping.

2.3.3.3 Railroad Swale (RU 22c)

<u>RU Description:</u> RU 22c is 2.4 acres in size and is located to the north of the P4 production areas along the northeastern boundary of the FMC Plant Site, as shown on Figure 1-2. The railroad swale was designed as a stormwater retention area. It received stormwater from the underground storm sewer piping within the plant production area. However, phossy water spills and releases from the furnace building and phos dock also discharged to the railroad swale, either through the underground storm sewer piping or by over-surface flows. As a result, the railroad swale received not only stormwater but also phossy water containing P4 and phossy solids. Because the railroad swale ran parallel to the ore stockpile, ore dust was also likely to have blown into the swale. In the mid-1980s the railroad swale was dug out to a depth of 10 to 20 feet and backfilled with slag. It was partially lined in 1993 to reduce infiltration of water into the subsurface.

Although the railroad swale received phossy water (and associated P4), this discharge was at ambient temperatures. Therefore, the P4 deposition was different than in the ponds within RU 22b, i.e., there is no evidence of concentrated areas of P4 in the railroad swale. During the SRI, one trench across the railroad swale was found to contain P4, as evidenced by slight smoking. It is presumed, based upon the SRI sampling and process knowledge that P4 concentrations in the sediment matrix within the railroad swale are fairly consistent and range from 0 ppm to less than 10,000 ppm.

<u>Fill Materials:</u> As summarized on Table 2-1, the fill materials within RU 22c consist of slag (presumed to be minus 2-inch crushed slag), phossy solids, and ore. Fill depth within RU 22c ranges from 5 to 20 feet (based upon historical knowledge and SRI findings).

As discussed in Section 4.19.4 of the *SRI Report*, the mass range of P4 estimated for RU 22c is 4 to 10 tons. The estimated total volume of all fill materials for RU 22c is 40,607 yd^3.

<u>Summary of Pertinent SFS Information for RU 22c:</u>

- P4 concentrations vary from 0 to less that 10,000;
- Depth of P4 contamination extends to 20 feet bgs;

- Total mass of P4 is 4 to 10 tons and total volume of fill is 40,607 yd^3;

- Particle size distribution for fill materials would range from minus ¼-inch to 2-inch (with crushed slag amassing to form monolithic particles several feet in diameter in some areas); and

- Other fill materials include slag, phossy solids, and ore.

2.3.3.4 Railroad Cars in Slag Pile (RU 19c)

RU Description: RU 19c is 2.7 acres in size and is located near the center of the slag pile (RU 19) as shown on Figure 1-2. In 1964, 21 railcars containing an estimated 10 to 25% P4 sludge were placed at the southern edge of the slag pile and covered with native soil. The railcars were then covered with 80 to 120 feet of slag as the slag pile progressed to the south. Although the sludge in the rail cars would have been pumped into the railcars at temperatures above the melting point of P4, the railcars would have been cooled to ambient temperatures (and the P4 sludge solidified) by the time the railcars were placed in the slag pile.

Fill Materials: The fill materials within RU 19c consist of slag (presumed to be uncrushed slag), phossy solids, and P4. Fill depth within RU 19c ranges from 80 to 120 feet (based upon process knowledge that the railcars were placed at the original soil elevation and then covered with slag).

As discussed in Section 4.15.4 of the *SRI Report*, the mass range of P4 estimated for RU 19c is 200 to 2,000 tons. The estimated total amount of all fill materials for RU 19c is 300,000 yd^3 including the volume of slag overlying the railcars.

Summary of Pertinent SFS Information for RU 19c:

- P4 concentrations of the sludge within the railcars range from 10 to 25%;

- Depth of railcars containing the P4 is 80 to 120 feet;

- Total mass of P4 is 200 to 2,000 tons and total volume of fill is 300,000 yd^3;

- Particle size distribution for fill materials would range from minus ¼-inch to large boulders (uncrushed slag): and

- Fill materials are primarily slag, although the railcars would include iron, P4, and phossy solids.

2.3.3.5 Areas with Underground Piping Suspected of Containing P4

There are a number of RUs that contain underground piping that was used to carry phossy water, precipitator slurry or CO gas from the furnace building, slag pit and phos dock to other areas of the plant. Underground storm water piping that at times likely conveyed phossy water also is present in RUs 1, 3, and 24. All this underground piping was left in place during decommissioning of the plant and, while it was allowed to gravity drain, it was not cleaned in place. As such, the underground piping may contain residual P4. These underground piping and stormwater lines exist in RUs 1, 2, 3, 8, 12, 13, 22b, and 24. Underground piping was constructed of mild steel, although the storm water piping in RUs 1 and 3 was constructed of concrete. While the underground piping was likely placed at least 3 to 5 feet below grade at the time of installation to protect against freezing, additional fill may have been placed on top of older piping such that some piping may be up to 10 to 15 feet below the current surface.

In contrast to the P4 processes in RU 1, the old underground pipelines that transported precipitator slurry or phossy water to the phossy ponds in RU 22b were not heated. The old pipelines were placed underground to prevent the wastewater in the pipelines from freezing during winter conditions. The P4 wastewater from RU 1 was at typical operating temperatures (60 to 66 C) when pumped into the pipelines. The temperature of the wastewater in the old underground pipelines would not have added a significant heat load, in terms of increased temperature, to the surrounding soil beyond a few feet from these lines.

Soil temperatures are not elevated above a natural range of subsoil temperatures (approximately 12 to 17 C) in the subsurface beneath the precipitator slurry and phossy water pipelines, excluding those segments of pipelines in RUs 1 and 2 that were within the 44° C isotherm associated with the slag pit. In the areas outside the 44° C isotherm in RUs 1 and 2, a release of P4 to the subsurface from a pipeline leak would freeze fairly rapidly and be immobilized in an area near the point of release. Migration of P4 beyond a few feet from the lines would have been limited to dissolved P4 at a concentration below 3 mg/L (i.e., the solubility limit of P4).

One underground CO line remains within RU 8, consisting of the former CO feed line to the calciners. While this CO line may contain a small quantity of fairly pure P4, the CO line most likely did not leak during plant operation because a leaking CO line would have been detected immediately as evidenced by the burning CO/P4 at the surface. With the cessation of operation, the CO line would have cooled and any remaining P4 would have solidified in place.

Underground storm water lines in RUs 1, 3, and 24 carried phossy water to the railroad swale. There is potentially some P4 remaining in the bottom of these storm sewer lines, although since these streams were managed at ambient temperatures, P4 would likely not have accumulated. Leaks may have occurred at the cement piping joints, although migration of P4 beyond a few feet would not be expected.

P4 concentrations within the underground piping may range from 1% to 100%. As discussed in Section 4.26.4 of the *SRI Report*, the mass range of P4 estimated collectively within the remaining phossy water and precipitator slurry underground pipelines is between 2.8 and 28 tons. The P4 estimated within the single remaining underground CO line is between 0.2 and 1.8 tons. The underground storm sewer piping is estimated to contain between 0.13 and 0.6 tons of P4. These P4 mass estimates do not include potential leakage or loss at pipeline cleanouts (from maintenance) that may have occurred but is not quantifiable.

Summary of Pertinent SFS Information for Underground Piping:

- Estimated P4 concentrations vary from 1% to 100% throughout the underground piping;
- Depth of P4 contamination is estimated to be no deeper than 15 feet below the current surface;
- Total volume of P4 is estimated to be between 3.13 to 30.4 tons collectively for all the underground piping;
- Other fill material in and around the underground piping includes slag, phossy solids, precipitator solids, ore, and native soils.

2.4 PREVIOUS INVESTIGATIONS AND SUMMARY OF FINDINGS

2.4.1 Introduction

The FMC Plant OU has been the subject of a number of environmental investigations. The investigations, reports, and decision documents that provide pertinent background to the SRI/SFS process are discussed below.

2.4.2 Preliminary Site Characterization Summary (*EMF PSCS*)

The *PSCS* presented the preliminary results of the RI and fulfilled the objective to provide an initial characterization of the EMF Site. The *EMF PSCS* characterized potential sources of releases, on-site and off-site soils, groundwater, surface water, and sediments, and included a survey of ecological resources, demography, and land uses within the EMF study area. Consistent with the RI, the *EMF PSCS* addressed the entire EMF Site, i.e., both the FMC and Simplot properties as well as adjoining areas not owned by either company. The *EMF PSCS* was prepared prior to the shutdown of the FMC phosphate ore processing operations.

The following are some of the key observations made in the *EMF PSCS* regarding the potential sources, groundwater, soils, sediment, and surface water at the Site:

- Potential sources were identified as the phosphate rock feedstock used by both the FMC and Simplot facilities as well as the products, by-products and waste streams generated as a result of phosphate rock processing. The constituents of potential concern/radionuclides of potential concern (COPCs/ROPCs) found in common in the feedstock, products, by-products and waste streams were cadmium, chromium (total), fluoride, total phosphorus, vanadium, iron, lead, silver, zinc, gross alpha and gross beta.

- Although control measures had been taken at both facilities that were found to have greatly reduced releases of constituents to groundwater, on-site shallow groundwater was found to have been impacted by releases from unlined waste management ponds at both facilities. The primary constituents associated with these impacts were found to be arsenic, chloride, fluoride, nitrate, selenium, sodium, and sulfate. While the natural alkaline pH of the soils in the EMF area was found to be an important attenuation factor for metals, constituents associated with Simplot and FMC activities were detected at Batiste Spring and Swanson Road Spring.

- While source materials (such as slag, phosphogypsum and phosphate ore) cover significant portions of both facilities, on-site subsurface soil quality was found to have been impacted only where either a sustained hydraulic head transported constituents from source materials into the underlying soils or where mechanical mixing of the source materials and subsurface soils had taken place.

- While process changes were found to have greatly reduced airborne dispersion of process materials, EMF-related constituents were detected immediately north and east of the facilities in off-site soils, suggesting historical deposition of windblown particulates from both facilities. The *EMF PSCS* described the subsurface soils located outside the companies' properties as not having been impacted by airborne releases.

The *EMF PSCS* concluded that sampling results generated as of the date of that report demonstrated that there was minimal human or ecological exposure to site-related constituents in groundwater, surface water, sediments, on-site soils, and off-site soils.

2.4.3 Eastern Michaud Flats Remedial Investigation Report

FMC and Simplot conducted the EMF Site RI/FS under the *1991 AOC* with EPA. In 1996, the companies issued and EPA approved the *EMF RI Report* characterizing the nature, extent, fate and transport of chemical constituents likely released from FMC and Simplot facility operations.

During the RI, FMC and Simplot performed extensive sampling and analyses of surface and subsurface soils, groundwater, surface water, sediment, aquatic and terrestrial ecology, and air. More than 1,500 groundwater samples were taken and more than 60,000 analyses were performed. Approximately 3,600 air samples were taken and analyzed for more than 20 constituents. A detailed emissions inventory was developed for both facilities and atmospheric dispersion models were used to characterize air emissions impacts. Industrial feedstocks and potential sources of constituent releases at both facilities were characterized. Soil samples were taken at 200 locations to a depth of as much as 70 feet.

Outside the processing facilities, soils were sampled on a radial grid at regular intervals along 16 compass directions up to a distance of approximately 3 miles. Approximately 250 surface water and sediment samples were collected and about 7,500 analyses were performed. Both aquatic and terrestrial exposures were characterized to support the *EMF Baseline Ecological Risk Assessment* (*Baseline ERA*, E&E 1995) that was performed by EPA's contractor, E&E.

The RI characterized the nature and extent of chemical constituents likely released from the FMC and Simplot processing facilities and the potential migration of these constituents within various media. The principal findings of the RI for soils include the following:

- Soils containing the highest levels of facility-related constituents are confined to the FMC and Simplot operational areas. These areas exclude residential uses.
- Although concentrations of site-related constituents are elevated primarily on properties owned by FMC and Simplot, there are off-site areas with concentrations above background levels.

The RI also characterized the nature and extent of contaminants in the following media, which were outside the scope of the SRI:

- Groundwater
- Surface Water and Sediments
- Terrestrial Ecology
- Air.

2.4.4 Feasibility Study Report for the FMC Subarea

The *FMC Subarea FS Report* was submitted to EPA in 1997. The *1991 AOC* required four interim FS deliverables: 1) the identification of candidate technologies memorandum, 2) the RAO memorandum, 3) the development and preliminary screening of Remedial Alternatives (DPSRA) memorandum, and 4) the comparative analysis report (CAR). These memoranda were submitted to EPA between 1993 and 1996. Remedial alternatives were developed for FMC Subarea COCs/ROCs that were associated with the soils/solids, groundwater, and air. Comparative analyses were conducted among 12 possible remedial alternatives. Alternative 4 was recommended as the best alternative when evaluated using the nine screening criteria specified in the National Contingency Plan (NCP) regulations. Alternative 4 consisted of the following:

Institutional Controls – Land use restrictions, groundwater use restrictions, and other legally binding restrictions to prevent unacceptable exposures in a future industrial land-use scenario.

Groundwater Monitoring – Ground water monitoring and evaluation would be conducted as part of the cleanup remedy for the FMC Plant OU to determine the effectiveness of the source control measures in reducing the contamination in the FMC plant area. Ground water monitoring would continue and be integrated, to the extent practicable, with the RCRA groundwater monitoring program. Ground water data would be periodically reviewed with the following goals: 1) ensure the source control measures at the plant site are effective, 2) ensure there are no new sources of contamination from existing or new hazardous waste surface impoundments or landfills, and 3) confirm eventual achievement of MCLs or RBCs.

Source Controls – These included grading, shaping to drain, and placement of soil cover at the old calciner pond solids storage area and the old phossy waste ponds area.

2.4.5 Treatment Technologies for Historic Ponds Containing Elemental Phosphorus – Summary and Evaluation (EPA, 2003)

This EPA report provided a summary and evaluation of available information about technologies that have the potential to treat soil and sludge in historical ponds contaminated with elemental phosphorus (P4), heavy metals, and radionuclides at the FMC Pocatello plant. These ponds were used by FMC during the manufacture of P4 from phosphate ore, and received the following wastes: phossy water, precipitator dust slurry, phossy solids, slag pit water and solids, and residuals from reclaiming P4 in other ponds.

The scope of this report was limited to a summary and review of available information from the technical literature and previous studies regarding the following:

- The 18 historical ponds identified in the *1998 ROD* that were not subject to RCRA operating and closure requirements, consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, 9S, 10S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E. However, it should be noted that substantial portions of Ponds 2E, 3E, 5E, and 6E are overlain by RCRA ponds, which have since been capped, per EPA-approved RCRA Closure Plans and are under RCRA post-closure care.

- Treatment technologies that have been used or show promise for treatment of P4 based on available information.

Overall Findings - Six (6) technologies were identified as potentially applicable: solidification/stabilization (S/S); caustic hydrolysis; chemical oxidation; mechanical aeration; incineration; and thermal desorption. The following is a summary and discussion of the major findings in this report.

- No technology has been used at full-scale to treat waste material similar to that found at the FMC ponds.

- No new treatment technologies have emerged as potentially applicable since the 1997 *FMC Subarea FS*.

- Other P4 manufacturing facilities primarily used capping as the remedy for similar waste.

- Minimal performance data exist for use of the six technologies to treat waste material similar to that contained in the FMC ponds.

- Additional testing would be necessary to assess whether treatment technologies could perform adequately across the range of contaminant concentrations and properties of the waste material found in the FMC ponds.

- The cost to implement any of the six treatment technologies would be high, based on the criteria used to identify high cost projects by EPA's National Remedy Review Board.

2.4.6 Secular Equilibrium Study

A work plan to assess secular equilibrium in the EMF Site surface soil was prepared in July 2004 (BEI, 2004b) to verify the assumption of secular equilibrium between uranium-238 and radium-226 that was described in the *EMF RI Report* surface soil investigation. In July 2003, EPA requested that FMC and Simplot perform a supplemental investigation of radium-226 and uranium-238 concentrations in the upper six inches of surface soils primarily in the Off-Plant OU, but also in the FMC Plant OU, to verify this assumption. A work plan to assess secular equilibrium in the EMF Site surface soil was prepared in July 2004 (BEI, 2004b). The secular equilibrium study field work was performed during 2004. As part of the field work, EPA requested and received split samples. Those were analyzed by the EPA National Air and Radiation Environmental Laboratory (NAREL). The results of samples analyzed by both EPA and the companies were reported to EPA on May 19, 2006. All the sample results were consistent with radioactive equilibrium between radium-226 and uranium-238. Specifically, the report stated that "[t]he Companies believe that the 2004/2005 work demonstrates that radium-226, a radionuclide in the uranium-238 decay series, is in secular equilibrium with uranium-238, which supports the original assumption made by EPA's contractor—Ecology and Environment—in the baseline human health assessment for the EMF Site."

2.4.7 RI Update Memorandum

The *RI Update Memo* was prepared as a directive of the *2003 AOC* for the FMC Plant OU. This memorandum presented the following information:

- An updated CSM for the FMC Plant OU. This CSM updated the description of potential sources, release mechanisms, exposure pathways, migration routes, and potential receptors.

- A compilation of available data describing the nature and extent of contamination relevant to the updated CSM.

- RBCs for P4 and other site COCs/ROCs.

- An assessment of potential ecological risks within the undeveloped areas of the FMC Plant OU for three COCs (cadmium, fluoride, and zinc) that were quantitatively evaluated in the *Baseline ERA*, and for two additional COCs (vanadium and chromium).

- A comparison of site data to RBCs, as a preliminary screen to identify areas in the FMC Plant OU (primarily the former working areas) that potentially require additional characterization.

- Identification of areas of the FMC Plant OU that: 1) were excluded from further investigation, 2) have adequate data to proceed with an evaluation of remedial alternatives under the SFS, and 3) have data gaps that need to be filled through SRI sampling and analysis.

The *RI Update Memo* recommended that two RUs proceed to evaluation of remedial action alternative in the SFS. These RUs consisted of RU 22b – the Old Phossy Ponds and RU 22c – the Railroad Swale. The *RI Update Memo* also recommended that RU 22a and RU 14 be excluded from the SRI/SFS process, because the ponds in RU 22a were being addressed under RCRA closure requirements and the calciner ponds in RU 14 were being addressed under a voluntary consent order between FMC and the State of Idaho. The *RI Update Memo* recommended that the SRI include the following additional investigations:

- Delineate the lateral extent of the FMC-proposed RCRA-engineered cap to prevent exposure to soils containing P4 associated with historic spills and leaks from RUs 1 and 2 (the historic P4 production, storage, and handling areas).

- Measure gamma radiation where slag had been use as fill.

- Sample sites in RUs 4, 5, and 20 where fuel oils and solvents had been managed, to determine the need for potential hotspot removal.

- Collect additional soil samples at RUs 3, 4, 5, 6, 9, 11, and 13 to compare inorganic constituents with screening criteria at a greater statistical confidence level than could be supported with the existing data.

2.4.8 SRI Report

The *SRI Report* was prepared as a directive of the *2003 AOC* for the FMC Plant OU. As discussed in Sections 4 and 5 of the *SRI Report*, the additional information generated during the SRI was determined to be sufficient to characterize the nature and extent of

COCs/ ROCs associated with the fill materials and incidental source materials at the FMC Plant Site. The types of fill and incidental source materials associated with each RU were identified through sampling within the RU, boundary (i.e., perimeter) sampling, and review of operational records and process descriptions. Fill materials in each RU were characterized based on analyses of each fill type from samples collected both prior to and during the SRI. With few exceptions (specifically, only in the presence of a sustained hydraulic head), COCs/ROCs were determined not to have leached from source and fill materials into the underlying soils, and thus they do not pose a threat to groundwater. Groundwater conditions at the FMC Plant OU as a whole were described in the separate EPA-approved *GWCCR* as discussed in Section 2.4.9.

Based on the RI and SRI findings and the results of the Supplemental HHRA for hypothetical future workers, the *SRI Report* recommends that all of the RUs proceed to the SFS for evaluation of remedial alternatives. The nature and extent of contamination associated with the primary source materials at the FMC Plant Site (including fill, incidental source materials, and P4) and associated risks to human health and the environment have been sufficiently bound to evaluate remedial alternatives for each of the RUs. While additional lateral delineation will ultimately be required at a few RUs to define the extent of historical ponds (RUs 8, 13, and 22b), there is sufficient information to proceed to the SFS remedial alternatives evaluation so long as the needed further delineation is performed/confirmed at a later stage of the CERCLA process (such as during remedial design). Remedial design and remedial action activities can adequately delineate the extent of contamination and therefore the extent of required remedial action taking into account historical information, RI data, SRI data, and further delineation/confirmation sampling as appropriate. Conservative assumptions regarding the additional area/volume of impact that will be verified later in the CERCLA process provide a sufficient basis for the SFS evaluation of remedial alternatives.

2.4.9 Groundwater Current Conditions Report (*GWCCR*)

The *GWCCR* provides a summary of the EMF RI groundwater investigations and presents in a single compendium the substantial amount of post-RI groundwater information developed under multiple regulatory programs with oversight from multiple agencies and augments the administrative record for the FMC Plant OU remedial action. The *GWCCR* is a companion to the SRI Report. The *GWCCR* contains information on current and future water use in the study area, regional and site-specific geology and hydrogeology, results of the EMF RI and FMC post-RI groundwater studies, groundwater quality and trends, a source area evaluation, groundwater fate and transport, and an updated groundwater human health risk assessment.

In summary, the groundwater system within the EMF study area is very stable and flow directions and gradients have not changed significantly, as demonstrated by 18 years of quarterly monitoring. FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water. However, the areal extent of FMC-impacted groundwater does not extend beyond FMC and Simplot-owned properties and no domestic or public water supply wells are located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.

The spatial extent of the FMC-related groundwater impacts is comparable to that defined during the EMF RI. Concentrations of FMC-related groundwater impacts in the western ponds area, central plant area and downgradient portions of the joint fenceline / calciner ponds area have decreased (groundwater quality beneath the plant site has improved) and are expected to continue to decrease due to discontinued use (i.e., no contaminant solute or mass addition) and lack of sustained hydraulic head to transport constituents through the unsaturated soil column to groundwater at any identified or potential source areas at the FMC Plant OU.

The following are the primary FMC-related source areas and source-distinguishable constituents contributing to groundwater impacts at the FMC Plant Site:

- Pond 8S within RU 22a (RCRA Ponds) - Potassium, chloride, sulfate, ammonia, nitrate, total phosphorus / orthophosphate, fluoride, arsenic, manganese, boron, selenium and total cyanide.

- Old "Phossy" Ponds (RU 22b) and portions of RU 13 with identified "phossy" pond solids in fill materials - Potassium, chloride, sulfate, ammonia, nitrate, total phosphorus / orthophosphate, fluoride, arsenic, manganese, boron, selenium and total cyanide.

- Furnace Building, Phos Dock and Secondary Condenser (RU 1) and Slag Pit (RU 2) – Elemental phosphorus.

- Former Kiln Scrubber Ponds and Calciners (RU 8) and Former Kiln Scrubber Overflow Pond (RU 9) - Ammonia, nitrate, fluoride, selenium, vanadium and total cyanide.

- Former Unlined Calciner Ponds, Calciner Sediment Storage Area 'A', Calciner Ponds (RU 14) - Potassium, chloride, fluoride, arsenic, manganese, boron and selenium.

- Calciner Solids Storage Area (RU 16) – Potassium, chloride, sulfate and selenium.

- Slag Pile (RU 19) – Potassium and sulfate.

The most significant factor in the reduction of groundwater constituent concentrations is advective mixing. Mixing of small volumes of EMF-affected groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as sulfate, along the groundwater flowpath.

There are no current exposed receptors to FMC-impacted groundwater (i.e., there are no domestic, industrial or agricultural wells that extract impacted groundwater). The updated groundwater human health risk assessment evaluated hypothetical future exposures. Arsenic remains the primary risk driver in groundwater at the FMC Plant OU. Arsenic-related incremental cancer risks to future workers exceed 1E-03, over three orders of magnitude greater than the *1998 ROD* RAO, in portions of the Central Plant Area and Joint Fenceline / Calciner Ponds Area of the site. A current representation of the arsenic groundwater plume is depicted in Section 7 of this report. The groundwater plume underlies and is fully contained within company-owned property boundaries.

Groundwater conditions at the FMC Plant OU have been characterized to a sufficient extent to determine the need for remedial action and support the identification and evaluation of remedial options with respect to their performance, cost, protectiveness and other regulatory criteria.

2.4.10 Supplemental Remedial Investigation Report Addendum for the FMC Plant Operable Unit

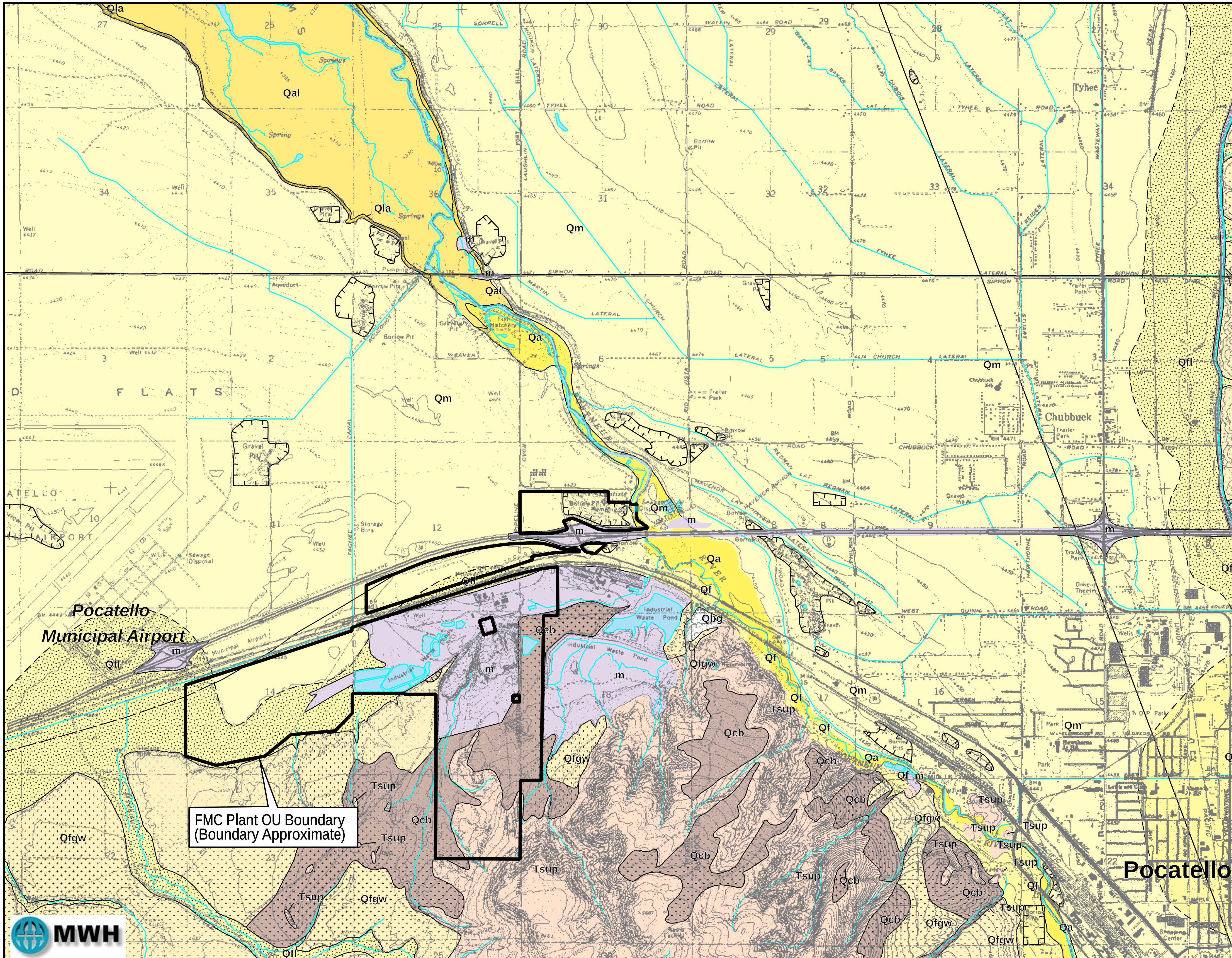
The *SRI Report Addendum* was prepared following additional field investigations during the fall of 2008 and is a companion document to the *SRI Report*. The Addendum activities consisted of the evaluation of human health and ecological risks associated with surface soils in the Southern and Western Undeveloped Areas (SUA and WUA) and the FMC-owned Northern Properties of the FMC Plant OU.

The results discussed in this report supported three overall conclusions. The first is that elevated levels of metals, fluoride, and radionuclides detected in surficial soil samples collected in the SUA, WUA and Northern Properties are the result of wind blown dust and stack emissions from past FMC and past/current Simplot manufacturing operations. The second supporting conclusion is that parcels located directly downwind of the FMC and Simplot plant sites (i.e., Parcels 3, 4, and 6) are more heavily impacted by the EMF facility-related constituents (i.e., have higher concentrations of all constituents) than parcels located either in an upwind and cross-wind direction (i.e., Parcel 1, SUA, and WUA). Lastly, surface soil impacts decrease with distance from the FMC and Simplot plant sites, which further supports the conclusion that EMF impacts are related to the dispersion and deposition of facility air emissions. Parcel 3, located immediately downwind of historical ore handling operations at the plant sites, contains the highest surface soil concentrations of all constituents, and these concentrations decrease with increasing distance downwind from the plant sites (e.g., Parcels 4 and 6).   These general findings are consistent with those stated in the *EMF RI Report*.

Based upon the SRI Addendum findings, it was determined that radium-226 concentrations in Northern Property Parcels 2 and 3 exceed the preliminary remediation goal (PRG) for commercial/industrial worker receptors. In addition, the *Supplemental HHRA Addendum* found that risks to hypothetical future residential receptors are above a level of concern within each of the Northern Property parcels.

With respect to ecological receptors, the Supplemental ERA Addendum findings were similar to those of EPA's *Baseline BERA*. Specifically, the *Supplemental BERA* found that fluoride is the only COC associated with potentially actionable ecological risks, only exceeding NOAEL HQs within Northern Property Parcels 2, 4 and 6 and marginally exceeding a LOAEL HQ in Northern Property Parcel 3.

In summary, the *SRI Addendum Report* determined that the SUA and WUA do not pose a risk to human health or the environment and, as such, do not require consideration of remedial alternatives in the SFS. However, the *SRI Addendum Report* recommends that the FMC Northern Properties proceed to the SFS for evaluation of remedial alternatives based on risks to human health (Parcels 1 through 6) and the environment (Parcels 2, 3, 4 and 6).



DESCRIPTION OF MAP UNITS

m	Made ground (historical)—Artificial deposits of disturbed, transported, and emplaced construction materials derived from various local sources. Primarily formed in the construction of highways, irrigation ditches, and industrial sites.
Qa	Alluvium of lower Portneuf River and Pocatello Creek (Holocene) — Stratified and interfingering deposits of sand and gravel veneered by silty reworked loess.
Qal	Alluvium and lacustrine deposits of the Portneuf River and Ross Fork delta (Holocene)-Laterally discontinuous beds of sand, silt, clay, muck, and peat.
Qf	Alluvial-fan and debris-flow deposits (Holocene)—Muddy sand and gravel and beds of silty redeposited loess.
Qfl	Alluvial-fan deposits composed mostly of reworked loess (Holocene)—Primarily bedded to massive silt that is redeposited loess.
Qm	Michaud Gravel (late Pleistocene)—Bouldery gravel and sand; more sand in channeled-flow pathways and in distal parts of deposit where grain size decreases.
Qbg	Gravel deposits of the Bonneville Flood, undifferentiated (late Pleistocene) Pebble gravel deposited in eddy bar of Bonneville Flood.
Qfgw	Loess-mantled alluvial-fan gravel of Wisconsin age (late Pleistocene)—Crudely stratified muddy sand and pebble- to boulder-sized gravel mantled with loess.
Qfgo	Loess-mantled alluvial-fan gravel of the ancesteral Pocatello Creek (early Pleistocene?) — Crudely stratified, muddy and sandy pebble-to cobble-sized gravel manteld with loess.
Qcb	Loess-mantled bedrock colluvium (Pleistocene)—Wind-blown and redeposited loess that mantles, interfingers with, or is mixed with stony colluvium derived from local bedrock.
Tsup	Rhyolite porphyry unit—Porphyritic rhyolite,

Source: Idaho Geological Survey, April 1997

N W E S

0 3000
Feet

FMC

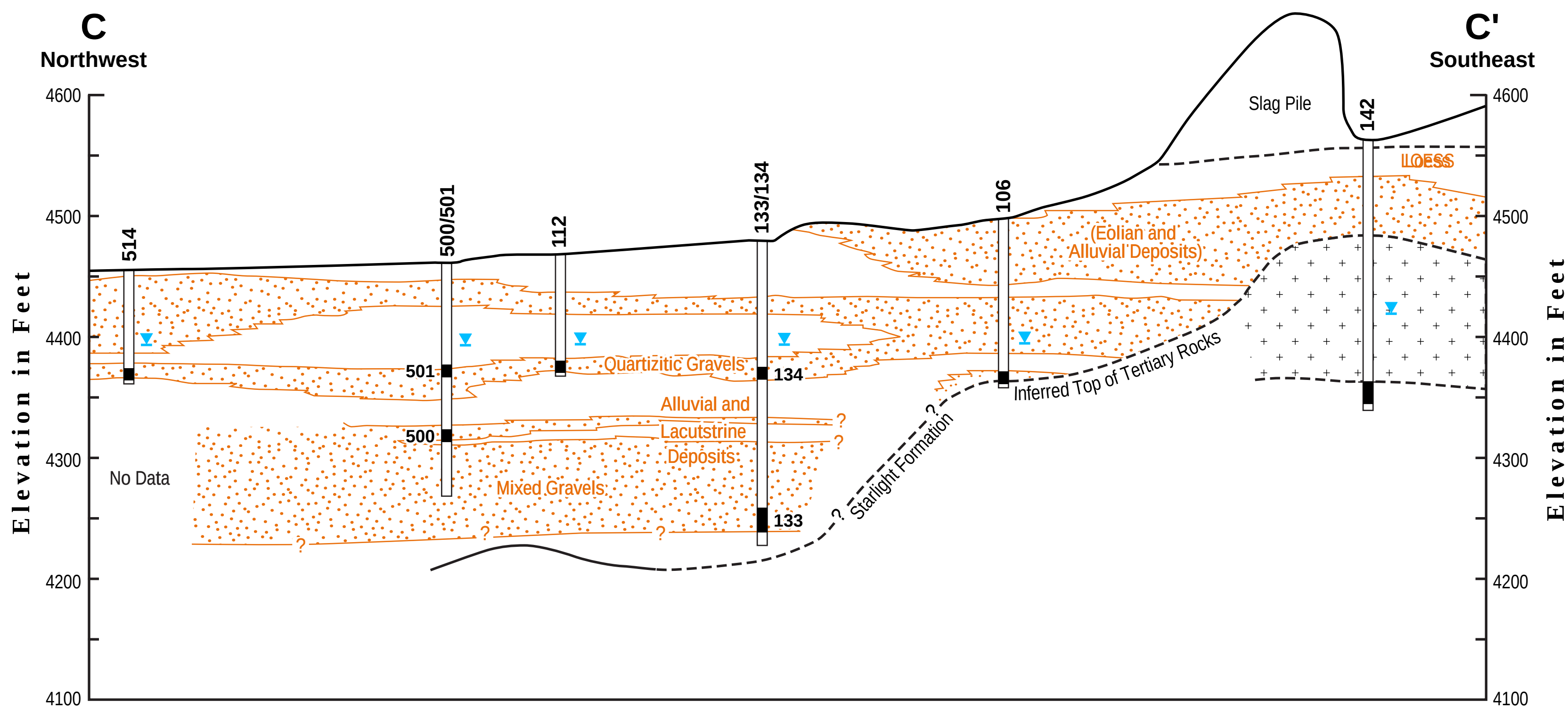
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

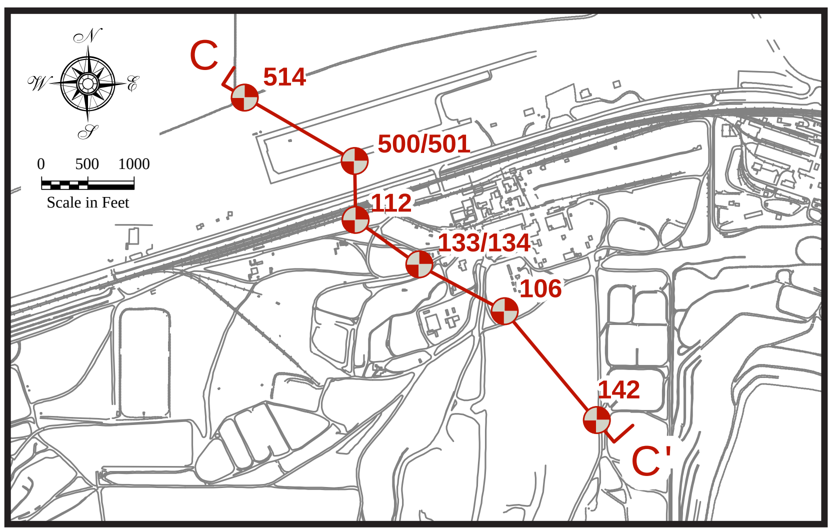
FIGURE 2-1
REGIONAL GEOLOGY

MWH

FILE *Fig 2-1 Regional Geologic map_1009.ai 10/11/09*

FILE *Fig 2-02_Hydro Cross Section C-C_1009.ai 10/11/09*





Vertical Scale in Feet: 0, 500, 1000, 1500

Horizontal Scale in Feet: 0, 500, 1000, 1500

0 x Vertical Exaggeration

- Approximate groundwater level
- ■ Screened interval

Source: RI for the EMF Site, Bechtel, 1996.

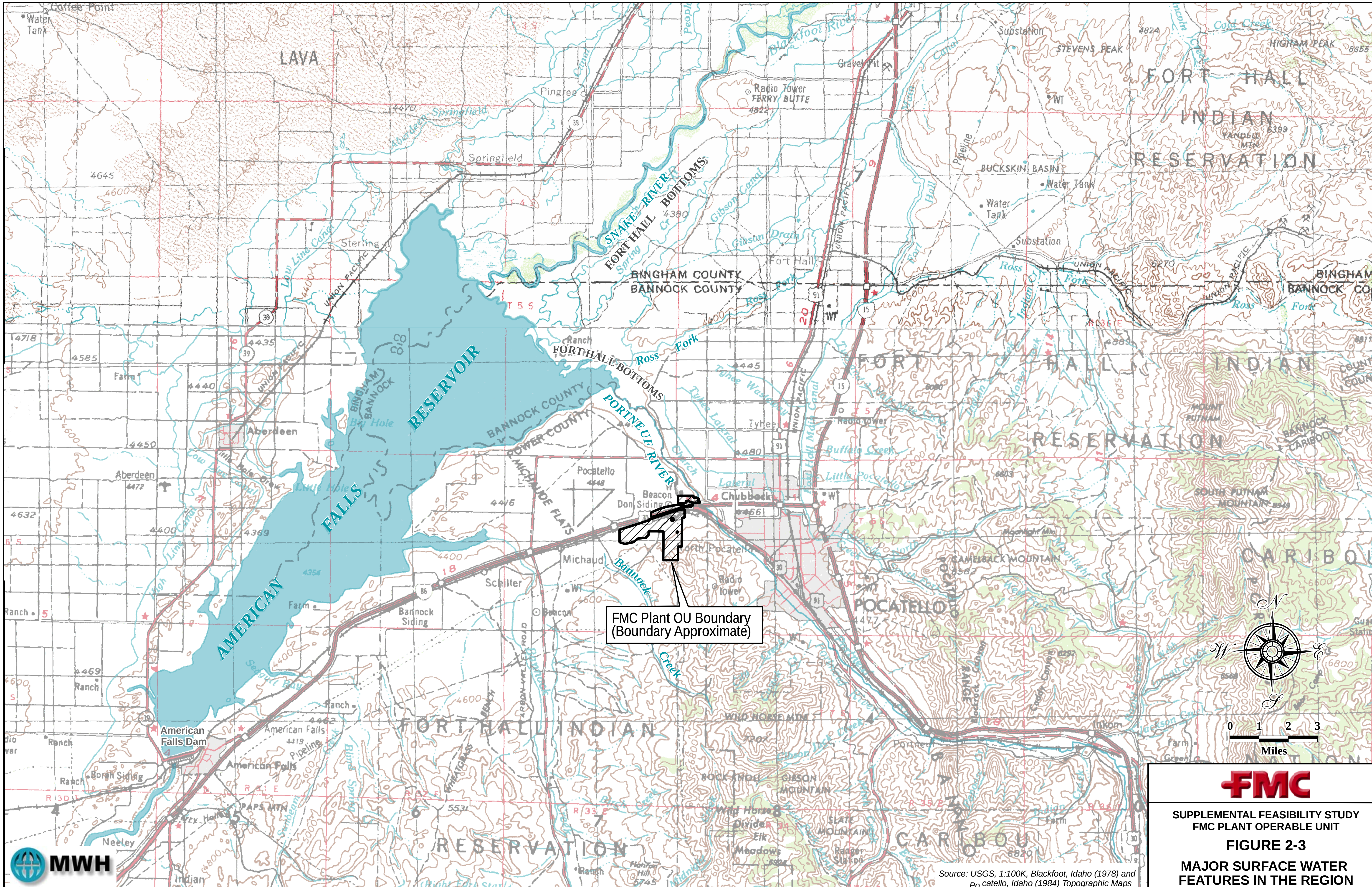
MWH

FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-2

HYDROGEOLOGIC CROSS SECTION C-C′



Source: USGS, 1:100K, Blackfoot, Idaho (1978) and Pocatello, Idaho (1984) Topographic Maps

FMC

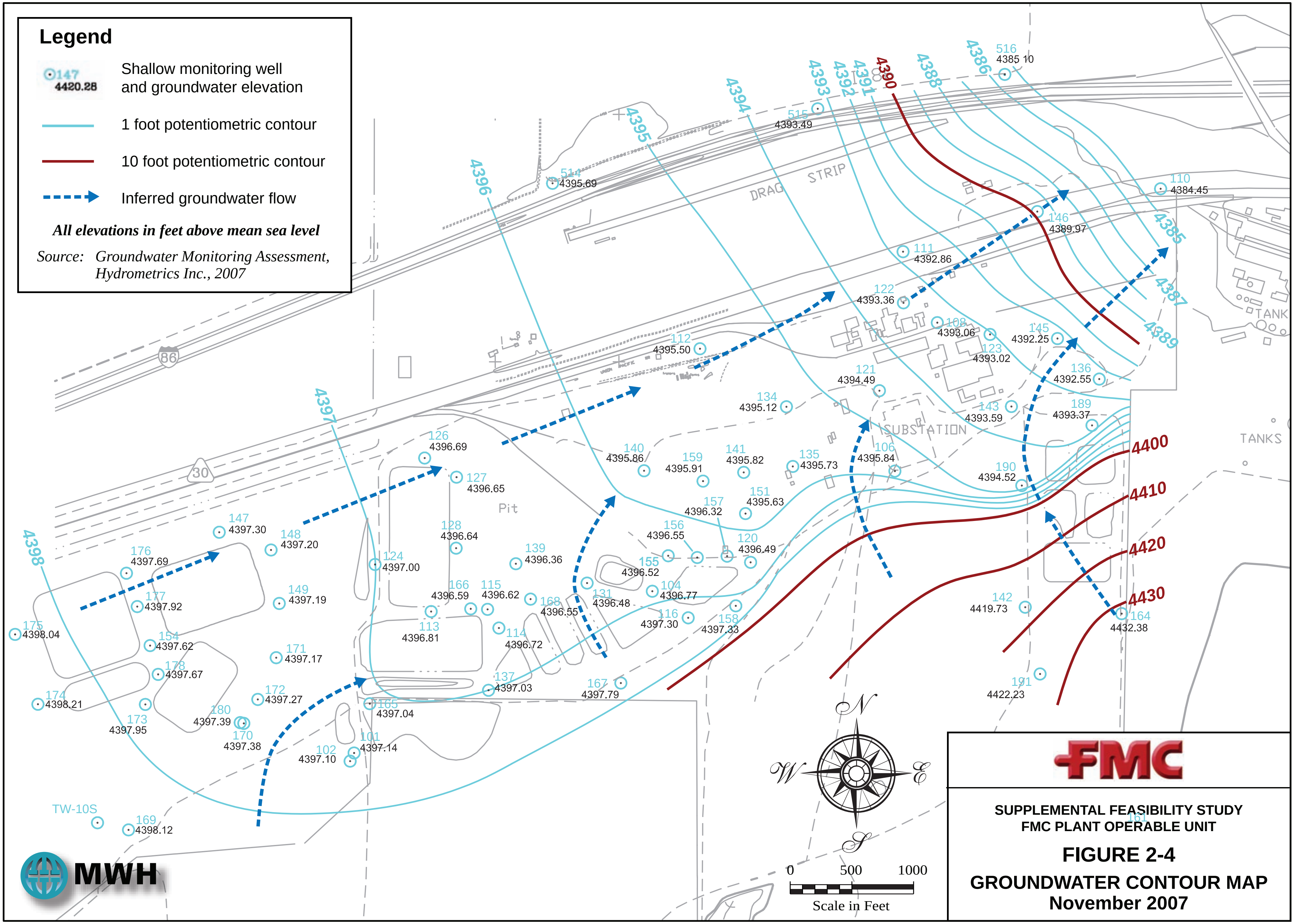
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-3

MAJOR SURFACE WATER FEATURES IN THE REGION

FILE Fig 2-3_Major Surface Water Features_1009.mxd 10/11/09

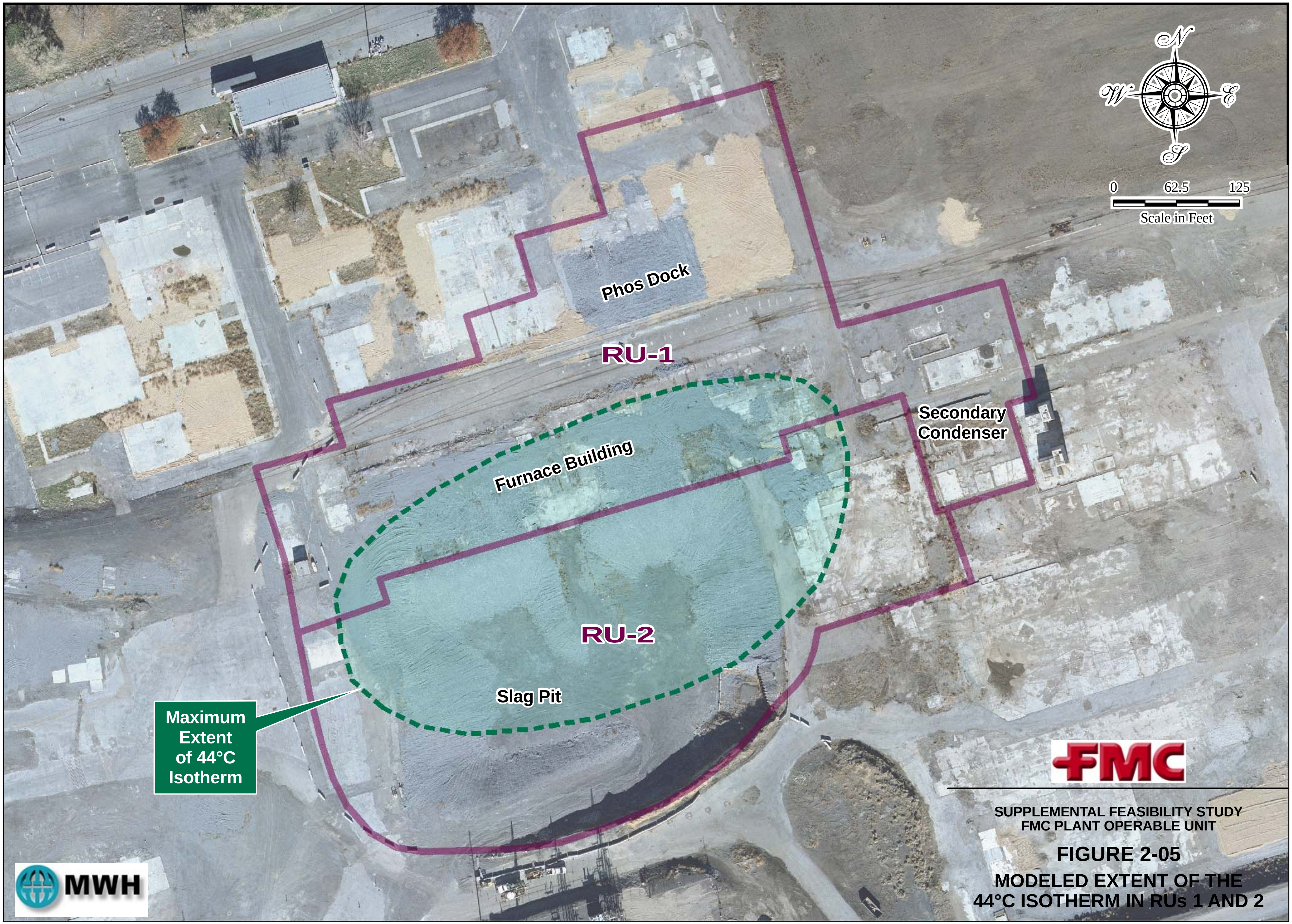
FILE *Fig 2-4 Groundwater Contour Map_Nov2007_0310.ai 3/01/10*



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-4
GROUNDWATER CONTOUR MAP
November 2007

FILE *Fig 2-05_44 degree isotherm_RU1RU2_1009.mxd* *10/28/09*



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-05

MODELED EXTENT OF THE 44°C ISOTHERM IN RUs 1 AND 2

TABLE 2-1

FILL/SOURCE MATERIALS OBSERVED IN EACH RU
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 1 of 4)

Remediation Unit Number, Name, and Size	Predominant Surface Fill Material [1]	Predominant Subsurface Fill Materials [2]	Potential Source Materials Incidental to Fill Material [3]	Depth to Native Soil Based upon RI/SRI Borings [3] (Feet bgs)	Depth of Fill from Cut & Fill Isopach Model (Feet)	Fill/Source Materials Considered for HHRA Exposure Scenarios[7]	Estimated Total Volume of Fill (yd^3)	Estimated Volume of P4 Min – Max. (tons)
RU 1: Furnace Building, Phos Dock and Secondary Condenser 4.1 acres	Slag Concrete foundations Asphalt w/ slag aggregate Silica	Slag Concrete foundations Silica	P4 Underground Piping [4] Precipitator solids Phossy solids	Min: 5 feet Max: 10 feet	Min: 2.7 Max: 14.5 Ave: 8.2	Slag P4 Precipitator solids Phossy Solids	56,580	580 to 5,470 An upper bound max. volume based upon 1% of lifetime production has been calculated at 52,400 tons
RU 2: Slag Pit 3.7 acres	Slag Concrete foundations	Slag Concrete foundations Reworked native soil w/ slag	P4 Precipitator Solids Underground Piping [4] Phossy solids	Min: No data Max: No data	Min: 1 Max: 12.3 Ave: 4.7	Slag P4 Precipitator solids Phossy solids	20,485	Included with RU 1
RU 3: Receiving, Stores, Paint Shop and P_4 Decon 1.3 acres	Slag Concrete foundations Asphalt w/ slag aggregate Silica Reworked native soil w/ slag	Slag Concrete foundations Silica Reworked native soil w/ slag	Underground Piping [5]	Min: 2 feet Max: 20 feet	Min: 2 Max: 20 Ave: 5.9	Slag	15,860	0[5] P4 present in the capillary fringe beneath this RU, down gradient of RU1 & RU2 is included in the volume estimated for RU1.
RU 4: Office Buildings and Training Center 2.5 acres	Slag Concrete foundations Asphalt w/ slag aggregate Silica Reworked native soil w/ slag	Slag Concrete foundations Silica Reworked native soil w/ slag		Min: 1.5 feet Max: 14 feet	Min: 1.5 Max: 14 Ave: 6.9	Slag	28,830	0
RU 5: Lab and Old Drainfield 0.6 acres	Slag Concrete foundations Asphalt w/ slag aggregate Silica Reworked native soil w/ slag	Slag Concrete foundations Silica Reworked native soil w/ slag		Min: 1.5 feet Max: 12 feet	Min: 1.5 Max: 18.1 Ave: 6.8	Slag	7,140	0
RU 6: Former Long-Term Phos Storage Tanks 1.4 acres	Slag	Slag Reworked native soil w/ slag	Coke Ferrophos	Min: 5 feet Max: 15 feet	Min: 5 Max: 17.2 Ave: 12.6	Slag Coke Ferrophos	28,294	0
RU 7: Shale Unload, Crushing and Stockpile 25.0 acres	Raw ore Slag Concrete foundations Asphalt w/ slag aggregate Silica	Raw ore Slag Concrete foundations Silica Reworked native soil w/ slag	Coke	Min: 1 feet Max: 25 feet	Min: 1 Max: 29.3 Ave: 9.3	Slag Ore Coke	487,542	0 P4 present in the capillary fringe beneath this RU, down gradient of RU1 & RU2 is included in the volume estimated for RU1.

[1] "Predominant Surface Fill Material" describes primary materials as observed on the surface during the SRI.
[2] "Predominant Subsurface Fill Material" describes primary materials as observed during SRI trenching/boring down to native soil interface.
[3] Based upon RI and SRI observations as reported on boring logs.
[4] Underground piping formerly used for precipitator slurry or phossy water, thus presumed to contain precipitator solids, phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 2.8 to 28 tons.
[5] Underground piping formerly used for stormwater, but often carried overflow phossy water from RU 1 to RU 22c, thus presumed to contain phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.13 to 0.6 tons.
[6] Underground piping formerly used for carbon monoxide gas, thus presumed to contain P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.2 to 1.8 tons.
[7] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.

TABLE 2-1

FILL/SOURCE MATERIALS OBSERVED IN EACH RU
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Remediation Unit Number, Name, and Size	Predominant Surface Fill Material [1]	Predominant Subsurface Fill Materials [2]	Potential Source Materials Incidental to Fill Material [3]	Depth to Native Soil Based upon RI/SRI Borings [3] (Feet bgs)	Depth of Fill from Cut & Fill Isopach Model (Feet)	Fill/Source Materials Considered for HHRA Exposure Scenarios[7]	Estimated Total Volume of Fill (yd^3)	Estimated Volume of P4 Min – Max. (tons)
RU 8: Former Kiln Scrubber Ponds and Calciners 6.7 acres	Calcined ore Slag Concrete foundations Asphalt w/ slag aggregate Silica	Calcined ore Slag Concrete foundations Silica Reworked native soil w/ slag	Kiln pond solids Underground Piping [6]	Min: 3 feet Max: 12.5 feet	Min: 1 Max: 17 Ave: 5.1	Slag Ore Calciner pond solids Calcined ore	41,630	0 [6]
RU 9: Silica Stockpiles and Former Kiln Scrubber Overflow Pond 12.9 acres	Calcined ore Raw ore Slag Silica Asphalt w/ slag aggregate	Calcined ore Raw ore Slag Silica Reworked native soil w/ slag	Kiln pond solids Coke	Min: 3 feet Max: 40 feet	Min: 1 Max: 40 Ave: 9.9	Slag Ore Calciner pond solids Coke Calcined ore	206,110	0
RU 10: IWW Pond and Ditch 1.3 acres	Slag Silica Asphalt w/ slag aggregate	Slag Silica Reworked native soil w/ slag	Precipitator solids	Min: 0 feet Max: 8 feet	Min: 1 Max: 18.7 Ave: 8.9	Slag Precipitator solids	22,883	0
RU 11: Equipment Area South of Calciners 8.4 acres	Slag Concrete foundations Asphalt w/ slag aggregate	Slag Concrete foundations Reworked native soil w/ slag		Min: 3 feet Max: 30 feet	Min: 1 Max: 30.7 Ave: 12.5	Slag	169,230	0
RU 12: Former RP&S Area and Mobile Shop 11.6 acres	Slag Concrete foundations Asphalt w/ slag aggregate	Slag Concrete foundations Reworked native soil w/ slag	Ferrophos PCDT water residues Underground Piping [4] Precipitator solids Phossy solids P4	Min: 1 feet Max: 13.5 feet	Min: 1 Max: 16.3 Ave: 6.9	Slag P4 Precipitator solids Phossy solids Ferrophos PCDT water residue	129,165	0 [4] Assumes P4 in shallow soils from historical pipeline releases.
RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area 3.6 acres	Slag Concrete foundations Asphalt w/ slag aggregate	Slag Concrete foundations	P4 Precipitator solids Phossy solids Underground Piping [4]	Min: 4 feet Max: 23 feet	Min: 1 Max: 24.5 Ave: 11.6	Slag Precipitator solids Phossy solids P4	66,630	25 to 60 Min. assumes 1000 ppm in fill. Max assumes 2500 ppm in fill.

[1] "Predominant Surface Fill Material" describes primary materials as observed on the surface during the SRI.
[2] "Predominant Subsurface Fill Material" describes primary materials as observed during SRI trenching/boring down to native soil interface.
[3] Based upon RI and SRI observations as reported on boring logs.
[4] Underground piping formerly used for precipitator slurry or phossy water, thus presumed to contain precipitator solids, phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 2.8 to 28 tons.
[5] Underground piping formerly used for stormwater, but often carried overflow phossy water from RU 1 to RU 22c, thus presumed to contain phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.13 to 0.6 tons.
[6] Underground piping formerly used for carbon monoxide gas, thus presumed to contain P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.2 to 1.8 tons.
[7] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.

TABLE 2-1

FILL/SOURCE MATERIALS OBSERVED IN EACH RU
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 3 of 4)

Remediation Unit Number, Name, and Size	Predominant Surface Fill Material [1]	Predominant Subsurface Fill Materials [2]	Potential Source Materials Incidental to Fill Material [3]	Depth to Native Soil Based upon RI/SRI Borings [3] (Feet bgs)	Depth of Fill from Cut & Fill Isopach Model (Feet)	Fill/Source Materials Considered for HHRA Exposure Scenarios[7]	Estimated Total Volume of Fill (yd^3)	Estimated Volume of P4 Min – Max. (tons)
RU 15: Oversize Ore, Used Electrode, Baghouse Dust Area 11.7 acres	Calcined Ore Slag Bullrock	Calcined Ore Slag Bullrock	Coke Graphite/carbon Calciner pond solids	Min: 5 feet Max: 39 feet	Min: 1 Max: 45 Ave: 11.4	Slag Ore Coke Calciner pond solids Calcined Ore	212,370	0
RU 16: Calciner Solids Stockpile 15.1 acres	Calciner pond solids Slag	Calciner pond solids Slag		Min: 1.5 feet Max: 42 feet	Min: 1 Max: 42 Ave: 4	Slag Calciner pond solids	92,750	0
RU 19: Slag Pile, Bull Rock Pile 151.5 acres	Slag Bull rock	Slag Bull rock	P4 Phossy solids (presumed at depth in buried rail cars)	Min: 5 feet Max: No data	Min: 1 Max: 152.8 Ave: 62.9	Slag Ore	14,528,100	200 to 2,000 P4 is associated with sludge in buried railcars in slag pile. Min. based upon railcars being 10% full. Max. is based upon railcars being 75% full.
RU 20: Former Bannock Paving Area 61.6 acres	Slag Concrete foundations Asphalt w/ slag aggregate	Slag Concrete foundations Reworked native soil w/ slag	Coke Ferrophos PCDT water residues Fuel spill residues	Min: 1.5 feet Max: 12 feet	Min: 1.5 Max: 42.1 Ave: 7.4	Slag Coke Ferrophos PCDT water residue Fuel spill residue	735,790	0
RU 21: Other Onsite Railspurs NA	Slag	Slag		Unknown	TBD	Slag	TBD	0
RU 22b: Old Ponds 37.7 acres	Slag Reworked native soil w/ slag	Slag Reworked native soil w/ slag	P4 Phossy solids Precipitator solids Ferrophos Underground Piping [4]	Min: 0 feet Max: 20 feet	Min: 0 Max: 43.9 Ave: 9.8	Slag Precipitator solids Phossy solids P4 Ferrophos	595,820	4,440 to 10,800 Min. is based upon plant estimate in 1991. Max. is based upon a percentage of total fill in ponds.

[1] "Predominant Surface Fill Material" describes primary materials as observed on the surface during the SRI.
[2] "Predominant Subsurface Fill Material" describes primary materials as observed during SRI trenching/boring down to native soil interface.
[3] Based upon RI and SRI observations as reported on boring logs.
[4] Underground piping formerly used for precipitator slurry or phossy water, thus presumed to contain precipitator solids, phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 2.8 to 28 tons.
[5] Underground piping formerly used for stormwater, but often carried overflow phossy water from RU 1 to RU 22c, thus presumed to contain phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.13 to 0.6 tons.
[6] Underground piping formerly used for carbon monoxide gas, thus presumed to contain P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.2 to 1.8 tons.
[7] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.

TABLE 2-1

FILL/SOURCE MATERIALS OBSERVED IN EACH RU
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Remediation Unit Number, Name, and Size	**Predominant Surface Fill Material [1]**	**Predominant Subsurface Fill Materials [2]**	**Potential Source Materials Incidental to Fill Material [3]**	**Depth to Native Soil Based upon RI/SRI Borings [3] (Feet bgs)**	**Depth of Fill from Cut & Fill Isopach Model (Feet)**	**Fill/Source Materials Considered for HHRA Exposure Scenarios[7]**	**Estimated Total Volume of Fill (yd^3)**	**Estimated Volume of P4 Min – Max. (tons)**
RU 22c: Railroad Swale 2.4 acres	Slag Reworked native soil w/ slag	Slag	P4 Phossy solids Ore	Min: 8 feet Max: 14 feet	Min: 8 Max: 15 Ave: 12	Slag Phossy solids P4 Ore	40,607	4 to 10 Min. assumes 1000 ppm in fill. Max assumes 2500 ppm in fill
RU 23: Road Segments not within RU Boundaries 23.0 acres	Slag Reworked native soil w/ slag Asphalt w/ slag aggregate	Slag Reworked native soil w/ slag	PCDT water residues	Min: 2 feet Max: 20 feet	Min: 1 Max: 20 Ave: 1	Slag PCDT water residue	33,904	0
RU 24: Plant Areas not within RU Boundaries 52.5 acres	Slag Concrete foundations Asphalt w/ slag aggregate Silica Reworked native soil w/ slag	Slag Concrete foundations Silica Reworked native soil w/ slag	Underground Piping [4]	Min: 1 feet Max: 13 feet	Min: 1 Max: 15 Ave: 6.7	Slag	565,430	0 [4]

[1] "Predominant Surface Fill Material" describes primary materials as observed on the surface during the SRI.
[2] "Predominant Subsurface Fill Material" describes primary materials as observed during SRI trenching/boring down to native soil interface.
[3] Based upon RI and SRI observations as reported on boring logs.
[4] Underground piping formerly used for precipitator slurry or phossy water, thus presumed to contain precipitator solids, phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 2.8 to 28 tons.
[5] Underground piping formerly used for stormwater, but often carried overflow phossy water from RU 1 to RU 22c, thus presumed to contain phossy solids and P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.13 to 0.6 tons.
[6] Underground piping formerly used for carbon monoxide gas, thus presumed to contain P4. Total P4 volume estimated collectively across the FMC OU in these underground pipes ranges from 0.2 to 1.8 tons.
[7] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.

TABLE 2-2

PHYSICAL PROPERTIES OF WHITE P4
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Physical Property	Characteristic
Chemical Formula	P_4
Appearance	White (or yellow) waxy solid at ambient temperatures
Boiling Point	280.5°C
Flash Point	Spontaneously combusts in air
Melting Point	44.1°C
Molecular Weight	123.89
Solubility	In water: 3 mg/L at 20°C
Vapor Pressure	0.026 mm Hg at 20°C

Section 3
SRI FINDINGS AND UPDATED CONCEPTUAL SITE MODEL

3.1 INTRODUCTION

This section summarizes the findings from the SRI and SRI Addendum and the updated CSM as presented in the final *SFS Work Plan* that was submitted to the EPA on January 22, 2010 with copies transmitted to IDEQ and the Tribes as specified in the *2003 AOC*. The SRI was conducted at the FMC Plant Site during the summer/fall of 2007. The SRI field work followed the EPA-approved *SRI Work Plan*, which included the *SRI Field Sampling Plan for the FMC Plant OU (SRI FSP*, MWH, 2007b*)*. The final *SRI Report* was submitted to EPA on May 14, 2009 (with copies transmitted to IDEQ and the Tribes) and approved by EPA on May 26, 2009. The SRI Addendum field work was conducted at the FMC Plant OU during the fall of 2008 in accordance with the EPA-approved *SRI Work Plan Addendum - Field Modification #13, Additional Southern and Western Undeveloped Areas Field Investigations (Field Mod #13,* MWH, 2008a*),* and *SRI Work Plan Addendum - Field Modification #14, Northern FMC-Owned Properties and Background Soil Sampling (Field Mod #14,* MWH, 2008b*)*. The final *SRI Addendum Report* was submitted to the EPA on November 18, 2009 (with copies transmitted to IDEQ and the Tribes) and approved by EPA on December 23, 2009.

3.2 SUMMARY OF SRI OBJECTIVES

3.2.1 SRI Performed in 2007

Based on the *Scoping and Planning Memo*, Attachment A SOW - Task 1.1, the SRI/SFS has the following site-specific objectives:

1) Ensure that all areas have been adequately characterized and that CERCLA remedial actions are consistent with the closures and remedial actions at other areas of the site where requirements/actions are already in progress.

2) Identify areas that pose unacceptable risk for the range of reasonably anticipated future land uses that would not be under the direct control of FMC.

3) Provide the basis for selecting a remedial action that assures protection of human health and the environment, minimizes the need for long-term care and maintenance and is compatible with reasonably anticipated future land use and development.

As confirmed by the *2003 AOC SOW*, the SRI/SFS (like the EMF RI/FS) will take into account the reasonably anticipated future uses of the site and will apply EPA's One Cleanup Program policy so that the CERCLA process also meets parallel RCRA corrective action requirements. The SRI/SFS AOC and SOW acknowledge that the FMC

Plant Site includes 1) hazardous waste management units that have been closed in accordance with RCRA regulatory and RCRA consent decree requirements, and 2) former Calciner Ponds where FMC has conducted remedial action pursuant to a voluntary consent order with IDEQ. The SRI/SFS process excludes evaluation of these units.

It was anticipated in the *2003 AOC* that the SRI/SFS would focus on the potential for exposure to shallow soils and solids under a future commercial or industrial land use scenario, as well as the potential for migration of constituents from soils and solids through the subsurface to groundwater. The air and groundwater pathways were evaluated on a site-wide basis in the *FMC Subarea FS Report*. The groundwater conditions at the FMC Plant OU as a whole are described in detail in the final *GWCCR* submitted on June 26, 2009.

3.2.2 SRI Performed in 2008

During the fall of 2008, FMC collected surface soil samples in the Southern and Western Undeveloped Areas (SUA and WUA) and the Northern Properties owned by FMC that are part of the FMC Plant OU. These investigations were performed per the EPA-approved *Field Mod #13*and *Field Mod #14,* respectively.

The primary objective of the 2008 SRI Addendum sampling in the SUA and WUA was to collect surface samples of native soils in order to develop analytical data to further evaluate risks to current and potential future ecological receptors and potential future human receptors (workers) in these areas. The analytical data was initially compared to ecological and worker soil screening levels (SSLs). Constituents with concentrations exceeding SSLs were carried forward into a quantitative risk assessment.

The primary objective of 2008 SRI Addendum sampling in the Northern Properties was to collect and analyze surface samples of native soils to further evaluate ecological and human health risks to current and potential future receptors in these areas. Furthermore, select subsurface samples were collected from the Northern Property parcel that exhibited the highest surface concentrations in the RI data set in order to evaluate subsurface risks to potential future site workers. The analytical data was initially compared to ecological, residential and commercial/industrial worker SSLs. Constituents with concentrations exceeding SSLs were carried forward into a quantitative risk assessment.

In addition to the sampling identified above, soil samples were also collected from select areas within a 6 to 11 mile radius of the former FMC Plant Site. These soil samples, which were located outside of the area impacted by EMF facility operations, were used to further develop background concentrations for metal and radionuclide constituents of concern in FMC Plant OU soils.

3.3 SUMMARY OF SRI FINDINGS

Table 3-1 summarizes the SRI findings by RU or area for the SRI field work performed in 2007 and 2008. This table contains the following information for each RU or sampling area: the RU/sampling area name, field programs conducted at each RU/sampling area, investigation rationale for each field program, analytes collected during each field program, a summary of the results, and a discussion of the findings in the final column labeled contamination assessment. The text in Section 4.0 of the *SRI Report* and Section 3.0 of the *SRI Addendum Report* supports and expands on the information presented in this table.

The following subsections discuss the FMC Plant OU SRI findings related to: 1) potential sources, 2) COCs/ROCs, 3) exposure media, 4) potential receptors, and 5) routes of exposure.

3.3.1 New Potential Sources or Site Conditions

While new potential sources were not identified during the SRI, new site conditions were encountered or information gathered that require the CSM to be updated. These new site conditions and/or information include:

- P4 was identified in the capillary fringe downgradient of the slag pit/furnace building area.
- With the completion of decommissioning and demolition activities at the FMC plant site, along with significantly reduced traffic on site, fugitive particulate emissions have been greatly reduced.
- The final two remaining underground fuel storage tanks were removed per RCRA UST requirements in 2006.
- While additional soil investigations were not performed at FMC plant site landfills during the 2007 or 2008 investigations, the CSM was updated based upon information gathered for these landfills including:
    - The construction debris landfill (RU 17),
    - The active landfill (RU 18),
    - The historic landfill in the slag pile (in the southwest corner of RU 19), and
    - The buried railcars in the slag pile (center of RU 19).

- While physical soil investigations for underground piping were not performed during the 2007 or 2008 SRI, the CSM was updated based upon information gathered for underground piping within the FMC plant site.

3.3.2 Site Contaminants of Concern

New COCs/ROCs were not identified during the SRI. However, new site conditions were encountered that required the CSM to be updated. The principal new site condition was that P4 was encountered in the capillary fringe overlying shallow groundwater downgradient of RUs 1 and 2. The updated COCs/ROCs evaluated in the current CSM based upon the SRI results are shown in Table 3-2. This table also shows the COCs/ROCs that were identified in the EMF Site *1998 ROD* and in the *RI Update Memo*.

The *GWCCR* for the FMC Plant Operable Unit presents a comprehensive update of the groundwater studies and monitoring performed at the FMC Plant OU subsequent to the EMF RI up through FMC's May 2008 groundwater monitoring event. As described in the *GWCCR*, FMC performed numerous groundwater monitoring programs that included the EMF RI groundwater COPCs and the EMF Site groundwater COCs identified in the 1998 EMF ROD Table 36. Additional "non-EMF RI" groundwater COPCs were also included in the groundwater monitoring events described in the *GWCCR*. The results of the EMF RI and subsequent groundwater monitoring and an evaluation of the updated groundwater COPCs/COCs for the FMC Plant OU are contained in the *GWCCR*. Table 3-3 presents the 1998 EMF ROD Table 36 (EMF Groundwater COCs) and a summary of the updated comparative values (CVs), groundwater results and identification of the groundwater COCs for the FMC Plant OU.

3.3.3 Potential Exposure Media

This section updates the description of the environmental media identified during the SRI that could be impacted by potential releases from sources within the FMC Plant OU that: 1) were not addressed in the EMF RI CSM or the 2004 CSM update for the FMC Plant OU, or 2) were included in these CSMs, but whose characterization has changed based on the SRI findings. Refer to Section 3.4 and Figure 3-1 for the changes to the CSM based on the SRI finding discussed below.

Soil - Impacts to soil quality that are updated in the current CSM as a result of the SRI include the following:

- Migration of P4 from manufacturing, storing, and loading facilities within the soil column 44ºC isotherm in RUs 1 and 2 down to the capillary fringe soils, including capillary fringe soils downgradient (to the northeast of RU 1) for a distance up to approximately 500 feet.

- Numerous special investigations were conducted during the SRI for solvents, fuels, PCBs, and coke in RUs 4, 5, 12, 20. With the exception of shallow native soil samples obtained from three boring locations in RU 20, no organic samples exceeded SSLs. At RU 20, these constituents are fuel-related PAHs (i.e., semi-volatile compounds).

Air – Potential impacts to air quality that are updated in the current CSM as a result of the SRI include the following:

- Radon emanation from feedstocks, byproducts, or waste materials containing radium-226 was measured in the ore stockpile area (RU 7), slag and bull rock piles (RU 19), and in the former waste pond areas (RU 22b). While some radon emanation rates were measured to be slightly higher than background, the emanation rates were significantly lower than the UMTRCA guideline of 20 µR/hr. Radon emanation does not constitute an exposure pathway of concern for future workers.

- Inhalation of volatile organic vapors in RUs 4, 5, 12, and 20 is not an exposure pathway of concern, as special investigations in these areas during the SRI did not find organic samples above SSLs (with the exception of three borings in RU 20 that had shallow native soil samples exceeding SSLs).

Groundwater – An additional impact to groundwater has been updated in the current CSM as a result of the SRI and GWCCR:

- Migration of P4 from manufacturing, storing, and loading facilities within the soil column 44ºC isotherm in RUs 1 and 2 down to the capillary fringe soils and groundwater, including capillary fringe soils downgradient (to the northeast of RU 1) for a distance up to approximately 500 feet.

3.3.4 Potential Receptors and Routes of Exposure

Individuals potentially exposed to FMC Plant OU-related contaminants include potential future site workers and nearby residents. Specifically, the updated CSM discussed in Section 3.4 of this report identifies 1) outdoor commercial/industrial workers, 2) indoor commercial/industrial workers, 3) construction workers, 4) utility workers, 5) maintenance workers and 6) nearby residents as being potential receptors to FMC Plant OU-related constituents.

Each of the receptors could be exposed to FMC Plant OU-related constituents via one or more exposure pathways or routes of exposure. The updated CSM based on the SRI findings summarizes the potential exposure pathways for each potential receptor. The identified pathways were developed based on the recommendations set forth in EPA Soil Screening Level (SSL) guidance documents for Superfund sites (EPA, 2002a; EPA, 2004a), as modified to reflect site-specific considerations at the FMC Plant OU. A complete description of the potential receptors and complete/incomplete routes of exposure is presented in the Supplemental Human Health Risk Assessment (HHRA) in Appendix J of the *SRI Report*.

As a result of the SRI field work and evaluations, risks associated with exposure to COCs/ROCs under several of the identified routes were determined to be no greater than those associated with background exposure, or below conservative risk-based screening levels. As such, the following exposure pathways identified in the CSM have been deemed to be of no further concern:

- Inhalation of radon in ambient air does not appear to be a significant potential route of exposure. The SRI has shown radon emanation rates to be very low (at or near background), and significantly lower than the risk-based UMTRCA guideline of 20 pCi/m^2/second.

- Inhalation of volatile organic vapors in ambient air in RUs 4, 5, 12, and 20 does not appear to be a significant potential route of exposure. Special investigations in these areas during the SRI did not find volatile organic COPCs in any samples above SSLs.

In addition, the SRI human health and ecological risk assessments determined that impacts to the following receptors are within EPA's acceptable risk range (Table 3-1) and, as such, do not warrant further evaluation in the SFS:

- Potential future workers in the southern and western undeveloped areas, and in Northern Property Parcels 1, 2, 4, 5 and 6,

- Hypothetical future nearby Off-Plant OU residents exposed to FMC Plant OU-related constituents, and

- Current and potential future ecological receptors on former processing areas of the FMC Plant Site (no viable habitat), the southern and western undeveloped areas and Northern Property Parcels 1, 2, 4, 5 and 6 (all LOAEL HQs less than 1) and Northern Property Parcel 3 (equal to a LOAEL HQ of 1.02 for fluoride for the red-tailed hawk, making community or population level effects unlikely due to the small area of this parcel versus the hawk's home range).

The EMF Site ROD addressed the receptors and routes of exposure (i.e., incidental ingestion, dermal contact, and consumption of fish) in what was then referred to as the Off-Plant Subarea associated with groundwater as well as surface water and sediment impacted by the discharge of impacted groundwater. Consistent with the *SRI Work Plan*, groundwater throughout the FMC Plant OU and soil conditions at FMC properties north of Highway 30 were not the subject of the *SRI Report*. Those instead are addressed in *GWCCR* and the *SRI Addendum Report*.

3.4 UPDATED CONCEPTUAL SITE MODEL FOR THE FMC PLANT OU

The current conceptual site model (CSM), along with associated notes, is presented in Figure 3-1. This CSM is a revised version of the 2004 CSM reflecting current site conditions as updated by the *SRI Report*, the *SRI Addendum Report*, and the *GWCCR*.

The updated CSM illustrates the fate and transport of contaminants from source areas to other media, and identifies which media are of principal concern with respect to potential current and future receptors and exposure pathways. The information has been used to develop RAOs for protection of human health and the environment and general response actions as presented and discussed in Section 4 of this report.

3.5 TRANSITION FROM RUs TO REMEDIATION AREAS (RAs)

As part of the SRI/SFS scoping and planning activities, the impacted areas of the FMC Plant Site were divided up into 24 Remediation Units (RUs). As described in Section 1.1, an RU was intended to delineate one or more Solid Waste Management Units (SWMUs) with similar former processes or characteristics (including types of constituents of potential concern) and typically in the same geographical area of the FMC Plant OU. The SRI Work Plan was based upon investigation of these RUs.

Upon completion of the SRI including additional investigation of the Northern Property parcels and undeveloped areas in the fall of 2008, the contamination assessment of each RU/parcel has shown many of them have similar characteristics, warranting evaluation of similar remedial approaches. As the CERCLA process moves into the SFS, combining (or in some cases dividing) RUs/parcels into new geographical areas based on remedial action similarities facilitates the SFS process, the amended ROD and the RD/RA. These new areas are referred to as Remediation Areas (RAs). In general, the RAs are defined based on the following: 1) geographic proximity, 2) similarity of contaminants of concern (COCs), 3) types of risks present, and 4) a consistent remedial approach. Table 3-4 includes a description of each RA (as shown on Figure 3-2) and summarizes the following information:

- The RUs/parcels contained within the RA;
- The size of the RA;
- The fill/source materials considered in the HHRA exposure scenarios; and
- A listing of former RCRA SWMUs contained within each RA.

A summary of the RAs is presented in the following subsections.

3.5.1 Remediation Area A (RA-A)

RA-A is 103 acres and is located within the north central portion of the FMC Plant Site. This RA consists of former office areas, parking areas, railroad siding, laydown areas, and the Bannock Paving area. Most of the remedial area is covered with non-leachable fill including primarily slag, coke, silica, concrete, asphalt, and native soil. Underground piping (storm sewers) containing COCs (potentially including P4) exists in RA-A. RA-A does not encompass any identified or potential sources of COC releases to groundwater. RA-A includes RUs 3, 4, 5, 6, 20, and portions of 24.

3.5.2 Remediation Area A1 (RA-A1)

RA-A1 consists of two small areas (total of < 1 acre) near the center of (and completely within) RA-A. This area is located at the former Bannock Paving area that included above ground fuel storage tanks and vehicle fueling area. This area was investigated during the SRI in 2007 and found to contain fuel PAHs above the soil SSLs. RA-A1 does not encompass any identified or potential sources of COC releases to groundwater.

3.5.3 Remediation Area B (RA-B)

RA-B is 10.8 acres and is located immediately east of RA-A within the central portion of the FMC Plant Site. This area contains the former furnace building, phos dock, secondary condenser, and slag pit and extends to the east to capture the capillary fringe soils contaminated with P4. Surface and/or subsurface fill within this remedial area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Underground piping containing COCs (potentially including P4) exists in RA-B. RA-B encompasses identified and potential sources of COC releases to groundwater. RA-B includes RUs 1, 2, and a small portion of 7.

3.5.4 Remediation Area C (RA-C)

RA-C is 34.6 acres and is located immediately south of RA-A within the FMC Plant Site. This area contains former phossy/precipitator slurry ponds, the piping corridor between RUs 1 and 2 and 22b, and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Underground piping containing COCs (potentially including P4) exists in RA-C. RA-C encompasses identified and potential sources of COC releases to groundwater. RA-C includes RUs 13, northern portion of 12, eastern portion of 22b, and a small portion of 24.

3.5.5 Remediation Area D (RA-D)

RA-D is 33.6 acres and is located south of RA-A and southeast of RA-C within the FMC Plant Site. This area contains former clarified phossy water/precipitator slurry overflow ponds and precipitator slurry ponds. No P4 is present but surface/subsurface fill contains phossy solids, precipitator solids, slag, and ore. RA-D encompasses identified and potential sources of COC releases to groundwater. RA-D includes the western portion of RU 22b (including former Pond 9S).

3.5.6 Remediation Area E (RA-E)

RA-E consists of two parcels with a total of 21.2 acres. The first parcel is located immediately southeast of RA-B and the second parcel is located to the south on the eastern FMC Plant Site boundary. This area contains the former ore kilns, kiln scrubber ponds, calciners, calciner pond solids stockpile, silica stockpiles, and calcined ore stockpiles. No P4 is present (except in piping) but surface/subsurface fill contains slag, ore, silica, kiln pond solids (subsurface). RA-E encompasses identified and potential sources of COC releases to groundwater. RA-E includes RUs 8, southern portion of 9, and southern portion of 16.

3.5.7 Remediation Area F (RA-F)

RA-F is 171 acres and is located south of RAs-B, C, and E within the FMC Plant Site. This area contains the slag pile and bullrock pile and former equipment maintenance/laydown areas. Surface and subsurface fill within this area consists predominantly of slag and bull rock. RA-F includes RUs 19, 11, and the southern portion of 12.

3.5.8 Remediation Area F1 (RA-F1)

RA-F1 is 2.7 acres and is located near the center of (and completely within) RA-F. This area contains 21 railcars placed in 1964 containing an estimated 10 to 25% P4. The railcars were covered with soil and then covered with 80 to 120 feet of slag as the slag pile progressed to the south. RA-F1 is identified as a potential source of COC releases to groundwater, although actual groundwater impacts have not been identified. RA-F1 includes only RU 19c.

3.5.9 Remediation Area F2 (RA-F2)

RA-F2 is 20.3 acres and is located at the southwestern corner of (and completely within) RA-F. This area contains historic landfill operations that began at the inception of plant operations in 1949 and ceased in 1980. Wastes placed in RA-F2 included slag, office wastes (consisting of office and lunchroom solid wastes), industrial wastes (consisting of asbestos, spent solvents, oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes, and AFM) furnace rebuild/digout wastes (consisting of furnace feed materials, carbon materials, concrete, rocks, and debris), IWW sediments, and baghouse dust. These wastes are covered by 50 - >100 ft of slag. RA-F2 is identified as a potential source of COC releases to groundwater, although actual groundwater impacts have not been identified. RA-F2 includes only RU 19b.

3.5.10 Remediation Area G (RA-G)

RA-G consists of two parcels with a total of 65.8 acres. The first parcel is located immediately northeast of RA-A and the second parcel is located to the south on the eastern FMC Plant Site boundary. This area contains the ore stockpiles, silica stockpile, IWW pond and ditch, dry process waste pile and the northern portion of the calciner pond solids stockpile. Surface and subsurface fill within this area include various plant solid materials including ore, baghouse dust, coke, carbon, calciner solids, and slag. RA-G does not encompass any identified or potential sources of COC releases to groundwater. RA-G includes RUs 7, northern portion of 9, 10, 15, northern portion of 16, and portions of 24.

3.5.11 Remediation Area H (RA-H)

RA-H consists of two parcels with a total of 17.5 acres, both of which are on the FMC Plant Site. The first parcel is located immediately southwest of RA-F and the second parcel is located to the east of the first parcel immediately south of RA-F. This area contains the active plant landfill and the construction/demolition debris landfill. Surface and subsurface fill within this area contains solid waste including plant trash, Andersen filter media (AFM), asbestos, empty containers, concrete, carbon, and furnace feed materials (ore, silica, coke). RA-H is identified as a potential source of COC releases to groundwater, although actual groundwater impacts have not been identified. RA-H includes RUs 17 and 18.

3.5.12 Remediation Area I (RA-I)

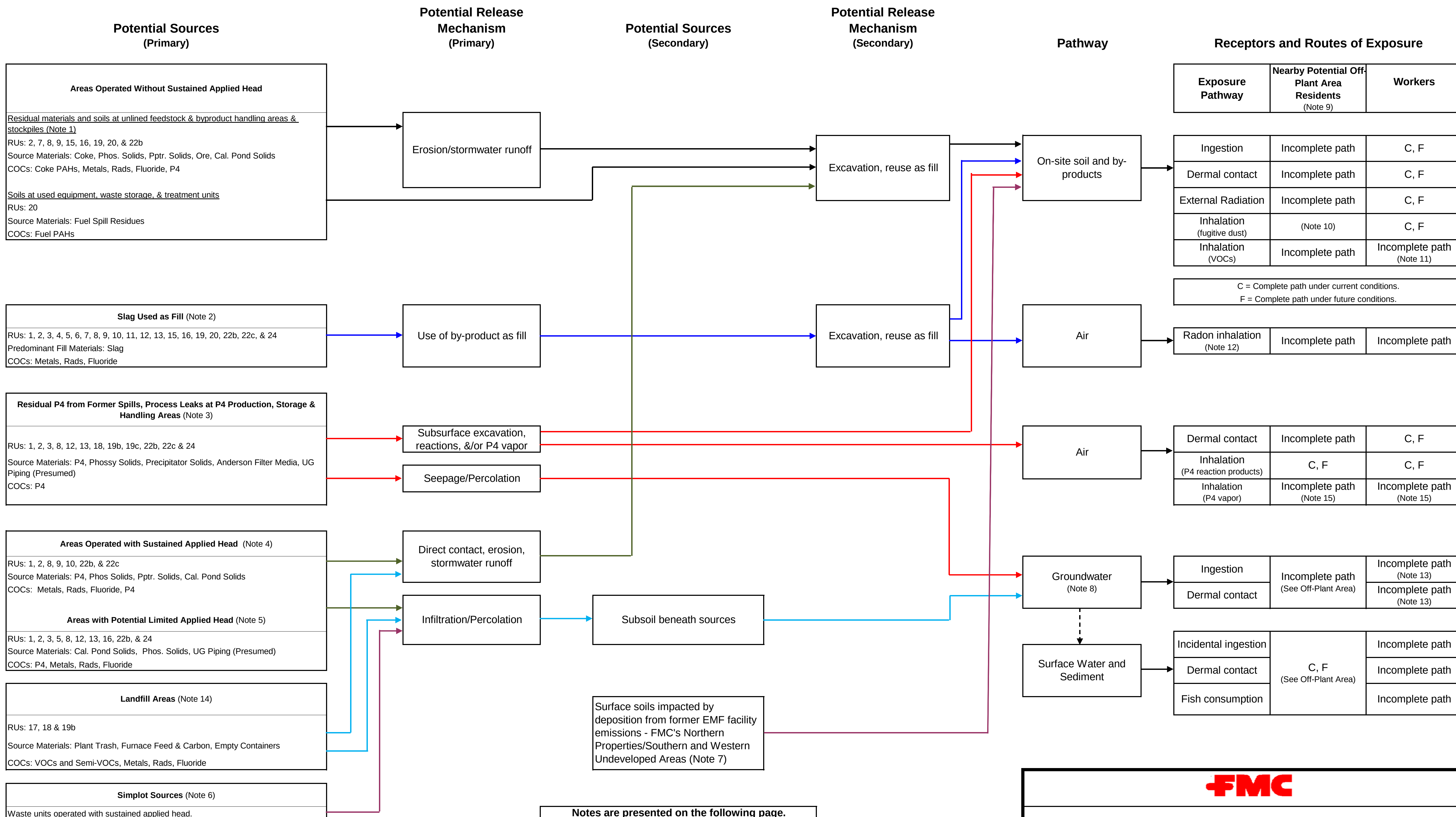
RA-I consists of five parcels with a total of 191 acres, all of which are within the FMC-owned Northern Properties. Parcels 1 and 2 are located immediately north of the FMC Plant Site, north of Highway 30 and south of I-86. Parcels 4, 5, and 6 are located northeast of Parcels 1 and 2, north of I-86. This area was not used for plant production activities, but was used for various agricultural, commercial and recreational activities. Some slag was applied to the surface for roads and parking. RA-I does not encompass any identified or potential sources of COC releases to groundwater. It should be noted that Parcel 5 within RA-I is currently being used as a “clean-fill” landfill. Topsoil was stockpiled on-site prior to the start of landfill activities and will be re-distributed over the site once landfilling is complete.

3.5.13 Remediation Area J (RA-J)

RA-J consists of two small areas (Parcel 3) with a total of 15 acres, both of which are within the FMC-owned Northern Properties. This area of the Northern Properties is located north of Highway 30 and south of I-86. RA-J was not used for plant production activities, but contains windblown dust primarily from the ore handling area. In addition, some slag was applied to the surface for roads and parking. RA-J does not encompass any identified or potential sources of COC releases to groundwater.

3.5.14 Remediation Area K (RA-K)

RA-K consists of a narrow strip of property with a total of 1.3 acres along the northeastern FMC Plant Site boundary. This area was used for stormwater retention but also received an intermittent flow of phossy water, known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. Based on SRI findings, the material from the 0 to 8 feet bgs interval would present a gamma risk because of the slag and ore, but does not contain P4. The material from the 8 to 10 feet bgs interval was identified during the SRI of having low concentrations of P4 (i.e., between 1,000 and 10,000 ppm based upon field observation). RA-K does not encompass any identified or potential sources of COC releases to groundwater.



FMC

Supplemental Feasibility Study
FMC Plant Operable Unit
Figure 3-1
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN EXPOSURE TO CONTAMINANTS

Note 0: Note that RUs under the RCRA Consent Decree (RU 22a) and IDEQ Voluntary Consent Order (RU 14) are not included in the CSM.

Note 1: Feedstock, waste piles, and by-products include ore and ore materials (i.e., bull rock [RU 19 and 15], calcined ore [RUs 8 and 9], & ore dust [RU 7]), slag (RUs 2 and 19), precipitator solids and phossy solids (RU 22b), ferrophos (RUs 20 and 22b), calciner solids (RUs 15 and 16), and coke (RU 20).

Note 2: Includes RUs where slag was observed to be one of the predominant fill materials within the RU.

Note 3: Includes all RUs where P4 was either observed or presumed during the SRI or based upon process knowledge and includes underground piping remaining in place that is presumed to contain precipitator slurry, phossy water, or CO.

Note 4: Includes areas where sustained hydraulic head was used, i.e., ponds, process sumps, water transport ditches, and liquid waste collection areas. RU 1 was added compared to the the 2004 CSM because of the furnace building sumps.

Note 5: These areas did not operate with a sustained hydraulic head in a manner similar to a pond. However, free liquids may have been present in the process/waste streams managed or disposed at the area. RUs 5 and 20 were removed from the 2004 CSM as a result of SRI findings. Includes underground piping left in place that would have carried process/waste streams with COCs, i.e., phossy water, precipitator slurry, or CO (containing P4).

Note 6: Potential sources at the Simplot facility are subject to the Simplot CERCLA RD/RA Consent Decree and applicable Clean Air Act standards. Evaluation of these sources, including development of remedial action objectives, is not within the scope of the Supplemental RI/FS for the FMC Plant OU.

Note 7: Includes potential depostion of historical emissions from the former FMC facility and historical and current emissions from the Simplot facility

Note 8: This pathway includes deposition of P4 in the capillary fringe immediately above the groundwater.

Note 9: Based upon the 1998 ROD definition of Off-Plant Areas (i.e., properties not owned by FMC or Simplot as of 1998). Future residential development of non-FMC owned areas adjacent to the FMC Plant Site is highly unlikely given that current and projected future zoning of this area is heavy industrial.

Note 10: Off-site residents might inhale fugitive dusts generated on-site as a result of wind erosion, traffic, or other on-site activities such as construction/maintenance.

Note 11: Based upon the 2007 SRI data, no volatile organic COPCs were detected above SSLs in any organic SIA.

Note 12: Radon flux measurements were taken during the 2007 SRI in areas with slag, ore and phossy/precipitator solids. Radon emanation rates were found to be at or below background, and significantly lower than the UMTRCA risk-based guidance level of 20 pCi/m2/second for outdoor workers. Radon sampling was performed in areas with slag, ore, and phossy/precipitator solids. Indoor exposure to radon is not a concern as future buildings on the FMC Plant Site are to be constructed with radon control measures, per the 1998 ROD.

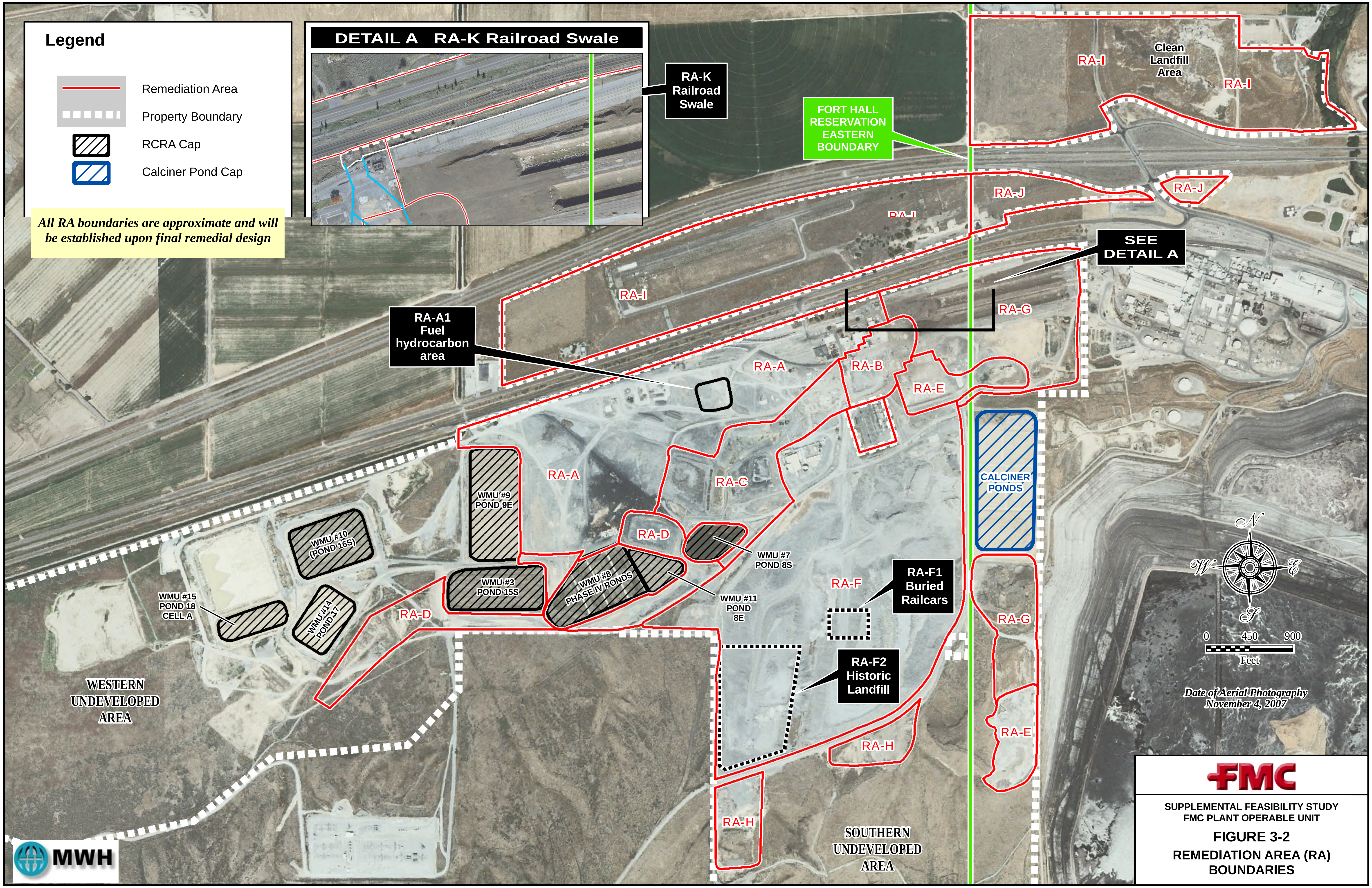
Note 13: Exposure to COCs through the groundwater pathway is presumed to be incomplete through administrative controls and land use restrictions currently in place.

Note 14: For the purposes of landfill identification, RU 19 has been subdivided into four areas: RU 19 - the slag pile, RU 19a - the bullrock pile, RU 19b - the former plant solid waste landfill, and RU 19c - the 21 buried railcars containing P4 sludge.

Note 15: While liquid P4 may evaporate and solid P4 may sublime at ambient temperatures in soils containing P4, vapor P4 concentrations would not be expected to reach levels of concern in the soil or in ambient air surrounding the soil. It should also be noted that 169 soil samples were collected during the SRI near areas suspected of containing P4 and were submitted to the laboratory for P4 analysis. All resulted in non-detects for P4 (with the exception of two very low level detects, consisting of one duplicate sample near RU 2 and one sample at RU 10).

FMC

Notes for Figure 3-1



FILE Fig 3-02_FMC_RA Boundaries_1109.mxd 11/11/09

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
2007 Supplemental Remedial Investigation Details (SRI Report- May 2009)						
RUs 1 and 2: Furnace Building, Phos Dock , Secondary Condenser and Slag Pit	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Residual subsurface P4 exceeds SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. U-238, Ra-226 and Pb-210 in RU 1 fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Antimony, arsenic, cadmium, lead, U-238, Ra-226, Pb-210, Po-210 and K-40 in RU 2 fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>All Receptors</u> Residual P4 within the subsurface of RUs 1 and 2 poses an unacceptable acute health hazard to potential future receptors due to the potential for spontaneous combustion of P4. <u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RUs 1 and 2 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials identified within RU 2 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to outdoor workers associated with incidental fill materials in RU 2 also exceed a hazard index of 1 for the dermal absorption pathway. <u>Construction Worker</u> Cancer and non-cancer risks associated with incidental fill materials in RU 2 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials in RU 2 also exceed a hazard index of 1 for the dermal absorption and inhalation pathways. Potential risks exceed ROD RAOs. As a result, these RUs will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RUs 1 and 2: Furnace Building, Phos Dock , Secondary Condenser and Slag Pit **(continued)**	P4 Delineation	Define the extent and concentration of P4 in shallow subsurface soils to: 1) define the extent of P4 in the subsurface and 2) evaluate the future worker risk for P4 outside the lateral extent of acute P4 risks.	Drilled 7 auger borings to groundwater around the perimeter of RU 1 and 7 auger borings to groundwater around the perimeter of RU 2. Visually evaluated cuttings for the presence of P4. Stepped-out as required.	Visual evaluation P4	P4 was not visually detected in RU 1 soils until reaching the capillary fringe in native soils borings SB004, SB004a, and SB005 as evidenced by smoking or burning. As a result, decision rules were revised and field modification #12 was approved. P4 was not visually detected in any other soil borings at the boundary of RU 1 and RU 2.	P4 was not visually detected until reaching the capillary fringe at the boundary of RU 1; however samples were submitted for laboratory analyses of P4 in the shallow soils (0-10' bgs) and are described below.
			Collected samples for laboratory analysis from 0-2' bgs and 0-10' bgs from outermost step-out locations.	P4	P4 was detected in one RU 2 boundary sample significantly below SSLs. P4 was not detected in any other RU1 or RU 2 boundary soil boring samples from 0-10' bgs.	P4 was not detected above SSLs in the shallow soil; therefore, no additional step-out borings are required, and the limit of P4 in the shallow subsurface is defined by the SRI confirmation borings and the current RU boundaries.
	SIA1 - P4 Capillary Fringe Investigation downgradient of RU 1 (SRI Field Mod #12)	Define the lateral (horizontal) extent of P4 within the capillary fringe associated with the shallow groundwater.	Drilled 6 percussion hammer borings downgradient of RU 1 because during the P4 Delineation program visual evidence of P4 was encountered at the capillary fringe in borings SB004, SB004a, and SB005. Visually evaluated cuttings for the presence of P4. Stepped-in for one boring. Collected samples for laboratory analysis from the two-foot interval above the water table.	P4 Geotechnical Analyses	P4 was not visually detected in native soils above, at, or below the capillary fringe. P4 was not detected in native soils samples collected within the capillary fringe.	The maximum lateral extent of P4 at the capillary fringe has been delineated downgradient of RU 1. This information will be taken into consideration during formulation of remedial alternatives.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RUs 1 and 2: Furnace Building, Phos Dock , Secondary Condenser and Slag Pit **(continued)**	Underground Piping, Sumps, and Other Structures SIA	Compile information on underground piping, sumps and structures that may have carried P4-containing waste streams and could contain residual P4 deposits or other COCs. Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RUs 1 and 2 has been compiled. <u>Risk Assessment:</u> Any residual P4 in underground piping presumed to exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual precipitator solids in precipitator slurry underground piping presumed to contain U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within these RUs. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded for consideration during the SFS. <u>Utility Workers</u> Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with precipitator and phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 3: Receiving Stores, Paint Shop and P4 Decon	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 3 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 3 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.
	SIA1 - Phossy Water	Characterize the potential impacts associated with phossy water P4 contamination in native soils to evaluate whether to remediate the specific investigation area or to take no further action.	Drilled 15 sample locations in the area of the phossy water surface flow path. Collected one sample from each boring for laboratory analysis from 0-2' bns.	P4 Metals Fluoride	P4 was not visually detected in native soils. Concentrations of metals, fluoride, and P4 in native soils were below SSLs.	Metals, fluoride, and P4 levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by possible phossy water. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[a]	Field Program Results	Contamination Assessment
RU 3: Receiving Stores, Paint Shop and P4 Decon **(continued)**	SIA - Underground Piping, Sumps, and Other Structures	Compile information on underground piping, sumps, and structures that may have carried P4-containing waste streams and could contain residual P4 deposits; Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RU 3 has been compiled. A Phase 2 investigation was not required during the SRI field work because RU 3 is being forwarded to the SFS based on the findings of the Supplemental HHRA. Risk Assessment: Any residual P4 in underground piping presumed to exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within this RU. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded for consideration during the SFS process. Utility Workers Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.
RU 4: Office Buildings and Training Center	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see “Other Studies” section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under “Other Studies”)	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 4 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 4 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 4: Office Buildings and Training Center **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.
	SIA1 – Organic Solvent – Lab-Related Solvents around soil boring F028B	Characterize the lateral and vertical extent of solvents to evaluate whether to remediate the solvent specific investigation area or to take no further action.	Phase 1: Drilled 14 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Lab-related solvents	Concentrations of lab-related solvents were not detected in any soil sample at any depth interval. Phase 2 sampling to define the lateral and vertical extent of solvent COCs was not required during the SRI field work at RU 4 because the SSLs were not exceeded.	Lab-related organic solvent concentrations in native soils were not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was necessary and the RU does not pose a threat to groundwater because of organic solvents.
RU 5: Lab and Old Drainfield	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 5 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 5 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 5: Lab and Old Drainfield **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.
	SIA1 – Organic Solvent – Lab-Related Solvents near SWMU 61 and Chemical Lab	Characterize the lateral and vertical extent of solvents to evaluate whether to remediate the solvent specific investigation area or to take no further action.	Phase 1: Drilled 24 borings on a random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Lab-related solvents	Six of 24 borings detected low-level concentrations of laboratory-related solvents. No detections of solvents in the deepest sample intervals. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of solvent COCs was not required during the SRI field work at RU 5 because the SSLs were not exceeded.	Lab-related organic solvent concentrations in native soils were not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was necessary and the RU does not pose a threat to groundwater because of organic solvents.
RU 6: Former Long-Term Phos Storage Tanks	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, nickel, vanadium and six coke-related PAHs in RU 6 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 6 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks to outdoor workers, primarily associated with incidental fill materials, exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to indoor workers, associated with incidental fill materials, also exceed the 1998 ROD RAO for the soil ingestion pathway. <u>Construction Worker</u> Non-cancer risks associated with incidental fill materials in RU 6 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 6: Former Long-Term Phos Storage Tanks **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.
	SIA1 – Phossy Water impacts under former storage tanks	Characterize the potential impacts associated with phossy water P4 contamination in native soils to evaluate whether to remediate the specific investigation area or to take no further action.	Drilled 20 borings on a random grid around former tanks and railspurs, and drilled 12 borings beneath the center of the former tanks. Visually evaluated cuttings for the presence of P4. Collected one sample from each boring for laboratory analysis from 0-2' bns.	P4 Metals Fluoride	P4 was not visually detected in native soils. Concentrations of metals, fluoride, and P4 in native soils were below SSLs.	Metals, fluoride, and P4 levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by possible phossy water. RU does not pose a risk to groundwater.
RU 7: Shale Unloading, Crushing and Stockpile	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, arsenic, cadmium and six coke-related PAHs in RU 7 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 7 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer risks to outdoor workers, primarily associated with incidental fill materials, exceed the 1998 ROD RAO for the soil ingestion pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 7: Shale Unloading, Crushing and Stockpile **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	One (1) of four (4) composite samples reported a level of K-40 above SSLs. Concentrations of all other metals, fluoride, and radionuclides in underlying native soils were below SSLs.	With the exception of one sample with K-40 concentration above SSLs, metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were generally not impacted by overlying fill. RU does not pose a risk to groundwater.
	SFS - Reference Area Investigation (Ore)	Characterize the soils beneath the shale (ore) stockpile in order to evaluate whether fill constituents have leached from the ore in underlying native soils.	Drilled 20 borings on random grid. Collected a sample in each boring from 0-2' bns for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	One (1) of 20 borings reported an exceedance of SSLs. One (1) sample reported an exceedance of the soil to groundwater SSL for chromium. Two (2) borings reported detections above background.	One sample reported an exceedance of SSL for chromium. Based on the limited number of concentrations above background, leaching from ore to underlying native soils is not a concern.
	SIA1 – Coke Constituents	Characterize the potential impacts associated with coke constituents in native soils to evaluate whether to remediate the specific investigation area or to take no further action.	Evaluated data from RU 20 Coke Reference Area Investigation	NA	Concentrations of coke PAHs in RU 20 SIA3 soils were below SSLs.	Leaching of coke PAHs from the coke handling areas in RU 7 to underlying native soils is not a concern.
	SIA – Radon Flux - Ore Fill Material	Characterize radon flux to evaluate radon emanation from ore fill material.	Collected 100 radon flux measurements on a random grid using electret ion chamber	Radon Flux	Radon flux rates were below the UMTRCA standard.	Radon mitigation measures do not need to be considered in the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 8: Former Kiln Scrubber Ponds and Calciners	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	U-238, Ra-226, Pb-210, Po-210, K-40, arsenic, cadmium, fluoride and thallium in RU 8 fill materials exceed background levels and SSLs – these constituents were carried forward as COCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 8 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials exceed the 1998 ROD RAO for the soil ingestion pathway. <u>Construction Worker</u> Non-cancer risks associated with incidental fill materials in RU 8 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	Kiln Pond Sediments Delineation	Define the extent of kiln pond sediments to: 1) define the lateral extent of pond solids 2) evaluate the future worker risk outside the extent of pond solids.	Visually evaluated cuttings for the presence of pond sediments down to native soil. Drilled 14 initial borings. Stepped-out 10' as required and collected a sample from 0-2' bns in final step-out borings for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Kiln scrubber pond sediments were not visually observed in the borings. Four (4) borings reported at least one exceedance of soil to groundwater SSLs for arsenic, cadmium, chromium, selenium, or thallium. A fifth boring reported a concentration of K-40 slightly above SSLs.	Additional step-out borings needed for delineation of kiln pond solids.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 9: Silica Stockpiles and Former Kiln Scrubber Overflow Pond	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, Po-210, K-40, arsenic, cadmium, fluoride, thallium and six coke-related PAHs in RU 9 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 9 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials exceed the 1998 ROD RAO for the soil ingestion pathway. Construction Worker Non-cancer risks associated with incidental fill materials in RU 9 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 10: IWW Pond and Ditch	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in RU 10 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 10 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials identified within RU 10 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to outdoor workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption pathway. <u>Construction Worker</u> Cancer and non-cancer risks associated with incidental fill materials in RU 10 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption and inhalation pathways. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soil were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 10: IWW Pond and Ditch **(continued)**	SIA1 – Phossy Water and Precipitator Solids - IWW Ditch and Pond Area	Characterize the potential impacts associated with phossy water P4 and precipitator solids in native soils and sediments to evaluate whether to remediate the specific investigation area or to take no further action.	Drilled 20 borings/excavated test pits. Visually evaluated cuttings for evidence of P4. Collected one sample from each location for laboratory analysis from 0-2' bns for the ditch and 0-2' bgs for the pond.	P4 Metals Fluoride Po-210 Pb-210	No visible P4 observed. One manganese detection above SSL in the IWW ditch. All four borings in IWW pond reported exceedances of arsenic, cadmium, chromium, Pb-210, manganese, mercury, Po-210, selenium, and thallium in the fill materials from 0-to-2' bgs in the IWW pond.	Metal, fluoride, and radionuclide levels in native soils are not elevated above any future worker or soil to groundwater SSL in the IWW ditch. Metals and radionuclides are elevated above SSLs in the IWW Pond. The impacted materials in RU 10 are confined to the IWW Pond and the lateral and vertical extent has been delineated.
RU 11: Equipment Area South of Calciners	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 11 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 11 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 12: Former RP&S Area and Mobile Shop	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium, lead, nickel and vanadium in RU 12 fill materials exceed background levels, CVs and SSLs – these constituents carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 12 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials identified within RU 12 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to outdoor workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption pathway. <u>Construction and Utility Workers</u> Cancer and non-cancer risks to construction workers associated with incidental fill materials in RU 12 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to construction workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption and inhalation pathways. Non-cancer risks to utility workers associated with incidental fill materials exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[a]	Field Program Results	Contamination Assessment
RU 12: Former RP&S Area and Mobile Shop **(continued)**	SIA1 – Liquid Petroleum Fuels and Organic Solvents – Mobile Shop and Fuel Islands	Characterize the lateral and vertical extent of fuels and solvents to evaluate whether to remediate the specific investigation area or to take no further action.	Phase 1: Drilled 16 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Shop-related solvents	Twelve of 16 borings detected low-level concentrations of shop-related solvents. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of solvent COCs was not required during the SRI field work at RU 12 because the SSLs were not exceeded.	Shop-related organic solvent concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was necessary and the RU does not pose a threat to groundwater because of organic solvents.
			Phase 1: Drilled 42 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Liquid Petroleum Fuels	Two of 42 borings detected low-level concentrations of fuel VOCs and 18 of 42 borings detected low level concentrations of fuel PAHs. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of fuel COCs was not required during the SRI field work at RU 12 because the SSLs were not exceeded.	Fuel VOC and PAH concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required for fuels and the RU does not pose a threat to groundwater because of fuels.
	SIA 2 - Fuels – Steam Cleaning Area	Characterize the lateral and vertical extent of fuels to evaluate whether to remediate the specific investigation area or to take no further action.	Phase 1: Drilled 8 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Liquid petroleum fuels	Two of 8 borings detected low-level concentrations of fuel VOCs and 8 of 8 borings detected low level concentrations of fuel PAHs. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of fuel COCs was not required during the SRI field work at RU 12 because the SSLs were not exceeded.	Fuel VOC and PAH concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required for fuels and the RU does not pose a threat to groundwater because of fuels..
	SIA3 – PCBs-Former Transformer Storage Area	Characterize PCBs in soil to evaluate whether to remediate the specific investigation area or to take no further action.	Drilled 33 borings on a random grid. Collected a discrete sample at surface, every 2.5' to native soil, native soil and 2' bns for laboratory analysis.	PCBs	Ten of 33 borings detected low-level concentrations of PCBs. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of PCB COCs was not required during the SRI field work at RU 12 because the SSLs were not exceeded.	PCB concentrations in soil are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required for PCBs and the RU does not pose a threat to groundwater because of PCBs.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 12: Former RP&S Area and Mobile Shop **(continued)**	SIA4 - Underground Piping, Sumps, and Other Structures	Compile information on underground piping, sumps and structures that may have carried P4-containing waste streams and could contain residual P4 deposits; Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RU 12 has been compiled. A Phase 2 investigation was not required during the SRI field work because the gamma levels were above the CV and the RU will be forwarded to the SFS. Risk Assessment: Residual P4 presumed to be present in underground piping at levels that exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual precipitator solids in precipitator slurry underground piping presumed to contain U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within this RU. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded to the SFS for consideration during the SFS. Utility Workers Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with precipitator and phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Residual subsurface P4 exceeds SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Gamma radiation, U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in RU 13 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs into the Supplemental HHRA.	<u>All Receptors</u> Residual P4 within the subsurface of RU 13 poses an unacceptable acute health hazard to potential future receptors due to the potential for spontaneous combustion of P4. <u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 13 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials identified within RU 13 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to outdoor workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption pathway. <u>Construction Worker</u> Cancer and non-cancer risks associated with incidental fill materials in RU 13 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption and inhalation pathways. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Pond sediments encountered in several borings on the border with RU 22b. Smoking P4 was encountered in one boring. Concentrations of metals and radionuclides in soils are above SSLs for all four composite samples	Metals, fluoride, and radionuclides levels in native soils are elevated above any future worker SSL or soil to groundwater SSL.
	SIA1 - Underground Piping, Sumps, and Other Structures	Compile information on underground piping, sumps and structures that may have carried P4-containing waste streams and could contain residual P4 deposits; Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RU 13 has been compiled. A Phase 2 investigation was not required during the SRI field work because the gamma levels were above the CV and the RU will be forwarded to the SFS. <u>Risk Assessment:</u> Any residual P4 in underground piping presumed to exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual precipitator solids in precipitator slurry underground piping presumed to contain U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within this RU. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded to the SFS for consideration during the SFS. <u>Utility Workers</u> Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with precipitator and phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 15: Oversize Ore, Used Electrode, Baghouse Dust Area	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	U-238, Ra-226, Pb-210, Po-210, K-40, arsenic, cadmium, fluoride, thallium and six coke-related PAHs in RU 15 fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 15 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials exceed the 1998 ROD RAO for the soil ingestion pathway. <u>Construction Worker</u> Non-cancer risks associated with incidental fill materials in RU 15 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SIA1 - Leaching Potential from Ore, Used Electrodes, and Baghouse Dust	Characterize vertical impact to native soils underlying these materials to assess potential transport of metals and fluoride in vadose zone for the purpose of designing the proposed cap/cover.	Drilled 5 borings. Collected samples at 0-2' bns and a discrete sample every 10' bns to refusal or groundwater for laboratory analysis.	Metals Fluoride	Two (2) of five (5) borings detected concentrations of cadmium above soil to groundwater SSL at shallow and deep depths in the vadose zone.	Exceedances of cadmium at shallow depths appear to be the result of mixture of fill and native soils. Exceedances of cadmium at depth may be natural or due to leaching

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 16: Calciner Solids Stockpile	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	U-238, Ra-226, Pb-210, Po-210, K-40, arsenic, cadmium, fluoride and thallium in RU 16 fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 16 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with predominant fill materials also exceed the 1998 ROD RAO for the soil ingestion pathway. Construction Worker Non-cancer risks associated with predominant fill materials in RU 16 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with predominant fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SIA1 - Leaching Potential from Calciner Solids	Characterize vertical impact to native soils underlying these materials to assess potential transport of metals and fluoride in vadose zone for the purpose of designing the proposed cap/cover.	Drilled 8 borings. Collected samples at 0-2' bns and a discrete sample every 10' bns to refusal or groundwater for laboratory analysis.	Metals Fluoride	Four (4) of eight (8) borings detected concentration of arsenic, cadmium, chromium, manganese, selenium, and thallium at shallow and deep depths in the vadose zone.	Exceedances of metals at shallow depths appear to be the result of mixture of fill and native soils. Exceedances of metals at depth appear to be due to migration of metals into the subsurface from calciner solids.
RU 19: Slag Pile	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	U-238, Ra-226, Pb-210, arsenic, and cadmium in RU 19 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA..	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 19 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 19: Slag Pile **(continued)**	Soil Cover Area Radiation Survey	Evaluate whether the test soil cover over slag material reduces the risk from surface external gamma radiation to future site workers to evaluate remedial alternatives.	Performed surface radiation scan over soil cover area.	NA	Gamma radiation with soil cover over slag was below the CV.	The soil cover over portions of the slag pile reduces gamma dose rates to regional background levels.
	SIA1 - Radon Flux - Measurements from the slag and bullrock piles	Characterize radon flux to evaluate the design of the proposed cap/cover (e.g., appropriate thickness).	Collect 100 radon flux measurements using electret ion chamber from each: slag pile, bull rock pile and test soil cover area, if required.	Radon Flux	Radon flux rates were below the UMTRCA standard for both the slag pile and bullrock pile. No measurements were required for the soil test cover area.	Radon mitigation measures do not need to be considered in the SFS.
RU 20: Former Bannock Paving Area	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226, Pb-210, nickel, vanadium and six coke-related PAHs in RU 20 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 20 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks to outdoor workers, primarily associated with incidental fill materials, exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to indoor workers, associated with incidental fill materials, also exceed the 1998 ROD RAO for the soil ingestion pathway. Construction Worker Non-cancer risks associated with incidental fill materials in RU 20 exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 20: Former Bannock Paving Area **(continued)**	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Concentrations of metals, fluoride, and radionuclides in underlying native soils were below SSLs.	Metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were not impacted by overlying fill. RU does not pose a risk to groundwater.
	SFS - Reference Area Investigation (Slag)	Characterize the soils beneath the slag to evaluate if fill constituents have leached in underlying native soils.	Drilled 20 borings on random grid. Collected a sample in each boring from 0-2' bns for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Two (2) of 20 boring reported exceedances of SSLs for two metals. One sample reported an exceedance of the soil to groundwater SSL for cadmium and one sample reported a slight exceedance of the manganese soil to gw SSL. Three (3) borings reported concentrations of metals above background.	Two samples reported slight exceedances of SSLs for two metals. Leaching from slag to underlying native soils is not a concern. Based on the limited number of concentrations above background, leaching from slag to underlying native soils is not a concern.
	SIA1 – Fuels near Hot Batch Plant	Characterize the lateral and vertical extent of fuels to evaluate whether to remediate the specific investigation area or to take no further action.	Phase 1: Drilled 43 borings on a random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis. Phase 2: Presented Phase 1 data to Agency. Designed a sampling program. Drilled 21 additional shallow soil borings on a random grid. Collected additional samples from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Liquid petroleum fuels	Three (3) of 43 borings detected low-level concentrations of fuel VOCs and several borings detected low level concentrations of fuel PAHs. Three borings detected concentrations of PAHs in the shallow intervals above SSLs. No detections of PAHs above SSLs in any of 21 Phase 2 borings. Four fuel-related PAHs detected above worker SSLs – these constituents were carried forward as COCs into the Supplemental HHRA.	Fuel VOC concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. Fuel PAHs in three borings exceeded PAHs in shallow interval but no exceedances reported for Phase 2. As a result, no additional lateral or vertical delineation was required for fuels and the RU does not pose a threat to groundwater because of fuels. Cancer and non-cancer risks to potential future workers from exposure to fuel-related PAHs and fill materials within the Former Hot Batch Plant area are comparable to the risk levels associated with exposure to fill materials in the remainder of RU 20 (described in the Risk Assessment Field Program).

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 20: Former Bannock Paving Area **(continued)**	SIA2 – Fuels around the Maintenance and Equipment Shop	Characterize the lateral and vertical extent of fuels and shop-related solvents to evaluate whether to remediate the specific investigation area or to take no further action.	Phase 1: Drilled 30 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis. Phase 1: Drilled 30 borings on random grid. Collected a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for laboratory analysis.	Shop-related solvents Liquid Petroleum Fuels	One of 30 borings detected a low-level concentration of a shop-related solvent. Concentration at was less than SSLs. Phase 2 sampling to define the lateral and vertical extent of solvent COCs was not required during the SRI field work at RU 20 because the SSLs were not exceeded. Five of 30 borings detected low-level concentrations of fuel VOCs and 12 of 42 borings detected low level concentrations of fuel PAHs. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of fuel COCs was not required during the SRI field work at RU 20 because the SSLs were not exceeded.	Shop-related organic solvent concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required for organic solvents and the RU does not pose a threat to groundwater because of organic solvents. Fuel VOC and PAH concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation is required for fuels and the RU does not pose a threat to groundwater because of fuels..
	SIA3 – Coke Constituents and Reference Area Investigation - Coke	Characterize the soils beneath the coke handling area to evaluate whether fill constituents have leached in underlying native soils.	Drilled 20 borings on random grid. Collected a sample in each boring from 0-2' bns for laboratory analysis.	Coke PAHs	Seven of 20 borings detected low-level concentrations of coke PAHs. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of coke COCs was not required during the SRI field work at RU 20 because the SSLs were not exceeded.	Coke PAH concentrations in native soils are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required for coke PAHs and the RU does not pose a threat to groundwater because of coke constituents.
	SIA4 – Coke Constituents underlying the Coke Settling Basins	Characterize the vertical extent of constituents associated with coke beneath the concrete-lined coke settling basins to evaluate the remediation vision for coke constituents.	Drilled 3 borings to 10' below the bottom of the basins. Collected a discrete sample from each boring at 0', 2' and 10' below the basin for laboratory analysis.	Metals Coke PAHs	One boring reported low level concentrations of coke PAHs SSLs. All three borings detected concentrations of metals. Concentrations at all depth intervals were less than SSLs. Phase 2 sampling to define the lateral and vertical extent of coke COCs was not required during the SRI field work at RU 20 because the SSLs were not exceeded.	Coke PAH and metals concentrations in native soil are not elevated above any future worker SSL or soil to groundwater SSL. As a result, no additional lateral or vertical delineation was required and .the RU does not pose a threat to groundwater because of coke PAHs or metals.
	SIA5 – Coke Constituents	Characterize toxicity of coke for handling purposes. Information will be used during the SFS for evaluation of potential remedial alternatives.	Collected 1 composite sample at the coke handling area and a composite sample from sediments in each of the three coke settling basins.	TCLP Metals Semi volatiles	Two (2) composite samples reported low level concentrations of mercury. No other SVOCs or metals were detected. Concentrations at all depth intervals were less than TCLP Maximum Contaminant Levels.	Coke in RUs 7 and 20 is not considered a hazardous waste as will not be managed as such.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 21: Other Onsite Railspurs	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 21 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Utility Workers Cancer and non-cancer risks associated fill materials present within RU 21 do not exceed the 1998 ROD RAOs. While potential risks do not exceed the ROD RAOs, given its close proximity to other RUs that do exceed these levels, RU 21 will proceed to the SFS.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 22b: Old Ponds	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials..	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Residual subsurface P4 exceeds SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium, lead, nickel and vanadium in RU 22b fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>All Receptors</u> Residual P4 within the subsurface of RU 22b poses an unacceptable acute health hazard to potential future receptors due to the potential for spontaneous combustion of P4. <u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 22b exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to outdoor workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption pathway. <u>Construction and Utility Workers</u> Cancer and non-cancer risks to construction workers associated with incidental fill materials in RU 22b exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks to construction workers associated with incidental fill materials also exceed a hazard index of 1 for the dermal absorption and inhalation pathways. Non-cancer risks to utility workers associated with incidental fill materials exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[a]	Field Program Results	Contamination Assessment
RU 22b: Old Ponds **(continued)**	SIA1 - Radon Flux	Characterize radon flux in the Ponds to evaluate the design of the proposed cap/cover.	Collected 100 radon flux measurements over the east-most parcel and 100 radon flux measurements over the combined three west-most parcels of the former ponds not covered by the RCRA ponds using electret ion chamber.	Radon Flux	Radon flux rates were below the UMTRCA standard.	Radon mitigation measures do not need to be considered in the SFS.
	Old Ponds Delineation	Define the horizontal extent of Old Phossy Pond sediments to 1) define the lateral extent of pond solids and 2) evaluate the future worker risk outside of the extent of pond solids.	Drilled 22 borings around RU 22b. Visually evaluated cuttings for the presence of pond sediments down to native soil. Collected samples for laboratory analysis from either or 0-2' bgs and 0-10'bgs or 0-2' bns based upon presence of fill material at the surface of the boring.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Phossy pond sediments were not visually observed in the borings. Eight (8) borings reported at least one exceedance of soil to groundwater SSLs for arsenic, antimony, cadmium, chromium, Pb-210, manganese, nickel, Po-210, K-40, selenium, thallium, and U-238.	Additional step-out borings needed for phossy pond sediment delineation.
RU 22b: Old Ponds **(continued)**	SIA - Underground Piping, Sumps, and Other Structures	Compile information on underground piping, sumps and structures that may have carried P4-containing waste streams and could contain residual P4 deposits or other COCs. Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RU 22b has been compiled. <u>Risk Assessment:</u> Any residual P4 present in underground piping presumed to exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual precipitator solids in precipitator slurry underground piping presumed to contain U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within this RU. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded to the SFS for consideration during the SFS. <u>Utility Workers</u> Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with precipitator and phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 22c: Railroad Swale	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Residual subsurface P4 exceeds SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic and cadmium in RU 22c fill materials exceed background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	<u>All Receptors</u> Residual P4 within the subsurface of RU 22c poses an unacceptable acute health hazard to potential future receptors due to the potential for spontaneous combustion of P4. <u>Outdoor and Indoor Commercial/Industrial Workers</u> Cancer risks associated with predominant fill materials present within RU 22c exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Cancer and non-cancer risks associated with incidental fill materials exceed the 1998 ROD RAO for the soil ingestion pathway. <u>Construction Worker</u> Non-cancer risks associated with incidental fill materials in RU 22c exceed the 1998 ROD RAO for the soil ingestion pathway. Non-cancer risks associated with incidental fill materials also exceed a hazard index of 1 for the inhalation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	P4 Delineation	Define the extent and concentration of P4 in shallow subsurface soils to: 1) define the extent of P4 in the subsurface and 2) evaluate the future worker risk for P4 outside the lateral extent of acute P4 risks.	Investigated 4 locations with test pits. Visually evaluated test pits and spoils pile for the presence of P4. Stepped-out as required. Collected samples for laboratory analysis from 0-2' bgs and 0-10' bgs from a boring proximate to the outermost step-out test pit location.	P4	P4 visibly observed in one of the test pits. Additional step-out trench and confirmation borings did not observe P4. Confirmation samples did not detect P4.	Visual observation and lack of detected P4, confirmed the lateral extent of P4 above a level of acute and chronic health concern.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 23: Road Segments not within RU Boundaries	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 23 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Maintenance Workers Cancer and non-cancer risks associated fill materials present within RU 23 do not exceed the 1998 ROD RAOs. While potential risks do not exceed the ROD RAOs, given its close proximity to other RUs that do exceed these levels, RU 23 will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	One (1) of four (4) composite samples reported a level of cadmium above SSLs. Concentrations of all other metals, fluoride, and radionuclides in underlying native soils were below SSLs.	With the exception of one (1) sample with a cadmium concentration above the soil to groundwater SSL, metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were generally not impacted by overlying fill. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
RU 24: Plant Areas not within RU Boundaries	Risk Assessment	Characterize risks to potential receptors from exposure to radiological, inorganic (metals, and fluoride) and organic constituents associated with residual surface and subsurface fill materials.	Performed surface radiation scan with NaI detectors to evaluate external gamma radiation risk. SFS field work below performed because gamma radiation was above its CV for the future site worker. Collected Fill Characterization data (see "Other Studies" section below) to supplement historical Fill Characterization data.	Gamma radiation Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210 (data collected under "Other Studies")	Gamma radiation, U-238, Ra-226 and Pb-210 in RU 24 fill materials exceed background levels, CVs and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Outdoor and Indoor Commercial/Industrial Workers Cancer risks associated with predominant fill materials present within RU 24 exceed the 1998 ROD RAO for the external exposure to gamma radiation pathway. Potential risks exceed ROD RAOs. As a result, this RU will proceed to the SFS.
	SFS	Determine nature and extent of possible leaching from fill materials into underlying native soils	Drilled 20 borings on a random grid. Native soil was detected in the upper 10 feet of each borehole[b], therefore collected one sample from each boring from 0-2' bns. Composited the 20 samples into groups of 5. Submitted 4 samples for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	One (1) of four (4) composite samples reported a level of cadmium above SSLs. Concentrations of all other metals, fluoride, and radionuclides in underlying native soils were below SSLs.	With the exception of one (1) sample with a cadmium concentration above the soil to groundwater SSL, metals, fluoride, and radionuclides levels in native soils were not elevated above any future worker SSLs or soil to groundwater SSLs. Native soils were generally not impacted by overlying fill. RU does not pose a risk to groundwater.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[a]	Field Program Results	Contamination Assessment
RU 24: Plant Areas not within RU Boundaries **(continued)**	SIA1 - Underground Piping, Sumps, and Other Structures	Compile information on underground piping, sumps and structures that may have carried P4-containing waste streams and could contain residual P4 deposits or other COCs. Use this information for an SFS evaluation.	Compiled information from existing drawings, construction records, aerial photos/maps, and conducted plant personnel interviews (i.e., persons knowledgeable regarding underground piping, sumps and structures).	NA	A detailed inventory of underground piping, conduits, sump, foundations, and other significant features in RU 24 has been compiled. A Phase 2 investigation was not required during the SRI field work because the gamma levels were above the CV and the RU will be forwarded to the SFS. Risk Assessment: Residual P4 presumed to be present in underground piping at levels that exceed SSLs – this COC was carried forward for qualitative evaluation in the Supplemental HHRA. Any residual precipitator solids in precipitator slurry underground piping presumed to contain U-238, Ra-226, Pb-210, Po-210, K-40, antimony, arsenic, cadmium and lead in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA. Any residual phossy solids in phossy water underground piping presumed to contain Pb-210, Po-210, K-40, antimony, arsenic, cadmium in excess of background levels and SSLs – these constituents were carried forward as COCs/ROCs into the Supplemental HHRA.	Piping, sumps and/or structures were identified as present within this RU. COCs could be present in these pipes/sumps/structures and could impact remedial alternative design/selection. This information will be forwarded to the SFS for consideration during the SFS. Utility Workers Residual P4 presumed to be present in the underground piping at levels that could pose an unacceptable acute health hazard due to the potential for spontaneous combustion of P4. Cancer and non-cancer risks associated with precipitator and phossy solids presumed present in underground piping do not exceed the 1998 ROD RAOs.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
Other Studies	SIA - Southern and Western Undeveloped Area – PIC Measurements	Characterize surface external gamma dose. Forward RU to the SFS data collection pathway if surface gamma dose rate exceeds the gamma benchmark.	Collected 100 PIC measurements from each area.	PIC Measurement	After removal of anomalies, such as slag roads and rock outcrops, the mean dose rate in the SUA is 15.4 uR/hr. After removal of anomalies, such as slag roads and disturbed areas with slag, the mean dose rate in the WUA is 14.4 uR/hr. The mean does rate in the borrow pit exposed in 2004/2005 was 14.4 uR/hr.	The mean gamma dose rate in the SUA is not determined to be impacted and does not need to be evaluated in the SFS. The roads and disturbed areas will be evaluated for remedial action in the SFS. The mean gamma dose rate in the WUA exceeded the background rate; however, the borrow source in the WUA was exposed since plant shut-down and has the same mean as the general WUA. It is believed that the site-specific background for these PIC measurements in 14.4 uR/hr and that the WUA does not need to be evaluated in the SFS. The roads and disturbed areas will be evaluated for remedial action in the SFS.
	SIA – Precipitator Solids Roadway Investigation	Evaluate whether precipitator dust/phossy solids were applied on roads.	Investigated 6 locations and a reference location. Collected 10 soil samples of the roadway material (approximately 0-0.5' bgs) at each location for laboratory analysis.	Pb-210	Statistical evaluations showed that the each of the six roadways are less than or equal to the reference roadway.	The areas were determined not to be impacted by precipitator solids and do not need to evaluated in the SFS. However, several FMC Plant Site roadways are in RUs that will proceed to the SFS. In addition RU 23 road segments will proceed to the SFS given their close proximity to other RUs that do exceed the 1998 ROD RAO.
	SIA – PCDT Roadway Investigation	Evaluate the potential impact of PCDT water application along roads within the FMC Plant OU.	Investigated 6 roadway locations and a reference roadway location. Collected 10 soil samples from the roadway material (approximately 0-0.5' bgs) at each location for laboratory analysis.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Statistical evaluation showed some metals in the worst-case road segment exceeded the reference road.	Roadways receiving PCDT water will be forwarded to the SFS for evaluation of metals and radionuclides. It must be noted that several FMC Plant Site roadways are in RUs that will proceed to the SFS. In addition RU 23 road segments will proceed to the SFS given their close proximity to other RUs that do exceed the 1998 ROD RAO.
	Fill Char. Study	Collect additional chemical information on specific source materials (e.g., phosphate ore) and waste streams (e.g., precipitator solids) historically managed at the plant for the SRI risk assessment.	Collect up to 7 samples of precipitator solids from EMF RI locations in RU 22b. Collect two sample of phossy solids form EMF RI location F025B. Collect 2 samples of calciner solids; one from southern area and one from northern area of RU 16. Collect 2 samples of kiln solids in RU 8. Collect 1 composite sample of ore material in RU 7.	Metals Fluoride Ra-226 U-238 K-40 Po-210 Pb-210	Samples were collected from all source materials except for kiln solids, which could not be located in RU 8. At least one sample of each fill type detected concentrations of metals and radionuclides that exceeded future worker SSLs.	Sample data confirms and supports historical sample data for specific source materials. Metals and radionuclide concentrations in these source materials were used in conjunction with historical data for these and other types of fill material, to bound risks to potential future receptors from exposure to the fill materials observed to be present within each RU.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
2008 Supplemental Remedial Investigation Details (*Final SRI Addendum Report*- November 2009)						
Background Soil Sampling		Background soil data was needed to develop comparative values (CV) for each COC which the soil data from the SUA/WUA and parcels were screened against.	A total of 10 background sampling locations were identified in the greater Pocatello area within a 6 to 11-mile radius of the former FMC Plant Site. At each site, 20 discrete samples, randomly located in a 10' by 10' grid, were collected from 2 intervals (0 to 2 inches and 2 to 6 inches bgs) for compositing into 2 samples. Discrete samples were collected from the center of the grid, one at 0 to 2 and another at 2 to 6 inches bgs for a total of 4 samples from each location that were submitted for analyses.	0 to 2 inches Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Fluoride Lead, Lithium, Manganese,Mercury Molybdenum, Nickel, Selenium, Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, Uranium-238 2 to 6 inches Radium-226, Lead 210,Uranium 238	The calculated 95% UCL concentrations within the 0 to 2 inch bgs sampling interval are generally similar between composite and discrete samples. Background samples from the 0 to 2 and 2 to 6 inch bgs intervals were analyzed for radionuclides and both the discrete and the composite samples from each interval have similar concentrations. The composite sample data were combined with the ecological and human health SSL to develop comparative values, against which the soil data collected from the SUA, WUA, and parcels 1-6 were screened (CVs = 95% UCL + SSLs).	NA
Southern Undeveloped Area (SUA)	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this relatively undisturbed area of the Plant Site because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	In both the SUA and WUA, a total of eight grids from a random origin were placed on these areas. Twenty discrete soil samples were collected from 0 to 2 inches bgs in each of these grids and used to prepare a single composite sample from each grid for a total of 8 composite samples from each area that were submitted for analyses.	0 to 2 inches Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Fluoride Lead, Lithium, Manganese,Mercury Molybdenum, Nickel, Selenium, Thallium,Uranium, Vanadium, Zinc	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the SUA (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Future Workers) – none • Ecological Risk Assessment – cadmium, fluoride, mercury, and vanadium.	Based on the findings of the *Supplemental ERA and HHRA Addenda*, no levels above a concern are exceeded in the SUA and thus it will not be forwarded to the SFS for evaluation of remedial alternatives.

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
Western Undeveloped Area (WUA)	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this relatively undisturbed area of the Plant Site because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	In both the SUA and WUA, a total of eight grids from a random origin were placed on these areas. Twenty discrete soil samples were collected from 0 to 2 inches bgs in each of these grids and used to prepare a single composite sample from each grid for a total of 8 composite samples from each area that were submitted for analyses.	<u>0 to 2 inches</u> Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Fluoride Lead, Lithium, Manganese,Mercury Molybdenum, Nickel, Selenium, Thallium,Uranium, Vanadium, Zinc	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the WUA (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Future Workers) – none • Ecological Risk Assessment – cadmium and fluoride.	Based on the findings of the *Supplemental ERA and HHRA Addenda*, no levels above a concern are exceeded in the WUA and thus it will not be forwarded to the SFS for evaluation of remedial alternatives.
Parcel 1	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	A total of eight grids, from a random origin, were placed over the Parcel 1 area. From each grid, twenty discrete soil samples were collected from 0 to 2 inches bgs and 2 to 6 inches bgs. These samples were used to prepare two composite samples from each grid (one from 0 to 2inches and another from 2 to 6 inches bgs) for a total of 16 composite samples from this area that were submitted for analyses.	<u>0 to 2 inches</u> Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238 <u>2 to 6 inches</u> Radium-226, Lead 210,Uranium 238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 1 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Residential) – cadmium, fluoride, vanadium, uranium-238, radium-226, and lead-210 • Human Health Risk Assessment (Future Workers) – uranium-238, radium-226, and lead-210 • Ecological Risk Assessment – cadmium, chromium, fluoride, mercury, vanadium, and zinc.	The risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 1 requires evaluation of remedial alternatives in the SFS for hypothetical future residential receptors. None of the COCs carried forward into the *Supplemental ERA Addendum* were found to be associated with risks above a level of concern.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
Parcel 2	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	A total of eight grids, from a random origin, were placed over the Parcel 2 area. From each grid, twenty discrete soil samples were collected from 0 to 2 inches bgs and 2 to 6 inches bgs. These samples were used to prepare two composite samples from each grid (one from 0 to 2inches and another from 2 to 6 inches bgs) for a total of 16 composite samples from this area that were submitted for analyses.	0 to 2 inches Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238 2 to 6 inches Radium-226, Lead 210,Uranium 238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 2 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Residential) – cadmium, fluoride, thallium, uranium, vanadium, uranium-238, radium-226, and lead-210 • Human Health Risk Assessment (Future Workers) – uranium-238, radium-226, and lead-210 • Ecological Risk Assessment – cadmium, chromium, fluoride, lead, mercury, selenium, vanadium, and zinc	The findings of the *Supplemental ERA Addendum* are similar to the findings of the BERA, namely that fluoride is the only COC that exceeds NOAEL HQs, although only marginally. As concluded in the BERA, the likelihood for adverse effects on population size or community composition is also considered marginal. Thus, although there are no mammalian or avian LOAEL HQs greater than one, potential fluoride ecological concerns in Parcel 2 were carried forward into the SFS on the basis of the avian NOAEL HQs which are marginally above one. In addition, the risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 2 requires evaluation of remedial alternatives in the SFS for hypothetical future residential receptors.
Parcel 3	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	A total of eight grids, from a random origin, were placed over the Parcel 3 area. From each grid, twenty discrete soil samples were collected from 0 to 2 inches bgs and 2 to 6 inches bgs. These samples were used to prepare two composite samples from each grid (one from 0 to 2inches and another from 2 to 6 inches bgs) for a total of 16 composite samples from this area that were submitted for analyses.	0 to 2 inches Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238 2 to 6 inches Radium-226, Lead 210,Uranium 238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 3 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Residential) – antimony, cadmium, fluoride, thallium, uranium, vanadium, uranium-238, radium-226, and lead-210 • Human Health Risk Assessment (Future Workers) – cadmium, uranium-238, radium-226, and lead-210 • Ecological Risk Assessment – cadmium, chromium, fluoride, lead, mercury, selenium, vanadium, and zinc.	The findings of the *Supplemental ERA Addendum* are similar to the findings of the BERA, namely that fluoride is the only COC that marginally exceeds NOAEL HQs, and a LOAEL HQ for one receptor, although only slightly. As concluded in the BERA, the likelihood for adverse effects on population size or community composition is also considered marginal. In addition, the risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 3 requires evaluation of remedial alternatives in the SFS for hypothetical future residential and future worker receptors.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho

Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[a]	Field Program Results	Contamination Assessment
Parcel 4	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	A total of eight grids, from a random origin, were placed over the Parcel 4 area. From each grid, twenty discrete soil samples were collected from 0 to 2 inches bgs and 2 to 6 inches bgs. These samples were used to prepare two composite samples from each grid (one from 0 to 2inches and another from 2 to 6 inches bgs) for a total of 16 composite samples from this area that were submitted for analyses.	0 to 2 inches Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238 2 to 6 inches Radium-226, Lead 210,Uranium 238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 4 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health Risk Assessment (Residential) – cadmium, fluoride, uranium, vanadium, uranium-238, radium-226, and lead-210 • Human Health Risk Assessment (Future Workers) – uranium-238, radium-226, and lead-210 • Ecological Risk Assessment – cadmium, chromium, fluoride, mercury, selenium, vanadium, and zinc.	The findings of the *Supplemental ERA Addendum* are similar to the findings of the BERA, namely that fluoride is the only COC which exceeds NOAEL HQs, although only marginally. As concluded in the BERA, the likelihood for adverse effects on population size or community composition is also considered marginal. Thus, although there are no mammalian or avian total or LOAEL HQs greater than one, potential fluoride ecological concerns in Parcel 4 were carried forward into the SFS on the basis of the avian NOAEL HQs which are marginally above one. In addition, the risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 4 requires evaluation of remedial alternatives in the SFS for hypothetical future residential receptors.
Parcel 5	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions. Based on future landuse of this parcel (a gravel pit), stockpiled soils and undisturbed areas of this parcel were sampled.	A total of three 20-part composite samples were collected throughout this parcel. No samples were collected within the gravel pit or in the areas that contain backfilled materials. Twenty discrete samples from 0 to 6 inches bgs were collected from each of the 3 composite sample grids and were combined to prepare one composite sample from each grid. A total of 3 composite samples from this parcel were submitted for analyses.	0 to 6 inches Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 5 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. This information is summarized below: • Human Health Risk Assessment (Residential) – cadmium, fluoride, uranium-238, radium-226, and lead-210 • Human Health Risk Assessment (Future Workers) – radium-226 • Ecological Risk Assessment – cadmium, fluoride, mercury, vanadium, and zinc	The risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 5 requires evaluation of remedial alternatives in the SFS for hypothetical future residential receptors. None of the COCs carried forward into the *Supplemental ERA Addendum* were found to be associated with risks above a level of concern.

TABLE 3-1

SUMMARY OF SRI FIELD PROGRAMS RATIONALE, RESULTS, AND CONTAMINANT ASSESSMENT
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation, Pocatello, Idaho
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Location Remediation Unit Number, Name	Field Programs (by RU)	Investigation Rationale	Field Program Data Collection Description	Data Collection Analytes[(a)]	Field Program Results	Contamination Assessment
Parcel 6	Surface Soil Char. Study	The surface soil investigation was conducted to see if there were impacts to this area because of historical FMC stack and fugitive dust emissions, along with current Simplot stack and fugitive dust emissions.	A total of eight grids, from a random origin, were placed over the Parcel 6 area. From each grid, twenty discrete soil samples were collected from 0 to 2 inches bgs and 2 to 6 inches bgs. These samples were used to prepare two composite samples from each grid (one from 0 to 2inches and another from 2 to 6 inches bgs) for a total of 16 composite samples from this area that were submitted for analyses.	0 to 2 inches Antimony, Arsenic Cadmium, Chromium,Fluoride, Lead,Manganese, Mercury,Selenium,Thallium,Uranium, Vanadium, Zinc, Lead-210, Radium-226, and Uranium-238 2 to 6 inches Radium-226, Lead 210,Uranium 238	Based on application of the decision rules from the *SRI Work Plan Addendum* to the validated data from the Parcel 6 (i.e., analyte comparisons to CVs), the following constituents exceeded CVs and were carried forward into the quantitative human health and/or ecological risk assessments. • Human Health (Residential) – cadmium, fluoride, uranium, vanadium, uranium-238, radium-226, and lead-210 • Human Health (Future Workers) – uranium-238, radium-226, and lead-210 • Ecological Risk Assessment – cadmium, chromium, fluoride, mercury, selenium, vanadium, and zinc.	The findings of the *Supplemental ERA Addendum* are similar to the findings of the BERA, namely that fluoride is the only COC that exceeds NOAEL HQs, although only marginally. As concluded in the BERA, the likelihood for adverse effects on population size or community composition is also considered marginal. Thus, although there are no mammalian or avian LOAEL HQs greater than one, potential fluoride ecological concerns in Parcel 6 were carried forward into the SFS on the basis of the avian NOAEL HQs which are marginally above one. In addition, the risks posed to human health have been sufficiently bound and provide adequate support to conclude that Parcel 6 requires evaluation of remedial alternatives in the SFS for hypothetical future residential receptors.

(a) P4 – elemental phosphorus
Metals – See list in Table 1-6
Ra-226 – radium-226
U-238 – uranium-238
K-40 – potassium-40
Po-210 – polonium-210
Pb-210 – lead-210

(b) Note that in a few soil borings, the native ground surface was greater than 10 feet bgs and in those instances, the borehole was extended to the native ground surface and a soil sample from 0-2' bns was collected.

bns – below native surface
bgs – below ground surface

TABLE 3-2

COCs/ROCs IN SOILS IDENTIFIED DURING THE SRI COMPARED TO THE EMF ROD AND RI UPDATE MEMO IDENTIFIED COCs/ROCs
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 1 of 2)

Parameter	EMF ROD COCs/ROCs	RI Update Memo COPCs/ROPCs	SRI COPCs/ROPCs	SRI COCs/ROCs
Antimony	X		X	X
Arsenic	X	X	X	X
Barium			X	
Beryllium	X		X	
Boron	X		X	
Cadmium	X	X	X	X
Chromium			X	
Cobalt			X	
Copper			X	
Coke PAHs and Metals			X[a]	X
Fluoride	X		X	X
Gross alpha	X[b]		b	
Gross beta	X[b]		b	
Lead			X	X
Lead-210	X	X[c]	X[c]	X
Liquid Petroleum Fuels[d]		X	X	X[g]
Lithium			X	
Manganese	X		X	
Mercury	X		X	
Molybdenum			X	
Nickel	X		X	X
PCBs		X	X	
Elemental Phosphorus (P4)		X	X	X
Polonium-210	X	X	X	X
Potassium-40	X		X	X
Radium-226	b	X	X	X
Radon	b, e		X	
Selenium	X		X	
Silver	X		X	
Solvents[f]		X	X	

TABLE 3-2

COCs/ROCs IN SOILS IDENTIFIED DURING THE SRI COMPARED TO THE EMF ROD AND RI UPDATE MEMO IDENTIFIED COCs/ROCs
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
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Parameter	EMF ROD COCs/ROCs	RI Update Memo COPCs/ROPCs	SRI COPCs/ROPCs	SRI COCs/ROCs
Thallium	X		X	X
Thorium-230	b			
Uranium			X	
Uranium-238	X		X	X
Vanadium	X		X	X
Zinc	X		X	

Notes:

[a] See Tables 1-6 and 1-8 for list of SRI coke PAHs and TCLP analytes

[b] Individual radionuclides potentially responsible for elevated gross alpha and gross beta levels are also ROPCs

[c] Lead-210 and Polonium-210 are known to occur in precipitator dust and phossy solids.

[d] RI Update Memo included benzene, toluene, ethylbenzene, and xylenes. See Table 1-6 for SRI liquid petroleum fuel constituents.

[e] Retained as a COPCs mainly for evaluation of potential radon infiltration into buildings under alternate future commercial or industrial uses at the site.

[f] RI Update Memo included TCE, PCE, Chloroform, 2-Butanone, and 1,1,1 TCA. See Table 1-6 for SRI lab- and shop-related constituents.

[g] Liquid petroleum fuel COCs identified in the SRI restricted to 6 PAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene

TABLE 3-3

EMF SITE GROUNDWATER COCs IDENTIFIED IN THE 1998 ROD
UPDATED COMPARATIVE VALUES AND FMC PLANT OU GROUNDWATER COCs
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

TABLE 36 FROM THE 1998 ROD FOR THE EMF SITE - RISK BASED AND MAXIMUM CONCENTRATION OF CONTAMINANTS OF CONCERN IN GROUNDWATER					UPDATED GROUNDWATER COMPARATIVE VALUES, SUMMARY OF GROUNDWATER RESULTS[1] AND IDENTIFICATION OF FMC PLANT OU GROUNDWATER COCS			
Substance of Concern	Units	Maximum Detected Concentration	Risk Based Concentration	Maximum Contaminant Level (MCL)	Updated Comparative Value (CV)[2]	Percentage of Results for FMC Wells >= CV[3]	Maximum Detected Concentration (2000-2008)[4]	FMC Plant OU Groundwater COC
Antimony	mg/l	1.07	0.006	0.006	0.006	1.5%	0.0073 [5]	
Arsenic	mg/l	5.53	0.000048	0.05	0.01	66.4%	0.393	**X**
Beryllium	mg/l	0.083	0.000019	0.004	0.004	0.0%	Zero detected	
Boron	mg/l	89	1.36	-	7.3	0.3%	6.24	
Cadmium	mg/l	3.9	0.008	0.005	0.005	0.2%	0.0013	
Chromium	mg/l	7.58	0.077	0.1	0.1	0.1%	0.0118	
Fluoride	mg/l	2,815	0.93	4	4	7.0%	193	**X**
Manganese	mg/l	91.2	0.077	-	0.05	44.4%	2.66	**X**
Mercury	mg/l	0.0043	0.0046	0.002	0.002	1.1%	0.00028	
Nickel	mg/l	3.46	0.299	0.1	0.73	0.0%	0.0451	
Nitrate	mg/l	660	25.03	10	10	18.5%	46.1	**X**
Radium-226	pCi/L	7.09	0.39	5*	5*	6.4% [6]	1.46 [7]	
Selenium	mg/l	19.73	0.07	0.05	0.05	4.9%	0.204	**X**
Thallium	mg/l	9.09	0.001	0.002	0.002	1.7%	0.0085 [8]	
Vanadium	mg/l	22.317	0.108	-	0.18	1.9%	0.182	**X**
Zinc	mg/l	28.9	3.92	-	71	0.0%	0.0209	
Tetrachloroethene	mg/l	0.035	0.001	0.005	0.005	3.9%	>0.001	
Trichloroethene	mg/l	0.028	0.002	0.005	0.005	0.8%	>0.001	
Gross Alpha [b]	pCi/L	1,690	-	15	15	4.0%	325 [9]	
Gross Beta [c]	pCi/L	1,355	-	4 mrem/yr	4 mrem/yr	NC [10]	960	

TABLE 3-3

EMF SITE GROUNDWATER COCs IDENTIFIED IN THE 1998 ROD
UPDATED COMPARATIVE VALUES AND FMC PLANT OU GROUNDWATER COCs
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

(continued) (continued)

Substance of Concern	Units	Maximum Detected Concentration	Risk Based Concentration	Maximum Contaminant Level (MCL)	Updated Comparative Value (CV)[2]	Percentage of Results for FMC Wells >= CV[3]	Maximum Detected Concentration (2000-2008)[4]	FMC Plant OU Groundwater COC
Elemental phosphorus	mg/l	NA	NA	NA	0.00073	6.2%	0.258	**X**
Total cyanide	mg/l	NA	NA	NA	0.2	4.8%	0.43 [11]	

Key (*1998 ROD Table 36*):

*Combined Ra 226 and Ra 228

[a] RBCs for groundwater based on drinking water and watering homegrown produce. RBC value based on cancer risk of 10-6 or HQ=1

[b] Individual radionuclides potentially responsible for elevated gross alpha and gross beta levels are also COPCs. These include, but are not limited to Lead-210, Polonium-210, Potassium-40, Thorium-230, Uranium-234, and Uranium-238.

[c] Beta particle and photon activity based on consumption of 2 liters/day

Shaded chemicals are COCs identified in the FS (*1997 FS Reports for EMF Subareas*)

Notes (*Updated Information*) :

[1] The FMC Plant OU groundwater results are from monitoring locations: 100-series wells are 100 through 191 inclusive; the TW-series wells are TW-1 through TW-12 inclusive (including shallow, intermediate and deep); the selected 500-series wells are 500, 501, 502, 514, 515, 516, 517, 521, 522, 523, 524 and 525; and Batiste Spring and Swanson Road Spring (aka the Spring at Batiste Road).

[2] The Comparative Values (CVs) are taken from Table 4.2-1 "Groundwater Representative Concentrations and Comparative Values" in the GWCCR, June 2009 Final.

[3] The percentage of valid results greater than the CV are for all results through May 2008 for the wells listed in note 1.

[4] The maximum valid detected result based on monitoring from January 2000 through May 2008 for the wells listed in note 1.

[5] For the antimony results with a detection limit below the CV, only 1 of 41 results (2.4%) is greater than the CV. That single result >= CV was at northern Joint Fenceline Area well 110 and does not appear to be attributable to FMC Plant OU sources.

[6] Percentage is for combined Ra-226 and Ra-228 activity >= CV.

[7] Maximum value is maximum combined result for Ra-226 plus Ra-228; maximum Ra-226 result is 0.57 pCi/l.

[8] Only 2 of 21 results from 2000 were reported detected above the CV and zero of 36 results from 2001 were reported detected above the CV (including the same wells sampled during 2000), the sporatic detection of thallium above the CV but below the representative (background) levels is consistent with the findings of the EMF RI that thallium is not related to FMC Plant OU sources.

[9] As described in detail in the GWCCR, June 2009 Final, the only gross alpha results that exceed the CV are at Joint Fenceline Area wells 161 and 164 and representative (background) well 515 and are not related to FMC Plant OU sources.

[10] A percentage was not calculted as results are in pCi/l and not comparable to the CV in mrem/yr.

[11] For the 2000-2008 cyanide results, only 4 of 79 results (5%) are greater than the CV; no post-2001 results are >= CV.

TABLE 3-4

DESCRIPTION OF REMEDIATION AREAS TO BE USED IN THE SFS
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

RAs Area	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs [1]
RA-A 103 acres	3, 4, 5, 6, 20, and portions of 24	This area contains former office areas, parking areas, railroad siding, laydown areas, and Bannock Paving area. Most of the remedial area is covered with non-leachable fill including primarily slag, coke, silica, concrete, asphalt, and native soil. Underground piping (storm sewers) containing COCs (including P4) exists in RU 3 as listed separately below. RA-A does not encompass any identified or potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios[2]:** Slag Coke Ferrophos PCDT water residue	SWMU# 1 Drum Storage Unit SWMU# 38 Road Segments SWMU# 39 Chemical Lab Drain Pit SWMU# 46 Railcar Loading and Unloading Area-BPC SWMU# 47 Bannock Paving Areas SWMU# 47 Coke Settling Pond (former BAPCO Unit) SWMU# 48 Surface roads Bannock Paving Company SWMU # 61 Laboratory Chemical Disposal Area SWMU# 63 Long-Term Phosphorus Storage Tanks SWMU# 66 Boiler Fuel Tank and Pipeline Area SWMU# 68 Railroad Spurs SWMU# 70 Satellite Storage Area for Spent Laboratory Solvents SWMU# 72 Former Satellite Storage Area for Waste Paint Solvents SWMU# 92 P4 Maintenance Cleaning Facility (Decon Building) SWMU# 99 Drum Storage Area at Training Center SWMU# 101 Railcar Loading Overflow Tank
RA-A1 < 1 acre	Portion of RU 20	This area is located at the former Bannock Paving area and included above ground fuel storage tanks and vehicle fueling area. This area was investigated during the SRI in 2007 and found to contain fuel PAHs above the soil SSLs. RA-A1 does not encompass any identified or potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios[2]:** Slag PCDT water residue Fuel spill residue	SWMU# 47 Bannock Paving Areas SWMU# 48 Surface roads Bannock Paving Company
RA-B 10.8 acres	1, 2, and down gradient to include P4-impacted capillary fringe.	This area contains former the furnace building, phos dock, secondary condenser, and slag pit and extends to the east to capture the capillary fringe soils contaminated with P4. Surface and/or subsurface fill within this remedial area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Underground piping containing COCs (including P4) exists in RA-B. RA-B encompasses identified and potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios[2]:** Slag P4 Precipitator solids Phossy solids Underground Piping Containing P4	SWMU# 5 Slag Pit Wastewater Collection Sump SWMU# 13 Andersen Filter Media (AFM) Washing Unit SWMU# 36 & 55 Rail Car Loading/Unloading, and Phos Dock SWMU# 38 Road segments SWMU# 41 (partial) Stacks and Vents SWMU# 54 Phos Dock Area SWMU# 60 Secondary Condenser/Former Fluid Bed Dryer Area SWMU# 68 Railroad Spurs SWMU# 73 Satellite Areas for Spent Anderson Filter Media SMWU# 74 East AFM Bin Area SMWU# 75 Precipitator Dust Slurry Pots SWMU# 76 Medusa Scrubber Blowdown Collection Tank SWMU# 77 P4 Load Dock, Scrub. Blowdown Sump, and NS Tank SWMU# 78 Washdown Collection Sumps--Furnace Building Area

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the “one clean-up” initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

DESCRIPTION OF REMEDIATION AREAS TO BE USED IN THE SFS
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

RAs Area	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs[1]
			SWMU# 79 Northeast Collection Sump - Furnace Building Area SWMU# 80 Southeast Collection Sump - Furnace Building Area SWMU# 81 Furnace Washdown Collection Tank (V-3600) SWMU# 82 Facility-Wide Wastewater Piping System SWMU# 86 V-3700 Tank and Associated Piping SWMU# 90 V-3800 Tank and Associated Piping SWMU# 91 NOSAP Intercept Tank (Tank T-8010) SWMU#102 Former Slag Pit (prior to slag handling) SWMU# 104 #3 P4 Sump
RA-C 34.6 acres	RUs 13, northern portion of 12, eastern portion of 22b, and a small portion of RU 24 between RUs 1 & 2 and RU 22b.	This area contains former phossy/precipitator slurry ponds, the piping corridor between RUs 1 and 2 and 22b (small portions of RUs 12 and 24), and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Underground piping containing COCs (including P4) exists in RUs 13, 22b and 24. RA-C encompasses identified and potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios[2]:** Slag Precipitator solids Phossy solids P4 Ferrophos PCDT water residue Underground Piping Containing P4	SWMU# 4 Former 8S Recovery Process SWMU# 25 Pond 0S SWMU# 26 Pond 00S SWMU# 27 Pond 1S SWMU# 28 Pond 2S SWMU# 29 Pond 3S SWMU# 30 Pond 4S SWMU# 31 Pond 5S SWMU# 32 Pond 6S SWMU# 33 Pond 7S SWMU# 34 Pond 10S (Including Precipitator Dust Pile atop pond 10S) SWMU# 38 Road Segments SWMU# 43 Ferrophos Storage Areas SWMU# 53 Old Pond 7S Tree-Line Area SWMU# 56 Drum Storage Area for other Nonhazardous Wastes SWMU# 57 Transformer Salvage Area SWMU# 58 PCB Storage Shed (removed 2000) SWMU# 59 Waste Oil Storage Area SWMU# 62 Area West of Mobile Shop SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas SWMU# 65 (partial) Precipitator Slurry Pipeline Cleanout Areas SWMU# 71 Satellite Storage Areas for Waste Degreasing Solvents SWMU# 82 (partial) Facility-wide Wastewater Piping System SWMU# 83 High-pressure steam cleaning Station SWMU# 84 Used Oil Collection Tank SWMU# 107 Portable Storage Tanker for Dielectric Fluid

1 RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
2 Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
3 These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

TABLE 3-4

DESCRIPTION OF REMEDIATION AREAS TO BE USED IN THE SFS
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

RAs Area	**RUs**	**Description and Fill/Source Materials**	**Associated RCRA SWMUs** [1]
RA-D 33.6 acres	Western portion of RU 22b including former Pond 9S	This area contains former clarified phossy water/precipitator slurry overflow ponds and precipitator slurry ponds. No P4 is present but surface/subsurface fill contains phossy solids, precipitator solids, slag, and ore. RA-D encompasses identified and potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios**[2]**:** Slag Precipitator solids Phossy solids PCDT water residue Underground Piping Containing P4	SWMU# 6 Area 9S SWMU# 19 Pond 1E SWMU# 20 Pond 2E SWMU# 21 Pond 3E SWMU# 22 Pond 4E SWMU# 23 Pond 5E SWMU# 24 Pond 6E SWMU# 52 Pond 7E
RA-E 21.2 acres	RU 8, southern portion of RU 9, and southern portion of RU 16.	This area contains former ore kilns, kiln scrubber ponds, calciners, calciner pond solids stockpile, silica stockpiles, and calcined ore stockpiles. No P4 is present but surface/subsurface fill contains slag, ore, silica, kiln pond solids (subsurface). Underground piping containing COCs (including P4) exists in RU 8 and is listed separately below. RA-E encompasses identified and potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios**[2]**:** Slag Ore Calciner pond solids Calcined ore Coke Underground Piping Containing P4	SWMU# 12 Wastewater Treatment Unit SWMU# 17 Calciner Pond Sediment Stockpile SWMU# 35 Three kiln Scrubber Ponds SWMU# 38 Road Segments SWMU# 41 Stacks and Vents (i.e., calciner system) SWMU# 51 Kiln (scrubber) Overflow Pond SWMU# 67 Former Flare Pit for Carbon Monoxide SWMU# 103 New Horizontal Flare Pit
RA-F 171 acres including RA-F1 and RA-F2	RUs 19, 11, and southern portion of 12	This area contains the slag pile and bullrock pile (RU 19) and former equipment maintenance/laydown areas (RUs 11 and 12). Surface and subsurface fill within this area consists predominantly of slag and bull rock. Southwestern corner of slag pile was location of the former plant landfill (RU 19b) and is listed separately below. Railcars containing P4 and phossy solids (RU 19c) are listed separately below. RA-F does not encompass any identified or potential sources of COC releases to groundwater. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Precipitator solids Phossy solids Ferrophos PCDT water residue	SWMU# 38 FMC surface road segments SWMU# 42 Slag Pile

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the “one clean-up” initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

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FMC Corporation, Pocatello, Idaho

RAs Area	**RUs**	**Description and Fill/Source Materials**	**Associated RCRA SWMUs** [1]
RA-F1 (Buried Railcars) 2.7 acres		In 1964, 21 railcars containing an estimated 10 to 25% P4 sludge were placed at the southern edge of the slag pile and covered with native soil. The railcars were then covered with 80 to 120 feet of slag as the slag pile progressed to the south. RU 19c is a potential source of COC releases to groundwater [3]. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Phossy solids P4	None
RA-F2 (Former Landfill) 20.3 acres		This sub-area is located within the southwestern corner of the slag pile (RU 19). Landfill operations within this sub-area (RU 19b) began at the inception of plant operations in 1949 and ceased in 1980. Wastes placed in RU 19b included slag, office wastes (consisting of office and lunchroom solid wastes), industrial wastes (consisting of asbestos, spent solvents, oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes, and AFM) furnace rebuild/digout wastes (consisting of furnace feed materials, carbon materials, concrete, rocks, and debris), IWW sediments, and baghouse dust. These wastes are covered by 50 - >100 ft of slag. RU 19b is a potential source of COC releases to groundwater [3]. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Office wastes Industrial wastes – asbestos wastes, spent solvents, and oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes AFM Furnace digout/rebuild wastes	SWMU# 44 Landfill (old)

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the “one clean-up” initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

TABLE 3-4

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RAs Area	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs [1]
RA-G 65.9 acres	RUs 7, northern portion of 9, 10, 15, northern portion of 16, and portions of 24.	This area contains the ore stockpiles, silica stockpile, IWW pond and ditch, dry process waste pile (RU 15) and the northern portion of RU 16. Surface and subsurface fill within this area include various plant solid materials including ore, baghouse dust, coke, carbon, calciner solids, and slag. RA-G does not encompass any identified or potential sources of COC releases to groundwater. The northeastern portion of RA-G (on State land) includes areas within the PCDA Development Agreement. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Ore Coke Calcined ore Calciner pond solids Precipitator solids	SWMU# 16 Calciner Solids Pile SWMU# 37 Shale Ore Handling Areas SWMU# 38 Road segments SWMU# 49 Industrial Wastewater Basin SWMU# 50 Industrial Wastewater Ditch SWMU# 69 Oversize Ore, Broken and Used Electrode, Baghouse Dust Storage and Recycling, and Used Conveyor Belt Area SWMU# 105 Coke Unloading Building SWMU# 106 Nodule Pile
RA-H 17 acres	RUs 17 and 18	This area contains the active plant landfill (RU 18) and the construction/demolition debris landfill (RU 17). Surface and subsurface fill within this area contains solid waste including plant trash, Andersen filter media (AFM), asbestos, empty containers, concrete, carbon, and furnace feed materials (ore, silica, coke). RA-H is a potential source of COC releases to groundwater [3]. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Furnace feed materials (ore, silica, coke) Office wastes Packaging materials AFM Asbestos containing materials Carbon	SWMU# 38 Road segments SWMU# 45 Landfill (also referred to as Solid Waste Landfill) SWMU# 89 Roadway Landfill
RA-I 191 acres	Northern Properties (Parcels 1, 2, 4, 5, and 6)	This area of the FMC Plant OU is north of the Plant Site and includes all land owned by FMC (Parcels 1, 2, 4, 5, and 6) with exception of Parcel 3. It was not used for plant production activities, but was used for various agricultural, commercial and recreational activities. Some slag was applied to the surface for roads and parking. RA-I does not encompass any identified or potential sources of COC releases to groundwater. **Sources Considered for HHRA and ERA Exposure Scenarios:** Fugitive dust and stack emissions deposited on land surface.	None

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

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DESCRIPTION OF REMEDIATION AREAS TO BE USED IN THE SFS
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RAs Area	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs [1]
RA-J 15 acres	Northern Properties (Parcel 3)	This area of the FMC Plant OU contains property (Parcel 3) north of Highway 30, but south of I-86 on State lands. It was not used for plant production activities, but was used for various agricultural and commercial activities. RA-J does not encompass any identified or potential sources of COC releases to groundwater. **Sources Considered for HHRA and ERA Exposure Scenarios:** Fugitive dust and stack emissions deposited on land surface.	None
RA-K (Railroad Swale) 2.4 acres	RU 22c	This sub-area is located along the northeastern border of the FMC Plant Site and was used for stormwater retention. In addition to stormwater, the Railroad swale (RU 22c) also received an intermittent flow of phossy water and is known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. RU 22c is a potential source of COC releases to groundwater[3]. **Fill/Source Materials Considered for HHRA Exposure Scenarios:** Slag Phossy solids P4 Ore	SWMU# 18 Railroad Swale
UG Piping		This sub-area includes underground piping that remains in place and may contain P4, precipitator solids, and/or phossy solids. This UG piping is believed to exist in RUs 1, 2, 3, 8, 12, 13, 22b and 24. UG Piping is a potential source of COC releases to groundwater[3]. **Fill/Source Materials Considered for HHRA Exposure Scenarios[2]:** P4 Precipitator solids Phossy solids	SWMU# 64 Phossy Waste Pipeline Cleanout Areas SWMU# 65 Precipitator Slurry Pipeline Cleanout Areas
FMC Plant OU Groundwater		The nature and extent of the FMC Plant OU wide impacted groundwater and evaluation / identification of FMC (and non-FMC) sources of groundwater impacts are described in the Groundwater Current Conditions Report for the FMC Plant OU (MWH, June 2009).	

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the “one clean-up” initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] These RAs / subareas have not been identified as sources that have discernibly impacted groundwater (GWCCR, June 2009); however, based on historical knowledge and/or the SRI results, the SFS will consider these RAs / subareas as potential sources of COC releases to groundwater.

Section 4
REMEDIAL ACTION OBJECTIVES, ARARs, AND GENERAL RESPONSE ACTIONS

4.1 REVIEW AND UPDATE OF THE ARARS BASED ON SRI FINDINGS

This section presents a general discussion of the ARAR process and summarizes the ARARs forwarded for consideration in the SFS. ARARs associated with the FMC Plant OU were developed based on contaminants of concern, the affected media, and other site conditions as presented in Section 3 of this report. Tables 4-1 and 4-1A present the ARARs for the FMC Plant OU. The sections below present how ARARs were established.

Given the time that has passed since the last ARAR development, which was presented in the *1997 FMC Subarea FS*, the ARARs presented in Table 4-1 are the result of a review of the current standards and represent a standalone list rather than an addendum to the ARARs presented in the *1997 FMC Subarea FS* and utilized in the *1998 ROD*. The RAOs presented in Table 4-2 are those set forth in the *1998 ROD* and *2003 AOC*. These RAOs are incorporated into Table 4-3, except as otherwise noted.

4.1.1 CERCLA Provision Requiring Remedial Actions to Meet ARARs

The requirement for identifying and meeting ARARs is established by CERCLA Section 121 (d)(2)(A), which states the following: "*With respect to any hazardous substance, pollutant or contaminant that will remain on-site, if – (i) any standard, requirement, criteria, or limitation under any Federal environmental law...; or (ii) any promulgated standard, requirement, or limitation under a State environmental or siting law that is more stringent than any Federal standard, requirement, criteria, or limitation...... and that has been identified …… in a timely manner, is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected ... shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant or appropriate standard, requirement, criteria, or limitation.*" CERCLA also exempts certain substantive standards from classification as ARARs, for example standards that are not of general applicability or have not been consistently applied in other similar circumstances.

4.1.2 Evaluation of Site-Specific ARARs

ARARs are substantive requirements that are either directly applicable or relevant and appropriate to actions or conditions at the site. A requirement is applicable if it is legally binding to a site condition and directly addresses the contaminants, locations or actions involved in the remedial action. A requirement may be relevant and appropriate if circumstances at the site are similar to the problems or situations intended to be addressed by the requirement.

ARARs do not include administrative requirements that facilitate the implementation of the substantive requirements of a statute or regulation. Examples of administrative requirements are approvals, consultations with administrative bodies, and agency exemption or variance processes.

The NCP at 40 C.F.R. §300.5 provides the following ARARs-related definitions:

> *Applicable Requirements* are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
>
> *Relevant and Appropriate Requirements* are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to the hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

As discussed in the NCP preamble at 55 FR 8741 (March 8, 1990), ARARs fall into three categories.

> <u>Chemical-Specific</u>: These requirements define permissible concentrations of chemicals for various environmental media, such as soil or ground water. They are health- or risk-based criteria. Some are set at uniform levels that apply to all sites while others are based on site-specific calculations. An example of a chemical-specific ARAR is the set of Safe Drinking Water Act MCLs for drinking water.
>
> <u>Action-Specific</u>: These requirements specify how a specific remedial action must be conducted or the performance criteria is must achieve. They are generally technology-based and apply to specific remedial approaches rather than to the site as a whole. Examples of action-specific ARARs would be the specifications or performance requirements (i.e., rules) for landfills or land treatment if those were components of the selected remedy.
>
> <u>Location-Specific</u>: These requirements may mandate or restrict particular actions solely due to site location, even if the same actions were acceptable elsewhere. An example of a location-specific set of ARARs would be the rules pertaining to jurisdictional wetlands. Those rules might prohibit remedial action-related fills to wetlands where there was a practicable alternative or impose the requirement for

compensatory mitigation where there was no such alternative. These same actions outside a wetland would not be subject to these requirements.

For the FMC Plant OU, the ARARs presented in Table 4-1 are organized by statute to minimize redundancy with respect to media, location and action-specific ARARs. These were previously presented in the draft *SFS Work Plan*. In addition, a separate table presenting RCRA ARARs is included to provide a more detailed analysis of RCRA requirements that are potential ARARs given that the FMC facility is also RCRA-regulated and the CERCLA remedial actions also will meet parallel RCRA corrective action requirements. The revised Table 4-1 is entitled "Potential Applicable or Relevant and Appropriate Requirements other than those based on RCRA or asserted Tribal standards for the FMC Plant Operable Unit at the Eastern Michaud Flats Superfund Site" and Table 4-1A is entitled "RCRA Regulatory Requirements that may constitute ARARs for FMC Plant OU Remedial Action." The revised Table 4-1 and new Table 4-1A respond to EPA and IDEQ comments regarding both organization and content of the original ARARs table.

Potential ARARs listed in Tables 4-1 and 4-1A were identified from pertinent environmental and health statutes including the following:

- Clean Air Act (42 U.S.C. § 7401 et seq.)
- Clean Water Act (33 U.S.C. § 1251 et seq.)
- Safe Drinking Water Act (42 U.S.C. § 300f et seq.)
- Resource Conservation and Recovery Act (42 U.S.C. § 6901 et seq.)
- Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 C.F.R. Part 192).

4.2 REVIEW AND UPDATE OF REMEDIAL ACTION OBJECTIVES

The National Contingency Plan (NCP) specifies that RAOs be developed to address 1) contaminants of concern, 2) media of concern, 3) potential exposure pathways, and 4) preliminary remediation levels or goals. The development of these goals for the FMC Plant OU involves evaluation of the results of the Supplemental HHRA and Supplemental HHRA Addendum presented in the *SRI Report* and *SRI Addendum Report* and the identification and application of ARARs. The SFS will assemble general response actions and technologies into remedial alternatives that meet these RAOs.

RAOs for the FMC Subarea from the *1998 ROD* are presented in Table 4-2. RAOs have been updated for the FMC Plant OU based on the findings of the RI, SRI, SRI Addendum, other data (including groundwater data presented in the *GWCCR*) collected since the RI, and the findings of the EPA Baseline HHRA and the FMC Supplemental HHRAs. Table 4-3 lists the updated RAOs that the SFS will apply in developing and evaluating remedial alternatives for the FMC Plant OU. The RAOs are organized by media (soil/solids, groundwater, and surface water) and then grouped by potential receptors for each medium. For each receptor, the potential exposure pathways are listed, as are the key risk driver COCs/ROCs for each pathway. The range of general response actions for each medium are listed in the final column of Table 4-3 that address the RAOs listed in the adjoining column.

As shown in Table 4-3, changes from the 1998 ROD RAOs include two additional pathways for soils and solids (dermal absorption and exposure to fire from P4 or resultant air emissions and potential phosphine exposure). In addition, inhalation of radon in ambient air does not appear to be a significant potential route of exposure as indicated by SRI sampling for radon. Therefore, radon is not included as a potential exposure pathway as was the case in the 1998 ROD RAOs. Also note that surface water and sediments will not be discussed as they are not media of concern for the FMC Plant OU.

4.3 PRELIMINARY REMEDIATION GOALS

Site specific preliminary remediation goals (PRGs) to achieve the RAOs presented in Section 4.2 were developed in the *SFS Work Plan* for the primary risk-driving chemicals and radionuclides of concern (COCs/ROCs) identified in the SRI and SRI Addendum human health risk assessments. The PRGs were developed assuming that individuals could be exposed via all viable pathways under a reasonable maximum exposure (RME) scenario, and thereby ensure that any potential future receptors at the FMC Plant OU would not be exposed to unsafe levels of site-related chemicals. The COC/ROC-specific PRGs are equivalent to a hazard quotient (HQ) of 1 for non-carcinogens and a 1E-04 cancer risk above background for carcinogens. The total risk associated with each of the cancer-based PRGs is within EPA's allowable risk range, as defined in OSWER Directives 9355.0-30 and 9200.4-18. Following review, EPA concurred that the PRGs set forth in the SFS Work Plan are appropriately calculated.

The PRGs for future commercial/industrial land use are summarized in Table 4-4. The PRGs shown in this table are the lower of the outdoor commercial/industrial worker and construction worker PRGs previously provided in Tables 4-4 and 4-5 of the SFS Work Plan. These PRGs are protective of all potential future workers at the FMC Plant OU. In addition, the PRGs developed for hypothetical future residential land use in the SFS Work Plan are presented in Table 4-5. The residential PRGs are used to evaluate cleanup of the FMC-owned Northern Properties to residential standards under Soil Alternatives 5 and 6 (see Section 7). All other soil remedial alternatives are evaluated based on cleanup to achieve the commercial/industrial goals shown in Table 4-4.

No PRGs were developed for ecological receptors since only marginal accidences of a HQ of 1 were found for fluoride in the Supplemental ERA. Specifically, marginal exceedances of a no-observed-adverse-effect-level (NOAEL) HQ of 1 were estimated for several FMC-owned Northern Property parcels, i.e., Parcels 2, 4 and 6; however, the more critical lowest-observed-adverse-effect-level (LOAEL) HQs were determined to be less than 1 for all receptors in these areas. Only one slight exceedance of a LOAEL HQ of 1 was estimated (HQ = 1.02 in Parcel 3 for the red tailed hawk). Because the hawk's home range of 4,374 acres is nearly 300 times the size of Parcel 3 (15 acres), no PRGs for fluoride are considered necessary. However, implementation of Soil Alternatives protective of hypothetical future workers in Parcel 3 will effectively reduce potential fluoride risks to ecological receptors to near background levels. Consideration of remedial action alternatives based on the NOAEL HQ exceedances in Parcels 2, 4 and 6 is inconsistent with EPA guidance, since community or population level impacts are unlikely. However, impacts in these areas will be otherwise evaluated during the consideration of remediation of all Northern Properties to residential levels under Soil Alternatives 5 and 6.

In summary, the risk-based PRGs provided in Tables 4-4 and 4-5 are proposed for the following reasons:

1. They are distinguishable from background and therefore measurable in the field;

2. They are within the risk range cited in the NCP (300.430(e) (2)(I)), as further defined in OSWER Directives 9355.0-30 and 9200.4-18; and

3. In addressing these primary COCs/ROCs, all other constituents will be addressed concurrently to below levels of concern.

4.4 GENERAL RESPONSE ACTIONS REVIEWED

General response actions describe those actions that will satisfy the RAOs as shown in Table 4-3. General response actions may include treatment, containment, excavation, extraction, disposal, institutional controls, or a combination of these. Like RAOs, general response actions are medium-specific.

The 2003 *AOC SOW* stated "the following general response actions will be evaluated - no action and application of a remedial action technology selected for similar site conditions in the *1998 ROD*." However, the SFS general response actions for soil/fill, surface water, and groundwater in the FMC Plant OU will be expanded to be more inclusive and will include the following:

- No Action
- Institutional Controls
- Containment
- Removal/Disposal
- Ex-situ Treatment
- In-situ Treatment.

Potential remedial technologies (general response actions) are similar for soil and groundwater because they are general classes of response. However, the process options or specific remedial technologies to be utilized will vary depending on the medium to be treated and the site-specific conditions. This process of identification and selection of the appropriate remedial technologies and general response actions are discussed in more detail in Section 5.

Note that in Table 4-3 surface water is listed as an environmental medium at the Site that has specific exposure pathways, potential future receptors, COCs, RAOs, and general response actions. However, surface water is remediated by remedial actions of other associated media, e.g., possible COCs in surface water at seeps and springs into the Portneuf River are controlled by managing or remediating groundwater at the FMC plant site or at the plant boundary. As a result, surface water will not be discussed further in the remainder of this report.

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OTHER THAN THOSE BASED ON RCRA OR ASSERTED TRIBAL STANDARDS FOR THE FMC PLANT OPERABLE UNIT AT THE EASTERN MICHAUD FLATS SUPERFUND SITE SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Potential Applicable or Relevant Requirements			
Subject matter	**Citation**	**Description**	**Discussion**
Discharges of pollutants or dredged and fill materials to surface waters and wetlands	Clean Water Act, 33 USC §§1311 and 1342; 40 CFR Parts 121-131	Point source discharges to rivers, streams and other waters of the United States generally require Clean Water Act NPDES permits and compliance with technology-based and water quality-based discharge limits.	NPDES permits and the technology-based and water quality-based effluent limits they establish are generally applicable to point source discharges to surface waters. With respect to discharges to surface waters that are a component of CERCLA response actions, the procedural requirement to obtain an NPDES permit would be waived under CERCLA Section 121(e) but the substantive NPDES requirements are potentially relevant and appropriate.
	40 CFR Part 131	As specified at CERCLA Sections 121(d)(2)(A)-(B)(i), federal water quality criteria are minimum levels of control that CERCLA cleanups must attain where such criteria are relevant and appropriate in the circumstances of the release.	Federal water quality criteria (FWQC) are potentially relevant and appropriate to FMC OU releases to surface waters depending on the designated or potential use of the water body, the environmental media affected, the purposes for which the criteria were developed, and the latest information, as specified at CERCLA §121(d)(2)(B)(i) and 40 CFR Part 131.
	IDAPA 58.01.02	Idaho water quality criteria and standards.	State water quality standards are potential ARARs with respect to FMC Plant OU releases to surface waters to the extent that the state standards are more stringent than the FWQC.
	Clean Water Act, 33 USC §§1311 and 1344; 33 CFR §§320 and 323	Clean Water Act Section 404 permits are generally required for discharges of dredged or fill material to wetlands and other waters of the United States.	The substantive requirements of the Section 404 program would be applicable to any CERCLA response action at the FMC Plant OU that involved filling jurisdictional wetlands, or dredging or filling in navigable waters, but no Section 404 permit would be required due to the CERCLA §121(e) permit waiver.
	40 CFR Part 403	Sets standards to control pollutants that pass through or interfere with	Substantive pretreatment requirements would apply to any discharges of water generated during the FMC Plant OU remedial action that was sent to a POTW

Potential Applicable or Relevant Requirements

Subject matter	Citation	Description	Discussion
		treatment processes at publicly-owned treatment works (POTWs) or that may contaminate POTW sludge. Applicable pass through/ interference standards are set by individual POTWs.	for treatment before discharge to surface waters. Administrative requirements for a pretreatment permit would not apply, due to the CERCLA §121(e) permit waiver.
	Executive Order No. 11990	Direction to federal agencies to implement federal programs and activities in a manner that minimizes the loss or degradation of wetlands.	Policy statement rather than an ARAR, but would be relevant consideration for any CERCLA response action that would result in wetland loss or degradation.
Releases to groundwater	Safe Drinking Water Act, 42 USC §300f et seq. (SDWA)	Standards for water supplied by public water systems for human consumption.	SDWA drinking water standards are potentially relevant and appropriate with respect to FMC Plant OU releases as discussed below.
	40 CFR Part 141; IDAPA 58.01.08.002	Primary maximum contaminant levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for water supplied by public water systems for human consumption.	MCLs and non-zero MCLGs (public health goals) are relevant and appropriate for any FMC Plant OU releases to current or potential sources of drinking water. Pursuant to CERCLA Sections 121(d)(2)(A)-(B)(i), MCLs and non-zero MCLGs are minimum levels of control CERCLA cleanups must attain depending on the circumstances of the release, i.e., where the release is to a current or potential drinking water source.
	40 CFR Parts 144-147	Provides protection of underground sources of drinking water applicable to Underground Injection Control (UIC) program.	UIC standards would be applicable or relevant and appropriate if the selected remedial action at the FMC Plant OU included injection of contaminants into underground sources of drinking water, although a UIC permit would not be needed due to the CERCLA §121(e) permit exemption.

Potential Applicable or Relevant Requirements			
Subject matter	**Citation**	**Description**	**Discussion**
	IDAPA 58.01.11	Establishes state ground water quality standards based on aquifer category and groundwater uses.	Applicable or relevant and appropriate for FMC Plant OU releases to groundwater to the extent that 1) MCLs and MCLGs are not relevant and appropriate, or 2) these ground water quality standards are more stringent than MCLs and non-zero MCLGs.
Radionuclide releases to soil or groundwater	Uranium Mill Tailings Radiation Control Act (UMTRCA), 42 U.S.C. §7901 et seq.; EPA Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 C.F.R. Part 92	EPA regulations establish ground water and soil concentration limits applicable to the uranium and thorium mill tailings sites identified under the UMTRCA statute.	Applicable only to the closed set of 24 sites identified under UMTRCA and the EPA regulations. Relevant and appropriate to the extent site uses are similar to those assumed in the Part 92 regulations given that the standards are health-based and focus on radium-226, the predominant radionuclide of concern (ROC) at the FMC Plant OU.
Releases to air	40 CFR Part 50 National Primary and Secondary Ambient Air Quality Standards (NAAQS)	Designed to form the basis for SIP, FIP and air operating permit requirements that are protective of human health and welfare.	Potential relevant and appropriate standards with respect to emissions-generating remedial actions such as air sparging/ biosparging, vapor extraction and bioventing.
	40 CFR Part 60 New Source Performance Standards (NSPS)	Sets emission standards for specific categories of new and modified sources.	Potential but unlikely applicable or relevant and appropriate standards for emissions-generating remedial actions such as air sparging/ biosparging, vapor extraction and bioventing. Like NAAQS, intended for incorporation into enforceable instruments such as SIPs and air operating permits. Not likely to be

TABLE 4-1

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OTHER THAN THOSE BASED ON RCRA OR ASSERTED TRIBAL STANDARDS FOR THE FMC PLANT OPERABLE UNIT AT THE EASTERN MICHAUD FLATS SUPERFUND SITE SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Potential Applicable or Relevant Requirements			
Subject matter	**Citation**	**Description**	**Discussion**
			applicable or relevant and appropriate because it is unlikely that the CERCLA remedial action for the FMC Plant OU will include treatment systems or other emission sources for which NSPS have been promulgated.
	IDAPA 58.01.01	State of Idaho air pollution control rules.	Potentially applicable or relevant and appropriate for emissions-generating remedial actions such as air sparging/ biosparging, vapor extraction and bioventing to the extent the state standards are more stringent than federal-based ARARs, including FARR requirements discussed below.
	Federal Implementation Plan under the Clean Air Act for the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation of Idaho (FARR), 40 C.F.R. §10701 et seq. (70 Fed. Reg. 18073, April 8, 2005).	Establishes air emissions limits, source registration, recordkeeping and other requirements.	Potential relevant and appropriate standards for emissions-generating remedial actions such as air sparging/ biosparging, vapor extraction and bioventing. Substantive emissions standards and other non-administrative requirements of the FARR should be considered and met with respect to emission sources that are components of the CERCLA remedial action.
Removal or remediation of underground storage tanks	40 CFR §§280.60 - .66	Standards for response/ corrective action for USTs containing petroleum or hazardous substances.	Part 280 release response requirements would be applicable if the selected remedy addresses releases from regulated UST systems and could be relevant and appropriate for releases from underground tank systems not addressed by these regulations.

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POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OTHER THAN THOSE BASED ON RCRA OR ASSERTED TRIBAL STANDARDS FOR THE FMC PLANT OPERABLE UNIT AT THE EASTERN MICHAUD FLATS SUPERFUND SITE
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Other Potentially Relevant Laws			
Subject matter	**Citation**	**Description**	**Discussion**
Migratory bird habitat	Migratory Bird Treaty Act, 16 USC §§703-712; 50 CFR §10.13	Prohibits taking, killing or selling federally-designated migratory birds.	Remedial action at FMC Plant OU must be designed and implemented to avoid takings or killings of migratory birds.
Bald eagle and golden eagle habitat	Bald Eagle and Golden Eagle Protection Act, 16 U/SC §§668-668d	Prohibits taking, killing or selling or bald eagles and golden eagles.	Remedial actions at FMC Plant OU must be designed and implemented to avoid takings or killings of bald eagles or golden eagles.
Occupational exposures to on-site remediation workers	Occupational Safety and Health Act, 29 USC §§651-678	Regulates worker health and safety. Sets general industry standards for workplace exposure to chemicals, and sets health and safety training requirements for workers at hazardous waste sites.	OSHA worker safety standards are independently applicable to hazardous waste and remediation sites.
	29 CFR Part 1910, Subpart Z	Establishes occupational exposure levels for specific contaminants.	OSHA worker safety standards are applicable to hazardous waste and remediation sites.

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RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
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Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
Hazardous waste generation and shipment to an off-site treatment, storage and/or disposal (TSD) facility	Determining whether generated waste is a RCRA hazardous waste	40 CFR §262.11	Requirement to determine at the point of generation whether waste is a RCRA hazardous waste	ARAR	Applicable to waste materials that are excavated or otherwise generated as part of the CERCLA remedial action
	Identification of RCRA hazardous waste	40 CFR §§261.2-.9, and 40 CFR Part 261 Subparts B (waste characteristics) and D (waste listings)	Criteria for determining if a material is a RCRA solid waste and RCRA hazardous waste, and not excluded from RCRA regulation	ARAR	Same as above
	Labeling and packaging of RCRA hazardous wastes that will be sent to an off-site TSD facility	40 CFR §§262.30-.33	RCRA hazardous wastes to be sent to an off-site TSD facility must be properly packaged, labeled and placarded	ARAR	Same as above
On-site hazardous waste management and storage	Management requirements for waste accumulation storage units	40 CFR §§262.34 and incorporated 40 CFR Part 265 Subpart I standards for containers, Part 265 Subpart J	Containers, tanks, drip pads and containment buildings in which RCRA hazardous wastes are accumulated on-site must meet unit integrity,	ARAR	These management requirements would be applicable to any wastes excavated or otherwise generated by the remedial action, determined to be RCRA hazardous waste, and stored on-site prior to shipment to

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RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
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Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
		standards for tanks, Part 265 Subpart W standards for drip pads, Part 265 Subpart DD standards for containment buildings, and Part 265 Subpart BB standards for any stored hazardous waste that contains 10% or more organics by weight	labeling and management requirements. For example, containers must be kept closed except when adding or removing waste, and tanks must meet leak detection and secondary containment requirements.		a TSD facility. The referenced management requirements would apply depending on the types of storage units that were used. Some of these standards, such as the requirements for keeping containers closed and similar physical requirements, also may be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create risks similar to those created by RCRA hazardous wastes if managed in units not meeting these standards.
	Alternate management requirements for storing hazardous remediation waste under Temporary Unit designation	40 CFR §264.553	Hazardous remediation waste may be stored on-site in containers and tanks under alternate conditions to those applicable to TSD facility operation	ARAR	Applicable to hazardous remediation waste managed under Temporary Unit criteria. May be relevant and appropriate to non-hazardous waste that creates risks from container and tank storage similar to those presented by hazardous waste.

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	General management requirements for ignitable, reactive, or incompatible wastes	40 CFR §§264.17/ 265.17	TSD facility owners and operators must separate and protect ignitable or reactive waste from sources of ignition or reaction, including for example open flames and hot surfaces and by posting "No Smoking" signs, to prevent accidental ignition or reaction. Also, where specifically required under other RCRA regulations, TSD owners and operators must take steps to prevent reactions that threaten human health or the environment including production of uncontrolled toxic mists or fumes in sufficient quantities to create such endangerment	ARAR	Applicable to any waste materials excavated or otherwise generated as part of the CERCLA remedial action that constitute ignitable, reactive or incompatible RCRA hazardous wastes and are managed on-site. May be relevant and appropriate to other types of hazardous and non-hazardous waste generated by the remedial action and managed on-site to the extent such management creates hazards similar to ignitable, reactive or incompatible RCRA hazardous waste.
	Management requirements for ignitable, reactive, or incompatible RCRA	40 CFR §§264.176 and 264.177; 40 CFR §§265.176	Containers into which ignitable or reactive RCRA hazardous wastes are placed must be located at	ARAR	Applicable to any waste materials excavated or otherwise generated as part of the CERCLA remedial action that constitute ignitable,

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	hazardous wastes: **containers**	and 265.177	least 15 meters (50 feet) from the facility's property boundary; and incompatible wastes generally must not be combined in the same container		reactive or incompatible RCRA hazardous wastes and are placed into containers. May be relevant and appropriate to other types of hazardous and non-hazardous waste generated by the remedial action and placed into containers to the extent such management creates hazards similar to ignitable, reactive or incompatible RCRA hazardous waste.
	Management requirements for ignitable, reactive, or incompatible RCRA hazardous wastes: **tanks**	40 CFR §§264.198 and 264.199; 40 CFR §§265.198 and 265.199	Ignitable or reactive RCRA hazardous waste must not be placed into tank systems, unless immediately treated to remove those characteristics or otherwise treated or stored to prevent ignition or reaction; and incompatible wastes generally must not be placed into tank systems	ARAR	Applicable to any waste materials excavated or otherwise generated as part of the CERCLA remedial action that constitute ignitable, reactive or incompatible RCRA hazardous wastes and are placed into tanks. May be relevant and appropriate to other types of hazardous and non-hazardous waste generated by the remedial action and placed into tanks to the extent they create hazards similar to ignitable, reactive or incompatible RCRA hazardous

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
					waste.
	Management requirements for ignitable, reactive, or incompatible RCRA hazardous wastes: **waste piles, surface impoundments, land treatment units, and landfills**	40 CFR §§ 264.256 and 264.257/ 40 CFR §§265.256 and 265.257 (waste piles); 40 CFR §§264.229 and 264.230/ §§265.229 and 265.230 (surface impoundments); 40 CFR §§264.281 and 264.282/ 40 CFR §§265.281 and 265.282 (land treatment units); and 40 CFR §§264.312 and 264.313/ 40 CFR §§265.312 and 265.313 (landfills)	Ignitable or reactive RCRA hazardous waste must be treated to remove those characteristics and meet RCRA Land Disposal Restriction (LDR) requirements before being placed in waste piles, surface impoundments, land treatment units or landfills; and incompatible wastes generally must not be placed into such units	ARAR	Applicable to any waste materials excavated or otherwise generated as part of the CERCLA remedial action that constitute ignitable, reactive or incompatible RCRA hazardous wastes and are placed in waste piles, surface impoundments, land treatment units or landfills. May be relevant and appropriate to other types of hazardous and non-hazardous wastes generated by the remedial action and placed in such units to the extent they create hazards similar to ignitable, reactive or incompatible RCRA hazardous waste.
	Management requirements for ignitable, reactive, or incompatible RCRA	40 CFR Part 264 Subpart X	Hazardous waste, including ignitable, reactive or incompatible hazardous wastes, that are	ARAR	Applicable to any waste materials excavated or otherwise generated as part of the CERCLA remedial action that constitute ignitable,

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	hazardous wastes: **miscellaneous units**		placed in miscellaneous units (i.e., units other than containers, tanks, landfills and other units for which there are specific Part 264 standards) must be managed in accordance with Part 264 Subpart X environmental and human health protectiveness standards and pertinent standards from Part 264 unit-specific provisions		reactive or incompatible RCRA hazardous wastes and that are managed in miscellaneous units. May be relevant and appropriate to other types of hazardous and non-hazardous wastes generated by the remedial action and placed in such units to the extent they create hazards similar to ignitable, reactive or incompatible RCRA hazardous waste.
	Accumulation area closure requirements	40 CFR §§262.34, 265.111 and 265.114	When RCRA hazardous waste accumulation areas are closed they must meet the decontamination and general health and environmental protectiveness criteria specified respectively at 40 CFR §§265.114 and 265.111	ARAR	Any accumulation areas storing RCRA hazardous waste generated by the CERCLA remedial action must be closed in accordance with 40 CFR §§265.114 and 265.111
On-site treatment of	Tanks	40 CFR Part 264/ 265 Subpart J; 40	Tank systems that are used to treat RCRA hazardous	ARAR	Applicable to any waste materials that are excavated or otherwise

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
hazardous waste generated by the CERCLA remedial action using specific treatment processes or facilities		CFR §264.553	waste must comply with the design and operating requirements specified in Part 264/ 265 Subpart J; unless those are modified for hazardous remediation waste treatment under 40 CFR §264.553 Temporary Unit designation		generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then treated in a tank system. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if managed in tanks not meeting these standards, and the standards are necessary to meet FMC Plant OU Remedial Action Objectives (RAOs).
	Containers	40 CFR Part 264/ 265 Subpart I; 40 CFR §264.553	Containers that are used to treat RCRA hazardous waste must comply with the requirements specified in Part 264/ 265 Subpart I; unless those are modified for hazardous remediation waste treatment under 40 CFR §264.553 Temporary Unit designation		Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then treated in containers. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if managed in containers that do not meet these standards, and the standards are necessary to meet

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
					FMC Plant OU Remedial Action Objectives (RAOs).
	Waste piles	40 CFR Part 264/ 265 Subpart L	Waste piles that are used for treating RCRA hazardous waste must comply with the design and operating requirements specified in Part 264/ 265 Subpart L	ARAR	Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then treated in a waste pile. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if managed in waste piles not meeting these standards, and the standards are necessary to meet RAOs.
	Land treatment	40 CFR Part 264/ 265 Subpart M	Land treatment units that are used for treating RCRA hazardous waste must comply with the design and operating requirements specified in Part 264/ 265	ARAR	Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then treated in a land treatment

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
			Subpart M		unit. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if managed in land treatment units not meeting these standards, and the standards are necessary to meet RAOs.
	Incinerators	40 CFR Part 264 Subpart O	Incinerators that are used to treat RCRA hazardous waste must meet the design and operating requirements specified in Part 264 Subpart O, including Clean Air Act requirements at 40 CFR Part 63 Subpart EEE during incinerator operations	ARAR	Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then treated in an incinerator. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if managed in incinerator units not meeting these standards, and the standards are necessary to meet RAOs.
	Miscellaneous units	40 CFR Part 264 Subpart X	Hazardous waste treatment in miscellaneous units (i.e., units other than containers,	ARAR	Applicable or relevant and appropriate to any waste materials that are excavated or otherwise

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
			tanks, landfills and other units for which there are Part 264 unit-specific standards) must comply with the environmental performance, monitoring and other standards specified in Part 264 Subpart X and pertinent requirements from Part 264 unit-specific provisions. Thermal treatment units, for example, are not addressed by specific Part 264 provisions and thus would be governed under Subpart X.		generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and that are treated in a miscellaneous unit. May be relevant and appropriate to wastes generated by the remedial action that are non-hazardous but that would create similar risks if treated in miscellaneous units not meeting these standards, and the standards are necessary to meet RAOs.
	Containment buildings	40 CFR Part 264/ 265 Subpart DD	Containment buildings that are used to store or treat RCRA hazardous waste must comply with the design and operating requirements specified in Part 264/ 265 Subpart DD	ARAR	Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and are then stored or treated in a containment building. May be relevant and appropriate to wastes generated by the remedial action

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
					that are non-hazardous but that would create similar risks if managed in containment buildings not meeting these standards, and the standards are necessary to meet RAOs.

Note: The next section of this list of potential RCRA ARARs discusses RCRA requirements associated with hazardous waste disposal. For RCRA requirements triggered by "disposal," it is important to note that as a threshold matter RCRA land disposal occurs only with respect to waste that is hazardous at the point of generation. For contaminated environmental media, the point of generation and thus the point of waste characterization is when the media are excavated during the remediation process. Secondly, whether RCRA hazardous waste "land disposal" occurs during remediation depends in part on how the waste is managed with respect to Areas of Contamination at the Site. As stated in EPA guidance: *" 'Land disposal' occurs when wastes from different AOCs are consolidated into one AOC; when wastes are moved outside an AOC (for treatment or storage) and returned to the same or a different AOC; or when wastes are excavated, placed in a separate hazardous waste management unit such as an incinerator or tank within the AOC, and then redeposited into the AOC."* This is stated at page 3 of "*Guide to Management of Investigation-Derived Wastes,*" OSWER 9345.3-03FS (January 15, 1992). Based on that EPA guidance, RCRA disposal does not occur when 1) wastes are moved and consolidated within the same AOC or unit, even if some degree of treatment occurs in the course of such consolidation ; 2) wastes are treated in-situ without excavation; or 3) wastes are capped or otherwise left in place. The cited EPA guidance also states as follows: *"Storing IDW in a container ('a portable device in which a material is stored, transported, treated, disposed of, or otherwise handled' (40 CFR 260.10)) within the AOC and then returning it to its source, however, is allowable without meeting the specified LDR treatment standards. Under the definition of 'hazardous waste management unit' (40 CFR 260.10), EPA states that 'a container alone does not constitute a unit; the unit includes the containers and the land or pad upon which they are placed.' Therefore, returning IDW that has been stored in containers (not tanks or other RCRA-regulated units) within the AOC to its source does not constitute land disposal, as long as containers are not managed in such a manner as to constitute a RCRA storage unit as defined in 40 CFR 260.10. In addition, sampling and direct replacement of wastes within an AOC do not constitute land disposal."* OSWER 9345.3-03FS (January 15, 1992), page 3 (emphasis in original). In addition to circumstances in which RCRA disposal requirements may be applicable, in other circumstances they may be relevant and appropriate where the CERCLA remediation waste is similar to but does not constitute RCRA hazardous waste or where the remediation waste is placed into a unit but not in one of the ways described above that make it RCRA "disposal." The evaluations presented below in this table discuss RCRA disposal requirements both as they would be applicable and also as they could be relevant and appropriate. Also, note that there are somewhat different criteria for applying ARARs to management and disposal of investigation-derived waste (IDW), such as the threshold criterion that ARARs apply to IDW only "to the extent practicable." See

Potential RCRA-based ARARs for FMC Plant OU

Subject	**Requirement**	**Regulatory citation**	**Description**	**Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)**	**Evaluation**
55 Fed. Reg. 8756 (March 8, 1990); OSWER 9345.3-03FS (January 15, 1992), page 1.					
On-site disposal of hazardous waste excavated or otherwise generated by the CERCLA remedial action	Location standards for RCRA hazardous waste TSD facilities	40 CFR §§265.18 (interim status standard) and 264.18 (applicable to RCRA Part B permitted facilities)	Part 265 interim status standard: RCRA hazardous waste generally cannot be placed in a salt dome, salt bed formation, underground mine, or cave. Part 264 permit standard: the interim status standard summarized above, and added seismic and floodplain standards as follows: 1) new TSD facilities must not be located within 61 meters (200 feet) of a Holocene era fault, and 2) TSD facilities located in a 100-year floodplain must be designed, operated and maintained to prevent washout of hazardous waste	ARAR	The TSD facility location standards would be applicable (Part 265) or relevant and appropriate (Part 264, which applies only to permitted facilities and not those like FMC Pocatello that have not yet been issued a Part B permit) with respect to any on-site storage, treatment or disposal of waste materials that 1) are excavated or otherwise generated as part of the CERCLA remedial action, 2) are determined to be RCRA hazardous waste and 3) whose treatment, storage or disposal would normally require a RCRA permit. These location standards also may be relevant and appropriate to units treating or otherwise managing CERCLA remediation waste that is not RCRA hazardous waste, if the risks of releases from those units caused by being located in the prohibited areas are similar to the

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
					risks meant to be prevented by the location standards, and these requirements are necessary to meet site RAOs.
	Minimum technological requirements (MTRs) for surface impoundments or landfills into which hazardous waste would be placed	40 CFR §§264.221/ 265.221 (surface impoundments) and 40 CFR §§264.301/ 265.301 (landfills)	New surface impoundments and landfills whose construction commenced after July 29, 1992, and replacements that began reuse after that date, must have two or more liners and a leachate collection and removal system installed between the liners	ARAR	Applicable to any waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be a hazardous waste, and which are then placed into a surface impoundment or landfill that is subject to the MTRs. The MTR requirements also may be relevant and appropriate where the remediation waste is not RCRA hazardous but presents risks of contaminant migration to the subsurface that the MTRs are designed to prevent, and these requirements are necessary to meet site RAOs.
	Alternate standards for land placement of hazardous	40 CFR §§264.552 and 264.554	Hazardous wastes generated from facility remediation can be placed on land under alternate	ARAR	Applicable to hazardous wastes excavated or otherwise generated from the remedial action that are subject to these alternate standards.

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	remediation wastes		standards specified for Corrective Action Management Units (40 CFR §264.552) and Remediation Waste Staging Piles (40 CFR §264.554)		May be relevant and appropriate to wastes generated from the remedial action that are not hazardous but that present risks from land placement similar to risks from hazardous waste that these standards are designed to prevent, and application of these standards is necessary to meet site RAOs.
	Land Disposal Restriction (LDR) treatment requirements	40 CFR Part 268	Wastes that are RCRA hazardous at the point of generation generally must be de-characterized and treated, before land placement or disposal, using the technologies and meeting the standards specified at 40 CFR §268.40. For most wastes this includes meeting the Universal Treatment Standards (UTSs) specified at 40 CFR §268.48. Soils exhibiting a hazardous waste characteristic or containing a listed waste	ARAR	Applicable to waste materials that are excavated or otherwise generated as part of the CERCLA remedial action and determined to be RCRA hazardous waste, and then disposed to the land through a means that is not exempt from LDR treatment requirements [examples of exemptions include wastewater treatment units discharging to a POTW or under an NPDES permit, see 40 CFR §268.1(c)(4)]. Not applicable to land placement of waste materials generated by the remedial action, whether RCRA hazardous or not, if the placement does not constitute

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RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
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Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
			may meet LDR requirements through the alternate treatment standards established on May 26, 1998 under the LDR Phase IV rule, codified at 40 CFR §268.49.		RCRA disposal (e.g., consolidation within a single AOC). Also not applicable to soils and other environmental media that are not excavated and are instead left in place, because environmental media are not RCRA wastes until they are generated through excavation. May be relevant and appropriate to land disposal of waste materials excavated or otherwise generated by the remedial action that are not RCRA hazardous waste, based on factors including 1) whether land placement of such materials without treatment would be inconsistent with the site RAOs and 2) the extent to which the waste is found in a more complex matrix (such as in combination with debris and/or other types of waste) than what was assumed in developing the LDR treatment standards.

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**RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
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Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
Closure and post-closure standards for hazardous waste management units	General RCRA performance standard for hazardous waste management unit closures	40 CFR §§264.111/ 265.111 and 40 CFR §§ 264.114/ 265.114	Waste management units that handled RCRA hazardous waste must be closed and receive post-closure care to minimize the need for further maintenance and to control, minimize or eliminate later escape of hazardous waste and constituents to the extent necessary to protect human health and the environment. In addition, equipment, structures and soil that become contaminated from contact with RCRA hazardous waste must be properly disposed of or decontaminated.	ARAR	Applicable to any storage, treatment or disposal units (and associated equipment, structures and soil) that would be used to manage waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate with respect to units that were used to manage non-hazardous remediation waste, where such waste presented risks similar to those from RCRA-regulated hazardous waste, and where meeting the general and specific closure and post-closure care standards (discussed in this table below) would address such risks and be necessary to meet site RAOs.
	Closure and post-closure standards for	40 CFR §§264.197/ 265.197	Tank systems that managed RCRA hazardous waste must be closed by	ARAR	Applicable to any tank system that would be used to manage waste materials excavated or otherwise

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	specific units: **tanks**		removal or decontamination of waste residues and contaminated structures and equipment and unless clean closed must receive post-closure care.		generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for any tanks that were used to manage non-hazardous remediation waste, where such waste presented risks similar to those presented by RCRA-regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.
	Closure and post-closure standards for specific units: **land treatment facilities**	40 CFR §§264.280/ 265.280	Land treatment facilities that managed RCRA hazardous waste must be closed in a manner that controls migration of hazardous waste and constituents into the groundwater, controls the release of contaminated run-off into surface water, controls the release of airborne particulate contaminants by wind	ARAR	Applicable to any land treatment facility that would be used to manage waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for any land treatment facility that was used to manage non-hazardous remediation waste, where such waste presented risks similar to those presented by RCRA-

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RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
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FMC Corporation, Pocatello, Idaho

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
			erosion, and meets the other requirements specified in the cited regulation including for post-closure care		regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.
	Closure and post-closure standards for specific units: **landfills**	40 CFR §§264.310/ 265.310	Landfills that manage RCRA hazardous waste must be closed by installation of a cover that 1) provides long-term minimization of liquids migration through the impoundment, 2) functions with minimal maintenance, 3) promotes drainage and minimizes erosion, 4) accommodates settling and subsidence without impairing the cover, and 5) has a permeability less than or equal to the permeability of any bottom liner system or natural subsoils. Post-closure care also must be provided.	ARAR	Applicable to any landfill that would be used to manage waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for any landfill that was used to manage non-hazardous remediation waste, where such waste presented risks similar to those presented by RCRA-regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	Closure and post-closure standards for specific units: **incinerators**	40 CFR §264.351	At closure, all RCRA hazardous waste and residues must be removed from the incinerator. No post-closure care required because all hazardous wastes and residues must be removed at closure.	ARAR	Applicable to any incinerator that would be used to treat waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for any incinerator that was used to treat non-hazardous remediation waste, where the waste remaining in the unit presented risks similar to those presented by RCRA-regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.
	Closure and post-closure standards for specific units: **miscellaneous units**	40 CFR Part 264 Subpart X	Miscellaneous units must be closed in accordance with the requirements set forth in pertinent unit-specific Part 264 regulations and must meet the post-closure care standards specified at 40 CFR §264.603	ARAR	Applicable to any miscellaneous unit that would be used to treat waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for any miscellaneous unit that was used to treat non-hazardous remediation

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
					waste, where such waste unit presented risks similar to those presented by RCRA-regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.
	Closure and post-closure standards for specific units: **containment buildings**	40 CFR §§264.1102/ 265.1102	Containment buildings that stored or treated RCRA hazardous waste must be closed by removal or decontamination of waste residues and contaminated structures and equipment. If it is impracticable to complete such remove or decontamination, post-closure care must be provided.	ARAR	Applicable to any containment building that would be used to store or treat waste materials excavated or otherwise generated by the CERCLA remedial action that were determined to be RCRA hazardous waste. May be relevant and appropriate for containment buildings used for storing or treating non-hazardous remediation waste, where such waste presented risks similar to those presented by RCRA-regulated hazardous waste, and where meeting this closure standard would be necessary to meet RAOs.
Corrective action program	Facilities that are required to obtain a RCRA permit for	40 CFR §§264.100, 264.101, and	Corrective action must ensure protection of human health and the environment	ARAR	Applicable to the contiguous FMC-owned property within the FMC Plant OU because FMC has

TABLE 4-1A

RCRA REGULATORY REQUIREMENTS THAT MAY CONSTITUTE ARARS FOR FMC PLANT OU REMEDIAL ACTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Subject	Requirement	Regulatory citation	Description	Potentially applicable or relevant and appropriate (ARAR) or to be considered (TBC)	Evaluation
	hazardous waste treatment, storage or disposal must carry out a corrective action program	264.92	and attainment of groundwater protection standard with respect to facility releases of hazardous wastes or constituents		applied for a RCRA permit for its facility. Also applicable based on application of RCRA corrective action requirements as part of this remedial action under the EPA One Cleanup Program.

TABLE 4-2

1998 ROD REMEDIAL ACTION OBJECTIVES – FMC SUBAREA[1]

SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 1 of 1)

	Remedial Action Objective
A	Reduce the exposure to radon that would occur in future buildings constructed within the plant area under a future industrial scenario
B	Prevent external exposure to radionuclides in soils at levels that pose estimated excess risk greater than 1x10-4, or site-specific background levels where that is not practical.
C	Prevent ingestion of soils containing Contaminants of Concern (COCs) at levels that pose estimated excess risks above 1x10-4, a non-cancer risk HQ of 1, or site-specific background levels where that is not practical.
D	Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentration (RBCs) or chemical specific Applicable or relevant and Appropriate Requirement (ARAR), specifically Maximum Contaminant Levels (MCLs).
E	Prevent potential ingestion of groundwater containing COCs having concentrations exceeding RBCs or MCLs (chemical specific ARARs) (see Table 36). The RBCs shown in Table 36 correspond to a cancer risk of 10-6 or a Hazard Index of 1.0.
F	Restore groundwater that has been impacted by site sources to meet all RBCs or MCLs for the COCs.

[1] Record of Decision for the Eastern Michaud Flat Superfund Site. EPA Region 10, June 1998.

TABLE 4-3

FMC PLANT OU REMEDIAL ACTION OBJECTIVES and GENERAL RESPONSE ACTIONS by MEDIUM
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation - Pocatello, Idaho
(Page 1 of 2)

Environmental Medium	Potential Future Receptors	Potential Exposure Pathways	Constituents of Concern[(a)] to be Addressed in the SFS	Remedial Action Objectives	General Response Actions
Soils and Solids	Outdoor Commercial/Industrial Worker Indoor Commercial/Industrial Worker Construction Worker Utility Worker Hypothetical Resident (Northern Properties)	1) Exposure to External Gamma Radiation	radium-226, potassium-40, lead-210, uranium-238	Prevent exposure via all viable pathways (external gamma radiation, incidental soil ingestion, dermal absorption, and fugitive dust inhalation) to soils and solids contaminated with COCs that would result in an unacceptable risk to human health assuming current or reasonably anticipated future land use.	• No Action • Institutional Controls • Containment • Removal/Disposal • Ex-situ Treatment • In-situ Treatment
		2) Incidental Ingestion	lead-210, polonium-210, potassium-40, radium-226, uranium-238, antimony, arsenic, cadmium, elemental phosphorus, lead, thallium, vanadium, diesel fuel-related PAHs, coke-related PAHs		
		3) Inhalation of Fugitive Dust	lead-210, polonium-210, radium-226, arsenic, cadmium, lead, nickel, vanadium		
		4) Dermal Absorption	arsenic, cadmium, diesel fuel-related PAHs, coke-related PAHs		
		5) Exposure to Fire and Inhalation of airborne phosphorus reaction products	elemental phosphorus (P4)	Prevent the direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard or resultant air emissions that represent a significant risk to human health and the environment; and, Minimize generation and prevent exposure to phosphine and other gases at levels that represent a significant risk to human health and the environment.	
Groundwater	Outdoor Commercial/Industrial Worker Indoor Commercial/Industrial Worker Construction Worker Utility Worker Maintenance Worker Hypothetical Resident (Northern Properties)	1) Ingestion	arsenic, fluoride, manganese, nitrate, selenium, elemental phosphorus (P4) and vanadium	Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher. Prevent potential ingestion of groundwater containing COCs having concentrations exceeding RBCs or MCLs (chemical-specific ARARs), or site-specific background concentrations if those are higher. Restore groundwater that has been impacted by site sources to meet RBCs or MCLs for the COCs, or site specific background levels where those are higher, wherever practicable and within a timeframe that is reasonable given the particular circumstances of the site.	• No Action • Institutional Controls • Containment • Removal/Disposal • Ex-situ Treatment • In-situ Treatment

TABLE 4-3

FMC PLANT OU REMEDIAL ACTION OBJECTIVES and GENERAL RESPONSE ACTIONS by MEDIUM
SUPPLEMENTAL FEASIBILITY STUDY WORK PLAN
FMC Corporation - Pocatello, Idaho
(Page 2 of 2)

Environmental Medium	Potential Future Receptors	Potential Exposure Pathways	Constituents of Concern[a] to be Addressed in the SFS	Remedial Action Objectives	General Response Actions
Surface Water [b]	Aquatic Receptor	1) Aquatic respiration	total phosphorus	Reduce the release and migration of COCs to surface water from facility sources that result in concentrations exceeding risk based concentrations (RBCs) or chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), including water quality criteria (WQC) pursuant to the Clean Water Act.	• No Action • Institutional Controls • Containment • Removal/Disposal • Ex-situ Treatment • In-situ Treatment

[a] These are constituents of concern that do not meet the RAOs and therefore must be addressed in the SFS.

[b] This environmental medium has been added to this list beyond the 1998 ROD RAOs.

TABLE 4-4

PRELIMINARY REMEDIATION GOALS FOR FUTURE WORKERS ON THE FMC PLANT OU[a]
FMC Corporation - Pocatello, Idaho
(Page 1 of 1)

COC/ROC	Worker Preliminary Remediation Goals[b, c]	
	Concentration (mg/kg or pCi/g)	Basis
Chemicals (mg/kg)		
Inorganics:		
Arsenic	1.5E+02	(Carc; TCR = 1.1E-04)
Cadmium	3.9E+01	(NC; THQ = 1)
Fluoride	4.9E+04	(NC; THQ = 1)[e]
Radionuclides (pCi/g) [d]		
Lead-210	6.7E+01	(Carc; TCR = 1.0E-04)
Radium-226	3.8E+00	(Carc; TCR = 1.5E-04)

NC = Non carcinogenic effect drives remediation goal.
Carc = Carcinogenic effect drives remediation goal.
THQ = Total hazard quotient.
TCR = Total cancer risk.

a) Remediation goals based on non-carcinogenic effects equivalent to a hazard quotient of 1 for all pathways combined; remediation goals based on cancer risks calculated as the 95% UCL background concentration + the concentration equivalent to a 1E-04 cancer risk for all pathways combined.

b) Remediation goals only provided for worker risk-driving COCs/ROCs on the FMC Plant Site or Northern Properties.

c) The lower of the outdoor commercial/industrial worker and construction worker PRGs from the SFS Work Plan is cited.

d) The cited radionuclide remediation goals are relevant to the 0-to-6 inch bgs depth interval (or greater). 0-to-2 inch bgs sample data would be compared to remediation goals calculated using modified 0-to-2 inch HEAST cancer slope factors for the external gamma pathway (6.8E+01 pCi/g for lead-210 and 5.7E+00 pCi/g for radium-226).

e) The soil ingestion remediation goal for fluoride incorporates a bioavailability factor of 0.65 (Clay and Sutie, 1985; NRC, 1980).

TABLE 4-5

PRELIMINARY REMEDIATION GOALS FOR HYPOTHETICAL FUTURE RESIDENTS ON THE FMC NORTHERN PROPERTIES[a]

FMC Corporation - Pocatello, Idaho

COC/ROC	Residential Preliminary Remediation Goals[b]	
	Concentration (mg/kg or pCi/g)	Basis
Chemicals (mg/kg)		
Inorganics:		
Cadmium[c]	Not Determined	-
Fluoride	7.2E+03	(NC; THQ = 1)[e]
Radionuclides (pCi/g) [d]		
Radium-226	2.5E+00	(Carc; TCR = 1.9E-4)

NC = Non carcinogenic effect drives remediation goal.

Carc = Carcinogenic effect drives remediation goal.

THQ = Total hazard quotient.

TCR = Total cancer risk.

a) Remediation goals based on non-carcinogenic effects equivalent to a hazard quotient of 1 for all pathways combined; remediation goals based on cancer risks calculated as the 95% UCL background concentration + the concentration equivalent to a 1x10-4 cancer risk for all pathways combined.

b) Remediation goals only provided for residential risk-driving COCs/ROCs on the FMC Northern Properties.

c) A remediation goal for cadmium has not been determined because it is not required to complete the SFS. If it is subsequently determined that a residential remediation goal is required for cadmium the home grown produce ingestion pathway will be considered.

d) The cited radium-226 remediation goal is relevant to the 0-to-6 inch bgs depth interval (or greater). 0-to-2 inch bgs sample data would be compared to a remediation goal calculated using a modified 0-to-2 inch HEAST cancer slope factors for the external gamma pathway (3.4E+00 pCi/g for radium-226).

e) The soil ingestion remediation goal for fluoride incorporates a bioavailability factor of 0.65 (Clay and Sutie, 1985; NRC, 1980).

Section 5
APPLICABLE TECHNOLOGY IDENTIFICATION AND INITIAL SCREENING

This section presents the general categories of remedial actions (i.e., general response actions), and the applicable technologies for remediation of COCs detected in soil and groundwater at the FMC Plant OU, which represent the potential exposure pathways at the site. For clarity, this section has been organized to discuss the full range of possible soil and groundwater technologies separately. Section 4.2.4 of the *EPA RI/FS Guidance* describes the evaluation of potentially applicable technologies as follows:

In this step, the universe of potentially applicable technology types and process options is reduced by evaluating the options with respect to technical implementability…….During this screening step, process options and entire technology types are eliminated from further consideration on the basis of technical implementability………

Per the *EPA RI/FS Guidance*, in this section of the *SFS Report* a preliminary screening according to *technical implementability* of each technology (e.g., containment/capping) and its associated process options (e.g., multi-layered cap, asphalt cap, evapotranspirative cap, etc.) is performed to systematically screen and eliminate the least applicable technologies and process options. A more rigorous screening of remaining technologies according to effectiveness, implementability, and costs is then performed in Section 6. The Section 6 screening ensures that all exposure pathways are addressed. Figure 1-6, which was adapted from the *EPA RI/FS Guidance*, depicts the recommended approach for alternative development including the initial technology screening (as presented in this section) and final selection of technologies (as presented in Section 6).

As discussed in Section 3.5, when the CERCLA activities progressed into the evaluation of the site remedy, the 24 existing RUs were combined (or in some cases divided) into new geographical areas specifically to facilitate evaluation of remedial alternatives and ultimately the remediation of the FMC Plant OU during the remedial design and remedial action phases of the process. These new areas are referred to as Remediation Areas (RAs) and include RAs designated A through K. Often in the discussions of the technologies below, and in Section 6 of this document, specific RUs or RAs are referred to as being candidates for a particular technology for treatment of contamination contained within that area. This *SFS Report* generally refers to the FMC Plant OU areas based on the new RA designations, including in the assembly of preliminary alternatives in Section 7. A description of the RAs and tracking of RUs (and associated SWMUs) to the RAs is provided in Table 3.4.

Preliminary Screening. In this section of the *SFS Report*, process options are screened based on their technical implementability. Technical implementability of process options is evaluated during this preliminary screening using the following overarching criteria including:

- Specific surface and subsurface physical conditions at the site;
- Specific constituents predominant at the site (i.e., primarily inorganic in this case); and
- Concentrations of constituents detected at the site.

This initial screening for the FMC Plant OU relies on the site characterization data gathered during the RI and SRI, as summarized in Sections 2 and 3 of this report. Site-specific physical characteristics or conditions that may affect the technical implementability of process options include, but are not limited to, the following:

- Soil/fill areas and volumes that will be necessary to cover, treat, or otherwise handle during remediation;
- Subsurface conditions, especially as they relate to elemental phosphorus (P4);
- Initial and final site topography needs (primarily for site drainage); and
- Current and future land usage including institutional controls, site improvements, and developments.

Process options that are not technically implementable due to these site-specific considerations are eliminated from further consideration in this section of the report. In addition, process options that are not applicable to, or may be incompatible with, the range of concentrations of constituents present at the FMC Plant OU also are eliminated in this section from further consideration.

The *EPA RI/FS Guidance* states, "*Two factors that commonly influence technology screening are the presence of inorganic contaminants, which limit the applicability of many types of treatment processes, and the subsurface conditions, such as depth to impervious formations or the degree of fracture in bedrock, which can limit many types of containment and ground-water collection technologies.……*" These factors are major considerations in determining the technical implementability of technology types and process options at the FMC Plant OU, based upon the following factors: 1) the COCs primarily are inorganic, 2) the first groundwater encountered is relatively deep (70 to 90 feet throughout most of the former plant processing areas), and 3) the first aquifer beneath the Plant Site is heterogeneous.

This SFS includes a significant focus on process options and technologies that are potentially effective to remediate P4 in the subsurface, due to the unique risks associated with management of P4 in conditions that expose it to ambient air. FMC prepared and submitted a document (*P4 Treatment Technologies*) to aid in review of the alternatives screening for soils and groundwater in which technologies for P4 treatment are evaluated. This document is provided in Appendix A and describes the process undertaken for the identification and preliminary screening of treatment technologies specific to P4 in the subsurface. While Sections 5, 6 and 7 provide summary information concerning the screening, evaluation and selection of P4 remedial technologies, Appendix A should be consulted for more detailed information on the screening and evaluation process.

The general response actions for soil are reviewed below, followed by descriptions of the full range of remedial technologies/process options that are appropriate for the COCs and other conditions found in the site soils and fill.

5.1 REMEDIATION OF SITE SOILS/FILL

Soils at the site have been impacted by historical activities including mixing of soils with facility feedstock, byproducts, and other fill materials, by seepage from former unlined ponds, and by facility spills. As a result, the RI and SRI have identified RUs/RAs that that will require remedial action for soils and fill materials.

Constituents originating from the FMC Plant OU are principally derived from phosphate ore, the primary feedstock for the former FMC plant. The ore contained apatite, a mineral containing calcium, phosphorus, and fluoride. The ore also contained trace amounts of heavy metals including arsenic, cadmium, chromium, vanadium, uranium (and its radioactive decay byproducts), and other elements.

Analytical results of soil samples collected within the FMC facility during the RI and SRI were compared against risk-based concentration (RBCs) for potential future worker exposure to COCs. Constituent concentrations in portions of the site were detected at levels that exceed RBCs for potential future worker exposure.

5.1.1 General Response Actions

Based on a review of the data collected during the RI and SRI and the established RAOs, six general categories of remedial actions, or general response actions, were identified for site soil including:

- No Action – represents a "base case" for comparison in the evaluation of the other five general categories of remedial action.
- Institutional Controls – includes such actions as fencing, security controls, and deed restrictions.
- Containment – includes capping and/or construction of barriers to limit direct contact with and minimize mobility of COCs.
- Removal and Disposal – includes excavation of materials that contain COCs followed by on-site or off-site disposal.
- Ex-Situ Treatment – includes excavation of site soils followed by treatment to reduce mobility, toxicity, or volume of COCs.
- In-Situ Treatment – includes treatment of soil in-place to reduce mobility, toxicity, or volume of COCs.

One or more remedial technologies may be associated with each general category of remedial action. A remedial technology may also have one or more process options. The potentially applicable technologies and process options are discussed in Section 5.2.

The general category of remedial action or general response actions will vary depending on the types and volumes of material present at the RU/RA being considered for remediation, their general chemical classification (i.e., metals, radionuclides, or P4) and the individual COCs that are present in the soil/fill. Ultimately, the viable technologies, and the remedial alternatives assembled using those technologies, also will vary depending on the RUs/RAs being considered for remediation.

5.1.2 Volumes and Areas of Impacted Soils and Fill Material

The *EPA RI/FS Guidance* states: *"Alternatives for remediation are developed by assembling combinations of technologies, and the media to which they would be applied, into alternatives that address contamination on a site-wide basis……"*. This process consists of six general steps, which are shown in Figure 1-6. The *EPA RI/FS Guidance* goes on to say that one of the general steps in the process is to:

"Identify volumes or areas of media to which general response actions (presented above in Section 5.1.1) *might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site."*

Based on a review of RI and SRI data and available areal images of facility topography before plant construction and after its shutdown, FMC determined the area of each RU and developed engineering estimates of the total volume of fill present at each RU. These are presented in Table 4-2 of the *SRI Report*. The total volume of fill for each RU was determined by developing an isopach cut and fill model across the fill-impacted portion of the FMC Plant OU. Although nearly 1,000 RI and SRI borings were advanced within the operational area of the FMC Plant OU, the areal density of borings is variable over the site and the low density or lack of borings in some RUs (e.g., RU 19) required that a modeling approach be used. The RI and SRI boring information was then used to calibrate the model.

It should be noted that for the fill volume calculations, the reported estimated total fill includes fill materials (e.g., slag, ore, bullrock, silica, precipitator solids, phossy solids, ferrophos, calciner/kiln pond solids, and coke) as well as P4, and reworked native soils (i.e., soil that has been mixed with other fill materials during earthmoving activities). A summary of the areal extent and volume of fill for each RU is provided in Table 5-1a. With the development of RAs as the CERCLA process progressed to the SFS, these areas and fill volumes have been carried forward into their respective RAs as presented in Table 5-1b. Note that the total areas and volumes for the site remain the same, they have simply been regrouped from RUs to RAs.

The areas and volumes presented in Tables 5-1a and 5-1b are important screening criteria for evaluating soil remedial technologies (e.g., capping, excavating, and/or treatment of these fill materials) and directly relate to technical implementability. Those process options that are less difficult and require a shorter time to implement are, in general, preferentially selected over otherwise viable technologies and process options. In addition, area and volume considerations are important in Section 6 to evaluate the relative costs among technologies and process options that are retained from the initial screening. These criteria also are used to evaluate soil alternatives and develop soil alternative costs in Section 7.

5.2 POTENTIALLY APPLICABLE SOIL TECHNOLOGIES

The applicable technologies retained for screening are discussed in this section and initially screened according to *technical implementability*. The COCs in soil/fill are listed in Table 4-3 and include the following: antimony, arsenic, cadmium, P4, lead, nickel, thallium, vanadium, lead-210, polonium-210, potassium-40, radium-226, uranium-238, diesel fuel-related PAHs, and coke-related PAHs. The viable technologies must be able to treat at least one of these COCs under the FMC Plant OU site-specific conditions. The complete set of applicable technologies retained for remediation of these contaminants is discussed below and organized by the general response actions (or remedial action categories) – "no action", institutional controls, containment, removal and disposal, ex-situ treatment, and in-situ treatment.

This preliminary screening of technologies and process options according to *technical implementability* is used to eliminate the least applicable technologies in the group before the more rigorous screening of technologies in Section 6 based on their effectiveness, implementability, and costs. The remaining technologies then are assembled into alternatives for remediation of site soil/fill in Section 7. Table 5-2a lists the soil technologies and process options. The final column in this table identifies those soil process options that will undergo further evaluation in Section 6 (i.e., retained process options). Those technologies that have been screened out as not being technically implementable (i.e., eliminated process options) are designated by shading in Table 5-2a.

5.2.1 No Action

The "no action" option is viable where concentrations of COCs are below site-specific risk-based levels and ARARs, i.e., when these constituents pose little or no threat to human health or the environment. The "no action" alternative should be considered if remediation efforts would cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved. The "no action" option is a required consideration under the NCP as part of the SFS Process.

5.2.2 Institutional Controls

5.2.2.1 Access Restrictions

Access restrictions prevent or control contact with impacted areas or prevent inappropriate future use of impacted or remediated areas. Two common types of access restriction are fencing and deed restrictions. Neither would reduce the mobility, toxicity, or volume of COCs. However, access restrictions may prevent direct contact with or exposure to the COCs, and preserve the integrity of the remediation.

- **<u>Fencing</u> -** Fencing and security controls limit access to the overall facility or to specific areas within the facility where COCs exceed risk-based standards. Restrictions may be applied to specific areas to limit the potential for exposure to site workers, the public, and/or wildlife. While the entire site may be fenced with appropriate warning signs and security-controlled entry points, fencing of specific areas may provide additional protection.

- **<u>Land Use Restrictions</u> -** Deed restrictions and covenants are legal mechanisms that prohibit or restrict future land uses at the site to prevent/control potential future exposure to contaminants or uses that may interfere with the integrity of the remediation.

- **<u>Soil Management</u> -** Soil management stipulations can be established and made enforceable under deed restrictions and covenants to control the management and redistribution of fill removed and/excavated during intrusive activities at the site following remediation.

5.2.2.2 Receptor-Initiated Remediation

Receptor-initiated remediation (RIR) is a process option that uses the access restrictions discussed above to limit risks to human health or the environment prior to final remediation of an RA at the time of and consistent with future land development. At the time a specific re-development project is identified for the RAs using the RIR process option, a suitable technology(ies) would be implemented to protect human health and the environment from exposure to the risks that the RA poses that are consistent with the type of land development being considered. For example, a component of future land development within an RA using the RIR process option may include installation of a parking lot. The parking lot, along with appropriate deed restrictions and covenants, could readily be designed to meet the technical requirements of an asphalt/concrete cap. These future remedial activities would include viable process options that are identified and discussed in Section 6 of this *SFS Report* and, following EPA review and approval, would be implemented concurrent with future land development. Areas where RIR would be considered pose no risk to groundwater and do not exceed RAOs for the future hypothetical workers.

5.2.3 Containment

The purposes of containment are to prevent direct contact with COCs and to eliminate infiltration of precipitation, to prevent potential exposures and reduce the mobility of COCs in the environment. Containment does not reduce the volume or toxicity of COCs. Containment can be achieved via capping, vertical barriers, and site controls.

5.2.3.1 Capping

Capping involves covering impacted areas with engineered soil covers to prevent direct contact with COCs and minimize the infiltration of precipitation, thereby reducing the migration of COCs to air, soils, and groundwater. Capping has been proven to be readily implementable at various sites and is effective at isolating COCs from the environment with minimal long-term maintenance. The following capping options were retained in this feasibility study for preliminary screening:

- **Multi-Layered Cap -** This option involves construction of a multiple-layered cap with at least one hydraulic barrier layer, consisting of either a compacted clay layer or geomembrane layer. In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer and vegetation layer. Due to the semi-arid location of the facility, compacted clay layers may be subjected to desiccation and cracking due to shrinkage of the clay. In addition, there are no sufficient sources of clay borrow sources identified nearby and therefore placement of a compacted clay layer would require importing of large quantities of material.. An alternative to a compacted clay layer would involve using some type of geomembrane/geotextile layer to serve as the hydraulic barrier layer.

- **Asphalt/Concrete Cap -** Asphalt and concrete caps area are constructed of a gravel sub-base layer overlain by asphalt or concrete. Asphalt and concrete caps are able to withstand traffic and are thus particularly suited for areas that will potentially receive future traffic. These caps are effective at both reducing infiltration of precipitation and eliminating direct contact with COCs. However, due to the high unit weight of these materials and cost, they would only be considered for small areas with material of sufficient bearing strength.

- **Evapotranspirative (ET) Cap -** RCRA Subtitle D provides that a regulatory agency may approve an ET soil cover, commonly referred to as an alternative final cover (AFC), if the alternative design includes an infiltration layer that will result in an equivalent net reduction in infiltration to that provided by conventional covers. Most of the AFCs employ the principle of “water balance” to minimize percolation (Benson et al., 2001). This principle involves designing the AFC around a homogenous soil layer to store precipitation that is subsequently removed through ET. The thickness of the soil layer is chosen to allow for sufficient storage of all infiltration water during periods of low ET. The movement of water from the soil to the atmosphere is controlled by the amount of evaporation and transpiration by vegetation, which are greatest during the warm and dry growing seasons. ET soil covers are readily implementable due to the fact that they are constructed of readily available native soil and vegetation.

- **Soil Cover Cap** - A soil cover cap or “gamma” cap involves placement of one foot of native soil over fill or soil containing radionuclide COCs, to eliminate gamma exposure from those COCs. Test plots constructed at the FMC Plant OU have shown that one foot of native soil cover is sufficient to reduce exposure to gamma radiation to regulatory standards. This information is discussed in Section 4.15.3.3 of the *SRI Report* which states, "...gamma exposure rates over the entire soil cover were below the CV of 18,500 cpm." Gamma caps are most likely not sufficient to minimize infiltration of precipitation and, accordingly will be considered primarily for those areas where only gamma radiation is above ARARs or risk-based standards.

5.2.3.2 Vertical Barriers

Vertical barriers in soil are used to restrict the *lateral* migration of COCs in site soils and include the construction of sheet pile or grout walls to prevent lateral migration of COCs through soils away from areas of concern (i.e., a source area). The RI and SRI data indicate that in their current state, COCs such as metals have not migrated laterally in site soils away from areas of release. It should be noted that P4 was found in the subsurface soil during the SRI at a depth of approximately 80 feet bgs (in the capillary fringe above the uppermost aquifer) outside of and downgradient of RA-B. As discussed in more detail in Section 4.2.4 of the *SRI Report*, the Conceptual Site Model has accounted for this P4 migration as a transport pathway via the uppermost aquifer, which deposited the P4 in the downgradient capillary fringe soil.

Vertical barriers, based on investigation findings, are not required to laterally contain metal COCs in site soils. They are more applicable for preventing lateral migration of COCs in groundwater. A discussion on the screening of vertical barriers for groundwater (including their applicability to prevent the migration of P4 in groundwater) is presented in Section 5.4.4.1 below. Based upon that evaluation, vertical barriers in soil have been <u>eliminated</u> from further consideration for use at the site.

5.2.3.3 Surface Controls

Infiltration of precipitation may be reduced by enhancing surface runoff away from areas of concern and re-vegetating impacted areas. Surface controls consist of the following two options:

- **<u>Soil Grading</u>** - Soil grading involves altering the topography of the site to control and direct surface water away from capped areas and to prevent ponding of surface water.

- **<u>Vegetation</u>** - Vegetation involves applying a vegetative soil layer followed by seeding with an appropriate seed mix. Vegetation promotes the reduction of infiltration of precipitation, runoff, and erosion.

These surface control options would be incorporated into the overall site restoration plan and would be performed in conjunction with other remedial technologies including capping and removal and consolidation.

5.2.4 Removal and Disposal or Reuse

5.2.4.1 Removal

Removal and disposal of impacted soils and fill material is a proven technology to reduce or eliminate onsite risks posed by COCs. By removing these materials and disposing them in appropriate locations, the COCs are no longer present to impact site soils and groundwater. Although removal of impacted material could be accomplished in some cases, for example at impacted areas having only metal contamination, removing soils with high concentrations and/or high volumes of P4 has been shown to present very high short-term health and safety risks during excavation and subsequent handling. Three removal options have been considered:

> **Modified and Conventional Excavation** – Conventional excavation involves the use of excavation equipment such as backhoes, trackhoes, scrapers, and/or bulldozers to dig, scrape or push materials which require treatment, relocation, or contouring. For those contaminated soils/fill without P4, conventional excavation could be used to remove materials within the area for one or more of the following: 1) removal of overlying fill/soil materials down to un-impacted native soil, 2) for contouring an area prior to application of a cap, or 3) for removal of non-P4-containing fill to allow access to underlying P4-contaminated fill. The removed materials would then be further treated, consolidated, placed under a cap or used in the construction of a cap. This process option is straightforward in areas with COCs other than P4 where these materials could be consolidated or reused during remediation of other RAs. It should be noted that historical information indicates the cost break-even point for excavation versus capping in place would be two to four feet, i.e., at two to four feet depth of fill material, it becomes more cost effective to cap the area than to excavate where excavation does not result in an appreciable incremental reduction in risk to human health and the environment.[1]
>
> Under the removal of fill/soil materials with the goal of reaching un-impacted native soils, it is assumed (as shown during the SRI) that the underlying native soils do not contain unacceptable levels of COCs. Confirmation sampling of the underlying native soil would be performed to demonstrate that the excavation had proceeded to the appropriate depth and that the RAOs are met at the remaining,

[1] *This statement is based upon the cost estimates developed for construction of ET covers and for performing conventional excavation on a per acre basis. The cost to construct one acre of ET cap is estimated to be $85,000/acre. The cost for conventional excavation (no P4 present) of one acre to a depth of 1 foot of slag (e.g., at RA-A) is estimated to be $40,300. This cost includes ripping, excavation, and transport to another RA (e.g., RA-F) for placement prior to capping followed by replacement with clean fill material. Therefore, conventional excavation of 2.5 feet of slag will approximately equal the cost to cover the same area with an ET cover. This provides an approximate "break-even" point of for capping versus excavation of "2 to 4 feet."*

exposed soil surface. The preliminary remediation goals (PRGs) for the FMC Plant OU soils are presented in Section 4.4.

Conventional excavation of P4-containing soils/fill would not meet all of the RAOs associated with exposure to P4 in soils/fill and P4 reaction products in air. In addition, there has been no documented experience or precedent at other sites for removing large quantities of P4-containing soils. In these cases, a process option of modified excavation, which involves the use of conventional excavation equipment where water would be added to the excavation or directly to the excavated material to prevent spontaneous combustion of P4 encountered, would be considered. In addition, controls over the excavation area may be required (e.g., sprung structures with associated air pollution control equipment) along with wastewater containment and treatment systems to manage wastewater used for P4-combustion control. Given these constraints, modified excavation likely would be limited to backhoes/trackhoes and excavation depths would be limited to 10 to 15 feet. While modified excavation would be considered for removal of P4-contaminated soils, it may only be feasible for soils containing concentrations of P4 less than 10,000 ppm. The application to soils with higher P4 concentrations, without extreme control measures, may result in failure of RAOs associated with exposure to P4 in soil and P4 reaction products in air. In either case, following excavation, the water-saturated soils/fill would require additional handling precautions prior to placement or treatment. A more detailed discussion of the procedures and challenges of using modified excavation for P4-contaminated soil/fill is provided in Section 2.2.1.1 of *P4 Treatment Technologies* (as provided in Appendix A).

Investigation results and process knowledge indicate that modified excavation would be successful in RA-K where SRI data indicate P4 concentrations of less than 10,000 ppm. Modified excavation may also be appropriate for the removal of underground piping potentially containing P4, as the volumes of P4 would be localized and largely contained within the pipe. For those site soils/fill with elevated concentrations of P4, such as in RAs B and C, even using modified excavation and control techniques likely would present significant health and safety concerns and potential environmental impacts during the excavation.

- **Wet Dredging** - Wet dredging typically involves the removal of sludges/wastes from surface impoundments. Wet dredging was used in some cases at the FMC facility for redistribution of P4-containing sediments within or between some of the phossy ponds while the ponds were in operation. This typically involved dredging sediments at 70 to 90 percent water content to other ponds or to a wet process. These ponded materials were covered with water when the facility was in operation and therefore, were able to be removed with wet dredging equipment without exposing the P4 to ambient air. However, since all of the former ponds currently under investigation have been de-watered and various ponds covered with fill materials (e.g., ponds in RA-C), this process option for removal of wastes would not be currently feasible. In addition, the former ponds that need to be remediated (e.g., ponds in RA-C) are unlined. Therefore, any water used during the remediation effort could mobilize COCs and threaten the underlying groundwater. Also, site workers performing these operations would have a low to moderate risk of dermal and inhalation exposure to P4 and P4 reaction products. Because wet dredging is not applicable to unsaturated pond sediments and other contaminated soils, fill, and ore/slag found at the Site, dredging has been eliminated from further consideration.

- **Hydraulic Pumping** - This process uses high-capacity pumps that are capable of pumping high volumes of water-slurried sediment. As with wet dredging, this process requires large quantities of water to slurry the contaminated soils, and could only be implemented in areas of very fine-to-small grained sediments/sludges. The predominant fill across the FMC Plant site consists of very coarse-grained material that could not be pumped using this technology. Table 2-1 lists the surface and subsurface fill materials present at the FMC Plant OU. As is evident, most of the material is a mixed combination of primarily slag along with concrete foundation debris, asphalt with slag, and reworked native soils with slag. As a result, hydraulic pumping would not be implementable or feasible for removal of P4-contaminated fill in most areas of FMC Plant Site.

  The water used to slurry the sediment also would pose a threat to the underlying shallow groundwater similar to the risks discussed above with respect to wet dredging. Site workers would be exposed to slurries with widely ranging concentrations of P4 that would present dermal and inhalation risks. Overall, hydraulic pumping is not feasible for use with the coarse fill materials found at the site, excess water would pose a threat to the environment, and the slurry would expose workers to unnecessary risks. Therefore, hydraulic pumping has been eliminated from further consideration.

5.2.4.2 Disposal

Disposal for soil and fill materials include the following options:

- **Consolidation and On-Site Disposal** – Consolidation and on-site disposal would involve excavation of impacted surface soil/fill followed by transport and placement elsewhere on site (either within the same RA or within another RA). Consolidation and on-site disposal would be beneficial to reduce the overall footprint of impacted areas and eliminate the necessity to transport large volumes of material through populated areas to off-site landfills. Standard engineering cost estimating factors, given conditions at the FMC site, indicate that the cost break-even point for excavation versus capping in place would be two to four feet, i.e., at two to four feet depth of fill material, it becomes more cost effective to cap the area than to excavate. RA-A and RA-J are examples of areas where soils/fill could be excavated down to un-impacted native soils with the excavated materials being placed under a cap within a different RA.

- **Off-Site Disposal** - Small volumes of impacted soils and solids not amenable to on-site treatment or consolidation may be transported to off-site treatment and disposal. Off-site disposal is less desirable than on-site disposal due to the increased risk to public safety and health as result of the increased possibility of transportation accidents and increased public exposure from possible spills. This is a significant concern in connection with any large-scale off-site disposal given that there are in excess of 18 million cubic yards of contaminated soil/fill at the site). In addition, any P4-containing material, such as underground piping, that would be shipped off-site for treatment/disposal, would require placement in 55-gallon drums prior to shipment to accommodate treatment facility requirements, thus greatly limiting the implementability of off-site disposal.

5.2.5 Ex-Situ Treatment

Ex-situ physical, chemical, thermal, or biological treatment technologies could be used to treat impacted soil and fill material following excavation to reduce the volume or toxicity of COCs. However, the excavation process prior to ex-situ treatment is considered very difficult to implement (i.e., technically challenging) for soil containing P4 at concentrations greater than 10,000 ppm. These challenges are due to the short-term safety and health risks associated with fire hazards when P4 is excavated and exposed to ambient air. These short-term risks would be present during each step of the ex-situ treatment process, including the initial excavation, material handling during transportation to the stockpile, management of the stored material, and when the material is sized, sampled, and/or blended prior to treatment. In addition, there would be public health and safety risks associated with ex-situ treatment as well as significant environmental risks associated with potential uncontrolled air releases. For a more complete discussion of these technical challenges and risks, refer to Section 2.2 of *P4 Treatment Technologies.*

Given these material handling issues, all the ex-situ treatment technologies discussed below are considered technically challenging, at least, to implement. The ex-situ treatment options evaluated for treatment of P4, radionuclide, and metal-contaminated material include the following physical, chemical, thermal, and biological processes.

5.2.5.1 Physical Treatment

Physical treatment technologies, such as stabilization and aeration, reduce the mobility or toxicity of COCs.

- **Stabilization/Solidification** - Stabilization/Solidification is a technology in which inorganic or organic agents are added to impacted soil to reduce the solubility or mobility of the COCs. Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilization agents, curing of the mass for optimal reduction in leachability, and then on-site or off-site disposal. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents used depend on the chemical composition of the material being stabilized. Stabilization and solidification has been shown to be effective for reducing the leachability of heavy metals. However, its effectiveness at treating wastes containing P4 has not been demonstrated. Off-gases of the reaction process of P4-contaminated materials would include phosphine (PH3) and phosphorus pentoxide (P2O5) that would require capture at the point of generation. Because of risks associated with the off-gases from any P4 treatment using stabilization/solidification, this process will be retained for further technology evaluation and screening in Section 6, but only for RAs that contain P4 below 1,000 ppm, metals, and radionuclides.

- **Mechanical Aeration -** Mechanical aeration involves the use of physical equipment, such as a mixer, to agitate a solid or slurry material and expose the material to the atmosphere where ambient oxygen would react with the P4 contained in the solid matrix. The United States Army Corps of Engineers (USACE) indicated that a mechanical aeration system could be used ex-situ or in-situ to expose P4 to oxygen. However, mechanical aeration has the following limitations: 1) Further studies would be required to determine how the degradation of P4 is affected by concentrations of dissolved oxygen, mixing rate, matrix characteristics, depth of material, temperature, and pH. 2) It has not been field tested, and the feasibility of applying this to P4-contaminated materials would need additional research and experimental work. 3) Hazardous off-gasses, such as PH3, likely would be generated during the mixing process and would need to be collected and treated. 4) It would not treat the metal or radionuclide COCs that are found in most site soils. As a result, mechanical aeration has been eliminated from further screening.

- **Dewatering** - Dewatering is an effective method for separating liquid from solid media for further treatment or disposal. Dewatering is not an appropriate technology for soils and solids being considered for the FMC Plant OU because none of the material contains free liquid. This technology therefore has been eliminated from further screening.

- **Separation** - Physical separation is a process whereby soils are slurried, and then passed through a gravity separation process to remove or extract organics. This process is most effective where there is a significant difference in particle size and the constituents of concern are concentrated in a narrow range of sizes. It is also effective where free metals are present and can be selectively removed. However, these conditions are not associated with the impacted soils at the FMC Plant OU. Therefore, this technology has been eliminated from further screening.

5.2.5.2 Chemical Treatment

Chemical treatment technologies rely on chemical reactions with chemical additives that convert chemicals into less hazardous compounds.

- **Chemical Oxidation** - Chemical oxidation involves the addition of chemical agents to react with COCs in the soil to form oxidized by-products. Chemical oxidation is effective for slurries and sludges containing organics and inorganics. It may be effective for fixation of some metals such as arsenic into insoluble form that will not fail TCLP criteria. Two types of ex-situ oxidation technologies have been identified for treatment of P4-contaminated materials: 1) a nitric/sulfuric acid process, and 2) an oxygen addition process using high speed air dispersion (HSAD). These processes are based on chemical transformation by oxidation. The acid oxidation technology was developed and tested by the Tennessee Valley Authority on sludge containing P4. The effluent from that process was reacted with ammonia to produce a nitrogen- and phosphate-containing plant nutrient. The HSAD technology was developed and tested by researchers at the University of Alabama on sludge from Astaris (previously FMC), Tennessee Valley Authority (TVA) and Occidental Chemical. Because chemical oxidation using these two processes was viable (with limitations), it will be retained for further technology evaluation and screening in Section 6.

- **Caustic Hydrolysis** - Caustic hydrolysis is a chemical process where P4 reacts with lime and water at elevated temperature and pressure to form various phosphate compounds, as well as PH3 gas. It has not been demonstrated for treatment of other site COCs apart from P4 (i.e., metals and radionuclides). For treatment of P4, this technology uses complex processing equipment. Key operating parameters include the amount of lime and water added, reaction pH, and the reactor temperature and pressure. Caustic hydrolysis would reduce the concentration of P4, but depending on the pH used, may result in the generation of significant amounts of PH3 gas as a by-product that would require subsequent treatment in a hydrator or thermal oxidation.

  A Land Disposal Restrictions (LDR) waste treatment system was partially constructed (but never operated) at the FMC facility to treat hazardous waste streams containing P4 and accumulated solids in Pond 18S. This LDR waste treatment system was based upon caustic hydrolysis technology. Because this technology was selected by FMC in the past for treatment of fine-grained P4-containing pond wastes, and caustic hydrolysis will be retained for further technology evaluation and screening in Section 6.

- **Chemical Extraction** - Chemical Extraction is a technology that utilizes a multiple stage process in which soils are excavated, screened, washed with a surfactant or other chemical extractant, and separated. This technology has been used for soils contaminated with a variety of organic constituents. However, chemical extraction has not been demonstrated to be effective for inorganics or

P4-contaminated soils. Therefore, this technology has been <u>eliminated</u> from further screening.

5.2.5.3 Thermal Treatment

Ex-situ thermal treatment generally involves the destruction or removal of contaminants through exposure to high temperature in treatment cells, combustion chambers, or other means to contain the contaminated media during the remediation process. The thermal treatment processes involve the application of energy in the form of heat to separate, destroy, or immobilize contaminants.

- **<u>Incineration</u>** - Incineration is a thermal process where soil, sludge and other wastes are treated at elevated temperatures (1,400 to 2200 °F) to volatilize and combust contaminants. Incineration would reduce the concentration of P4 in soil. Elemental phosphorus would be oxidized to P2O5 and natural organic matter in the soil would be converted to carbon dioxide. Oxidized P4 would be captured by off-gas treatment systems such as scrubbers and treated further or discharged as a by-product. Heavy metals and radionuclides in the soil would not be oxidized to a significant extent, but would primarily remain in the residual ash from the incinerator and would require proper disposal either on-site or in a commercial hazardous waste landfill.

  A full-scale on-site incinerator would need a large capacity to remediate the volume of waste containing P4 at the FMC site. In addition, material handling prior to treatment and ash disposal after incineration would present technical challenges. An on-site incinerator also would be very expensive to design, construct, and maintain in accordance with substantive permit requirements. Because this technology has been used by FMC in the past for treatment of P4-contaminated piping, equipment, and sludges (although only using off-site commercial incinerators) , on-site incineration is retained for further technology evaluation and screening in Section 6.

  Off-site incineration at a commercial facility is available and is considered viable for small quantities of waste containing P4 greater than 1,000 ppm (e.g., underground piping). This is considered as viable only for small quantities of wastes as the materials must be placed in 55-gallon drums prior to shipment off-site. Based on these factors, off-site incineration for small quantities is retained for further evaluation and screening in Section 6.

- **<u>Thermal Desorption</u> -** Thermal desorption is used to treat soil and sludge by heating (directly or indirectly) to volatize contaminants and separate them from the solid matrix without combustion. The temperatures used in a thermal desorber are lower than in an incinerator, and area generally on the order of 200 to 600 °F. The volatilized contaminants (vapors) generally are collected and treated by one or more off-gas treatment technologies. Thermal desorption would reduce the concentrations of P4 through volatilization, and P4 vapors would be recovered by treatment of the off-gas. Thermal desorption would not reduce concentrations of heavy metals or radionuclides in the solids. The USACE reported that a patented infrared system, operating on a batch basis, was used to treat 300 tons of P4-contaminated soil in Ogden, Utah at a cost of $267/ton. The treatment rates for this system were reported to average 1 hr and 40 minutes for each 5 cubic yard batch for a total treatment time of 4 days for the 300 tons processed.

All of the ex-situ treatment processes have similar problems associated with excavation, storage, and health/safety issues related to P4 wastes prior to treatment. Based on the discussion above, ex-situ thermal desorption would require a long time to treat higher concentrations of P4 (i.e., for individual batches) and would present a fire or explosive hazard during relatively low-temperature treatment (i.e., 200 to 600 degrees F). In addition, thermal desorption has not been demonstrated on similar P4-containing wastes, i.e., 10% P4 mixed with other site fill materials containing metals and radionuclides. When the technical implementability challenges presented by ex-situ thermal desorption are compared to the incineration process, a demonstrated thermal treatment technology that has been used successfully on these types of wastes, incineration was deemed a significantly more viable treatment technology for wastes containing P4. In addition, there are off-site incinerators that are commercially available and are considered viable for treating small quantities of waste containing P4 greater than 1,000 ppm (e.g., underground piping). As a result, thermal desorption has been eliminated from further screening, while on-site and off-site ex-situ incineration are retained.

- **ERCO Pot Still -** The ERCO pot still (pot still) employs a simple, labor intensive, physical batch process to heat the soil matrix in a molten metal bath to vaporize water and P4 for subsequent condensation and recovery. It is effective for small batches (the vessel is 10 feet in diameter by 3 feet high, thus providing a maximum of 9 cubic yards/batch) of high-level P4 wastes (sludges with P4 concentrations greater than 20%). The pot stills can effectively process metal and non-metal debris containing P4; however, due to lower heat transfer rates, processing soils/rock is much less efficient. In general, processing (heating) each batch requires an average of 20-30 hours to first distill off the water, then the P4. Significantly longer processing times are needed if the feed P4 concentration is lower, as additional heat and time is needed to heat the soil matrix associated with the P4.

  At the FMC site, small, isolated pockets of solidified P4 may exist at concentrations exceeding 20% (i.e., underground piping and/or piping discharge areas at old historic ponds [RA-C]). However, once excavated, the materials would be blended by the excavation process resulting in much lower P4 concentrations. In addition, these small, isolated pockets of P4 make up a very small percentage of the overall volume of P4-contaminated materials that must be addressed in the SFS. This labor- and energy-intensive, small-batch process therefore would not be efficient or effective at this site due to the following factors: 1) the relatively low average P4 concentration, 2) the high volume of soil/fill that would be encountered, and 3) the longer processing time required for wastes containing primarily rock/soil. Because other ex-situ technologies for treating soils/fill are more implementable than the ERCO pot stills and because this process option would only be implementable for a very small amount of site P4-contaminated materials, it has been eliminated from further screening.

5.2.5.4 Biological Treatment

Ex-situ biological treatment of solids and solids consists of enhancing the biological degradation of organic constituents by microorganisms. Biological treatment typically is implemented by creating favorable conditions for microbial activity. Biological treatment is generally effective for hydrocarbon containing soil and solids. While there are a number of biological treatment processes, landfarming is chosen here as it is typically applied to the type of shallow-soil diesel spill encountered at the FMC site. The following description of landfarming technology is based on an EPA guidance document entitled *How To Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites: A Guide For Corrective Action Plan Reviewers* (EPA, 1994).

- **Landfarming** - Landfarming, also known as land treatment or land application, is an above-ground (or at the ground surface) remediation technology for soils that reduces concentrations typically of hydrocarbon constituents through biodegradation. This technology usually involves spreading excavated contaminated soils in a thin layer on the ground surface and stimulating aerobic microbial activity within the soils through aeration and/or the addition of minerals, nutrients, and moisture. The enhanced microbial activity results in degradation of adsorbed petroleum product constituents through microbial respiration. If contaminated soils are shallow (i.e., less than 3 feet below ground surface), it may be possible to effectively stimulate microbial activity without excavating the soils, but tilling/mixing in place. If petroleum-contaminated soil is deeper than 5 feet, the soils should be excavated and reapplied on the ground surface.

  Landfarming would not be effective or implementable on soils contaminated with most of COCs present at the FMC Plant OU. However, RA-A1 has hydrocarbons (from historic diesel spills) in the shallow soil. Ex-situ landfarming therefore is retained for further evaluation and screening in Section 6, but only for the small quantity of hydrocarbon-contaminated soils identified in this area.

5.2.6 In-Situ Treatment

“In-situ” or “in place” treatment would treat impacted soil and fill material in place using either physical, chemical, thermal, and at some sites, biological processes to reduce the volume or toxicity of COCs. Because in-situ treatment would not require excavating the material, in-situ treatment is generally considered safer to implement than ex-situ technologies. However, it may be difficult for in-situ technologies to completely treat the constituents detected in site soils in-place. That creates the risk that some COCs would be left above risk-based benchmarks. The following in-situ treatment options have been considered for treatment of soils containing P4, radionuclides, and metals.

5.2.6.1 Physical Treatment

Physical treatment technologies, such as stabilization and aeration reduce the mobility or toxicity of COCs.

- **Stabilization/Solidification -** Stabilization/Solidification is a technology in which inorganic or organic agents are added to impacted soil to reduce the solubility or mobility of the COCs. In-situ stabilization generally involves mechanical mixing of the solids in-place with stabilization agents. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents that are used depend on the chemical composition of the material being stabilized. Stabilization and fixation has been shown to be effective for reducing the leachability of heavy metals. However, its effectiveness for treating P4-containing wastes is not well understood and has not been established. One significant down-side is the inability of this technology to control a reaction and reaction products once a P4 reaction begins.

  An in-situ stabilization treatability study was performed at Tarpon Springs to treat P4-contaminated sludge. However, the treatability study resulted in violent reactions of the stabilization mixture with P4, resulting in combustion of the P4 and generation of phosphine gas. That treatability study has since been cancelled. This has caused stabilization to be removed as a potential treatment technology for Tarpon Springs. Instead, containment was selected remedial option at that site, as presented in the Explanation of Significant Difference #4 (ESD 4, in Appendix F). Because in-situ stabilization/ solidification is viable for soil/fill containing COCs other than P4 (e.g., calciner solids at RA-E), it will be retained for further technology evaluation and screening in Section 6.

- **Mechanical Aeration** - Mechanical aeration involves the use of physical equipment, such as a mixer or drill auger, to agitate a solid or slurry material and expose the material to the atmosphere where ambient oxygen can react with the P4 contained in the solid matrix. The USACE indicated that a mechanical aeration system could be used ex-situ or in-situ to expose P4 to oxygen. However, further studies would be required to determine how the degradation of P4 is affected by concentrations of dissolved oxygen, mixing rate, matrix characteristics, depth of material, temperature, and pH. The USACE stated that in-situ mechanical aeration has not been field tested, and that the feasibility of using an auger to aerate soils/fill containing P4 would need additional research and experimental work. Aeration likely would generate hazardous off-gasses, such as PH3 gas, during treatment that would need to be collected and treated. Also, being in-situ, reaction rates could not be easily controlled. Therefore, in-situ mechanical aeration has the following limitations: 1) Further studies would be required to determine how the degradation of P4 is affected by concentrations of dissolved oxygen, mixing rate, matrix characteristics, depth of material, temperature, and pH. 2) It has not been field tested, and the feasibility of applying this to P4-contaminated materials at the site would need additional research and experimental work. 3) Hazardous off-gasses, such as PH3, likely would be generated during the mixing process and would need to be collected and treated. 4) It would not treat metals or radionuclides COCs found in most site soils. As a result, in-situ mechanical aeration has been eliminated from further screening.

- **Soil Vapor Extraction** - Soil vapor extraction (SVE) involves the extraction of contaminant vapors followed by treatment of the vapors. Soil vapor extraction is a common technology used for the remediation of soils containing volatile organic contaminants. As there are no areas of known volatile organic contamination at the FMC Plant OU, SVE has been eliminated from further screening.

5.2.6.2 Chemical Treatment

Chemical treatment technologies are typically used as ex-situ processes that use equipment to mix chemical additives with contaminated soils and through the subsequent chemical reactions convert COCs into less hazardous compounds. In-situ application of chemical treatment processes has only occurred at bench-scale and EPA (2003) does not discuss in-situ chemical treatment processes because of the "difficulties associated with implementation at full scale." As a result, in-situ chemical treatment processes have been eliminated from further discussion. However, ex-situ chemical treatment processes including chemical oxidation and caustic hydrolysis have been retained for further evaluation in Section 6.

5.2.6.3 Thermal Treatment

Thermal treatment technologies involve the application of energy in the form of heat to catalyze the COCs to immobilize or detoxify inorganic compounds, or destroy them generating nontoxic constituents (e.g., water, carbon dioxide).

- **Vitrification** - Vitrification is a thermal treatment process that immobilizes inorganic compounds and destroys organic compounds by electrically heating and fusing the soil into a stable, glass-like block. Due to the presence of P4 in most areas containing metals above risk-based levels, vitrification will produce flammable and highly toxic gases such as P4 and PH3 gas when heated to the temperatures required for vitrification. In addition, vitrification is usually performed on relatively small areas of contamination due to the high energy consumption required vitrify the matrix and is not implementable for the large quantities of impacted soil at the FMC Plant OU. Therefore, vitrification has been eliminated from further screening.

- **Thermal Desorption** - In-situ thermal desorption (ISTD) uses thermal wells, paired with heated extraction wells to remediate COCs. Heat is applied to soil from a high-temperature surface in contact with the soil (i.e., the thermal well), so that radiation and thermal conduction heat transfer are effective near the heated extraction wells. As a result, thermal conduction and convection occur in the soil mass between the heated wells. Near the heated wells is a zone of very high temperature (>1,000 °F), which can oxidize or pyrolize contaminants. A soil vapor extraction system is used to remove contaminants from the subsurface for further treatment or disposal.

  ISTD has primarily been used to treat organic contaminants, including free product in the form of light non-aqueous phase liquids (LNAPLS) or dense non-aqueous phase liquids (DNAPLs). However, it has not been tested on soils contaminated with P4. Representatives of TerraTherm, a company that pioneered the technology, indicated that significant testing would be required to determine whether this process could be utilized on P4.

  ISTD technical limitations for application at the FMC site include the following: 1) difficulties associated with implementing it at the depth and geologic conditions at this site; 2) unproven effectiveness for treating soils containing P4; 3) the P4 and PH3 gases produced by this process would be difficult to contain/capture; and 4) it is not applicable for other site COCs (metals and radionuclides). Given the extremely large volumes of soil contaminated with P4 at the FMC Plant OU that would require treatment, ISTD would require an extremely long treatment time-frame. Operational concerns include the quantity of energy that would be needed to sustain ISTD and possible fire or explosion hazards. Hot spots of P4 would present a fire and explosive hazard if P4 were to spontaneously ignite during the ISTD process. For these reasons, ISTD has been eliminated from further screening.

5.2.6.4 Biological Treatment

In-situ biological treatment has been eliminated from further consideration because biological treatment processes would not be effective or implementable on soils contaminated with most of COCs present at the FMC Plant OU (i.e., P4, metals, and radionuclides). However, ex-situ biological treatment (i.e., landfarming), which is easier to implement and to verify that the contamination zone has been completely treated, is retained for treatment of the hydrocarbon impacted soils in RA-A1 and will be discussed further in Section 6.

5.2.7 Summary of Preliminary Soil Technology Screening

In Section 5.2, all of the possible process options and technologies considered for remediation of soil/fill at the FMC Plant OU are discussed. These technologies and process options initially are screened based on their potential technical implementability for treating the COCs in soil and fill encountered at the FMC Plant OU. The technologies that have not been eliminated based on this preliminary screening for technical implementability are retained for further screening according to implementability (administrative and technical), effectiveness, and cost in Section 6. The soil technologies considered for remediation of the FMC Plant OU soils and those that are retained for further screening in Section 6 are summarized in Table 5-2a.

5.3 REMEDIATION OF SITE GROUNDWATER

5.3.1 Introduction

The nature of the FMC Plant OU-related impacts to groundwater can be summarized as elevated (i.e., greater than the representative level) concentrations of common ions, decreased pH, elevated concentrations of nutrients such as ammonia, nitrate and orthophosphate, and metals such as arsenic and manganese. Arsenic is the risk-driving groundwater COC. The extent of arsenic concentrations in groundwater above the MCL defines the outer extent of site-impacted groundwater for the purpose of evaluating groundwater remedial actions in the SFS. However, the technologies and process options are screened based on all of the site-related groundwater constituents coincident with, or as localized areas within, the overall arsenic groundwater plume.

5.3.2 General Categories of Remedial Action

Based on a review of the data collected during the RI and SRI and the established RAOs, six general categories of remedial action were identified for site groundwater including:

- No Action –represents a "base case" for comparison in the evaluation of the other five general categories of remedial action.
- Institutional Controls – includes such actions as fencing, security controls, routine groundwater monitoring, deed restrictions, and groundwater extraction/use restrictions.
- Source Controls – includes actions to remove or control (contain) historic or potential sources of site-related constituent migration to groundwater.
- Containment – includes construction of subsurface barriers to control lateral flow direction of groundwater.
- Removal and Disposal – consists of groundwater pumping and either recycling for beneficial reuse or disposal by surface discharge or injection.
- Ex-Situ Treatment – consist of physical, chemical, thermal, or electrolytic treatment of extracted groundwater prior to recycling or disposal.
- In-Situ Treatment – injection of chemical agents or air to neutralize, precipitate, or destroy the COCs in site groundwater.

One or more remedial technologies may be associated with each general category of remedial action. A remedial technology may also have one or more process options. Potentially applicable technologies and process options for contaminated groundwater underlying the FMC Plant OU are discussed below.

5.4 POTENTIALLY APPLICABLE GROUNDWATER TECHNOLOGIES

All of the groundwater technologies considered for use at the FMC Plant OU are presented in this section. They are initially screened, as were the soil technologies, according to *technical implementability*. The COCs in groundwater that fail RAOs for the FMC Plant OU are listed in Table 4-3 and include arsenic, fluoride, manganese, nitrate, selenium, P4, and vanadium. The complete list of possible remedial technologies that could be used for protection of human health and the environment from these contaminants are discussed below and are organized by the general response actions (or remedial action) categories – "no action," institutional controls, containment, removal and disposal, ex-situ treatment and in-situ treatment. Table 5-2b depicts the groundwater technologies that are evaluated and those that are retained for further evaluation in Section 6. This preliminary screening of technologies and process options according to technical implementability is used to eliminate the least applicable technologies in the group before the more rigorous screening of technologies in Section 6 according to effectiveness, implementability, and costs. The remaining viable technologies are then assembled into alternatives for groundwater remediation in Section 7.

5.4.1 No Action

The "no action" option is viable where concentrations of COCs are below site-specific risk-based levels and ARARs, i.e., when these constituents pose little or no threat to human health or the environment. The "no action" alternative should be considered if remediation efforts would cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved. The "no action" option is a required consideration under the NCP as part of the FS process.

5.4.2 Institutional Controls

5.4.2.1 Access Restrictions

Access restrictions prevent or control contact with impacted areas or prevent inappropriate future use of impacted or remediated areas and site groundwater. Two common types of access restrictions are fencing and deed restrictions. Neither would reduce the mobility, toxicity, or volume of COCs. However, deed restrictions may prevent exposure to the COCs in groundwater by limiting or preventing use.

- **Fencing** - Fencing is necessary to prevent access to areas that have been remediated (e.g., capped or otherwise treated) to prevent exposure. Signs are often used in combination with fencing to notify workers of exposure risks and of procedures necessary when entering the area.

- **Land and Groundwater Use Restrictions** - Deed restrictions and covenants are legal mechanisms to restrict future land and groundwater uses at the site. These legal restrictions may involve state and local governmental restrictions on the use of land and the resources associated with it, or restrictions that the property owners place unilaterally on the future use of the property, including both the land and groundwater.

5.2.4.2 Groundwater Monitoring

Groundwater monitoring is used to evaluate potential changes to hydraulic (flow) conditions and extent / concentrations of site-impacted groundwater over time that might result in migration towards downgradient receptors and the effectiveness and efficiency of a remedial actions (source control actions and/or active groundwater technologies). FMC is currently performing groundwater monitoring under its RCRA, Calciner Ponds Remedial Action and voluntary CERCLA groundwater monitoring programs. The number and location of the wells that are routinely monitored, constituents analyzed, and the frequency of monitoring are described in detail in the GWCCR (MWH, June 2009). The long-term CERCLA groundwater monitoring program, including number and location of wells, constituents analyzed and frequency of monitoring will be developed and reviewed/approved by EPA as part of the remedial design and remedial action process.

5.4.3 Source Controls

Source controls include actions that reduce or eliminate constituent migration to groundwater from identified and potential source areas. Numerous source controls have already been implemented (e.g., RCRA Pond 8S closure and Calciner Pond remedial action). Source controls previously performed at the former FMC facility mainly involved pond closures and construction of caps. Source controls (e.g., caps) are discussed as part of the remedial technologies for soil in Section 5.2 and therefore are not repeated in this section.

5.4.4 Containment

5.4.4.1 Vertical Barriers

Vertical hydraulic barriers essentially form groundwater barriers and can consist of extraction wells, injection wells, slurry or grout walls, or a combination of these. At the FMC Plant OU, the screening of these process options is applicable to all site groundwater COCs, (i.e., metals and P4).

- **Extraction Wells** - An extraction well option would be comprised of extraction wells designed to create a hydraulic barrier or hydraulic control by intercepting the flow of impacted groundwater containing COCs at levels that exceed RAOs. Extracted groundwater may require treatment prior to disposal or reuse.

- **Injection Wells -** An injection well option would be similar to the extraction well option, except that water would be injected into the aquifer to form a hydraulic barrier by increasing the water level downgradient of the impacted portion of the aquifer. This option would require a large amount of clean water to be injected into the subsurface. Given the hydrogeological conditions in the underlying aquifer (i.e., high gradients and high flow rates of groundwater in the potential injection area), injection wells would not be technically practical or implementable. As a result, injection wells have been eliminated from further consideration at the site.

- **Cut-Off (Slurry or Grout) Walls** - Slurry walls are usually constructed by excavating materials to the required depth, and backfilling with a mixture of fine-grained soils and bentonite clay. Grout walls can be constructed in a similar manner, replacing the excavated material with cement or silica gel grout mixture. Grout walls typically are constructed by drilling overlapping large diameter borings and backfilling them with cement grout. Cut-off walls would be a technical challenge at the FMC Plant OU because: 1) it is difficult to ensure proper placement of deep walls (e.g., it is 80 feet just to the shallow water table), 2) they may degrade over time due to site conditions, 3) the geology is complex underlying the FMC Plant OU is complex and it would be difficult to key the bottom of the wall into a low permeability layer (e.g., a clay aquitard), and 4) it is difficult to assess their performance over time. As a result, cut-off walls for contaminated groundwater have been eliminated from further consideration for use at the site.

5.4.5 Removal and Disposal

5.4.5.1 Removal

Removal of groundwater by extraction for hydraulic control or treatment requires pumping from extraction wells. The equipment required depends on the location and depth of the wells, the required flow rate, and the treatment or disposal method. Extraction and disposal of site groundwater could reduce the volume and horizontal migration of contaminated groundwater.

- **Pumping** - Groundwater extraction would be accomplished by installing a sufficient number of wells to result in complete capture of the impacted groundwater to prevent lateral migration. Extraction would be performed in conjunction with ex-situ treatment and some type of disposal, whether to a POTW or to a surface impoundment, or recycling/reuse.

5.4.5.2 Disposal

Options available for the disposal of treated or untreated groundwater include recycling for beneficial reuse, surface water discharge, discharge to a publicly-owned treatment works (POTW), and surface water discharge.

- **Recycle/Reuse** - Recycling of groundwater would be dependent on the water quality and quantity. Depending on the quality of the extracted groundwater, some degree of treatment may be required. Recycled groundwater could be used for dust control and irrigation to facilitate revegetation of the facility. However, depending on flow rates, recycling may only be able to use a portion of the extracted groundwater.

- **Surface Water** - Discharge to the Portneuf River would require a National Pollutant Discharge Elimination System (NPDES) permit that would stipulate the flow rate and concentrations of constituents that could be discharged. Following permanent plant shutdown, FMC officially terminated its former NPDES permit (ID-000022-1) in October 2002. Thus, a completely new NPDES permit would be required as opposed to discharge under an existing or modified permit. Significant administrative and technical issues would be encountered to obtain a new NPDES permitted discharge to the Portneuf River due to its impaired water quality status on Idaho's current §303(d) list, including carryovers from previous lists (2002, 1998, and 1996), and also revisions to assessment units with approved TMDLs (Portneuf River TMDL Revision and Addendum - October 2009, IDEQ, 2009). Among other pollutants (e.g., total suspended solids, E. Coli bacteria), the Portneuf River is listed as impaired for the nutrients total phosphorus and nitrogen that are constituents in FMC-impacted groundwater. IDEQ worked with numerous stakeholders including the Portneuf Watershed Advisory Group to develop / revise the waste load allocations presented in the October 2009 Portneuf River TMDL Revision and Addendum and is working to complete the multi-year process to finalize the TMDL revision. Any new discharges would require further revision to the waste load allocations and, according to IDEQ, a "new" round of negotiations on waste load allocations and revision to the TMDL would require 1 to 2 years. Further, IDEQ reports that it currently does not have staff resources to begin another "round" of revision to the TMDL which could further extend the timing. Treatment of extracted groundwater to reduce total phosphorus and nitrate to meet an IDEQ-stakeholder negotiated waste load allocation for a new NPDES permitted discharge may be technically infeasible or at a minimum very costly compared to other disposal options. As a result, discharge to surface water is eliminated from further consideration.

- **Evaporation/Infiltration Basin -** Discharge to an evaporation/infiltration basin likely would require some treatment of the groundwater before it is discharged to the basin. The WUA would be the most likely location of a surface impoundment, because if caps are constructed over portions of the site (e.g., gamma source areas), the borrow soil from the WUA would create a depression that could be used for an infiltration basin.

- **POTW** - Discharge to a POTW would require a discharge permit and approval by the POTW. The amount of pretreatment required would be dependent on flow rate and the concentrations in the groundwater. This option may require sewer improvements to provide additional conveyance capacity to the POTW.

- **Reinjection** - Following treatment, extracted groundwater could be reinjected directly into the aquifer using injection well(s) to replace a portion of the extracted volume. The amount of reinjected water would be dependent upon hydrogeological conditions, water quality, and potentially on State of Idaho and Underground Injection Control (UIC) regulations. However, reinjection using wells is more difficult to implement and is no more effective than an infiltration basin, while typically being much more expensive to construct and maintain. As a result, reinjection has been eliminated from further consideration for use at the site.

5.4.6 Ex-Situ Treatment

Ex-situ treatment technologies would be performed in conjunction with pumping to treat the extracted groundwater to acceptable levels to allow for disposal or recycling. The following ex-situ treatment options have been considered for treatment of contaminated site groundwater and include physical, chemical, thermal and biological processes.

5.4.6.1 Physical Treatment

Physical treatment process options evaluated include solid/water separation, filtration, and other technologies as listed below:

- **Solid/Water Separation** - Separation consists of mechanical and gravity methods for bulk removal of suspended solids from groundwater. Considering that most of the groundwater constituents are in the dissolved phase, separation would most likely not be sufficient as a "stand-alone" technology, but would be incorporated into the treatment train of a larger treatment system.

- **Filtration** - Filtration is applicable for a wide range of solid sizes, but primarily used for "polishing" the final effluent prior to discharge. Often filtration is used downstream of gross solid/water separation. Filtration would not be effective for dissolved metals or orthophosphate (i.e., it would not remove these constituents). Although filtration of some solids may be incorporated into an overall treatment design, it would not be effective as a standalone technology for dissolved constituents.

- **Adsorption** - Adsorption uses various adsorbents to remove dissolved phase constituents from groundwater. Adsorption would be capable of removing metals such as arsenic to levels below MCLs. The influent pH may be required to be increased to improve the efficiency of this technology. Often this technology is used as a polishing step before final discharge to the receiving facility.

- **Ion Exchange** - Ion exchange is a treatment technology in which cation and anion exchange resins are used to remove ions from water/wastewater. Ion exchange resins are selected to preferentially remove specific ions from the feed water and replace them with highly soluble, non-toxic forms. Due to generation and rinsing requirements, the ion exchange process would result in waste materials, which would require further handling and treatment. Ion exchange may be an appropriate option for arsenic and selenium in combination with other technologies.

- **Reverse Osmosis** - Reverse osmosis (RO) is a physical treatment process in which pressurized water is passed through a semi-permeable membrane. The applied pressure to the waste stream is greater than the osmotic pressure of the feedwater. As water passes through the membrane, dissolved constituents in the water are concentrated on the influent (feed) side of the membrane to form the waste brine and a more dilute, pure water is formed on the permeate side of the membrane. Depending upon the feedwater concentrations, the waste brine may be as much as 15-percent to 25-percent of the total feedwater flow. The brine would require further handling and/or treatment prior to disposal. RO would effectively treat metals and total phosphate in the combined influent groundwater stream but at a high cost.

- **Electrodialysis** - Electrodialysis is a very effective membrane process that employs an electronic field as the driving force for separating a liquid influent into a concentrated waste stream and clean effluent. Electrodialysis is typically used for low flow rate and high contaminant concentration wastewater treatment applications. Electrodialysis has not been demonstrated for removing arsenic, the key groundwater risk driver at the FMC Plant OU. Electrodialysis has therefore been eliminated from further consideration for use at the site.

5.4.6.2 Chemical Treatment

Chemical treatment involves processes where the COCs are altered into a less toxic form or precipitated from solution.

- **Solvent Extraction** - Solvent extraction is the separation of constituents from a liquid by contact with another immiscible liquid. Solvent extraction is effective on organic constituents, but is not an effective treatment method for metals removal. Therefore, solvent extraction is not an appropriate technology for COCs in site groundwater and has been eliminated from further screening.

- **Chemical Precipitation** - Chemical precipitation is a treatment method in which dissolved metal ions and/or dissolved salts are precipitated in the form of insoluble salts. Precipitation is the result of the addition of chemicals to reach chemical saturation and/or is achieved by varying the pH. Often filtration is used to remove fines following addition of chemicals and precipitation. The insoluble salts (the precipitate) may be removed from the water using a combination of sedimentation, coagulation, flocculation, and/or filtration. Chemical precipitation is a commonly used technology for removal of metals.

- **Oxidation/Reduction** - Chemical oxidation and reduction, such as combined use of ozonation, chlorination, hydrogen peroxide, and ultraviolet light, employs agents that raise the oxidation states of COCs and oxidize them. Oxidation/reduction reactions have been demonstrated as a standalone process for treatment of organics and possibly for P4 in groundwater. In the case of inorganics, such as arsenic and selenium, oxidation/reduction may improve the separation characteristics and would be used with other technologies for treatment of site COCs.

5.4.6.3 Thermal Treatment

Thermal treatment technologies involve the application of energy in the form of heat to catalyze the COCs to immobilize or detoxify inorganic compounds, or destroy them generating nontoxic constituents (e.g., water and carbon dioxide).

- **Evaporation/Distillation** - Evaporation is a process in which water is heated to the boiling point. The water vapor is condensed to form condensate (distilled water) which is a clean product. The COCs are concentrated in the brine that remains following the heating process. Mechanical evaporation may be an applicable process option for COCs in conjunction with other technologies.

- **Wet Air Oxidation** - Wet air oxidation is a combustion process that occurs in the liquid phase by adding air at high temperatures and pressure. The products of this technology are water, nitrogen compounds, carbon dioxide, and an oxidized liquid stream. While the process is effective at destroying organic compounds, it is not considered effective for inorganics. Therefore, wet air oxidation is not an appropriate technology for COCs in site groundwater and has been eliminated from further screening.

5.4.6.4 Biological Treatment

Biological treatment involves the degradation of COCs by microorganisms. For example, microbial activities can transform organic components to intermediate by-products and basic constituents (e.g., carbon and water), thus reducing concentrations of biodegradable organic compounds. Biological treatment has not been shown to be effective for arsenic and phosphate. Therefore, biodegradation is not an appropriate technology for COCs in site groundwater and has been eliminated from further screening.

5.4.7 In-Situ Treatment

In-situ treatment technologies are designed to treat contaminated groundwater without extracting the water. The following in-situ treatment options have been considered for treatment of contaminated site groundwater and include physical, chemical, thermal, and biological processes.

5.4.7.1 Physical Treatment

- **<u>Mechanical Aeration</u>** - Mechanical aeration would involve injecting air into the subsurface, similar to that done as part of air sparging to oxidize COCs. Mechanical aeration would have the same issues associated with chemical injection. Mechanical aeration would not be effective for treatment of metals, but could be used to oxidize the P4 in the capillary fringe.

5.4.7.2 Chemical Treatment

- **<u>Chemical Injection (Oxidation/Hydrolysis)</u> -** Chemical agents are directly injected into the impacted region of the aquifer to treat groundwater. The injected chemical agents, either oxidizing or reducing compounds, interact with the constituents in the groundwater plume to neutralize, precipitate, immobilize, fixate, or destroy the COCs. Issues associated with chemical injection include heterogeneity of subsurface sediments that result in areas that go untreated, production of undesirable by-products, and incomplete reactions.

- **<u>Permeable Reactive Barrier/ Chemical Injected Reductive Reaction Zone</u> –** These technologies are discussed together because both are closely related and have been applied in combination at several sites. The concept of a permeable reactive barrier (PRB) is relatively simple. Reactive materials are placed in the subsurface, often in a trench, which a plume of contaminated groundwater must move through it as it flows, typically under its natural gradient (creating a passive treatment system). Treated water comes out the other side (EPA, 1998). In addition, injection of reactive media into groundwater upgradient of in-situ PRBs has been used to improve PRB performance and longevity of this kind of treatment system. Treatment media may include zero-valent iron, chelators, sorbents, and microbes to address a wide variety of ground-water contaminants, such as chlorinated solvents, other organics, metals, inorganics, and radionuclides. The contaminants are concentrated and either degraded or retained in the barrier material, which may need to be replaced periodically.

  The majority of installed PRBs use iron metal, zero valent iron (Fe(0)), as the reactive media for converting contaminants to nontoxic or immobile species. Iron metal has the ability to reductively dehalogenate hydrocarbons, such as converting trichloroethene (TCE) to ethene. It also can reductively precipitate anions and oxyanions, for example, converting soluble Cr(VI) oxides to insoluble Cr(III) hydroxides.

  Zero-valent iron has performed successfully in PRB technology and is now being applied directly for source zone treatment, though this latter measure is not considered a PRB, pneumatic fracturing and injection, hydraulic fracturing, and injection via direct push rigs have been used to introduce the reactive media to the ground-water or soil source area.

5.4.7.3 Thermal Treatment

- **<u>Thermal Desorption</u> -** ISTD uses thermal wells, along with heated extraction wells, to remediate COCs. Heat is applied using a high-temperature surface in contact with the groundwater and aquifer matrix, so that radiation and thermal conduction heat transfer are effective near the heated extraction wells. As a result, thermal conduction and convection occur in the soils above the aquifer and the aquifer mass (i.e., sediments and groundwater) between the heated wells. Near the heated wells is a zone of very high temperature (>1000 °F), which can oxidize or pyrolize contaminants. A soil vapor extraction system is used to remove contaminants from the subsurface for further treatment or disposal. ISTD primarily has been used to treat organic contaminants, including free product in the form of LNAPLs or DNAPLs.

5.4.7.4 Biological Treatment

In-situ biological treatment of groundwater uses the same principles of ex-situ biological treatment. It consists of enhancing the biological degradation of organic constituents by microorganisms. In-situ biological treatment is not considered effective for treatment of the COCs found at the site (i.e., primarily inorganics). Therefore, in-situ biodegradation is not an appropriate technology for COCs in site groundwater and has been <u>eliminated</u> from further screening.

5.4.8 Summary of Preliminary Groundwater Technology Screening

This Section 5.4 has presented all of the possible process options and technologies for remediation of groundwater at the FMC Plant OU. These technologies and process options have been initially screened based on their potential technical implementability for treating the COCs in groundwater encountered at the FMC Plant OU. The technologies that have not been eliminated based upon this preliminary screening for technical implementability are retained for further screening according to implementability (administrative and technical), effectiveness, and cost in Section 6. The groundwater technologies considered for remediation of the FMC Plant OU groundwater and those that are retained for further screening in Section 6 are summarized in Table 5-2b.

TABLE 5-1a
SUMMARY OF CONTAMINATED FILL/SOIL VOLUME BY RU
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Remediation Unit	Estimated Area (Acres)	Estimated Fill/Soil - Volume (cubic yards)
Remediation Units		
1	4.1	56,580
2	3.7	20,485
3	1.3	15,860
4	2.5	28,830
5	0.6	7,140
6	1.4	28,294
7	25.0	487,542
8	6.7	41,630
9	12.9	206,110
10	1.3	22,883
11	8.4	169,230
12	11.6	129,165
13	3.6	66,630
15	11.7	212,370
16	15.1	92,750
17	8.1	See note (1)
18	9.4	See note (1)
19 - Slag Pile	143	14,528,100
19a - Bullrock	Included in RU 19.	Included in RU 19.
19b - Former Plant Landfill	20.3	3,924,667 [(2)].
19c - Buried Railcars	2.7	300,000 [(3)]
20	61.6	735,790
21	TBD	TBD
22b	53.6	595,820
22c	2.4	40,607
23	23	33,904
24	52.5	565,430
Northern Property Parcel 1	52	13,983 [(4)]
Northern Property Parcel 2	52	13,983 [(4)]
Northern Property Parcel 3	15	4,034 [(4)]
Northern Property Parcel 4	40	10,756 [(4)]
Northern Property Parcel 5	31	8,336 [(4)]
Northern Property Parcel 6	16	4,302 [(4)]

Notes:

(1) The total weight of wastes within RU 17 and RU 18 (not counting cover materials) has been estimated to be 2,600 and 5,200 tons, respectively. However, no alternative within the SFS contemplates removal of the waste and/or cover material. Therefore a volume has not been determined.

(2) This is the volume of slag overlying the former landfill in RU 19b which is also accounted for in the volume of RU 19. The weight of waste materials (excluding slag) in RU 19b has been estimated to be 9,000 tons.

(3) This is the volume of slag overlying the railcars in RU 19c which is also accounted for in the volume of RU 19. The weight of P4 and P4-contaminated materials that would have to be treated if excavated is estimated to be 1,000 tons.

(4) Assumes a 2-inch soil contamination depth.

TABLE 5-1b

SUMMARY OF CONTAMINATED FILL/SOIL VOLUME BY REMEDIATION AREA (RA)

SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Remediation Area	Estimated Area (Acres)	Estimated Fill/Soil - Volume (cubic yards)
Remediation Areas		
RA-A	103	1,203,234
RA-A1	> 1	4,205 [1]
RA-B	10.8	135,570
RA-C	34.6	410,165
RA-D	33.6	350,606
RA-E	21.2	171,423
RA-F	171	14,841,591
RA-F1 (Buried Railcars)	2.7	300,000 [2]
RA-F2 (Former Landfill)	20.3	3,924,667 [3]
RA-G	65.8	1,078,092
RA-H	17.5	See note (4)
RA-I	191	42,963
RA-J	15	4,028
RA-K (Railroad Swale)	1.3	22,000

Notes:

(1) This volume includes only the hydrocarbon-contaminated soils within RA-A1 and does not include the overlying slag which is accounted for in RA-A.

(2) This is the volume of slag overlying the railcars in RA-F1 which is also accounted for in the volume of RA-F. The weight of P4 and P4-contaminated materials that would have to be treated if excavated is estimated to be 1,000 tons.

(3) This is the volume of slag overlying the former landfill in RA-F2 which is also accounted for in the volume of RA-F. The weight of waste materials (excluding slag) in RA-F2 has been estimated to be 9,000 tons.

(4) The total weight of wastes within RA-H (not counting cover materials) has been estimated to be 7,800 tons. However, no alternative within the SFS contemplates removal of the waste and/or cover material. Therefore a volume has not been determined.

TABLE 5-2a

SUMMARY OF INITIAL SOIL TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 1 of 2)

SOIL/SOLIDS			
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Initial Screening Results**
No Action	No Action	NA	Retain
Institutional Controls	Access Restrictions	Fencing	Retain
		Land and Groundwater Use Restrictions	Retain
		Soil Management	Retain
	Receptor Initiated Remediation	Receptor Initiated Remediation	Retain
Containment	Capping	Multi-Layered Cap	Retain
		Asphalt/Concrete Cap	Retain
		ET Cap	Retain
		Soil Cover (Gamma) Cap	Retain
	Vertical Barrier	Sheet Piling	Reject
		Grout Wall	Reject
	Surface Controls	Soil Grading	Retain
		Vegetation	Retain
Removal and Disposal	Removal	Modified and Conventional Excavation	Retain
		Wet Dredging	Reject
		Hydraulic Pumping	Reject
	Disposal	Consolidation and On-Site Disposal	Retain
		Off-Site Disposal	Retain
Ex-Situ Treatment	Physical	Stabilization/Solidification	Retain
		Mechanical Aeration	Reject
		Dewatering	Reject
		Separation	Reject
	Chemical	Chemical Oxidation	Retain
		Caustic Hydrolysis	Retain
		Chemical Extraction	Reject
	Thermal	Incineration	Retain
		Thermal Desorption	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 6.

TABLE 5-2a

SUMMARY OF INITIAL SOIL TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 2 of 2)

Soil/Solids			
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Initial Screening Results**
Ex-Situ Treatment (cont.)		ERCO Pot Still	Reject
	Biological	Landfarming	Retain
In-Situ Treatment	Physical	Stabilization/Solidification	Retain
		Mechanical Aeration	Reject
		Soil Vapor Extraction	Reject
	Chemical	various in-situ processes	Reject
	Thermal	Vitrification	Reject
		Thermal Desorption	Reject
	Biological	various In-situ processes	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 6.

TABLE 5-2b

SUMMARY OF INITIAL GROUNDWATER TECHNOLOGY SCREENING

SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

GROUNDWATER			
General Response Action	**Treatment Technologies**	**Process Options**	**Initial Screening Results**
No Action	No Action	NA	Retain
Institutional Controls	Access Restrictions	Fencing	Retain
		Land and Groundwater Use	Retain
	Monitoring	Groundwater Monitoring	Retain
Source Controls	Various Caps or Treatment Options	(process options retained in Soil Technologies)	Retain
Containment	Vertical Barriers	Extraction Wells	Retain
		Injection Wells	Reject
		Cut-off (Slurry or Grout) Wall	Reject
Removal and Disposal	Removal	Pumping	Retain
	Disposal	Recycle/Reuse	Retain
		Surface Water	Reject
		Evaporation/Infiltration Basin	Retain
		POTW	Retain
		Reinjection Wells	Reject
Ex-Situ Treatment	Physical	Solid/Water Separation	Retain
		Filtration	Retain
		Adsorption	Retain
		Ion Exchange	Retain
		Reverse Osmosis	Retain
		Electrodialysis	Reject
	Chemical	Solvent Extraction	Reject
		Chemical Precipitation	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 6.

TABLE 5-2b

SUMMARY OF INITIAL GROUNDWATER TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

GROUNDWATER			
General Response Action	**Treatment Technologies**	**Process Options**	**Initial Screening Results**
Ex-Situ Treatment (continued)	Chemical (continued)	Oxidation/Reduction	Retain
	Thermal	Evaporation/Distillation	Retain
		Wet Air Oxidation	Reject
	Biological	Biological	Reject
In-Situ Treatment	Physical	Mechanical Aeration	Retain
	Chemical	Chemical Injection (Oxidation /Hydrolysis)	Retain
		Permeable Reactive Barrier (PRB) / Chemical Injected Reductive Reaction Zone	Retain
	Thermal	Thermal Desorption	Retain
	Biological	Biological	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 6.

Section 6
FINAL SCREENING OF REMEDIAL TECHNOLOGIES

In this section, the potentially applicable remedial technologies and associated process options identified in Section 5 as potentially viable, based on their technical implementability, are systematically screened and retained or eliminated in accordance with the *EPA RI/FS Guidance*, which states:

"……In the fourth step of alternative development, the technology processes considered to be implementable (technically) are evaluated in greater detail before selecting one process to represent each technology type. One representative process is selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design……Process options are evaluated using the same criteria – effectiveness, implementability, and cost – that are used to screen alternatives prior to the detailed analysis……the evaluation should typically focus on effectiveness factors at this stage with less effort directed at the implementability and cost evaluation."

As depicted in Figure 1-6 and instructed in the text above, the technologies and process options are screened in this section to address the various human health and environmental impacts identified for COCs detected at the FMC Plant OU. The three screening criteria used are:

- Effectiveness
- Implementability
- Cost

The remedial technologies and process options that are retained from this final screening step are then assembled into several comprehensive remedial alternatives for contaminated soils/fill and groundwater at the site. This process allows the development of remedial alternatives to be streamlined by limiting the number of technologies for each medium requiring remediation, and thereby also putting parameters on the assembly of remedial alternatives. More detail on the assembly and screening of technologies and their process options is provided below.

6.1 TECHNOLOGY SCREENING METHODS

The general response actions (GRAs) and the full range of technology types and process options that were identified in Section 5 for soils and groundwater included all those originally screened in the *1997 FMC Subarea FS.* However, additions and deletions have been made to the list of the original technologies based on the findings of the *SRI Report, SRI Addendum Report*, *GWCCR*, the supplemental documents that augment this *SFS Report* (included as appendices to this report), and EPA reviews and comments on interim SFS deliverables.

In the final screening of technologies presented in this section, medium-specific and area-specific technologies are evaluated based on their anticipated effectiveness, potential implementability, and order of magnitude estimates of cost. Similarly, process options for each technology are screened relative to each other based on these same criteria. Tables 6-1 and 6-2 are presented to summarize the screening of soil and groundwater technologies, respectively, using these three primary criteria. Additional information also is included in Table 6-1 (the soil remediation technology screening table) because of site-specific considerations associated with remediation of P4. This is further discussed in Section 6.2.

The goal of this screening step is to further reduce the number of remaining process options to a subset consisting of *only* the most viable technologies for the development of remedial alternatives for each environmental medium within the RAs present at the FMC Plant OU. Consistent with the development of the RAOs, GRAs, and the initial technology screening presented in Sections 4 and 5, final screening is conducted for technologies applicable to COCs, media, and other site-specific conditions within each RA.

6.1.1 Effectiveness Evaluation

The primary measure of effectiveness used in the screening evaluation is the degree to which a process option would contribute to achievement of the RAOs for the site. Other effectiveness criteria specified in Section 4.2.5.1 of the *EPA RI/FS Guidance* are summarized here:

- The capacity to handle the estimated areas or volumes of media to be remediated;
- Potential impacts to human health and the environment during the construction and implementation phase; and
- The demonstrated reliability with respect to the COCs and conditions at the site.

Process options also were evaluated on the basis of effectiveness relative to other process options within the same technology type.

6.1.2 Implementability Evaluation

The technologies and process options eliminated from further consideration based upon their technical implementability during the initial screening process are discussed in Section 5. The technical and administrative feasibility of implementing remaining technologies or process options is further considered during the final evaluation of the remaining technologies. The *EPA RI/FS Guidance* states: *"….technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits* *for offsite actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology."*

As a result, administrative aspects of implementability are emphasized in this final round of technology screening.

The technical literature also was reviewed to determine where a particular technology might have been implemented, the physical conditions of the site remediated, and if the technology performed as intended. This final implementation criterion was especially critical for P4 technologies. Many such technologies exist, but very few have been implemented at full scale. EPA, USACE, and FMC have prepared documents evaluating P4 treatment technologies for the FMC Plant OU. EPA's report entitled *Treatment Technologies for Historic Ponds Containing Elemental Phosphorus – Summary and Evaluation* (*2003 Treatment Technology Report*, EPA, 2003) was specifically focused on treatment of P4-containing sludges within ponds at the FMC Plant Site. USACE's report entitled *Remediation of P_4 Contaminated Matrices at FMC, Pocatello, Idaho – January 2009* (USACE, 2009) provided an independent assessment of technologies to remediate the P_4 contamination at the FMC Plant Site.

FMC's report, *P4 Treatment Technologies*, was prepared to aid in EPA/stakeholder review of the alternatives screening tables for soils and groundwater in which technologies for P4 treatment are evaluated. The *P4 Treatment Technologies Report* is provided in Appendix A. As the findings of EPA's *2003 Treatment Technology Report* are central to the SFS P4 treatment technology evaluation and screening, a summary, discussion and update of those findings are presented in Section 6.1.2.1. The general findings of FMC's 2009 *P4 Treatment Technologies* report are presented in Section 6.1.2.2. The USACE report did not identify any new or different P4-treatment technologies that were not otherwise discussed in either the EPA or FMC reports.

6.1.2.1 Updates To the Overall Findings of EPA's 2003 Treatment Technologies Report

EPA Report Finding No. 1: No technology has been used at full-scale to treat waste material similar to that found at the FMC Plant Site.

<u>*Summary of EPA finding No. 1*</u>***:*** *Only limited information is available in the literature covering the remediation of white phosphorus (WP), with fewer than 10 studies identified that discuss the potential use of treatment technologies for WP. This primarily includes studies performed at WP manufacturing facilities and at military facilities. While technologies have been used to treat WP in bench- and pilot-scale studies, no technologies were identified as having been used for full-scale treatment.*

<u>*Current Update to EPA Finding No. 1*</u>*:* Based upon the review of internal FMC technical documents related to P4, discussions with personnel at other P4 manufacturing facilities, review of technical information from these sources related to P4 treatment, and search of

the Internet for technical documents related to P4 treatment, there have been no significant developments in P4 treatment technologies since 2003.

EPA Report Finding No. 2: No new treatment technologies have emerged as potentially applicable since the EMF Feasibility Study.

*Summary of EPA finding No. 2**:** The six technologies in the 2003 EPA report had been identified in the Feasibility Study for the FMC Subarea prepared in 1996.*

<u>*Current Update to EPA Finding No. 2*</u>*:* Again, no new treatment technologies have emerged as potentially applicable to the FMC Plant Site.

EPA Report Finding No. 3**: **Other WP manufacturing facilities primarily used capping as the remedy for similar waste.

<u>*Summary of EPA findng No. 3*</u>***:*** *Eight other WP manufacturing sites were identified that have similar contaminated historical ponds as those at the FMC Plant OU. Six of the eight sites have installed or plan to install caps. For the two remaining sites, one (Rhodia, located at Silver Bow, Montana) indicated that the ponds are not under corrective action or closure programs that would require capping, and the other (Stauffer, located at Tarpon Springs, Florida) is evaluating a remedy of in situ S/S.*

<u>*Current Update to EPA Finding No. 3*</u>*:* EPA's finding regarding the WP manufacturing sites that have installed or plan to install caps as soil/solid waste remedies remains valid, although additional WP sites have been identified where the final remedy also has included capping / containment. Updates regarding the Rhodia-Silver Bow and Stauffer-Tarpon Springs sites are provided below.

The Rhodia, Inc. phosphorus manufacturing facility in Silver Bow, Montana is currently evaluating treatment technology for waste in a process clarifier consisting of solidified, phosphorus-rich (20%) sludge. Rhodia is conducting this evaluation under the RCRA corrective action program. The clarifier is 100 feet in diameter, 12 feet deep, open-topped, with reinforced concrete walls and base. It contains 8 to 9 feet of phosphorus-rich waste, covered by more than 2 feet of water. To date, this evaluation has not yielded a selected corrective action.

The Stauffer site in Tarpon Springs, Florida completed a treatability study after the 2003 EPA Report that evaluated in-situ S/S. In-situ S/S has since been rejected as not being viable and a capping remedy has been selected. See the *Explanation of Significant Differences # 4* (ESD #4) for the Tarpon Springs site as included in Appendix F of this *SFS Report* and the discussions below.

EPA Report Finding No. 4: Minimal performance data currently exist for use of the six technologies to treat similar waste material as found at EMF.

Summary of EPA finding No. 4: *Performance data were identified for treatment of WP using chemical oxidation, mechanical aeration, and incineration. However, these data are not for treatment of wastes in historical ponds at a WP manufacturing facility. Performance data for chemical oxidation and mechanical aeration are for work at bench- and pilot-scale, while data for incineration are for ordnance wastes with a higher percentage of WP than found in the FMC historical ponds. Thermal desorption was used for the treatment of WP in contaminated soil. Recent attempts to obtain specific information on the project revealed that the technology vendor was sold to another company. Personnel at this company were not familiar with the current availability of the technology. Therefore, it is unknown if the WP-contaminated soil was similar to waste material as found at the FMC Plant OU and no specific performance data were available for review. No performance data were identified for treatment of WP using S/S and caustic hydrolysis. Both technologies have been considered for the treatment of similar waste material at WP manufacturing sites.*

The Stauffer site in Tarpon Springs, Florida is planning to test in situ S/S in 2003. Although the information from this test program could be used to evaluate the effectiveness of S/S at the FMC Plant OU, the test program at Tarpon Springs may not be an accurate predictor of performance for the FMC Plant OU waste. Reasons for this include: the type of phosphate ore used at Tarpon Springs is different from that used at EMF, elemental phosphorus is not a primary contaminant at Tarpon Springs, and the scale of the Tarpon Springs site is smaller. Caustic hydrolysis was considered for use at the Rhodia site in Silver Bow, Montana. In addition, caustic hydrolysis was identified as the Land Disposal Restrictions treatment technology for process waste streams from the FMC plant, but construction of that treatment system was halted with the plant shutdown.

Current Update to EPA Finding No. 4: In February 2006, Stauffer initiated the field-scale studies for in-situ solidification and stabilization within Pond 48. As a result of the cement curing, the P4 ignited and created a persistent fire. The Field Scale study was discontinued due to the fire, resulting air emissions from phosphorus hydrolysis and oxidation , and uncertainty regarding the potential locations of buried P4 that could create additional fires. In May 2007 a modified remedy was selected consisting of the construction of a groundwater cut-off wall and cap as a replacement for the planned in-situ stabilization remedy.

EPA Report Finding No. 5: Additional testing would be necessary to assess whether treatment technologies could perform adequately across a range of contaminant concentrations and properties of the waste material as found at EMF.

Summary of EPA finding No. 5: *Limited site characterization data are available and the historical ponds are assumed to be heterogeneous in physical and chemical composition. Therefore, extensive site assessment and treatability testing would be needed to verify the potential for any technology to treat the soil and sludge at the FMC Plant OU.*

Treatability tests would include evaluating how the technology would perform for the specific matrices in the different ponds, and the variations in performance across the range of concentrations and physical properties.

Although the six technologies are at various stages of commercial development, the technologies would all require testing to establish that they could perform reliably for the waste material in the historical ponds. S/S, chemical oxidation, incineration, and thermal desorption have been applied commercially at full-scale for site remediation, but have not been used to treat WP pond material. Caustic hydrolysis and mechanical aeration have not been used extensively for site remediation, and significant developmental testing would be required for scale-up along with treatability testing. Developmental and treatability testing for the six technologies would require additional time and resources to undertake.

Current Update to EPA Finding No. 5: No additional input to this finding.

EPA Report Finding No. 6: A series of technologies may be necessary to collectively treat all the types of contaminants.

*Summary of EPA finding No. 6**:** The soil and sludge in the historical ponds contain multiple types of contaminants that all may require treatment. For example, incineration, thermal desorption, mechanical aeration, and chemical oxidation show potential to treat WP, but would not be able to treat heavy metals or radionuclides. In these cases, an additional treatment process would likely be needed, such as S/S, using what is often referred to as a "treatment train."*

Current Update to EPA finding No. 6: No additional input to this finding.

EPA Report Finding No 7: Of the six technologies, only S/S and caustic hydrolysis have the potential to be effective for treatment of heavy metals and radionuclides.

*Summary of EPA finding No. 7**:** S/S is applied frequently at full-scale to reduce the mobility of heavy metals (radionuclides are expected to behave in a manner similar to heavy metals) at contaminated sites. Caustic hydrolysis would convert heavy metals to metal oxides and hydroxides, which generally are less soluble than the metal compounds, and could be removed by filtration or settling processes.*

Current Update to EPA Finding No. 7: It is not clear that caustic hydrolysis would treat waste streams containing metals or radionuclides to levels that would not require further treatment. At a minimum, treatability studies would be necessary to evaluate effectiveness of caustic hydrolysis in treating all COCs at the site.

<u>EPA Report Finding No 8:</u> ***Soil and sludge may require pre-processing to homogenize the material for use by treatment technologies.***

<u>Summary of EPA finding No. 8</u>: *Pre-processing may include crushing, grinding, or milling, to break up large masses of soil and sludge. For both ex-situ and in-situ technologies, pre-processing may be necessary depending on the distribution of contaminants in the ponds and the methods used to implement the treatment technologies.*

<u>Current Update to EPA finding No. 8</u>: As discussed in the *2009 P4 Treatment Technologies Report*, ancillary processes: 1) are integral to the overall remedial alternative, 2) present engineering challenges as difficult as the treatment process itself, 3) will have major cost impacts, and 4) pose significant potential environmental, site worker safety and public safety issues. The remedial action evaluation would need to consider the capital and O&M costs and other decisional criteria with respect to the measures that would be required to safely pre-process the soils, sludges, and fill materials before implementing treatment technologies.

<u>EPA Report Finding No 9:</u> ***Residuals from treatment, such as solid, liquid, or gaseous materials, would require further management.***

<u>Summary of EPA finding No 9</u>: *Residual management may include characterizing and transporting these residuals to a storage or disposal facility (on- or off-site), or performing further treatment (such as for off-gases) prior to release to the environment.*

<u>Current Update to EPA finding No. 9:</u> Management of residuals likely would have significant implementability and cost impacts, and could pose significant potential environmental, site worker safety and public safety issues. The remedial alternative evaluation including the cost analysis would have to consider the capital and O&M costs and other factors associated with implementing the measures that would be needed to manage residuals.

<u>EPA Report Finding No. 10:</u> ***The estimated volume of waste material to treat (500,000 cubic yards) would entail a large remediation project, including significant engineering issues.***

<u>Summary of EPA finding No. 10</u>: *The physical layout of the site, where historical ponds are located near RCRA ponds, structures, and slag piles, may impact the implementation of a treatment technology, including the need for space to stage equipment or to store material before or after treatment.*

<u>Current Update to EPA Finding No. 10</u>: Based upon the current estimates for RUs 1, 2, 13, 22b, and 22c and areas with underground piping potentially containing P4, the total volume of materials to be treated in areas impacted by P4 is estimated at 780,122 yd^3. The total amount of P4 within this volume is estimated to range from 5,050 to 16,380 tons.

***<u>EPA Report Finding No. 11:</u>* Site workers would need to follow stringent health and safety precautions for handling soil or sludge containing WP.**

*<u>Summary of EPA finding No. 11</u>***:** *WP is an inorganic compound that ignites spontaneously in warm air. It is toxic by ingestion and inhalation, and skin contact with WP causes burns. Site workers would likely need to use Level C personal protective equipment (respiratory and skin contact protection) when conducting work on the soil or sludge in the historical ponds. In addition, health and safety precautions related to metals and radionuclides would also have to be considered.*

<u>Current Update to EPA Finding No. 11</u>: Although neither the EPA *2003 Treatment Technologies Report* nor this paper was intended as a full evaluation of the health and safety precautions necessary for site remediation workers, very stringent worker protection measures certainly would be required. It is clear that Level C PPE would not be sufficient or adequate to protect against thermal burn hazards and/or gas generation associated with P4 reactions (which could include PH_3). For any work inside enclosures where P4 gases were present, supplied air would be necessary (Level A PPE) in addition to aluminum gear to prevent direct dermal exposure to P4. The remedial action evaluation would need to address the capital and O&M costs and other factors associated with the needed health and safety precautions, protections, and procedures.

***<u>EPA Report Finding No. 12:</u>* The cost to implement any of the six treatment technologies would be high, based on the criteria used to identify high cost projects by EPA's National Remedy Review Board (NRRB).**

*<u>Summary of EPA finding No. 12</u>***:** *The NRRB identifies high cost remedial actions as those that cost more than $30 million, or more than $10 million and 50 percent greater in cost than the least costly cleanup alternative. Although the technology cost estimates in this report could be above or below the actual costs, the actual total treatment costs are likely to be higher. Specifically, the technology costs estimates do not include costs for associated project components, such as excavation (if required), preprocessing of waste material, health and safety (such as ambient gas control), and residual management, which could be integral parts of a remediation project at the FMC Plant OU using any of the six technologies.*

<u>Current Update to EPA Finding No. 12</u>: FMC has prepared SFS-level cost estimates associated with the screened P4 treatment technologies that are presented in Section 7 of this *SFS Report*.

6.1.2.2 General Findings of FMC's 2009 P4 Treatment Technologies Report

The following are the general findings of the *P4 Treatment Technologies* report:

- When screening and evaluating remedial technologies for P4-impacted materials, it is very important to consider the ancillary process options that would be necessary to complete the overall P4 treatment train. While some components of these ancillary process options have been used in other settings, none have been applied directly to materials representing a combination of P4/soil/fill materials like those present at the FMC Plant Site. Ancillary process options, especially those associated with ex-situ treatment, may present greater challenges for implementability than the treatment technology itself.

- Treatability studies for one or more of the ancillary and treatment processes likely would be required before categorizing any of the P4 treatment technologies as viable remedial options.

- EPA's 2003 *Treatment Technologies Report* appears to have been a complete and accurate evaluation of the availability of treatment technologies, the level of development, and the challenges of implementing a full-scale treatment system.

The following is a brief summary of the P4 treatment technologies identified and evaluated in the *P4 Treatment Technologies* as applied to the types of soils and fill materials found at the FMC Plant OU.

- <u>Stabilization and Solidification (S/S)</u>: S/S is potentially applicable, either in-situ or ex-situ, to areas with metals and radionuclides (but without P4 contamination) although would not likely be effective at addressing gamma. S/S might also be potentially applicable ex-situ to small volumes of shallow soils with low P4 impacts, e.g., soils around process piping that may have leaked, although likely not for the piping itself. S/S is likely not applicable for in-situ application for P4-impacted soils due to the inability to control mixing and reaction in variable P4 concentrations within the soils, similar to the experience at Tarpon Springs.

- <u>Mechanical Aeration</u>: While aeration has been used successfully applied at a site where relatively shallow, low-concentration P4 exists in soils (Eagle River Flats), in-situ aeration or mechanical aeration is likely not applicable for P4-impacted soils at the FMC Plant OU due to the inherent safety risks of controlling P4 burning and gas generation rates in soils with highly, locally variable levels of P4 impact. Also, ex-situ mechanical aeration is likely not applicable due to lack of performance testing: even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity. Mechanical aeration also does not address radionuclides and metals and would require combination with other remedial technologies to address all co-located COCs.

- <u>Caustic Hydrolysis</u>: Caustic hydrolysis is likely not applicable for in-situ application due to the inherent safety risks of controlling P4 burning and gas generation rates in soils with highly, locally variable levels of P4 impact. It may be applicable for ex-situ treatment of shallow P4 impacted soils where P4 concentrations are generally < 2 % in a matrix without significant amounts of larger particles (e.g., slag). Those parameters are necessary to provide some assurance of overcoming feed material sizing and blending challenges, above and beyond the excavation challenges that also would have to be met. To the extent that RU 13, 22b and 22c contain some portions of P4-impacted soils that meet these parameters, caustic hydrolysis, in combination with other technology (treatment or containment) for the generally much larger portion of those RUs where this technology would not be applicable, may warrant further evaluation. EPA (2003) indicates that caustic hydrolysis may convert some heavy metals present in process feed material (from site soils) to metal oxides and hydroxides. These metal oxides and hydroxides may not require additional treatment, although further testing would be required in this regard. The fate of radionuclides in the caustic hydrolysis process would also have to be determined.

- Chemical Oxidation: Chemical oxidation is likely not applicable for in-situ application for P4-impacted soils due to the inherent safety risks of controlling gas generation rates in soils with highly, locally variable levels of P4 impact. Chemical oxidation is also likely not applicable for ex-situ application due to lack of performance testing. This means that even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies are potentially more effective in reducing P4 mobility and toxicity.

- Incineration: Incineration is an ex-situ treatment technology only. Use of off-site incineration is potentially applicable to small volumes of shallow soils with low P4 impacts, e.g., soils around process piping that may have leaked. Off-site incineration is likely not applicable for large volumes due to transportation risks inherent with the total number of truck loads required and the packaging requirements (containers of 55 gallons or less). On-site incineration is likely not applicable due to the inability to treat other co-located COCs. Even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity as well as metals and radionuclides. On-site incineration also is likely not applicable due to the stringent design, environmental evaluation and operational requirements that would have to be met.

- Thermal Desorption: Thermal desorption is an ex-situ treatment technology that is similar to incineration, but the treatment temperatures are much lower. Unlike offsite incineration, there are no known commercial offsite thermal desorption systems in operation so the system would have to be built on-site. Use of thermal desorption is potentially applicable to small volumes of shallow soils with low to moderate P4 impacts, e.g., soils around process piping that may have leaked. Thermal desorption is likely not applicable due to the inability to treat other co-located COCs (i.e., metal and radionuclides). Alternate technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity as well as metals and radionuclides, again assuming that excavation, feed material sizing, and blending challenges could be overcome.

6.1.3 Cost Evaluation

The cost analysis is performed on the basis of information in EPA guidance documents, experience in costing similar projects, independent estimate, and engineering judgment. The costs of implementing process options relative to other options in the same technology type were estimated as high, moderate, and low for both capital costs and the operation and maintenance (O&M) costs. Where applicable, the volume/area estimates contained in Section 5 were considered in estimating the anticipated costs of each process option. In accordance with the *EPA RI/FS Guidance*, those process options providing similar effectiveness at significantly higher relative costs are eliminated from further consideration in this final screening stage.

6.2 TECHNOLOGY SCREENING FOR SOILS AND FILL

Potentially applicable technologies for the remediation of impacted soils/fill at the FMC Plant OU were identified and preliminarily screened in Section 5.2. In this section, the technologies that address soils and fill are further screened against the three criteria discussed above. The reasons for retaining or eliminating each technology are presented below, with a description of where in the FMC Plant OU each retained technology may be applicable. General response actions, technologies, and process options retained as a result of this screening process are further evaluated in Section 7 where they are combined or “assembled” into site-wide alternatives.

The screening of the remedial technologies that address soil and fill is briefly summarized in Table 6-1 and discussed in more detail in the following subsections, based on the three primary screening criteria. Given the unique conditions at the site (e.g., presence of P4 in soils/fill), additional information on safety and site-specific considerations also is discussed below and included in Table 6-1. This additional information is critical to provide site-specific information that is necessary to evaluate and select or reject a particular technology. The treatment technologies and process options are discussed below in the context of the general response action categories, as they were in Section 5 (i.e., “no action”, institutional controls, containment, removal and disposal, ex-situ treatment and in-situ treatment).

6.2.1 “No Action”

The “no action” option is always carried forward as a baseline case in the FS process and is required by the NCP, as discussed in the *EPA RI/FS Guidance*. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

<u>Effectiveness</u>: Acceptable for constituents that meet ARARs and RAOs.

<u>Implementability</u>: Not applicable.

Cost: None

Safety Concerns During Construction: No increased hazard to remedial site workers or to the public.

Decision Rationale: This option is always retained in the FS as a base case and may be used in areas that pose no risk.

Site-Specific Considerations: This option may be appropriate for areas that pose no risk.

Potentially Applicable to RAs: Potentially applicable to RAs that meet the RAOs.

Retained: Yes

6.2.2 Institutional Controls

Institutional controls encompass both engineering and administrative controls implemented to limit site access and use. The primary institutional controls anticipated for use on the FMC Plant OU include fencing, land use restrictions, and soil management, each of which are discussed below. In addition, receptor-initiated remediation (RIR) introduced in Section 5 as a process option under institutional controls is screened below.

6.2.2.1 Access Restrictions

Access restrictions involve fencing and deed restrictions/covenants to limit site access and future use.

- Fencing - The fencing option restricts the ability of humans and animals to enter certain areas of the FMC facility Plant OU. By limiting access to specific areas, fencing contributes to a reduction of risk by reducing the potential for exposure through direct contact with COCs. However, it does not reduce the toxicity, mobility, or volume of the COCs. Evaluation of this process option against the three screening criteria and additional site considerations are presented below.

  Effectiveness: Effective for prevention of direct contact with all site constituents of concern in soil and for prevention of direct gamma exposure from radionuclides of concern in soil, reducing direct exposure risks. Does not address minimizing infiltration of precipitation at potential sources of constituent migration to groundwater or exposure to wind-blown dust.

  Implementability: Straightforward to implement.

Cost: Low capital, low O&M.

Safety Concerns During Construction: Low hazard to remedial site workers and no hazard to the public.

Decision Rationale: Fencing is effective at limiting access and direct exposure to COCs on the site. Fencing is typically part of a selected remedial alternative.

Site-Specific Considerations: Fencing is already in place around most of the FMC Plant Site perimeter, although some fence improvements may be required.

Potentially Applicable to RAs: Applicable to restricting access to portions of the site after implementation of remedial actions (e.g., capped areas).

Retained: Yes

- Land Use Restrictions - Deed restrictions and covenants are legal mechanisms to restrict future land uses at the site to prevent/control potential future exposure to contaminants or prohibit uses that may interfere with the integrity of the remediation. For example, deed restrictions or other legally binding restrictions for contaminated sites could limit or prohibit future residential or agricultural uses of the land and activities that involve excavation or other site disturbances. Evaluation of this option against the three screening criteria and additional site considerations are presented below.

  Effectiveness: Effective at prohibiting designated types of land (e.g., residential) or groundwater (e.g., human consumption) use through legal mechanisms such as deed restrictions, covenants, and environmental easements that have continuing effect in perpetuity or until occurrence of a defined terminating event.

  Implementability: Straightforward to implement.

  Cost: No capital, low O&M.

  Safety Concerns During Construction: No hazards to the remedial site workers or to the public.

  Decision Rationale: Deed restrictions are effective at limiting access and direct exposure to COCs (both soil and groundwater) on the site. Deed restrictions are typically part of a selected remedial alternative.

  Site-Specific Considerations: Deed restrictions preventing residential land use are already in place on all FMC Plant OU properties with the exception of the Batiste Spring property (Parcel 6). FMC is in the process of placing similar restrictions at the Batiste Springs parcel prohibiting development for residential use or operation of child-care or schooling facilities. Land use and groundwater use restrictions were selected in the 1998 ROD and are still an appropriate component of the remedy. It is likely that deed restrictions would be placed on all areas not receiving a “no further action” determination.

Potentially Applicable to RAs: Potentially applicable to restricting access and land use across the entire site.

Retained: Yes

- Soil Management - Excavation of soil may be required during future site activities (e.g., installation of foundations or utilities). In areas that do not meet soil RAOs and where caps are installed, soil management will be required to ensure that fill materials placed under a cap are not re-distributed to the surface. A soil management plan would be developed to provide procedures for handling excavated soils and repairs to any cap. A soil management plan would be developed and made enforceable under deed restrictions to prescribe procedures for excavating, handling, and disposing of contaminated site soil/fill. Evaluation of this option against the three screening criteria and additional site considerations are presented below.

  Effectiveness: Effective for controlling the inappropriate redistribution of fill (e.g., excavations that would bring slag to the surface of a gamma cap).

  Implementability: Straightforward to implement. Would be incorporated in any deed restrictions recorded on the property deed after EPA issuance of the ROD.

  Cost: Low capital, low O&M

  Safety Concerns During Construction: No hazards to the remedial site workers or to the public.

  Decision Rationale: Soil Management establishes practices for future management of contaminated fill materials remaining on the site. Soil Management is typically part of a selected remedial alternative.

  Site-Specific Considerations: Incorporated into a deed restriction and thereby made enforceable with respect to any future intrusive activities in areas that were not remediated to levels below the RAOs for soils/fill.

  Potentially Applicable to RAs: Potentially applicable to areas where redistribution of fill to the surface is a concern.

  Retained: Yes

6.2.2.1 Receptor-Initiated Remediation

Receptor-initiated remediation (RIR) is a process option that uses the access restrictions discussed above to limit risks to human health or the environment prior to final remediation of an RA at the time of and consistent with future land development. At the time a specific re-development project is determined for the RAs using the RIR process option, a suitable technology(ies) would be implemented to protect human health and the environment from exposure to the risks that the RA poses that are consistent with the type of land development being considered. For example, a component of future land development within an RA using the RIR process option may include installation of a parking lot. The parking lot, along with appropriate deed restrictions and covenants, could readily be designed to meet the technical requirements of an asphalt/concrete cap.

Effectiveness: Effective when used with the other legal and physical engineering controls (i.e., access restrictions) discussed above.

Implementability: Straightforward to implement. Once a re-development project is determined at an RA under the RIR option, then the appropriate remedial action would be implemented to protect human health and the environment.

Cost: Low capital, low O&M

Safety Concerns During Construction: No hazards to the remedial site workers or to the public prior to re-development project. Following re-development project determination, the RA would undergo remedial actions that are consistent with the re-development.

Decision Rationale: RIR is effective when combined with other institutional controls in the short term and in the long term is effective when a re-development project(s) is determined and appropriate remedial actions are implemented based on that re-development.

Site-Specific Considerations: It is envisioned that these future remedial activities, implemented at the time of future land development with EPA review and approval, would include viable process options comparable to those identified and discussed in Section 6 of this *SFS Report*.

Potentially Applicable to RAs: Potentially applicable to RAs that are likely candidates for re-development.

6.2.3 Containment

6.2.3.1 Capping

Capping is a readily implementable and proven technology for eliminating direct exposure of humans and environmental receptors to the site's COCs, in addition to minimizing potential future impacts to groundwater. However, a given cap's effectiveness at achieving these objectives is based on its structural components, which in turn affect the cost of implementing a given cap design. The cost of each cap design must be weighed against the limitations of its design (i.e., effectiveness) to determine which cap design is the most cost-effective at achieving the necessary reduction in risk.

MWH prepared a *Capping Memo* that compares the effectiveness of conventional (i.e. multi-layered) caps to ET cover systems on a site-specific basis. A copy of this document is provided in Appendix D. For the evaluation of "effectiveness" of the different cap types being evaluated, the following are the four primary performance criteria.

1. Preventing Direct Exposure
2. Reducing Infiltration
3. Design Consideration for the Fate and Transport of Gasses
4. Long-Term Durability

The following cap designs, identified in Section 5, are directed at specific objectives that may limit their applicability only to certain types of contamination and specific RAs.

- Multi-Layered (Conventional) Cap - The multi-layered cap involves construction of a cap with at least one hydraulic barrier layer, consisting of either a compacted clay layer or geomembrane layer. In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer and vegetation layer. Due to the semi-arid location of the facility, compacted clay layers may be subject to desiccation and cracking due to shrinkage of the clay. In addition, there are no sufficient sources of clay borrow sources identified nearby. Installing a clay layer therefore would require importing large quantities of material. An alternative to a compacted clay layer would involve using some type of geomembrane/geotextile layer to serve as the hydraulic barrier layer. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effectiveness as evaluated against the four primary cap performance criteria is summarized below:

  1. Preventing Direct Exposure – When implemented with deed restrictions that prevent future disturbance of the cap, the multi-layered cap is effective for reducing direct exposure and ingestion for all COCs (i.e., P4, metals and radionuclides [including direct exposure to gamma radiation]).
  2. Reducing Infiltration – As long as cap integrity is maintained, it is effective at reducing infiltration and potential migration of COCs to groundwater.
  3. Design Consideration for the Fate and Transport of Gasses - Multi-layered caps, when placed over P4-containing wastes prone to generate PH3 gas,

have been shown to accumulate/concentrate PH3 to levels that may pose a direct exposure risk to site workers and/or the public.

4. Long-Term Durability – The lack of information regarding the long-term durability of membrane liners and potential for significant damage during placement brings into question the long-term durability of multi-layered caps.

Implementability: More complex than other types of caps, i.e., several layers are required including compacted clay and/or synthetic liners. May include multiple cap designs for different areas depending on the mobility of the COC being capped.

Cost: High capital, moderate O&M.

Safety Concerns During Construction: Low hazard to remedial site workers. Low hazards to the public.

Decision Rationale: Effective for protection of groundwater and minimizing direct exposure and ingestion of all site COCs when implemented in conjunction with other institutional controls (e.g., fencing and deed restrictions). Accumulation/concentration of PH3 gas in areas containing P4-contaminated materials have been demonstrated at multi-layered caps currently in use at the site. Long-term durability of multi-layered caps has been questioned.

Site-Specific Considerations: Multi-layered caps have been installed at the site as part of RCRA closure of specific waste management units. Multi-layered caps are a potential option for areas with potential groundwater impacts from all site COCs or from soils containing P4 such as RAs B, C, D, and E. Access restrictions to limit cap intrusion and resulting exposure to underlying wastes/contaminated soils would also be required.

Potentially Applicable to RAs: Potentially applicable for areas with potential groundwater impacts from all site COCs or from soils containing P4. May include multiple designs based upon mobility and risk posed by the specific COCs being capped.

Retained: Yes

- Asphalt/Concrete Cap - Asphalt and concrete (A/C) caps are constructed of a gravel sub-base layer overlain by asphalt or concrete. Asphalt and concrete caps are able to withstand traffic and are thus are particularly suited for areas that may receive future traffic. These caps are effective at both reducing infiltration of precipitation and eliminating direct contact with COCs. However, due to the high unit weight of these materials and cost, they would only be considered for small areas and for construction with materials of sufficient bearing strength.

Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effectiveness as evaluated against the four primary cap performance criteria is summarized below:

1. Preventing Direct Exposure – When implemented in conjunction with deed restrictions that prevent future disturbance of the cap, the A/C cap is effective for reducing direct exposure and ingestion for all COCs (i.e., P4, metals and radionuclides [including direct exposure to gamma radiation]).
2. Reducing Infiltration – As long as cap integrity is maintained, this cap is effective at reducing infiltration and potential migration of COCs to groundwater. Significant O&M would be required to maintain cap integrity.
3. Design Consideration for the Fate and Transport of Gasses – A/C caps, when placed over P4-containing wastes prone to generate PH3 gas, would have similar concerns as for multi-layered caps with respect to potential PH3 gas accumulation and as such may pose a direct exposure risk to site workers and/or the public.
4. Long-Term Durability – As A/C caps are typically used for traffic/parking areas, significant O&M would be required to maintain long-term durability.

Implementability: A/C caps can be implemented easily. However, they are not practical for implementation over large area when compared to other cap options, primarily based on cost and durability. Does not return site to a more natural state. A possible option for small portions of the site depending on future land use.

Cost: High capital, moderate O&M.

Safety Concerns During Construction: Low hazards to the remedial site workers. Low hazard to the public.

Decision Rationale: A/C caps can be effective and easily implemented. May be an option at smaller areas of the site where a robust cap is appropriate and future vehicle traffic is necessary or anticipated.

Site-Specific Considerations: A/C caps could be used in areas along the property boundary depending upon preferred future land use. Would be used in conjunction with access restrictions to limit exposure to underlying wastes/contaminated soils.

Potentially Applicable to RAs: Potentially applicable to areas where future traffic or parking is desirable or necessary.

Retained: Yes

- Evapotranspirative (ET) Cap - An ET cap involves constructing a soil cover of native soil and vegetation to provide sufficient water storage and ET capacity to store and remove precipitation, thereby eliminating infiltration. ET cover systems also typically have a capillary break layer comprised of coarse material (e.g., cobbles) that limits the infiltration into the underlying wastes. ET soil covers have been used in arid and semi-arid regions of the western United States and have been effective at eliminating infiltration of precipitation and isolating waste.

  Historically, regulatory agencies have considered multi-layered covers to be more protective than other approaches. However, FMC Plant OU site-specific performance data (i.e., from the RCRA ponds) and from other sites demonstrate that, once established, alternative covers are equally if not more effective at preventing direct contact and limiting infiltration. Once established, an ET cover is likely to provide greater long-term protection because of its use of geological materials rather than synthetic materials (i.e., flexible membrane liners) or a clay layer that may desiccate, crack and allow infiltration in semi-arid climates such as at the EMF site. The concern over the long-term durability of geomembrane liners was the major reason that a combined conventional and ET cover was used at the FMC facility RCRA ponds.

  In the case of performance with respect to the fate and transport of phosphine (PH3) gas, the available technical information from the site and from research suggests that a cap that "breathes", i.e., allows the movement of ambient air through the cap as result of barometric pressure changes, would favor the degradation of PH3 gas to its non-toxic byproducts within the cap. In addition, the areas containing P4 that would be capped as part of the remedial action do not have the same site conditions or potential to generate PH3 as found within the closed RCRA ponds at the site. RCRA ponds were capped and closed in a manner in which free water and comingled waste streams were present in combinations that favored PH3 production. These conditions do not exist at any of the RAs containing P4 being evaluated for capping remedial alternatives.

  Based on information presented in the *Capping Memo* and summarized in Table 6-1, it is recommended that an alternative cover consisting of a capillary-break cover, instead of a more conventional multi-layer cap, be considered for capping of RAs containing P4 and other COCs that present a threat to groundwater. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effectiveness as evaluated against the four primary cap performance criteria is summarized below:

1. Preventing Direct Exposure – When implemented in conjunction with deed restrictions that prevent future disturbance of the cap, the ET cap is effective for reducing direct exposure and ingestion for all COCs (i.e., P4, metals and radionuclides [including direct exposure to gamma radiation]).
2. Reducing Infiltration – As long as cap integrity is maintained, an ET cap is effective at reducing infiltration and potential migration of COCs to groundwater.
3. Design Consideration for the Fate and Transport of Gasses – ET caps are believed to be better suited than multi-layer caps for placement over P4-containing wastes prone to generate PH3 gas, because an ET cap will allow air into the cap. This allows any PH3 to react to form phosphoric acid, thus minimizing the potential for accumulation/concentration of PH3.
4. Long-Term Durability – Because ET caps are constructed of earthen materials, long-term durability is believed to be superior to multi-layered caps. The potential effect of phosphoric acid generation in areas capping P4-contaminated wastes is not fully understood, although site experience to date does not indicate a problem. An O&M plan to monitor the ET cap vegetation and cap materials would be required to ensure long-term durability and effectiveness.

Implementability: Implementation of ET caps is straightforward. Uses readily available native soil to store water and native vegetation to remove water through evapotranspiration.

Cost: Moderate capital, low O&M.

Safety Concerns During Construction: Low hazards to the remedial site workers. No hazard to the public.

Decision Rationale: ET caps have become increasingly used in the arid and semi-arid regions to prevent future groundwater impacts and to minimize direct exposure and ingestion of site COCs when applied with other institutional controls (e.g., fencing and deed restrictions). ET caps have benefits with respect to prevention of gas accumulation and for ensuring long-term durability.

Site-Specific Considerations: Specific design will be based on performance criteria that would include eliminating future groundwater impacts and direct exposure and ingestion of site COCs. Would be used with other access restrictions to limit exposure to underlying wastes/contaminated soils.

Potentially Applicable to RAs: Potentially applicable for areas with potential groundwater impacts for site all COCs or soils with P4..

Retained: Yes

- Soil Cover Cap - A soil cover cap or "gamma" cap involves placement of one foot of native soil over fill or soil with radionuclide COCs to eliminate gamma exposure. Test plots constructed at the FMC Plant OU have shown that one foot of native soil cover is sufficient to reduce exposure to gamma radiation to regulatory standards. This information is discussed in Section 4.15.3.3 of the *SRI Report* which states, "...gamma exposure rates over the entire soil cover were below the CV of 18,500 cpm." Gamma caps are most likely not sufficient to minimize infiltration of precipitation and therefore would not be appropriate for RAs with soil contaminated with metals and P4. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effectiveness as evaluated against the four primary cap performance criteria is summarized below:

  1. Preventing Direct Exposure – One foot of native soil cover has been shown to be effective at reducing gamma radiation to acceptable levels. This cover also limits direct contact exposure to other COCs (e.g., ingestion, dermal contact, and inhalation) if implemented with sufficient deed/access restrictions.
  2. Reducing Infiltration – Soil caps having one-foot thickness are not entirely effective at reducing infiltration of precipitation and therefore are not considered appropriate for RAs with soil contaminated with metals and P4.
  3. Design Consideration for the Fate and Transport of Gasses – Soil caps would not be considered for areas with P4-contaminated soils.
  4. Long-Term Durability – Because soil caps are constructed of earthen materials, long-term durability is presumed to be superior.

  Implementability: Soil caps are straightforward to implement. Uses native soil for cover soil and vegetation for surface stability.

  Cost: Low capital (with on-site soil source), low O&M.

  Safety Concerns During Construction: Low hazards to remedial site workers. No hazard to the public.

  Decision Rationale: Previous studies by other parties and on-site testing has shown gamma caps (1 foot of native soil) to be effective for reducing gamma exposure to acceptable levels at the surface. Gamma caps are also effective at minimizing direct contact and ingestion of certain COCs (e.g., metals). Easily implemented with local borrow sources.

Site-Specific Considerations: Soil caps are considered for areas on site with gamma radiation and for wastes with non-leachable levels COCs (e.g., areas with slag on the surface). Would be used in conjunction with access restrictions to limit exposure to underlying wastes/contaminated soils.

Potentially Applicable to RAs: Potentially applicable to areas with gamma levels posing risk but not appropriate for RAs with soil contaminated with metals and P4.

Retained: Yes

6.2.3.2 Surface Control

- Soil Grading - Surface grading has been retained as part of the overall remediation of the site to control stormwater runoff and eliminate ponding of surface water at the site. This option could be implemented as part of any cap system option to provide a sufficient soil depth to maintain cap integrity. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Surface grading is effective for reducing infiltration by promoting drainage of storm water runoff away from capped/impacted areas.

  Implementability: Surface grading is straightforward. Surface grading would be incorporated into overall site restoration grading plan.

  Cost: Low capital, low O&M

  Safety Concerns During Construction: Low hazards to remedial site workers and no hazards to the public.

  Decision Rationale: Effective for reducing groundwater infiltration. Would be incorporated into the overall remediation strategy (i.e., the selected alternative) to control storm water.

  Site-Specific Considerations: Will be used throughout the site to control storm water runoff/infiltration.

  Potentially Applicable to RAs: Would be applicable site-wide.

  Retained: Yes

- Vegetation - Vegetation has been retained as part of the overall remediation of the site to return large portions of the site to a natural appearance, reduce erosion of soil, and reduce infiltration of precipitation via evapotranspiration. In addition, vegetation will be incorporated into the design of all caps constructed at the FMC Plant OU. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Vegetation on soil-covered areas is effective in reducing infiltration and erosion. Vegetation would be incorporated into all soil covers/caps.

Implementability: Vegetation is straightforward. Long-term monitoring and maintenance would be required.

Cost: Low capital, low O&M

Safety Concerns During Construction: Low hazards to the remedial site workers and no hazards to the public.

Decision Rationale: Effective for reducing groundwater infiltration and dust in arid areas when used at soil caps and other areas with exposed soil. Vegetation will be incorporated into overall site reclamation.

Site-Specific Considerations: Vegetation would be used in conjunction with caps and in other areas of the site as part of the overall site restoration.

Potentially Applicable to RAs: Would be applicable site-wide.

Retained: Yes

6.2.4 Removal and Disposal (or Reuse)

6.2.4.1 Removal

Removal followed by some form of appropriate disposal is a proven method for effectively removing COCs to a level below risk-based standards. However, due to the presence of P4 in some RAs, removal presents significant short-term safety risks to site workers and potential of public exposure to P4 and reaction product gases.

- Modified and Conventional Excavation - Conventional excavation involves the removal of soil and solids through the use of conventional excavation equipment including trackhoes, dozers, and scrapers. Conventional excavation is typically an implementable and effective risk reduction technology, although disposition of the material, once excavated, is of primary concern. Standard engineering cost estimating factors, given conditions at the FMC site, indicate that the cost break-even point for excavation versus capping in place would be two to four feet, i.e., at two to four feet depth of fill material, it becomes more cost effective to cap the area than to excavate in areas where excavation does not yield additional reduction in risks to human health and the environment (although deeper excavation is possible for small areas or areas that are not amenable to capping).[1]

Conventional excavation would be appropriate for removing site fill consisting of slag or soils mixed with slag, ore materials, concrete, asphalt, etc. Typical safety and environmental precautions would be required for conventional excavation, including:

- Use of conventional excavating equipment;
- Use of typical PPE for a construction area;
- Use of typical dust control measures; and
- Use of typical non-hazardous decon procedures.

However, excavation activities in areas of the site that may encounter P4 in the subsurface (e.g., RAs B, C, F1, and K, as well as areas that contain underground process piping) would require modified excavation techniques. Excavation in these areas would likely result in the spontaneous oxidation reaction of exposed P4 and/or PH3 gas (if present) which would result in significant short-term health and safety risks for site workers and potential exposure of the public and environment to reaction gases and particulates. In addition, as modified excavation equipment would be limited to certain types (e.g., backhoes or trackhoes), it is expected that excavation depths would be limited to 10 to 15 feet within relatively limited areas. In order to mitigate these potential risks, the following safety and environmental precautions would be required for modified excavation, including:

- Use of excavating equipment with cabs and environmental controls;
- Use of modified Level B PPE;
- Use of large amounts of water to minimize P4 oxidation;
- Use of extreme fume/gas control measures such as enclosures over the excavation area and associated air scrubbing equipment capable

[1] *This statement is based upon the cost estimates developed for construction of ET covers and for performing conventional excavation on a per acre basis. The cost to construct one acre of ET cap is estimated to be $85,000/acre. The cost for conventional excavation (no P4 present) of one acre to a depth of 1 foot of slag (e.g., at RA-A) is estimated to be $40,300. This cost includes ripping, excavation, and transport to another RA (e.g., RA-F) for placement prior to capping followed by replacement with clean fill material. Therefore, conventional excavation of 2.5 feet of slag will approximately equal the cost to cover the same area with an ET cover. This provides an approximate "break-even" point of for capping versus excavation of "2 to 4 feet."*

of removing fine particulates (P2O5), mists/fumes (H3PO4), and gases (PH3);

- Substantial emergency control systems capable of response to P4 fires;

- Significant waste handling systems capable of managing P4-containing solids and water streams;

- Use of typical decon procedures capable of handling P4-contaminated debris.

Therefore, the modified excavation requirements would add significantly to the cost of implementing this process option. Refer to the document *P4 Treatment Technologies* in Appendix A for specifics related to human and environmental risks associated with excavation of soils containing P4. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective at removing soils posing risk. Requires disposal in appropriate on-site or off-site landfills or treatment of removed material. However, may not be effective at removing P4 due to direct exposure hazards from phosphorus and phosphorus-related gas emissions during implementation.

Implementability: Straightforward using conventional excavation in areas with shallow contamination and metals/radionuclide COCs (without P4 present) where these materials would be consolidated or reused during remediation of other RAs. Not practical for depths greater than two to four feet, except in relatively small areas, as capping options become much more cost effective. Although modified excavation may be appropriate for some areas containing P4, may not be applicable for areas with significant amounts of buried P4 (e.g., old phossy waste ponds, furnace building, slag pit) due to safety concerns related to the direct exposure to P4 and oxidation products. Modified excavation depths would be limited to 10 to 15 feet within a relatively limited area due to the types of equipment that would be used. Excavation of P4 may result in failure of RAOs associated with exposure to soil and air. In addition, there has been no documented experience or precedent for removing large quantities of P4-containing soils.

Cost: High capital, low O&M

Safety Concerns During Construction: Low hazards to remedial site workers and no hazards to the public for conventional excavation, where P4 is known not to be present. High hazards to remedial site workers requiring extreme control measures for modified excavation in areas where P4 is suspected of being present. Medium hazards for public exposure in the event that safety/environmental controls were ineffective for modified excavation at areas where P4 is suspected of being present.

Decision Rationale: Conventional excavation is an ancillary process option for application along with other treatment, disposal, or reuse options. Conventional excavation is typically considered for large areas with relatively shallow fill depths (two to four feet) because capping is more cost effective. Conventional excavation would be required in conjunction with on-site consolidation and reuse, on-site/off-site disposal, or ex-situ treatment. Significant safety/environmental precautions would have to be implemented prior to removing any soil containing P4. Modified excavation may be utilized for P4 contamination in small areas, at shallow depths and low concentrations with very specific operating and safety procedures.

Site-Specific Considerations: Given the safety and environmental concerns of excavating materials containing P4, modified excavation would be limited to relatively small areas. Conventional excavation would be appropriate for shallow areas of soils/solids that contain metals and radionuclides.

Potentially Applicable to RAs: Conventional excavation is applicable to areas with metal, organic and radiological COCs where P4 is known not to be present. Modified excavation may possibly be applicable for areas of relatively shallow P4 contamination. Use of modified excavation at RAs containing P4 concentrations greater than 10,000 ppm poses significant safety and environmental challenges.

Retained: Yes for both modified and conventional excavation.

6.2.4.2 Disposal

Disposal of wastes would have to be considered as part of any remedial alternative involving removal. Two types of disposal options have been screened.

- On-Site Disposal - Onsite disposal involves the excavation of site soils and fill materials (i.e., slag and ore) followed by consolidation in on-site areas that will eventually receive caps/soil covers. To ensure long-term isolation of waste and prevent future groundwater impacts, the consolidated waste would require placement in an area that would receive an appropriate cover/cap for the COCs present in the waste. For example, soils with only gamma radiation concerns (e.g., most of RA-A) would be consolidated in an area with similar contamination that then would receive a gamma soil cover (e.g., RA-F, the Slag Pile). Note that in some cases, very shallow soil contamination (e.g., wind-blown deposition of ore dust onto the top 2 inches of soil on the Northern Properties) may achieve RAOs by tilling the soil to reduce COC concentrations - a form of on-site disposal. On-site disposal of soil and fill material (e.g., slag and ore) is an effective way to reduce the impacted post-remedial footprint at the FMC Plant

OU while avoiding the safety risks to the public associated with transportation of large amounts of material off site. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective at reducing impacted footprint at the site by consolidation and subsequent capping (and in the case of very shallow soil contamination, soil tilling).

Implementability: Primarily applicable for soils and fill material with depths not more than 2 to 4 feet that can be consolidated with similar materials elsewhere on the site. On-site disposal through tilling could easily be applied to large areas with shallow soil contamination (0 to 2 inches). Also, implementable for small areas or small volumes of materials containing P4 (e.g., underground process piping and/or soils in RA-K).

Cost: Moderately high capital, low to moderate O&M.

Safety Concerns During Construction: Low hazards to remedial site workers and no hazards to the public. Modified excavation methods would be required for any area containing P4.

Decision Rationale: Possible method for remediating portions of the site where fill materials do not exceed 2 to 4 feet in depth. Potentially applicable for small areas or small volumes of materials containing P4.

Site-Specific Considerations: Large areas of the FMC site contain materials (e.g., slag and/or ore materials) to shallow depths (e.g., RAs A, D, E, and G). Consolidation and on-site disposal would be effective for achieving RAOs in all or portions of these areas. On-site disposal through tilling could easily be applied to large areas with surficial soil contamination.

Potentially Applicable to RAs: Would be applicable to areas of the FMC site containing relatively shallow fill materials..

Retained: Yes

- Off-Site Disposal - Off-site disposal would be implementable for small amounts of specific waste. Due to the extremely large volume of impacted soil and fill material present at the FMC site, there may not be a landfill located nearby that has the capacity for this volume of waste. Furthermore, only select disposal sites in the United States (e.g., Clean Harbors facilities in El Dorado, Arkansas) have the ability to handle P4-contaminated materials through incineration. Elemental phosphorus-containing materials must be packaged for transported and incineration in 55-gallon drums. This would not be implementable for the large volumes of P4-contaminated waste present at the facility. In addition, the off-site disposal of large quantities of waste would jeopardize public safety during transportation due to the increased possibility of vehicular accidents and spills. However, off-site disposal of small quantities of waste (such as the underground piping) has been retained for further consideration. Evaluation of this process option against the three screening criteria and additional site considerations are presented below.

Effectiveness: Effective at reducing on-site risk posed by contaminants because those would be removed and dispose elsewhere.

Implementability: Effective for metals and radiological wastes, although due to the very high volumes of some waste streams, off-site disposal may not be implementable for large volumes due to transportation and disposal costs and landfill availability. No facilities are known that will accept P4-containing waste in bulk. Of those disposal (and treatment) facilities that have been identified, P4 wastes must be packaged in 55-gallon or smaller containers. DOT requirements also restrict shipments of P4-containing wastes to 55-gallon or smaller. Therefore, off-site disposal is considered and option only for material not containing P4 or small volumes of P4 wastes that can be safely containerized.

Cost: High capital, low O&M.

Safety Concerns During Construction: Low hazards to remedial site workers and low hazards to the public for shipment of non-P4-containing wastes to off-site disposal facilities. Modified excavation methods and packaging methods would be required for any area containing P4.

Decision Rationale: Off-site disposal is not considered to be applicable to large volume wastes. Only small quantities of P4-contaminated wastes that can be safely excavated and packaged would be considered for off-site disposal.

Site-Specific Considerations: Off-site disposal is only considered for small quantities of P4-contaminated wastes that can be safely excavated, packaged and shipped for off-site incineration.

Potentially Applicable to RAs: Potentially applicable to materials containing metals and radionuclides with small quantities of P4, e.g., underground piping.

Retained: Yes

6.2.5 Ex-Situ Treatment

Ex-situ treatment involves the excavation of soils and solids (i.e., fill) contaminated with COCs followed by treatment of the removed material to reduce the toxicity, mobility, or volume of COCs. For any ex-situ process there would be a myriad of technical and physical hazards associated with excavation, handling, and then ex-situ treatment of soils containing P4, detailed in the attached document *P4 Treatment Technologies* in Appendix A. A summary of some of the challenges to ex-situ treatment of P4 is presented here.

Ex-situ technologies require the excavation of soil and solids followed by an above-ground treatment process. Ex-situ technologies also require that a portion of the site be used and potentially impacted to implement the technology, including possible staging areas for treatment equipment and soil stockpiles. Prior to any possible ex-situ treatment or disposal (on-site or off-site), P4-contaminated soils/sludges would require removal through conventional excavation so that the wastes could be transported for treatment. The material handling issues associated with excavation of soils containing P4 at concentrations over 1,000 ppm and preparation of those soils for treatment are documented as the most difficult issues to overcome with active treatment of P4 wastes. These are discussed above in Section 6.2.4.1.

Various P4 handling processes that would be ancillary, but critically important to the success of the treatment technology, include the following:

- Process utilities:
    - Steam, power, and water.
- Material/waste handling:
    - P4 excavation processes necessary to get P4-impacted materials to an ex-situ treatment process;
    - P4-impacted material transportation to the ex-situ treatment process, and temporary storage of such material near the treatment process to provide surge capacity;
- Treatment process feedstock preparation:
    - Sizing, such as crushing and screening, of the material to provide a consistent feed particle size to the ex-situ treatment process;
    - Blending with other extracted streams or inert materials into the feed to provide consistent P4 content to the ex-situ treatment process; and
- Management of treatment residues
    - Treatment of wastewater, further treatment and disposal of solid residues, and collection and treatment of process off-gases.

Site worker safety is one of the most difficult elements to resolve with respect to “active” ex-situ treatment of P4-contaminated soils. Skilled site workers are essential for any successful ex-situ treatment process, because the potential processes are complex and mostly unproven. In the context of the FMC site, with the factors of unproven technologies, unique site contaminants, and handling challenges associated with widely varying P4 concentrations (even within a small area), would make it difficult to design and implement the proper design and operating procedures to ensure worker safety. Well-designed processes, highly-trained site workers, and a comprehensive Environmental, Health, and Safety Management System (including extensive health, safety and environmental procedures) would be necessary but possibly not sufficient to ensure adequate protection of site workers.

During any remedial action that involved the handling of P4-contaminated soils, engineering controls also would be in place to protect site workers. However, unlike controlled manufacturing processes, excavation and treatment of P4 wastes could cause uncontrolled releases, especially to the air, due to the widely varying site conditions and difficulty in designing appropriate engineering controls. The risk of uncontrolled air releases would increase with the quantity of P4 soils being remediated, as well as the degree of impact, e.g., active remediation of greater quantities of impacted materials having higher concentrations of P4 presents greater risk than active remediation of smaller quantities with lower concentrations. Short-term public exposures to airborne contaminants including P_2O_5, PH3 gas, and phosphoric acid also might occur, due to the many unforeseen circumstances that could arise.

Environmental concerns related to the handling of P4-contaminated soils include potential impacts to air and water/groundwater. As discussed above, there are also significant worker risks from direct exposure to pure P4, phosphorus gases, and contaminated process water and risks to the public from air emissions and impacted groundwater.

Effectiveness, implementability, and cost considerations would be significant, requiring quantification of the capital and O&M costs associated with providing ancillary process systems, adequate site worker protective systems, and protection of public and the environment, if such systems could be designed and reliably implemented.

For this technology screening, four general categories of ex-situ treatment technologies for soils and fill remain after the initial screening in Section 5 and include: physical, chemical, thermal, and biological categories and their associated process options.

6.2.5.1 Physical Treatment

- Stabilization/Solidification (S/S) – S/S is a technology in which inorganic or organic agents are added to impacted soil to reduce the solubility or mobility of the COCs. Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilization agents, curing of the mass for optimal reduction in leachability, followed by on-site or off-site disposal. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents used depend on the chemical composition of the material being stabilized. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for reducing long-term on-site risks by reducing the mobility of heavy metals and radionuclides in soil and sludge where P4 is not present. S/S reduces the leachability of heavy metals and radionnuclides. However, its effectiveness at treating wastes containing P4 has not been demonstrated. By-products of P4 reactions would include PH3 gas, P2O5 particulate and H3PO4 mists, which would require capture/treatment at the point of generation. Most likely this technology would not be appropriate for wastes containing high levels of P4 (i.e., greater than 1,000 ppm). However, S/S may be effective for soils/fill that contain metals, radionuclides, and low concentrations of P4 (below 1,000 ppm).

Implementability: Difficult to implement on a large scale because a large amount of excavation would be required if P4 were present. Has not been shown to be implementable in that stabilizing additives react violently with P4 contaminated soil and release P4 reaction products. One pilot study conducted at Tarpon Springs, Florida involved testing the implementability of in-situ stabilization of soils and sludges containing P4. The pilot test resulted in violent reaction of the P4 with the stabilizing agents, resulting in combustion of the P4 and release of P_2O_5 and PH_3 gases. The pilot study was halted due to safety and health concerns. S/S treatment has since been removed as a possible remedial technology at Tarpon Springs. The Tarpon Springs pilot study indicates that S/S treatment of P4 currently is not technically implementable for materials with high levels of P4. In addition, the requirement for the soils and solids to be excavated for ex-situ treatment increases the short-term health and safety risks to remedial workers, as well as the public, due to the high probability of P4 reactions.

Cost: High capital, high O&M.

Safety Concerns During Construction: Low hazards to remedial site workers and no hazards to the public for S/S treatment of non-P4 materials. Safety concerns are high to remedial site workers given that the technology is unproven for application to materials containing P4 at levels greater than 1,000 ppm.

Decision Rationale: S/S has been demonstrated to be effective for treating metals and radionuclides, although not necessarily effective for gamma control. There is no history of successful laboratory or field testing of this technology with P4-contaminated soils. Stabilizing additives would likely react violently with P4 and would be difficult to control and therefore would be applicable only for low P4 concentrations with evenly sized and blended feed material.

Site-Specific Considerations: While applicable for some soils containing leachable metals and radionuclides to reduce mobility and potential for migration in the subsurface to groundwater, not likely effective for meeting gamma RAO for soils. Would not be implementable where P4 is found at concentrations greater than 1,000 ppm.

Potentially Applicable to RAs: Potentially applicable to areas with metals and radionuclide COCs. May be applicable for soil contaminated with relatively low, consistent P4 concentrations.

Retained: Yes

6.2.5.2 Chemical Treatment

- Chemical Oxidation - Chemical oxidation is a batch process that involves the addition of chemical agents to react with COCs in the soil to form oxidized by-products. Chemical oxidation of soils and solids containing P4 has only been conducted on the bench-scale and pilot scale using nitric/sulfuric acid and HSAD processes described in Section 5.2. Although the pilot scale study conducted by the TVA was capable of reducing the concentrations of P4, operational concerns included feed sizing and the generation of relatively large amounts of wastes (including gases) that required further management or disposal. In addition, the pilot plant was only capable of processing the 30,000 lbs of P4 sludge at 380 liters per batch.

  Ex-situ chemical oxidation would require the excavation and preprocessing (feed sizing) of P4-contaminated materials, resulting in significant short-term health and safety and environmental risks. The two studies also indicated that chemical oxidation resulted in the increase in the TCLP levels of some heavy metals, although some metals (e.g., arsenic) appear to have been immobilized in the process residues. In either case, it is likely that additional treatment for metals, as well as radionuclides, would be required prior to disposing of the treatment residue. Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Moderately effective for slurries and sludges containing organics and inorganics. Effective for fixation of some metals such as arsenic into insoluble form that will pass TCLP. Has only been shown to be effective for treating P4 in bench-scale studies. Other issues with effectiveness include:

  - The batch process is slow, is largely unproven, and is ineffective and would be difficult to implement for site COCs, especially P4.

  - This process would require additional treatment of process residues for metals and radionuclides prior to disposal. However, there is some evidence to suggest that some of the metals (e.g., arsenic) will be made insoluble in the treatment residues.

- Safety and health risks to workers, the public, and the environment associated with excavation of soil containing P4 are similar to the risks associated with other ex-situ options.

<u>Implementability</u>: Has only been shown to be implementable in bench-scale studies. May be difficult to implement on large scale. Possible fire hazard associated with oxidation of P4-contaminated soil.

<u>Cost</u>: High capital, high O&M.

<u>Safety Concerns During Construction</u>: Safety concerns are medium to high for remedial site workers and moderate for the public for application to materials containing P4 at levels greater than 1,000 ppm given that the technology is unproven for such wastes.

<u>Decision Rationale</u>: Not effective for soil with metal and radionuclide contamination. Use at the site would be limited due to the small particle size necessary for treatment and the inability of this process to effectively treat large quantities of soils containing high levels of P4. Liquid, gas, and solid by-products would require capture and treatment by a sophisticated treatment processes to prevent worker, public, and environmental exposure to COCs.

<u>Site-Specific Considerations</u>: Extent of soils with P4 are much larger than other sites that have been considered for chemical oxidation. Even if proven effective for P4 treatment, most site soils/fill would require further treatment to address other COCs (e.g., metals, radionuclides, and gamma).

<u>Potentially Applicable to RAs</u>: Probably not applicable to any area soils/fill.

Retained: No

- <u>Caustic Hydrolysis</u> – Caustic hydrolysis is a chemical process where P4 is reacted with lime and water at elevated temperatures and pressures to form various, more stable phosphate compounds. A caustic hydrolysis process was partially constructed at the FMC facility in 2000/2001. This was referred to as the Land Disposal Restriction (LDR)Treatment System. The LDR Treatment System was designed to treat the waste stream slurries from the furnace production process. These slurries contained homogenous, low-level concentrations of P4. Its objective was to assure that the waste stream, after treatment, did not exhibit any RCRA hazardous waste characteristics and met LDR treatment standards, and to produce stable, treated material that could be disposed in an on-site landfill. The LDR Treatment System was never completed or operated. As designed, the LDR Treatment System had many narrow operational specifications (e.g., injection rates, particle size cutoffs, and P4 concentrations). The feed tanks for the LDR system were designed to maintain a slurry temperature of 150°F, a P4 concentration of 2.15 percent, a suspended solids concentration of 18 percent, a retention time of 12 hours, and a throughput of 50 gallons per minute (gpm). These parameters were derived from bench-scale tests that determined these operating criteria were required to meet the necessary P4 destruction efficiencies. Any of these design requirements could make the treatment of soils and solids containing high-level P4 or inconsistent feed stock containing P4 infeasible. In addition, additional treatment of the produced effluent waste stream would likely require further treatment (such as S/S to address the remaining metals and radionuclides) and placement under a cap to address gamma. As with any ex-situ process, the LDR-like system would require excavation and storage of large amounts of soil containing P4 that would present a high short-term risk to safety and health of site workers and present environmental concerns.

Ex-situ caustic hydrolysis has been retained because:

- This process was selected for LDR treatment requirements of plant waste streams (although the system was never operated or demonstrated).

- This technology is believed to have the ability to treat consistent, low level P4 waste streams. However, achieving this type of feed stream from the high-level P4-contaminated soil/fill as found on the FMC site would involve considerable technical challenges.

- This technology was identified as the “most preferred” treatment technology by the EPA.

Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: The effectiveness of caustic hydrolysis would be largely determined by the soil-water matrix conditions. An evaluation of the conditions and properties of the soil to be treated would be necessary to determine the amount of caustic material (i.e., lime) to be added as well as the many other necessary treatment parameters. Has not been demonstrated for treatment of non-P4 site COCs (e.g., metals and radionuclides).

Implementability: Difficult to implement on a large scale involving excavation of large amounts of P4-containing soil/fill. Concerns with implementability of caustic hydrolysis treatment are:

- The processed waste stream would require additional treatment, because of metals and radionuclides, prior to disposal.

- Given the volumes of P4-contaminated materials that would need to be treated and a reasonably sized treatment process, the duration of treatment would be 20 to 40 years, depending on the depth of excavation.

- Safety and health risks to workers, the public, and environment associated with excavation of soil containing P4 are similar to the risks associated with other ex-situ options.

- Would be necessary to capture and treat P4 reaction products using an air scrubber system (i.e., P2O5 and PH3) at the excavation using and air scrubber system and some sort of temporary structure (e.g., sprung structure). Also would be necessary to capture and treat emissions generated by the treatment process.

- Likely would have a capital and O&M cost comparable to other ex-situ treatment technologies (e.g., incineration).

Cost: High capital, high O&M.

Safety Concerns During Construction: Safety concerns are high for remedial site workers and moderate for the public for treating materials containing P4 at levels greater than 1,000 ppm given that the technology is unproven. This is the case even for homogenous process wastes containing P4 as the LDR Treatment System was never operated.

Decision Rationale: Two hydrolysis processes were identified (Zimpro and alkali treatment) for treating P4, but are limited by the small particle size necessary for treatment and lack of ability to treat soils with high concentrations of P4. Residual sludges from these hydrolysis processes likely would contain phosphorus and might require treatment prior to on- or off-site disposal. Excavation, storage, and sizing of P4 soils presents risks to workers, the public, and the environment. In addition, ancillary treatment processes would be required to capture and treat by-product off-gases and liquids.

Site-Specific Considerations: Elemental phosphorus at concentrations greater than 1,000 ppm is suspected to be present in RAs B, C, F1 and in underground piping. The LDR Treatment System that was constructed (but never operated and since has been demolished) at the FMC plant was designed to treat production waste streams that are significantly different than those present in the soil/fill. The LDR system, as designed, could not handle these soil/fill materials without significant feed preparation. A reasonable designed LDR system feed rate would require an extremely long remediation time (> 30 yrs) given the amount of P4-contaminated soil/fill that would require treatment.

Potentially Applicable to RAs: Potentially applicable for ex-situ treatment of soil/fill contaminated with relatively low, consistent P4 concentrations. Significant feed preparation would be required if applied to P4-contaminated soils/fill believed to be present in RAs B and C. Probably not applicable for contaminated equipment or piping.

Retained: Yes

6.2.5.3 Thermal Treatment

- Incineration - Incineration of excavated soil either on-site or off-site would reduce the concentration of P4 and volume of contaminated soil. Heavy metals and radionuclides in the soil would not be oxidized and would be concentrated in the residual ash from the incinerator. This ash would require further treatment, possibly by S/S treatment (to address metals and radionuclides), followed by disposal under a cap to address gamma. Only one captive incinerator has been constructed on a site to treat P4. This on-site incinerator was constructed at the Crane Army Ammunition Activity (CAAA) in Wayne, Indiana to treat P4 contained in munitions. Although the system proved to be effective, the treatment of the P4at that site was significantly different from the P4 that found within the soil/fill at the FMC site, i.e., the P4 at CAAA was very pure product, and was contained within small packaged units (i.e., the munition casing) that prevented the P4 from coming into contact with air.

  As of August 1991, the facility had operated for more than 7,000 hours, and 1.5 million rounds containing 4.3 million pounds of P4 had been processed to form 18 million pounds of phosphoric acid.

  On-site incineration would require the soils to first be excavated using modified excavation as described in Section 6.2.4.1. The excavated material would have to be stored and transported under water as a slurry. The feed stream would require some sizing, although not as tight of a sizing specification as required for the caustic hydrolysis technology. However, unlike the commercial incinerators that treat 55-gallon containers or the CAAA incinerator that treated smaller munitions, the on-site incinerator would have to be designed to accept a bulk, slurried feed stream, a technology that has not been demonstrated. In addition, the P4 would make up only a small fraction of the total feed stream (which would also contain water and other fill material) such that a disproportionately large amount of energy would be required to heat up/boil off the solids and water.

  The treatment process would require an air scrubber system to capture and treat process off-gases. Residuals from the treatment process would require treatment for metals and radionuclides (likely S/S) prior to disposal under a cap to address the gamma. However, it should be noted that compared to caustic hydrolysis (also retained for on-site treatment) on-site incineration has the advantage of allowing less stringent feed specifications (i.e., particle sizing and P4 concentration).

Ex-situ incineration, at an off-site facility, has been retained for use in limited situations during the site remedial activities because:

- Commercial incinerators are available (although future availability would have to be confirmed).

- Incineration would be effective for treatment of limited quantities of material containing highly variable levels of P4. However, the excavation, material handling and transportation hazards/issues would be very challenging.

- Incineration would be implementable for specific small quantity areas of the site (i.e., underground piping). However, it would not be practical to drum and ship large quantities of material containing P4 and it would be prohibitively costly for large quantities of material.

Off-site incineration is envisioned for certain site remediation wastes. For example, P4-containing wastes generated during cleaning of underground sewer line could be placed in 55-gallon drums and then transported off site for incineration at a commercial incinerator.

Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: While incineration has been demonstrated as an effective method for treating highly variable concentrations of P4, treatment of the large volumes of soil contaminated with P4 by means of incineration has not been demonstrated to be effective. While commercial off-site incineration capacity is available, the excavation, handling, storage and packaging requirements would not be amenable to a large volume of P4-contaminated soil/fill. Off-site incineration might be appropriate for small areas of highly variable P4 concentration materials (e.g., clean-up residues). On-site incineration of P4-contaminated soil/fill has not been demonstrated for the type of feed and the large volumes that would be encountered during the FMC Plant OU remediation. For both on-site and off-site incineration, this technology is not effective for addressing metals, radionuclides, or gamma.

Implementability: Off-site incineration is a commercially available technology for treatment of drummed P4-contaminated soil/fill. Off-site incineration of large volumes of P4-contaminated soil/fill would not be implementable. On-site incineration at the large scale and the types of P4-contaminated soil/fill encountered at the site has not been demonstrated.

Cost: High capital, high O&M.

Safety Concerns During Construction: Safety concerns are high for remedial site workers and moderate for the public for application to materials containing P4 at levels greater than 1,000 ppm, given the packaging requirements for off-site incineration and the uncertainty for on-site incineration.

Decision Rationale: Off-site commercial incinerators are available and can be used for drummed wastes containing P4 provided the volumes were relatively small. For incineration, many of the heavy metals and radionuclides in the soil would not be oxidized and would be concentrated in the residual ash from the incinerator. These ashes would require additional treatment and proper disposal. On- or off-site incineration has not been used on a large scale for treating P4-contaminated soils. On-site incineration would require construction of an incinerator and hydrator that would need to meet RCRA and Clean Air Act performance standards. Excavation, storage, and sizing of P4 soils presents risks to workers, the public and the environment, in addition to requiring ancillary treatment processes to capture and treat off-gases and liquids.

Site-Specific Considerations: Treatment of the large volume of soil potentially contaminated with P4 at the FMC Plant OU using incineration has not been demonstrated to be implementable. Off-site incineration might be appropriate for small areas of highly variable P4 concentrations (e.g., cleanup residues).

Potentially Applicable to RAs: Potentially applicable to limited areas of the site with localized contamination that could be cleaned up and placed into drums (e.g., cleaning of underground storm drains).

Retained: Yes, but only for small quantities and only for off-site incineration.

6.2.5.4 Biological Treatment (Landfarming)

Biological treatment of solids and solids consists of enhancing the biological degradation of organic constituents (e.g., hydrocarbons) by microorganisms. Biological treatment of soils containing petroleum hydrocarbons is relatively straightforward when compared to chlorinated hydrocarbons. Biological treatment, including land farming, is typically implemented by creating favorable conditions for microbial activity. The process would not be effective or implementable on soils contaminated with most of COCs present at the FMC site. Evaluation of the biological treatment option is limited to landfarming based upon the following factors:

- RA-A1 contains hydrocarbons in the shallow soil (less than 5 feet). As a result, ex-situ landfarming would be an effective remedy in this portion of the site.

- Ex-situ landfarming requires some excavation and tilling of the contaminated soils. The area of contamination thus typically can be visually defined, possibly with the assistance of hand held meters.

- Landfarming of hydrocarbons is a common practice and is easily implemented.

- The cost is low when compared to other ex-situ technologies for remediation of hydrocarbon-contaminated soil.

Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Landfarming has been proven to be effective in treating petroleum hydrocarbons and other less volatile, biodegradable hydrocarbons. A pilot study would need to be performed to determine the optimal biodegradation rates and clean-up times. Landfarming is not considered effective for soil contaminated with other site COCs, including metals, radionuclides, or P4 .

Implementability: Landfarming has been shown to be readily implementable for hydrocarbon-contaminated soils having the volumes and depths as found at RA-A1.

Cost: Low capital, Moderate O&M.

Safety Concerns During Construction: Safety concerns are low for remedial site workers and present no hazards to the public for application to the hydrocarbon spill area at RA-A1 only.

Decision Rationale: Landfarming is a viable technology for soil contaminated with organic contaminants such as fuel PAHs and VOCs. Not retained as a viable technology for soil/fill with other site COCs (i.e., metals, radionuclides, and/or P4).

Site-Specific Considerations: Only one small area (a diesel spill area) is amenable to landfarming.

Potentially Applicable to RAs: The diesel fuel spill area in RA-A1.

Retained: Yes for hydrocarbon-contaminated soil area in RA-A1 only.

6.2.6 In-Situ Treatment

In-situ treatment would treat impacted soil and fill material in place using physical, chemical, or thermal processes to reduce the volume or toxicity of COCs. Because in-situ treatment would not require excavating the material, in-situ treatment is typically considered safer to implement than ex-situ technologies. However, it may be difficult for in-situ technologies to completely treat the contaminated soil in-place, which may leave COCs in the soil above risk-based standards. An evaluation of the physical, chemical, and thermal in-situ treatment technologies considered for contaminated soils at the FMC Plant site is provided below.

6.2.6.1 Physical Treatment

- Stabilization/Solidification - In-situ S/S treatment has been effective at reducing the mobility and toxicity of soil and sludges contaminated with heavy metals and radionuclides. Only limited studies have been performed on in-situ S/S treatment effectiveness at treating P4-containing waste. A pilot study conducted at Tarpon Springs, Florida involved studying the implementability of stabilizing P4 containing soil and sludges. The pilot test resulted in a violent reaction of P4 with the stabilizing agents, resulting in combustion of the P4 and the release of PH3 gas and P2O5 particulates (EPA, 2006). The pilot study was halted due to safety and health concerns. S/S treatment has since been removed as a possible remedial technology at Tarpon Springs. The Tarpon Springs pilot study indicates that S/S treatment of P4 is not implementable.

  Evaluation of this process option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective for reducing long-term on-site risks by reducing mobility of constituents. Effectiveness of in-situ S/S decreases with increasing depth. Has not been demonstrated to be effective for P4-contaminated soil/fill.

  Implementability: Can be difficult to implement for in-situ materials containing large cobbles, boulders, or debris because these materials interfere with the necessary subsurface mixing. If subsurface conditions are appropriate, maximum depth of application would be 20 feet. Treatability tests at Tarpon Springs, Florida have shown that in-situ S/S cannot be implemented at areas with high P4 concentrations.

  Cost: Moderate to moderately high capital, Low O&M.

  Safety Concerns During Construction: Safety concerns are moderate for remedial site workers and present no hazards to the public when utilized at areas without P4. Treatability tests have shown high safety concerns for both remedial site workers and the public when utilized at areas with P4.

  Decision Rationale: In-situ S/S has been used and is effective for treating metals and radionuclides. However, stabilizing additives identified to date react violently with P4. Off-gases from the in-situ S/S process would require containment and treatment. Excess water used in the process could mobilize other COCs.

Site-Specific Considerations: Might be applicable to relatively small areas with fine particle size and with COCs limited to metals and radionuclides. However, often difficult to achieve complete in-situ mixing of pozzalonic materials with large quantities of soil at depths greater than 20 feet. Free liquids might create hydraulic head to move some metal COCs into the shallow groundwater.

Potentially Applicable to RAs: No areas of the site would be amenable to in-situ S/S.

Retained: No

6.3 TECHNOLOGY SCREENING FOR GROUNDWATER

Potentially applicable technologies for the groundwater pathway at the FMC Plant OU were identified and preliminarily screened in Section 5.4. Contaminants that exceed groundwater RAOs as shown in Table 4-3 include: arsenic, fluoride, manganese, nitrate, selenium, P4, thallium, and vanadium. However, it is assumed that the blended groundwater from either the FMC source areas or at the FMC plant boundary would primarily contain elevated arsenic and total phosphorus, which would drive the technology selection.

In this section, the technologies that address these primary and secondary groundwater COCs are further screened for effectiveness, implementability and relative cost, in addition to safety as described in Section 6.1. General response actions, technologies, and process options retained as a result of this screening process are further evaluated in Section 7 where they are combined or "assembled" into site-wide alternatives. The screening of the remedial technologies that addresses groundwater is summarized in Table 6-2, as are the reason(s) for retaining or eliminating each technology. The technologies and process options are organized below by the response action category as they were in Section 5 (i.e., "no action", institutional controls, containment, removal and disposal, ex-situ treatment and in-situ treatment).

6.3.1 "No Action"

The "no action" option is being retained because it is required to be evaluated as a base case by the NCP and under current *EPA RI/FS Guidance document*. Evaluation of the "no action" option against the three screening criteria as well as additional site considerations is presented below.

Effectiveness: Acceptable for constituents that meet ARARs and Remedial Action Objectives (RAOs).

Implementability: Not applicable.

Cost: None.

Decision Rationale: Always retained in FS as a base case and may be used in areas that pose no risk.

Retained: Yes

6.3.2 Institutional Controls

Institutional controls involve access restrictions, groundwater monitoring, and source controls to limit use of groundwater, assess groundwater migration, and eliminate sources of groundwater contamination.

- Land and Groundwater Use Restrictions - Access restrictions for groundwater involve deed restrictions or covenants to limit use of site groundwater. Deed restrictions are effective for limiting use of site groundwater. Deed restrictions would be incorporated into the overall remediation of the site, in addition to other institutional controls such as site security and fencing, to reduce potential exposure to COCs. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective at prohibiting designated types of land (e.g., residential) or groundwater (e.g., human consumption) use through legal mechanisms such as deed restrictions, covenants and environmental easements that have continuing effect in perpetuity or until occurrence of a defined terminating event.

  Implementability: Straightforward.

  Cost: Low capital, low O&M.

  Decision Rationale: Deed restrictions preventing residential land use are already in place. Groundwater use restrictions were selected in the 1998 ROD and are still an appropriate component of the groundwater remedy.

  Retained: Yes

- Groundwater Monitoring - Groundwater monitoring can be an effective way of evaluating groundwater quality over time and can be implemented to monitor the performance of a remediation system or to monitor natural attenuation. FMC is currently performing groundwater monitoring under its RCRA, Calciner Ponds Remedial Action and voluntary CERCLA groundwater monitoring programs. The number and location of the wells that are routinely monitored, constituents analyzed, and the frequency of monitoring are described in detail in the GWCCR (MWH, June 2009). The long-term CERCLA groundwater monitoring program, including number and location of wells, constituents analyzed and frequency of monitoring will be developed and reviewed/approved by EPA as part of the remedial design and remedial action process. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for monitoring any trends in concentrations, extent and migration of site-impacted groundwater.

Implementability: Straightforward. May require installation of additional monitoring wells to optimize well network.

Cost: Moderate capital, low O&M.

Decision Rationale: Groundwater monitoring is currently on-going at the site, was selected in the 1998 ROD and is still an appropriate component of the groundwater remedy.

Retained: Yes

6.3.3 Source Controls

Source controls are an effective way for reducing further migration from historic and potential future source areas to groundwater by removing or containing the source of groundwater contamination. Source controls can include treatment of source areas through containment (capping), in-situ treatment and/or removal and ex-situ treatment. The technologies associated with source controls are discussed as part of the remedial technologies for soil. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for reducing or eliminating constituent migration to groundwater from identified and potential source areas. However, does not address COCs already in the vadose zone or groundwater.

Implementability: Generally straightforward. Numerous source control actions (e.g., Pond 8S closure, Calciner Pond Remedial Action) have already been completed at the FMC Plant OU. Soil remedial actions will address source controls for the remainder of the OU.

Cost: Moderate capital, moderate O&M.

Decision Rationale: Major source controls actions have already been completed at the site. Source controls were identified in the 1998 ROD as a component of the groundwater remedy and remain an appropriate component of the remedy. Source controls can include treatment of source areas through containment (capping), in-situ treatment, and/or removal and ex-situ treatment. The technologies associated with source controls are discussed as part of remedial technologies for soil.

Retained: Yes

6.3.4 Containment

6.3.4.1 Vertical Hydraulic Barriers

Hydraulic barriers are formed through the addition or withdrawal of groundwater from the target aquifer or construction of a slurry or grout wall to limit or control groundwater movement. These measures contain the water to limit receptor exposure. In some cases, these measures also can support groundwater extraction and treatment. Hydraulic barriers can consist of extraction wells, injection wells, cutoff (slurry or grout) walls, or a combination of these. Cut-off walls and injection wells were eliminated from further consideration based on technical implementability discussed in Section 5.

- <u>Extraction Wells</u> - Extraction wells are an effective technology to capture groundwater downgradient of source areas to contain migration of groundwater that exceeds RAOs. The use of extraction wells would need to be implemented in conjunction with treatment and disposal technologies. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  <u>Effectiveness</u>: Effective for providing capture and hydraulic containment to minimize downgradient migration of impacted groundwater.

  <u>Implementability</u>: Straightforward. Would require installation of an extraction well network. Would likely require treatment of extracted groundwater prior to use/disposal.

  <u>Cost</u>: Moderate capital, high O&M.

  <u>Decision Rationale</u>: Effective and implementable. Groundwater extraction for hydraulic control was identified in the 1998 ROD as a contingent component of the groundwater remedy and is still appropriate for consideration as a component of the remedy.

  Retained: Yes

6.3.5 Removal and Disposal

6.3.5.1 Removal

- <u>Pumping</u> - Pumping of groundwater proximal to identified source areas could capture groundwater prior to further downgradient migration and would reduce the volume of impacted groundwater. This process option would be implemented in conjunction with treatment and disposal technologies. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for capturing and decreasing mass of constituents in groundwater.

Implementability: Readily implementable but would require installation of a groundwater extraction well network, and likely would require treatment of groundwater prior to discharge or re-use.

Cost: Moderate capital, high O&M.

Decision Rationale: Retained mainly to evaluate extraction in areas of highest groundwater constituent concentrations (e.g., highest mass removal) for comparison to extraction for hydraulic control.

Retained: Yes

6.3.5.2 Disposal

- Recycle/Reuse - Pumped groundwater following treatment could be used for dust suppression and/or irrigation. This option for disposal would be beneficial as well as cost-effective. However, reuse may not be capable of handling all of the groundwater that is pumped. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective for providing a beneficial-use for the extracted groundwater. Uses may include irrigation and dust control.

  Implementability: Potentially implementable, but would likely require treatment of groundwater prior to discharge or re-use. Would also require a consistent, year-round use.

  Cost: Low capital, low O&M.

  Decision Rationale: Retained as a disposal option to promote beneficial water use. May not be able to use all water that is pumped and/or provide a consistent, year-round use.

  Retained: Yes

- Evaporation/Infiltration Basin - Discharge to an evaporation/infiltration basin would require some treatment of the groundwater before it is discharged to the basin. The Western Undeveloped Area (WUA) would be the most likely location of a surface impoundment given that if caps are constructed over portions of the site (e.g., gamma source areas), the soil borrow area in the WUA would create a depression that could be used for an infiltration basin. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for disposal of treated water.

Implementability: Implementable, but would require pretreatment of groundwater prior to discharge to the basin. The Western Undeveloped Area borrow site would be the most likely location of an infiltration basin and straightforward to implement.

Cost: Moderate capital, low O&M.

Decision Rationale: Readily implementable in the Western Undeveloped area, is effective for reintroducing clean groundwater into the aquifer, and is a low to moderate cost.

Retained: Yes

- POTW - Discharge to a POTW might require pretreatment prior to discharge. However, it is possible the combined flow from extraction wells installed at the plant boundary would be within acceptable POTW influent criteria for total phosphorus, arsenic, and other constituents. The possible sewer lines running from the FMC site to the POTW might require repair and/or upgrading of to increase capacity. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective for disposal of treated water.

  Implementability: Potentially implementable, but would likely require treatment of groundwater prior to discharge to POTW. Would also require that the POTW has long-term capacity and treatment capability to accept the water.

  Cost: Low capital, low O&M.

  Decision Rationale: Retained as a disposal option for large quantities of water. Would require acceptance by the POTW and an industrial discharge permit, which would likely require treatment of water prior to discharge.

  Retained: Yes

6.3.6 Ex-Situ Treatment

A detailed description of the ex-situ treatment technologies that were deemed technically implementable in Section 5 for the groundwater COCs at the site is provided below. Prior to full-scale implementation, one or more of the technologies that would form the treatment train for treatment of site groundwater would need to be pilot tested to determine their effectiveness at reducing COCs to acceptable levels. Three general categories of ex-situ treatment technologies for groundwater are evaluated below including physical, chemical, and thermal categories and their associated process options.

6.3.6.1 Physical

- Solid/Water Separation - Separation is an effective technology for removing suspended solids from groundwater, but would not be a sufficient standalone technology to remove the dissolved COCs. While separation alone would not be effective in treatment of the groundwater, it may be potentially applicable in conjunction with other treatment technologies, such as chemical precipitation or adsorption. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective in conjunction with other treatment technologies to remove suspended (precipitated) solids, which may contain constituents of concern.

  Implementability: Readily implementable. May require additional treatment to meet discharge standards.

  Cost: Moderate capital, moderate O&M.

  Decision Rationale: Retained for use in conjunction with other treatment options, but ineffective as a standalone technology.

  Retained: Yes

- Filtration - Filtration is an effective technology for removing a wide size range of suspended solids from groundwater, but would not be a sufficient standalone technology to remove the dissolved COCs. While filtration alone would not be effective in treatment of the groundwater, it may be potentially applicable in conjunction with other treatment technologies, such as chemical precipitation or adsorption. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective in conjunction with other treatment technologies to remove suspended (precipitated) solids, which may contain constituents of concern.

Implementability: Readily implementable. May require additional treatment to meet discharge standards.

Cost: Moderate capital, moderate O&M.

Decision Rationale: Retained only for possible use in conjunction with other treatment options. Ineffective as a standalone treatment technology.

Retained: Yes

- Adsorption - Adsorption would be useful as when combined with other treatment technologies for possible necessary reduction of metals to meet MCLs (e.g., arsenic) and potentially P4. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective in conjunction with other treatment technologies to remove dissolved arsenic to meet the MCL standards.

  Implementability: Readily implementable. May require additional treatment to meet discharge standards.

  Cost: High capital, high O&M.

  Decision Rationale: Not retained as an effective treatment technology by itself. However, adsorption may be useful, as a polishing step, when combined with other treatment technologies for possible necessary reduction of dissolved metals to meet the MCLs (e.g., arsenic) and potential reduction of P4.

  Retained: Yes

- Ion Exchange - While ion exchange may be applicable to treating contaminants in the site groundwater, this technology will generate a brine stream from the regeneration and rinsing of the resins. The brine stream may require additional treatment prior to disposal. Furthermore, ion exchange is more expensive than other equally effective and implementable ex-situ treatment options. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Not effective for constituents of concern in groundwater.

  Implementability: Readily implementable, but requires generation of additional waste streams.

  Cost: Moderate capital, moderate O&M.

Decision Rationale: The brine stream from this process would require additional treatment. Ion exchange is more expensive than equally effective and implementable ex-situ water treatment technologies.

Retained: No

- Reverse Osmosis - While reverse osmosis would be effective at removing metals from site groundwater, it will produce a brine stream that likely would require further treatment prior to disposal. In addition, the reverse osmosis process has pretreatment and high energy demand requirements, which make it much more costly than other equally effective and implementable ex-situ treatment technologies. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective for removing dissolved solids down to discharge standards.

  Implementability: Readily implementable, but has high electrical power requirements and produces an additional waste stream that would require treatment.

  Cost: High capital, high O&M.

  Decision Rationale: The brine stream from this process would require additional treatment. RO is more expensive than equally effective and implementable ex-situ water treatment technologies.

  Retained: No

6.3.6.2 Chemical

- Chemical Precipitation - Assuming appropriate pretreatment involving the use of chemical reagents ($FeCL_3$ or $Ca(OH)_2$) and separation/filtration, chemical precipitation would be capable of reducing concentrations of site constituents below MCLs. In addition, chemical precipitation has a relatively low cost when compared to other ex-situ treatments/technologies. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Effective for reducing most of the site COCs to meet the MCL standards.

  Implementability: Common treatment process that is straightforward to implement for low to medium flows

Cost: Moderate capital, high O&M.

Decision Rationale: Retained as a treatment technology for removal of metals and/or phosphate. Likely would require other ex-situ process options (e.g., separation, filtration) to complete the treatment train depending on the discharge requirements..

Retained: Yes

- Oxidation/Reduction - Oxidation/reduction is considered in conjunction with other technologies, such as chemical precipitation, that may require oxidation/reduction to alter the oxidation state of the constituents being treated. For example, because the arsenic chemical state is unknown, it may be necessary to oxidize the influent groundwater so that arsenite can be changed to arsenate for improvement of arsenic removal efficiency in the chemical precipitation process. Oxidation/reduction also may be appropriate for treating P4-containing groundwater. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Potentially effective for converting P4 to phosphate, but would require additional treatment to remove the phosphate if discharge is necessary. Considered in conjunction with other technologies such as chemical precipitation, which may require an oxidation/reduction step to change the oxidation state of the constituents being treated (e.g., arsenite to arsenate) so they can more effectively be removed during chemical precipitation.

  Implementability: Implementable for dissolved phase P4 and some dissolved metal removal.

  Cost: Moderate capital, high O&M.

  Decision Rationale: Retained as a treatment step (component). Might be necessary to oxidize arsenite in influent groundwater to arsenate for improved arsenic removal efficiency in the chemical precipitation process.

  Retained: Yes

6.3.6.3 Thermal

- Thermal Evaporation/Distillation - Evaporation has high capital and O&M costs compared to other effective treatment technologies. In addition, it may require construction of storage basins to store water prior to treatment. Therefore, evaporation has been eliminated from further consideration. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Effective for concentrating dissolved metals and inorganics in conjunction with other processes.

Implementability: Cannot be implemented for large quantities of extracted groundwater unless pond is constructed for water storage.

Cost: High capital, high O&M.

Decision Rationale: Not retained due to high capital and O&M costs compared to other equally effective technologies.

Retained: No

6.3.7 In-Situ Treatment

A detailed description of the in-situ treatment technologies that were deemed implementable in Section 5 for the groundwater COCs is provided below. Prior to full-scale implementation, the technologies would need to be pilot tested to determine their effectiveness at reducing the levels of COCs to target cleanup levels. An evaluation of the physical, chemical and thermal in-situ treatment technologies considered for contaminated groundwater at the FMC Plant OU is provided below.

6.3.7.1 Physical

- Mechanical Aeration - Mechanical aeration would not be effective at treating metals and in fact may increase the mobility of some constituents. Predicting the dispersion of air within the formation to forecast the effectiveness of this treatment would be difficult. Furthermore, treatment of the capillary fringe at the site using mechanical aeration would be difficult due to the presence of low-permeability silts. This technology therefore has many factors that would affect its implementability. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Not effective for treatment of inorganic COCs (e.g., metals, nutrients). Potentially effective for oxidizing P4-containing groundwater. Effectiveness may be reduced due to inability to deliver uniform spatial coverage.

  Implementability: May be difficult to implement due to the depth to groundwater and the low hydraulic conductivity of silts at the capillary fringe.

  Cost: Moderate capital, high O&M.

Decision Rationale: Due to limitations with respect to spatial coverage, mechanical aeration likely is not a viable in-situ technology.

Retained: No

6.3.7.2 Chemical

- Chemical Injection (Oxidation/Hydrolysis) - Injection of chemicals (e.g., Fenton's Reagent) is most effective for altering the pH of groundwater to precipitate COCs such as metals. This often causes additional chemical reactions within the formation and may significantly reduce the permeability of the zone being treated. This would make it much more difficult for groundwater to flow through the formation. However, predicting the dispersion of chemicals within the formation to determine the effectiveness of the treatment would be difficult. Furthermore, treatment of the capillary fringe at the site (the target zone) using chemical injection would thus be difficult due to the presence of low-permeability silts. Therefore, this technology has many factors that would affect its usefulness, implementability and effectiveness. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: Not effective for treatment of inorganic COCs (e.g., metals, nutrients). Potentially effective for oxidizing or hydrolyzing P4-containing groundwater, but effectiveness likely would be reduced due to inability to deliver uniform spatial coverage. May also increase mobility of inorganic species (e.g., metals).

  Implementability: May be difficult to implement due to the low hydraulic conductivity of silts in the capillary fringe.

  Cost: Moderate capital, high O&M.

  Decision Rationale: Chemical oxidation may be effective at accelerating oxidization of dissolved P4 in groundwater. However, it may increase the mobility of some other inorganic species (e.g., metals). In-situ hydrolysis of P4-containing groundwater would have similar challenges to chemical/physical oxidation, i.e., effective delivery and coverage, but also would have the negative effect of adding salts (TDS) to the groundwater system.

  Retained: No

- Reactive Barrier/Chemical Injected Reductive Reaction Zone - Permeable reactive barriers (PBRs) and chemical-injected reductive reaction zones are both closely related technologies, and will be referred to here as PBRs. PBRs are potentially useful for treatment of metals and nutrients in the site groundwater. However, they are limited by the depth to which they can be placed (maximum demonstrated depth is 45 feet). Predicting the dispersion of chemicals within the formation, which ultimately would determine the effectiveness of PBR treatment, would be difficult. There is also uncertainty regarding the long-term effectiveness of this technology. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: PRBs are potentially effective for treatment of inorganic COCs (metals and nutrients). Effectiveness may be limited due to existing groundwater near source areas that already is near typical target conditions for reactive barriers (e.g. reduced redox and anion saturation to promote mineral precipitation). Effectiveness may also be limited due to the inability to deliver uniform spatial coverage due to the presence of low-permeability silts in the zone of potential application at the FMC Plant OU. There are also uncertainties regarding the long-term performance/functional life of chemical injection.

Implementability: Chemical injection (e.g., in-situ redox manipulation) has been implemented at full scale at Hanford Site 100 D area using sodium dithionite with a potassium carbonate/potassium bicarbonate buffer (pH 11). However, after initial installation, additional modifications have been found to be necessary to meet performance objectives. The current proposal at Hanford is to inject polyacetate and micron-sized ZVI and increase pumping and treatment flow rates. Chemical injection may be difficult to implement at the FMC Plant OU due to the low hydraulic conductivity of silts at the capillary fringe and upper saturated zone.

Cost: Moderate to high capital, high O&M.

Decision Rationale: PBRs have been used with some success to treat groundwater contaminated with metals and nutrients. However, a chemical-injection reductive reaction zone likely is not a viable technology due to the following factors: 1) existing groundwater chemistry conditions, 2) uncertainties associated with the ability to achieve uniform mixing throughout the vertical profile of the shallow groundwater zone 3) performance uncertainties, and 4) associated moderate to high capital and high O&M costs.

Retained: No

6.3.7.3 Thermal

- Thermal Desorption – In-situ thermal desorption (ISTD) uses thermal wells, along with heated extraction wells, to remediate COCs. Heat is applied using a high-temperature surface in contact with the groundwater and aquifer matrix, so that radiation and thermal conduction heat transfer are effective near the heated extraction wells. As a result, thermal conduction and convection occur in the soils above the aquifer and in the aquifer mass (i.e., the sediments and groundwater) between the heated wells. ISTD has been used to treat VOCs and SVOCs mostly in soil, but not the inorganic constituents that are the primary COCs in the FMC Plant OU groundwater. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: ISTD has been effective at treating soil contaminated with VOCs and SVOCs, but is not effective for treatment of inorganic COCs (e.g., metals, nutrients). ISTD has not been tested on soils/groundwater contaminated with P4. Representatives of TerraTherm have indicated that significant testing would be required to determine whether this technology could be utilized for P4-containing wastes. They have stated that based upon their initial review, this technology is not suitable for the site conditions.

Implementability: ISTD has been implemented at full-scale to treat soil contaminated with VOCs and SVOCs. However, it has never been implemented at a site with P4 and has never been demonstrated to be effective at treating P4. ISTD would require the continuous addition of oxygen into the treatment zone to promote oxidation. Due to the estimated depth of the treatment zone (80-90 feet bgs), the background oxygen levels would be low and would be quickly consumed during the process. To ensure continued oxidation, air would need to be introduced uniformly throughout the target treatment zone. This would be very difficult, if not impossible, given the low-permeability fine-grained sediments (primarily silts) in the target zone. In addition, removal of the P4 reaction products would be difficult due to the fine-grained nature of the treatment zone.

Cost: High capital, high O&M.

Decision Rationale: ISTD has been used to treat soils contaminated with organics but is not effective for metals and nutrients. However, this technology has limited applicability in the capillary fringe/groundwater containing P4 at the FMC Plant OU based upon the following factors: 1) the difficulties associated with the depth to groundwater and the fine-grained sediments in the target zone, 2) its unproven effectiveness for treating soils/groundwater containing P4, and 3) associated high capital and O&M costs.

Retained: No

TABLE 6-1

SOIL REMEDIATION TECHNOLOGY SCREENING TABLE
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
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Process Option	Effectiveness	Implementability	Cost	Potential Impacts to Human Health & Environment During Construction		Decision Rationale	Potentially Applicable to RAs	Retained
				Remedial Site Worker	Public			
No Action								
No Action See § 6.2.1	Low	Not applicable	None	No Hazard	No Hazard	Always retained in FS as base case and may be use in areas that pose no risk.	Potentially applicable to RAs that meet the RAOs.	Yes
Institutional Controls								
Access Restrictions								
Fencing See § 6.2.2.1	High when applied with other remedial actions.	High	Low capital, low O&M	No Hazard	No Hazard	Fencing is effective at limiting access and direct exposure to COCs on the site. Fencing is typically part of a selected remedial alternative.	Applicable to restricting access to portions of the site after implementation of remedial actions (e.g., capped areas).	Yes
Land and Groundwater Use Restrictions See § 6.2.1	High when applied with other remedial actions.	High	Low	No Hazard	No Hazard	Deed restrictions are effective at limiting access and direct exposure to COCs (both soil and groundwater) on the site. Deed restrictions are typically part of a selected remedial alternative.	Potentially applicable to restricting access and land-use to overall site.	Yes
Soil Management See § 6.2.2.1	High when applied with other remedial actions.	High	Low capital, low O&M	No Hazard	No Hazard	Soil Management establishes practices for future management of contaminated fill materials remaining on the site. Soil Management is typically part of a selected remedial alternative.	Potentially applicable to areas where capping is placed.	Yes
Receptor Initiated Remediation	High when applied with other institutional controls.	High	Low	No Hazard	No Hazard	RIR is effective when combined with other institutional controls in the short term and in the long term is effective when land use is determined and redevelopement actions are coordinated with remedial actions.	Applicable to RA where risks are limited to hypothetical future worker and the area is likely to be redeveloped.	Yes
Containment								
Capping								
Multi-Layered Cap See § 6.2.3.1	High	Moderate	High capital, moderate O&M	Low Hazard	No Hazard	Effective for protection of groundwater and minimizing direct exposure and ingestion of all site COCs when applied with other institutional controls (e.g., fencing and deed restrictions). Potential for accumulation/concentration of PH3 gas in areas containing P4-contaminated materials under impermeable multi-layered caps. Long-term durability of multi-layered caps has been questioned.	RAs B and C	Yes
Asphalt/Concrete Cap See § 6.2.3.1	High	High	High capital, moderate O&M	Low Hazard	No Hazard	A/C caps can be effective and implemented. May be applicable to smaller areas of any site where a robust cap is appropriate and future vehicle traffic is necessary.	RAs A, G and K	Yes
Evapotranspirative (ET) Soil Cover See § 6.2.3.1	High	High	Moderate capital (with on-site soil source), low O&M	Low Hazard	No Hazard	ET caps have become increasingly used in the arid and semi-arid regions to prevent future groundwater impacts and to minimize direct exposure and ingestion of site COCs when applied with other institutional controls (e.g., fencing and deed restrictions). ET caps have presumed benefits for fate and transport of gases as well as long-term durability.	RAs B, C, D, E, F1, F2, and H	Yes
Soil Cover Cap See § 6.2.3.1	High, but only for gamma protection.	High	Low capital (with on-site soil source), low O&M	Low Hazard	No Hazard	Previous studies by other parties and on-site testing has shown gamma caps (1 foot of native soil) to be effective for reducing gamma exposure to acceptable levels at the surface. Gamma caps are also effective at minimizing direct contact and ingestion of certain COCs (e.g., metals). Easily implemented with local borrow sources.	RAs A, F, F1, F2 and G	Yes
Surface Control								
Soil Grading See § 6.2.3.2	High when applied with other remedial actions.	Hiigh	Low capital, low O&M	Low Hazard	No Hazard	Effective for reducing groundwater infiltration. Would be incorporated into overall remediation strategy (i.e., the selected alternative) to control storm water.	Potentially applicable to all RAs.	Yes
Vegetation See § 6.2.3.2	High when applied with other remedial actions.	High	Low capital, low O&M	Low Hazard	No Hazard	Effective for reducing groundwater infiltration and dust in arid areas when used in conjunction with soil caps and other areas with exposed soil. Vegetation will be incorporated into overall site reclamation.	Potentially applicable to all RAs.	Yes
Removal and Disposal								
Removal								
Modified and Conventional Excavation See § 6.2.4.1	High for areas without P4. Low to moderate for areas with P4.	High for areas without P4. Low to moderate for areas with P4.	High capital, low O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Conventional excavation is an ancillary process option for application along with other treatment, disposal, or reuse options. Conventional excavation is typically considered for areas with relatively shallow fill depths (2 to 4 feet) as capping is more cost effective. Conventional excavation would be required in conjunction with on-site consolidation and reuse, on-site/off-site disposal, or ex-situ treatment. Significant safety/environmental pre-cautions would have to be implemented prior to removing any soil with P4. Modified excavation may be utilized for P4 contamination in small areas, at shallow depths and low concentrations with very specific operating and safety procedures	Conventional excavation - RAs A, I, and J. Modified excavation: RAs B, C, F1 and K and underground piping.	Yes
Disposal (or Reuse)								
Consolidation and On-site Disposal See § 6.2.4.2	High for areas without P4. Low to moderate for areas with P4.	High for areas without P4. Low to moderate for areas with P4.	Moderately high capital, low to moderate O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Possible method for reducing capped areas over portions of the site where fill materials do not contain P4. Fill depths greater than 4 feet are typically more cost effective to cap in-place. Areas with shallow soil contamination (0 to 2 inches) may be amenable to diposal in-place through tilling (e.g., RAs I and J). Potentially applicable for small areas or small volumes of materials containing P4 (e.g., underground process piping and/or soils in RA-K). Movement of materials from one RA to another may require AOC unit designations.	RAs A, E, G, I, J ,and K.	Yes

TABLE 6-1

SOIL REMEDIATION TECHNOLOGY SCREENING TABLE
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Process Option	Effectiveness	Implementability	Cost	Potential Impacts to Human Health & Environment During Construction		Decision Rationale	Potentially Applicable to RAs	Retained
				Remedial Site Worker	Public			
Removal and Disposal (continued)								
Off-Site Disposal See § 6.2.4.2	High	High for areas without P4 and low volumes. Low to moderate for areas with P4 and low volumes.	High capital, low O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Off-site disposal is not considered to be applicable to large volume wastes. Only small quantities of P4-contaminated wastes that can be safely excavated and packaged would be considered for off-site disposal.	Underground piping.	Yes
Ex-Situ Treatment								
All ex-situ technologies would require the excavation, transport, storage, sizing, blending of contaminated soil and fill material prior to treatment. For soils containing P4, this would result in significant health and safety risks to the site worker associated with dermal contact of P4 and the public/environment associated with the combustion of P4, and generation of PH3 and P2O5 vapors. Also water used to blanket P4 in an effort to preclude combustion, might be released to the environment. Therefore, excavation of soils containing P4 would result in failure of RAOs associated with exposure to soil, air, and potentially groundwater containing P4.								
Stabilization/Solidification See § 6.2.5.1	Moderate for areas without P4 (metals and radionuclides only), but doesn't necessarily limit gamma radiation. Low for areas with P4.	Moderate for areas without P4. Low for areas with P4.	Very High capital, Very High O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	S/S has been demonstrated to be effective for treating metals and radionuclides, although not necessarily effective for gamma control. There is no history of laboratory or field testing of this technology with P4 contaminated soils. Stabilizing additives would likely react violently with P4 and would be difficult to control and therefore would be applicable only for low P4 concentrations with evenly sized and blended feed material.	RA K	Yes
Chemical Oxidation See § 6.2.5.2	Low for most metals, radionuclides and P4	Moderate for areas without P4. Low for areas with P4.	Very High capital, Very High O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Not effective for soil with metal and radionuclide contamination. Likely is limited by the small particle size necessary for treatment and lack of ability to treat soils with high levels of P4. Liquid, gas, and solid by-products would require capture and treatment by a sophisticated treatment processes to prevent worker, public, and environmental exposure to COCs.	Probably not applicable.	No
Caustic Hydrolysis See § 6.2.5.2	Low for areas without P4. Low to moderate for areas with P4. COCs other than P4 would require further treatment.	Moderate for areas without P4. Low for areas with P4.	Very High capital, Very High O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Two hydrolysis processes were found (Zimpro and alkali treatment) for treating P4, but are limited by the small particle size necessary for treatment and lack of ability to treat soils with high levels of P4. Residual sludges from these hydrolysis processes likely would contain phosphorus and might require treatment prior to on- or off-site disposal. Excavation, storage, and sizing of P4 soils presents risks to workers, the public, and the environment, in addition ancillary treatment processes would be required to capture and treat by-product off gases and liquids.	RAs B, C, F1, and K.	Yes*
Incineration See § 6.2.5.3	Low for areas without P4. Low to moderate for areas with P4. Other COCs would require further treatment.	Low for areas without P4. Low to moderate for areas with P4 but only for small quantities.	Very High capital, Very High O&M	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	Off-site commercial incinerators are available and can be used for drummed wastes containing P4 provided volumes would be relatively small. For incineration, many of the heavy metals and radionuclides in the soil would not be oxidized and would be concentrated in the residual ash from the incinerator. These ashes would require additional treatment and proper disposal. On- or off-site incineration has not been used on a large scale for treating P4 contaminated soils. On-site incineration would require construction of an incinerator and hydrator that would need to meet RCRA and Clean Air Act standards. Excavation, storage, and sizing of P4 soils presents risks to workers, the public and the environment, in addition to ancillary treatment processes to capture and treat off gases and liquids.	Underground piping.	Yes
Landfarming See § 6.2.5.4	High only for shallow soil hydrocarbon contamination. Low for all other site COCs.	High only for shallow soil hydrocarbon contamination. Low for all other site COCs.	Low capital, Moderate O&M	Low if only considered for soils contaminated with organics.	Low if only considered for soils contaminated with organics.	Viable technology for soil contaminated with organics contaminants such as fuel PAHs and VOCs. Not retained as a viable technology for soil/fill with other site COCs (i.e., metals, radionuclides, and P4.	RA-A1	Yes
In-Situ Treatment								
Stabilization/Solidification See § 6.2.6.1	High for areas without P4 and at shallow depths, but low for gamma. Low for areas with P4.	Moderate for areas without P4. Low for areas with P4.	Moderate to moderately high capital, low O&M.	Low for areas without P4. High for areas with P4.	Low for areas without P4. Moderate to high for areas with P4.	In-situ S/S has been used and is effective for treating metals and radionuclides. However, stabilizing additives identified to date react violently with P4. Off gases from the in-situ S/S process would require containment and treatment. Excess water used in the process could mobilize other COCs.	Probably not applicable.	No

* EPA selected caustic hydrolysis as the most viable ex-situ treatment technology and directed it be retained.

TABLE 6-2

GROUNDWATER REMEDIAL TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Process Option	Effectiveness	Implementability	Cost	Decision Rationale	Retained
No Action					
No Action See § 6.3.1	High for constituents that meet ARARs and Remedial Action Objectives (RAOs).	Not applicable	None	Always retained in FS as base case and may be used in areas that pose no risk.	Yes
Institutional Controls					
Access Restrictions					
Land and Groundwater Use Restrictions See § 6.3.2	High	High	Low capital, Low O&M	Deed restrictions preventing residential land use are already in place. Groundwater use restrictions were selected in the 1998 ROD and are still an appropriate component of the groundwater remedy.	Yes
Monitoring					
Ground Water Monitoring See § 6.3.2	High	High	Moderate capital, Low O&M	Groundwater monitoring is currently on-going at the site, was selected in the 1998 ROD and is still an appropriate component of the groundwater remedy.	Yes
Source Controls					
Source Controls See § 6.3.3	High	High	Moderate capital, Moderate O&M	Major source controls actions have already been completed at the site, source controls were identified in the 1998 ROD as a component of the groundwater remedy and remain an appropriate component of the remedy. Source controls can include treatment of source areas through containment (capping), in-situ treatment, and/or removal and ex-situ treatment. The technologies associated with source controls are discussed as part of remedial technologies for soil.	Yes
Containment					
Vertical Barriers					
Extraction Wells See § 6.3.4.1	Moderate to High	Moderate to High	Moderate capital, High O&M	Effectiveness and implementability will be more difficult in the source areas than at the NE corner of the Plant Site. Groundwater extraction for hydraulic control was identified in the 1998 ROD as a contingent component of the groundwater remedy and is still appropriate for consideration as a component of the groundwater remedy.	Yes

TABLE 6-2

GROUNDWATER REMEDIAL TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
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Process Option	Effectiveness	Implementability	Cost	Decision Rationale	Retained
Removal and Disposal					
Removal					
Pumping See § 6.3.5.1	High	High	Moderate capital, High O&M	Retained mainly to evaluate extraction in areas of highest groundwater constituent concentrations (e.g., highest mass removal) for comparison to extraction for hydraulic control.	Yes
Disposal					
Recycle-Reuse See § 6.3.5.2	High if there is a demand for the water.	Low to moderate.	Low capital, Low O&M	Retained as a disposal option to promote beneficial water use. May not be able to use all water that is pumped e.g., for watering vegetation on various caps and therefore additional sources for disposal would be necessary for treated water.	Yes
Evaporation/Infiltration Basin See § 6.3.5.2	High if water is treated.	Moderate to high.	Moderate capital, Low O&M	Readily implementable in the Western Undeveloped area, is effective for reintroducing clean groundwater into the aquifer, and is a low to moderate cost.	Yes
POTW See § 6.3.5.2	High is POTW will accept water. May require pre-treatment.	High if POTW will accept water.	Low capital, Low O&M	Retained as a disposal option for large quantities of water. Would required industrial discharge permit with the City of Pocatello.	Yes
Ex-Situ Treatment					
All ex-situ technologies would require the pumping of impacted groundwater from extraction wells prior to treatment. The ex-situ technologies identified and screened below are for treatment of the overall site-impacted					
Solid/Water Separation See § 6.3.6.1	High when used in combination with other primary water treatment technologies.	Moderate to high.	Moderate capital, Moderate O&M	Retained for use in conjunction with other treatment options, but ineffective as a standalone technology.	Yes
Filtration See § 6.3.6.1	High when used in combination with other primary water treatment technologies.	Moderate to high.	Moderate capital, Moderate O&M	Retained only for possible use in conjunction with other treatment options, ineffective as a standalone treatment technology.	Yes
Adsorption See § 6.3.6.1	High for some COCs (As) when applied to appropriate water treatment.	Moderate to high.	High capital, High O&M	Not retained as an effective treatment technology by itself. However, adsorption may be useful, as a polishing step, when combined with other treatment technologies for possible necessary reduction of dissolved metals to below the MCLs (e.g., arsenic) and potentially elemental phosphorus.	Yes
Ion Exchange See § 6.3.6.1	Low for COCs on the site.	Moderate to high.	Moderate capital, Moderate O&M	The brine stream from this process would require additional treatment. Ion exchange is more expensive than equally effective and implementable ex-situ water treatment technologies, which are of lower cost. As a result, it is not retained.	No
Reverse Osmosis (RO) See § 6.3.6.1	High	Moderate to high.	High capital, High O&M	The brine stream from this process would require additional treatment. RO is more expensive than equally effective and implementable ex-situ water treatment technologies, which are of lower cost. As a result, it is not retained.	No
Chemical Precipitation See § 6.3.6.2	High	High	Moderate capital, High O&M	Retained as a treatment technology for removal of metals and/or phosphate. Likely, would need other ex-situ process options to complete the treatment train depending on the discharge requirements (e.g., separation, filtration).	Yes

TABLE 6-2

GROUNDWATER REMEDIAL TECHNOLOGY SCREENING
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Process Option	Effectiveness	Implementability	Cost	Decision Rationale	Retained
Ex-Situ Treatment (continued)					
Oxidation/Reduction See § 6.3.6.2	Low to moderate for COCs on site.	Moderate	Moderate capital, High O&M	Retained as a treatment step (component). Might be necessary to oxidize arsenite in influent groundwater to arsenate for improved arsenic removal efficiency in the chemical precipitation process.	Yes
Thermal Evaporation (Distillation) See § 6.3.6.3	Moderate	Low for volumes of water anticipated.	High capital, High O&M	Not retained due to high capital and O&M costs compared to other equally effective technologies.	No
In-Situ Treatment					
The in-situ technologies identified and screened below are for treatment of the overall site-impacted groundwater (e.g., arsenic, nutrients, fluoride). Technologies that may be effective for treatment of P4 in groundwater					
Mechanical Aeration See § 6.3.7.1	Low for metals/radionuclides. Moderate for P4.	Low given the depth of groundwater at the site and low hydraulic conductivity in the capillary fringe.	Moderate capital, High O&M	Due to limitations with respect to spatial coverage, mechanical aeration is not likely a viable in-situ technology.	No
Chemical Injection (Oxidation/Hydrolysis) See § 6.3.7.2	Low for metals/radionuclides. Moderate for P4.	Low given the depth of groundwater at the site and low hydraulic conductivity in the capillary fringe.	Moderate capital, High O&M	Chemical oxidation may be effective at accelerating oxidization of dissolved P4 in groundwater. However, it may increase mobility of some other inorganic species (e.g., metals). In-situ hydrolysis of P4-containing groundwater would have similar challenges to chemical/physical oxidation (effective delivery and coverage) but would also have the negative effect of adding salts (TDS) to the groundwater system.	No
Permeable Reactive Barriers and Chemical Injection (Reductive Reaction Zone) See § 6.3.7.2	Low to moderate for COCs on site.	Low given the depth of groundwater at the site and low hydraulic conductivity in the capillary fringe.	Moderate to High capital, High O&M	Chemical injection reaction zones have been used with some success to treat groundwater contaminated with metals and nutrients. However, 1) existing groundwater chemistry conditions, 2) uncertainties associated with ability to achieve uniform mixing throughout vertical profile of shallow groundwater zone 3) performance uncertainties, and 4) associated moderate to high capital and high O&M costs, a chemical injection reductive reaction zone is not likely a viable technology.	No
Thermal Desorption See § 6.3.7.3	Low for COCs on site.	Low given the depth of groundwater at the site and low hydraulic conductivity in the capillary fringe.	High capital, High O&M	ISTD has been used to treat soils contaminated with organics but is not effective for metals and nutrients. However, 1) due to the difficulties associated with the depth to groundwater and geologic conditions at this site, 2) unproven effectiveness for treating soils/groundwater containing P4, and 3) associated high capital and O&M costs, this technology has limited applicability in the capillary fringe / groundwater containing P4 at the site.	No

Section 7
ASSEMBLY AND SCREENING OF REMEDIAL ALTERNATIVES

This section presents the assembly and screening of remedial alternatives for soil/fill and groundwater. The remedial alternatives are assembled by combining viable remedial technologies and process options as presented in Section 6 into various combinations to create alternatives for remediation of COCs detected in the site soils and groundwater. The assembled alternatives span the range of general response actions (GRAs) that were developed for each site medium. The GRAs developed in Section 4 describe those actions that will satisfy the remedial action objectives (RAOs) and consist of the following potential actions for soil and groundwater: 1) "no action;" 2) institutional controls; 3) containment; 4) removal/disposal; and 5) ex-situ and in-situ treatment. The *EPA RI/FS Guidance* states: *"Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate"* and "*Alternatives should be developed that will provide decision-makers with an appropriate range of options and sufficient information to adequately compare alternatives against one another. In developing alternatives, the range of options will vary depending on site-specific conditions."*

The assembled remedial alternatives then are screened based on their effectiveness, implementability, and cost and their ability to achieve the RAOs and ARARs presented in Section 4. In Section 4.3 (Alternative Screening Process), the *EPA RI/FS Guidance* states: *"Defined alternatives are evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated more generally in this phase than during the detailed analysis."*

For clarity, the remedial alternatives for site soils/fill and groundwater are assembled and discussed separately. However, the remedial alternatives ultimately will be combined into an overall remedial alternative that addresses RAOs and ARARs for both media.

7.1 SELECTION OF TECHNOLOGIES FOR ALTERNATIVE ASSEMBLY

In Section 6.0, technologies for remediation of soil and groundwater were evaluated according to effectiveness, implementability, and cost. Based on that evaluation, Table 7-1a and Table 7-1b were prepared. These tables list the soil and groundwater technologies that were retained for assembling alternatives. Explanations are provided in these tables to assist the reader in understanding the site-specific conditions in which each technology and/or process option would be used in the assembly of soil and groundwater alternatives. Technologies are selected from these tables to remediate the identified COCs, to satisfy site GRAs and RAOs, and to provide a range of "*treatment and containment options*" (as suggested by *EPA RI/FS Guidance*) in the alternatives presented for evaluation.

7.1.1 Consideration of Principal Threat Waste in the SFS

The NCP has established an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP §300.430(a)(1)(iii)(A)). Where EPA determines that it is not practicable to use treatment to address principal threat source materials (PTSM), they may be transported offsite, consistent with the Off-Site Disposal Rule, 40 CFR 300.440, or managed safely onsite, consistent with ARARs and risk-based action levels.

EPA has designated elemental phosphorus (P4) in subsurface soils and underground process piping as a PSTM at the FMC Plant OU due to the potential for future exposure (due to intrusive excavation activity) in specific RAs. The following RAO was developed to address P4 as a PTSM:

"Prevent direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard, or resultant air emissions that represent a significant risk to human health and the environment."

The NCP and EPA's 1991 guidance indicate that there may be situations where wastes identified as PTSM may be contained rather than treated, or be given limited treatment, due to difficulties in treating the wastes. Specific situations where this may be the case include the following:

- Treatment technologies are not technically feasible or are not available within a reasonable time frame;
- The extraordinary volume of materials or of the site make implementation of treatment technologies impracticable;
- Implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation; or
- Several effects across environmental media resulting from implementation would occur.

The SFS process included a rigorous review and evaluation of potential P4 treatment alternatives for subsurface P4 within RA-B (including in the capillary fringe) and RA-C including detailed evaluation of treatment technologies, evaluation of independent studies, consideration of site factors and review of EPA decisions at the Stauffer Tarpon Springs NPL (former elemental phosphorus manufacturing) site:

- Based on EPA's Office of Solid Waste and Emergency Response report entitled "Treatment Technologies for Historical Ponds Containing Elemental Phosphorus – Summary and Evaluation" (EPA, 2003), FMC's update of the EPA 2003 technology evaluation documented in "Identification and Evaluation of P4

Treatment Technologies – January 2009" (MWH, 2009c), and the U.S. Army Corp of Engineers P4 treatment technology review and evaluation documented in "Remediation of P_4 Contaminated Matrices at FMC, Pocatello, Idaho – January 2009" (USACE, 2009), there are no technically feasible P4 treatment technologies available or likely to become available in the near future for treatment of the volume and type of P4 contaminated materials (soils and fill) at the FMC Plant Site.

- The predominant hazard associated with P4 is the potential for spontaneous oxidation to cause acute thermal burns to anyone coming into direct contact with this material. For all RAs where P4 is present, it is below the ground surface and direct exposure could only occur if the P4 were excavated.

- Containment in place has been the primary selected remedial action at similar sites, including TVA sites and the Stauffer Chemical Tarpon Springs site. Containment of elemental phosphorus wastes through installation of low-permeability covers also has specifically been approved by EPA and implemented at the FMC Pocatello facility for RCRA closure of elemental phosphorus-containing process waste ponds.

Due to the relatively shallow depth of the piping and relatively lower estimated volume of potential residual P4 material contained within the piping, removal and treatment of PTSM in underground process and sewer piping are evaluated as "discrete" components of several soil remedial alternatives in the SFS.

7.1.2 Consideration of Area of Contamination (AOC) Units

As discussed below, assembled soil Alternative 4 explicitly identifies the need for designation of an Area of Contamination (AOC) Unit for movement of P4-contaminated soils/fill excavated from RA-K to another RA where P4 is known to be present (e.g., RA-B), and then capped with an ET cap. Other alternatives (e.g., soil Alternatives 5 and 6, may require that P4-contaminated materials be removed from the RA for storage, feed preparation, and/or treatment. The full evaluation of the necessity or appropriateness for designation of AOC Units on the site to accommodate the movement, excavation, consolidation, storage, packaging, and/or treatment of soils/fill will be part of the remedial design (RD) process.

7.2 ASSEMBLY OF SITE SOILS/FILL ALTERNATIVES

Some site soils/fill at the FMC Plant OU have been impacted by historical activities and potentially present health risks under various risk scenarios. Fill material encountered during the RI and SRI investigations consist of reworked native soil, imported soil, and other materials generated during facility operations. The fill material types and thicknesses for each RU are described in Table 2-1. Fill and other source material at the FMC Plant Site observed during the SRI drilling included reworked native (loess, sand,

and gravel), slag, ore (including calcined ore and bull rock), ferrophos, concrete, asphalt, silica, calciner pond solids, phossy solids, precipitator solids, and coke. The exposure pathways associated with impacted site soils include exposure to gamma radiation, and inhalation, ingestion, and dermal contact of soils impacted by heavy metals and P4. Data collected during the RI and SRI indicate that with few exceptions (specifically, only in the presence of a sustained, or limited, hydraulic head) the COCs in site soils do not leach from these source and fill materials into the underlying soils, and thus they do not pose a threat to groundwater.

In Sections 5, possible soil technologies were assembled based on the site COCs and then were evaluated and screened based on their technical implementability. Viable technologies from this initial screening were further screened in Section 6 based on their effectiveness, implementability, and cost. Table 7-1a presents the technologies that were retained after the final technology screening in Section 6 and those that were used in the assembly of soil alternatives in Section 7.3.

The evolution of the soil alternatives presented in Section 7.3 involved meetings and teleconferences with EPA, IDEQ, and the Tribes. Following initial discussions at the February 2009 meeting in Salt Lake City, FMC submitted electronically an interim SFS deliverable on May 5, 2009 entitled *Assembled Soil Alternatives for the FMC Plant Operable Unit*. This interim SFS deliverable was developed to aid in discussion of preliminary soil alternatives at a meeting with EPA, IDEQ, and the Tribes on May 20 and 21, 2009 in Seattle, Washington. Following the discussion of those preliminary alternatives at the Seattle meeting, EPA suggested that FMC create a table assembling soil alternatives by RA and then screen these initial alternatives based upon implementability, effectiveness, and cost in accordance with the *EPA RI/FS Guidance* methodology.

Table 7-2 was prepared in response to this EPA request. The information contained in this table is summarized from left to right as follows:

- The RA name.
- The three site-specific decision criteria columns that help determine the applicability of the technologies and process options.
- The technologies and/or process options that were retained in Section 6 and are potentially viable for remediation of the RAs. The “Xs” in these columns indicate technologies or process options that are used within one or more of the assembled alternatives for that RA. The “Os” in these columns indicate that the technology or process option was initially considered but rejected for that RA. An empty cell indicates that the technology or process option was not identified as viable for that RA.
- The five assembled remedial alternatives (in addition to “no action”), organized by RA and developed from the technologies identified in the preceding columns.

7.2.1 Common/Core Elements of the Assembled Alternatives

For these five assembled alternatives (in addition to the "no action" alternative), there are common or core elements that will be incorporated into the remedial design and will be an integral part of each alternative. These core elements may vary somewhat from one assembled alternative to another and likely will not be fully defined until the remedial design (RD). A general discussion of the seven common or core elements is provided below. The discussion of the five assembled alternatives is presented in Sections 7.3.

7.2.1.1 Institutional Controls

Institutional controls will be a significant component of any selected alternative. Institutional controls may apply to all or part of the site and may include any or all of the following, in addition to those institutional controls already in place:

- Access controls consisting of fencing, entrance gate controls, site entrance logs, warning signs, and/or required training.
- Land use covenants, such as deed restrictions, establishing controls on one or more of the following:

    a. Restrictions on the types of activities and/or development (e.g., limited to commercial or industrial);
    b. Prohibition of intrusive activities, construction and/or excavation at ET or multi-layer caps, and compliance with a soil/fill management plan at gamma caps;
    c. Requirements for soil/fill management (see discussion below);
    d. Restrictions on the use of shallow/impacted groundwater: and/or
    e. Notices such as those already in place for the closed RCRA ponds.

7.2.1.2. Soil/Fill Management

A soil/fill management plan would be incorporated into deed restrictions to ensure that disturbance, management, and/or disposition of site-impacted soil/fill are controlled under enforceable restrictions that attach to and run with the land. The soil/fill management plan would be designed to control redistribution of impacted soil/fill. Soil management would likely include prohibition of excavation in areas containing ET or multi-layer caps, and strict management of excavated soil/fill in areas where excavation may be allowed (e.g., utility trenching within a gamma cap).

7.2.1.3 Cap Integration, Monitoring and Maintenance

- Integration with Existing Site Features. The site currently has 11 ponds that were capped and closed pursuant to a RCRA Consent Decree and applicable RCRA regulations. These ponds (known as the RCRA Ponds) are currently being managed under EPA-approved RCRA post-closure plans. There are also 5 ponds (known as the Calciner Ponds) that were capped and are currently being managed under a Voluntary Consent Order with the IDEQ. Each of the assembled alternatives would require construction of one or more caps that may intersect with one or more of the caps that are already in place. In addition, there likely will be several instances where caps that could be constructed as part of the CERCLA remedial action would intersect. Therefore, careful consideration will be required during the RD to ensure that:

a. Intersection of caps will maintain the integrity and performance of both caps.
b. Cap grading design will adequately control and provide for management of stormwater runoff.
c. Access roads (e.g., roads to RCRA ponds, power substations, etc.) are maintained and integrated into the cap design, as appropriate.
d. Existing easements and infrastructure (e.g., active power lines, access to the Don substation, etc.) are integrated into the cap design.
e. Monitoring wells, pond leachate collection systems, and other monitoring and/or maintenance systems are integrated into the cap design and remain functional and accessible.

- Cap Monitoring. As required and performed for existing site caps, any new caps installed as part of the selected remedy would require long-term monitoring. This monitoring effort would be implemented to ensure the effectiveness and longevity of the various cap types installed during the remedial action. The conceptual strategy for the cap monitoring initially is developed in the detailed analysis of this SFS and then will be finalized and documented in the remedial design. The cap monitoring program would depend on the cap type, but in general the monitoring would include:

  a. Settlement monitoring;
  b. Erosion monitoring (periodic and after certain storm events);
  c. Vegetation monitoring on the surface of the capped areas;
  d. Security monitoring (fences, signage, etc.); and
  e. Stormwater/precipitation drainage system monitoring.

- Phosphine (PH3) Monitoring. Elemental phosphorus is known or suspected to be present in the subsurface soil/fill in the following areas:

  a. Furnace building, phos dock, and secondary condenser area (in RA-B) including within the capillary fringe immediately downgradient of this area;
  b. Slag pit area (in RA-B);
  c. Pond 8S recovery process area (in RA-C);
  d. Railcars buried within the slag pile (in RA-F);
  e. Former phossy ponds and precipitator slurry ponds (in RA-C);
  f. Railroad swale (in RA-K); and

g. Areas with underground piping or storm sewers that conveyed CO gas (in RA-E), precipitator slurry (in RA-B, RA-C, RA-D, and RA-E), and phossy water (in RA-B, RA-C and RA-D).

Experience at Pond 16S (one of the capped RCRA ponds) has shown that PH3 can accumulate under synthetic cap layers (e.g., flexible membrane liners). Based upon the current CSM, the areas listed above would not be expected to generate or accumulate PH3 at levels found at Pond 16S because they are significantly different than Pond 16S (i.e., there should be very little free water present, the pH is different, and similar co-mingled wastes are not present). However, PH3 generation may occur in those areas where P4 and water are present, although at expected rates much lower than at Pond 16S. Therefore, PH3 monitoring is warranted in these areas if P4 is capped in place to ensure that PH3 does not accumulate to levels that would threaten human health or the environment. This monitoring would be implemented for any type of cap placed over these areas and would include the following elements:

- Monitoring the surface of the cap to identify potential PH3 releases to ambient air through the cap;
- Monitoring the shallow subsurface around the cap to identify potential releases of PH3 from the perimeter of the cap; and
- Monitoring of the soil properties within the cap materials to ensure there are no changes in the basic soil properties that would threaten the cap integrity or vegetative cover.

This monitoring would continue on a periodic basis (e.g., semi-annually) until the first 5-year review, at which time the need for further monitoring would be reviewed. The conceptual strategy for the PH3 monitoring is initially developed in the detailed analysis of this SFS and will be finalized and documented in the RD.

7.2.1.4 Stormwater Management

Site-wide stormwater runoff management will be critical to minimize cap erosion and ponding/infiltration at areas where leachable COCs remain in the soil/fill. Stormwater will be addressed by site-wide grade planning, integration into cap design, and collection of stormwater to minimize degradation of the caps and maintain a zero discharge of stormwater from the site to surface waters. One or more stormwater retention basins likely will be needed for stormwater management. For example, if a capping alternative is selected for site remediation, it is likely that one or more stormwater collection basins will be necessary to retain any surface flow from the caps constructed on topographically higher areas in RA-B, RA-C, RA-D, and RA-E. However, the final grading and stormwater management design will depend on the alternative selected and the integration of the caps, and will be developed in the RD.

7.2.1.5 *Fugitive Dust Control*

Fugitive dust generation on the site would need to be controlled during the construction phase and the implementation phase of the remedial action. Given the significant earthmoving activities associated with all of the assembled alternatives (except "No Action"), fugitive dust control (including control of P2O5 generated from potential P4 fires) during the construction phase will be a significant challenge. A fugitive dust mitigation plan developed for the construction phase likely would include:

- Maintaining existing site vegetation wherever possible (undisturbed areas);
- Application of water and dust control agents to active unpaved roadways;
- Use of existing paved roadways to the extent practicable;
- Application of water, dust control agents and other best management practices in areas of active earthmoving (excavating and/or placement); and
- Inspections during the construction phase to ensure the effectiveness of the fugitive dust mitigation program.

Fugitive dust mitigation during the implementation phase of the remedial action likely would include:

- Establishing and maintaining vegetation on all cap surfaces;
- Application of water and dust control agents to unpaved active roadways;
- Use of paved roadways to the extent practicable; and
- Inspections during implementation to ensure the effectiveness of the fugitive dust mitigation program.

For alternatives that include excavation in P4 areas (as discussed below in Section 7.2.2.7), water would be used in modified conventional excavation and in the handling/processing of P4-impacted soil/fill to minimize airborne releases. The necessity and types of fugitive dust control will be detailed in the RD and the Remedial Action Work Plan (RAWP) and will depend on the soil alternative selected for site remediation and the RD.

7.2.1.6 *Groundwater Monitoring*

Long-term groundwater monitoring will be performed to evaluate the performance of the soil remedial actions at identified and potential groundwater impact source areas and as a core component of the groundwater remedial alternatives described in Section 7.5 below. The current interim CERCLA, RCRA and Calciner Ponds Remedial Action groundwater monitoring programs are described in greater detail in the *Interim CERCLA Groundwater Monitoring Plan- March 2010* (MWH, 2010d) that is attached to this SFS as Appendix G. In addition to the existing CERCLA, RCRA and Calciner Ponds Remedial Action groundwater monitoring well networks, the capping alternatives for the site landfills (RA-H and RA-F2) also would incorporate the construction and installation of additional groundwater monitoring wells. The specific locations and construction details of these wells will be determined, in part, based on the final site grading plan developed during the RD. Monitoring of these additional wells will be integrated with the existing programs. This will be detailed in the long-term CERCLA groundwater monitoring plan that will be developed during the RD.

7.2.1.7 Ancillary P4 Treatment Processes and Issues

When addressing P4-impacted soils/fills in the assembled soil alternatives, it is important to recognize that any ex-situ P4 treatment technology will require several ancillary process steps. These ancillary process steps are common to many of the P4 treatment technologies, as discussed in detail in the *P4 Treatment Technologies* report found in Appendix A.

Ancillary process steps that would be integral to the treatment process must be considered when screening/evaluating potential technologies using the NCP decision criteria of implementability, effectiveness, and cost. Common ancillary P4 treatment processes for soils/fill materials include the following:

- Material/waste handling issues:
  - P4 excavation processes necessary to get P4-impacted materials to an ex-situ treatment process;
  - P4-impacted material transportation to the ex-situ treatment process, and
  - Temporary storage of such material near the treatment process to provide surge capacity.

- Treatment process feedstock preparation:
  - Sizing, such as crushing and screening, of the material to provide a consistent feed particle size to the ex-situ treatment process; and
  - Blending with other extracted streams or inert materials of the feed to provide consistent P4 content to the ex-situ treatment process.

- Management of treatment residues:
  - Treatment of wastewater, further treatment and disposal of solid residues, and collection and treatment of process off-gases.

There are also several engineering and safety challenges, unique to P4 waste handling and treatment, that must be identified and addressed in the overall technology treatment evaluation using the fundamental decision criteria of implementability, effectiveness, and cost. These include the following:

- Site worker health and safety;
- Public health and safety; and
- Potential environmental impacts.

7.2.1.8 Site Worker Health and Safety

Site worker safety is one of the most difficult elements to resolve with respect to "active" ex-situ or in-situ handling and treatment of P4-contaminated soils. The principal concerns are exposure to P4 (solid, liquid, and vapor phases) and P4 reaction products (P2O5, other phosphorus oxides, PH3, and phosphoric acid).

These constituents have been evaluated in the site-specific risk assessments performed by EPA (*EMF RI Report*) and FMC (*SRI Report*) and by numerous medical, research, and environmental agencies including the Centers for Disease Control and Prevention (CDC), the EPA Integrated Risk Information System (IRIS), and the Cold Regions Research Engineering Laboratory (CRREL). These risks have been well documented by FMC and others that currently manufacture or formerly manufactured P4 in a commercial/industrial setting, including Stauffer (Rhodia), Monsanto, and Albright and Wilson.

P4 is relatively safe when managed under water and using well-engineered process equipment, experienced operators, and established procedures. However, when not under a blanket of water or other inert material, the P4 operations and maintenance personnel necessary for the remediation activities would potentially be exposed to widely ranging physical risks due to the nature and extent of P4 in certain areas of the FMC Plant Site. The largely uncontrolled conditions during excavation could expose workers to fire, dermal, and respiratory hazards.

In some instances, to control risk of airborne releases, excavation and/or processing likely would occur in an enclosed structure, vented to an air pollution control device. Workers within such enclosures would be required to wear Level A PPE, although significantly modified (if practical) to protect them from P4 thermal exposure (most Level A protective suits do not protect against P4 burns). P4 protective suits worn at most P4 manufacturing plants are constructed with an aluminum coating, designed to be immediately shed in the event of P4 exposure. This approach would not be consistent with most PPE decontamination procedures typically applied within remediation exclusion zones or contamination reduction zones. Well-designed processes, highly-trained site workers, and a comprehensive Environmental, Health, and Safety Management System (including extensive health, safety and environmental procedures) would be critical but might not be sufficient to ensure adequate protection of site workers. Cost considerations also would be significant, requiring quantification of the capital and O&M costs associated with providing adequate site systems if indeed such systems could be designed and reliably implemented.

7.2.1.9 Public Health and Safety

During operation of the FMC plant, public health and exposure often were controlled by the same measures that FMC put into place to keep plant workers safe. Typical engineering controls such as fencing prevented public access to hazardous areas throughout the site. Air monitoring and scrubbers were installed to meet Clean Air Act requirements to control phosphorus-related and other air emissions from the plant production operations. During any remedial action that involved the handling of P4-contaminated soils, engineering controls similarly would be in place to protect site workers. However, unlike the controlled manufacturing process, excavation and treatment of P4 wastes could cause uncontrolled releases, especially to the air, due to the widely varying site conditions and difficulty in designing appropriate engineering controls. The risk and potential impact of uncontrolled air releases would increase with the quantity of P4-soils being remediated. Active remediation of higher concentrations of P4 in impacted materials and remediation of greater quantities of impacted materials present greater risk than active remediation of lower concentrations and smaller quantities. Some of these difficulties are discussed above and in other reports. Short-term public exposures to airborne contaminants including P2O5, PH3, and phosphoric acid also might occur, due to the many unforeseen circumstances that could arise. For alternatives that contemplate the excavation or processing of quantities of P4 that could result in a fire too large to be readily extinguished with conventional methods, an enclosure could be required to contain potential air emissions. The enclosure would then be vented to large scrubbers or other air pollution control devices.

7.2.1.10 Environmental Impacts

Environmental concerns related to the handling of P4-contaminated soils include potential impacts to air and water/groundwater. Possible worker risks from direct exposure to pure P4, phosphorus gases, and contaminated process water and risks to the public from air emissions and impacted groundwater are described above. The following discussion addresses the release mechanisms potentially triggered by active or intrusive remediation of P4-containing soils, which often also contain heavy metals and radionuclides, and the resulting potential on- and off-site impacts.

- Air Impacts: Intrusive remediation into P4-impacted soils, including excavation, grinding, and/or sizing, could result in fire and P4 combustion products and phosphine being released to the atmosphere. Their concentrations would depend in large part on the amount of P4 contamination, the quantity of P4-impacted soils being remediated, and the effectiveness of the engineering controls at the excavation, storage and processing areas. If the gases were treated with activated carbon or dry filter systems, solid wastes would be generated. If these gases were to be captured and treated by a scrubber, the scrubber water would need to be treated in a waste water treatment (WWT) process. The WWT process typically would consist of neutralization (because of phosphoric acid capture by the scrubber), clarification, and sand filtration. Solids would be removed by that process and consolidated by a filter press, then transported and disposed in a landfill depending on analytical testing. This material could be high in heavy metals and/or radionuclides. The water would be discharged for reuse in scrubber operations, directly discharged to the groundwater or surface water, or sent to a publicly-owned treatment works (POTW) for later discharge to surface water.

- Water/Groundwater: Water would be necessary during most steps of a P4 material handling process to prevent P4 exposure to air (oxygen) that would result in P4 combustion. During initial intrusive soil work, water would be added to the excavation as necessary to prevent/extinguish a fire. Water also would be necessary during many of the material handling processes, such as material sizing.

During modified conventional excavation, water would be added to the excavation to prevent/extinguish any P4 combustion. Water also likely would need to be added to each excavator bucket load for transfer to trucks and/or roll-off containers. Although adding water simply to "wet" the soil in the excavation (e.g., for dust control) would not be expected to represent a significant risk for mobilization of constituents to groundwater, the potentially significant water addition necessary to prevent or extinguish P4 combustion within the excavation area could represent a risk for mobilization of COCs and subsequent impacts to groundwater.

Water also would be necessary in the tank or truck trailer to prevent P4 ignition while being transported from the excavation area to a material handling/processing area. In the material handling/processing area, water might be used in the sizing process or used to cover the P4-contaminated soil. Prior to a caustic hydrolysis treatment process, additional water would be added to prepare the 15% slurry feed. Water also would be used in the scrubbers that would be necessary to control emissions of P4-related gases at any locations in the handling process, such as the excavation and storage areas, where such emissions would occur.

In addition to using water to prevent/control fires during modified conventional excavation, process water might be lost to the environment during any phase of the excavation, transportation, storage, and/or treatment process. If released in significant volumes and in areas where soil/fill contains mobile COCs, water could provide sufficient hydraulic head to mobilize those COCs and create a source of impact to shallow groundwater.

The seven core elements discussed above are an integral part of the assembled alternatives for both soil/fill and groundwater. The assembled alternatives for both media are presented and screened below.

7.3 REMEDIAL ALTERNATIVES FOR SOIL/FILL

The remedial alternatives for soil and fill are discussed in detail in this section. These soil/fill alternatives were developed in conjunction with EPA, as described in the introduction to Section 7.2 and presented in Table 7-2.

7.3.1 Soil Alternative 1 – "No Action" Alternative

Soil Alternative 1 – evaluation of the "no action" alternative in the CERCLA FS process is required under the NCP. This alternative is a baseline to which all other alternatives are compared. It will be retained for comparison to other alternatives throughout the remainder of the FS process.

For the FMC Plant OU, this alternative would represent the status quo. However, no long-term CERCLA groundwater monitoring (as is currently conducted voluntarily by FMC) would be performed. The institutional controls that are currently in place would remain in place. This alternative would not meet the site RAOs because it would not address all of the complete exposure pathways listed in Table 4-3.

7.3.2 Soil Alternative 2 – (See Figure 7-1 and Table 7-2)

In general, this alternative uses containment (i.e., caps) to achieve soil RAOs. ET caps would cover RAs, including underground piping potentially containing P4, that are identified or considered to be source(s) of COCs to underlying groundwater. This would reduce the potential groundwater threat from these RAs. Soil (gamma) caps would cover RAs/subareas that contain radionuclides, present a gamma threat, and are not likely candidates for near-term re-development. Several RAs/subareas, which due to their locations are likely candidates for near-term re-development, are initially left untreated with current institutional controls in place. Potential future remedial requirements at these RAs will be determined on the basis of specific future uses, i.e., receptor-initiated remediation. These areas pose no unacceptable risk, except for gamma radiation to a hypothetical future worker (primarily for gamma radiation), and given that re-development could include paving or other ground cover, installation of a soil cover likely would be duplicative. Once future land use is determined, any additional necessary remedial action will be implemented to address the potential exposure pathways and protect the specific receptors associated with that land use. Under this alternative, the storm-sewer piping would be cleaned in place and the sludge would be treated off site. In addition, RA-I (i.e., Parcels 1, 2, 4, 5, and 6) would use the core elements discussed in Section 7.2.1 above as necessary to minimize human and environmental exposures in commercial/industrial use.

In addition to the remedial actions discussed above, all the other common/core remedial actions also would be performed during the implementation of this remedy as presented in Section 7.2.1, e.g., institutional controls, grading, stormwater management, and monitoring. Figure 7-1 depicts the surface of each RA following the remedial action proposed by Soil Alternative 2. The specifics of this alternative are presented below.

7.3.2.1 Use of ET Caps

This alternative involves installation of ET caps on or within RAs that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater. ET caps, when combined with institutional controls that limit excavation through the cap discussed in Section 7.2.1 above, meet RCRA Subparts C and D technical standards and satisfy site RAOs for protection of humans and the environment with respect to potential soil exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, 5) threat of phosphine exposure (given the current CSM), and 6) inhalation of fugitive dust. After grading to establish the appropriate subgrade slopes and stormwater drainage/collection, ET caps would be installed at the following RAs:

- RA-B: Includes RUs 1 and 2, where the furnace building, phossy dock, secondary condenser and slag pit formerly were located, and encompasses the P4-impacted capillary fringe soils downgradient of these RUs. Surface and/or subsurface fill within this remedial area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Underground piping containing COCs (potentially including P4) also exists in RUs 1 and 2. RA-B is considered a threat to groundwater.

- RA-C: Includes RUs 13, the northern portion of RU 12, the eastern portion of RU 22b, and a small portion of RU 24 between RUs 1 & 2 and RU 22b. This area contains former phossy/precipitator slurry ponds, the piping corridor between RUs 1 and 2 and 22b (located in small portions of RUs 12 and 24), and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Underground piping containing COCs (potentially including P4) is present in RUs 13, 22b and 24. RA-C is considered a threat to groundwater.

- RA-D: Includes the western portion of RU 22b and Pond 9S. This area contains former clarified phossy water/precipitator slurry overflow ponds and precipitator slurry ponds. No significant quantity of P4 is present, but surface/subsurface fill contains phossy solids, precipitator solids, slag, and ore. RA-D is not known to contain P4 other than presumably in underground piping. RA-D is considered a threat to groundwater.

- RA-E: Includes RU 8, the southern portion of RU 9, and the southern portion of RU 16. This area contains former ore kilns, kiln scrubber ponds, calciners, calciner pond solids stockpiles, silica stockpiles, and calcined ore stockpiles. No P4 is present, but surface/subsurface fill contains slag, ore, silica, and kiln pond solids (subsurface). Underground piping containing COCs (potentially including P4) is present in RU 8 and is listed separately below. RA-E is considered a threat to groundwater.

- RA-H: Includes RUs 17 and 18. This area contains the active plant landfill (RU 18) and the construction/demolition debris landfill (RU 17). Surface and subsurface fill within this area contains solid waste including plant trash, Andersen filter media (AFM), asbestos, empty containers, concrete, carbon, and furnace feed materials (ore, silica, coke). RA-H is considered to be a "potential" threat to groundwater, which means that an actual threat to groundwater has not been identified. However, this SFS addresses the potential for a groundwater threat from this area.

- RA-K (the Railroad Swale): Includes RU 22c. This area is located along the northeastern border of the FMC Plant Site and was used for stormwater retention. It also received an intermittent flow of phossy water, known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. RA-K is considered to be a "potential" threat to groundwater, which means that because an actual threat to groundwater has not been identified, the groundwater RAO is not applicable. However, this SFS addresses the potential for a groundwater threat from this area.

7.3.2.2 Use of Soil Cover (Gamma) Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials, do not pose a threat to groundwater, and are not considered likely re-development areas primarily due to location. A gamma cap with the appropriate core elements (i.e., primarily institutional controls) satisfies site RAOs for potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include the following:

- RA-F: Includes RUs 19, 11, and the southern portion of RU 12. This area contains the slag pile and bullrock pile (RU 19) and former equipment maintenance/laydown areas (RUs 11 and 12). Surface and subsurface fill within this area consists predominantly of slag and bull rock. The southwestern corner of the slag pile was the location of the former plant landfill (RU 19b) and is listed separately below. Railcars containing P4 sludge heels (RU 19c) are listed separately below. RA-F is not considered a threat to groundwater.

- RA-F1 (Buried Railcars): Includes RU 19c. In 1964, 21 railcars containing an estimated 10 to 25% P4 sludge were placed at the southern edge of the slag pile and covered with native soil. The railcars were then covered with 80 to 120 feet of slag as the slag pile progressed to the south. RA-F1 is considered to be a "potential" threat to groundwater, which means that an actual threat to groundwater has not been identified. A soil cover is assumed to be appropriate here because the primary exposures at the surface are from gamma radiation and direct contact, both of which are addressed by using a soil cap along with appropriate core elements. A properly sloped soil cap, added to the existing 80 feet of slag overlying the railcars, is considered to provide ample protection from infiltration to the depth of the buried railcars. Furthermore, no groundwater has been identified in this area, however, if present, the groundwater would be expected to be in excess of 100 feet below the native soil surface. Therefore, leaching of COCs is considered unlikely, especially once the area is covered by a properly designed, vegetated soil cover.

- RA-F2 (Former Plant Landfill): Includes RU 19b. This sub-area is located within the southwestern corner of the slag pile (RU 19). Landfill operations within this sub-area (RU 19b) began at the inception of plant operations in 1949 and ceased in 1980. Wastes placed in RU 19b included slag, office wastes (consisting of office and lunchroom solid wastes), industrial wastes (consisting of asbestos, spent solvents, oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes, and AFM) furnace rebuild/digout wastes (consisting of furnace feed materials, carbon materials, concrete, rocks, and debris), IWW sediments, and baghouse dust. These wastes are covered by 50 - to 140 ft of slag. RA-F2 is considered to be a “potential” threat to groundwater, which means that an actual threat to groundwater has not been identified. A soil cover is assumed to be appropriate here because the primary exposures at the surface are from gamma radiation and direct contact, both of which are addressed by using a soil cap and appropriate core elements. A properly sloped soil cap, added to the existing 80 feet of slag overlying the railcars, is considered to provide ample protection from infiltration to the depth of the buried waste materials. Furthermore, no groundwater has been identified in this area, however, if present, the groundwater would be expected to be in excess of 100 feet below the native soil surface. Therefore, leaching of COCs is considered unlikely, especially once the area is covered by a properly designed, vegetated soil cover.

7.3.2.3 Remediation Based Upon Future Site Re-Development

For other site areas that are candidates for re-development and that meet all RAOs except for human health endpoints (i.e., hypothetical future workers with potential exposure to gamma radiation), remedial action would be deferred until site re-development is determined, referred to in the SFS Report as “receptor-initiated remediation” (RIR). When land use and receptor exposure pathways are defined based on specific planned development, the appropriate remedial measures could be identified and implemented. For instance, many likely re-development scenarios would include the construction of asphalt/concrete parking lots that could be designed to meet the same technical standards as a soil (gamma) or ET cap. Alternatively, there could be a re-use/re-development scenario that would not create significant worker exposure (e.g., equipment storage) and thus would not warrant the same degree of remediation as for land uses involving greater exposures. Any re-development, and the associated remedial actions selected, would require EPA review and approval to ensure the appropriate level of protectiveness. Until that time, appropriate core elements, such as institutional controls in the form of fencing and signage, would restrict access to these areas where necessary and would ensure that RAOs are met. The remediation and potential re-development status of each RA using the RIR option would be included in the 5-year review process. The areas where the RIR option would be implemented include the following:

- RA-A: Includes RUs 3, 4, 5, 6, 20, and portions of RU 24. Highway 30 forms its northern boundary. This area contains former office areas, parking areas, railroad siding, laydown areas, and the Bannock Paving area. Most of this RA is covered with non-leachable fill, primarily slag, coke, silica, concrete, asphalt, and native soil. Underground piping (storm sewers) containing COCs (potentially including P4) is present in RU 3 is discussed separately below. RA-A is not considered a threat to groundwater.

- RA-A1: Includes portions of RU 20. This RA is located at the former Bannock Paving Area and includes above-ground fuel storage tanks and a vehicle fueling area. This area was investigated during the SRI in 2007 and found to contain fuel polycyclic aromatic hydrocarbons (PAHs) above the soil screening levels (SSLs) in the approximately 3 to 4.5 foot below the native ground surface (or 6 to 8 feet below the current ground surface). RA-A1 is not considered a threat to groundwater.

- RA-G: Includes RU 7, the northern portion of RUs 9, 10, 15, the northern portion of RU 16, and portions of RU 24. This area contains the ore stockpiles, the silica stockpile, the IWW pond and ditch, the dry process waste pile (RU 15) and the northern portion of RU 16. Surface and subsurface fill within this area includes various plant solid materials including ore, baghouse dust, coke, carbon, calciner solids, and slag. RA-G is not considered a threat to groundwater.

- RA-J: Includes a portion of the FMC Northern Properties (Parcel 3 only). This area of the FMC Plant OU contains property north of Highway 30 and south of I-86 that is within State of Idaho jurisdiction. It was not used for plant production activities. This property is within the PCDA Development Agreement. RA-J is not considered a threat to groundwater. It should be noted that RA-J is also the location of the FMC office trailers. This area is “capped” with asphalt and silica rock in a manner that currently meets the industrial RAOs for this area.

7.3.2.4 Sub-Area Remediation

Underground Process Piping - This sub-area includes underground process piping that remains in place and may contain P4, precipitator solids, and/or phossy solids. This underground piping is believed to exist in RAs B, C, D and E. Underground piping is considered to be a “potential” threat to groundwater, which means that an actual threat to groundwater has not been identified. However, this SFS will consider the potential groundwater threat from this underground process piping. Under this alternative, all P4 areas (including P4 associated with underground process piping) would be under ET caps, with the exception of the potential P4 residues in underground storm sewer piping in RA-A as discussed below.

Containment of underground process piping under an ET cap meets the RAO for P4, e.g., direct exposure to phosphorus under conditions that may spontaneously combust, etc., is prevented with construction and maintenance of the ET cap over the underground piping. Additionally, while the statutory preference for treatment of a PTSM is not attained, this approach is consistent with the NCP and EPA’s 1991 guidance that there are situations where wastes identified as PTSM may be contained rather than treated. Specifically, implementation of an excavation/treatment-based remedy would result in greater overall risk to human health and the environment due to the risk posed to workers and/or the surrounding community during the construction phase.

Underground Sewer Piping – Potential P4 residues in underground storm sewer piping in RA-A as depicted on Figure 7-1 would be cleaned as part of the remedial action under this alternative. These 16-inch, reinforced concrete sewer pipes would be cleaned to remove potential residual P4 and soil/materials potentially containing metal and radiological constituents. These cleanout sludges would be disposed of off-site following characterization and, depending on the characterization, either be disposed in an appropriate landfill or incinerated. This approach would allow these storm sewers to remain in place for continued stormwater management.

Given the small volumes of P4-contaminated sludges within the underground storm sewer piping, the size, and condition of the underground storm sewer piping (16-inch diameter concrete piping), cleaning of this piping in-place using hydro-jet technology followed by off-site treatment of cleanout sludges can meet RAO for P4, e.g., provided strict procedures are implemented to prevent direct exposure to phosphorus under conditions that may spontaneously combust, etc. In this case, the statutory preference for treatment of a PTSM is attained.

7.3.2.5 Achievement of RAOs

Alternative 2 meets all of the soil RAOs, noting that RA-A, RA-A1, RA-G, and RA-J rely on institutional controls until re-development occurs under the RIR option (including deed restrictions that prevent change in land use that could change current exposure scenarios). At that time, the development planning process would include evaluation and implementation of further remedial action based upon the prospective site receptors and the type of development taking place to ensure that RAOs continue to be met. EPA approval of remedial and re-development plans would be stipulated as a requirement in the deed restrictions and covenants. Until these RAs are re-developed, the risk exposure pathway is not completed and the RAO to prevent exposure is met.

7.3.3 Soil Alternative 3 – (See Figure 7-2 and Table 7-2)

Much like Alternative 2, this alternative uses caps to satisfy the soil RAOs. ET caps cover RAs/Subareas that contain P4, and/or are potential sources of COCs in underlying groundwater, thereby reducing the potential groundwater threat from these RAs. Soil (gamma) caps will be installed at RAs that contain radionuclide COCs and present a gamma threat. Underground process piping and storm sewers would be addressed similarly to Alternative 2. Northern properties would also be addressed similarly to Alternative 2.

In addition to the remedial actions discussed above, all other common/core remedial actions also would be performed during the implementation of this remedy as presented in Section 7.2.1, for example, institutional controls, grading, stormwater management, and monitoring. Figure 7-2 depicts the surface of each RA following the remedial action proposed by Soil Alternative 3. The specifics of Alternative 3 are discussed below.

7.3.3.1 Use of ET Caps

This alternative involves installation of ET caps within RAs that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill. ET caps, when combined with institutional controls that limit excavation through the cap as discussed in Section 7.2.1 above, meet RCRA Subparts C and D technical standards, satisfy site RAOs for groundwater, and protect against potential human exposure through pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, 5) threat of phosphine exposure (given the current CSM), and 6) inhalation of fugitive dust.

After grading to establish the appropriate subsurface slopes and stormwater drainage/collection, ET caps would be installed at the same RAs as Alternative 2, consisting of RA-B, RA -C, RA-D, RA-E, RA-H, and RA-K as presented in Section 7.3.2.1 above. In addition, ET caps also would be installed over:

- RA-F1 (Buried Railcars): Includes RU 19c which is located in approximately the center of the slag pile (RU 19) and contains 21 railcars as described above in Section 7.3.2.2. The railcars were covered with 80 to 120 feet of slag as placement of slag on the pile progressed to the south. RU 19c is considered to be a “potential” threat to groundwater, which means that an actual threat to groundwater has not been identified. However, this alternative will consider the potential groundwater threat from this area.

- RA-F2 (Former Plant Landfill): Includes RU 19b. This sub-area is located within the southwestern corner of the slag pile (RU 19). These wastes, as detailed above and described in the *SRI Report,* are covered by 50 to 140 feet of slag. RU 19b is considered to be a “potential” threat to groundwater, which means that an actual threat to groundwater has not been identified. However, this alternative will consider the potential groundwater threat from this area.

7.3.3.2 Use of Soil Cover (Gamma) Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials, but do not pose a threat to groundwater. A gamma cap, with the appropriate core elements (i.e., primarily institutional controls), satisfies site RAOs for potential human exposure through pathways including: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust.

Similar to Alternative 2, this alternative has a gamma cap in the large area represented by the former slag pile (RA-F). However, under Alternative 3 gamma caps also would be installed in RAs that used the RIR process option in Alternative 2. These areas include:

- RA-A: The northern plant boundary, which abuts Highway 30, forms the northern boundary of this area. RA-A is covered with non-leachable fill including primarily slag, coke, silica, concrete, asphalt, and native soil. RA-A is not considered a threat to groundwater, but does present a potential risk to hypothetical future workers from radionuclides in soils/fill and PAHs associated with coke.

- RA-A1: This area was investigated during the SRI and found to contain fuel PAHs above the soil SSLs. Since the PAHs were not considered to be a threat to groundwater, but rather a direct contact threat, use of a soil (gamma) cover over this area meets the RAOs.

- RA-G: This area contains the ore stockpiles, silica stockpile, IWW pond and ditch, and dry process waste piles. Surface and subsurface fill within this area include various plant solid materials including ore, baghouse dust, coke, carbon, calciner solids, and slag. RA-G is not considered a threat to groundwater.

Note that areas identified for gamma caps in RA-A and RA-G could be replaced with a stormwater retention basin, building foundation, or parking lot(s) during the RD phase, based on final design and redevelopment plans which exist at that time. These structures would be design to be as protective (or more) than the gamma cap.

7.3.3.3 Excavation and Consolidation

The excavation and consolidation option is appropriate for use in RAs where contaminated fill/soil is generally shallow and not a threat to groundwater (i.e., where the RI and SRI found COCs in the surficial fill and re-worked soil areas but not in the underlying native soils). The only area to utilize excavation and consolidation in this alternative is RA-J, as discussed below.

- RA-J: Includes SRI Addendum Parcel 3, in the FMC-owned Northern Properties. This area of the FMC Plant OU consists of FMC property north of Highway 30 and south of I-86 on lands within State of Idaho jurisdiction (i.e., outside the exterior boundary of the Fort Hall Reservation). RA-J was not used for plant production activities, but contains windblown dust primarily from the FMC and J.R. Simplot Company ore handling areas. In addition, some slag was applied to the surface for roads and parking. This property is within the PCDA Development Agreement and is not considered a threat to groundwater.

  The excavation and consolidation at RA-J under this alternative would involve excavation (surface scraping) to a maximum of 6 inches bgs (or mechanically mixed by tilling in place) with the objective of achieving the industrial/commercial PRGs listed in Table 4-4. Removal (or mixing in-place) of the upper 6 inches of fill/soil materials in RA-J, will expose the underlying native soils which do not further contain significant quantities of COCs. Confirmation sampling of the underlying native soil in excavated areas will be performed to demonstrate that the RAOs are met. Excavated material from this RA would be further characterized to determine if the excavated soil, through the mechanical mixing that would occur during scraping, could be used as surface capping material in constructing gamma or ET caps at other RAs. If unacceptable for that use, the material would be placed under one of the gamma or ET caps as subgrade material.

7.3.3.4 Sub-Area Remediation

Underground process piping and sewer piping would be handled the same as discussed under soil Alternative 2 in Section 7.3.2.4. In summary, under this alternative the underground process piping would be covered with ET caps and the underground sewer piping in RA-A would be cleaned in-place, with the sludge from the cleaning operation being containerized and properly disposed off-site.

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7.3.3.5 Achievement of RAOs

The remedial actions in Alternative 3, when combined with common/core elements presented in Section 7.2.1 (including institutional controls, grading, stormwater management, various monitoring activities, etc.), meet all of the soil RAOs.

7.3.4 Soil Alternative 4 – (See Figure 7-3 and Table 7-2)

Much like Alternatives 2 and 3, this alternative primarily uses containment (i.e., capping) to satisfy the soil RAOs. ET caps would cover RAs that contain P4 (including underground piping) and/or are identified sources of COCs in groundwater, thus satisfying the RAO for migration of COCs to groundwater. Soil (gamma) caps are used only on RAs that contain radionuclide COCs and present a gamma or direct contact threat, but do not pose a threat to groundwater. Underground process piping and storm sewers would be addressed similarly to Alternatives 2 and 3. In contrast to Alternatives 2 and 3, however, this alternative utilizes the excavation and consolidation process option for RA-A. Excavation and consolidation under this alternative involves excavation of overlying fill materials down to native soil (which, with the exception of RA-A1, was demonstrated during the RI and SRI as not impacted). These excavated fill materials would be consolidated under appropriate caps at other RAs. The Northern Properties would be addressed in the same manner as in Alternative 3 (as discussed in Section 7.3.3). Soil Alternative 4 also uses excavation and consolidation for RA-K, which while it contains P4, has been shown to have relatively low concentrations (approximately 1,000 ppm based upon limited field observations). RA-K would be excavated using modified excavation techniques and consolidated under an ET cap in an RA where P4 is present (e.g., RA-B).

In addition to the remedial actions discussed above, all other common/core remedial actions would be performed during the implementation of this remedy as presented in Section 7.2.1, including institutional controls, grading, stormwater management, and monitoring. Figure 7-3 depicts the surface of each RA following the remedial action proposed by Soil Alternative 4. The specifics of this alternative are discussed below.

7.3.4.1 Excavation and Consolidation

The excavation and consolidation option can be used in RAs where contaminated fill/soil is generally shallow and is not a threat to groundwater (i.e., in areas where the RI and SRI did not find COCs in the underlying native soils). For those RAs with contaminated soils that meet these criteria and do not contain P4, conventional excavation methods would be employed to rip, scrape, and/or push soils for consolidation or reuse within caps at other RAs. Two examples would be: 1) fill materials on the surface in RA-A, consisting of primarily slag, which may be ripped, removed down to native soils (ranging in depth from 1 to 18 feet and averaging 7 feet below ground surface) and re-used in constructing ET caps at other RAs, and 2) shallow soils (0 to 6 inches) from RA-J that would be either scraped and mixed for re-use in constructing ET caps at other RAs or mechanically mixed in place to RAOs for surface concentrations.

Additionally, RA-K, which was shown to contain low-levels of P4 (approximately 1,000 ppm, based on historic information and field observations during the SRI), has also been identified for excavation and consolidation in this alternative. As a result, excavated materials from RA-K would be removed and placed under an ET cap at an RA where P4 is known to be present (e.g., RA-B). The discussion below provides details regarding how excavation and consolidation would differ from that done under Alternatives 2 or 3 and identifies the cap types that are appropriate at each RA to cover the excavated material. The RA-K excavation and consolidation would require an appropriate EPA AOC designation for this alternative to be administratively implementable.

- RA-A: Includes former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, the railroad siding (RU 21), and the northern portion of RU 24. The average depth of contaminated fill (primarily slag and concrete) in RA-A is approximately 7.5 feet and ranges from 1 to 18 feet in thickness. In RA-A, conventional excavation equipment would be used remove fill down to native soils. Any material excavated and removed would be placed under a cap that is protective for gamma radiation and direct exposure. In order to contour the site for proper stormwater runoff management, replacement of excavated/removed fill with clean fill likely would be required. The cost estimate for this alternative assumes that adequate clean fill is available on-site as backfill for RA-A. The final grading plan and clean fill requirements would be developed during the remedial design.

- RA-A1: Includes a small area of eastern RU 20. This RA is located at the former Bannock Paving Area and includes former above-ground fuel storage tanks and the former vehicle fueling area. This area was investigated during the SRI in 2007 and found to contain fuel PAHs above the soil SSLs at depth of approximately 3 to 4.5 feet below the native soil interface. The contaminated soil/fill from this area would be excavated, then consolidated under one of the ET caps at another RA.

- RA-K: Includes RU 22c, the railroad swale. This area is located along the northeastern border of the FMC Plant Site and was used for stormwater retention. It also received an intermittent flow of phossy water, known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. In 1993, an approximately 30 foot wide by 330 foot long segment of the railroad swale, beginning just west of the western storm drain pipe, was lined with 30-mil PVC to reduce infiltration in that area of the swale. Based on the SRI findings, the material from the 0 to 8 feet bgs interval would present a gamma risk because of the slag and ore but does not contain P4. Conventional excavation equipment would be used to remove this material and place it under one of the gamma caps (e.g., in RA-G or RA-F) being constructed concurrently. The materials from approximately 8 to 10 feet bgs would be excavated using modified conventional excavation to ensure safe removal of P4-contaminated soils/fill (as identified during the SRI). These materials then would be placed under an ET cap in an area containing P4 (e.g., RA-B).

7.3.4.2 Use of ET Caps

As with the previous alternatives, remedial efforts under Alternative 4 involve the installation of ET caps on RAs that have been identified in the RI and SRI as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater or that are suspected to contain P4. ET caps, when combined with institutional controls that limit excavation through the cap (as discussed in Section 7.3.1 above), meet RCRA Subparts C and D technical standards and satisfy site RAOs for groundwater. They also protect against potential human exposure through pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) exposure to P4 fire, 5) threat of phosphine exposure (given the current CSM), and 6) inhalation of fugitive dust.

After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed at the same RAs as described above in Alternative 3, consisting of RA–B, RA-C, RA-D, RA-E, RA-F1, RA-F2, and RA–H.

7.3.4.3 Use of Soil Cover (Gamma) Caps

Under this alternative, the number and acreage of gamma caps would be reduced from those in Alternative 3 mainly as result of excavation and consolidation at RA-A. After grading to establish the appropriate subgrade slopes and stormwater drainage/collection, gamma caps would be placed over those areas that are covered by fill materials and do not pose a threat to groundwater, but do contain radionuclides posing a gamma risk. A soil (gamma) cap, with the appropriate core elements (i.e., primarily institutional controls), satisfies site RAOs for potential human exposure pathways including: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust.

Similar to Alternatives 2 and 3, this alternative includes a gamma cap constructed over RA-F and RA-G. RA-F and RA-G are not considered threats to groundwater.

7.3.4.4 Sub-Area Remediation

Underground process piping and underground sewer piping would be handled in the same manner as discussed under Alternatives 2 and 3. To summarize, under Alternative 4 the underground process piping would be covered with ET caps and the underground sewer piping would be cleaned in-place, with the sludge from the cleaning being containerized and properly disposed offsite.

7.3.4.5 Achievement of RAOs

The remedial actions in Alternative 4, when combined with common/core elements presented in Section 7.2.1 (institutional controls, grading, stormwater management, various monitoring activities, etc.) meets all of the soil RAOs for the site.

7.3.5 Soil Alternative 5 – (See Figure 7-4 and Table 7-2)

Under this alternative, RA-A, RA-D, RA-E, RA-F, RA-F1, RA-F2, RA-G, and RA-H would be addressed similarly to Alternative 4. In addition, this alternative includes extensive excavation of the site soils/fill that contain P4 to a depth of 10 feet and treatment of the P4-contaminated soils/fill on-site as discussed in detail in Section 7.3.5.2 below. The excavated materials containing P4 would be treated on-site using a caustic hydrolysis treatment process.

The only other change for this alternative from Alternative 4 is that RA-I and RA-J in the Northern Properties would be excavated (or tilled in place if feasible and effective) to a depth of 12 inches to meet residential PRGs, as specified in Table 4-5. Also, at RA-A1 the hydrocarbon-contaminated soils would be treated in place by landfarming as opposed to excavation and placement under an ET cap.

In addition to the remedial actions discussed above, all other common/core remedial actions also would be performed during the implementation of this remedy as presented in Section 7.2.1, such as institutional controls, grading, stormwater management, and monitoring. Figure 7-4 depicts the surface of each RA following the remedial action proposed by Alternative 5. The specifics of this alternative are discussed below.

7.3.5.1 Excavation and Consolidation

This alternative involves excavation of some RAs (or portions of RAs) down to native soil and consolidation/incorporation of these excavated materials under caps in other RAs, as described in Alternative 4 (see Section 7.3.4.1). Details regarding excavation and consolidation in individual RAs that are different from Alternative 4 are discussed below.

- RA-I: Includes the Northern Properties (Parcels 1, 2, 4, 5, and 6). These parcels (with exception of Parcel 5) would be scraped (or tilled/mixed in place) to a maximum of 12 inches bgs, with the objective of achieving the residential PRGs listed in Table 4-5. Excavated soil from this RA would be further characterized to determine if the excavated soil, through the mechanical mixing that would occur during scraping, could be used as surface capping material for re-use in the construction of gamma or ET caps being installed under this alternative at other RAs. If unacceptable for this use, the material would be placed under one of the gamma or ET caps at other RAs as subgrade material.

  It should be noted that Parcel 5 within RA-I is currently being used as a "clean-fill" landfill. Topsoil was stockpiled on-site prior to the start of landfill activities. It is presumed (based upon SRI sampling of the topsoil) that re-distribution of the topsoil over the landfill once the landfill reaches its useful life will result in surface conditions that meet the same residential PRGs as applied to the remainder of RA-I.

- RA-J: Includes Parcel 3 in the Northern Properties. Under this alternative, RA-J would be scrapped to a maximum of 12 inches bgs (or tilled/mixed in place) with the objective of achieving the residential PRGs listed in Table 4-5. Excavated material from RA-J would be further characterized to determine if the excavated soil, through the mechanical mixing that would occur during scraping, could be used as surface capping material for re-use in the construction of gamma or ET caps being installed under this alternative at other RAs. If unacceptable for this use, the material would be placed under one of the gamma or ET caps at another RA as subgrade material.

7.3.5.2 Excavation and Treatment On-Site

This alternative involves excavation of 10 vertical feet of P4-contaminated soil/fill and treatment by caustic hydrolysis. Soils/fill in RA-B and RA-C containing P4 would be excavated to approximately 10 feet below the point at which P4 is expected to be encountered and at which point modified excavation would be required. (Ten feet is considered to be the practical limit of modified conventional excavation and the prescribed depth to which a site construction worker could be exposed per EPA protocol.) For example, in RA-B, P4 is expected to be encountered at very shallow depths and total excavation depth is expected to be 10 feet below the current ground surface. In RA-C, historic ponds have had fill materials place over the top of the closed, dewatered ponds to depths up to 10 feet. Therefore, in RA-C, conventional excavation would be used to remove the overlying fill materials that do not contain P4, until the P4-containing pond materials are encountered. Modified excavation would then be used to remove an additional 10 feet of P4-containing material. The excavated materials containing P4 would be treated on-site using a caustic hydrolysis treatment process. The excavation at

RA-K would be similar to Alternative 4, except that excavated material containing P4 would be treated on-site as opposed to placement under an ET cap. All underground process/sewer piping potentially containing P4 would also be excavated and treated on-site.

In RA-B and RA-C, excavated overlying fill materials and the treated waste from the on-site treatment process would be placed back in the original excavation as fill, which then would be covered with an ET cap. The final capping step would be necessary because of metals and radionuclides remaining in the soil below the zone of excavation.

The area encompassed by the RAs to be excavated, the process handling facilities, and the treatment infrastructure (buildings and ancillary facilities) would be within a single designated area of contamination (AOC). It is envisioned that AOC(s) would be defined in a manner that provides flexibility for management, treatment and/or disposal within the area of the FMC Plant Site.

Although Alternative 5 contains significant modified excavation and caustic hydrolysis treatment of P4-containing materials at RA-B and RA-C, there are significant unproven technical challenges to implement this alternative. These challenges include:

- Unique, unproven, and costly ancillary processes (i.e., excavated material handling and storage, feed preparation for caustic hydrolysis treatment, treatment waste residue handling, air pollution control systems, etc.) would be necessary to achieve P4-contaminated material treatment. While some components of these ancillary process options have been used in other settings, none have been applied directly to materials representing a combination of P4/soil/fill materials like those present at the FMC Plant OU. Ancillary processes options associated with ex-situ treatment may present greater challenges for implementability than the treatment technology itself.

- Treatability studies for one or more of the ancillary and treatment processes likely would be required before categorizing any of the P4 treatment technologies as viable remedial options.

- While caustic hydrolysis may be a potential ex-situ treatment option for P4-impacted soils/fill, consistent feed (e.g., consistency in particle sizing and P4 content) and other ancillary process steps would be critical to system effectiveness and stability. In addition, the fate of metals and radionuclides in the caustic hydrolysis process would likely require further treatment measures such as for the process effluent. Given a caustic hydrolysis process operational capability similar to the FMC-designed LDR plant, treatment of P4-containing materials under this alternative would take an estimated 20 to 25 years after start-up of the treatment unit.

RAs Containing P4. Under this alternative, the following RAs would have their P4-impacted soils excavated and treated on-site using caustic hydrolysis:

- RA-B: Surface and/or subsurface fill within this remedial area contains P4, phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Significant underground process piping containing COCs (potentially including P4) also exists in RA-B. P4 is expected to be present near the ground surface in this RA. As a result, RA-B modified excavation would be required from the ground surface to 10 feet bgs with the P4-contaminated soils/fill treated on-site by caustic hydrolysis. RA-B is considered a threat to groundwater and would remain a threat following placement of treated process waste back in the excavation. The backfilled area would require an ET cap.

- RA-C: This area contains former phossy water and precipitator slurry ponds, the underground process piping corridor between RUs 1 and 2 and 22b, and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4, phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Significant quantities of underground piping containing COCs (potentially including P4) also exist. Because the former ponds in this RA were backfilled with slag/fill when they were taken out of service and de-watered, P4-containing materials are present below the overlying fill. As a result, in the former pond portions of RA-C, the overlying fill would first be removed using conventional excavation to expose the P4-containing materials. Modified excavation would then be used to extend the excavation depth to an additional 10 feet to remove P4-contaminated materials. Only the materials contaminated with P4 would be treated using caustic hydrolysis. Overlying fill without P4 would be placed untreated back into the excavation. RA-C is considered a threat to groundwater, and would remain a threat following placement of overlying fill and treated process waste back to the excavation. The backfilled area would require an ET cap.

  RA-K: The excavation at RA-K would be similar to Alternative 4, except that excavated material containing P4 would be treated on-site as opposed to being placed under an ET cap.

- All underground process and sewer piping potentially containing P4 would be removed to a depth of 10 feet bgs, processed on-site, and then used as fill under one of the ET caps (e.g., RA-B or RA-C).

RA-A1 (Hydrocarbon Area). Under this alternative, the hydrocarbon-contaminated soils in RA-A1 would be excavated and landfarmed (or landfarmed in place) on-site until cleanup levels are achieved. If the soils were excavated, confirmation sampling would be carried out to verify that all the contaminated soils had been removed. The landfarmed soils, whether excavated or treated in place, would be sampled at the completion of the operation to verify that cleanup standards had been met. The landfarming operation would be performed within or adjacent to the area of this soil contamination.

7.3.5.3 Use of ET Caps

As with the previous alternatives, remedial efforts under Alternative 5 involve the installation of ET caps on RAs (and in some instances, parts of RAs) that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater. ET caps, when combined with institutional controls that limit excavation through the cap as discussed in Section 7.3.1 above, meet RCRA Subparts C and D technical standards and satisfy site RAOs for groundwater. These caps also protect against potential human exposure through pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) exposure to P4 fire, 5) threat of phosphine exposure (given the current CSM), and 6) inhalation of fugitive dust.

After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed at the same RAs as described above in Alternatives 3 and 4, consisting of RA–B, RA-C, RA-D, RA-E, RA-F1, RA-F2, and RA–H. Soils left below the excavation depth of 10 feet in RA-B and RA-C would contain COCs representing a threat to groundwater (metals and radionuclides) and would require an ET cap. In addition, these RAs would contain process waste from treatment of P4 in the upper 10 feet of soils. This waste would contain metals and radionuclides following processing that likely would present a potential threat to groundwater. As discussed previously, for this reason the treated material would be placed back in the original excavation and then would be covered with an ET cap.

7.3.5.4 Use of Soil Cover (Gamma) Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, gamma caps would be placed over those areas that are covered by fill materials that contain radionuclides but do not pose a threat to groundwater. A gamma cap, with the appropriate core elements (i.e., primarily institutional controls), satisfies site RAOs for potential human exposure through pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust.

Similar to Alternatives 2, 3, and 4, this alternative has a gamma cap constructed over the large area represented by the former slag pile or RA-F. RA-F is not considered a threat to groundwater. RA-G similarly is not considered a threat to groundwater and thus a gamma cap also would be installed over this RA.

7.3.5.5 Sub-Area Remediation

<u>Underground Piping</u> - Under this alternative, all underground process piping and storm sewers potentially containing P4 would be excavated and treated on-site as discussed above in Section 7.3.5.2. Given the unknown volumes of P4-contaminated materials within and potentially around the underground process piping, excavation and on-site treatment of P4 materials in underground piping will create a challenge in meeting the

RAO for P4, e.g., prevent direct exposure to phosphorus under conditions that may spontaneously combust which would result in risk to site remedial workers and the public. However, in this case, the statutory preference for treatment of a PTSM is attained.

7.3.5.6 Achievement of RAOs

The remedial actions in Alternative 5, when combined with common/core elements presented in Section 7.2.2, (institutional controls, grading, stormwater management, various monitoring activities, etc.) could meet all of the soil RAOs, although the time needed to excavate and treat soil/fill in areas with P4-contamination would be 20 to 25 years after start-up of the treatment system. It is not clear that achievement of the RAO to prevent direct exposure to elemental phosphorus under conditions that may spontaneously combust could be assured, given the significant potential to expose elemental phosphorus to air during the extensive excavations included in this alternative.

7.3.6 Soil Alternative 6 – (See Figure 7-5 and Table 7-2)

Alternative 6 is essentially the same as Alternative 5 discussed above in Section 7.3.5. However, under Alternative 6, in RAs where P4 is known to exist excavation would not stop at 10 feet into the P4-contaminated soils/fill but would continue until either 1) it is not physically possible for the equipment to excavate any deeper or 2) all the P4-contaminated materials have been removed. The excavated soil containing P4 would be treated on-site using caustic hydrolysis. In addition, in this alternative RA-F1 (the Buried Railcars) would be excavated and treated on-site using the caustic hydrolysis process. In each instance, the excavated areas would be capped by ET caps.

All of the common/core remedial actions also would be performed during the implementation of this remedy as presented in Section 7.2.2, e.g., institutional controls, grading, stormwater management, and monitoring. Figure 7-5 depicts the surface of each RA following the remedial action proposed by Soil Alternative 6. The specifics of this alternative are discussed below.

7.3.6.1 Excavation and Consolidation

This alternative involves excavation of some RAs (or portions of RAs) down to native soil and consolidation/incorporation of these excavated materials under caps in other RAs. Since in the areal extent of this work in Alternative 6 is the same as under Alternative 5, refer to Section 7.3.5 for a discussion of the excavation and consolidation that would be conducted.

7.3.6.2 Excavation and Treatment On-Site

Alternative 6 involves excavation of <u>all</u> P4-contaminated soil/fill, to the extent possible, and treatment on-site by caustic hydrolysis. However, unlike Alternative 5, excavation would not stop at 10 feet below the first encountered P4 in RA-B and RA-C, but would continue until 1) it is not physically possible for the equipment to excavate any deeper or 2) all the P4 contamination has been removed as verified by visual means (i.e., lack of smoking). In RA-F1 (Buried Railcars), excavation would continue until the buried railcars are found, removed, and treated.

A discussion of the technical challenges of excavation and treatment of P4-containing materials is provided in Section 7.3.5.2 above. However, additional challenges would be encountered in the effort to excavate P4-containing materials below 10 feet. Key concerns are summarized below:

- Groundwater is first encountered under RA-B from 80 to 90 feet. As discussed in Section 2.3.3.1, within the 44°C isotherm at the furnace building and slag pit, P4 is likely to be within native soils, consisting of gravelly silts and sands in the upper3 to 9 feet, followed by 20 to 30 feet of silt to sandy silt, 40 to 50 feet of coarse sands, gravels, and cobbles, and finally 10 feet of silts and sandy silts at the capillary fringe down to groundwater. Assuming a 3:1 slope on an excavation to allow for safe equipment access, the excavation at RA-B would be approximately 1,500 feet in diameter (greater than ¼ mile) and 90 feet deep and would require removal of 2.5 million yd^3 of soil/fill. As P4 would be present, all of the technical, health and safety, and environmental challenges accompanying a modified excavation (as discussed in Section 5.2.4.1) would be encountered.

- Excavation, removal and treatment of the railcars and contents buried in the slag pile (RA-F1) would also present significant technical challenges including:

    - The railcars currently are buried beneath 80 to 120 feet of slag, requiring excavation and replacement of approximately 300,000 yd^3 of slag assuming a 3:1 slope on the sides of the excavation.

    - Because the railcars are reportedly covered with soil, the soil would have to be carefully removed from around all the railcars to provide access. If the railcars have leaked, this soil could contain P4. The P4-contaminated soil would have to be excavated and containerized. To prevent releases of P4 oxidation products, it is expected that the railcars would have to be enclosed in a structure to contain emissions. The structure would have to be equipped with a scrubber to capture and control those emissions. A significant temporary electrical power source therefore would be required within the excavation area. Water for firefighting would also have to be provided in that area.

    - Because it must be assumed that the railcars are filled with water, a pumping system would be required to remove and containerize that water. The water, approximately 15,000 gallons per railcar and 315,000 gallons total, would have to be temporarily stored, characterized, and potentially placed into containers for transport to the on-site treatment system.

- Uncertainty regarding the extent of corrosion or other deterioration of the railcars requires an assumption that the railcars could not be removed in one piece. Thus each railcar would have to be cut up into pieces small enough to be placed in a drop bin filled with water. Although P4-contaminated equipment sometimes was cut up for decontamination within the decon building during plant operations, it is uncertain how this would be done on the scale of a railcar within an approximate 100-foot deep excavation.

- It is expected that decontamination of the dismantled railcar pieces would not be performed in the slag pit excavation, but in a separate decon structure. The drop bin containing the cut-up railcar pieces would need to be hauled out of the excavation to the decontamination area. This building would have to include air pollution controls and a package boiler to generate steam (either electric or natural gas), and would have to be provided with water, electrical power, natural gas or propane heaters, a phossy water containment and treatment system to collect the removed P4 sludge, and safety systems typical of a P4 handling operation.

- In order to minimize the amount of material to be shipped off-site for incineration, a wastewater treatment system would be required to separate P4-containing materials from water used in the cleaning process. In addition, there would be air pollution control wastes containing phosphoric acid, potentially P4, and other COCs that would have to be appropriately stored, transported, and disposed.

- Given a caustic hydrolysis process operational capability similar to the FMC-designed LDR plant, treatment of P4-containing materials under this alternative would take an estimated 30 to 40 years after start-up of the treatment system.

- Following treatment of P4 in the soil/fill by caustic hydrolysis, the treated soils (process wastes) would contain elevated metals and radionuclides. These wastes would be placed back into the excavation and would still require an ET cap. Like the ET caps that would be placed under other alternatives, this cap would meet the RAO for elimination of the potential release and migration of COCs to groundwater.

As in Alternative 5, the area encompassed by the: 1) RAs to be excavated, 2) the process handling facilities, and 3) the treatment infrastructure (buildings and ancillary facilities) would be within a single designated area of contamination (AOC). It is envisioned that AOC(s) would be defined in a manner that provides flexibility for management, treatment and/or disposal within the FMC Plant Site area.

7.3.6.3 Use of ET Caps

Since the ET Caps installed under this alternative would be essentially the same as those described in Alternative 5, refer to Section 7.3.5 for a complete ET cap discussion.

7.3.6.4 Use of Soil Cover (Gamma) Caps

Since the soil covers installed under this alternative would be essentially the same as those described in Alternative 5, refer to Section 7.3.5 for a complete soil cover (gamma) cap discussion.

7.3.6.5 Sub-Area Remediation

Because underground piping and hydrocarbon-impacted soil subareas are the same as those described under Alternative 5, refer to Section 7.3.5 for a complete discussion of these subareas.

7.3.6.6 Achievement of RAOs

The remedial actions in Alternative 6, when combined with common/core elements presented in Section 7.2.2 (including institutional controls, grading, stormwater management, various monitoring activities, etc.), could meet all of the soil RAOs for the FMC Plant OU, although the time needed to excavate and treat soil/fill in areas with P4-contamination would be 30 to 40 years after start-up of the treatment system. It is not clear that achievement of the RAO to prevent direct exposure to elemental phosphorus under conditions that may spontaneously combust could be assured, given the significant potential to expose elemental phosphorus to air during the extensive excavations included in this alternative.

7.4 SCREENING OF THE ASSEMBLED SOIL ALTERNATIVES

In this section, the assembled soil alternatives are screened against the short and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Screening on the basis of these criteria is specified in the NCP and consistent with Section 4.3 of the *EPA RI/FS Guidance*. In this step, the alternatives are reduced in number so that remaining, most viable alternatives can undergo a more extensive detailed analysis of alternatives in Section 8.0. The evaluation of soil alternatives presented in this section is summarized in Table 7-2.

- **Effectiveness –** There are three key aspects in the screening of the assembled alternatives for effectiveness. Alternatives are qualitatively ranked as to their effectiveness in:

    1. Overall protection of human health and the environment;

2. Reducing the toxicity, mobility, or volume of the contaminated media through the use of treatment that decreases the threats or risks associated with the site contamination; and
3. Short-term (referring to the construction and implementation period) and long-term (referring to long-term permanence of the alternative) reduction of site risks.

- **Implementability** –as a screening criterion, is the measure of both:

  1. Administrative feasibility; and
  2. Technical feasibility of constructing, operating, and maintaining a remedial alternative given the particular process options and site-specific conditions.

- **Cost –** Cost estimates during the screening stage typically are based on a variety of cost-estimating data, including vendor information, conventional cost estimating guides, and previous project totals from similar work. Both O&M and capital costs are developed, and the costs are reduced to a single figure for each alternative, comprising an overall project remediation cost.

As discussed in the *EPA RI/FS Guidance*, "*Absolute accuracy of the cost estimates during the screening is not essential.*" However, the estimated costs provided in this section are within the +50% to -30% range as recommended by *EPA RI/FS Guidance*. They are presented in terms of net present value, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

7.4.1 Soil Alternative Evaluation

Soil alternatives 1 through 6 are evaluated below based on the screening criteria of-effectiveness, implementability, and cost. The post-remedial action physical condition for each of the RAs is shown conceptually on Figures 7-1 through 7-5. Table 7-3 summarizes the discussions below for each of the soil alternatives. Refer to Sections 7.3.1 through 7.3.6 for a detailed description of soil alternatives 1 through 6. In addition to the remedial actions discussed under each soil alternative discussed in Section 7.3, all other common/core remedial actions that would be performed during the implementation of the various remedial alternatives is presented in Section 7.2.1, including institutional controls, grading, stormwater management, and monitoring.

7.4.1.1 Soil Alternative 1 – "No Action" Alternative (Refer to Table 7-3)

The description of Soil Alternative 1 can be found in Section 7.3.1. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

  1. Protective of Human Health and the Environment : "No Action" would not reduce potential future migration of all Site COCs to groundwater, reduce gamma radiation exposure from radionuclides, or reduce risks associated with metals found in site soils.

  2. Reduces Toxicity , Mobility , or Volume: Would not reduce toxicity, mobility, or volume of site COCs.

  3. Short/Long-Term Effectiveness: This alternative is not effective in the short-term or long-term for reducing any of the exposure pathways from existing COCs and therefore would not satisfy any of the RAOs for the Site.

- Implementability:

  1. Administrative Feasibility: "No Action" would maintain the status quo, which is administratively workable.

  2. Technical Implementability: "No Action" requires only the continued implementation of institutional controls already in place at the Site.

- Cost:

  There is no additional cost associated with "No Action."

Therefore, "No Action" would not meet site RAOs for soil. Although the "No Action" Alternative fails these three criteria, it is carried forward into the detailed analysis because this is required under the NCP and because it is the baseline to which all other alternatives are compared.

7.4.1.2 Soil Alternative 2 – (Refer to Figure 7-1 and Table 7-3)

The complete description of Soil Alternative 2 can be found in Section 7.3.2. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

  1. Protective of Human Health and Environment: The various caps, when combined with institutional controls limiting excavation through the caps, prevent direct exposure to soil COCs and minimize/prevent potential release and migration of COCs that threaten groundwater. As a result, the RAOs for soil/fill (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas, and inhalation of fugitive dust) and groundwater (reduce the release and migration of COCs to groundwater) will be met. In

addition, in RAs where remediation will coincide with development (i.e., under the RIR option), institutional controls such as access and use restrictions prevent potential exposure until development is determined. At that time additional remedial actions will be identified and implemented as appropriate based on the exposure pathways and receptors specific to the planned development. This approach meets RAOs both under current and future site uses. As stated in EPA's comments on the draft SFS Report, EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement. This alternative would result in minimal P4 (or reaction product) exposure to remediation workers and the public during the construction or implementation phase of the remedial action.

2. Reduces Toxicity, Mobility, or Volume: Mobility of COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping; although there will be no appreciable reduction in toxicity or volume of COCs in the underlying soils/fill. Active treatment is used only for the sludges removed from the sewer piping in RA-A, reducing the toxicity and volume of the soil COCs. Use of ET caps reduces the mobility of COCs.

3. Short/Long-Term Effectiveness: This alternative would be effective in the short-term based on the institutional controls that would limit access to and use of RA-A, RA-A1, RA-G, and RA-J and the various caps that would be installed throughout the site to limit COC exposure by containment. Excluding the time required for entry of an RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 1 to 2 years from commencement to completion of construction, assuming typical Southeast Idaho construction seasons. Under this alternative, operation of a treatment system is not required. Future land use decisions in the RIR areas would trigger the final remediation in RA-A, RA-G and RA-J. This alternative results in minimal soil disturbance, especially in P4 areas, and minimizes the potential generation of fugitive dust and/or P4 reaction products and the associated short-term risks to site workers and the environment. Long-term effectiveness also would be assured through construction of caps (i.e., ET and Gamma caps) comprised of natural materials that will have long-term permanence and effectiveness. Long-term effectiveness also would be assured in RIR areas through implementation of additional remedial actions as necessary based on future re-development risk profiles.

- Implementability:

1. Administrative Feasibility: Capping (containment) is the primary technology used in this remedy. It is a proven, straightforward remedy that is relatively easy to design and construct. On-site sources of cap construction materials exist (e.g., soil, granular materials). Future remedy selection in RIR areas should not, but could, present some administrative challenges. As a result, this alternative is feasible and relatively easy to implement administratively.

2. Technical Implementability: Capping (containment) is the primary technology used in this remedy and it is a proven, straightforward remedy that is relatively easy to design and construct. Capping has been implemented at other large sites (e.g., mining sites or landfills) for mitigation of similar risks and COCs (primarily inorganics). Enforceable deed restrictions to specify requirements for re-development in areas posing a risk only to hypothetical future site workers would be implemented. Future re-development in these areas would require EPA review and approval of re-development plans, similar to those implemented at sites requiring radon or soil vapor mitigation at the time of future development.

- Cost:

  Soil Alternative 2 will have a capital cost of approximately $28.4M and annual O&M costs of approximately $513K. The 30-year net present value cost of this alternative is $32.7M, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Soil Alternative 2: 1) meets the soil RAOs, 2) satisfies the majority of the effectiveness benchmarks, 3) is implementable both technically and administratively, and 4) is of relatively low cost when compared to other alternatives.

7.4.1.3 Soil Alternative 3 – (Refer to Figure 7-2 and Table 7-3)

The complete description of Soil Alternative 3 can be found in Section 7.3.3. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

  1. Protective of Human Health and the Environment: The various caps, when combined with institutional controls limiting excavation through the caps, prevent direct exposure to soil COCs and minimize/prevent potential release and migration of COCs that threaten groundwater. As a result, the RAOs for soil/fill (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas, and inhalation of fugitive dust) and groundwater (reduce the release and migration of COCs to groundwater) will be met. This alternative would result in minimal P4 (or reaction product) exposure to remediation workers and the public during the construction or implementation phase of the project.

  2. Reduces Toxicity, Mobility, or Volume: Mobility of COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping; although there will be no appreciable reduction in toxicity or volume of COCs in the underlying soils/fill. Active treatment is used only for the sludges (removal) in sewer piping in RA-A,

reducing the toxicity and volume of the soil COCs. Use of ET caps reduces the mobility of COCs.

3. Short/Long-Term Effectiveness: Much like Alternative 2, this alternative would be effective in the short-term based on institutional controls that would limit access to RA-J and the various caps that would be installed throughout the site to limit exposure. Excluding the time required for entry of an RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 2 to 3 years from commencement to completion of construction, assuming typical Southeast Idaho construction seasons. Under this alternative, operation of a treatment system is not required. This alternative results in minimal soil disturbance, especially in P4 areas, and minimizes the potential generation of fugitive dust and/or P4 reaction products and the associated short-term risks to site workers and the environment. Long-term effectiveness also would be assured through construction of caps (i.e., ET and Gamma caps) comprised of natural materials that will have long-term permanence and effectiveness.

- Implementability:

1. Administrative Feasibility: Capping (containment) is the primary technology used in this remedy and it is a proven, straightforward remedy that is relatively easy to design and construct. On-site sources exist for cap construction materials (e.g., soil, granular materials). Therefore, this alternative is feasible and relatively easy to implement administratively.

2. Technical Implementability: Capping (containment) is the primary technology used in this remedy and it is a proven, straightforward remedy that is relatively easy to design and construct. Capping has been implemented at other large sites (e.g., mining sites or landfills) for mitigation of similar risks and COCs (primarily inorganics).

- Cost:

Soil Alternative 3 will have a capital cost of approximately $43.6M and annual O&M costs of approximately $602K. The 30-year net present value cost of this alternative is $47.2M, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Soil Alternative 3 meets soil RAOs that were developed for the FMC Plant OU and the groundwater RAO regarding reducing release and migration of COCs to groundwater. In addition, Alternative 3: 1) satisfies the majority of the effectiveness benchmarks, 2) is implementable both technically and administratively, and 3) is of relatively low cost when compared to other alternatives.

7.4.1.4 Soil Alternative 4 – (Refer to Figure 7-3 and Table 7-3)

The complete description of Soil Alternative 4 can be found in Section 7.3.4. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

  1. Protective of Human Health and the Environment: The excavation/consolidation and installation of various caps, when combined with institutional controls, eliminates direct exposure to soil COCs and minimizes/ prevents potential release and migration of COCs that threaten groundwater. As a result, the RAOs for soil (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas, and inhalation of fugitive dust) and groundwater (reduce release and migration of COCs to groundwater) will be met. This alternative would result in minimal P4/phosphine (or reaction product) exposure to remediation workers and the public during the construction or implementation phase of the project. Only limited P4/phosphine exposure might occur, associated with cleaning the underground sewer pipes in RA-A (followed by off-site commercial incineration of the removed material) and that which would occur during the excavation of the materials from RA-K and placement under an ET cap.

  2. Reduces Toxicity, Mobility, or Volume: Mobility of COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping and excavation/consolidation of material under an appropriate cap; although there will be no appreciable reduction in toxicity or volume of COCs in the underlying soils/fill. Active treatment (removal) is used only for sewer piping in RA-A, reducing the toxicity and volume of the soil COCs. Use of ET caps reduces the mobility of COCs.

  3. Short/Long-Term Effectiveness: Much like Alternatives 2 and 3, this alternative would be effective in the short-term based on institutional controls that would limit access to the various caps that would be installed throughout the site to limit exposure to COCs. Excluding the time required for entry of an RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 2 to 4 years from commencement to completion of construction, assuming normal Southeast Idaho construction seasons. Under this alternative, operation of a treatment system is not required. The alternative results in about 120 acres of soil disturbance, including in P4-contaminated soil in RA-K, thus resulting in the potential generation of fugitive dust containing COCs and/or P4 reaction products and the associated short-term risks to site workers and the environment. Long-term effectiveness also would be assured through construction of caps (i.e., ET and Gamma caps) comprised of natural materials that will have long-term permanence and effectiveness.

- Implementability:

    1. Administrative Feasibility: Capping (containment) is the primary technology used in this remedy and it is a proven, straightforward remedy that is relatively easy to design and construct. On-site sources exist for cap construction materials (e.g., soil, granular materials). Therefore, this alternative is feasible and relatively easy to implement administratively assuming that AOC's can be developed that will allow placement of P4-containing wastes excavated from one area under an ET cap in another (i.e., placement of P4-contaminated materials from RA-K under a cap at RA-B without treatment). Excavation at RA-K also presents challenges in getting acceptance from the Union Pacific railroad, as RA-K is within a few feet of the existing, active rail line.

    2. Technical Implementability: Capping (containment) is the primary technology used in this remedy and it is a proven, straightforward containment technology that is relatively easy to design and construct (technical implementable). Excavation and consolidation under an existing cap presents no unique technical challenges. The safe and successful excavation of significant quantities of P4-impacted soil/fill (as would be encountered by removing an estimated 22,000 yd^3 at RA-K) has not been previously demonstrated. As a result, this alternative is only moderately implementable administratively and/or technically.

- Cost:

    Soil Alternative 4 will have a capital cost of approximately $76.8M and annual O&M costs of approximately $547K. The 30-year net present value cost of this alternative is $81.6M, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Soil Alternative 4: 1) satisfies the majority of the effectiveness benchmarks, 2) is moderately implementable both technically and administratively, and 3) has a high cost when compared to Alternatives 2 and 3.

7.4.1.5 Soil Alternative 5 – (Refer to Figure 7-4 and Table 7-3)

The complete description of Soil Alternative 5 can be found in Section 7.3.5. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

    1. Protective of Human Health and the Environment: The excavation/consolidation and installation of various caps, when combined with institutional controls, eliminates direct exposure to soil COCs and minimize potential release and migration of COCs to groundwater. As a result, the RAOs will be met for soil and groundwater. However, this alternative will result in significant risks of

direct exposure of site workers, the public, and the environment to P4/phosphine or P4/phosphine reaction products during excavation, handling, and treatment of P4-impacted soils. The modified excavation technology and the caustic hydrolysis treatment technology are unproven for the volumes and types of materials found at the FMC Plant OU. This presents a high probability that unacceptable risks/exposures would result during implementation of this alternative.

2. Reduces Toxicity, Mobility, or Volume: Potential release and migration of COCs to groundwater (i.e., mobility) would be effectively reduced after capping the area (excavation of 10-feet of P-4 contaminated soils at the surface does not reduce the toxicity and volume of COCs remaining in the vadose zone).

   It should be noted that during the excavation period (estimated to be 20 to 25 years), the required use of water in the excavation to control P4-combustion, would likely increase the mobility of the COCs to groundwater. Active treatment is used for P4-contaminated soil/fill in to 10 feet bgs in RAs B, C, K as well as all underground piping. As a result, toxicity and volume of excavated P4 is reduced by caustic hydrolysis treatment. However, process wastes would contain elevated levels of metals and radionuclides. Their toxicity and volume would not be reduced and thus would require placement under an ET cap. Also, the modified excavation technology and the caustic hydrolysis treatment technology are unproven for the volumes and types of materials found at the FMC Plant OU. This presents a high probability of failure to achieve a reduction (and possibly an increase) of mobility of COCs.

3. Short/Long-Term Effectiveness: This alternative would be effective in the short-term and long-term based on institutional controls that would limit access to various caps, containment of site COCs by capping, and the removal of some of the P4 in soil by excavation and on-site treatment. However, P4 treatment would result in exposure to P4 and P4 reaction products, which could result in significant short- and long-term risks to site workers, the public, and the environment. Excluding the time required for entry of an RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 20 to 25 years from commencement to completion of construction, assuming normal Southeast Idaho construction seasons. Under this alternative, operation of a treatment system would be required.

- Implementability:

  1. Administrative Feasibility: Earthwork and capping remain the primary remedy elements of this alternative and are administratively feasible as discussed above. The on-site treatment of P4 (unproven for the types and volumes of wastes encountered at the FMC Plant OU) would require significant scale-up testing and design approvals. It also would require achievement of the substantive requirements of Clean Air Act (CAA) and RCRA permitting programs for the

full-scale system and the ancillary air treatment systems installed on the excavation/handling area enclosures and on the process building. This alternative is implementable administratively, but much more difficult than previous straightforward capping alternatives due to substantive CAA and RCRA requirements and the treatability studies, complex designs, and necessary EPA design approvals.

2. Technical Implementability: Earthwork and capping are straightforward remedy elements that are relatively easy to design and construct. However, the excavation and on-site treatment of large volumes of P4-impacted soils have not been demonstrated at the full-scale level at any facility and thus the technical implementability is highly uncertain. In addition, as discussed in Section 2.2 of *P4 Treatment Technologies* report (included in Appendix A), the ancillary processes necessary to perform the modified excavation, prepare the feed for the treatment process, and control/manage air and waste streams will also create significant challenges which to date have not been demonstrated on a scale necessary for this alternative.

- Cost:

  Soil Alternative 5 will have a capital cost of approximately $353.0M and annual O&M costs of approximately $4.5M. The 30-year net present value cost of this alternative is $405.1M, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Soil Alternative 5: 1) satisfies the effectiveness benchmark after the construction and processing operations are completed (if those steps can be successfully carried out), but presents significant risks of P4 and/or P4 reaction product exposures during a 20 to 25-year period to implement the remedy, 2) presents significant administrative and extreme technical challenges for implementability, and 3) is of very high cost when compared to Alternatives 2, 3, or 4. This alternative is: 1) no more effective than the capping that would be conducted under Alternatives 2 or 3, 2) is much more challenging to implement, and 3) has significantly higher cost.

7.4.1.6 Soil Alternative 6 – (Refer to Figure 7-5 and Table 7-3)

The complete description of Soil Alternative 6 can be found in Section 7.3.6. Evaluation of this soil alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

1. Protective of Human Health and the Environment: The excavation/consolidation and installation of various caps, when combined with institutional controls, eliminates direct exposure to soil COCs and minimizes potential release and migration of COCs to groundwater. As a result, the RAOs will be met for soil

and groundwater. However, this alternative will result in significant risks of direct exposure to site workers, the public, and the environment from P4/phosphine or P4/phosphine reaction products during excavation, handling, and treatment of P4-impacted soils. The modified excavation technology and the caustic hydrolysis treatment technology are unproven for the volumes and types of materials found at the FMC Plant OU. This presents a high probability that unacceptable risks/exposures would result during implementation of this alternative.

2. Reduces Toxicity, Mobility, or Volume: Potential release and migration of COCs to groundwater (i.e., mobility) would be effectively reduced after capping the area (excavation of P-4 contaminated soils would not appreciably reduce the toxicity and volume of COCs remaining in the vadose zone). It should be noted that during the excavation period (estimated to be 30 to 40 years), the required use of water in the excavation to control P4-combustion, would likely increase the mobility of the COCs to groundwater. Active treatment is used for P4-contaminated soil/fill to groundwater in RA-B and to 10 feet bgs in RA- C and RA-K as well as all underground piping. As a result, toxicity and volume of P4 is reduced by caustic hydrolysis treatment. Active treatment (removal) is used for P4 in the soil to the groundwater at RA-B and to 10 feet in RA-C and RA-K and all underground piping. As a result, toxicity and volume of P4 may be reduced by caustic hydrolysis treatment. However, process wastes would contain elevated levels of metals and radionuclides. Their toxicity and volume would not be reduced and thus would require placement under an ET cap. Also, the modified excavation technology and the caustic hydrolysis treatment technology are unproven for the volumes and types of materials found at the FMC Plant OU. This presents a high probability of failure to achieve a reduction in (and possibly could increase) the mobility of COCs.

3. Short/Long-Term Effectiveness: This alternative would be effective in the short-term and long-term based on institutional controls that would limit access to various caps, containment of site COCs by capping, and the removal of some of the P4 in soil by excavation and on-site treatment. However, P4 treatment would result in significant potential exposure to P4 and P4 reaction products, which could result in significant short- and long-term risks to site workers, the public, and the environment. Excluding the time required for entry of an RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 30 to 40 years from commencement to completion of construction, assuming normal Southeast Idaho construction seasons. Under this alternative, operation of a treatment system would be required.

- Implementability:

1. Administrative Feasibility: Earthwork and capping remain the primary remedy elements of this alternative and are administratively feasible as discussed earlier.

The on-site treatment of P4 (largely unproven for the types and volumes of wastes to be encountered at the FMC Plant OU) would require significant scale-up testing and EPA design approvals. It also would require achievement of substantive permitting requirements for the full-scale system and the ancillary air treatment systems installed on the excavation/handling area enclosures and on the process building. This alternative is implementable administratively, but much more difficult than previous straightforward capping alternatives (Alternatives 2 through 4) due to substantive permitting requirements, and the treatability studies, complex design, and approval process that would be necessary.

2. Technical Implementability: Earthwork and capping are straightforward remedy elements that are relatively easy to design and construct (technically implementable). However, the excavation and on-site treatment of large volumes of P4-impacted soils have not been demonstrated at full-scale at any facility and thus the technical implementability is uncertain. In addition, as discussed in Section 2.2 of *P4 Treatment Technologies* report (included in Appendix A), the ancillary processes necessary to perform the modified excavation, prepare the feed for the treatment process, and control/manage air and waste streams will also create significant challenges which to date have not been demonstrated on a scale necessary for this alternative.

- Cost:

  There is a net present value cost of significantly greater than $450M for this alternative, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Soil Alternative 6: 1) satisfies the effectiveness benchmarks once remedial action is accomplished (if that is possible), but presents significant risks of P4 and/or P4-reaction product exposures during a 30 to 40-year period to implement the remedy, 2) presents significant administrative and extreme technical challenges for implementability, and 3) is of extremely high cost when compared to Alternatives 2 and 3. This alternative is: 1) no more effective than the previously described capping Alternatives 2, 3, or 4, 2) is much more challenging to implement, and 3) has significantly higher cost.

7.4.2 Soil Alternatives Screening Summary and Selection

A summary of the soil alternative screening for the FMC Plant OU is presented in Table 7-3. As is noted above, soil Alternatives 2, 3, and 4 use containment (i.e., various caps) as the primary remedial technology to limit exposure and therefore site risks. Although these soil alternatives provide varying degrees of protectiveness using the RIR process option until the site is re-developed for new commercial/industrial use, all the alternatives will be equally protective of human health and the environment. Soil Alternatives 2, 3 and 4 are both effective and implementable, although the costs progressively increase under each alternative because of the increased amount of soil remediation work. However, they are still much lower in cost and deemed to be more implementable than Alternatives 5 and 6. It should be noted that the cost estimate for Alternative 2, which uses the RIR process option, does not include costs for future remedial actions, and thus has a lower initial cost. Finally, when capping proposed under these alternatives is used in conjunction with the common or core elements (Section 7.3.1), which strengthen the protectiveness of the alternatives, the soil RAOs are satisfied. In addition, the ET caps proposed under these alternatives provide protection from migration of COCs to groundwater thereby satisfying a principal groundwater RAO.

Soil Alternatives 5 and 6 include many of the same capping options as Alternatives 2, 3, and 4. However, these alternatives include excavation and onsite treatment of P4 using caustic hydrolysis followed by capping of the process wastes because of residual metals and radionuclide contamination. These alternatives reduce the volume and toxicity of P4, but they do nothing to remove the other site COCs (i.e., metals and radionuclides). In addition, the excavation and handling of P4 soils prior to and during the treatment process would result in significant exposure to P4/phosphine and P4/phosphine reaction products that could result in significant short- and long-term risks to site workers, the public, and the environment. The treatment of P4 on-site would require extensive scale-up testing, design approvals, and achievement of substantive permitting requirements for feed preparation, treatment, air pollution control and waste management systems. These alternatives thus are implementable administratively, but are deemed to be much more difficult to implement (if even technically possible) than Alternatives 2, 3, and/or 4. However, excavation, handling, treatment and disposal of process wastes have never been attempted at the scale proposed under these alternatives and technical implementability would be difficult and uncertain.

The NPV costs for soil Alternatives 1 through 6 are as follows:

- **Soil Alternative 1 - $0**
- **Soil Alternative 2 - $32.7M**
- **Soil Alternative 3 - $47.2M**
- **Soil Alternative 4 - $81.6M**
- **Soil Alternative 5 - $405.1M**
- **Soil Alternative 6 - >$450M.**

The cost for the lowest-priced treatment alternative (soil Alternative 5 at approximately $405.1M) is 5 times higher than highest priced capping alternative (Alternative 4 at approximately $81.6M) and over 12 times higher than the lowest priced capping alternative (Alternative 2 at approximately $32.7M).

Quoting from the *Role of Cost in Superfund Remedy Selection* (EPA, 1996), *"The NCP describes cost as one of three "screening" criteria (the others being effectiveness and implementability) used to identify higher cost alternatives that should not be carried forward for detailed evaluation. Alternatives may be screened out if they:*

1. *Provide "effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost" (40 CFR 300.430(e)(7)(iii)).*

2. *Have costs that are "grossly excessive compared to [their] overall effectiveness" (40 CFR 300.430(e)(7)(iii)). For example, the costs associated with treating a complex mixture of heterogeneous wastes without discrete hot spots (e.g., a large municipal landfill) would likely be considered excessive in comparison to the effectiveness of such treatment. As a result, a treatment alternative for such a site would likely be eliminated from consideration during the screening process.*

Cost estimates at the alternative screening stage should focus on relative, rather than absolute, accuracy. At the screening stage, it may also be unnecessary to evaluate costs that are common to all alternatives."

As described above, soil Alternatives 5 and 6:

- Are no more effective than Alternatives 2, 3, and 4 in meeting the soil RAOs;
- Are much more difficult administratively and technically to implement;
- Have higher short-term and long-term risks to human health and the environment; and
- Have grossly excessive costs.

As a result, soil Alternatives 5 and 6 have been <u>eliminated</u> from further consideration for site remediation. Soil Alternatives 2, 3, and 4 are forwarded into the detailed analysis in Section 8.

7.5 REMEDIAL ALTERNATIVES FOR GROUNDWATER

In this section the groundwater alternatives are assembled for the FMC Plant OU from the viable technologies retained from Section 6 of this report. Hydrologic conditions underlying the FMC Plant OU and the source areas for its groundwater contamination are discussed in detail in the *GWCCR*. That report is integral to the development of remedial alternatives for groundwater cleanup, just as the *RI, SRI, and SRI Addendum Reports* supported the development of soil alternatives. Groundwater in the shallow aquifer beneath portions of the FMC Plant OU has been impacted by site-related constituents and if shallow groundwater were used for drinking water it could pose a threat to future workers and, on Northern Properties Parcels 2, 3 and 6, to hypothetical future workers or residents. Risk assessments performed as part of the EMF RI, and updated for the post-RI data in the *GWCCR*, indicate that the COCs for the FMC Plant OU are arsenic, fluoride, manganese, nitrate, selenium, P4, and vanadium. These are the COCs that failed to meet the RAOs for groundwater discussed in Section 4 and listed in Table 4-3.

As discussed in Section 2 of this report, the *GWCCR* summarizes the groundwater investigations that have been completed for the FMC Plant OU. Specifically, the

GWCCR contains the results of the EMF RI and FMC post-RI groundwater studies and includes groundwater quality and trends, a source area evaluation, groundwater fate and transport discussions, and an updated groundwater human health risk assessment. In addition, the *GWCCR* provides information on regional and site-specific geology and hydrogeology and the current and future water/groundwater use in and around the FMC Plant OU.

Major groundwater findings detailed in the *GWCCR* include:

- The groundwater system within the EMF study area is very stable and flow direction and gradients have not changed significantly over 18 years of quarterly monitoring.

- FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water. However, the areal extent of FMC-impacted groundwater does not extend beyond FMC and Simplot-owned properties.

- There are no domestic or public water supply wells located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.

- Concentrations of FMC-related groundwater impacts in the western ponds area, central plant area and downgradient portions of the joint fenceline/calciner ponds area have decreased (groundwater beneath the FMC Plant Site has improved) over time and continued improvement is expected due to the lack of sustained or limited applied hydraulic head on any identified or potential source areas located on the FMC Plant OU.

- Arsenic remains the primary risk driver in groundwater at the FMC Plant OU.

- The most significant factor in the reduction of groundwater constituent concentrations is advective mixing. Mixing of small volumes of EMF-affected groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as sulfate, along the groundwater flowpath.

The assembled groundwater remedial alternatives were refined by the groundwater flow and contaminant transport model constructed for the FMC Plant OU. The groundwater modeling effort and results are presented in the *GW Modeling Report*, which is included in Appendix E. The model was developed as a tool to support the detailed evaluation and comparative analysis of groundwater remedial alternatives in this SFS. The four groundwater remedial alternatives presented and described in detail in this *SFS Report* are:

- Alternative 0: "No action";
- Alternative 1: Source controls, institutional controls and long-term monitoring (LTM);
- Alternative 2: Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, and 1) discharge to the City of Pocatello POTW or 2) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site; and
- Alternative 3: Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and 1) on-site treatment and discharge to the City of Pocatello POTW or 2) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

For modeling purposes, no predictive simulation was performed for SFS groundwater Alternative 0 ("no action") because this alternative does not meet any of the groundwater Remedial Action Alternatives (RAOs). Alternatives 0 and 1 ("no action" and Source Controls and Long-Term Groundwater Monitoring) are similar in that no groundwater extraction is included, such that the predictive simulation would also be similar. However, the Alternative 1 simulation includes the predicted infiltration reduction for identified and potential source areas consistent with the source controls included in SFS Soil Alternatives 2, 3, 4, 5, and 6. Therefore, three predictive simulations (for groundwater Alternatives 1, 2, and 3) were performed to evaluate and compare the performance and effectiveness of the alternatives and estimate the time required to achieve the groundwater restoration RAO.

As described in detail in the *GW Modeling Report*, the groundwater model was constructed and predictive simulations were performed in four general steps as follows:

1. The three-dimensional groundwater flow model was developed and refined during calibration to provide the underlying flow regime for contaminant fate and transport simulations;

2. The contaminant transport model was developed for the site-related groundwater constituents arsenic, total phosphorus / orthophosphate, and potassium, and then was refined during calibration (plume matching) to improve estimates of transport parameters;

3. The modeled groundwater remedial alternatives 2 and 3 extraction well configurations and pumping rates were developed and refined to meet appropriate capture and well drawdown criteria; and,

4. The predictive simulations were performed for groundwater Alternatives 1, 2 and 3.

Sensitivity analyses were performed for the groundwater flow model, contaminant transport model, and predictive simulations at each step in the project.

Over the course of the FMC groundwater model project, FMC convened five meetings with EPA, the Idaho Department of Environmental Quality, and the Shoshone-Bannock Tribes to discuss the planning, development, and preliminary results of the model at each of the steps described above. This series of meetings is summarized below and the full meeting documentation (agendas, meeting presentations, minutes, and follow-up materials circulated in response to comments/questions) is included as Appendix A to the *GW Modeling Report*. The five meetings were as follows:

- May 21, 2009 — Conceptual FMC groundwater remedial alternatives; and overview / plan to construct groundwater flow and transport model to support SFS evaluations.

- July 1, 2009 — Summary of site geology, hydrogeology and nature and extent of site-impacted groundwater; flow model construction and calibration; transport model planning and review of conceptual groundwater remedial alternatives.

- August 17-18, 2009 — FMC site tour; review flow model and final calibration results; review transport model input parameters and preliminary calibration / plume matching; planning (inputs) for predictive simulations, and review preliminary particle tracking results for conceptual remedial alternatives.

- September 21, 2009 — Review groundwater flow model refinement and final calibration results; review calibrated transport model input parameters, plume matching / calibration and sensitivity analysis; review inputs for predictive simulations and refine remedial alternatives particle tracking results.

- October 21, 2009 Review of the calibrated groundwater flow and contaminant transport model; particle tracking results for the refined remedial alternatives; predictive contaminant transport simulations and path forward for preparation of groundwater model report.

The final calibrated groundwater flow and transport model and predictive simulations of remedial alternatives (e.g., refinement of the groundwater remedial alternatives such as extraction well locations and flow rates, and assumptions regarding the J.R. Simplot Plant OU sources and sinks) were modified based on feedback from EPA, IDEQ and the Tribes and guidance obtained during these meetings.

The results of the groundwater model predictive simulations were utilized to evaluate the effectiveness and comparative performance of groundwater Alternatives 1, 2A/B and 3A/B. The model simulations were used to predict the residual areal extent and residual mass of FMC-impacted groundwater for the modeled parameters over the 100 year simulation runs for the groundwater alternatives. The residual aerial extent and mass of arsenic, total phosphorus / orthophosphate and potassium in groundwater were calculated for the FMC Plant Site only to minimize effects from the assumptions for the Simplot Plant OU and areas downgradient from both sites toward the Portneuf River. The model simulation results for Groundwater Alternatives 1, 2 and 3 provide useful insight into the predicted short and long-term effectiveness and relative (comparative) performance of the alternatives as described in the subsections below. The model simulations predict that none of the alternatives will achieve the groundwater restoration RAO within the 100 year modeled period; however, the results of the current FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO.

The FMC source areas of contaminants detected in groundwater are discussed in more detail when presenting Groundwater Alternative 3 options, which includes a discussion of groundwater extraction at two identified FMC source areas in the western ponds area. The alternatives for remediation of COCs in groundwater underlying the FMC Plant OU are discussed below.

7.5.1 Groundwater Alternative 0 – “No Action”

Groundwater Alternative 0 - the “No Action” alternative is a requirement of the National Contingency Plan (NCP; EPA, 1988) and must be considered in the CERCLA FS process. This alternative is a baseline to which all other alternatives are compared. It will be retained for comparison to other groundwater alternatives throughout the remainder of the FS process.

7.5.2 Groundwater Alternative 1 – Source Controls, Institutional Controls, and Long-Term Groundwater Monitoring

Alternative 1 is comprised of three primary elements, as identified in Table 6-2:

1. Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources,

2. Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, and

3. Long-term groundwater monitoring (LTM) would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls.

Source controls were implemented at two of the identified source areas at the FMC Plant Site - RCRA Pond 8S and the former unlined calciner ponds (that underlie the lined calciner ponds). The closure of Pond 8S was completed in 1999 in accordance with the EPA-approved RCRA Closure Plan that specified the installation of a low-permeability cover system (cap) at Pond 8S. Note that ten other lined ponds were similarly closed and capped in accordance with EPA-approved RCRA Closure Plans. However, these ponds have not been identified as sources to groundwater, as these ponds were lined. Remediation of the lined calciner ponds (and underlying, former unlined calciner ponds) was completed in 2005 in accordance with the IDEQ-approved Remedial Action Plan that specified the installation of a low-permeability cover system (cap) at the calciner ponds. The remaining identified source areas for COCs detected in groundwater (primarily historic closed, unlined ponds) would be removed and treated and/or capped to minimize or prevent potential infiltration of precipitation and leaching of COCs from these source areas into the shallow groundwater. All of the proposed soil alternatives (with the exception of the “No Action” Soil Alternative) would include some type of source control that minimizes or prevents further leaching of COCs to groundwater (i.e., through extraction and treatment or capping). COCs already in the groundwater would naturally attenuate over time from the natural mixing in the aquifer. While no significant biological or chemical degradation of COCs has been observed (or would be expected), significant attenuation has been observed through mixing of site groundwater with the Michaud Flats aquifer.

Access restrictions, in the form of land and groundwater use restrictions/prohibitions, would be implemented to prevent any future ingestion of or exposure to contaminated groundwater (i.e., deed restrictions or restrictive covenants including prohibitions on extraction and consumption of impacted groundwater).

FMC-related constituents are attenuated in the groundwater system by several of the processes described in "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Directive 9200.4-17P, April 1999). Per OSWER Directive 9200.4-17P: "*The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.*" The EMF RI (Section 5.3.2 Principal factors affecting migration in the Saturated Zone) and the GWCCR (Section 6.2 Principal Factors Affecting Migration in the Saturated Zone) document that FMC-related constituents are attenuated in-situ by the processes of dilution, chemical stabilization (precipitation) and transformation (oxidation). A brief summary of information presented in the EMF RI and GWCCR follows:

- The most significant process that attenuates groundwater constituent concentrations is advective mixing (dilution). Mixing of small volumes of FMC-impacted groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as potassium, along the groundwater flowpaths. As reported in the GWCCR, potassium and arsenic concentrations in groundwater immediately downgradient from former Pond 8S average about 700 mg/l and 0.15 mg/l respectively (1996-1998 average at wells 155, 156 and 157). Approximately 4, 000 feet downgradient along the flowpaths and at the northern FMC Plant Site property boundary, potassium and arsenic concentrations in groundwater migrating beyond the FMC Plant Site average about 48 mg/l and 0.027 mg/l respectively (1996-1998 average at wells 111 and 146). This represents a dilution / attenuation factor (DAF) of approximately 15 and 5.6 for potassium and arsenic respectively. The estimated DAF for arsenic is likely conservative (low) due to additional arsenic loading from other former unlined ponds in the western ponds area along the flowpaths to the FMC Plant Site northern property boundary.

- Phosphate (total phosphorus and orthophosphate) and fluoride transport is limited by natural attenuation reactions involving the precipitation of calcium and/or iron phosphate solids [Ca3(P04) 2 and FeP04·2H20] and fluorite [CaF2] , respectively. Evidence of precipitation of phosphate solids is supported by comparing the estimated DAF for total phosphorus / orthophosphate with the DAF of potassium and arsenic that are primarily attenuated by dilution along the flowpaths from former Pond 8S to the northern FMC Plant Site property boundary. As reported in the GWCCR, total phosphorus / orthophosphate concentrations in groundwater immediately downgradient from former Pond 8S average about 145 mg/l (1996-1998 average at wells 155, 156 and 157). Approximately 4, 000 feet downgradient along the flowpaths and at the northern FMC Plant Site property boundary, total phosphorus / orthophosphate concentrations average about 2.6 mg/l (1996-1998 average at wells 111 and 146). This represents a DAF of approximately 55 compared to the estimated DAFs of 15 and 5.6 for potassium and arsenic respectively. The significantly higher total phosphorus / orthophosphate DAF (3.5 times the estimated DAF for potassium) cannot reasonably be accounted for by dilution alone.

With respect to fluoride migration, fluoride concentrations were over 1,500 mg/l in former Pond 8S fluids compared with 0.4 mg/l to 0.8 mg/l in representative groundwater. Equilibrium modeling indicates that the groundwater is nearly saturated with respect to fluorite at concentrations of about 0.75 mg/l and, therefore, conditions in the aquifer favor precipitation of the mineral fluorite (SII, 1994).

- Ammonia is transformed (oxidized) to nitrate as a result of the shift from reducing to oxidizing conditions as the infiltrating fluids (e.g., former Pond 8S solute) mix and equilibrate with the groundwater. As reported in the GWCCR, ammonia concentrations in groundwater immediately downgradient from former Pond 8S average about 5.5 mg/l (1996-1998 average at wells 155, 156 and 157), but is consistently below detection limits in monitoring wells at the FMC Plant Site northern property boundary and wells farther downgradient toward the Portneuf River.

- Elemental phosphorus (P4) has been routinely detected in groundwater at wells 108 and 122 downgradient from RUs 1 and 2, but has not been detected at the nearest downgradient wells 111, 146 and 110 at the FMC Plant Site northern property boundary or any wells farther downgradient toward the Portneuf River. Although the decrease in P4 concentrations to below detectable levels could be due in part to advective mixing, transformation (oxidation and/or hydrolysis) of P4 in groundwater are likely the primary mechanisms whereby the P4 is converted to phosphorus compounds (e.g., orthophosphate).

Long-term groundwater monitoring (LTM) would be designed to continue to monitor the identified natural attenuation mechanisms in the groundwater system and monitor the performance of the selected source control (soil) remedies to demonstrate that concentrations of COCs decrease over time as predicted by the groundwater model. Under this alternative, the long-term CERCLA groundwater monitoring program will be designed to monitor the effectiveness of the source control remedial action(s). However, the objectives and methodology for the long-term plan cannot be developed until the final remedy is selected. An interim CERCLA groundwater monitoring plan that creates a foundation for a LTM plan and acknowledges the need to integrate the existing RCRA post-closure and Calciner Ponds post-remedial groundwater monitoring programs into the long-term CERCLA groundwater monitoring program is included in Appendix G.

Based on the modeling conducted, LTM would continue for >100 years before the levels of COCs are predicted to fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.) in groundwater beneath the FMC Plant Site.

7.5.3 Groundwater Alternative 2A – Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and Direct Discharge to POTW

This alternative includes the source controls, institutional controls, and LTM discussed in Groundwater Alternative 1 and adds groundwater extraction from the shallow aquifer to provide hydraulic containment of the contaminated groundwater thereby preventing further downgradient migration of site COCs. The extracted groundwater would be discharged directly to the POTW for treatment. Figure 7-6 depicts the process flow diagram for this alternative. Specifics of this alternative are discussed below.

As discussed in the *GWCCR*, migration of site-related constituents from the shallow groundwater zone to the deeper zone is inhibited by upward vertical hydraulic gradients and the presence of confining strata throughout large portions of the EMF study area. The northward flow of impacted shallow groundwater from the western ponds area, central plant source areas, and joint fenceline area is generally limited to the area south of I-86, due to the effects of converging Michaud aquifer groundwater flowing from the west and northwest that is moving eastward towards the Portneuf River. This large-volume Michaud groundwater flow overwhelms the groundwater flow from the Site and comingles with the small-volume shallow groundwater flow along the northern boundary of the former Plant Site. The combined flow continues to move towards the east-northeast, ultimately discharging to the Portneuf River at Batiste Spring, the Spring at Batiste Road (aka Swanson Road Springs), and as bank seeps and base flow to the river in the reach bounded by these springs. Figure 7-7 depicts the arsenic concentrations in shallow groundwater beneath the FMC Plant OU and is indicative of the hydrologic conditions discussed above.

As a result of these hydrogeologic conditions, the extraction wells would be located in the northeastern corner of the former FMC Plant Site to capture impacted shallow groundwater before it can migrate downgradient beyond the FMC Plant Site boundary. Groundwater modeling indicates that 5 extraction wells would be sufficient for hydraulic capture (containment) of the remaining plume before it leaves the FMC Plant OU. The *GW Modeling Report*, including figures of the plume capture zone, is provided in Appendix E. A total combined extraction rate of approximately 530 gallons per minute (gpm) in this area would be necessary for capture of the FMC Plant OU plume. The approximate locations of the proposed extraction wells are depicted on Figure 7-8.

Based on analytical results from groundwater samples collected in area monitoring wells, the average concentrations of total phosphorus (orthophosphate) and arsenic in the combined groundwater extracted from these well would be approximately 2.5 and 0.035 mg/L as measured in Well 110, Well 146, and TW-9S. Other less significant COCs including selenium, fluoride, and nitrate would average approximately 0.012, 0.30, and 6.65 mg/L. As a result of the low average COC concentrations in extracted groundwater, the water from the site should be permissible for direct pumping to POTW for treatment, without any pre treatment. The current City of Pocatello POTW pollutant influent limits (Title 13, Chapter 13.20, and Local Limit 13.20.045) are shown in Table 7-4 and compared to the probable average levels of COCs in the extracted groundwater based on historic analytical data.

These influent constituent concentrations are much below the average concentration of constituents in influent typically received by the POTW, so permitting this discharge to the POTW should be relatively straightforward. However, there are several hurdles to overcome in implementing this remedy, including a better understanding of: 1) whether the existing POTW treatment capacity could handle the proposed discharge and how low that treatment capacity would be available, 2) the difficulty of obtaining a discharge permit from the City, and 3) the integrity and capacity of the exiting sewer line from FMC to the POTW. In response to a preliminary inquiry concerning the potential to discharge extracted groundwater to the City of Pocatello's waste water treatment plant, the City of Pocatello replied in a letter dated October 28, 2009, *"We are concerned about the potential effects of this discharge on our WWTP operations and Biosolids Land Application Program. In addition, the volume of remediated groundwater would use a large hydraulic capacity in our plant and severely limit our ability to serve our existing customers with their future needs without considerable capital outlay."* Additional discussions with the City of Pocatello to address these concerns have not yet occurred. Therefore, the viability of discharging extracted groundwater to the POTW remains uncertain.

Based on the modeling conducted, extraction would have to continue for >100 years before the levels of COCs are predicted to fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.) in groundwater beneath the FMC Plant Site and pumping could be discontinued.

7.5.4 Groundwater Alternative 2B – Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary, Onsite Treatment, and Discharge to Evaporation/Infiltration Basin

This alternative includes the source controls, institutional controls, and LTM as presented in Groundwater Alternative 1 and groundwater extraction from the shallow aquifer for hydraulic containment of the contaminated groundwater, thereby preventing further downgradient migration of site COCs described in Alternative 2A.

Groundwater Alternative 2B is the same as Alternative 2A, including a sustained groundwater extraction rate of 530 gpm from 5 wells, except that the groundwater extracted from the aquifer in the northeastern portion of the FMC Plant Site would be: 1) treated for elevated arsenic to the MCL of 0.010 mg/L and total phosphorus to the 95th percentile background of 0.3 mg/L documented in the EMF RI Report (the other COCs would be below their MCLs or other remedial action standards) and 2) discharged to an evaporation/infiltration basin located in the Western Undeveloped Area (WUA). These treatment targets are preliminary values for identification of an appropriate water treatment technology for this disposal option. If EPA selects a groundwater extraction / treatment alternative, details around the final treatment targets and water treatment technology would be developed during the remedial design and remedial action. Under this alternative, the majority (net of evaporative loss) of extracted groundwater would be reintroduced to the shallow aquifer via the infiltration basin in the WUA. Figure 7-9 depicts the preliminary design location of the extraction wells, the treatment plant, and the infiltration basin based on the hydrologic conditions at the site and the soil remedial alternatives that will use soil from the WUA for capping. The groundwater would be treated by chemical precipitation, and then filtered to meet the remedial action requirements prior to discharge to the WUA evaporation/infiltration basin. Figure 7-6 depicts the process flow diagram for this alternative.

While there are other potential ex-situ treatment technologies available, chemical precipitation combined with filtration has been selected as the representative treatment option. This is because chemical precipitation (when combined with filtration) is capable of removing all COCs that would exceed the MCLs or other remedial action criteria in extracted groundwater. However, FeCl3 would be required as a precipitating agent in order to achieve the arsenic (As) removal efficiencies required to meet the MCL target. Filtration would be necessary to remove the remaining small particulates prior to discharge to the evaporation/infiltration basin. The precipitate from the process, and the resulting filter cake, is assumed to be hazardous in this alternative. Experience with FeCl3 precipitation has shown that As will readily leach from the precipitates under a TCLP analysis. As a result, the filter cake is assumed to be disposed of at an offsite commercial landfill as hazardous waste (i.e., As is assumed to be leachable).).

Based on the groundwater modeling conducted to date, the extraction would have to continue for >100 years before the levels of COCs are predicted to fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.) in groundwater beneath the FMC Plant Site and pumping could be discontinued.

7.5.5 Groundwater Alternative 3A – Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and at Identified Source Areas, Onsite Pretreatment, and Discharge to POTW

This alternative includes: 1) the source controls, institutional controls, and LTM discussed in Groundwater Alterative 1, 2) groundwater extraction from the shallow aquifer in the northeastern portion of the FMC Plant Site, similar to Alternatives2A and 2B, to provide hydraulic containment of the contaminated groundwater, and 3) adds groundwater extraction downgradient of specific identified source areas as depicted in Figure 7-10.

Based on information presented in the *GWCCR* and discussions with EPA, the three primary areas targeted for removal of contaminated groundwater from west to east would include:

- Area A - Former "Phossy" Ponds 3E through 6E (beneath Pond 15S and Phase IV ponds area);
- Area B - Former Pond 8S; and
- Area C - Northeast Plant Site (Alternative 2) that will capture COCs from a variety of sources, including non-FMC sources in the joint fenceline area.

Area A would require approximately 4 extraction wells with a total groundwater removal rate of 60 gpm. Area B would require 5 extraction wells with a total extraction rate of 90 gpm. Area C uses the same number and locations for extraction wells as Alternative 2; so 5 wells would be necessary to extract groundwater in this case at 520 gpm. The combined total groundwater removal rate from all zones is approximately 670 gpm. Figure 7-10 depicts the locations of these identified source areas, the treatment plant, and POTW, in addition to the approximate locations and number of extraction wells in each of these areas.

Under Groundwater Alternative 3A, the extracted groundwater would require pretreatment by chemical precipitation to remove primarily arsenic and total phosphorus, but also other metal COCs. The pre-treated water then would be discharged to the POTW for final treatment and disposal. Pretreatment is necessary in this case, because the COCs in the groundwater extracted from these source areas are higher in average concentration than the groundwater extracted under Alternative 2A and would meet or exceed the POTW influent requirements for arsenic (0.06 mg/L) and total phosphorus (7.0 mg/L). In addition, unlike Alternative 2B, the treatment does not require achieving the MCL for As and treatment with lime (instead of $FeCl3$) is appropriate. Table 7-5 shows the estimated average concentration of extracted groundwater from each source area and the estimated average concentrations for the combined groundwater. In this case, filtration, as included in Alternative 2B, would not be necessary to meet the POTW influent requirements and is not included in the treatment design. The solids from the chemical precipitation process, and the resulting filter cake, would be *non* hazardous because treatment is performed with lime. Experience has shown that precipitates from lime treatment would not leach metals, and therefore would be non-hazardous. As a result, these solids are assumed to be classified as *non-hazardous* because of the stable chemical composition of the precipitate and would be disposed of at an appropriate offsite commercial landfill as a non-hazardous waste. Figure 7-11 depicts the process flow diagram for the proposed treatment system.

Based on the groundwater modeling conducted to date, the extraction would be required for >100 years before the levels of COCs are predicted to fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.) in groundwater beneath the FMC Plant Site and pumping could be discontinued.

7.5.6 Groundwater Alternative 3B – Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and at Identified Source Areas, Onsite Treatment, and Discharge to Evaporation/Infiltration Basin

Groundwater Alternative 3B consists of the same components as Alternative 3A (e.g., the same number, locations, and extraction rates of wells located in each extraction area) except that the groundwater extracted from the plant boundary and two source areas of the FMC Plant Site would be: 1) treated to the arsenic MCL of 0.010 mg/L and treated for total phosphorus to the background level of 0.3 mg/L (the other COCs also would be below their MCLs or other remedial action standards) and 2) discharged to an evaporation/infiltration basin located in the WUA. Under this alternative, the majority of the extracted groundwater will be reintroduced to the shallow aquifer via the infiltration basin. Figure 7-12 depicts the preliminary design location of the extraction wells, the treatment plant, and the evaporation/infiltration basin based on the hydrologic conditions at the site and the soil remedial alternatives that will borrow soil from the WUA for capping. The extracted groundwater would be treated by chemical precipitation then filtered to meet the remedial action requirements, prior to discharge to the WUA evaporation/ infiltration basin. Figure 7-13 depicts the process flow diagram for this alternative.

As mentioned under Alternative 2B and 3A, while there are other potential ex-situ treatment technologies available, chemical precipitation combined with filtration has been selected as the representative treatment option. This is because chemical precipitation (when combined with filtration) is capable of removing all COCs that would exceed MCLs or other remedial action criteria in extracted groundwater. $FeCl_3$ was chosen as the precipitating reagent in Alternative 2B mainly because of the ratio of arsenic to phosphorus. The lower phosphorus to arsenic ratio in the influent favors treatment using ferric chloride. However, the higher ratio of phosphorus to arsenic in the influent for Alternative 3B favors treatment using lime. Precipitating arsenic and phosphorus with lime would generate a carbonate complex that is very stable and would not require the sludge to be treated as hazardous waste. Ultimately, the most appropriate precipitating reagent will be specified during the remedial design. Filtration would be necessary to remove the remaining small particulates prior to discharge to the infiltration basin. As discussed above, the filter cake is assumed to be disposed of at an offsite commercial landfill as *non-hazardous* waste because of stable chemical composition of the precipitate (i.e., the COCs likely would not be leachable).

Based on the groundwater modeling conducted to date, the extraction would have to continue for >100 years before the levels of COCs are predicted to fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.) in groundwater beneath the FMC Plant Site and pumping could be discontinued.

7.6 SCREENING OF THE ASSEMBLED GROUNDWATER ALTERNATIVES

In this section, the assembled groundwater alternatives are evaluated against the short- and long-term aspects of the three screening criteria: effectiveness, implementability, and cost. These three screening criteria for the assembled groundwater alternatives are the same as those applied to the assembled soil alternatives, as described in the introductory paragraphs in Section 7.4. In this step, the alternatives are reduced in number so that remaining alternatives can undergo a more extensive detailed analysis of alternatives in Section 8.

7.6.1 Groundwater Alternative Evaluation

In this section, groundwater Alternatives 0, 1, 2A, 2B, 3A, and 3B are evaluated based on their effectiveness, implementability, and cost. The conceptual locations of the components of the treatment system under each remedy (excluding groundwater Alternatives 0 and 1) are shown on Figures 7-6 through 7-9. In addition, there are figures for the process flow diagrams for the groundwater Alternatives 2 and 3 extracted groundwater treatment and disposal options. Note that these groundwater alternatives address groundwater remediation for the entire FMC Plant OU. The development and screening of groundwater remedial alternatives is primarily focused on their effectiveness achieving the groundwater RAOs but also evaluates their effectiveness in supporting achievement of the surface water RAO. Evaluation of the effectiveness of FMC remedial alternatives in achieving the surface water RAO is complicated due to the comingling of FMC- and Simplot-impacted groundwater prior to discharge to the Portneuf River as surface water. Table 7-6 summarizes the screening and evaluation results for each of the groundwater alternatives.

As described in Section 7.5, the results of the groundwater model predictive simulations were utilized to evaluate the effectiveness and comparative performance of groundwater Alternatives 1, 2A/B and 3A/B.   The model simulations were used to predict the residual areal extent and residual mass of FMC-impacted groundwater for the modeled parameters over the 100 year simulation runs for the groundwater alternatives. The residual aerial extent and mass of arsenic, total phosphorus / orthophosphate and potassium in groundwater were calculated for the FMC Plant Site only to minimize effects from the assumptions for the Simplot Plant OU and areas downgradient from both sites toward the Portneuf River. The model simulation results for Groundwater Alternatives 1, 2 and 3 are described in detail in the *GW Modeling Report* (Appendix E) and a comparison of the predicted performance as a percent reduction from the groundwater model initial conditions (2008) are summarized below:

Groundwater Alternative	Predicted Reduction Arsenic Areal Extent			Predicted Reduction Arsenic Mass		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	11%	16%	26%	24%	32%	44%
2	12%	16%	28%	24%	33%	45%
3	13%	20%	37%	30%	41%	54%

Groundwater Alternative	Predicted Reduction Total P / Orthophosphate Areal Extent			Predicted Reduction Total P / Orthophosphate Mass		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	29%	40%	62%	28%	44%	63%
2	30%	41%	64%	38%	54%	73%
3	36%	53%	79%	64%	74%	81%

Groundwater Alternative	Predicted Reduction Potassium Areal Extent			Predicted Reduction Potassium Mass		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	20%	34%	51%	15%	32%	56%
2	24%	38%	56%	23%	40%	63%
3	27%	45%	65%	40%	57%	73%

The model simulations predict that none of the alternatives will achieve the groundwater restoration RAO within the 100 year modeled period; however, the results of the current FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO.

7.6.1.1 Groundwater Alternative 0 – "No Action" (Refer to Table 7-6)

The description of Groundwater Alternative 0 can be found in Section 7.5.1. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

    1. Protective of Human Health and the Environment: "No Action" would not: a) reduce potential future migration of site COCs to groundwater, b) reduce COCs currently in the groundwater, beyond any reduction achieved through natural attenuation, or c) prevent ingestion of COCs in groundwater.

2. Reduces Toxicity, Mobility, or Volume: Would not reduce toxicity, mobility, or volume of COCs to or within the groundwater.

3. Short/Long-Term Effectiveness: This alternative is not effective in the short-term or long-term for reducing any of the exposure pathways from existing COCs and therefore would not satisfy any of the RAOs for the Site.

- Implementability:

1. Administrative Feasibility: "No Action" would maintain the status quo, which is administratively workable.

2. Technical Implementability: "No Action" only requires the continued implementation of institutional controls already in place at the Site.

- Cost:

There is no additional cost associated with "No Action."

Although the "No Action" Alternative fails these three criteria, it is carried forward into the detailed analysis because it is the basis to which all other alternatives are compared and it is a requirement of the NCP. "No Action" would not meet any of the site RAOs for groundwater.

7.6.1.2 Groundwater Alternative 1 – (Refer to Table 7-6)

The complete description of Groundwater Alternative 1 can be found in Section 7.5.2. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

1. Protective of Human Health and the Environment: Source and institutional controls to be implemented under this alternative meet 2 of the 3 groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater, through use of institutional controls, and 2) reducing/ eliminating the release of COCs from identified sources through source controls (i.e., future soil remedial actions). However, groundwater modeling indicates that the time frame for achieving the third RAO, that of achieving groundwater restoration, is "unreasonable" given the predicted greater than 100 years for natural processes to restore groundwater quality to the established benchmarks (e.g., MCLs).

   LTM data gathered under this alternative would be used to provide the information necessary for evaluation of groundwater quality trends following the elimination of precipitation on identified soil/fill source areas to groundwater (e.g., following capping of RA-C). Institutional controls, in the form of access restrictions, would be effective at preventing the ingestion of impacted groundwater throughout the FMC Plant OU.

2. Reduces Toxicity, Mobility, or Volume: When the institutional controls are combined with an appropriate soil alternative for source control, Alternative 1 will reduce future human exposure and infiltration of precipitation and leaching of COCs in source areas into shallow groundwater (i.e., migration/mobility of COCs to groundwater). The reduction in toxicity and volume of the COCs in groundwater *through treatment* is not addressed.

3. Short/Long-Term Effectiveness: Alternative 1 would be effective in the short-term (and long-term) at limiting access to (exposure to) impacted site groundwater and monitoring groundwater quality and trends over time. When combined with the selected soil remedy (source control), it will eliminate sources from continued degradation of groundwater quality (i.e., limit the mobility). There also is no short-term risk to the community, workers, or the environment resulting from implementation of this remedy. However, in the short-term, this alternative does not address the potential risks associated with continued migration of the groundwater plume beyond the FMC Plant Site northern boundary. In the long-term, the groundwater model predicted the areal extent of arsenic (as defined by the 0.01 mg/l contour) would be reduced by 26 percent and residual arsenic mass would be reduced by 44 percent in groundwater beneath the FMC Plant Site over 100 years through source controls and natural attenuation under Alternative 1. Table 7-7 presents a summary of the effectiveness of Alternatives 1, 2A/B and 3A/B based on the groundwater model predicted residual aerial extent of the arsenic plume exceeding the MCL at the FMC Plant Site after 100 years. Table 7-7 also presents a summary of the NPV cost estimate and cost per acre for the predicted areal reduction of the FMC Plant Site arsenic plume in 100 years for Alternatives 1, 2B and 3B. The cost estimates for Alternatives 2A and 2B were not used due to uncertainty with the implementability of these options. The groundwater modeling predicts that source controls and natural attenuation will not reduce the toxicity and volume of COCs in groundwater to levels below the remedial action benchmarks in 100 years, which is not a reasonable time frame for "restoration" of groundwater.

- Implementability:

1. Administrative Feasibility: Groundwater Alternative 1 is administratively feasible. It requires review of existing and possible implementation of "new" deed restrictions to prohibit consumption of contaminated groundwater, along with implementation of an LTM plan much like that currently in place for the FMC RCRA post-closure care program. All of these activities are relatively easy to perform.

2. Technical Implementability: It is technically implementable if it is combined with a soil capping or treatment remedy that controls, reduces or eliminates releases or potential releases from, the sources of groundwater contamination at the Site. This alternative and its process components would be straightforward, reliable, and the process would relatively easy to design so technically this alternative would be easy to implement. In addition, the services and materials required for construction of this alternative are readily available.

- Cost:

  Alternative 1 will have a capital cost of approximately $57K and annual O&M costs of approximately $71K. The 30-year net present value cost of this alternative is $960K, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate. The costs associated with Alternative 1 include processing the deed restrictions on groundwater use, installation of additional monitoring wells associated with monitoring the effectiveness of source control measures, and conducting LTM. However, the Alternative 1 cost estimate does not include the soil alternative that is selected to reduce or eliminate leaching of COCs to groundwater which will be costly.

Groundwater Alternative 1 satisfies, at a minimum, 2 of the 3 groundwater RAOs including: 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater. In the long-term, this alternative fails to 3) restore impacted groundwater within a reasonable time frame (similar to the other remedies with extract and treat remedies). This alternative is effective, when combined with source controls, at limiting exposure of receptors to contaminated groundwater and future degradation of groundwater, it is easy to implement, and the costs for this alternative are the lowest of all the viable alternatives.

7.6.1.3 Groundwater Alternative 2A – (Refer to Figure 7-8 and Table 7-6)

The complete description of Groundwater Alternative 2A can be found in Section 7.5.3. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

1. Protective of Human Health and the Environment: Source controls, institutional controls, and LTM from Groundwater Alternative 1 when combined with extraction and direct discharge and treatment of groundwater at the local POTW as proposed under this alternative, meets two of three groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater through institutional control and 2) reducing/ eliminating the release of COCs from identified sources through source controls and by hydraulic containment of the contaminated groundwater to prevent further

migration beyond the FMC Plant Site boundary. However, groundwater modeling predicts that the time frame for attainment of the third groundwater RAO regarding groundwater restoration is “unreasonable” given the predicted greater than 100 years to restore groundwater quality to the established benchmarks (e.g., MCLs).

2. Reduces Toxicity, Mobility, or Volume: Alternative 2A reduces the mobility, toxicity, and volume of groundwater COCs through a combination of source controls, hydraulic containment, and treatment at the City of Pocatello POTW.

3. Short/Long-Term Effectiveness: Alternative 2A would be effective in the short-term with respect to: 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater. Operation would begin as soon as sewer connection between the FMC Plant Site and the POTW could be evaluated (and upgraded if necessary), the waste water discharge permit was in place, and the extraction wells were installed and developed. There is little short-term risk to the community, workers, or the environment resulting from implementation of this alternative. Excluding the time required for entry of a RD/RA consent decree and obtaining EPA approval of the RAWP, this alternative is estimated to require 1 to 2 years to construct and make operational. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 2A are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC’s Northern Properties in the 25 to 50 year timeframe (refer to Groundwater Model Report Figure 3-11). However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy. Simplot has performed mass loading calculations and estimates that FMC-impacted groundwater migrating downgradient from the FMC Plant Site northern boundary accounts for less than 5 percent of the total arsenic and total phosphorus mass load to EMF-impacted groundwater migrating to the Portneuf River (Simplot, 2009). Although EPA has not approved the Simplot mass loading calculation, EPA’s Interim Amendment to the ROD for the Simplot Plant OU states that EPA believes Simplot is a significantly larger contributor (of phosphorus to the River) than FMC. In the long-term, the areal extent of arsenic (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent and the arsenic residual mass would be reduced by 45 percent in groundwater beneath the FMC Plant Site over 100 years under Alternative 2A (see Table 7-7). The groundwater modeling predicts that this alternative will not reduce the toxicity and volume of COCs in groundwater to levels below the remedial action benchmarks within 100 years, which is not a reasonable time frame for “restoration” of groundwater.

- Implementability:

    1. Administrative Feasibility: Administratively, the most difficult hurdle would be applying for and receiving a wastewater discharge permit for the estimated 530 gpm that would be produced by the extraction wells installed in the northeastern corner of the plant site and discharged to the local POTW. In addition, the designs of all the alternative components would be reviewed and, as appropriate, approved by EPA. As discussed in Section 7.5.3, preliminary feedback from the POTW is not encouraging. However, it is assumed that Alternative 2A is administratively implementable.

    2. Technical Implementability: Groundwater extraction and direct discharge to/treatment by the POTW are the primary components used in this remedy. This alternative and its process components would be straightforward, reliable, and the process would relatively easy to design. Thus this alternative would be easy to implement from a technical standpoint. In addition, the services and materials required for construction of this alternative are readily available.

    As a result, this alternative is feasible technically and relatively easy to implement administratively, although there is uncertainty about POTW capacity to take the extracted groundwater.

- Cost:

    This alternative would have a capital cost of approximately $579K dollars and annual O&M costs of approximately $712K. There is a net present value cost of approximately $9.6M for Alternative 2A, assuming 2009 dollars for capital and O&M expenses, a 7% discount rate and a 30 year time period for operation of the system components.

Groundwater Alternative 2A addresses current risks to human health and the environment by using a combination of upfront institutional controls in the form of access or deed restrictions to prevent exposure now and in the future and source controls which prevent migration of COCs from known sources of contamination. Long-term pumping would provide containment of contaminated groundwater at the FMC Plant Site northern boundary in the 25 to 50 year time frame, and treatment of groundwater at the POTW would reduce toxicity and volume of the Site COCs.

Groundwater Alternative 2A is effective in the short-term with respect to preventing ingestion of COCs through institutional controls and reducing migration/ mobility of the site COCs to groundwater. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 2A are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above. In the long-term, this alternative is not predicted to achieve the groundwater restoration RAO beneath the FMC Plant Site in a reasonable time frame. It is moderately easy to implement technically, but may not be administratively implementable due to uncertainty regarding the ability to obtain a permit from the Pocatello POTW for discharge of the extracted groundwater. It has moderate cost, but lower cost than the other active groundwater alternatives (2B, 3A, and 3B).

7.6.1.4 Groundwater Alternative 2B – (Refer to Figure 7-9 and Table 7-6)

The complete description of Groundwater Alternative 2B can be found in Section 7.5.4. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

    1. Protective of Human Health and the Environment: Source controls, institutional controls, and LTM from Groundwater Alternative 1, when combined with extraction for containment, treatment of groundwater, and discharge to an upgradient evaporation/infiltration basin, meet two of the three groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/eliminating the release of COCs from identified sources through source controls and by containing the contaminated groundwater to prevent further migration beyond the FMC Plant OU boundary. However, groundwater modeling predicts that the time frame for the third RAO regarding groundwater restoration is "unreasonable" given the predicted greater than 100 years that would be necessary to restore groundwater quality to the established benchmarks (e.g., MCLs).

    2. Reduces Toxicity, Mobility, or Volume: Alternative 2B also reduces the mobility, toxicity, and volume of groundwater COCs through source controls, hydraulic containment, and on-site treatment. The filter cake from the chemical precipitation process would be landfilled offsite, likely as a hazardous waste.

    3. Short/Long-Term Effectiveness: Alternative 2B would be effective in the short-term with respect to 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater. Operation would begin as soon as the extraction wells were installed and developed, the chemical precipitation process was constructed and optimized, and the infiltration basin conveyance system was installed. There is little risk to the community, workers, or the environment resulting from construction of this alternative in the short-term. Excluding the time required to enter an RD/RA consent decree and gain EPA approval of the RAWP, this alternative is estimated to require 2 to 3 years to construct and make operational. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 2B are predicted to achieve restoration of groundwater downgradient

from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe. Achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above for Alternative 2A. In the long-term, the areal extent of arsenic (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent and residual arsenic mass would be reduced by 45 percent in groundwater beneath the FMC Plant Site over 100 years under Alternative 2B (see Table 7-7). The groundwater modeling predicts this alternative will not reduce the toxicity and volume of COCs in groundwater to levels below the remedial action benchmarks within 100 years, which is not a reasonable time frame for "restoration" of groundwater.

- Implementability:

  1. Administrative Feasibility: Administratively, because most of the process components are located on-site, the treatment technology is a well known, industry standard, and because no new permits would be required for the process, it should be relatively easy to implement administratively. However, designs of all the alternative components would need to be reviewed and, as appropriate, approved by EPA.

  2. Technical Implementability: Groundwater extraction, treatment by chemical precipitation, and discharge into an onsite evaporation/infiltration basin for shallow aquifer recharge are the primary components used in this remedy. This alternative and its process components would be straightforward, reliable, and the process would relatively easy to design so technically this alternative would be easy to implement. In addition, the services and materials required for construction of this alternative are readily available.

  As a result, this alternative is feasible technically and relatively easy to implement administratively, possibly easier than Alternative 3A.

- Cost:

  This alternative would have a capital cost of approximately $2.7M dollars and annual O&M costs of approximately $552K. There is a net present value cost of approximately $11.2M for this alternative, assuming 2009 dollars for capital and O&M expenses, a 7% discount rate, and a 30 year time period for operation of the system components.

Alternative 2B addresses current risks to human health and the environment by using a combination of upfront institutional controls in the form of access or deed restrictions to prevent groundwater exposure now and in the future, and source controls that prevent migration of COCs from known sources of contamination. Long-term pumping would provide containment of contaminated groundwater at the FMC Plant Site northern boundary in a 25 to 50 year time frame, and onsite treatment of groundwater will reduce toxicity and volume of the COCs. The filtered chemical precipitate will be disposed of in an offsite commercial landfill.

Alternative 2B is effective in the short-term with respect to preventing ingestion of COCs through institutional controls and reducing migration/ mobility of the site COCs to groundwater. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 2A are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above. In the long-term, this alternative is not predicted to achieve the groundwater restoration RAO beneath the FMC Plant Site in a reasonable time frame. It is relatively easy to implement both technically and administratively when compared to the Alternative 3 options. It is slightly more costly than Alternative 2A, primarily for construction and operation of an on-site treatment system. However, it is less costly than any of the Alternative 3 options.

7.6.1.5 Groundwater Alternative 3A – (Refer to Figure 7-10 and Table 7-6)

The complete description of Groundwater Alternative 3A can be found in Section 7.5.5. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

    1. Protective of Human Health and the Environment: Source controls, institutional controls, and LTM from Groundwater Alternative 1, when combined with 1) extraction of groundwater for containment of the groundwater plume and from two identified source areas within the plume for mass removal, 2) pretreatment of groundwater, and 3) discharge to the POTW for final treatment and disposal, meets two of the three groundwater RAOs for protection of human health and the environment similar to the other alternatives. The groundwater RAOs are met by: 1) preventing the ingestion of contaminated groundwater and 2) reducing/eliminating the release of COCs from identified sources through source controls and by hydraulic containment of the contaminated groundwater to prevent further migration beyond the FMC Plant Site. However, groundwater modeling indicates that the time frame for attainment of the third groundwater RAO regarding groundwater restoration is "unreasonable" given the predicted greater than 100 years to restore groundwater quality to the established benchmarks (e.g., MCLs).

    2. Reduces Toxicity, Mobility, or Volume: Alternative 3A does reduce the mobility, toxicity, and volume of groundwater COCs through source controls, hydraulic containment, and source area extraction and treatment both on-site and at the

POTW. The filter cake from the chemical precipitation process would be landfilled offsite, likely as a non-hazardous waste.

3. Short/Long-Term Effectiveness: Alternative 3A would be effective in the short-term with respect to 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater. Operation would begin as the: 1) extraction wells were installed and developed, 2) the chemical precipitation pre treatment process was built and optimized, 3) the wastewater discharge permit was in place, and 4) the sewer line was upgraded (if necessary). This alternative would take slightly longer to construct than Alternatives 2A and 2B because more extraction wells would have to be installed and pretreatment of groundwater would be necessary before the water could be discharged to the POTW for final treatment (unlike Alternative 2A, which also sends extracted groundwater to the POTW for treatment, but without pretreatment). There is little risk to the community, workers, or the environment resulting from construction of this alternative in the short-term. Excluding the time required for entry of an RD/RA consent decree and to gain EPA approval of the RAWP, this alternative is estimated to require 3 to 4 years to construct and make operational. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 3A are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe (refer to Groundwater Model Report Figure 3-14). However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above for Alternative 2A. In the long-term, the areal extent of arsenic (as defined by the 0.01 mg/l contour) would only be reduced by 37 percent and the arsenic residual mass would be reduced by 54 percent in groundwater beneath the FMC Plant Site over 100 years under Alternative 3A (see Table 7-7). The groundwater modeling predicts that this alternative will not reduce the toxicity and volume of COCs in groundwater to levels below the remedial action benchmarks within 100 years, which is not a reasonable time frame for "restoration" of groundwater.

- Implementability:

1. Administrative Feasibility: Administratively, based on the number of process components, this alternative is the most complex of the groundwater treatment alternatives proposed for the FMC Plant OU and so it likely will be more difficult administratively to organize and complete than the other groundwater alternatives. The most difficult hurdle likely would be applying for and receiving a wastewater discharge permit from the local POTW for the estimated 670 gpm that would be produced by the extraction wells installed at the two source areas and the hydraulic containment wells located at the northeastern corner of the FMC Plant Site. In addition, the designs of all the alternative process components would be reviewed and, as appropriate, approved by EPA. As discussed in Section 7.5.3,

preliminary feedback from the POTW is not encouraging. However, it is assumed that Alternative 3A is administratively implementable.

3. Technical Implementability: Groundwater extraction, onsite pretreatment, and discharge to/final treatment by the POTW are the primary components used in this remedy. Alternative 3A and its process components would be straightforward, reliable, and the process would relatively easy to design so technically this alternative would be easy to implement. In addition, the services and materials required for construction of this alternative are readily available. However, the extraction wells drilled at the source areas likely would be more difficult to install, develop, and to produce water from because of the tighter (i.e., lower hydraulic conductivity) soils and more heterogeneous aquifer in the source areas than the wells located in the northeastern corner of the FMC Plant OU (i.e., it would more difficult to implement technically). The hydrogeologic conditions (i.e. low hydraulic conductivity) might require installation of more extraction wells than are currently estimated based on evaluation of the performance of the remedy during implementation which makes this alternative more technically difficult to implement.

- Cost:

  This alternative would have a capital cost of approximately $5.1M dollars and annual O&M costs of approximately $1.4M. There is a net present value cost of approximately $25.1M for this alternative, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Groundwater Alternative 3A is effective in the short- and long-term with respect to preventing ingestion of COCs through institutional controls and reducing migration/mobility of the site COCs to groundwater. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 3A are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above for Alternative 2A. In the long-term, this alternative is not predicted to achieve the groundwater restoration RAO beneath the FMC Plant Site in a reasonable time frame. Treatment of groundwater, first on-site and then at the POTW, will reduce toxicity and volume of the groundwater COCs. The chemical precipitate would be disposed of in an offsite commercial landfill, likely as a non-hazardous waste.

This alternative is moderately easy to implement technically, but may not be administratively implementable due to uncertainty regarding the ability to obtain a permit from the Pocatello POTW for discharge of the extracted groundwater. It has a higher cost than either of the Alternative 2 options because of the additional capital costs associated with the installation of wells in the source areas, installation and operation of a pretreatment system prior to discharge to and final treatment at the POTW, and higher O&M costs associated with increased water production and treatment (670 gpm). Alternative 3A is more costly than Alternative 3B primarily because constructing a pretreatment process followed by the O&M costs associated with final treatment at the POTW costs more than construction and O&M of onsite treatment system under Alternative 3B.

7.6.1.6 Groundwater Alternative 3B – (Refer to Figure 7-12 and Table 7-6)

The complete description of Groundwater Alternative 3B can be found in Section 7.5.6. Evaluation of this groundwater alternative for short and long-term aspects of the three screening criteria is presented below.

- Effectiveness:

  1. Protective of Human Health and the Environment: Source controls, institutional controls, and LTM from Groundwater Alternative 1, when combined with: 1) extraction of groundwater for containment of the groundwater plume and from identified source areas within the plume for mass removal, 2) onsite treatment of groundwater to remove COCs, and 3) discharge to an upgradient evaporation/infiltration basin for shallow aquifer recharge meets two of the three groundwater RAOs for protection of human health and the environment similar to the other alternatives (i.e., except “No Action”). The groundwater RAOs are met by preventing the ingestion of contaminated groundwater and reducing/eliminating the release of COCs from identified sources through source controls and by containing the contaminated groundwater to prevent further migration offsite. However, groundwater modeling indicates that the time frame for meeting the third groundwater RAO regarding groundwater restoration is “unreasonable” given the predicted period of greater than 100 years to restore groundwater quality to the established benchmarks (e.g., MCLs).

  2. Reduces Toxicity, Mobility, or Volume: Alternative 3B reduces the mobility, toxicity, and volume of groundwater COCs through source controls, groundwater extraction for hydraulic containment and source area COC mass removal, and onsite groundwater treatment. The filter cake from the chemical precipitation process would be landfilled offsite, likely as a non-hazardous waste.

  3. Short/Long-Term Effectiveness: This alternative would be effective in the short-term with respect to 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater. Operation would begin as the extraction wells are installed and developed, the chemical precipitation process was built and optimized, and the infiltration basin conveyance system was completed. There is little risk to the community, workers, or the environment resulting from the construction of this alternative in the short-term. Excluding the time required to enter an RD/RA consent decree and gain EPA approval of the RAWP, this alternative is estimated to require 2 to

4 years to construct and make operational. The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 3B are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe (refer to Groundwater Model Report Figure 3-14). However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above for Alternative 2A. In the long-term, the areal extent of arsenic (as defined by the 0.01 mg/l contour) would only be reduced by 37 percent and the arsenic residual mass would be reduced by 54 percent in groundwater beneath the FMC Plant Site over 100 years under Alternative 3B (see Table 7-7). The groundwater modeling predicts that this alternative will not reduce the toxicity and volume of COCs in groundwater to levels below the remedial action benchmarks within 100 years, which is not a reasonable time frame for "restoration" of groundwater.

- Implementability:

1. Administrative Feasibility: Administratively, because most of the process components are located on-site and the treatment technology is a well known, it should be relatively easy to implement. The designs of the alternative process components, however, would be subject to EPA review and approval.

2. Technical Implementability: Groundwater extraction, pretreatment by chemical precipitation, and discharge into an onsite evaporation/infiltration basin for shallow aquifer recharge are the primary components used in this remedy. This alternative and its process components would be straightforward, reliable, and the process would relatively easy to design so technically this alternative would be easy to implement. In addition, the services and materials required for construction of this alternative are readily available. However, the extraction wells drilled at the source areas likely would be more difficult to install, develop, and produce water from because of the tighter (i.e., lower hydraulic conductivity) soils and more heterogeneous aquifer in the source areas than the wells located in the northeastern corner of the site (i.e., it would be more difficult to implement technically). The hydrogeologic conditions (i.e. low hydraulic conductivity) might require installation of more extraction wells than are currently estimated based on evaluation of the performance of the remedy during implementation which makes this alternative more technically difficult to implement.

For these reasons, Alternative 3B is feasible technically and relatively easy to implement administratively, possibly easier than Alternative 3A because a POTW wastewater discharge permit would not be required.

- <u>Cost:</u>

  This alternative would have a capital cost of approximately $6.5M dollars and annual O&M costs of approximately $1.1M. There is a net present value cost of approximately $24.2M for this alternative, assuming 2009 dollars for capital and O&M expenses and a 7% discount rate.

Alternative 3B addresses current risks to human health and the environment by using a combination of up-front institutional controls in the form of access or deed restrictions to prevent exposure now and in the future, and source controls that prevent migration of COCs from known sources of contamination. Under this alternative, the extracted groundwater is discharged to an on-site, upgradient infiltration basin and most of the treated water would re-enter the shallow aquifer, although there would be some evaporative loss during the summer months. In addition, long-term pumping will provide containment of contaminated groundwater at the northern FMC Plant Site boundary in a 25 to 50 year time frame. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy. In the long-term, this alternative is not predicted to achieve the groundwater restoration RAO beneath the FMC Plant Site in a reasonable time frame. On-site treatment of groundwater would reduce toxicity and volume of the groundwater COCs. The filtered chemical precipitate would be disposed of in an offsite commercial landfill, likely as a non-hazardous waste.

Alternative 3B is more difficult to implement both technically and administratively than the Alternative 2 options, but less difficult to implement than Alternative 3A. It has higher cost than the Alternative 2 options, because of capital expenses associated with the installation of wells in the source areas and higher O&M costs associated with increased water production (670 gpm) and resulting treatment costs. However, this alternative costs slightly less than 3A because it is less expensive to construct and operate an on-site treatment system compared to Alternative 3A, which has a pretreatment process component followed by substantial O&M costs associated with final treatment and disposal at the local POTW.

7.6.2 Groundwater Alternatives Screening Summary and Selection

A summary of the groundwater alternative screening for the FMC Plant OU is presented in Table 7-6. As is noted above, similar to Groundwater Alternative 1, all the groundwater extraction and disposal alternatives (i.e., 2A, 2B, 3A, and 3B) include source controls (i.e., the likely soil remedial alternatives) and institutional controls (i.e., groundwater use restrictions) to reduce or eliminate future migration of COCs to groundwater and prevent exposure to contaminated groundwater. These actions will limit human and environmental exposures to site COCs and thereby greatly reduce site risks.

Groundwater alternatives 1, 2A, 2B, 3A, and 3B meet two of the three RAOs established for groundwater underlying the site by: 1) reducing/eliminating the release of COCs from identified sources through source controls (for all alternatives) and by containing groundwater from further migration beyond the FMC Plant Site boundary through installation and pumping of extraction wells (for Alternatives 2A through 3B) and 2) preventing the ingestion of contaminated groundwater through prohibitions on groundwater consumption (for Alternatives 1 through 3B). However, based on groundwater modeling results *none* of these alternatives will 3) restore groundwater quality to remedial action benchmarks (e.g., MCLs) at the FMC Plant Site within a reasonable time frame given that the restoration time frame for these alternatives are all predicted to be greater than 100 years. Section 6.2.2.3 of *EPA RI/FS Guidance* states:

> *The (Technical Impracticability) waiver may be used when neither existing nor innovative technologies can reliably attain the ARAR in question; or attainment of the ARAR is not practicable from an engineering perspective. For groundwater remedies, technical impracticability may be measured in terms of restoration time frame. A time frame beyond 100 years would generally warrant the technical impracticability waiver.*
> (EPA, 1988).

All groundwater alternatives (0, 1, 2A/B and 3A/B) would appear to require a TI waiver as MCLs are not predicted to be achieved in a reasonable time frame.

Groundwater Alternative 0, the "No Action" Alternative, meets none of the groundwater RAOs that were established for the Site.

Effectiveness. Groundwater Alternatives 1, 2A, 2B, 3A, and 3B are all effective in that during the implementation period, they protect human health and the environment. These alternatives prevent ingestion of contaminated groundwater through the use of institutional controls and reduce or eliminate migration of COCs from known sources through the implementation of source/soil remedies. The groundwater Alternatives 2A, 2B, 3A, and 3B reduce the toxicity, mobility, and volume of constituents in groundwater through extraction (which contains the groundwater plume) and treatment either on-site and/or at the POTW (which reduces the toxicity and volume of COCs in groundwater).While the toxicity, mobility, and volume of constituents in groundwater would be reduced under Alternatives 2A/Band 3A/B, the total mass of these inorganic COCs is conserved and would be largely transferred to the POTW wastewater sludge or on-site treatment residual solids (e.g., filtercake). The toxicity and mobility of the COCs would be reduced in the sludge or solid phase, but the volume would increase proportional to the added volume of treatment reagents (precipitants).

The hydraulic containment wells at the northern FMC Plant Site are a common component in Alternatives 2 and 3 and are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's Northern Properties in the 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy as described above for Alternative 2A. The Alternative 3 options more aggressively remove COCs found in groundwater with additional extraction and treatment of groundwater from the two primary source areas. However, this more aggressive removal and treatment is not predicted to substantially decrease the areal extent or residual mass of the arsenic plume within the FMC Plant Site within a 100 year time frame. The groundwater model predicts that Alternative 3 will decrease the areal extent of arsenic above the MCL by only 9% compared to Alternative 2, and by only 11% compared to Alternative 1 (see Table 7-7). The groundwater model predicts that Alternative 3 will decrease the mass of arsenic by only 9% compared to Alternative 2, and by only 10% compared to Alternative 1. Alternative 1 does not contain future downgradient migration of contaminated groundwater (i.e., reduction in mobility through containment), although the institutional controls that will be in place will prevent ingestion of that groundwater. In addition, Alternative 1 does not reduce the toxicity and volume of contamination through treatment.

All of these alternatives would be effective in the short-term with respect to 1) preventing ingestion of COCs through institutional controls and 2) reducing migration/ mobility of the site COCs to groundwater, and because the alternatives would be relatively easy to implement both technically and administratively. Excluding the time required to enter an RD/RA consent decree and obtain EPA approval of the RAWP, all of these alternatives likely could be constructed and made operational within one to 4 years, depending on the level of complexity (i.e., number of extraction wells and types of treatment).

For Alternative 1, administrative details regarding necessary institutional controls could be worked out quickly and the LTM program would be integrated with FMC's ongoing groundwater monitoring and continued into the future. For Alternatives 2A through 3B, full operation would require a longer time frame, but could begin as soon as 1) the extraction wells were installed and developed, 2) the treatment process was built and optimized (where necessary), and 3) the disposal option was completed (either to a POTW or an infiltration basin). For Alternatives 2A and 3A there would be additional administrative time necessary to apply for and receive the POTW wastewater discharge permit. In the long-term, none of these alternatives (i.e., 1, 2A, 2B, 3A, and 3B) are not predicted to achieve the groundwater restoration RAO beneath the FMC Plant Site in a reasonable time frame.

Implementability. Groundwater Alternative 1 is easier to implement technically than the Alternatives 2 or 3 options, because Alternative 1 requires primarily administrative processes to complete the deed restrictions rather than construction as under the Alternatives 2 and 3 options. The source controls implemented under Alternatives 1, 2 and 3 would be performed under the FMC Plant OU selected soil alternative and in the timeframe required for the selected soil alternative. Groundwater Alternative 3 options would be more difficult to implement technically than the Alternative 2 options because, in addition to the extraction wells installed in the northeastern corner of the site for groundwater containment, there would be extraction wells installed to withdraw groundwater at two primary source areas. The wells drilled at the source areas likely would be more difficult to install, to develop, and to produce water from because of the tighter (i.e., lower hydraulic conductivity) soils and more heterogeneous aquifer in the source areas. Even given these technical challenges, because all of these alternatives use proven, straightforward technologies for extraction, treatment and discharge of groundwater, they are relatively easy to implement technically, although Alternative 1 would be the easiest to implement.

Administratively, all of the groundwater alternatives would require review of existing deed restrictions and covenants and likely filing of additional land and groundwater use restrictions. Groundwater alternatives 2A and 3A also would require application for and granting of a wastewater discharge permit by the City of Pocatello, Idaho for treatment of groundwater at the POTW, which makes these alternative more difficult to implement administratively. Based on the POTW's published influent requirements, it appears that discharge is technically feasible. However, the capacity of the POTW to receive this quantity of water (estimated 530 gpm for Alternative 2 and 670 gpm for Alternative 3) is of concern and the integrity and construction of the sewer system from the FMC Plant Site to the POTW would have to be evaluated. Groundwater Alternative 1 is the easiest to implement administratively and is a necessary and required component of all the other alternatives. Based on the groundwater model predictions that none of the alternatives will achieve the groundwater restoration RAO within a reasonable timeframe, a technical impracticability waiver would likely be needed for Alternatives 1, 2A/B and 3A/B. The TI waiver could be prepared either prior to (i.e., pre-ROD) or after implementation of the selected groundwater remedy.

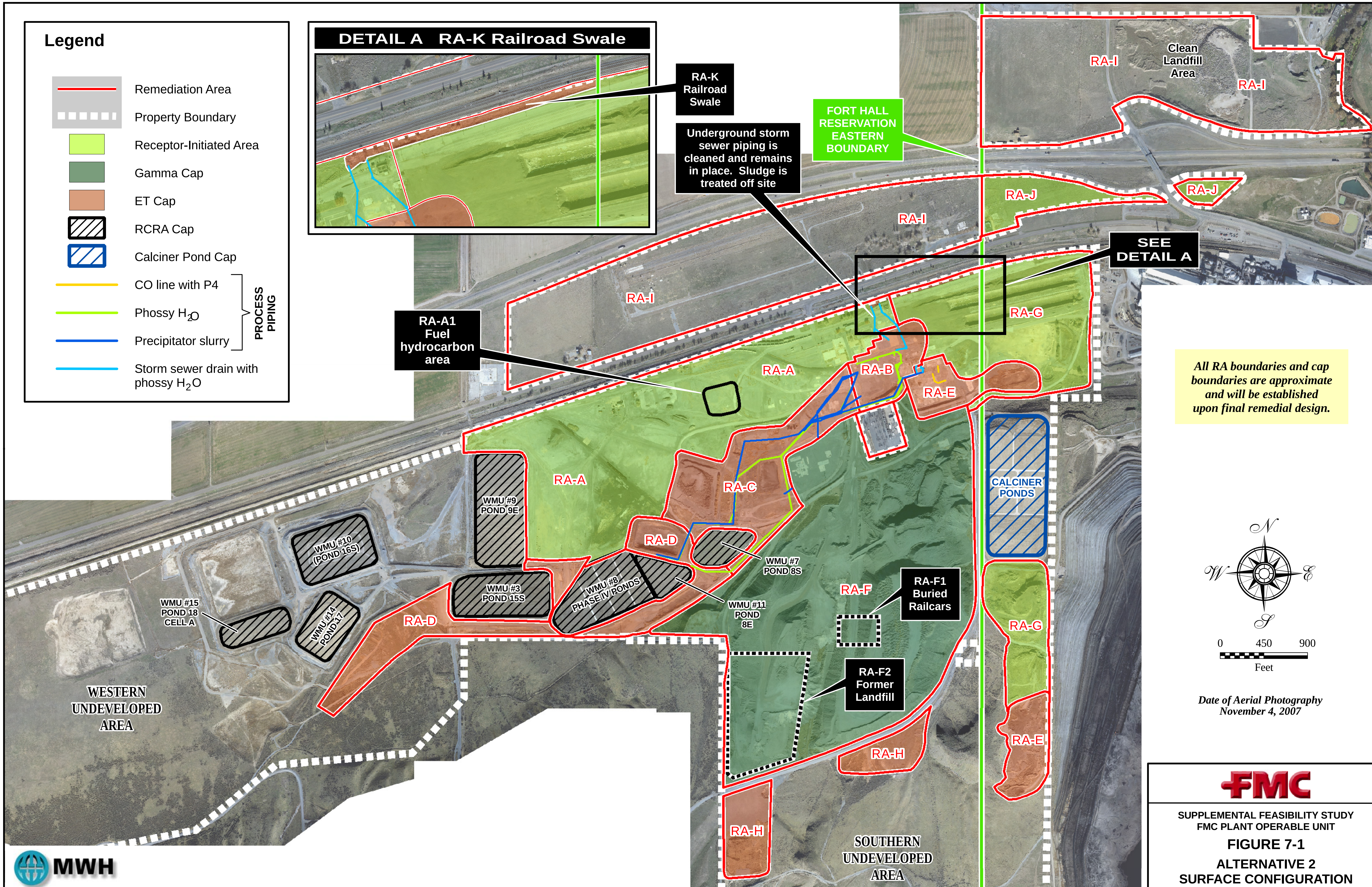
Based on the discussions above, groundwater Alternatives 1, 2A, 2B, 3A, and 3B are implementable both technically and administratively, with varying degrees of difficulty depending on the process options and the site conditions. Arguably, the most difficult alternative to implement both technically and administratively is Alternative 3A, because of pretreatment on-site and final treatment and discharge offsite at the POTW.

Cost. Total costs for Alternative 0 – "No Action" are used as the base case for comparison to the other groundwater alternatives including Alternative 1 (the source and institutional controls alternative with LTM) and the active groundwater withdrawal and treatment options presented in groundwater Alternatives 2A through 3B. All the active groundwater remedies contain the components of Alternative 1. As a result, Alternative 1 is substantially less expensive than the active groundwater withdrawal and treatment Alternatives 2A through 3B. The primary expense associated with Alternative 1 is for LTM.

With regard to the active treatment options, groundwater Alternatives 2A and 2B are less expensive than the groundwater Alternatives 3A and 3B, primarily because both the number of wells and the total extraction rate are greater when using Alternatives 3A and 3B. As a result, not only are the initial capital costs higher, but the annual O&M costs are higher for the additional chemical amendments, solids disposal, electricity, replacement of process components, etc. Within Alternatives 2A and 2B, direct disposal of extracted groundwater to the POTW without pretreatment is less expensive than construction and operation of an on-site treatment system. However, groundwater Alterative 3A, which includes discharge to the POTW, is more expensive than 3B, because construction of a treatment plant for pretreatment prior to discharge to the POTW is slightly more expensive than construction and operation of an on-site treatment system and discharge to an infiltration pond. The NPV costs for groundwater Alternatives 0 through 3B are as follows:

- **Groundwater Alternative 0 - $0**
- **Groundwater Alternative 1 - $960K**
- **Groundwater Alternative 2A - $9.6M**
- **Groundwater Alternative 2B - $11.2M**
- **Groundwater Alternative 3A - $25.1M**
- **Groundwater Alternative 3B - $24.2M**

Based on the information presented above, groundwater Alternatives 1, 2A/B and 3A/B are viable when evaluated using the criteria of effectiveness, implementability, and cost. However, there is the major caveat that none of the alternatives are predicted to meet the groundwater RAOs with respect to restoring groundwater within a *reasonable* timeframe (i.e., less than 100 years). Alternatives 2A/B and 3A/B are equivalently effective with respect to hydraulic containment of groundwater at the FMC Plant Site northern boundary. However, Alternative 3A/B is predicted to be only a marginally more effective than Alternative 2A/B (approximately 9 percent decrease in the areal extent of arsenic above the MCL and approximately 9 percent decrease in arsenic residual mass in groundwater beneath the FMC Plant Site after 100 years) but is over 2-times the cost. Consistent with EPA RI/FS guidance regarding screening to reduce the number of alternatives subject to detail analysis, Alternatives 3 A and B have been eliminated from further consideration and are not carried into the detailed analysis of alternatives. Alternative 0, although it fails all of the groundwater RAOs, will be carried forward because it is required by the NCP (EPA, 1988) and is used as the baseline for comparison of other alternatives.



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-1
ALTERNATIVE 2
SURFACE CONFIGURATION

FILE Fig 7-01_FMC_Soil Alt 2_709.mxd 11/11/09

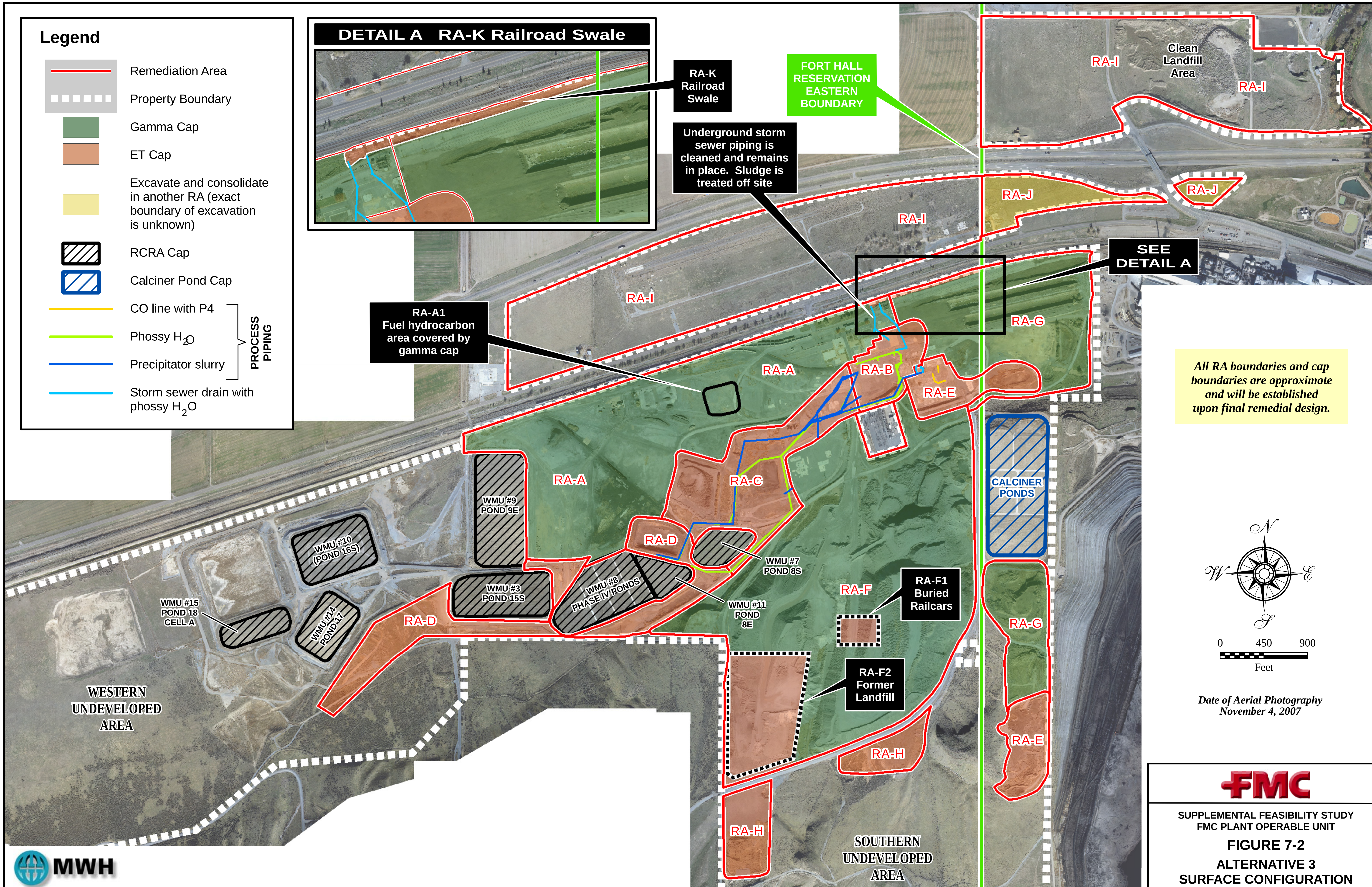
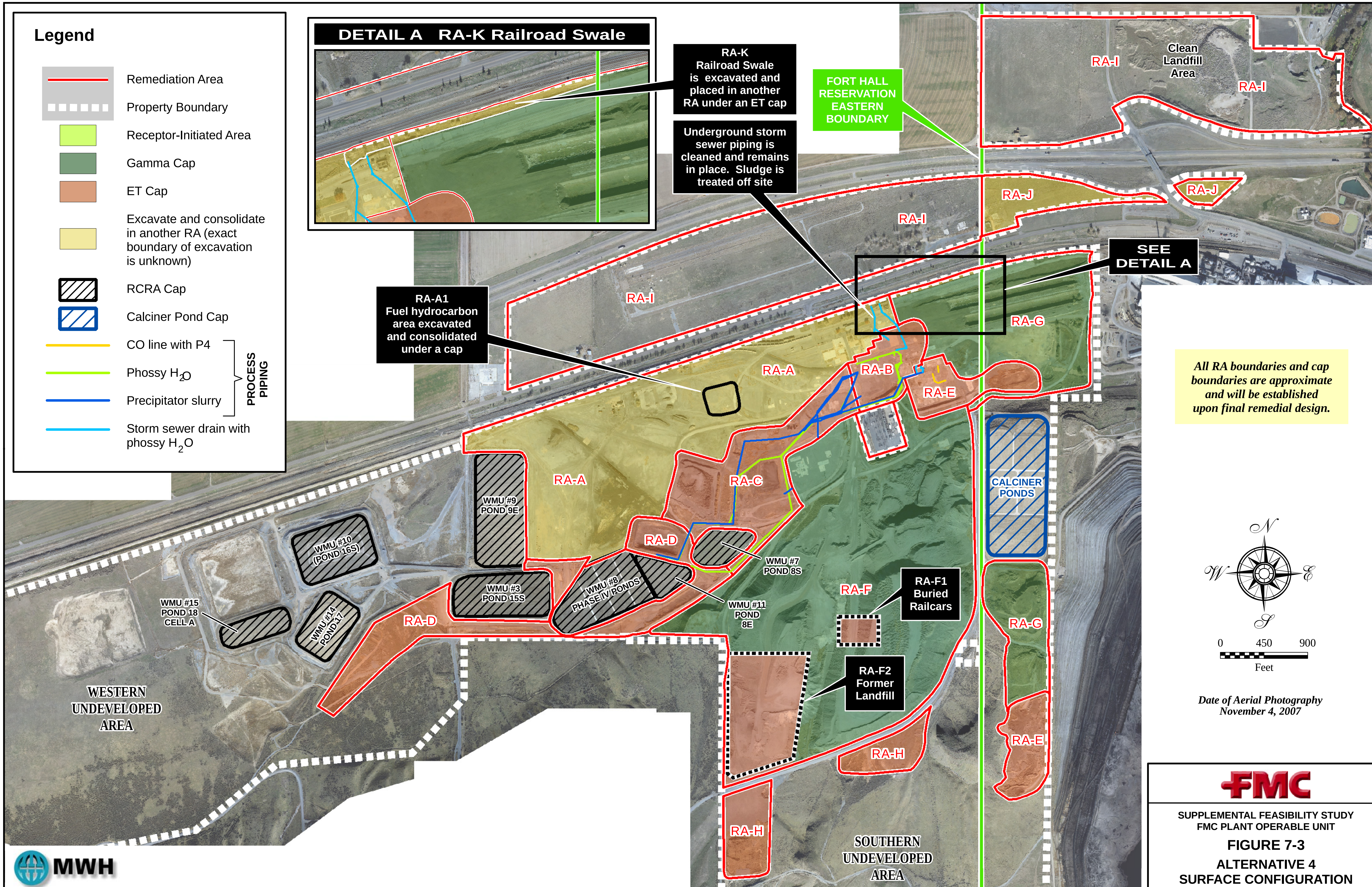
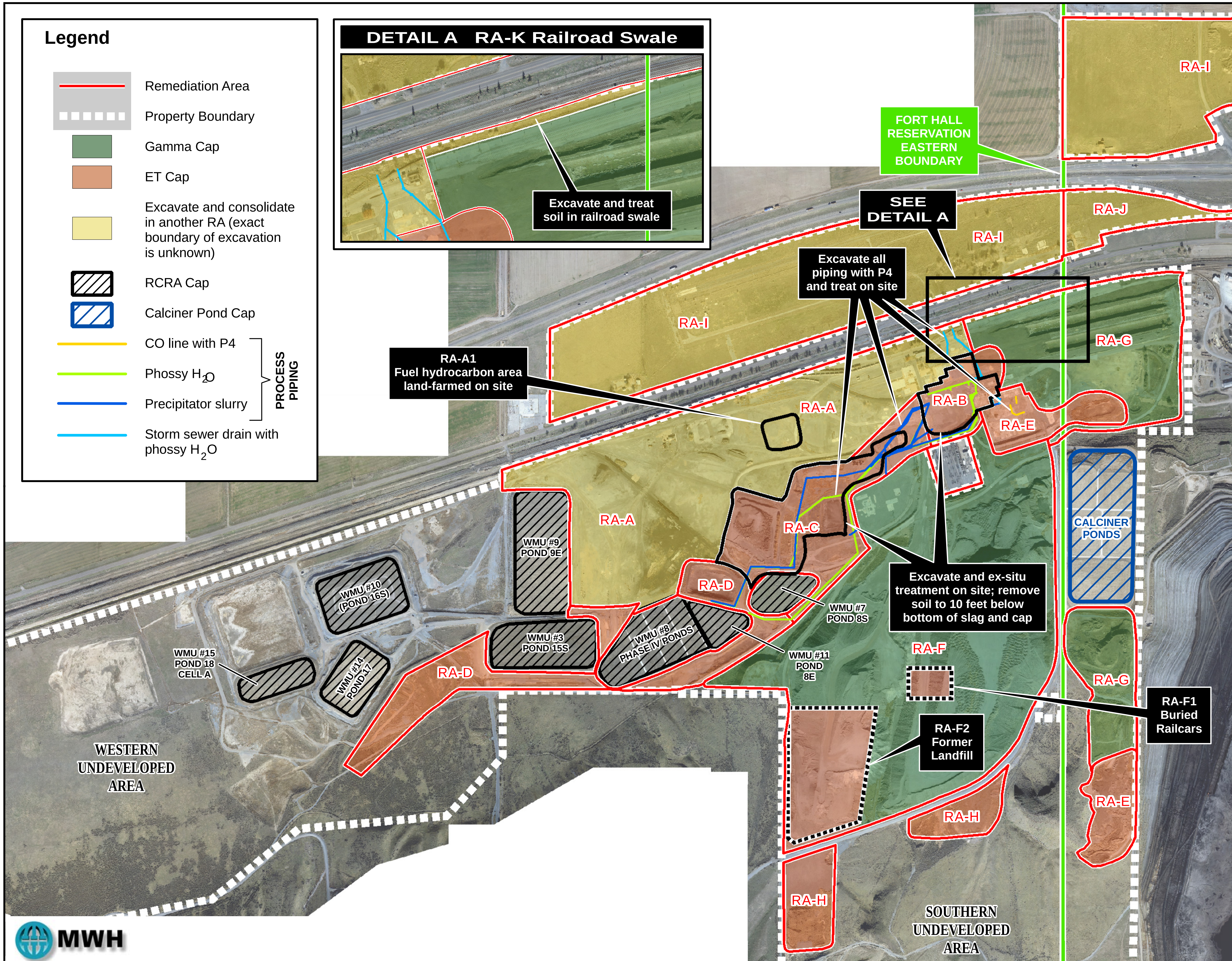


FIGURE 7-2
ALTERNATIVE 3
SURFACE CONFIGURATION

FILE Fig 7-02_FMC_Soil Alt 3_0210.mxd 2/24/10



FILE Fig 7-03_FMC_Soil Alt 4_0210.mxd 2/23/10

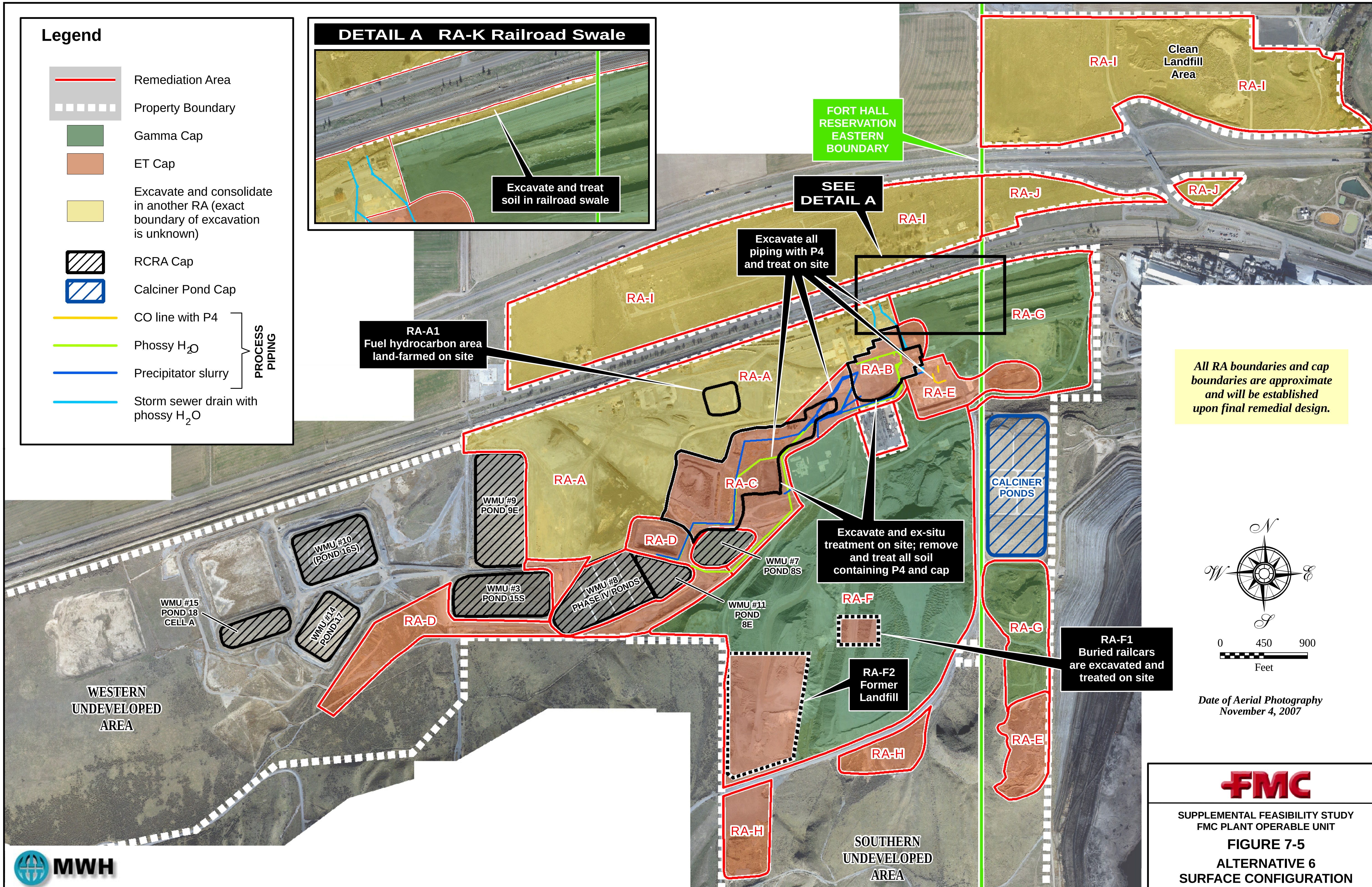


SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-4

ALTERNATIVE 5
SURFACE CONFIGURATION

FILE Fig 7-04_FMC_Soil Alt 5_1109.mxd 11/11/09

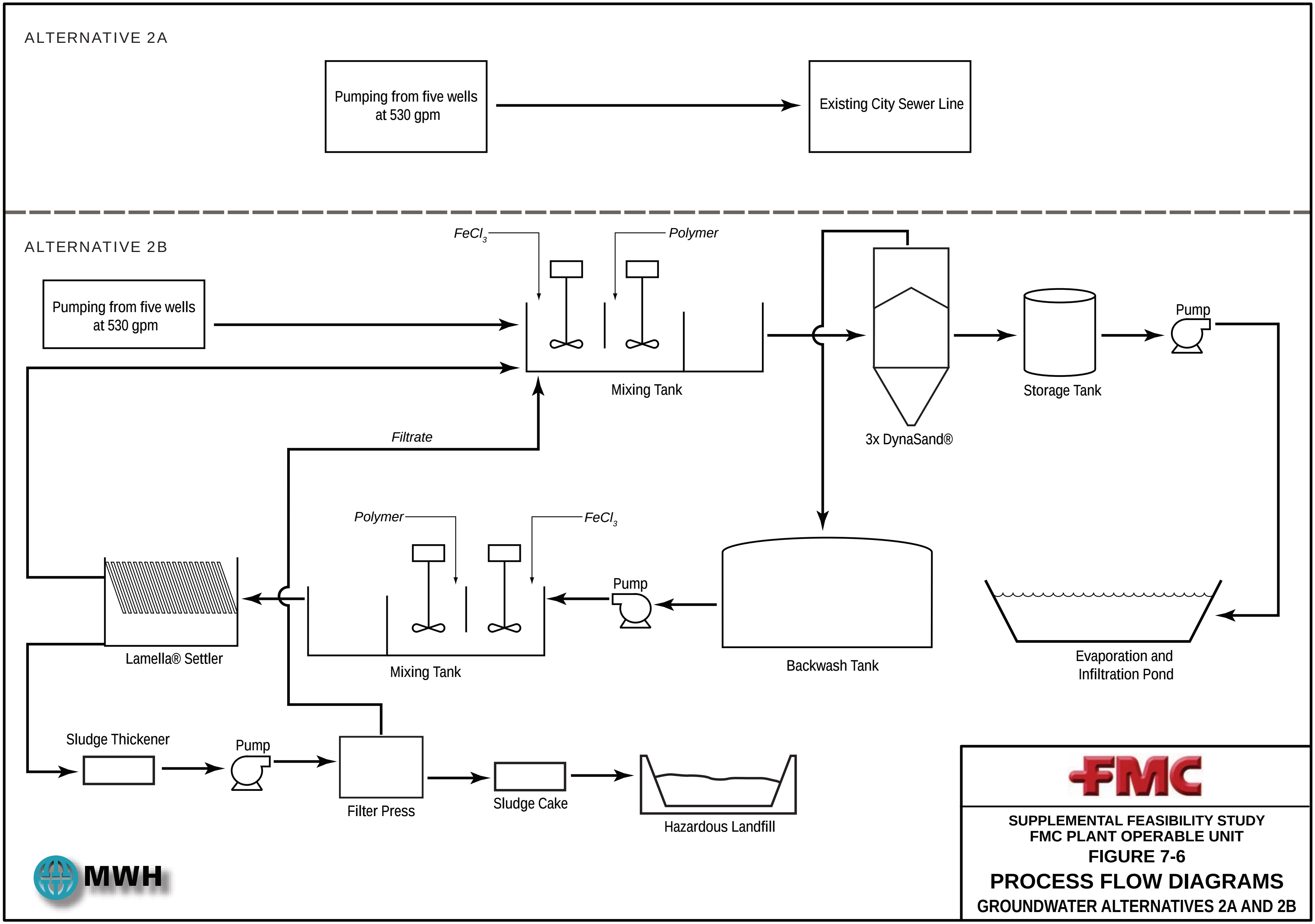


SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-5
ALTERNATIVE 6
SURFACE CONFIGURATION

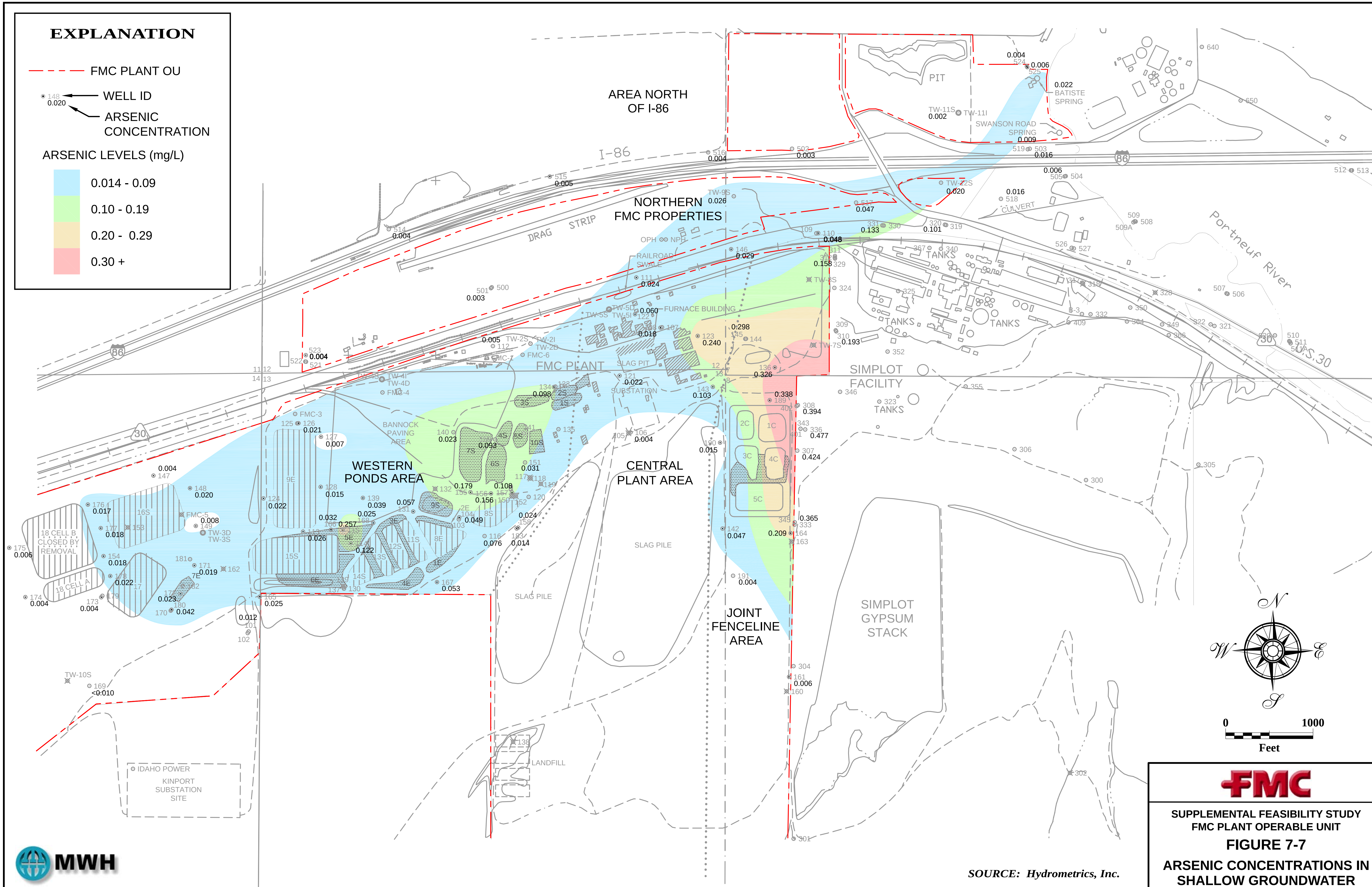
FILE Fig 7-05_FMC_Soil Alt 6_1109.mxd 11/11/09

FILE *Fig 7-06_Alt_2A_2B Schematic_1009.ai 10/30/09*



FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 7-6
PROCESS FLOW DIAGRAMS
GROUNDWATER ALTERNATIVES 2A AND 2B



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-7

ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER

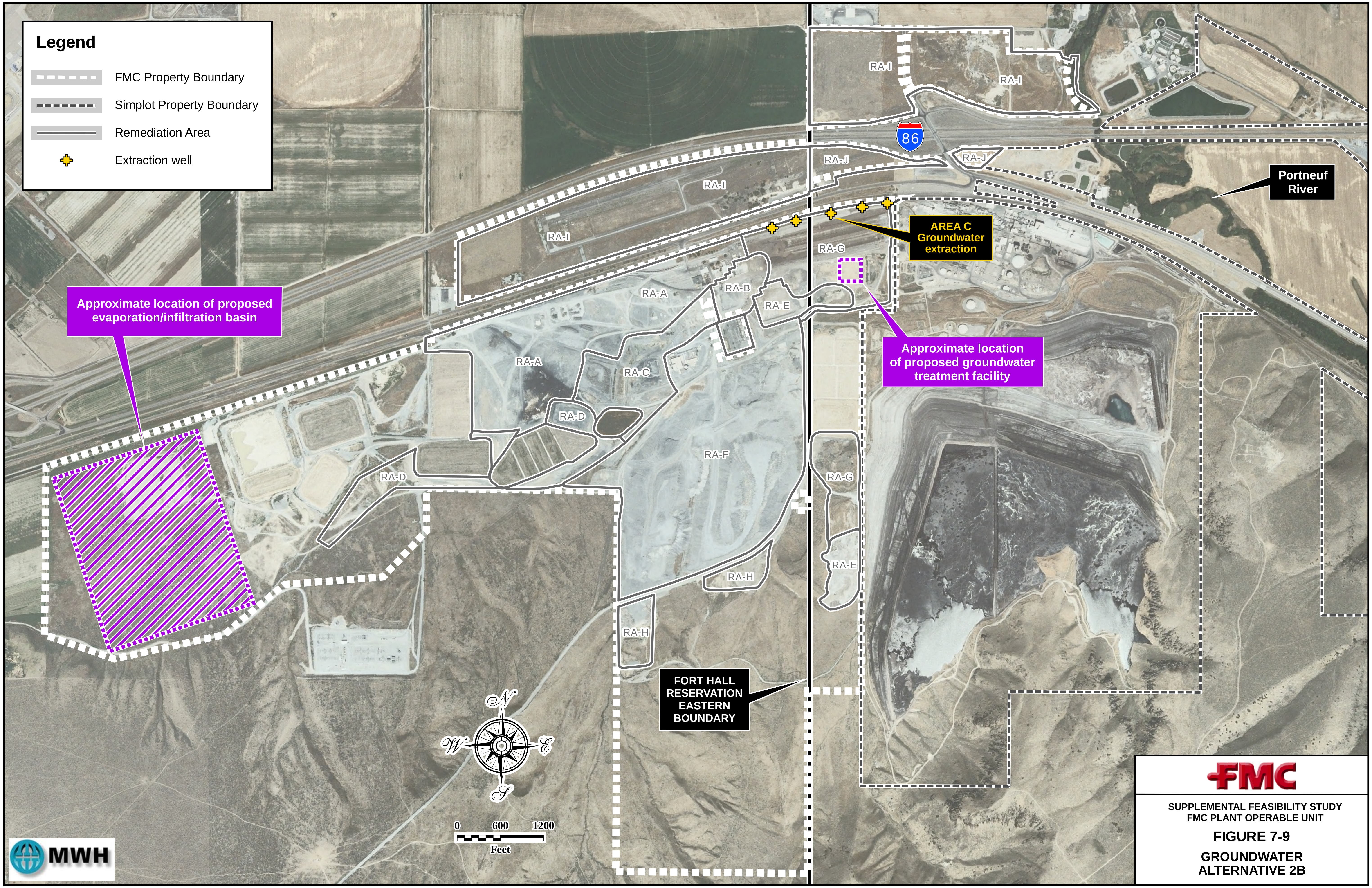
FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-8

GROUNDWATER ALTERNATIVE 2A

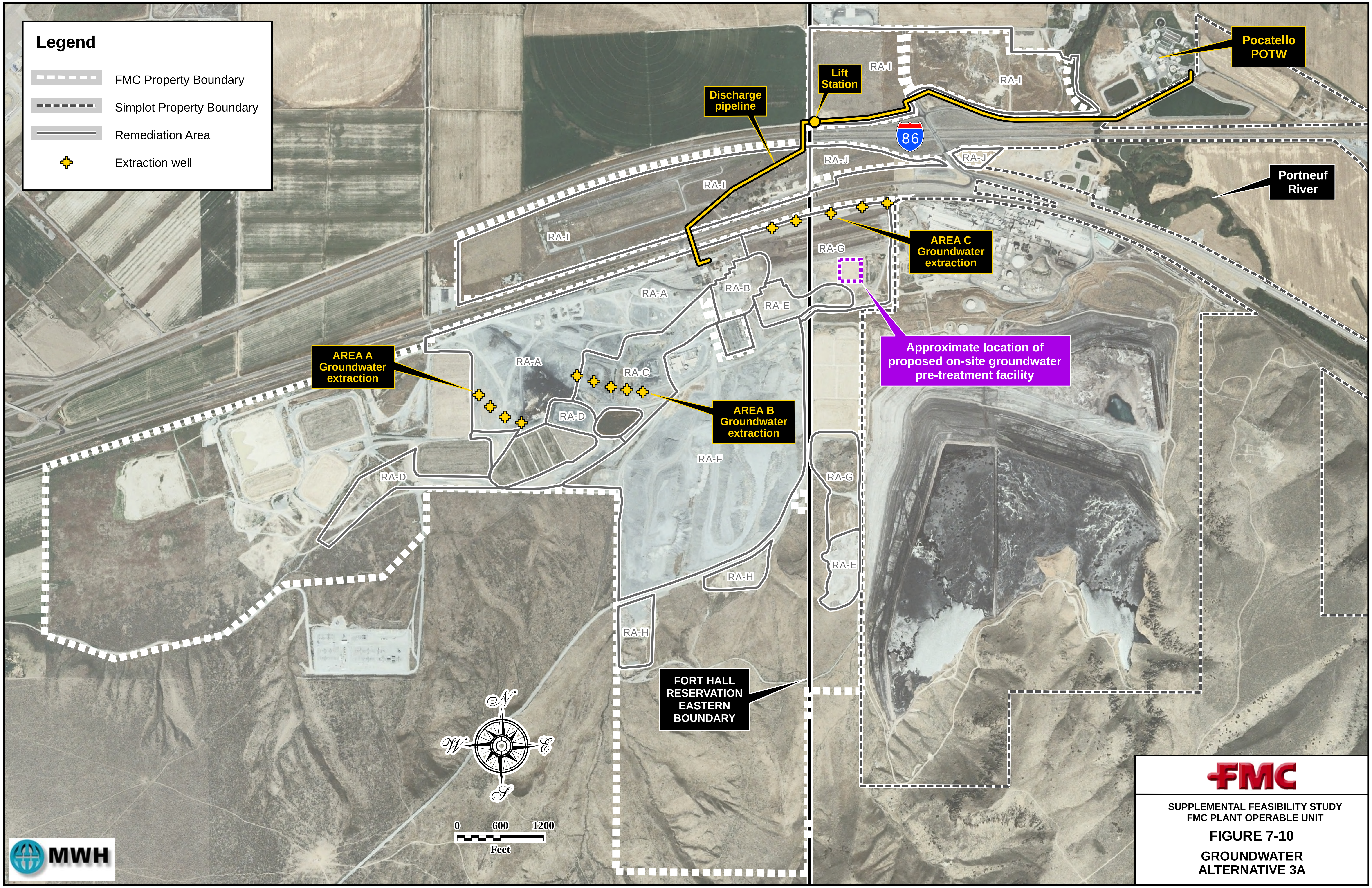
FILE Fig 7-08_FMC_GW Alt 2A_1109.mxd 11/11/09



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-9
GROUNDWATER ALTERNATIVE 2B

FILE Fig 7-09_FMC_GW Alt 2B_1109.mxd 11/11/09



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

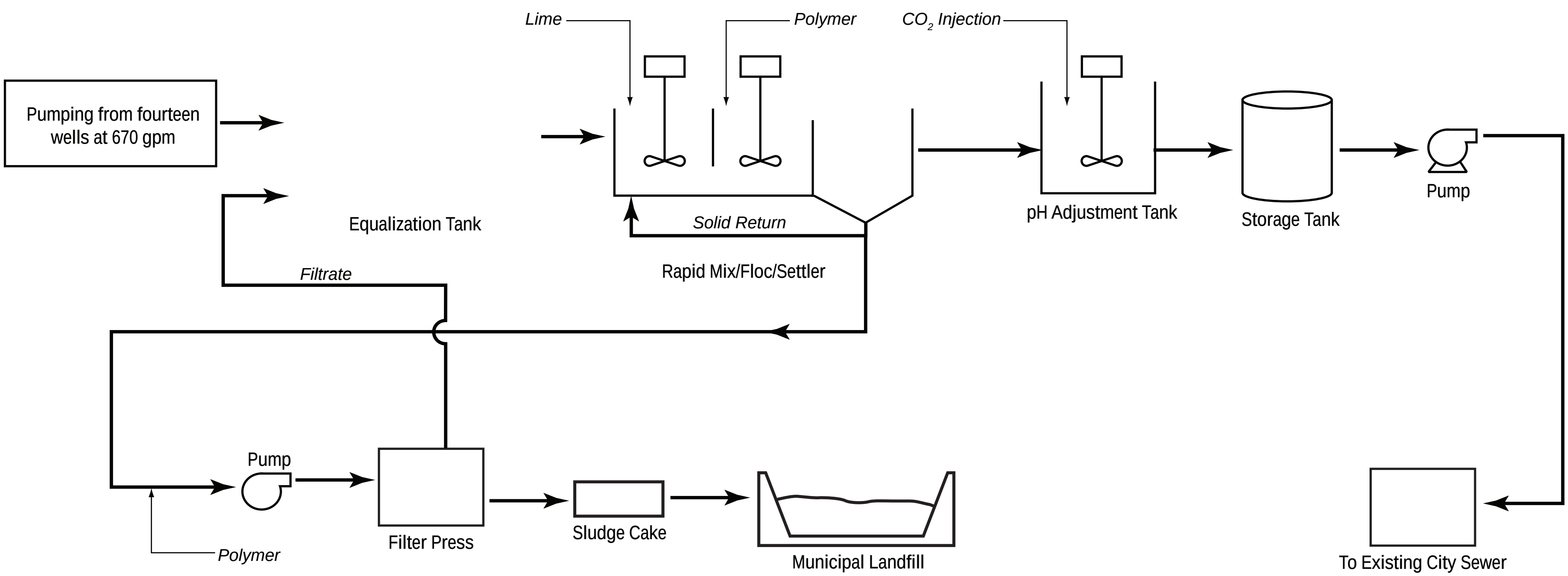
FIGURE 7-10

GROUNDWATER ALTERNATIVE 3A

FILE Fig 7-10_FMC_GW_Alt 3A_1109.mxd 11/11/09

FILE *Fig 7-11_Alt_3A Schematic_1009.ai 10/30/09*

ALTERNATIVE 3A



MWH

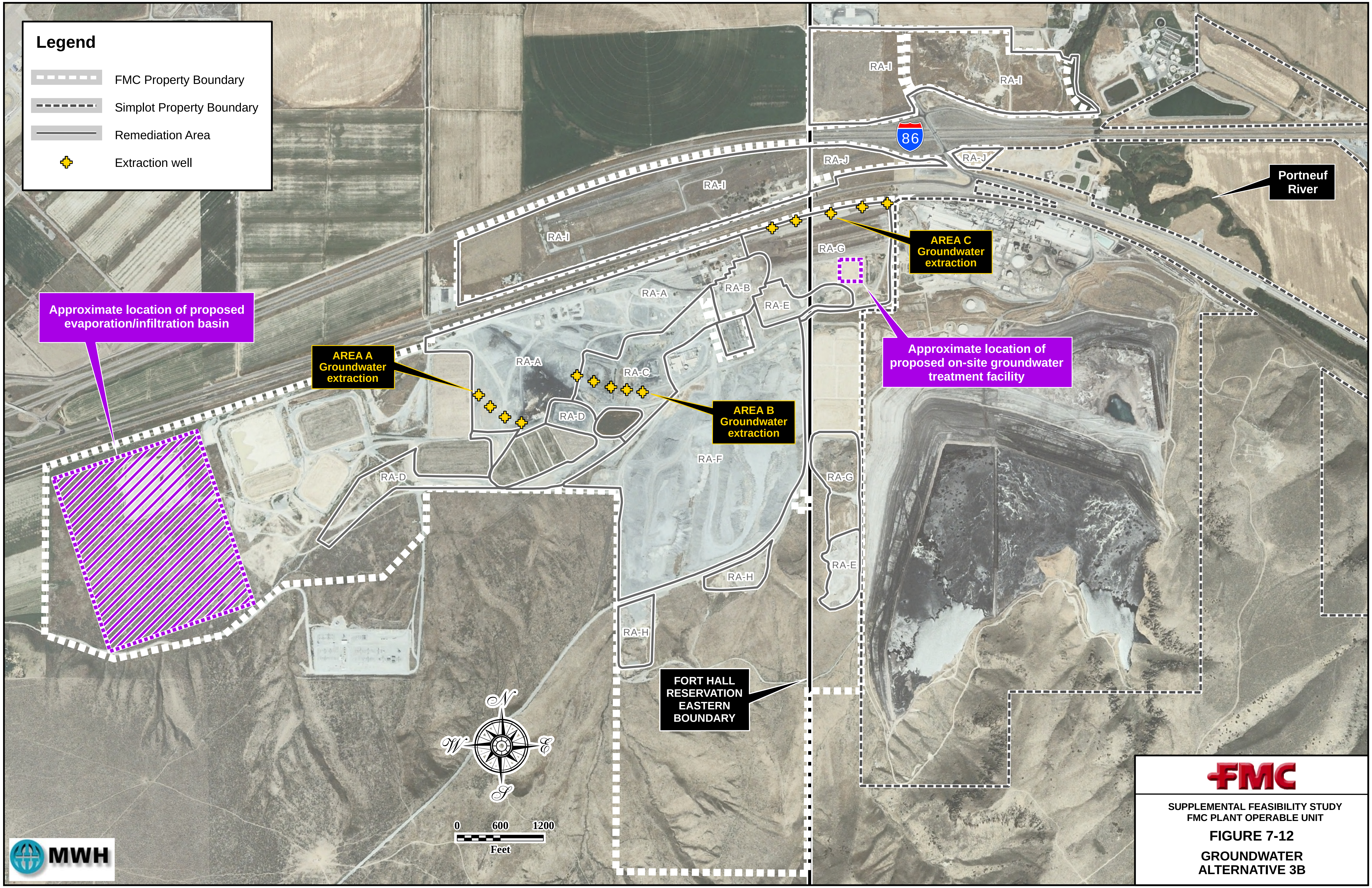
FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-11

PROCESS FLOW DIAGRAM

GROUNDWATER ALTERNATIVE 3A



SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

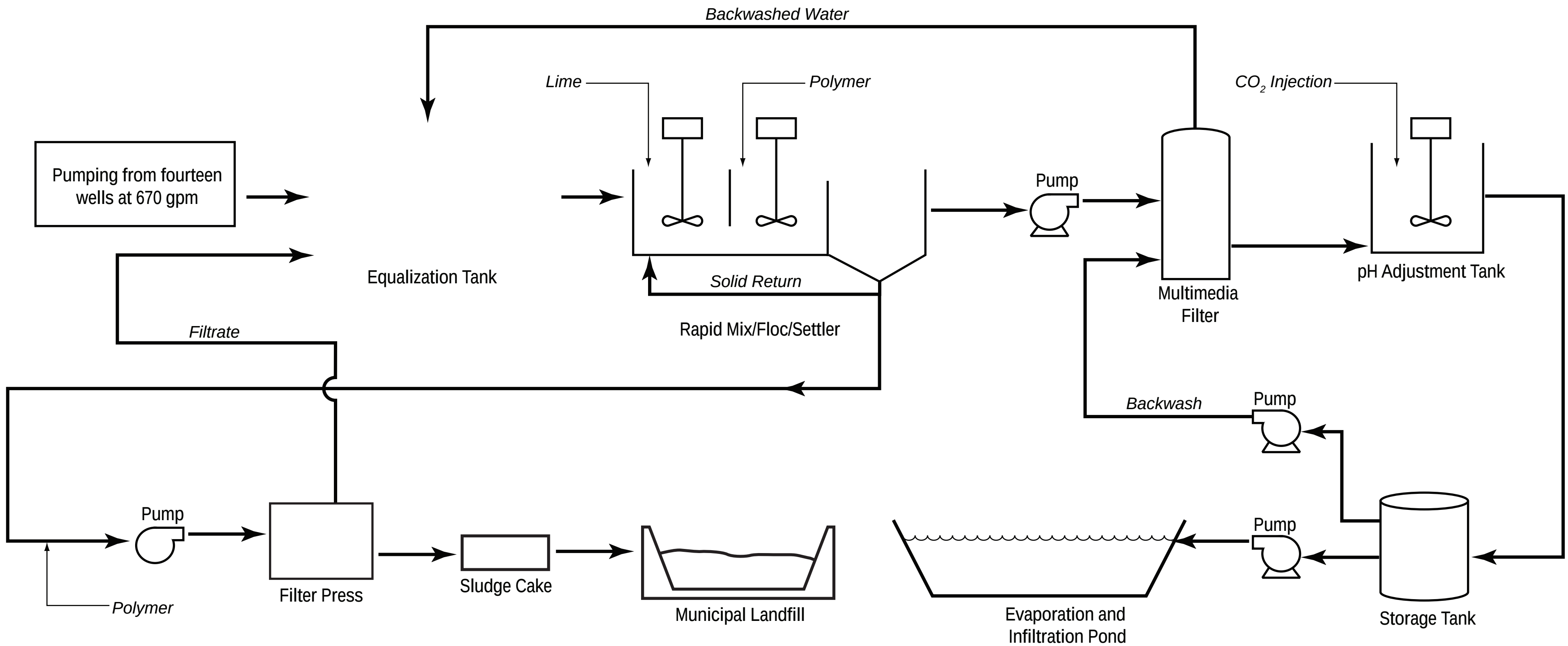
FIGURE 7-12

GROUNDWATER ALTERNATIVE 3B

FILE Fig 7-12_FMC_GW_Alt 3B_1109.mxd 11/11/09

FILE *Fig 7-13_Alt_3B Schematic_1009.ai 10/30/09*

ALTERNATIVE 3B



MWH

FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 7-13

PROCESS FLOW DIAGRAM

GROUNDWATER ALTERNATIVE 3B

TABLE 7-1a
SOIL TECHNOLOGIES USED FOR ASSEMBLY OF REMEDIAL ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT - FMC PLANT OU

General Response Action	Technologies/ Process Options Retained	Technology Selected for Use in an Assembled Alternative?	Explanation
No Action			
	No Action	Yes	Provides base case as required by the NCP.
Institutional Controls			
	Fencing	Yes	Used as a core element in conjunction with other process options (e.g., capping) to prevent site or area access.
	Landuse Restrictions	Yes	Used as a core element in conjunction with other process options (e.g., capping) to prevent future site activity that would be inconsistent with remedial action.
	Soil Management	Yes	Used as a core element in conjunction with other process options (e.g., capping) to prevent future site activity (e.g., digging, trenching, boring, etc.) that would re-distribute fill or contaminates creating new risk pathways.
Containment			
Capping	Multi-layered (Conventional) Cap	No	Not used as ET caps believed to be technically superior for covering all COCs where infiltration could potentially impact groundwater.
	Asphalt/Concrete Cap	Possibly for Receptor-Initiated Alternatives	Could be used in conjunction with core elements for areas where traffic or parking is required.
	Evapotranspirative (ET) Cap	Yes	Used in conjunction with core elements for areas containing any site COCs (including metals, radionuclides, P4, and gamma) where infiltration could potentially impact groundwater.
	Soil Cover Cap	Yes	Used in conjunction with core elements for areas gamma and direct exposure protection is required.
Surface Control	Soil Grading	Yes	Used as a core element across the site in all alternatives to control/manage stormwater runoff and erosion.

TABLE 7-1a
SOIL TECHNOLOGIES USED FOR ASSEMBLY OF REMEDIAL ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT - FMC PLANT OU

General Response Action	Technologies/ Process Options Retained	Technology Selected for Use in an Assembled Alternative?	Explanation
Surface Control - continued	Vegetation	Yes	Used as a core element for all capped areas or areas where soil remains on the surface.
Removal and Disposal (Reuse)			
Removal	Modified and Conventional Excavation	Yes	Used in alternatives where soil/fill and/or underground piping is removed for consolidation or on/off site treatment/disposal. Conventional excavation would be used in areas where P4 is absent. Modified excavation would be used in areas where P4 is suspected of being present.
Disposal	Consolidation and On-Site Disposal	Yes	Used in areas where soil/fill and/or underground piping is removed for consolidation and placement under an appropriate cap in another area on the site.
	Off-Site Disposal	Yes	Used in areas were small volumes of P4-contaminated wastes could be excavated, packaged in drums, and shipped off-site for incineration and disposal (e.g., RA-K, underground piping and clean-up residues).
Ex-Situ Treatment			
	Stabilization/ Solidification (S/S)	No	Not currently used in any of the alternatives.
	Caustic Hydrolysis	Yes	Used in alternatives where large volumes of P4-contaminated soil/fill are to be excavated for on-site treatment.
	Off-site Incineration	Yes	Used in alternatives where small volumes of P4-contaminated soil/fill/debris are to be excavated and shipped off-site for treatment.
	Landfarming	Yes	Used only for shallow, hydrocarbon-contaminated soils in alternatives where such soils are not otherwise under a cap or removed.
In-Situ Treatment			
	None Selected	No	None of the in-situ treatment options were considered superior to any of the selected ex-situ process options.

TABLE 7-1b
GROUNDWATER TECHNOLOGIES USED FOR ASSEMBLY OF REMEDIAL ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT - FMC PLANT OU

General Response Action	Technologies/ Process Options Retained	Technology Selected for Use in an Assembled Alternative?	Explanation
No Action			
	No Action	Yes	Provides base case as required by the NCP
Institutional Controls			
	Land and Groundwater Use Restrictions	Yes	Used as a core element to prevent future site activity that would be inconsistent with the remedial action.
	Groundwater Monitoring	Yes	Used as a core element to monitor effectiveness of selected groundwater remedial alternative.
Source Controls			
	Source Controls	Yes	Source controls will be used but will be included in soil remedial alternatives.
Containment			
	Extraction Wells	Yes	Used to remove groundwater from the shallow aquifer for any groundwater remedial alternative that requires extraction of groundwater followed by treatment and disposal.
Removal and Disposal (Reuse)			
Removal	Pumping	Yes	Used in conjunction with extraction wells to remove groundwater from the shallow aquifer for any groundwater remedial alternative that requires extraction of groundwater followed by treatment and disposal.
Disposal	Recycle/Reuse	Yes	Used in conjunction with pumping and treatment, recycle/reuse will be used if a full- or part-time demand is identified (e.g., used to establish and maintain vegetation on constructed caps).
	Evaporation/Infiltration Basin	Yes	Used in conjunction with pumping and treatment, may be used as an option for disposition of treated water.
	Publically owned treatment works	Yes	Used in conjunction with pumping and treatment, may be used as an option for disposition of treated water.

TABLE 7-1b
GROUNDWATER TECHNOLOGIES USED FOR ASSEMBLY OF REMEDIAL ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT - FMC PLANT OU

General Response Action	Technologies/ Process Options Retained	Technology Selected for Use in an Assembled Alternative?	Explanation
Ex-Situ Treatment			
	Solid/Water Separation	Yes	Used in conjunction with pumping and treatment, may be used as a component of a treatment system.
	Filtration	Yes	Used in conjunction with pumping and treatment, may be used as a component of a treatment system.
	Adsorption	Yes	Used in conjunction with pumping and treatment, may be used as a component of a treatment system.
	Chemical Precipitation	Yes	Used in conjunction with pumping and treatment, may be used as a component of a treatment system.
	Oxidation/Reduction	Yes	Used in conjunction with pumping and treatment, may be used as a component in the overall groundwater treatment process.
In-Situ Treatment			
	None Selected		None of the in-situ treatment options were considered superior to any of the selected ex-situ process options.

RA Name	Site-Specific Decision Criteria			Technologies or Process Options							Assembled Alternatives[1]				
	Identified Source of Constituents in GW	Area Contains P4	Area is a Gamma Risk	Core Elements[2]	Receptor-Initiated Remediation	Gamma Cap	ET Cap	Excavate and Treat Offsite	Excavate and Treat On-site	Excavate and Consolidate	Soil Alternative 2	Soil Alternative 3	Soil Alternative 4	Soil Alternative 5	Soil Alternative 6
RA-A	No	No	Yes	X	X	X				X	Receptor-Initiated Remediation	Gamma Cap	Excavate and Consolidate[3]	Excavate and Consolidate[3]	Excavate and Consolidate[3]
RA-A1 (Fuel Hydrocarbon Area)	No	No	No[4]	X	X	X		O	X	X	Receptor-Initiated Remediation	Gamma Cap	Excavate and Consolidate	Excavate and Treat On-site[5]	Excavate and Treat On-site[5]
RA-B	Yes	Yes	Yes	X		O	X	O	X		ET Cap	ET Cap	ET Cap	Excavate and Treat On-site, then ET Cap[6, 7]	Excavate and Treat On-site, then ET Cap[6, 8]
RA-C	Yes	Yes	Yes	X		O	X		X		ET Cap	ET Cap	ET Cap	Excavate and Treat On-site, then ET Cap[6, 7]	Excavate and Treat On-site, then ET Cap[6, 8]
RA-D	Yes	Yes[9]	Yes	X		O	X				ET Cap	ET Cap	ET Cap	ET Cap	ET Cap
RA-E	Yes	No	Yes	X		O	X				ET Cap	ET Cap	ET Cap	ET Cap	ET Cap
RA-F	No	No	Yes	X		X					Gamma Cap	Gamma Cap	Gamma Cap	Gamma Cap	Gamma Cap
RA-F1 (Buried Railcars)	No[10]	Yes	No[4]	X		X	X	O	X		Gamma Cap	ET Cap	ET Cap	ET Cap	Excavate and Treat On-site then ET Cap [6, 8]
RA-F2 (Former Landfill)	No[10]	No	No[4]	X		X	X				Gamma Cap	ET Cap	ET Cap	ET Cap	ET Cap
RA-G	No	No	Yes	X	X	X	O				Receptor-Initiated Remediation	Gamma Cap	Gamma Cap	Gamma Cap	Gamma Cap
RA-H	No[10]	No	Yes	X		O	X				ET Cap	ET Cap	ET Cap	ET Cap	ET Cap
RA-I	No	No	Only hypothetical resident	X	X					X	Core Elements	Core Elements	Core Elements	Excavate and Consolidate[11]	Excavate and Consolidate[11]
RA-J	No	No	Yes	X	X	O				X	Receptor-Initiated Remediation	Excavate and Consolidate[12]	Excavate and Consolidate[12]	Excavate and Consolidate[11]	Excavate and Consolidate[11]
RA-K (Railroad Swale)	No[10]	Yes	Yes	X		O	X		X	X	ET Cap	ET Cap	Excavate and Consolidate within AOC	Excavate and Treat On-site[6]	Excavate and Treat On-site[6]
UG Piping – Storm Sewer	No[10]	Yes	No[4]	X				X	X		Clean In Place and Treat Offsite[13]	Clean In Place and Treat Offsite[13]	Clean In Place and Treat Offsite[13]	Excavate and Treat On-site[6]	Excavate and Treat On-site[6]
UG Piping – Process Piping	No[10]	Yes	No[4]	X			X	X	X		ET Cap	ET Cap	ET Cap	Excavate and Treat On-site[6]	Excavate and Treat On-site[6]

Notes

Regarding Site-Specific Decision Criteria:

- √ if the RA was found to be a source of constituents to Groundwater (GW), then technologies and process options focus on those that mitigate the threat to GW including ET caps or direct treatment options.
- √ if the RA contains P4 within 10 feet of the ground surface it is considered a potential risk for direct contact with the containment option limited to ET caps and the treatment options include on and offsite treatment.
- √ if the RA presents only a gamma risk, then applicable technologies and process options are limited to receptor-initiated remediation or a gamma cap. These areas also can be remediated by excavation and consolidation of the waste in another RA with the appropriate cover system.

"O" indicates a technology or process option that was considered for the RA, but because of site-specific criteria above was not included in the assembled alternatives, as discussed in the body of the SFS Report in this section.

[1] Alternative 1 is the "No Action" Alternative in accordance with NCP requirements.

[2] Core elements are common to each alternative and include: Institutional Controls; Soil/Fill Management; Cap Integration, Monitoring, and Maintenance; Stormwater Management; Fugitive Dust Control; Groundwater Monitoring; and Ancillary P4 Treatment Processes and Issues as discussed in the *Interim Deliverable -Assembled Soil Alternatives for the FMC Plant Operable Unit* (MWH, 2009). Core elements are necessary components of any site remedy and must be considered in association with selected technologies and process options at each RA.

[3] The total area of "Excavation and Consolidation" within RA-A will be dependent on the final grading plan, storm water management design, and fill depth. Any material excavated and removed will be placed under a cap that is protective for gamma radiation.

[4] This RA has gamma radiation associated with surrounding fill materials (e.g., slag), but not in the materials uniquely described in this sub-area.

[5] On-site Treatment for the fuel hydrocarbon area would involve landfarming of soils containing hydrocarbons.

[6] On-site Treatment for P4 areas assumes the treatment process would be caustic hydrolysis.

[7] Following excavation and treatment of the upper 10 feet of soils containing P4 in this RA, the area would be covered with an ET Cap because of the P4 and other COCs that will remain in place below the excavation zone and may present a threat to GW.

[8] This alternative includes excavation and treatment of all soils containing P4 including those RAs where P4 is present at depths greater than 10 feet below ground surface. The area would be covered with an ET Cap because of other COCs that will remain in place as backfill and/or below the excavation zone that may present a threat to GW.

[9] RA-D is not known to contain P4 other than in underground piping, however, it was so noted with a "yes" at the request of EPA.

[10] Since an actual threat to GW has not been identified, the GW RAO is not applicable; however, the SFS will consider a potential threat from this area

[11] Excavation in this case is to 12 inches below ground surface. Samples will be collected from the underlying soil to verify that preliminary remediation goals (PRGs) for future residents have been met (Table 4-5 in SFS Report).

[12] Excavation in this case is to 6 inches below ground surface. Samples will be collected from the underlying soil to verify that preliminary remediation goals (PRGs) for future site workers have been met (Table 4-4 in SFS Report).

[13] " Excavation and Treatment Offsite" in this case includes cleaning the storm sewer piping in place and treating the removed residues which contain P4 in an offsite incinerator.

TABLE 7-3
ASSEMBLED SOIL REMEDIATION ALTERNATIVES, INITIAL SCREENING, AND SELECTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Alternative Name/ Number	Soil Alternative Description (Refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Selected for Detailed Analysis (YES/NO)
Soil Alternative 1 – No Action	The No Action Soil Alternative is a requirement of the National Contingency Plan (NCP; EPA, 1988) and must be considered in the CERCLA FS process. This alternative is a baseline to which all other alternatives are compared. It will be retained for comparison to other alternatives throughout the remainder of the FS process. For the FMC Plant OU, this alternative would represent the status quo. However, no long-term CERCLA groundwater monitoring (as is currently conducted voluntarily by FMC) would be performed. The institutional controls that are currently in place would remain in place. This alternative would not meet the site RAOs because it would not address any of the exposure pathways listed in Table 4-3.	Protective of Human Health and the Environment? Low Reduces Toxicity, Mobility, or Volume? Low Short Term Effectiveness: Low Long-Term Effectiveness: Low	Administrative Feasibility: High Technical Implementability: High	($0)	YES
Soil Alternative 2 *(Refer to Figure 7-1 and Section 7.3.2)*	Core elements are common to all the RAs in this remedy. Under this alternative, the following remedial actions would take place at these RAs. Core Elements: RA-I Receptor Initiated Remediation: RA-A RA-G RA-A1 RA-J Soil Cover (Gamma) Cap: RA-F RA-F1 RA-F2 ET Cap: RA-B RA-C RA-D RA-E RA-H RA-K Underground process piping Excavate and Treatment Offsite: Underground storm sewer piping would be cleaned in place and the residues would be shipped offsite for incineration. Excavate and Treatment On site: NA Excavate and Consolidate: NA Construction Complete: An estimated 1 to 2 years from commencement to completion of construction.	Protective of Human Health and the Environment? Moderate to High Reduces Toxicity, Mobility, or Volume? Moderate Short Term Effectiveness: Moderate to High Long-Term Effectiveness: High	Administrative Feasibility: High Technical Implementability: High	($32.7M)	YES

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

TABLE 7-3
ASSEMBLED SOIL REMEDIATION ALTERNATIVES, INITIAL SCREENING, AND SELECTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Alternative Name/ Number	Soil Alternative Description (Refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Selected for Detailed Analysis (YES/NO)
Soil Alternative 3 *(Figure 7-2 and Section 7.3.3.)*	Core elements are common to all the RAs in this remedy. Under this alternative, the following remedial actions would take place at these RAs. Core Elements: RA-I Receptor Initiated Remediation: NA Soil Cover (Gamma) Cap: RA-A RA-A1 RA-F RA-G ET Cap: RA-B RA-C RA-D RA-E RA-F1 RA-F2 RA-H RA-K Underground process piping Excavate and Treatment Offsite: Underground storm sewer piping would be cleaned in place and the residues would be shipped offsite for incineration. Excavate and Treatment On site: NA Excavate and Consolidate: RA-J Construction Complete: An estimated 2 to 3 years from commencement to completion of construction.	Protective of Human Health and the Environment? High Reduces Toxicity, Mobility, or Volume? Moderate Short Term Effectiveness: High Long-Term Effectiveness: High	Administrative Feasibility: High Technical Implementability: High	($47.2M)	YES

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

Alternative Name/ Number	Soil Alternative Description (Refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Selected for Detailed Analysis (YES/NO)
Soil Alternative 4 *(Refer to Figure 7-3 and Section 7.3.4)*	Core elements are common to all the RAs in this remedy. Under this alternative, the following remedial actions would take place at these RAs. Core Elements: RA-I Receptor Initiated Remediation: NA Soil Cover (Gamma) Cap: RA-F RA-G ET Cap: RA-B RA-C RA-D RA-E RA-F1 RA-F2 RA-H Underground process piping Excavate and Treatment Offsite: Underground storm sewer piping would be cleaned in place and the residues would be shipped offsite for incineration. Underground Process Piping not otherwise under an ET cap would be excavated, containerized and treated at an offsite incinerator. Excavate and Treatment On site: NA Excavate and Consolidate: RA-A RA-A1 RA-J RA-K Construction Complete: An estimated 2 to 4 years from commencement to completion of construction.	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Moderate Short Term Effectiveness: Moderate Long-Term Effectiveness: High	Administrative Feasibility: Moderate Technical Implementability: Moderate	($81.6M)	YES

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

Alternative Name/ Number	Soil Alternative Description (Refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Selected for Detailed Analysis (YES/NO)
Soil Alternative 5 *(Refer to Figure 7-4 and Section 7.3.5)*	Core elements are common to all the RAs in this remedy. Under this alternative, the following remedial actions would take place at these RAs. Core Elements: NA Receptor Initiated Remediation: NA Soil Cover (Gamma) Cap: RA-F RA-G ET Cap: RA-B (following treatment) RA-C (following treatment) RA-D RA-E RA-F1 RA-F2 RA-H Excavate and Treatment Offsite: NA Excavate and Treatment On site: RA-A1 RA-B RA-C RA-K Underground storm sewer piping Underground Process Piping Excavate and Consolidate: RA-A RA-J RA-K Construction Complete: Is estimated to require 20 to 25 years for soil excavation, on-site treatment and capping in order to complete the construction portion of this remedial action.	Protective of Human Health and the Environment? Low Reduces Toxicity, Mobility, or Volume? Moderate Short Term Effectiveness: Low Long-Term Effectiveness: High	Administrative Feasibility: Low Technical Implementability: Low	($405.1M)	NO

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

TABLE 7-3
ASSEMBLED SOIL REMEDIATION ALTERNATIVES, INITIAL SCREENING, AND SELECTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Alternative Name/ Number	Soil Alternative Description (Refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Selected for Detailed Analysis (YES/NO)
Soil Alternative 6 *(Refer to Figure 7-5and Section 7.3.6)*	Core elements are common to all the RAs in this remedy. Under this alternative, the following remedial actions would take place at these RAs. Core Elements: NA Receptor Initiated Remediation: NA Soil Cover (Gamma) Cap: RA-F RA-G ET Cap: RA-B (following treatment) RA-C (following treatment) RA-D RA-E RA-F1 (following treatment) RA-F2 RA-H Excavate and Treatment Offsite: Excavate and Treatment On site: (excavation would not be limited to 10 vertical feet into P4 contaminated soils) RA-A1 RA-B RA-C RA-F1 RA-K Underground storm sewer piping Underground Process Piping Excavate and Consolidate: NA RA-A RA-J RA-K Construction Complete: Is estimated to require 30 to 40 years for soil excavation, on-site treatment and capping in order to complete the construction portion of this remedial action.	Protective of Human Health and the Environment? Low Reduces Toxicity, Mobility, or Volume? Moderate Short Term Effectiveness: Low Long-Term Effectiveness: High	Administrative Feasibility: Low Technical Implementability: Low	(>$450M)	NO

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

TABLE 7-4

ALTERNATIVE 2A EXTRACTED GROUNDWATER ESTIMATED AVERAGE CONCENTRATIONS VS. POTW INFLUENT CRITERIA
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
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PARAMETER	WELL-110	WELL-146	TW-9S	Average Concentration of Constituent in Groundwater	Pocatello POTW Influent Standards
Sampling Event Date	4thQ2006 thru 2ndQ2008	4thQ2006 thru 2ndQ2008	4thQ2006 thru 2ndQ2008		
Field Measurments					
Depth to Water (Feet)	66.2	69.6	64.8	**66.9**	**NA**
pH (Field)	6.86	7.11	7.06	**7.01**	**6.0-10.0**
SC (UMHOS/CM)	1429	1294	1842	**1521.7**	**NA**
Redox (mV)	-100	-100	-100	**-100.0**	**NA**
Turbidity (NTU)	0.4	0.35	8	**2.9**	**NA**
Water Temperature (C)	17.1	16.9	14.4	**16.1**	**NA**
General WQP (mg/L)					
Potassium	25.4	46.3	58.4	**43.4**	**NA**
Sulfate	215	128	161	**168.0**	**NA**
Chloride	89.8	132	187	**136.3**	**NA**
Fluoride	0.44	0.38	0.10	**0.30**	**32.0**
Ammonia	0.15	0.15	0.2	**0.17**	**NA**
Nitrate	3.8	6.13	9.95	**6.63**	**NA**
Orthophosphate/ Total Phosphorus	3.09	1.33	3.21	**2.54**	**7.0**
Metals (mg/L)					
Arsenic	0.048	0.029	0.027	**0.03**	**0.06**
Cadmium	ND	ND	ND	**0.00**	**0.2**
Copper[1]	0.0015	<0.025	0.0011	**0.00**	
Cyanide[1]	NA		NA		**0.2**
Flouride[1]	0.44	0.5	0.07	**0.34**	**32.0**
Lead[1]	<0.003	<0.003	<0.003	**0.00**	**0.3**
Mercury[1]	<0.0002	<0.0002	<0.0002	**<0.0002**	**0.0006**
Nickel[1]	<0.04	<0.04	<0.04	**<0.04**	**1**
Silver[1]	<0.005	<0.005	<0.005	**<0.005**	**0.6**
Selenium	0.029	0.003	0.005	**0.012**	**NA**
Zinc[1]	0.00036	0.0024	0.00037	**0.001**	**1.2**

[1] - Results from November 2001 Special Groundwater sampling event.
NA-Not Analyzed
ND- Not Detected

TABLE 7-5

ALTERNATIVE 3A CONCENTRATION OF CONSTITUENTS BY PUMPED AREA AND TOTAL CONCENTRATION OF ARSENIC/ PHOSPHORUS IN COMBINED GROUNDWATER
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	AREA A - Former Phossy Ponds				AREA B-Former Pond 8S				AREA C - Joint fenceline			
Parameters	**WELL-114**	**WELL-115**	**WELL-139**	**Average Ex-Area A**	**WELL-155**	**WELL-156**	**WELL-157**	**Average Ex-Area B**	**WELL-110**	**WELL-146**	**TW-9S**	**Average Ex-Area C**
Field Measurments												
Depth to Water (Feet)	74.3	73.6	71.8	**73.2**	95.1	98.4	106	**99.8**	66.2	69.6	64.8	**66.9**
pH (Field)	7.17	7.24	6.92	**7.11**	7.32	7.15	6.92	**7.13**	6.86	7.11	7.06	**7.01**
SC (UMHOS/CM)	1647	2198	4643	**2829.3**	2506	6331	2941	**3926.0**	1429	1294	1842	**1521.7**
Redox (mV)	0	0	60	**20**	-50	-100	-100	**-83**	-100	-100	-100	**-100**
Turbidity (NTU)	0.543	0.457	0.45	**0.5**	0.657	0.886	0.457	**0.7**	0.4	0.35	8	**2.9**
Water Temperature (C)	11.1	11.5	12.8	**11.8**	14.6	15.4	16	**15.3**	17.1	16.9	14.4	**16.1**
General WQP (mg/L)												
Potassium	23.5	12.3	38.5	**24.8**	473	1305	325	**701.0**	25.4	46.3	58.4	**43.4**
Sulfate	112	176	1051	**446.3**	209	221	212	**214.0**	215	128	161	**168.0**
Chloride	143	153	886	**394.0**	197	348	213	**252.7**	89.8	132	187	**136.3**
Fluoride	0.866	0.23	0.583	**0.56**	0.125	0.105	0.456	**0.23**	0.44	0.38	0.10	**0.30**
Ammonia	1.51	0.175	0.175	**0.62**	0.171	13.9	2.36	**5.48**	0.15	0.15	0.2	**0.17**
Nitrate	0.095	22.7	35.5	**19.43**	2.92	0.086	0.228	**1.08**	3.8	6.13	9.95	**6.63**
Orthophosphate/ Total Phosphorus	2.71	2.13	0.74	**1.9**	39.39	278.00	117.03	**144.8**	3.09	1.33	3.21	**2.5**
Metals (mg/L)												
Arsenic	0.122	0.257	0.039	**0.139**	0.179	0.156	0.108	**0.148**	0.048	0.029	0.027	**0.035**
Selenium	0.01	0.011	0.038	**0.020**	0.007	0.004	0.011	**0.007**	0.029	0.003	0.005	**0.012**

	Average Conc (mg/L)	Extraction Rate (GPM)	Extraction Rate (liters/min)	Total milligrams of P (mg/min)	Total milligrams of As (mg/min)	Conc of P (mg/L)	Conc of As (mg/L)
Area A							
Total P	1.9	60.00	227.10	431.49			
Arsenic	0.139				31.57		
Area B							
Total P	144.8	90.00	340.65	49,326.12			
Arsenic	0.148				50.42		
Area C							
Total P	2.54	520.00	1,968.20	4,999.23			
Arsenic	0.035				68.89		
Totals		670.00	2,535.95	54,756.84	150.87	**21.59**	**0.06**

TABLE 7-6
ASSEMBLED GROUNDWATER REMEDIATION ALTERNATIVES, INITIAL SCREENING, AND SELECTION
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FMC Corporation, Pocatello, Idaho

Alternative Name/ Number	Groundwater Alternative Description (please refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Select for Detailed Analysis (YES/ NO)
Groundwater Alternative 0 – No Action *(Refer Section 7.5.1)*	Groundwater Alternative 1 - the "No Action" alternative is a requirement of the National Contingency Plan (NCP; EPA, 1988) and must be considered in the CERCLA FS process. This alternative is a baseline to which all other alternatives are compared. It will be retained for comparison to other groundwater alternatives throughout the remainder of the FS process. For the FMC Plant OU, no long-term CERCLA groundwater monitoring (as is currently conducted voluntarily by FMC) would be performed. The institutional controls that are currently in place would remain in place. This alternative would not meet the site RAOs because it would not address any of the exposure pathways listed in Table 4-3.	Protective of Human Health and the Environment? Low Reduces Toxicity, Mobility, or Volume? Low Short Term Effectiveness: Low Long-Term Effectiveness: Low	Administrative Feasibility: High Technical Implementability: High	(None)	YES
Groundwater Alternative 1 – Source Controls, Institutional Controls, and Long-Term Monitoring *(Refer Section 7.5.2)*	This alternative includes the following general response actions for groundwater remediation. • Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, • Institutional Controls: o Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, o Long-term groundwater monitoring (LTM) would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls (monitored natural attenuation). Remedial Action Complete: The groundwater modeling predicts that pumping and treatment of COCs won't appreciably reduce the toxicity and volume of COCs in groundwater below the remedial action benchmarks for more than 100 years. The modeling predicts Alternative 1 will reduce the extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) by 26 percent in 100 years.	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Low to Moderate Short-Term Effectiveness? Moderate Long-Term Effectiveness? Moderate	Administrative Feasibility? High Technical Implementability? High	($960K)	YES
Groundwater Alternative 2A – Source and Institutional Controls, LTM, Extract Groundwater for Hydraulic Control at the Property Boundary, and Direct Discharge to POTW *(Refer to Figure 7-8 and Section 7.5.3)*	This alternative includes the following general response actions for groundwater remediation. • Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, • Institutional Controls: o Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, o LTM would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls (monitored natural attenuation). • Containment/Removal: Groundwater would be extracted at the northeastern corner (i.e., the joint fenceline area) of the former FMC Plant Site, o 5 extraction wells would be sufficient for hydraulic capture (containment) of the remaining plume before it leaves the FMC Plant Site. o A total combined extraction rate of approximately 530 gallons per minute (gpm) in this area would be necessary for capture of the groundwater plume at the FMC Plant Site northern boundary. • Ex-Situ Treatment/Disposal: Extracted groundwater from the Site could be directly pumped to POTW for treatment (without any pre treatment) and disposal. Remedial Action Complete: The groundwater modeling predicts that pumping and treatment of COCs won't appreciably reduce the toxicity and volume of COCs in groundwater below the remedial action benchmarks for more than 100 years. The modeling predicts Alternative 2A will reduce the extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) by only 28 percent in 100 years. .	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Moderate Short-Term Effectiveness? Moderate Long-Term Effectiveness? Moderate to High	Administrative Feasibility? Low to Moderate Technical Implementability? Moderate	($9.6M)	YES

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

Alternative Name/ Number	Groundwater Alternative Description (please refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Select for Detailed Analysis (YES/ NO)
Groundwater Alternative 2B – Source and Institutional Controls, LTM, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary, Onsite Treatment, and Discharge to Evaporation/Infiltration Basin *(Refer to Figure 7-9and Section 7.5.4)*	This alternative includes the following general response actions for groundwater remediation. • Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, • Institutional Controls: o Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, o LTM would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls(monitored natural attenuation). • Containment/Removal: Groundwater would be extracted at the northeastern corner (i.e., the joint fenceline area) of the former FMC Plant Site, o 5 extraction wells would be sufficient for hydraulic capture (containment) of the remaining plume before it leaves the FMC Plant Site. o A total combined extraction rate of approximately 530 gallons per minute (gpm) in this area would be necessary for capture of the groundwater plume at the FMC Plant Site northern boundary. • Ex-Situ Treatment/Disposal: Extracted groundwater from the Site would be treated by chemical precipitation, and then filtered to meet the remedial action requirements prior to discharge to the WUA evaporation/infiltration basin for disposal. Remedial Action Complete: The groundwater modeling predicts that pumping and treatment of COCs won't appreciably reduce the toxicity and volume of COCs in groundwater below the remedial action benchmarks for more than 100 years. The modeling predicts Alternative 2B will reduce the extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) by only 28 percent in 100 years.	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Moderate Short-Term Effectiveness? Moderate. Long-Term Effectiveness? Moderate to High	Administrative Feasibility? Moderate to High Technical Implementability? Moderate	($11.2 M)	YES
Groundwater Alternative 3A – Source and Institutional Controls, LTM, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and at Identified Source Areas, Onsite Pre-Treatment, and Discharge to POTW *(Refer to Figure 7-10 and Section 7.5.5)*	This alternative includes the following general response actions for groundwater remediation. • Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, • Institutional Controls: o Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, o LTM would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls (monitored natural attenuation). • Containment/Removal: Groundwater would be extracted from 3 areas including: o Area A - Former "Phossy" Ponds 3E through 6E (beneath Pond 15S and Phase IV ponds area) using 4 extraction wells with a total groundwater removal rate of 60 gpm for contaminant mass removal o Area B - Former Pond 8S, using 5 extraction wells with a total extraction rate of 90 gpm for contaminant mass removal. o Area C - Joint fenceline area that will capture/contain COCs from a variety of sources, including non-FMC sources, using 5 wells with a total extraction rate of 520 gpm. • Ex-Situ Treatment/Disposal: Extracted groundwater would require pre-treatment by chemical precipitation to remove primarily arsenic and total phosphorus, but also other metal COCs. The pre-treated water then would be discharged to the POTW for final treatment and disposal. Remedial Action Complete: The groundwater modeling predicts that pumping and treatment of COCs won't appreciably reduce the toxicity and volume of COCs in groundwater below the remedial action benchmarks for more than 100 years. The modeling predicts Alternative 3A will reduce the extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) by only 37 percent in 100 years.	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Moderate Short-Term Effectiveness? Moderate Long-Term Effectiveness? Moderate to High	Administrative Feasibility? Low to Moderate Technical Implementability? Moderate	($25.1M)	NO

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

TABLE 7-6
ASSEMBLED GROUNDWATER REMEDIATION ALTERNATIVES, INITIAL SCREENING, AND SELECTION
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

Alternative Name/ Number	Groundwater Alternative Description (please refer to Section 7 of SFS Report for full alternative description)	Effectiveness	Implementability	NPV Cost[1]	Select for Detailed Analysis (YES/ NO)
Alternative 3B – Source and Institutional Controls, LTM, Extract Groundwater at Boundary for Hydraulic Control and at Identified Source Areas, Onsite Treatment, Discharge to Evaporation/ Infiltration Basin *(Refer to Figure 7-12and Section 7.5.6)*	This alternative includes the following general response actions for groundwater remediation. • Source controls would be (and have already been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, • Institutional Controls: o Deed restrictions or restrictive covenants would be reviewed and added as necessary to prevent access to and consumption of site-impacted shallow groundwater, o Long-term groundwater monitoring (LTM) would be conducted to evaluate the short and long-term decline of COCs in groundwater resulting from source controls(monitored natural attenuation). • Containment/Removal: Groundwater would be extracted from 3 areas (like Alt 3A) including: o Area A - Former "Phossy" Ponds 3E through 6E (beneath Pond 15S and Phase IV ponds area) using 4 extraction wells with a total groundwater removal rate of 60 gpm for contaminant mass removal o Area B - Former Pond 8S, using 5 extraction wells with a total extraction rate of 90 gpm for contaminant mass removal. o Area C - Joint fenceline area that will capture/contain COCs from a variety of sources, including non-FMC sources, using 5 wells with a total extraction rate of 520 gpm. • Ex-Situ Treatment/Disposal: The extracted groundwater would be treated by chemical precipitation then filtered to meet the regulatory requirements, prior to discharge to the WUA evaporation/ infiltration basin. Figure 7-13 depicts the process flow diagram for this alternative. Remedial Action Complete: The groundwater modeling predicts that pumping and treatment of COCs won't appreciably reduce the toxicity and volume of COCs in groundwater below the remedial action benchmarks for more than 100 years. The modeling predicts Alternative 3B will reduce the extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) by only 37 percent in 100 years.	Protective of Human Health and the Environment? Moderate Reduces Toxicity, Mobility, or Volume? Moderate Short-Term Effectiveness? Moderate Long-Term Effectiveness? Moderate to High	Administrative Feasibility? Moderate to High Technical Implementability? Moderate	($24.2M)	NO

[1] Preliminary NPV Cost: Assuming a 30 year net present value, 7% discount rate in 2009 dollars.

TABLE 7-7. SUMMARY OF PREDICTED EFFECTIVENESS AND ESTIMATED COST OF GROUNDWATER REMEDIAL ALTERNATIVES 1, 2A/B AND 3A/B

Alternative	Modeled Constituent	Initial Areal Extent (AC)	Predicted Areal Extent 100 Years (AC)	Predicted Decrease 100 Years (AC)	Percent Decrease Areal Extent	Incremental Percent Decrease	Estimated NPV Cost ($K)	Cost per Acre of Areal Reduction Arsenic Extent 100 Years ($K/AC)
1	Arsenic	431	320	111	26%	-	$960	$8.6
	Total/OrthoP	292	112	180	62%	-		
	Potassium	420	204	216	51%	-		
2	Arsenic	431	311	120	28%	2%	$11,200	$93.3
	Total/OrthoP	292	104	188	64%	2%		
	Potassium	420	185	235	56%	5%		
3	Arsenic	431	270	161	37%	9%	$24,200	$150.3
	Total/OrthoP	292	62	230	79%	15%		
	Potassium	420	148	272	65%	9%		

NOTES:
Intial areal extent, predicted areal extent 100 years, predicted decrease 100 years and percent decrease areal extent for the FMC Plant Site taken from the *Groundwater Model Report for the FMC Plant OU* .
Estimated costs are for Alternative 1, 2B and 3B due to uncertainty regarding implementability of Alternatives 2A and 3A.

SECTION 8
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

In this section, a detailed analysis of the four soil (Alternatives 1, 2, 3 and 4) and four groundwater (Alternatives 0, 1, 2A and 2B) remedial alternatives (each including the "no action" alternative) is performed using *EPA RI/FS Guidance* (EPA, 1988)(EPA,1990). A description of the nine evaluation criteria is presented in Section 8.1. Sections 8.2 and 8.3 present the Individual Analysis of soil and groundwater alternatives, respectively, where each alternative is individually assessed against the criteria. Section 9 presents the Comparative Analysis that compares the relative performance of each alternative by media.

8.1 DESCRIPTION OF EVALUATION CRITERIA

The NCP establishes nine criteria for evaluating remedial action alternatives. *EPA RI/FS Guidance* (EPA, 1988)(EPA,1990) elaborates on these criteria and discusses how they are to be applied. The NCP divides the criteria into the three groups as discussed below.

8.1.1 Threshold Criteria

These are the criteria that each alternative *must* satisfy to be eligible for selection based on statutory requirements. The threshold criteria consist of:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

8.1.2 Balancing Criteria

These are the technical criteria upon which the detailed analysis is primarily based. The balancing criteria consist of:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

8.1.3 Modifying Criteria

These criteria relate to the acceptance of the remedial alternative by the public and regulatory agencies. These criteria are formally assessed after the public comment period, at which time state/community support is factored into selection of the preferred alternative. The modifying criteria consist of:

- State (Support Agency) Acceptance
- Community Acceptance

8.1.4 Detailed Discussion of the Nine Evaluation Criteria

The following describes the nine evaluation criteria in greater detail.

8.1.4.1 Threshold Criteria

Overall Protection of Human Health and the Environment - Remedial alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short-term and long-term, from unacceptable risks posed by contaminants by eliminating, reducing, or controlling exposure to concentrations above risk thresholds. This criterion also draws on the assessment of other evaluation criteria such as short-term effectiveness, long-term effectiveness and permanence, and compliance with ARARs.

Compliance with ARARs - Alternatives are assessed to determine whether they meet ARARs, consisting of legal requirements that are either applicable or relevant and appropriate to the site conditions or implementation of the alternative. An example of an ARAR that is *applicable* at the FMC Plant OU is the set of RCRA hazardous waste treatment, storage and disposal regulations at 40 C.F.R. Part 265, given that the FMC plant site is a RCRA interim status facility. ARARs specific to the FMC Plant OU remedial alternatives for soil and groundwater are discussed in Section 4.1.1 and are presented in Table 4-1 and Table 4-1A.

8.1.4.2 Balancing Criteria

Long-Term Effectiveness and Permanence - Alternatives are assessed to determine whether they provide long-term effectiveness and permanence. Factors to be considered include:

- The magnitude of residual risk associated with untreated media or treatment residuals remaining after remedial activities are complete.
- The adequacy and reliability of controls, such as containment systems and institutional controls, necessary to manage untreated media or treatment residuals and wastes.

Reduction of Toxicity, Mobility, or Volume through Treatment - The discussion on the reduction of toxicity, mobility, or volume through treatment addresses the anticipated performance of the treatment technologies that a remedy may employ. This evaluation relates to the statutory preference for selection of a remedy that reduces hazardous substances in the environment. Alternatives are assessed to determine the degree to which the alternative utilizes a treatment (destruction or disposal) that reduces toxicity, mobility, or volume of contaminants. Factors to be considered include:

- The treatment/recycling process specific to site contaminants
- The volume of material the alternative will treat
- The degree of expected reduction in toxicity, mobility, or volume through treatment
- The degree to which the treatment is irreversible
- The type and quantity of residuals remaining following treatment.

Short-Term Effectiveness - Alternative are assessed to determine whether they are effective in the short-term. Factors to be considered include:

- The short-term risks that might be posed to the community during implementation of the alternative
- The potential impacts to on-site workers during remedial activities and the effectiveness and reliability of protective measures
- The potential environmental impacts posed during remedial activities, and the effectiveness and reliability of measures taken to mitigate impacts
- The time necessary to achieve RAOs

Implementability - Alternatives are assessed to determine the ease or difficulty associated with implementing the alternative. Factors to be considered include:

- Administrative feasibility, including the ability to coordinate efforts needed to implement the remedy and the ability and/or time required to obtain any necessary agency approvals and permits
- Technical feasibility, including the ability to construct and operate the technology, the reliability of the technology, the ease of undertaking additional remedial actions if necessary, and the ability to monitor the effectiveness of the remedy
- The availability of services and materials required to implement the remedy

Cost - Alternatives are assessed to determine costs, including capital costs, annual O&M costs, and the net present value of capital and O&M costs. These costs are based on a variety of information including vendor quotes, published cost estimating guides (e.g., Means Heavy Construction Cost Data), and professional experience. This *SFS Report* has determined net present value costs for 30 years at a 7 percent discount rate with an accuracy of a least +50 and -30 percent, consistent with the EPA guidance document entitled *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000).

Please note that "low cost," evaluated in itself and without reference to the other criteria, is ranked "High" under the cost criterion and that, conversely, "high cost" is ranked "Low." This convention is used in all the remedial alternatives evaluations in this report.

8.1.4.3 Modifying Criteria

State Acceptance - Alternatives are assessed to determine the State's general acceptance or preferences, to the extent known, among the proposed alternatives.

Community Acceptance - Alternatives are assessed to determine the community's general acceptance of the proposed alternatives, to the extent their acceptance is known.

The final two criteria, state and community acceptance, typically are evaluated following public review and comment on the Proposed Plan. Because state and community acceptance are addressed after the FS Report has been completed, these criteria will not be discussed further in this *SFS Report*.

8.2 DETAILED ANALYSIS OF SOIL ALTERNATIVES

The three viable soil remedial alternatives that remain following the screening conducted in Section 7 have been further evaluated against seven of the nine evaluation criteria identified in Section 8.1.4 (i.e., excluding the balancing criteria of state and community acceptance, which will be evaluated following public review and comment on the Proposed Plan). The "no action" alternative also is evaluated, but it is only used for comparison as required by the NCP and it is not a viable alternative for the site. Each alternative is given a ranking (high, moderate, or low) under each of the evaluation criteria.

- High denotes good performance in the category,
- Moderate denotes satisfactory performance, and
- Low denotes unsatisfactory performance.

A summary of this detailed Individual Analysis for the retained soil alternatives is provided in Table 8-1. Critical or deciding factors evident in the Individual Analysis are discussed below for each alternative.

8.2.1 Soil Alternative 1 – "No Action"

Evaluation of the "no action" soil alternative is a requirement of the NCP (EPA, 1988) and must be conducted in the CERCLA FS process. This alternative is a baseline to which all other alternatives are compared. It will be retained for comparison to other alternatives.

For the FMC Plant OU, this alternative would represent the status quo. However, no long-term CERCLA groundwater monitoring (as is currently conducted voluntarily by FMC) would be performed. The institutional controls that are currently in place would remain in place. The following discusses application of the seven criteria capable of being evaluated at this time (i.e., excluding the factors of state and community acceptance) to this alternative. Table 8-1 summarizes the screening of this and all other retained soil alternatives. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health and the Environment: Rank = Low

"No action" would not reduce potential future migration of site COCs to groundwater, reduce gamma radiation exposure from radionuclides, or reduce risks associated with metals found in site soils/fill. Therefore, "no action" would not meet any of the RAOs for soils/fill and thus would not be protective of human health and the environment.

Compliance with ARARs: Rank = Low

"No action" would not comply with certain ARARs, such as requirements relating to some soils/fill RAs. As a result, the "no action" alternative would not comply with ARARs.

Long-Term Effectiveness and Permanence: Rank = Low

This alternative is not effective in the short- or long-term at reducing any of the exposure pathways from existing COCs, and therefore would not satisfy any of the soil/fill RAOs.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Low

There is no treatment or containment under the "no action" alternative, so that the toxicity, mobility, and volume of the COCs in soil and fill would not be reduced or contained.

Short-Term Effectiveness: Rank = Low

There is no risk to the community, workers, or the environment resulting from implementation in the short-term. However, this alternative is not effective in the short- (or the long-term) at reducing any of the exposure pathways from existing COCs and therefore it would not satisfy any of the soil/fill RAOs.

Implementability: Rank = High

"No action" would maintain the status quo, which is administratively feasible. In addition, "no action" only requires the continued implementation of institutional controls already in place at the site. Thus it does not present any technical challenges.

Cost: Rank = High

"No action" cost is the status quo (i.e., no capital or operations and maintenance [O&M] costs would be associated with the "no action" alternative). The only costs associated with the "no action" soil alternative would be for the CERCLA-mandated Five-Year Reviews to verify remedy protectiveness. Costs for the Five-Year Reviews have been included for the "no action" alternative and all of the soil alternatives discussed below. Additional information on the costs and assumptions used in development of the detailed costs for each alternative is provided in Appendix H.

8.2.2 Soil Alternative 2

In general, this alternative uses containment (i.e., caps) to satisfy the soil RAOs. Under this alternative, ET caps would cover RAs/subareas that contain P4 and/or are the identified source of COCs in underlying groundwater (consisting of RA-B, RA-C, RA-D, RA-E, RA-H, RA-K, and underground process piping potentially containing P4). The ET caps would reduce the potential exposure threats from these RAs. Soil (Gamma) caps would be used to cover RAs that present gamma threats (consisting of RA-F, RA-F1, and RA-F2). RA-A, RA-A1, RA-G, and RA–J would be left undisturbed, with institutional controls in place until RIR is implemented based on actual (rather than hypothetical) future re-development projects and associated specific receptors at these RAs. Once a re-development project is defined, additional EPA-approved remedial action will be implemented in conjunction with the re-development activity to provide the appropriate level of protection based on the actual receptors and pathways associated with the project. RA-I is left undisturbed but with institutional controls in place to restrict use to commercial/industrial. Also, under this alternative, the storm-sewer piping would be cleaned in place and the sludge would be treated offsite, likely by incineration.

In addition to the remedial actions discussed above, all other common/core remedial actions would be conducted during remedy implementation as presented in Section 7.3.1, (e.g., institutional controls, grading, stormwater management, and monitoring). The core elements would be universally applied to this and all the remaining soil alternatives and for that reason will not be specifically mentioned further in the following evaluations. Figure 7-1 depicts the surface of each RA following the remedial action proposed by Soil Alternative 2. Note that the specifics of this soil alternative are presented in Section 7. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health/Environment: **Rank = Moderate to High**

The various caps, when combined with institutional controls limiting excavation through them, prevent direct exposure to soil COCs and minimize or prevent the potential release and migration of COCs that could threaten groundwater. As a result, the RAOs for soil/fill (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas, and inhalation of fugitive dust) and groundwater (reduce release and migration of COCs to groundwater) will be met. In addition, in RAs where remediation will coincide with development (i.e., the RIR option), institutional controls (access and use restrictions) prevent potential unacceptable exposure until re-development occurs. At that time the RAOs will be met by implementing additional remedial action as necessary based on the actual receptors and exposure pathways associated with the re-development project. As stated in EPA's comments on the draft SFS Report, EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement. This alternative would result in minimal potential fugitive dust and/or P4/phosphine (or reaction products) exposure to remediation workers and the public during the construction or implementation phase of the project.

Compliance with ARARs: Rank = High

This alternative would comply with ARARs.

Long-Term Effectiveness and Permanence: Rank = High

Long-term effectiveness would be assured through construction of caps (i.e., ET and Gamma caps) comprised of natural materials that will have long-term permanence and effectiveness. Long-term cap monitoring and maintenance will assure long-term cap performance and integrity. Long-term effectiveness also would be assured in RIR areas through implementation of additional remedial actions as part of future re-development.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Moderate

COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping (reduction in mobility). Active treatment (reduction in toxicity and volume) under Soil Alternative 2 is used only for the sludges in sewer piping in RA-A. As a result, this alternative does not appreciably reduce the toxicity and volume of soil COCs through treatment, although COC mobility will be significantly reduced.

Short-Term Effectiveness: Rank = Moderate to High

This alternative would be effective in the short term based on the various caps that would be installed throughout the site after EPA approval of the Remedial Action Work Plan (RAWP). The caps would limit exposure to COCs through containment. They would be augmented by institutional controls that would limit access to and use of RIR areas RA-A, RA-A1, RA-G, and RA-J. Future land use decisions in the RIR areas would extend the overall remediation schedule but would not impede the short-term effectiveness of this alternative with respect to current receptors and exposures pathways. RA-I is left undisturbed, but with institutional controls in place to limit use to commercial/industrial. This alternative results in minimal site-wide soil disturbance because RIR redevelopment-driven covers will likely consist of concrete and/or asphalt covers as opposed to excavation and placement of soil covers derived from the WUA borrow area and/or off-site sources. This is especially beneficial in P4 areas, because this reduces the potential generation of fugitive dust containing COCs and/or P4 reaction products. This minimizes the short-term risks to site workers, the public, and the environment. Excluding the time required to have an RD/RA consent decree entered and gain EPA approval of the RAWP for the FMC Plant OU, this alternative is expected to require 1 to

2 years from commencement to completion of construction (not taking into account future remedial actions under the RIR process options).

Implementability: Rank = High

Administrative Feasibility: Capping (containment) is the primary technology used in this alternative. It is a proven, straightforward remedy that is relatively easy to design and construct. EPA review and approval will be required for the cap designs and the remedial actions associated with future re-development in the areas of RIR.

Technical Feasibility: Capping has been implemented at other large sites (e.g., mining sites or landfills) for mitigation of similar risks and COCs (primarily inorganics). Potential future RIR measures would be designed to meet the implementability criterion and would be consistent with the primary technical strategy of the selected soil remedy (e.g., if capping is the primary remedial strategy for COC containment, then scraping and consolidating the materials at the RIR RAs under an appropriate cap would be feasible and compatible).

Availability of Services and Materials: Construction services are expected to be available. On-site sources exist for cap construction materials (e.g., soil, granular materials).

Cost: Rank = High

The total capital costs for soil Alternative 2 assuming 2009 dollars, including labor and materials for construction of the caps, fencing/access controls, cleaning and treatment of the sludges offsite, etc. are approximately $28.4M. O&M costs, which primarily would relate to cap monitoring and repair, are $513K/year again assuming 2009 dollars. Total present value costs (capital and O&M costs) over a 30-year period when using a 7% discount rate are $32.7M. Capital and O&M costs associated with future RIR on RA–A, RA-A1, RA-G, and RA-J have not been included in these totals because the remedial actions for these RAs would be incorporated into the re-development activity, e.g., construction of parking lots or other ground cover. Additional information on the costs and assumptions used in development of the detailed costs for each alternative is provided in Appendix H. Although this present value cost is high, it is the lowest of the all the soil alternatives (except “no action”).

8.2.3 Soil Alternative 3

Much like Alternative 2, this alternative uses caps to meet the soil RAOs. ET caps would be placed at RA-B, RA-C, RA-D, RA-E, RA-F1, RA-F2, RA-H, and RA-K (including all underground process piping within these RAs which potentially contains P4 and/or are an identified source of COCs to underlying groundwater). The ET caps would reduce the potential threat to human health and the environment from these RAs. Soil (Gamma) caps would be installed at RA-A, RA-A1, RA-F, and RA-G, which contain radionuclide

COCs and present a gamma threat but do not present a threat to groundwater. RA-J would be excavated (or tilled in-place) to a depth of 6 inches and would be subject to institutional controls that would restrict use to commercial/industrial. Excavated soils would be used in the construction of caps within other RAs. RA-I is left undisturbed but would be subject to institutional controls restricting its use to commercial/industrial. Under this alternative, the storm-sewer piping at RA-A would be cleaned in place and the sludge would be treated and disposed offsite. Figure 7-2 depicts the surface of each RA following the remedial action proposed by Soil Alternative 3. Note that the specifics of this soil alternative, including the core elements, are presented in Section 7 of this *SFS Report*. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health/Environment: **Rank = High**

The various caps, when combined with institutional controls limiting access to excavation through them, prevent direct exposure to soil COCs and prevent or minimize the potential release and migration of COCs to groundwater. As a result, the RAOs for soil/fill (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas and inhalation of fugitive dust) and groundwater (reduce release and migration of COCs to groundwater) will be met. Also, this alternative would result in minimal P4/phosphine (or reaction products) exposure during the construction or implementation phase of the project and thus would be more protective to remediation workers and the public than alternatives that involved greater risk of such exposure.

Compliance with ARARs: Rank = High

This alternative would comply with ARARs.

Long-Term Effectiveness and Permanence: Rank = High

Long-term effectiveness would be assured through construction of caps (i.e., ET and gamma caps) comprised of natural materials that will have long-term permanence and effectiveness. Long-term cap monitoring and maintenance will assure long-term cap performance and integrity. Long-term effectiveness and permanence at RA-J would be demonstrated through confirmation sampling after excavation and consolidation (or tilling in place).

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Moderate

COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping (reduction in mobility). Active treatment (reduction in toxicity and volume) is used only for the sludges in sewer piping in RA-A. This alternative thus does not appreciably reduce the toxicity and volume of soil COCs through treatment, although COC mobility is greatly reduced.

Short-Term Effectiveness: Rank = High

This alternative would be effective in the short term based on the various caps that would be installed throughout the site after EPA approval of the RAWP. The caps would limit exposure to COCs through containment. Institutional controls would be implemented at RA-I. RA-J would be excavated (or tilled in place) to a depth of 6 inches, and enhanced institutional controls limiting use to industrial/commercial would be implemented. This alternative results in additional soil disturbance (compared to Alternative 2) to excavate (borrow) and place gamma caps on the additional acreage, however, P4 areas are not disturbed. This is especially important in P4 areas because this reduces the potential generation of fugitive dust containing COCs, exposure to fire and phosphine, and/or P4 reaction products, and thus minimizes the short-term risks to site workers, the public, and the environment. Excluding the time required to enter a RD/RA consent decree and gain EPA approval of the design and remedial action work plan (RAWP), this alternative is expected to require 2 to 3 years from commencement to completion of construction.

Implementability: Rank = High

Administrative Feasibility: Capping (containment) is the primary technology used in this alternative (along with excavation/consolidation or tilling at RA-J). These technologies are proven, straightforward remedies that are relatively easy to design and construct. The cap design would require EPA review and approval.

Technical Feasibility: Capping and excavation/consolidation have been implemented at other large sites (e.g., mining sites or landfills) for mitigation of similar risks and COCs (primarily inorganics) and is a proven technology.

Availability of Services and Materials: Construction services are expected to be available. On-site sources exist for cap construction materials (e.g., soil, granular materials).

Cost: Rank = Moderate to High

The total capital costs assuming 2009 dollars for Soil Alternative 3, including labor and materials for construction of the caps, fencing/access controls, cleaning and treatment of the sludges offsite, etc., are approximately $43.6M. O&M costs, which primarily would relate to cap monitoring and repair, are $602/year, again assuming 2009 dollars. Total present value costs (capital and O&M costs) over a 30 year period when using a 7% discount rate are $47.2M. Additional information on the costs and assumptions used in development of the detailed costs for each alternative is provided in Appendix H. Although this present value cost is high, it is the second lowest of the all the soil alternatives (except “no action”).

8.2.4 Soil Alternative 4

This alternative employs capping to contain soil COCs and excavation/consolidation of relatively shallow, non-P4 contaminated fill in RA-A and excavation/consolidation of low level P4-impacted soils in RA-K. Both of these actions would meet the soil RAOs. ET caps would be placed at RA-B, RA-C, RA-D, RA-E, RA-F1, RA-F2, and RA-H (including underground process piping within these RAs), which potentially contain P4 and/or are identified sources of COCs to underlying groundwater. The ET caps would not only eliminate direct exposure at these areas but also reduce COC infiltration, thus meeting the RAO for migration of COCs to groundwater. Soil (gamma) caps are used at RA-F and RA-G that contain radionuclide COCs and present a gamma threat. Excavation/consolidation would be implemented for RA-A, RA-A1, RA-J and RA-K. RA-A would be excavated down to un-impacted native soil, with the removed material placed under a cap at another RA. RA-A1 would be excavated to approximately 5 feet below the native soil interface to remove hydrocarbon-impacted soils. These soils would be placed under a cap within another RA. RA-J would be excavated (or tilled in-place) to a depth of 6 inches, with removed soils to be used in the construction of caps at other RAs. RA-K would be excavated to a depth of about 10 feet to remove all P4-contaminated soils. These P4 soils would be placed under an ET cap within an RA that is suspected of having subsurface P4 (e.g., RA-B). RA-I is left undisturbed but with institutional controls in place to limit use to commercial/industrial. Underground storm-sewer piping at RA-A would be cleaned in place and the sludge would be treated off-site by incineration.

Figure 7-3 depicts the surface of each RA following the remedial action proposed by Soil Alternative 4. Note that the specifics of this soil alternative, including its core elements, are presented in Section 7 of this *SFS Report*. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health and the Environment: **Rank = Moderate**

The excavation/consolidation and installation of various caps, when combined with institutional controls, eliminate direct exposure to soil COCs and minimizes/prevents potential release and migration of COCs that threaten groundwater. Thus, the RAOs for soil (exposure to gamma radiation, incidental ingestion, direct dermal exposure, exposure to fire and phosphine in P4 areas, and inhalation of fugitive dust) and groundwater (reduce release and migration of COCs to groundwater) will be met. This alternative could result in P4/phosphine (or reaction products) exposure to remediation workers and the public during the construction or implementation phase of the project at RA-K, where P4-contaminated soils will be excavated. While P4 concentrations at RA-K are expected to be low (i.e., 1,000 ppm, based on historic information and limited observations during the SRI) P4 exposure (or exposure to P4 reaction products) could occur during the remedial activities at this RA.

Compliance with ARARs: Rank = High

This alternative would comply with ARARs.

Long-Term Effectiveness and Permanence: Rank= High

Long-term effectiveness would be assured through construction of caps (i.e., ET and gamma caps) comprised of natural materials that will have long-term permanence and effectiveness. Long-term cap monitoring and maintenance will assure long-term cap performance and integrity. Long-term effectiveness and permanence at areas that involve excavation and consolidation would be demonstrated through confirmation sampling after those actions were completed.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Moderate

COCs that present threats to groundwater, human health, and the environment would be effectively controlled and/or eliminated through capping (reduction in mobility). Consolidation under this alternative does not appreciably reduce toxicity, mobility or volume of soil COCs. Active treatment is used only for the residual solids in sewer piping in RA-A (reduction in toxicity and volume). The toxicity and volume of site COCs thus are not appreciably reduced through treatment, although their mobility is greatly reduced.

Short-Term Effectiveness: Rank = Moderate

This alternative would be effective in the short term based on the various caps that would be installed throughout the site after EPA approval of the remedial action work plan. The caps would limit exposure to COCs through containment. Institutional controls at RA-I limit its use to commercial/industrial. Soils would be excavated (or tilled in place) to 6 inches at RA-J. This alternative results in P4-impacted soil disturbance during excavation of RA-K that could create a potential for exposure to P4, phosphine and P4-reaction products and result in short-term risks to site workers, the public, and the environment. This alternative also requires the excavation/removal of 1.2 million yd^3 of earthen materials from RA-A. This will create a potential for significant exposure to fugitive dusts containing metal and radionuclide COCs. Excluding the time required to enter a RD/RA consent decree and gain EPA approval of the RAWP, this alternative is expected to require 2 to 4 years from commencement to completion of construction.

Implementability: Rank = Moderate

<u>Administrative Feasibility:</u> Capping (containment) and excavation/consolidation are the primary technologies used in this alternative. These technologies are proven, straightforward remedies that are relatively easy to design and construct, with the exception of the excavation/consolidation of material from RA-K that is known to contain P4. Excavation of P4-containing materials from RA-K (if possible) and their placement under an ET cap at another RA (e.g., RA-B) without treatment would likely require an AOC delineation that would encompass RA-B and RA-K, at a minimum. In addition, the cap design will require EPA review and approval.

<u>Technical Feasibility:</u> Capping and excavation/consolidation have been implemented at other large sites (e.g., mining sites or landfills) for mitigation of similar risks and COCs

(primarily inorganics). However, excavation and consolidation of large quantities of P4-contaminated material from RA-K involves largely unproven technology.

Availability of Services and Materials: Construction services are expected to be available, although unique experience, training, and procedures will be required for the modified excavation techniques that would be required at RA-K. On-site sources exist for cap construction materials (e.g., soil, granular materials).

Cost: Rank = Low

The total capital costs assuming 2009 dollars for Soil Alternative 4, including labor and materials for construction of the caps, excavation and consolidation, fencing/access controls, cleaning and treatment of the sludges offsite, etc., are approximately $76.8M. O&M costs, primarily relating to cap monitoring and repair, are $547M/year assuming 2009 dollars. Total present value costs of this alternative (capital and O&M costs) over a 30-year period when using a 7% discount rate are $81.6M. Additional information on the costs and assumptions used in development of the detailed costs for each alternative is provided in Appendix H. This present value cost is the highest of the all the soil alternatives retained, nearly double the present value cost of $47.2M for Alternative 3.

8.3 DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES

The three viable groundwater remedial alternatives described in Section 7 (in addition to the “no action” alternative) have been further evaluated against the seven (two threshold and five balancing) evaluation criteria discussed above. The “no action” alternative also is evaluated here, but it is only used for comparison as required by the NCP and it is not a viable alternative for the site. A summary of this Individual Analysis for groundwater alternatives is provided in Table 8-2.

In this section, the detailed analysis of groundwater remedial alternatives is primarily focused on their effectiveness achieving the groundwater RAOs but also evaluates their effectiveness in supporting achievement of the surface water RAO. Evaluation of the effectiveness of FMC remedial alternatives in achieving the surface water RAO is complicated due to the comingling of FMC- and Simplot-impacted groundwater prior to discharge to the Portneuf River as surface water.

As described in greater detail in Section 7.5 and 7.6, the FMC groundwater model simulation results for Groundwater Alternatives 1, 2 and 3 provide useful insight into the predicted short and long-term effectiveness and relative (comparative) performance of the alternatives. The model simulations predict that none of the alternatives will achieve the groundwater restoration RAO within the 100 year modeled period; however, the results of the current FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO.

As discussed in Section 8.1, state and community acceptance typically are evaluated following public review and comment on the Proposed Plan. Because state and community acceptance will be addressed after this *SFS Report* has been completed, these criteria are not evaluated here.

Critical or determinative factors identified in the Individual Analysis are discussed below for each groundwater alternative.

8.3.1 Groundwater Alternative 0 – "No Action"

The "no action" groundwater alternative is a requirement of the NCP (EPA, 1988) and must be considered in the CERCLA FS process. This groundwater alternative is a baseline to which all other alternatives are compared. It will be retained throughout the detailed analysis of groundwater alternatives. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health and the Environment: Rank = Low

The "no action" alternative would not meet any of the groundwater RAOs for: 1) reducing release and migration of site COCs to groundwater, 2) preventing ingestion of COCs in groundwater, and/or 3) restoring groundwater quality in a reasonable time frame to meet RBCs or MCLs. However, soil remedies that might be implemented would reduce the release and migration of COCs to groundwater by using technologies to treat the remaining identified source areas within the FMC Plant OU.

Compliance with ARARs: Rank = Low

"No action" would not meet ARARs pertaining to releases to groundwater. As a result, the "no action" alternative for groundwater would not comply with ARARs.

Long-Term Effectiveness and Permanence: Rank = Low

In the long term (here considered to be over 100 years), this alternative does not address the risks associated with potential release and migration of COCs from the identified source areas to groundwater. In addition, this alternative does not reduce the risk of ingestion because it does not establish groundwater use restrictions.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Low

There would be no treatment of groundwater under this alternative, or engineering controls to limit the mobility of COCs. As a result, this alternative does not reduce the toxicity, mobility, and volume of COCs in groundwater.

Short-Term Effectiveness: Rank = Low

As there is no action under this alternative (beyond the source controls under the soil alternatives), there would be no additional risk to the community, workers, or the environment during implementation of the remedial action. However, the groundwater RAOs would not be achieved in the foreseeable future. Because no actions are implemented, this alternative is not effective in the short-term.

Implementability: Rank = High

"No action" would maintain the status quo, which is administratively feasible. In addition, "no action" only requires the continued implementation of institutional controls already in place at the site. Thus it does not present any technical challenges.

Cost: Rank = High

There is no cost associated with this alternative. Costs for EPA CERCLA 5 year reviews have been included for all of the soil alternatives, but have not been included for the no action groundwater alternative or any of the groundwater alternatives because this cost would be uniformly applied to all alternatives and are included, at least in part, in the soil alternative costs.

8.3.2 Groundwater Alternative 1 – Source Controls, Institutional Controls, and Long-Term Monitoring

Groundwater Alternative 1 is comprised of three primary elements, as identified in Table 7-6, consisting of: 1) source controls that would be (and have already partially been) implemented to prevent further degradation of the shallow groundwater underlying identified sources, 2) existing and additional deed restrictions or restrictive covenants as necessary to prevent potential future access to and consumption of site-impacted shallow groundwater, and 3) long-term groundwater monitoring (LTM) to evaluate the short- and long-term decline of COCs in groundwater (i.e., natural attenuation) resulting from source controls. See Section 7.5.2 for a detailed description. Evaluation against the threshold and balancing criteria is presented below.

Overall Protection of Human Health and the Environment: Rank = Moderate

Source and institutional controls to be implemented under this alternative meet 2 of the 3 groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/ eliminating the release of COCs from identified sources through source controls (i.e., soil remedial actions). However, groundwater modeling indicates that the time frame for the third RAO regarding groundwater restoration is “unreasonable” given that it will require an estimated >100 years for natural processes to restore groundwater quality to remedial benchmarks (e.g., MCLs).

LTM data gathered under this alternative would be used to provide the information necessary for evaluation of groundwater quality trends (i.e., COC declines) following the actions at identified soil/fill source areas to minimize infiltration to groundwater (e.g., following capping of RA-C). Institutional controls, in the form of access and use restrictions, would be effective at preventing the ingestion of impacted groundwater throughout the FMC Plant OU.

Compliance with ARARs: Rank = Moderate

Alternative 1 would comply with some ARARs by preventing potential future contact with contaminated groundwater through institutional controls and minimizing continued degradation of shallow groundwater through soil source controls.

Long-Term Effectiveness and Permanence: Rank = Moderate

In the long term, access of potential receptors to contaminated groundwater would be eliminated through institutional controls. Source controls from the selected soil alternative would minimize and gradually eliminate continued contribution of COCs to the groundwater. Based on the groundwater modeling, source controls and natural attenuation processes will not achieve the groundwater restoration RAO beneath the FMC Plant Site within the 100 year modeled timeframe, which is not a reasonable time frame for “restoration” of groundwater quality (EPA, 1988).

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Low to Moderate

When the institutional controls are combined with an appropriate soil alternative for source control, this groundwater alternative will prevent potential future human exposure and minimize infiltration of precipitation and leaching of COCs from the source areas into shallow groundwater (achieving a reduction of mobility of COCs to groundwater). Natural attenuation of COCs in the groundwater will gradually reduce their toxicity and volume. However, the reduction in toxicity and volume of the COCs in groundwater *through treatment* is not addressed under this alternative.

Short-Term Effectiveness: Rank = Moderate

Alternative 1 would be effective in the short term (and long term) at 1) limiting potential future access to (exposure to) impacted site groundwater, 2) monitoring groundwater quality and trends over time, and 3) eliminating sources, when combined with the selected soil remedy of source control, that could cause continued degradation of groundwater quality (i.e., this alternative would limit COC mobility). Alternative 1 does not achieve the groundwater restoration RAO beneath the FMC Plant Site within a reasonable time frame. However, there is no short-term risk to the community, workers, or the environment resulting from implementation of this remedy because there will be no infrastructure built under this remedy other than the source controls.

Implementability: Rank = High

Administrative Feasibility: Groundwater Alternative 1 is administratively feasible. It would require review of existing and possible implementation of additional deed restrictions to prohibit consumption of contaminated groundwater, along with implementation of an LTM plan that would be designed to integrate the *Interim CERCLA Groundwater Monitoring Plan* (see Appendix G) with the current RCRA post-closure and Calciner Ponds Remedial Action groundwater monitoring programs. All of these activities are relatively easy to perform. However, Alternative 1 would require a Technical Impracticability (TI) waiver or other administrative action that recognizes the arsenic MCL (ARAR) will not be achieved in groundwater within a reasonable time frame. Discussion of reasonable time frames for groundwater restoration is presented in EPA's *Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (EPA, 1988; Section 6.2.2.3).

Technical Feasibility: Alternative 1 is technically feasible when combined with soil capping remedies that control, reduce, or eliminate releases from identified sources of groundwater contamination at the site.

Availability of Services and Materials: Services for long-term monitoring are available. No significant materials are required.

Cost: Rank = High

Long-term monitoring of groundwater will have a capital cost of approximately $57K dollars, primarily for installation of additional monitoring wells, and an annual O&M costs will be approximately $71K per year, using 2009 dollars. The 30 year present value cost of this alternative is $960K. There are little to no additional costs associated with Alternative 1 other than processing the deed restrictions on groundwater use, installation of additional monitoring wells to appropriately monitor the performance of CERCLA soil remedial actions, and implementation of LTM. The soil alternative that is selected to reduce or eliminate leaching of COCs to groundwater will be costly, but those costs are not included in this Alternative 1 cost. This is the most cost-effective alternative when compared to the other viable remedies.

Additional information on the labor, equipment, and O&M costs and assumptions used in development of the detailed costs for each alternative is provided in Appendix H.

8.3.3 Groundwater Alternative 2A – Source and Institutional Controls, LTM, Extract GW for Hydraulic Control at the Property Boundary, and Direct Discharge to POTW

This alternative includes the source controls, institutional controls, and LTM discussed in Groundwater Alternative 1, and adds groundwater extraction from the shallow aquifer to provide hydraulic containment at the FMC Plant Site northern boundary. This prevents further downgradient migration of COCs beyond the plant boundary. The extracted groundwater would be discharged directly to the City of Pocatello POTW for treatment.

Due to hydrogeologic conditions, the extraction wells would be located in the northeastern corner of the former FMC Plant Site to capture the Plant Site plume before it migrates beyond Highway 30 to the FMC Northern Properties and eventually to the Portneuf River in the reach between and including Batiste Spring and Swanson Road Spring (aka the Spring at Batiste Road). Groundwater modeling indicates that 5 extraction wells would be sufficient for hydraulic capture (containment) of the plume before it leaves the FMC Plant OU. The *Groundwater Model Report for the FMC Plant OU*, including figures of the plume capture zone, is provided in Appendix E. A total combined extraction rate of approximately 530 gallons per minute (gpm) in this area would be necessary for capture of the groundwater plume at the FMC Plant Site.

Based on analytical results from groundwater samples collected in the Alternative 2 extraction area monitoring wells (used to estimate average COC concentrations in extracted groundwater) and a review of the current City of Pocatello POTW pollutant influent limits, extracted groundwater could be directly pumped to the POTW for treatment, without any pretreatment being required. Permitting this discharge to the POTW should be relatively straightforward. However, as stated in Section 7.5.3, the City of Pocatello is *"concerned about the potential effects of this discharge on our WWTP operations and Biosolids Land Application Program…and… the volume of remediated groundwater would use a large hydraulic capacity."* Additional discussions with the City of Pocatello to address these concerns have not yet occurred. Therefore, the viability of discharging extracted groundwater to the POTW remains uncertain.

Based on the groundwater modeling conducted, extraction would need to continue for >100 years before the levels of COCs will fall below their remedial action benchmarks (i.e., MCLs, PRGs, etc.) and pumping could be discontinued. Evaluation of this alternative against the threshold and balancing criteria is presented below.

Overall Protection of Human Health/Environment: Rank = Moderate

Source controls, institutional controls, and LTM from Groundwater Alternative 1, when combined with extraction and direct discharge and treatment of groundwater at the local POTW, as proposed under this alternative meets 2 of the 3 groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/ eliminating the release of COCs from identified sources through source controls and by hydraulic containment of the contaminated groundwater to prevent further migration beyond the FMC Plant Site northern boundary. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame (refer to Groundwater Model Report Figure 3-11). However, the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent over 100 years. The time frame for attainment of the third groundwater RAO, for groundwater restoration, is predicted to be >100 years to meet the established remedial benchmarks (e.g., MCLs).

Compliance with ARARs: Rank = Moderate

Alternative 2A would comply with some ARARs, by preventing potential future contact with contaminated groundwater through institutional controls and limiting continued degradation of shallow groundwater through source controls.

Long-Term Effectiveness and Permanence: Rank = Moderate to High

Long-term considerations for this alternative include:

- FMC owns the land overlying the groundwater plume, and institutional controls (deed restrictions) that run with the property will prevent contact with contaminated groundwater.
- Soil remedies implemented at the source areas will control/eliminate future contamination of the groundwater from these identified sources.
- Extraction will begin capturing site-impacted groundwater and decrease future downgradient migration of contaminated groundwater. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame.

However, the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent over a 100-year period. Thus this alternative does not restore groundwater to remedial benchmarks within a reasonable time frame.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Moderate

This groundwater alternative reduces the mobility, toxicity, and volume of groundwater COCs through a combination of source controls, extraction for hydraulic containment, and treatment of contaminated groundwater at the City of Pocatello POTW.

Short-Term Effectiveness: Rank = Moderate

This alternative would be effective in the short-term by 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/ eliminating the release of COCs from identified sources through source controls and by capturing site-impacted groundwater to reduce the future downgradient migration of contaminated groundwater beyond the FMC Plant Site northern boundary. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame. Operation would begin as soon as the sewer connection between the FMC Plant Site and the POTW could be evaluated (and upgraded if necessary), the waste water discharge permit was in place, and the extraction wells were installed and developed. In addition, there is little short-term risk to the community, workers, or the environment resulting from implementation of this alternative. Excluding the time required to enter a RD/RA consent decree and obtain EPA approval of the RAWP, this alternative is estimated to require 1 to 2 years to construct and make operational. However, once constructed, the RAO for restoration of groundwater quality would not be achieved within 100 years.

Implementability: Rank = Low to Moderate

Administrative Feasibility: Groundwater Alternative 2A is administratively feasible. It would require review of existing and possible implementation of additional deed restrictions to prohibit consumption of contaminated groundwater, along with implementation of an LTM plan that would be designed to evaluate performance of the selected source control (soil remedial) actions and this groundwater alternative. All of these activities are relatively easy to perform. However, the following administrative hurdles exist:

- The City of Pocatello POTW would have to accept and permit the extracted groundwater discharge (estimated to be 530 gpm) for the foreseeable future; and,
- Alternative 2A likely would require a TI waiver or other administrative action that recognizes the arsenic MCL (ARAR) will not be achieved in groundwater within a reasonable time frame, in that the estimated cleanup time frame is much greater than the 100-year period discussed as a reasonable period for groundwater restoration in EPA's *Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (EPA, 1988; Section 6.2.2.3).

Technical Feasibility: Alternative 2A is technically feasible when combined with soil capping remedies that control, reduce, or eliminate releases from identified sources of groundwater contamination at the site.

Availability of Services and Materials: Services for long-term monitoring and for extraction system installation are available. No significant issues with obtaining materials are foreseen.

Cost: Rank = Moderate

The total capital costs assuming 2009 dollars for Groundwater Alternative 2A, including labor and materials for installation of extraction wells, are approximately $579K. O&M costs, primarily for POTW fees (but also including LTM), are $712K/year assuming 2009 dollars. Total present value costs (capital and O&M costs) over a 30-year period when using a 7% discount rate are $9.6M.

Additional information on the labor, equipment, and O&M costs and assumptions used in development of the detailed costs for each groundwater alternative is provided in Appendix H.

8.3.4 Groundwater Alternative 2B – Source and Institutional Controls, LTM, GW Extraction for Hydraulic Control at the Plant Site Boundary, Onsite Treatment, and Discharge to Evaporation/Infiltration Basin

This alternative includes the source controls, institutional controls, and LTM discussed in Groundwater Alternative 1 and groundwater extraction from the shallow aquifer to provide hydraulic containment at the FMC Plant Site northern boundary, thereby preventing further downgradient migration of Site COCs as described in Alternative 2A.

Groundwater Alternative 2B is the same as Alternative 2A, including a sustained groundwater extraction rate of 530 gpm from 5 wells, except that the groundwater extracted from the aquifer in the northeastern portion (the joint fenceline area) of the former FMC Plant Site would be: 1) treated for elevated arsenic to the MCL of 10 mg/L and total phosphorus to background at 0.3 mg/L (the other COCs would be below their MCLs or other regulatory standards) and then 2) discharged to a evaporation/infiltration basin located in the Western Undeveloped Area (WUA). Under this alternative, extracted groundwater would be reintroduced to the shallow aquifer via the infiltration basin in the WUA. The groundwater would be treated by chemical precipitation, and then filtered to meet the regulatory requirements prior to discharge to the WUA evaporation/infiltration basin. Figure 7-6 depicts the process flow diagram for this alternative.

Filtration would be necessary to remove the remaining small particulates prior to discharge to the evaporation/infiltration basin. The precipitate from the process, and the resulting filter cake, are assumed to be a hazardous waste. As a result, the filter cake is assume to be disposed of at an offsite commercial landfill as hazardous waste because of the chemical composition of the precipitate (i.e., the COCs may be leachable).
Based on the groundwater modeling conducted to date, the extraction would have to continue for >100 years before the levels of COCs will fall below their respective remedial action benchmarks (i.e., MCLs, PRGs, etc.). Evaluation of this alternative against the threshold and balancing criteria is presented below.

Overall Protection of Human Health and the Environment: **Rank = Moderate**

Source controls, institutional controls, and LTM from Groundwater Alternative 1, when combined with extraction for containment, treatment of groundwater, and discharge to an upgradient evaporation/infiltration basin, meet 2 of the 3 groundwater RAOs for protection of human health and the environment by: 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/eliminating the release of COCs from identified sources through source controls and by containing the contaminated groundwater to prevent further migration beyond the FMC Plant Site northern boundary. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame (refer to Groundwater Model Report Figure 3-11). However, the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent over 100 years. Thus the time frame for attainment of the third groundwater RAO, for groundwater restoration, is predicted to be >100 years to restore groundwater quality to the established benchmarks (e.g., MCLs).

Compliance with ARARs: Rank = Moderate

Alternative 2B would comply with some ARARs, by preventing potential future contact with contaminated groundwater through institutional controls and limiting continued degradation of shallow groundwater through source controls.

Long-Term Effectiveness and Permanence: Rank = Moderate to High

Long-term considerations for this alternative include:

- FMC owns the land overlying the groundwater plume, and institutional controls (deed restrictions) that run with the property will prevent contact with contaminated groundwater
- Soil remedies implemented at the source areas will control/eliminate future contamination of the groundwater from identified sources.
- Extraction will begin capturing site-impacted groundwater and decrease future downgradient migration of contaminated groundwater. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame.

However, the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would only be reduced by 28 percent over 100 years. Thus this alternative does not restore groundwater to remedial action benchmarks within a reasonable time frame.

Reduction in Toxicity, Mobility, and Volume through Treatment: Rank = Moderate

Alternative 2B reduces the mobility, toxicity, and volume of groundwater COCs through source controls, extraction for hydraulic containment, and on-site treatment. The filter cake from the chemical precipitation process would be treated and disposed off-site, likely as a hazardous waste.

Short-Term Effectiveness: Rank = Moderate

This alternative would be effective in the short-term by 1) preventing the ingestion of contaminated groundwater through institutional controls, and 2) reducing/ eliminating the release of COCs from identified sources through source controls and by capturing site-impacted groundwater to reduce future downgradient migration of contaminated groundwater beyond the FMC Plant Site northern boundary. Groundwater modeling predicts that Alternative 2A will achieve containment of FMC arsenic-impacted groundwater at the Plant Site northern boundary in a 25 to 50 year time frame. Operation would begin as soon as the extraction wells were installed and developed, the chemical precipitation process was constructed and optimized, and the infiltration basin conveyance system was installed. Excluding the time required to enter a RD/RA consent decree and gain EPA approval of the RAWP, this alternative is estimated to require 2 to 3 years to construct and make operational. There is little short-term risk to the community, workers, or the environment resulting from implementation of this alternative. However, once constructed, the RAO for restoration of groundwater quality would not occur within 100 years.

Implementability: Rank = Moderate to High

Administrative Feasibility: Groundwater Alternative 2B is administratively feasible. It would require review of existing and possible implementation of additional deed restrictions to prohibit consumption of contaminated groundwater, along with implementation of an LTM plan that would be designed to evaluate performance of the selected source control (soil remedial) actions and this groundwater alternative. All of these activities are relatively easy to perform. However, Alternative 2B likely would require a TI waiver or other administrative action that recognizes the arsenic MCL (ARAR) will not be achieved in groundwater within a reasonable time frame, in that the estimated cleanup time frame is much greater than the 100-year period discussed as a reasonable restoration period in Section 6.2.2.3 of EPA's *Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (EPA, 1988).

Technical Feasibility: Alternative 2B is technically feasible when combined with soil capping remedies that control, reduce, or eliminate releases from the identified sources of groundwater contamination at the site. This alternative would be more challenging technically as result of the groundwater treatment that would be required. Treatability studies would likely need to be conducted prior to remedial design.

Availability of Services and Materials: Services for long-term monitoring, for extraction system installation, and for treatment system design/construction are available. No significant issues with obtaining materials are foreseen.

Cost: Rank = Moderate

The total capital costs assuming 2009 dollars for Groundwater Alternative 2B, including labor and materials for installation of extraction wells and construction of the treatment plant and an infiltration basin, are approximately $2.7M. O&M costs, primarily for operation of the treatment plant and groundwater monitoring, are $552K/year assuming 2009 dollars. Total present value costs (capital and O&M costs) over a 30-year period when using a 7% discount rate are $11.2M. This dollar amount is the highest of the active groundwater alternatives for the FMC Plant OU.

Additional information on the labor, equipment, and O&M costs and assumptions used in development of the detailed costs for each groundwater alternative is provided in Appendix H.

TABLE 8-1

DETAILED ANALYSIS SUMMARY – SOIL ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho
(Page 1 of 1)

EVALUATION CRITERION	**Soil Alternative 1: "No Action"** (refer to Section 8.2.1 for complete discussion)	**Soil Alternative 2: Core Elements (all), RIR (4 RAs), Gamma and ET Capping (10 RAs), Clean and Treat Offsite (1 RA)** (refer to Section 8.2.2 for complete discussion)	**Soil Alternative 3: Core Elements (all), Gamma and ET Capping (13 RAs), Excavate and Consolidate (1 RA), Clean and Treat Offsite (1 RA)** (refer to Section 8.2.3 for complete discussion)	**Soil Alternative 4: Core Elements (all), Gamma and ET Capping (10 RAs), Excavate and Consolidate (4 RAs), Clean and Treat Offsite (1 RA)** (refer to Section 8.2.4 for complete discussion)
Overall Protection of Human Health and the Environment	**Low**	**Moderate to High**	**High**	**Moderate**
Compliance with ARARs	**Low**	**High**	**High**	**High**
Long-Term Effectiveness and Permanence *-Reliability of overall remedy* *-Adequacy of Controls* *-Magnitude of residual risk*	**Low**	**High**	**High**	**High**
Reduction of Toxicity, Mobility, or Volume through Treatment	**Low**	**Moderate**	**Moderate**	**Moderate**
Short-Term Effectiveness *-Time to achieve protection* *-Protection of the community, workers, and environment*	**Low**	**Moderate to High**	**High**	**Moderate**
Implementability *-Administrative Difficulty* *-Technical Challenges* *-Availability of Services*	**High**	**High**	**High**	**Moderate**
Cost Effectiveness[1]	**High**		**Moderate to High**	**Low**
Capital Cost	$0	$28.4M	$43.6M	$76.8M
Annual O&M Cost	$0	$513K	$602K	$547K
	$0	$32.7M	$47.2M	$81.6M

NPV Cost

Ranking: **High** = Good performance in the category. **Moderate** = Satisfactory performance in the category. **Low** = Unsatisfactory performance in the category.

[1] A high cost is <u>less</u> cost effective and is ranked Low. Conversely, a low cost is <u>more</u> "cost effective" and is ranked High.
All cost estimates are in 2009 dollars. NPV is based on 7% discount rate over 30-year period.

High

TABLE 8-2

DETAILED ANALYSIS SUMMARY – GROUNDWATER ALTERNATIVES
SUPPLEMENTAL FEASIBILITY STUDY REPORT
FMC Corporation, Pocatello, Idaho

EVALUATION CRITERION	**Groundwater Alternative 0: "No Action"** (refer to Section 8.3.1 for complete discussion)	**Groundwater Alternative 1: Institutional Controls, and Monitored Natural Attenuation** (refer to Section 8.3.2 for complete discussion)	**Groundwater Alternative 2A: Institutional Controls, LTM, Extract Groundwater at Property Boundary Using Wells for Hydraulic Control and Direct Discharge to POTW** (refer to Section 8.3.3 for complete discussion)	**Groundwater Alternative 2B: Institutional Controls, LTM, Extract Groundwater at Property Boundary Using Wells for Hydraulic Control, On-Site Treatment, and Discharge to Evaporation/ Infiltration Basin** (refer to Section 8.3.4 for complete discussion)
Overall Protection of Human Health and the Environment	**Low**	**Moderate**	**Moderate**	**Moderate**
Compliance with ARARs	**Low**	**Moderate**	**Moderate**	**Moderate**
Long-Term Effectiveness and Permanence *-Reliability of overall remedy* *-Adequacy of Controls* *-Magnitude of residual risk*	**Low**	**Moderate**	**Moderate to High**	**Moderate to High**
Reduction of Toxicity, Mobility, or Volume through Treatment	**Low**	**Low to Moderate**	**Moderate**	**Moderate**
Short-Term Effectiveness *-Time to achieve RAOs* *-Protection of the community, workers, and environment during the remedial action*	**Low**	**Moderate**	**Moderate**	**Moderate**
Implementability *-Administrative Difficulty* *-Technical Challenges* *-Availability of Services*	**High**	**High**	**Low to Moderate**	**Moderate to High**
Cost Effectiveness[1]	**High**	**High**	**Moderate**	**Moderate**
Capital Cost:	$0	$57K	$579K	$2.7M
Annual O&M Cost:	$0	$71K	$712K	$552K
NPV Cost:	$0	$960K	$9.6M	$11.2M

Ranking: **High** = Good performance in the category. **Moderate** = Satisfactory performance in the category. **Low** = Unsatisfactory performance in the category.

[1] A high cost is less cost effective and is ranked Low. Conversely, a low cost is more "cost effective" and is ranked High.
All cost estimates are in 2009 dollars. NPV is based on 7% discount rate over 30-year period.

Section 9
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the comparative analysis for alternatives that have undergone the detailed analysis in Section 8. In the detailed analysis, each alternative initially was ranked as high, moderate, or low in relation to the seven (7) EPA criteria excluding state and community acceptance. The nine (9) criteria again are:

Threshold Criteria. These are the criteria that each alternative *must* satisfy to be eligible for selection based on statutory requirements. Threshold criteria include:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs.

Balancing Criteria. These are the technical criteria upon which the detailed analysis is primarily based. Balancing criteria include:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost.

Modifying Criteria. These criteria are related to the acceptance of the remedial alternative by the public and regulatory agencies. These criteria are formally assessed after the public comment period; at which time, state/community support is factored into the selection of the preferred alternative. Modifying criteria include:

- State (Support Agency) Acceptance
- Community Acceptance.

The final two criteria, state and community acceptance, typically are evaluated following public review and comment on the FS Report and Proposed Plan. Because state and community acceptance are addressed after the FS Report has been completed, these criteria will not be discussed further here.

In the comparative analysis, the alternatives are evaluated against each other using each of the criteria above to determine their respective strengths and weaknesses and identify the key trade-offs that must be balanced for the site. Identification of the “preferred” alternative for both soil and groundwater is the outcome of the sections below.

9.1 SOIL ALTERNATIVES COMPARATIVE ANALYSIS

In this section the soil alternatives are compared to one another based on each of the threshold criteria and balancing criteria. The individual alternatives and their comparative rankings of high, moderate, or low under each criteria are presented in Table 8-1.

9.1.1 Threshold Criteria

9.1.1.1 Overall Protection of Human Health and the Environment

The "no action" soil alternative would meet none of the RAOs for the site. When combined with institutional controls (which would be required in all of the soil alternatives being compared), each of the soil Alternatives 2, 3, and 4will meet the soil RAOs developed for the site. Initially, Alternative 2 relies on institutional controls (i.e., enforceable land-use covenants) to meet the RAOs in RA-A, RA-G, and RA-J until such time of re-development in those RAs. Appropriate remedial actions would be implemented as part of and consistent with the re-development, ensuring that RAOs would be met after re-development. As stated in EPA's comments on the draft SFS Report, EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement. Therefore, soil Alternative 2 ranks slightly lower than Alternative 3. Alternative 4 ranks slightly lower than either Alternative 2 or 3 as this alternative involves the excavation of P4-contaminated soils/fill from RA-K. As described in Sections 5, 6, and 7, the greatest potential risks during the construction phase of the site remedial actions are: 1) P4 fire/phosphine/P4 reaction products exposures to the site remediation workers, and 2) P4 reaction product exposures to the public and the environment.

9.1.1.2 Compliance with ARARs

The no action alternative will not comply with ARARs and is thus ranked low. To the extent that the "no action" alternative does not meet RAOs or ARARs, the threshold criteria are not met, and thus further evaluation against the balancing criteria is not appropriate. Soil Alternatives 2, 3, and 4 will comply with ARARs.

9.1.2 Balancing Criteria

9.1.2.1 Long-Term Effectiveness and Permanence

Alternatives 2, 3, and 4 all use capping as the predominant remedial approach along with associated institutional controls. The caps are constructed of local earthen materials of varying thicknesses. All caps are engineered for comparable long-term effectiveness and performance as well as proper stormwater drainage. As such, no significant deterioration is expected to occur on any of the caps. Long-term O&M includes monitoring and repair as necessary to maintain long-term cap integrity. The remedial actions to be implemented in Alternative 2 at the time of re-development would be expected to have similar long-term effectiveness and permanence as those initially implemented in Alternatives 3 and 4. While Alternative 4 has a smaller cap footprint (given that RA-A and RA-K are excavated and consolidated rather than being capped), the reduction in capping area from Alternative 3 to Alternative 4 is 104.5 acres (458.8 acres vs. 354.5 acres, respectively). Therefore, all three of these alternatives are considered to have a comparable ranking for long term-effectiveness and permanence.

9.1.2.2 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 2, 3, and 4 all use capping as the predominant remedial approach along with associated institutional controls. Capping does not significantly reduce the toxicity or volume of COCs. All three alternatives are effective at reducing the mobility of COCs in soil by addressing the following: 1) soil (gamma caps) are effective at preventing exposure of receptors to gamma radiation and direct contact with COCs, 2) ET caps will minimize the migration of COCs into the groundwater, and 3) both types of caps are effective at preventing windblown dust from transporting COCs offsite. As a result, all three soil Alternatives 2, 3, and 4 are similarly ranked for the reduction of toxicity, mobility, and volume.

9.1.2.3 Short-Term Effectiveness

When combined with institutional controls (which would be included as a core element in all of the soil alternatives being compared), each of the soil Alternatives 2, 3, and 4 are effective in the short-term based on the various caps that would be installed throughout the site to limit exposure to COCs and institutional controls that would be (or have been) placed on the site. The time to construct the remedial actions (time to achieve protection) is slightly different within each soil alternative, for the following reasons: 1) remedial actions in Alternative 2 would not be constructed in RA-A, RA-G, and RA-J until re-development occurs (although there would not be commercial/industrial receptors in these areas until the time of re-development), and 2) Alternative 4 would require a longer construction due to the amount of material that would have to be removed and consolidated from RA-A, RA-J and RA-K.

As Alternative 4 requires the excavation/excavation of 22,000 yd^3 of P4-contaminated soil/fill from RA-K (with the potential risk of P4 fire/phosphine/P4 reaction products exposures) and the excavation/consolidation of 1.2 million yd^3 of slag, coke, and hydrocarbon-impacted soils from RA-A, the short-term potential for impacts to site remedial workers, public health and the environment is much higher than in Alternatives 2 and 3.

9.1.2.4 Implementability

The primary technology (capping and institutional controls) utilized in all three soil alternatives is a proven, straightforward remedy that is relatively easy to design and construct (both administratively and technically). Capping is a well-understood technology that is typically applied to the remediation of large mining and mineral processing sites with similar COCs (i.e., metals, radionuclides, and P4). Sources of soil and crushed slag are available on-site for cap construction. Engineering and construction services are also expected to be readily available.

However, soil Alternative 4 presents more significant technical challenges than soil Alternatives 2 or 3 for the following reasons:

1. The excavation/consolidation of RA-K involves the removal, storage, transport, and placement of 22,000 yd^3 of soil/fill adjacent to the northern FMC Plant Site boundary that has been demonstrated during the SRI to contain elemental P4. This process option presents significant technical challenges, as the excavation and handling of this much P4-contaminated material has not been successfully demonstrated.

2. The excavation/consolidation of RA-A involves the removal, transport, and placement of 1.2 million yd^3 of slag, coke, and hydrocarbon-contaminated soils. In order to contour the site for stormwater management and/or future land use, it is anticipated that a similar amount of clean fill would need to be placed back into RA-A. The sheer magnitude of this excavation/consolidation makes this process option significantly more technically challenging than placement of a soil cap over the area, which would require placement of approximately 166,000 yd^3 of soil.

9.1.2.5 Cost

Costs progressively escalate from Soil Alternative 2 to Alternative 4. Total present worth cost for the soil alternatives are:

- Soil Alternative 2 - $32.7M
- Soil Alternative 3 - $47.2M
- Soil Alternative 4 - $81.6M.

This *SFS Report* has determined net present worth (or present value) costs for 30 years at a 7 percent discount rate with an accuracy of +50 and -30 percent, consistent with the EPA guidance document entitled *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000).

9.1.3 Summary and Recommendation

Based on the comparative analysis presented above, Soil Alternative 2 is the recommended soil remedy for the FMC Plant OU. This soil alternative will be combined with the groundwater alternative that is selected below for implementation at the site.

The three soil alternatives compared within this analysis share a significant number of process options, including:

- Soil (gamma) caps on areas that pose only a risk of exposure to gamma radiation or direct contact with metals and/or radionuclides. These areas do not pose a threat to groundwater.
- ET caps on areas that also pose a threat to groundwater and/or are known or suspected of containing P4.
- Application of core elements which include: institutional controls, soil/fill management, cap integration, monitoring, and maintenance, stormwater management, fugitive dust control, and groundwater monitoring.

Therefore, the comparative analysis focuses on the difference between the three soil alternatives as discussed in the following subsections.

9.1.3.1 Remediation Area A (RA-A))

RA-A consists of 103 acres immediately south of the northern FMC Plant Site boundary (Highway 30) and north of the historical and RCRA ponds (RA-C and RA-D). The predominant fill material is slag with lesser amounts of concrete, asphalt, silica, coke, and ferrophos, and hydrocarbon-contaminated soils. Slag was originally placed on the area to provide a stable, flat surface that was amenable to heavy traffic, an road asphalt plant, and equipment storage. During the SRI, surface gamma scans, soil borings, and associated soil samples indicated that the only unacceptable risks identified were to future hypothetical site workers from gamma radiation (over the entire RA-A area) as well as direct contact with coke and/or soils contaminated with hydrocarbons (both relatively small areas within RA-A).

<u>Soil Alternative 2</u>: In soil Alternative 2, no active remediation is undertaken until site re-development is determined. As this area borders highway 30, is large and flat, and has railway access (including numerous rail spurs), RA-A is considered to be a likely candidate for imminent re-development. This area also is currently covered by a covenant prohibiting residential use and will be covered by additional enforceable land-use covenants that expand the use prohibitions (and therefore exposure risks). The re-development cannot occur until re-development plans (and associated remedial actions consistent with the proposed land use) are reviewed and approved by EPA to become part of the overall selected CERCLA site remedial action. Examples of potential re-development include:

- A parking lot to support the Pocatello Regional Airport. The parking lot would be designed in a manner that meets the technical requirements of a gamma cap (i.e., protects against gamma radiation and direct contact with metals, radionuclides, coke PAHs, and fuel PAHs).

- A car dealership. The dealership lot would again be designed in a manner that meets the technical requirements of a gamma cap.
- A solar panel or wind-generator site. The majority of the land space would be utilized for solar panels or wind generators which would require little operator attention (just a few hours per week). Operators would normally remain within a control building designed to prevent gamma radiation exposure or direct contact with metals, radionuclides, coke PAHs or fuel PAHs.

In these examples, immediate remedial action (beyond institutional controls) within RA-A would not be necessary to provide an acceptable level of protection, and may well inhibit the beneficial future development of the area.

Soil Alternative 3: In soil Alternative 3, RA-A is covered with a soil cap and incorporates land-use covenants for soil management and protection of the soil cap. The soil cap would be designed to limit gamma radiation exposure as well as direct contact with metals, radionuclides, coke PAHs, and soil contaminated with hydrocarbon-PAHs. While area re-development could still be realized, a soil cap would likely not meet the surface requirements of each and every potential future development. Therefore, additional soil covers, contouring, etc. would be required. Therefore, remedial actions would not be as efficient as in soil Alternative 2. The cost of place a soil cap on RA-A would be approximately $2.5M, without an overall significant increase in protectiveness.

Soil Alternative 4: In soil Alternative 4, RA-A approximately 1.2 million yd^3 of soil/fill is excavated down to un-impacted native soils (from 1 to 18 feet from the current ground surface) using conventional excavation. This material is placed under a cap within another RA, likely as cap construction materials. In order to bring the surface elevation back to original grade and to meet stormwater management requirements, a similar volume of clean fill would be required be placed back into RA-A. The cost to perform this excavation/consolidation in RA-A is approximately $27.5M, without an overall significant increase in protectiveness.

9.1.3.2 Remediation Areas F1 and F2 (RA-F1 and RA-F2)

RA-F1 consists of about 2.7 acres and is located near the center of the slag pile (RA-F which has a total of 171acres). RA-F1 contains 21 railcars containing an estimated 10 to 25% P4 sludge covered with 80 to 120 feet of slag. RA-F2 consists of about 20 acres and is located within the southwestern corner of the slag pile and contains the historic plant landfill. Landfill operations within this area began at the inception of plant operations in 1949 and ceased in 1980. Wastes placed in the landfill included slag, office wastes (consisting of office and lunchroom solid wastes), industrial wastes (consisting of asbestos, spent solvents, oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes, and AFM) furnace rebuild/digout wastes (consisting of furnace feed materials, carbon materials, concrete, rocks, and debris), IWW sediments, and baghouse dust. This former landfill is covered by 50 to 120 feet of slag.

Soil Alternative 2: In soil Alternative 2, RA-F1 and RA-F2 remain buried within the slag pile, but are covered with a 1-foot soil (gamma) cap that extends over the entire RA-F. A soil cover is believed to be appropriate here because the primary threat at the surface is from gamma radiation and there is a considerable layer of slag overlying the railcars and historic landfill. Because of the thick layer of coarse material (50 to 120 feet of slag), leaching of COCs is considered unlikely once it is covered by a vegetated soil cover.

Soil Alternatives 3 and 4: In soil Alternatives 3 and 4, RA-F1 and RA-F2 remain buried within the slag pile, but are covered with an ET cap that is integrated into the soil (gamma) cap that extends over the rest of RA-F. While an ET cap is typically considered a superior cap for prevention of infiltration of precipitation into underlying wastes, a soil cap is considered to be generally comparable for infiltration reduction in this instance given the 50 to 120 feet of overlying slag. The cost of placement of an ET cap on RAs – F1 and F2 would be approximately $2.0M, without an overall significant increase in protectiveness.

9.1.3.2 Remediation Area J (RA-J)

RA-J consists of two small, non-contiguous parcels with a total of 15 acres that straddle the I-86/West Pocatello Road interchange immediately north of the northeastern corner of the FMC Plant Site. This property was never used as part of the FMC P4 manufacturing operations, but did accumulate deposits of wind-blown dust, primarily from former FMC and historic J.R.Simplot Company dry ore handling operations. SRI sampling has shown the contamination to be shallow (0 to 2 inches).

Soil Alternative 2: In soil Alternative 2, no active remediation is undertaken until site re-development is determined. As this area straddles an interchange, is small and in two pieces, it has only a limited potential for re-development. This area also is currently covered by a covenant prohibiting residential use and will be covered by additional enforceable land use covenants that expand the use prohibitions (and therefore further reduce the exposure risks). The re-development cannot occur until re-development plans are developed and EPA reviews and approves associated additional remedial action under the overall CERCLA site remedial action. Examples of potential re-development are small commercial operations or transportation-related retail.

Soil Alternatives 3 and 4: In soil Alternatives 3 and 4, RA-J is excavated (or tilled) down to 6 inches using conventional excavation, with the removed soil transported to the FMC Plant Site for use in construction of a cap(s). The area after excavation is expected to meet all of the commercial/industrial RAOs, allowing any type of commercial development (excepting child-care or schools). The cost of excavation/consolidation at RA-J would be approximately $375K.

9.1.3.3 Remediation Area K (RA-K)

RA-K consists of a narrow, 1.3 acre parcel on the northern FMC Plant Site boundary that lies immediately south of and adjacent to the Union Pacific railroad tracks. RA-K was used for stormwater retention, but also received an intermittent flow of phossy water, known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. In 1993, an approximately 30 foot wide by 330 foot long segment of the railroad swale, beginning just west of the western storm drain pipe, was lined with 30-mil PVC to reduce infiltration in that area of the swale. Trenching during the SRI indicated low-levels of P4 still exist at a depth interval of approximately 8 to 10 feet bgs.

Soil Alternatives 2 and 3: In soil Alternatives 2 and 3, RA-K is covered with an ET cap to prevent migration of metals and radionuclides from precipitation infiltration, exposure to gamma radiation, and direct contact with metals, radionuclides and P4.

Soil Alternative 4: In soil Alternative 4, RA-K is excavated down to approximately 10 feet using modified excavation, with the removed soil (approximately 22,000 yd^3) transported to one of the RA designated for an ET cap and which is expected to already contain P4 in the subsurface (e.g., RA-B). Once excavated, RA-K would be backfilled with 22,000 yd^3 of soil. While the excavation of RA-K would remove soil contaminants, this area is too small and too close to the Union Pacific railroad tracks to be considered for future re-development use (except for continued use as a stormwater retention pond). Proximity to the Union Pacific rail tracks also complicates excavation logistics and may impose restraints should this alternative be selected. Also, as described in Sections 5, 6, and 7, the greatest potential risks during the construction phase of the site remedial actions are: 1) P4 fire/P4 reaction products exposures to the site remediation workers, and 2) P4 reaction product exposures to the public and the environment. Under the current three alternatives being compared, only Alternative 4 involves an excavation of P4-contaminated material (from RA-K), using modified excavation technology that has not been demonstrated. The cost of excavation/consolidation at RA-K (assuming it can be accomplished) would be approximately $186K.

9.2 GROUNDWATER ALTERNATIVES COMPARATIVE ANALYSIS

In this section the groundwater alternatives are compared to each other using each of the seven EPA criteria. The individual alternatives and their comparative rankings of high, moderate, or low under each criteria is presented in Table 8-2.

FMC developed a groundwater flow and transport model to support the SFS (*Groundwater Model Report*, Appendix E). The primary purpose of the groundwater flow and contaminant transport model for the FMC Plant OU was to compare the fate of groundwater contaminants under the proposed SFS groundwater remedial alternatives. Over the course of the FMC groundwater model project, FMC convened five meetings with EPA, IDEQ, and the Tribes to engage the agencies in the planning, development, and preliminary results of this modeling effort. The results from the model predictive runs for the groundwater alternatives are summarized below:

- Simulation of Alternative 1 indicated that the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would be reduced by 26 percent over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (above background levels) would be reduced by 62 and 51 percent over 100 years, respectively, under Alternatives 1. RAOs were not met within 100 years under this alternative.

- Simulation of Alternative 2 indicated that the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l contour) would be reduced by 28 percent over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (as defined by their respective background levels) would be reduced by 64 and 56 percent over 100 years, respectively, under Alternative 2. RAOs were not met within 100 years under this alternative.

- Simulation of Alternative 3 indicated that the areal extent of arsenic in groundwater within the FMC Plant Site (as defined by the 0.01 mg/l) would be reduced by 37 percent over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (as defined by their respective background levels) would be reduced by 79 and 65 percent over 100 years, respectively, under Alternative 3. RAOs were not met within 100 years under this alternative.

- Sensitivity analysis indicated that the transport model was most sensitive to uncertainty in sorption coefficients. Therefore, additional predictive simulations were run in which these coefficients were halved and doubled. Even with these lower sorption coefficients, RAOs were not met for any of the groundwater constituents within 100 years.

As described in sections 7 and 8, the model simulation results for Groundwater Alternatives 1, 2 and 3 provide useful insight into the predicted short and long-term effectiveness and relative (comparative) performance of the alternatives. The model simulations predict that none of the alternatives will achieve the groundwater restoration RAO within the 100 year modeled period;the results of the current FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO.

9.2.1 Threshold Criteria

9.2.1.1 Overall Protection of Human Health and the Environment

The No Action groundwater alternative would meet *none* of the RAOs for Site groundwater. The source controls (e.g. capping), institutional controls, and long-term monitoring under Alternatives 1 and 2A/B meet two of three groundwater RAOs for protection of human health and the environment by:

- Preventing the ingestion of contaminated groundwater through institutional control; and
- Reducing/ eliminating the release of COCs from identified sources by source controls implemented under the soil remediation program.

The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternative 2A/B are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's northern properties in a 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy. Simplot has performed mass loading calculations and estimates that FMC-impacted groundwater migrating downgradient from the FMC Plant Site northern boundary accounts for less than 5 percent of the total arsenic and total phosphorus mass load to EMF-impacted groundwater migrating to the river, as reported in the report entitled *Groundwater Extraction and Monitoring System Remedial Design Report* (Simplot, 2009). Although EPA has not approved the Simplot mass loading calculation, EPA's Interim Amendment to the ROD for the Simplot Plant OU states that EPA believes Simplot is a significantly larger contributor (of phosphorus to the River) than FMC.

Alternative 2A/B is predicted to incrementally reduce the areal extent of groundwater exceeding the arsenic MCL on the FMC Plant Site by 2 percent and 9 percent respectively compared to Alternative 1 (see Table 7-7). The groundwater modeling predicts that none of the alternatives will achieve the RAO for groundwater restoration beneath the FMC Plant Site in a reasonable time frame (within 100 years).

9.2.1.2 Compliance with ARARs

Groundwater Alternative 0 (No Action) will *not* comply with the groundwater ARARs. Alternatives 1 and 2A/B would comply with the Safe Drinking Water Act ARAR by preventing use (receptor contact) of contaminated groundwater above MCLs through institutional controls. The source controls under Alternatives 1 and 2A/B support meeting groundwater quality ARARs by reducing or eliminating future release of site COCs to groundwater. However, the groundwater model predicts that none of the alternatives will fully comply with the groundwater quality ARARs beneath the FMC Plant Site within a reasonable timeframe.

9.2.2 Balancing Criteria

9.2.2.1 Long-Term Effectiveness and Permanence

In the long-term, the No Action Alternative does not prevent potential future exposure to (consumption) of impacted groundwater or reduce the release or potential release of source area COCs to groundwater.

As described above in Section 9.2.1.1, the source controls (e.g. capping), institutional controls, and long-term monitoring under Alternatives 1 and 2A/B will be effective in the long term by:

- Preventing the ingestion of contaminated groundwater through institutional control; and
- Reducing/ eliminating the release of COCs from identified sources by source controls implemented under the soil remediation program.

The hydraulic containment wells at the FMC Plant Site northern property boundary under Alternatives 2A/B are predicted to achieve restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's northern properties in a 25 to 50 year timeframe. However, achieving groundwater restoration downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy.

Alternative 2A/B is predicted to incrementally reduce the areal extent of groundwater exceeding the arsenic MCL on the FMC Plant Site by 2 percent compared to Alternative 1 (see Table 7-7). The groundwater modeling predicts that none of the alternatives will achieve the RAO for groundwater restoration beneath the FMC Plant Site in a reasonable time frame (i.e., within 100 years).

9.2.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

The No Action Groundwater Alternative does not address this criterion. Alternative 1 reduces/eliminates release and migration (i.e., mobility) of COCs from the source areas to underlying groundwater by implementing source controls. In addition to source controls, Alternatives 2A/B hydraulically contain impacted groundwater from migrating downgradient from the FMC Plant Site northern property boundary and reduce the volume of site-impacted groundwater. However, Alternative 2A/B is predicted to take 25 to 50 years to restore groundwater downgradient from the FMC Plant Site and beneath FMC's northern properties and, over the 100 year simulation, incrementally reduce the areal extent of groundwater exceeding the arsenic MCL by 2 percent and reduce the residual mass of arsenic by 1 percent beneath the FMC Plant Site compared to Alternative 1, both of which limit the benefit of Alternative 2A/B.

9.2.2.3 Short-Term Effectiveness

The No Action Groundwater Alternative is not effective in the short term. Alternative 1 is effective in the short-term at preventing access to (exposure to) impacted site groundwater through institutional controls and reducing/eliminating release and migration (i.e., mobility) of COCs from the source areas to underlying groundwater by implementing source controls. The time-frame for implementation of Alternative 1 will be dependent on the selected soil (source control) remedy, but the institutional controls and LTM could be implemented essentially immediately following EPA approval of the Remedial Design and Remedial Action Work Plan.

In addition to the short-term effectiveness of source and institutional controls, Alternative 2A/B hydraulically contains impacted groundwater at the FMC Plant Site northern property boundary. However, Alternative 2A/B restoration of groundwater downgradient from the FMC Plant Site and beneath FMC's northern properties is predicted to take 25 to 50 years, which limits its short-term effectiveness. The short-term risks associated with Alternative 1 would be the same as those associated with the selected soil (source control) remedy. As for Alternative 1, the time-frame for implementation of Alternative 2A/B will be dependent on the selected soil (source control) remedy, but the institutional controls and LTM could be implemented essentially immediately following EPA approval of the Remedial Design and Remedial Action Work Plan. The final design of Alternative 2A/B will require additional confirmation of hydrogeologic parameters in the extraction zone. Alternative 2A will require additional negotiations with the Pocatello POTW to determine the feasibility / discharge permit conditions. Alternative 2B will require detailed design of the treatment system and percolation ponds. Alternative 2A/B would take a relatively short time (within the same time frame as the source controls) to construct and begin operation depending on the complexity of the system. The construction and operation of Alternative 2A/B would present little risk to the community, the workers, or the environment compared to Alternative 1.

9.2.2.4 Implementability

The No Action alternative is the easiest to implement under this criterion. Alternative 1 also is relatively easy to implement both administratively and technically consistent with relative implementability of the selected soil (source control) remedy. Alternative 2B is also relatively easy to implement both technically and administratively, again consistent with relative implementability of the selected soil (source control) remedy. Alternative 2A is more difficult to implement both technically and administratively because of uncertainties regarding the treatment system necessary and ability to obtain a permit to discharge to the Pocatello POTW.

9.2.2.5 Cost

There are no costs associated with the No Action Alternative. Alternative 1 includes source controls, which are implemented under the soil remediation program (costs not included in the groundwater alternative estimates) and institutional controls. There would be an annual O&M costs associated with long term groundwater monitoring that would be applied to each of the alternatives because LTM would be a requirement to monitoring groundwater trends.

The Alternative 2A/B options are significantly higher cost to implement than Alternative 1. Alternative 2A has lowest lower NPV cost because the extracted groundwater is treated directly at the POTW without construction of and pretreatment at the facility located on site. The NPV cost of Alternative 2B is more than 2A primarily because of capital costs associated with construction of an onsite groundwater treatment facility and an on-site infiltration basin. O&M costs under Alternative 2A are mostly for POTW disposal fees and these costs are higher than the Alternative 2B O&M costs.

Total present worth cost for the groundwater alternatives are:

- Groundwater Alternative 0 - $0
- Groundwater Alternative 1 - $960K
- Groundwater Alternative 2A - $9.6M
- Groundwater Alternative 2B - $11.21M

9.2.3 Summary and Recommended Groundwater Alternative

Based on the comparative analysis presented above, Groundwater Alternative 1 is the recommended groundwater remedy for the Site. This groundwater alternative will be combined with the soil alternative that is selected in Section 9.1 for implementation at the Site.

Groundwater Alternative 1 is recommended for the following reasons:

- Alternative 1 meets two of the three RAOs for groundwater by: 1) Preventing the ingestion of contaminated groundwater through institutional control and 2) reducing / eliminating the release of COCs from identified sources by source controls. When combined with the selected soil remedy, this alternative will minimize release and migration of COCs from the identified sources and minimize the potential for further degradation of the groundwater (i.e., limit the mobility of COCs from the sources) and the levels of COCs in groundwater will attenuate (decline) over time.
- None of the alternatives are predicted to achieve the third groundwater RAO of restoration of groundwater to levels below MCLs within a reasonable time frame. In addition, Alternative 2 A/B is predicted to yield a small incremental reduction (approximately 2 percent) in the areal extent of arsenic above the MCL and approximately 1 percent decrease in arsenic mass in groundwater beneath the FMC Plant Site in 100 years compared to Alternative 1.
- Alternative 1 and 2A/B are essentially equivalent with respect to compliance with ARARs. None of the alternatives is predicted to achieve reduction of the arsenic impacted groundwater to levels below the MCL within a 100 year timeframe.
- Alternative 2A/B is predicted to provide a higher degree of long-term effectiveness through hydraulic containment at the FMC Plant Site northern property boundary than Alternative 1. However, Alternative 2A/B is predicted to take 25 to 50 years to restore groundwater downgradient from the FMC Plant Site and beneath FMC's northern properties. Achieving groundwater restoration further downgradient in the area where FMC and Simplot-impacted groundwater discharges to the Portneuf River is highly dependent on the success of the Simplot groundwater remedy. Simplot has performed mass loading calculations and estimates that FMC-impacted groundwater migrating downgradient from the FMC Plant Site northern boundary accounts for less than 5 percent of the total arsenic and total phosphorus mass load to EMF-impacted groundwater migrating to the river (Simplot, 2009). As stated above, Alternative 2A/B yields a small incremental reduction in the areal extent of the arsenic plume beneath the FMC Plant OU.
- Alternative 1 ranks higher than the other alternatives based on implementability and cost. Alternative 1 is the most easily implemented alternative (excluding the No Action alternative) and is of a significantly lower cost.

As described above, a TI Waiver will likely be necessary prior to a final groundwater remedy decision for the FMC Plant OU groundwater remedy. Alternative 1 is appropriate as an interim groundwater remedy since, in the short-term, the greatest risk reduction is achieved through implementation of the institutional controls and source control (soil remedial alternative) measures. The LTM program would be established to evaluate the performance of the source control measures and continue monitoring groundwater quality at the site. During the Remedial Design, Remedial Action Work

Plan development and implementation of the soil remedy (and associated addition of monitoring wells for source control performance monitoring), additional geologic and hydrogeologic information will be gathered that could 1) support and/or refine the groundwater modeled prediction and 2) more fully support a TI evaluation. Based on the additional information gathered during interim implementation of Alternative 1, Alternative 2A/B would be preserved as a "contingent" groundwater remedy should new information come to light that the source control actions are not performing as predicted or a refined evaluation predicts that Alternative A/B would be capable of achieving groundwater restoration within a reasonable time frame.

Section 10
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