FMC Idaho LLC, Pocatello, Idaho

Supplemental Remedial Investigation Work Plan for the FMC Plant Operable Unit

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Supplemental Remedial Investigation
and Supplemental Feasibility Study
for the FMC Plant Operable Unit

WORK PLAN

for the Supplemental Remedial Investigation:
FMC Plant Operable Unit

FMC Idaho LLC
Pocatello, Idaho

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5-1 Data Deliverable Requirements

ACRONYMS/ABBREVIATIONS

µg/kg	micrograms per kilogram
µR/hr	microrem per hour
µg/kg	microgram per kilogram
1,1,1-TCA	1,1,1-Trichloroethane
AOC	Administrative Order of Consent
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BAPCO	Bannock Paving Company]
bgs	below ground surface
bns	below native surface
BTEX	benzene, toluene, ethylbenzene, xylene
ºC	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	calibration factor
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CO	carbon monoxide
COC	constituent of concern and chain of custody
COD	coefficient of the determination
COPC	constituent of potential concern
cpm	counts per minute
CSM	Conceptual Site Model
CV	comparative value
DAF	dilution attenuation factor
DEM	Digital Elevation Model
dpm	disintegrations per minute
DQA	Data Quality Assessment
DQO	data quality objective
EDD	Electronic Data Deliverable
EMF	Eastern Michaud Flats
EPA	Environmental Protection Agency
FMC	FMC Corporation
FSP	field sampling plan
ft	feet
FU	flux units

g	gram
GC	gas chromatograph
GC/NPD	gas chromatograph/ nitrogen phosphorus detector
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCL	hydrochloric acid
Hg	mercury
HHRA	Human Health and Risk Assessment
HQ	hazard quotient
hr	hour
HRGS	high resolution gas chromatograph
HRMS	high resolution mass spectrometry
ICP	inductively coupled plasma
ICR	incremental cancer risk
IDEQ	Idaho Department of Environmental Quality
IDW	investigation derived waste
ISE	ion-selective electrode
IWW	industrial waste water
K-40	potassium-40
keV	kilo electron volt
km	kilometer
LCS	laboratory control sample
LDR	land disposal restriction
m	meter
MCA	mulit-channel analyzer
MCL	maximum contaminant level
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
MS	mass spectrometer
MWH	MWH Americas, Inc.
NA	not applicable
NaI	sodium iodide
NCP	National Contingency Plan
NFA	No Further Action

NIST	National Institute of Standards and Technology
NORM	naturally occurring radioactive materials
NPD	nitrogen/phosphorus detector
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OU	operable unit
P4	elemental phosphorus
PAH	polynuclear aromatic hydrocarbon
Pb-210	lead-210
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi	picoCuries
pCi/m^2-sec	picoCuries per square meter per second
PIC	pressurized ionization chamber
PID	photoionization detector
Po-210	polonium-210
PPE	personal protective equipment
Precipitator Dust	phossy solids, phossy wastes, precipitator slurry
PWTP	Phossy Waste Treatment Plant
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Ra-226	radium-226
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RF	response factor
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Managers
RSD	relative standard deviation
RU	remediation unit
SC	study constituents
SD	standard deviation
SDG	Sample Deliver Group
SFS	Supplemental Feasibility Study
SOP	Standard Operating Procedures

SOW	Statement of Work
SRI	Supplemental Remedial Investigation
SSL	soil screening level
SVOC	semivolatile organic compounds
SWMU	solid waste management unit
TCE	trichloroethene
TCLP	toxicity characteristics leaching procedure
TIP	Technology Innovation Program
TISAB	total ionic strength adjustment buffer
TPH	total petroleum hydrcarbons
U-238	uranium-238
UMTRCA	Uranium Mill Tailings Radiation Control Act
USEPA	United States Environmental Protection Agency
VOA	volatile organic analysis
VOC	volatile organic compound
VSP	Visual Sampling Plan
Work Plan	Supplemental Remedial Investigation Work Plan

Section 1
INTRODUCTION AND PROGRAM MANAGEMENT

This Supplemental Remedial Investigation (SRI) Work Plan describes the data collection activities and documents the rationale, methods, quality criteria and data uses for the SRI of the FMC Corporation (FMC) Plant operable unit (OU). The SRI activities will be conducted upon U.S. Environmental Protection Agency (EPA) approval of this Work Plan. This document has been prepared to meet the requirements of Tasks 2.1 and 2.1.1 of the Statement of Work (SOW, 2003). These tasks are:

- Task 2.1: Prepare a Work Plan for the Supplemental Remedial Investigation, and
- Task 2.1.1: Prepare a Sampling and Analysis Plan (SAP).

The FMC Plant OU is a part of the larger Eastern Michaud Flats (EMF) Superfund Site, and is located in southeastern Idaho, approximately 2.5 miles northwest of Pocatello, Idaho. The EMF site was listed on the National Priorities List (NPL) on August 30, 1990. The EMF site includes two adjacent phosphate production facilities, the FMC Plant OU and the J.R. Simplot "Don" Plant (Figure 1-1), and encompasses the areal extent of contamination at both plants and impacted off-plant areas as identified in the Remedial Investigation (RI) for the EMF site (BEI, 1996). 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 was an operating manufacturing plant when EPA selected a remedy for the FMC Subarea of the EMF site in 1998. The 1998 Record of Decision (ROD; USEPA, 1998) assumed that the most likely future land use at the FMC Plant OU was continued industrial use, with the company operating its facility and controlling exposures to hazardous substances, pollutants, and contaminants in accordance with environmental requirements applicable to ongoing manufacturing operations.

Phosphate ore processing at the FMC Plant OU ceased in December 2001 and its potential future industrial or commercial redevelopment has led FMC and EPA to initiate the Supplemental Remedial Investigation/Supplemental Feasibility Study (SRI/SFS). This additional work will allow EPA to ensure that cleanup requirements are appropriate to the current status of the FMC Plant OU and compatible with its potential future commercial/industrial use.

1.1 PROGRAM/TASK ORGANIZATION

This subsection presents an overview of the SRI organization.

1.1.1 Project Team Organization

The SRI project team organization is shown on Figure 1-2. Contact information for key personnel is presented in Table 1-1. The responsibilities of key program personnel are as follows.

1.1.1.1 FMC Associate Director

The FMC Associate Director, Ms. Barbara Ritchie, is responsible for overall program execution and quality and has overall responsibility for the execution of the SRI, including the implementation of the work described in this document. The FMC Associate Director is ultimately responsible for the quality of the data collected and the interpretations based upon these data that will be presented in the SRI Report.

1.1.1.2 FMC Project Manager

The FMC Project Manager, Mr. James Sieverson, is responsible for managing all activities of the SRI that are associated with the field work, laboratory, data management, and data interpretations/presentations. The FMC Project Manager ensures that contracts are in place to provide required analytical support, execute field data collection, perform laboratory analyses and data management, and to prepare the SRI Report.

1.1.1.3 SRI Project Manager

The SRI Project Manager, Mr. Marc Bowman of MWH Americas, Inc. (MWH), manages the contractor and subcontractor personnel performing field activities. The SRI Project Manager is responsible for staffing and execution of field activities and the preparation of the SRI Report.

1.1.1.4 Quality Manager

The Quality Manager, John Garr of MWH, is responsible for maintaining the quality assurance (QA) process and supervising any audit of the project for compliance with program procedures and specifications. The Quality Manager has the authority to suspend site or project activities if quality standards are not maintained. Additional responsibilities include reviewing, monitoring, auditing, and evaluating sampling activities and laboratory performance associated with the SRI. The Quality Manager is responsible for the quality of data gathered and conducts oversight to verify that the work procedures and project specifications required under this Work Plan are met.

1.1.1.5 Data Verification

Independent data verification for all data generated during the SRI will be performed by Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California. The LCD project manager will be Ms. Linda Rauto. LCD will assure that analytical data meet the QC requirements specified in this Work Plan. While LDC will work closely with the Quality Manager and Data Administrator to obtain the information needed to conduct the data verification, LDC it will be directly accountable to the FMC Associate Director and will make its determinations using its independent professional judgment.

1.1.1.6 Data Administrator

The Data Administrator, Mr. Ken Moosman of MWH is responsible for compiling, updating, and maintaining an electronic database of all SRI/SFS analytical data, field measurements, and associated data validation information.

1.1.1.7 Analytical Laboratory Managers

The Analytical Laboratory Managers are responsible for managing all day-to-day analytical activities, and developing laboratory analytical reports in a timely manner. Individual Analytical Laboratory Managers will be identified once laboratories are subcontracted for the analytical work. The person responsible for management of the analytical laboratories is Mr. Craig Moore of MWH.

1.1.1.8 Field Sampling Team Members

Field sample collection will be led by the SRI Field Sampling Team Leader, Ms. Leah Wolf Martin of MWH, and will be performed by qualified field personnel. The SRI Field Sampling Team Leader and the field personnel are responsible for implementing the field activities of the SRI Work Plan, under the supervision and direction of the SRI Project Manager and the FMC Project Manager.

1.1.1.9 Risk Assessor

Hanna Associates, Inc. is responsible for risk assessment, including modeling and evaluation of data collected in support of this Work Plan. Mr. Nick Gudka is the primary contact.

1.1.1.10 Data Users

The SRI data will be used by the following:

- EPA – The EPA provides federal regulatory oversight. The EPA Region 10 Remedial Project Manager (RPM) for the FMC SRI/SFS is Ms. Linda Meyer.

- State of Idaho – The State of Idaho Department of Environmental Quality (IDEQ) oversees activities with respect to environmental compliance at the portions of the FMC Plant OU that are located outside the boundaries of the Fort Hall Indian Reservation. The point of contact is Mr. Douglas Tanner, Regional Environmental Manager.

- Shoshone-Bannock Tribes – The Environmental Waste Management Program Manager for the Shoshone-Bannock Tribes is Mr. Kelly Wright.

All personnel will be responsible for identifying problems that may arise in the collection and reporting of program data and for overseeing the implementation of the necessary corrective actions. Personnel will inform the Analytical Laboratory Managers and Quality Manager of any such problems and corrective actions. The Quality Manager tracks, reviews, and verifies the effectiveness of the corrective actions.

1.1.2 Regulatory Oversight

EPA Region 10 personnel approve decisions and recommendations presented in all project reports and monitor the progress of the work. EPA coordinates with IDEQ and the Shoshone-Bannock Tribes with respect to project oversight.

1.2 PROBLEM DEFINITION/BACKGROUND

As identified in the RI (Remedial Investigation) Update Memorandum (BEI, 2004b), there are data gaps at specific remediation units (RUs) within the FMC Plant OU with respect to exposures that could occur under future commercial/industrial use of the property. These RUs largely consist of the former plant operating areas. Data gathered during the SRI will be incorporated into the existing RI data set. The combined data set will then be evaluated to determine whether changes to the remediation visions documented in the RI Update Memorandum (BEI, 2004b) and summarized in Table 1-2 are needed. Specifically, the SRI data will be used to support a decision as to whether or not further action is needed at some RUs and to establish the scope of the SFS.

Based on the work performed in the RI Report (BEI, 1996) and the RI Update Memorandum (BEI, 2004b), a Remediation Vision was developed for each RU to facilitate scoping and planning, based upon information available at the time, while remaining consistent with the 1998 ROD. It is recognized that data collected during the SRI and the subsequent outcome of the risk assessment could lead to a change in the Remediation Visions. Therefore, if the new data collection activities, based on either visual or laboratory data, determine that the no action anticipated to be necessary designation (also referred to as no further action anticipated to be necessary or NFA) is no longer appropriate, then the area will be carried forward to the SFS. However, in the event that all of the measurements associated with an RU support the no action anticipated to be necessary Remediation Vision (e.g., all values for COCs and COPCs are less than the applicable comparative values [CVs]), then the Remediation Vision will have been verified and no further action is anticipated to be necessary, pending final risk management decisions.

It is recognized that in several RUs with a Remediation Vision of no further action as established in the RI Update Memorandum (BEI, 2004b), investigations have been designed with the presumption that remedial actions for a portion of the RU will be required. For example, cap delineation studies will require sampling in the following RUs, which may result in the extension of a cap into a no further action (NFA) RU:

- RU 9 as a result of the cap delineation for RU 8 that will extend the cap to the RU 9 kiln overflow pond;

- RUs 12, 13, 20 and 24 as a result of the cap delineation for RU 22b that will extend the cap to the identified subsurface pond solids in those RUs.

FMC recognizes the potential inconsistency between the presumption of a remedial action and the NFA Remediation Vision. However, to date, there have been no SRI data collection activities that would require or suggest a change in the Remediation Vision. Therefore, this SRI Work Plan will continue to identify NFA Remediation Visions until SRI data are collected that require or suggest a change. FMC proposes that this evaluation and review will be performed with the agencies at the appropriate time in the SRI process (e.g., after the initial gamma scan). At that time FMC and the agencies can determine whether it is more appropriate to redraw RU boundaries, or create subareas within an NFA RU that would require remedial action.

This Work Plan describes data quality objectives (DQOs) for each RU, details the tasks that will be conducted to address these objectives, and defines the necessary sampling program and data collection and analysis requirements for each type of measurement to ensure that the objectives are met. Section 2 details the SRI approach and DQOs. Table 1-2 summarizes the work to be performed during the SRI. Additional details on the SRI characterization methods are presented in Section 3 and Appendix A.

Background information is summarized in the following subsections to provide a context for and to support the proposed SRI activities. Background information includes site description, physical setting, history, and previous investigations. An overview of the SRI data collection concepts is also provided to summarize the various purposes for which data will be generated during the investigation. General information on the SRI radiological assessment, including rationale for the radiological parameters and recommended methods for measurement, is also provided because the proposed SRI radiological assessment differs somewhat from that previously discussed during Agency meetings following submittal of the RI Update Memorandum (BEI, 2004b). The adjustments in the approach presented herein are the result of the iterative DQO process. The SRI radiological assessment approach included in this SRI Work Plan is consistent with the approach presented during the Agency meeting on February 7, 2006. Information is also provided on the assessments to be performed for chemical constituents.

1.2.1 Site Description

A more detailed description of the FMC Plant OU can be found in the RI Update Memorandum (BEI, 2004b). Table 1-3 presents a description of the facilities and conditions within each RU. The boundaries of the RUs are shown on Figure 1-3. Figure 1-4 is a Digital Elevation Model (DEM) of the FMC Plant OU.

The terrain is generally flat for several miles from the southwest, clockwise through north-northeast of the Simplot facility. East of Pocatello, the Pocatello Mountain Range rises from about 4,400 feet to about 6,500 feet above mean sea level. Southeast of the FMC and Simplot facilities is the city of Pocatello, located in the funnel-shaped Portneuf River Valley. The valley virtually closes at the southern end of Pocatello.

The north end of the Bannock Range is just south of the FMC Plant OU. The Bannock Range and Michaud Flats meet along an escarpment that runs east-west through the FMC Plant OU. Within the FMC Plant OU, the slag pile covers this feature. However, it is evident in the western portion of the FMC Plant OU (Figure 1-4). Detailed information on land use in the EMF Site study area is presented in Section 3.6 of the EMF RI Report (BEI, 1996).

The EMF site study area has a semi-arid climate and receives approximately 11 inches of total precipitation annually. The net annual evapotranspiration rate exceeds annual precipitation. Prevailing winds are from the southwest. Detailed information on the climate of the study area is presented in Section 3.5 of the EMF RI (BEI, 1996).

The FMC Plant OU is situated north and west of Pocatello, Idaho, on the eastern portion of the Snake River Plain. Volcanic bedrock, containing naturally occurring radioactive material, and coarse gravels underlie the study area. The general stratigraphy in the study area 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, the Michaud gravels, Aberdeen alluvial terrace deposits (locally) and calcareous silts and clays. The latter surface sediments, which typically range in thickness from 10 to 40 feet within the facility areas, have an alkaline pH that neutralizes acidic solutions and precipitates metals.

Groundwater within the FMC Plant OU flows from the Bannock Range foothills toward the north/northeast through unconsolidated sediments that overlie the volcanic bedrock (Figure 1-5). Shallow and deep aquifer zones, separated by confining strata, are evident in the plant areas and to the north (Figure 1-6). Shallow groundwater flows into the Portneuf River Valley, where it mixes with the more prolific Michaud Flats and Portneuf River groundwater systems.

Groundwater within the deeper aquifer is captured by the Simplot facility's production wells or continues northward where, in response to upward vertical gradients and discontinuous confining strata, it flows upward into the shallow aquifer. The shallow groundwater and a significant portion of the deeper groundwater beneath the facility discharges to the Portneuf River through Batiste Springs, Swanson Road Springs, and as base flow to the river in the reach between these springs.

Detailed information on the geology and hydrogeology of the EMF Site study area and the FMC Plant OU is presented in Sections 3.1 and 3.3, respectively, of the EMF RI Report (BEI, 1996). Appendix K of the EMF RI Report presents details of the hydrogeologic modeling effort that was conducted during the RI study.

1.2.2 FMC Site History

The FMC plant produced elemental phosphorus from phosphate-bearing shale ore mined regionally. Phosphate ore processing at the plant ceased in December 2001. Ore was shipped to FMC via the Union Pacific Railroad during the summer months. Because ore could not be shipped during the winter months, it was stockpiled on the facility property to ensure a steady supply for processing throughout the year. The estimated quantity of ore processed at the plant was about 1.5 million tons per year.

Elemental phosphorus production operations at the facility changed little from the time plant operations began in 1949 until they ceased in 2001. Ore from the stockpiles was sized, briquetted, calcined, and proportioned for feeding into any one of the four electric arc furnaces. The furnace reaction yielded gaseous elemental phosphorus in addition to other by-products. The elemental phosphorus was subsequently condensed to a liquid state and stored in tanks prior to shipment off-site as product. Elemental phosphorus will burn upon contact with air, therefore, to prevent oxidation, the condensed product was covered with water from the time it was produced through its transport off the site.

The plant outputs, apart from elemental phosphorus, included ferrophos as a co-product, calcium silicate slag, and wastewater. The wastewater contained various suspended and dissolved solids as well as minor amounts of elemental phosphorus. Liquid wastes were managed in a series of surface impoundments. Other types of solid waste management units (SWMUs) included landfills, treatment units, and waste storage areas. More detailed information regarding the FMC

plant product manufacturing, by-product handling, and waste management operations is provided in Sections 1.1.2 through 1.1.3 of the EMF RI (BEI, 1996).

1.2.3 Previous Studies

The FMC Plant OU has been the subject of a number of environmental investigations. Many of these are detailed in the EMF RI (BEI, 1996). Previous investigations, reports and decision documents that provide pertinent background to the SRI are discussed below.

1.2.3.1 EMF RI

In 1996, FMC presented the findings from an RI performed by FMC and Simplot at the EMF study area, in accordance with an Administrative Order of Consent (AOC) issued by EPA on May 30, 1991. Extensive sampling and analysis of surface and subsurface soils, groundwater, surface water, sediment, aquatic and terrestrial ecology, and air were conducted. As a result, the nature, extent, fate and transport of chemical constituents that may have been released from past or current practices at the FMC and Simplot processing facilities were characterized.

1.2.3.2 Record of Decision

In 1998, EPA issued the ROD (USEPA, 1998) wherein EPA's selected remedial actions were presented for the EMF site in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The IDEQ concurred with the selected remedies. The Shoshone-Bannock Tribes concurred with some but not all of the selected remedies.

Major components of the selected remedies at the FMC Subarea included establishing property use restrictions; capping of the Old Phossy Waste Ponds and Calciner Solids Storage Area; groundwater monitoring; implementing groundwater extraction/treatment systems as a contingent remedy; and maintaining areas capped pursuant to CERCLA.

1.2.3.3 LDR Plant RCRA Baseline Assessment for Soils (ZIMPRO Pilot Test Report, 2001)

A demonstration of a test procedure and associated quality assurance and quality control (QA/QC) protocols for the FMC Pocatello Phossy Waste Treatment Plant (PWTP) ZIMPRO™ Demonstration Test was conducted in 1999–2000 (BEI, 1999). Analysis of process stream samples from the PWTP demonstration run provided data needed to evaluate how well the process output met the RCRA land disposal restriction (LDR) standards and the 1999 RCRA Consent Decree requirements for the FMC Pocatello facility. Data were also used to design and operate a full-scale PWTP and prepare future RCRA Part B and air permit applications for the full-scale treatment plant.

1.2.3.4 Secular Equilibrium Study

A work plan to assess secular equilibrium in the EMF site surface soil was prepared in July 2004 (BEI, 2004a) to verify the assumption of secular equilibrium between uranium-238 and radium-226 that was part of the EMF RI (BEI, 1996) surface soil investigation. In July 2003,

EPA requested a supplemental investigation by FMC / J.R.Simplot regarding an evaluation of radium-226 and uranium-238 in the upper 6 inches of surface soils in the Off-Plant Operable Unit for the Eastern Michaud Flats site to verify the assumption of secular equilibrium between uranium-238 and radium-226 that was part of the EMF RI (BEI, 1996) surface soil investigation. A work plan to assess secular equilibrium in the EMF site surface soil was prepared in July 2004 (BEI, 2004a). As part of the field work, EPA requested split samples, which were analyzed by the EPA National Air and Radiation Environmental Laboratory (NAREL). The results of samples analyzed by both EPA and FMC / J.R.Simplot were reported to EPA on May 19, 2006. In summary, the sample results were all consistent with radioactive equilibrium between radium-226 and uranium-238. Specifically the report states "[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."

1.2.3.5 RI Update Memorandum

When FMC discontinued manufacturing operations at its Pocatello elemental phosphorus production facility in December 2001, FMC initiated activities to decommission the facility. The RI Update Memorandum (BEI, 2004b) for the FMC Plant OU is part of an SRI/SFS process that updates environmental information for the FMC Plant OU and supports site redevelopment. An evaluation of existing data and identified data gaps is based on the assumption that FMC will no longer operate the facility.

In the RI Update Memorandum (BEI, 2004b), extensive environmental characterization data obtained during the EMF RI during 1992–1994 is combined with subsequent groundwater, soil, and waste management unit characterization data. Current conditions at the former working areas of the plant and at over 100 SWMUs were evaluated to update the assessment of potential hazardous substance source areas and to group these areas into 23 RUs (expanded to 24 RUs in this Work Plan).

1.2.4 SRI Data Collection Concepts

The AOC for the SRI/SFS for the FMC Plant OU Statement of Work (SOW, 2003) requires that FMC complete the following:

- Task 1 – Establish the objectives of the SRI/SFS. This task has been completed by preparation of the Scoping and Planning Memorandum (BEI, 2004c), update of the Conceptual Site Model (CSM) as presented in the RI Update Memorandum (BEI, 2004b), compilation of data in former working areas not previously evaluated as presented in the RI Update Memorandum (BEI, 2004b), development of a risk-based concentration (RBC) for elemental phosphorus as presented in the RI Update Memorandum (BEI, 2004b), and update of the Remedial Investigation Report as presented in the RI Update Memorandum (BEI, 2004b).

- Task 2 – Perform an SRI. This task is the subject of this SRI Work Plan.
- Task 3 – Perform an SFS of Remedial Action Alternatives.

Given the long history of site studies, the EMF RI, and the 1998 ROD, Task 2 is truly "supplemental" in nature. As such, the SRI data collection is primarily designed to address data gaps identified in the RI Update Memorandum (BEI, 2004b) as needed to support the risk assessment for those RUs with a remediation vision of no further action anticipated to be necessary (also referred to as NFA). In addition, the SRI data collection will address data gaps for cap/cover delineation for those RUs with a remediation vision of capping as well as investigation of specific areas, (also referred to as "specific investigation areas") i.e., those areas known or suspected of having historical releases of site constituents to the ground surface or subsurface. However, in conjunction with the field activities associated with the SRI, there is also an opportunity to efficiently collect some information needed to support the SFS. As such, there are the four data types presented in this SRI Work Plan:

- Cap/cover delineation,
- Specific investigation areas,
- Risk assessment, and
- Subsurface characterization to support the SFS.

Figure 1-7 is provided as an SRI data collection concept map. This figure is not intended to be a work flowchart or a definitive decision tree. Rather, Figure 1-7 is intended to provide an overall concept of how data collection will progress and the relationship of one data type to another.

For each RU with a remediation vision of capping and/or containing specific investigation areas, the cap/cover delineation and investigation areas will be performed in every case as depicted on the center flow path of Figure 1-7. For those RUs with an NFA remediation vision, risk assessment data collection (depicted in the left-most flow path of Figure 1-7) will proceed within that RU until:

1) The gamma dose rate measurements are above a risk-based CV[1]
2) All necessary data are collected to perform a risk assessment which shows that the total risk is greater than applicable CVs; or
3) All necessary data are collected to perform a risk assessment.

[1] Risk-based CVs will be used during the SRI to inform field data collection activities; in particular, for determining whether a candidate NFA RU should follow the risk assessment or preliminary SFS data collection path (per Figure 1-7). Regarding the measurement of total gamma exposure under future worker scenarios, the CV will be a defined level above background that is equivalent to the upper end of remediation levels that have been selected at radioactively contaminated CERCLA sites (i.e., 3x10-4 above background), consistent with EPA's OSWER Directive 9200.4-18 (Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination).

In cases 1 or 2, the objective of subsequent SRI data collection efforts will shift from risk assessment to subsurface characterization in order to support the SFS (as depicted on the right-most flow path of Figure 1-7).

For the SRI data collection concept map and throughout this SRI Work Plan, the CVs may be RU-specific, sample-specific, and/or specific to the constituents of concern (COCs) or constituents of potential concern (COPCs). For example, the CV may be a cumulative target risk threshold; soil screening levels (SSLs) for P4, metals, fluoride and organics; or background concentrations for arsenic and specific radioisotopes. In the case of gamma radiation exposure, the CV may be a pre-determined gamma count rate (as measured with a sodium iodide detector during the radiation surface survey), or a pre-determined risk-based gamma exposure rate (as measured quantitatively with a pressurized ion chamber [PIC] instrument).

A key concept of Figure 1-7 is that for those RUs with a remediation vision of NFA, the type of data collection activities may shift from those to support the risk assessment to data collection activities to support the SFS. This shift in data type would occur if risk levels associated with gamma radiation exposure (the primary risk-driving pathway at the site) clearly exceed the CV. Thus, this shift in data type also represents a shift in the remediation vision, i.e., from NFA to a remedial action with the RU being carried forward to the SFS. For example, it is anticipated that the radiation surface survey will be performed early in the risk assessment data collection process. If the results of the radiation surface survey are above the CV, then the data collection objective will shift to that associated with SFS support. Table 1-2 summarizes the data collection needs for each data type.

It is important to note that while the investigation within a given RU with a remediation vision of NFA may shift from risk data collection activities to SFS data collection activities, this SRI Work Plan is not intended to supplant Task 3 of the AOC as identified above. As part of Task 3 of the AOC, an SFS Work Plan will be developed to address SFS data needs as determined in the SFS process. However, there are certain SFS data needs that can be identified and addressed during the SRI; specifically, determination of the depth/volume of fill materials (consisting primarily of ore and slag) that overlie native soils and the potential for contaminant migration into native soils from fill materials.

1.2.5 Radiological Constituents of Concern

The following sections provide background information on radiological constituents of concern.

1.2.5.1 Radiological Assessment

Radioactivity present at the site results from naturally occurring radioactivity present in native soil and from feedstocks and waste streams historically processed at the plant. This section provides a general discussion about naturally occurring radioactivity. Also discussed is the rationale for the radiological parameters selected for analysis in the SRI and the recommended measurement methods.

In radiological assessments, radionuclides in soil generally can be said to originate from four sources: 1) naturally occurring nuclides, 2) nuclides produced by natural processes, 3) nuclear

weapons debris, and 4) human activities that create radioactive nuclides. Each is described below. Also described are the FMC Plant OU processing activities that could concentrate certain radionuclides in waste streams.

Naturally Occurring Radionuclides

The naturally occurring radionuclides were created millennia ago during the creation of the universe, thus, only those radionuclides with extremely long half-lives still exist. As documented in Appendix K of the RI Update Memorandum (BEI, 2004b), native soils at the FMC Plant OU have been shown to contain uranium-238 (U-238) with a half-life of 4.5×10^9 years, uranium-235 with a half-life of 7.0×10^8 years, thorium-232 with a half-life of 1.4×10^{10} years, and potassium-40 (K-40) with a half-life of 1.3×10^9 years. Thorium-232 and its daughters have been seen only in low concentrations. Uranium-235 and its daughters are also usually detected at the normal isotopic concentrations. However, uranium-235 is only naturally present at very low concentrations (less than approximately 0.7 percent of all uranium). Uranium-238 has several daughters that may be in radioactive equilibrium with the parent. Some of these daughters can be measured by alpha spectrometry and a few may be measured by gamma spectrometry.

As also documented in Appendix K of the RI Update Memorandum (BEI, 2004b), several of the source materials historically processed at the FMC Plant OU contain uranium-238, its daughters, and/or potassium-40 at levels that exceed those in background soils, due to the relatively high levels of uranium-238 in phosphate ore processed at the FMC Plant OU. Above-background radiological risks at the FMC Plant OU are associated with exposure to these naturally occurring radioactive materials (NORM).

Radionuclides Produced by Cosmic Activity

Another group of radionuclides is produced by cosmic activity. Because this production is a continuing process, these radionuclides have shorter half-lives than those that originated during creation of the universe. The two most common radionuclides in this group are hydrogen-3 (tritium) and carbon-14. These radionuclides exist in low concentrations in nature.

Nuclear Weapons Debris

Nuclear weapons debris from weapons-testing fallout can be found almost everywhere in nature. The concentrations are very low and normally present little added risk. The radionuclide most often found is cesium-137, which is sometimes observed in gamma spectra of natural materials. The levels are low and typically present no human health hazard.

Human Activities That Create Radionuclides

There have been no activities at the FMC Plant OU that used equipment such as nuclear reactors or cyclotrons that could create radionuclides. Commercially-available bin level indicators containing sealed sources of Cs-137 were used at the FMC Plant OU. These sealed sources of Cs-137 no longer are used on the FMC Plant OU.

Processing Activities that Concentrated Naturally Occurring Radionuclides

Although there were no activities at the FMC Plant OU that could create radionuclides, there were processing activities that concentrated certain radionuclides in process waste streams at concentrations greater than those that would be found in equilibrium with the parent uranium-238. Uranium-238 daughters with lower boiling points could be boiled off during high-temperature processing operations (kiln/calciner operations and the furnace operations) and thereby be concentrated in the waste streams from these operations. Uranium-238 has a boiling point of 3,818°C and did not appreciably boil off, but passed through the process and remains in the slag. Radium-226 (Ra-226), lead-210 (Pb-210), and polonium-210 (Po-210) have boiling points of 1,737°C, 1,740°C, and 962°C, respectively. These low-boiling-point radionuclides (relative to uranium) could be expected to be concentrated in kiln/calciner off-gas solids (kiln/calciner solids) and/or in furnace precipitator dust (phossy solids). Therefore, these radionuclides will be investigated as part of this SRI in RUs with a remediation vision of NFA where these materials are suspected.

Radium-226 decays to radon-222, a gas that can be released to the atmosphere. Radon-222 has been demonstrated to be a health concern where the gas is confined in an occupied space with little or no air turnover, (e.g., a basement of a building). Whether or not radon-222 emanation is a potential risk with respect to future site development is a current data gap. Therefore, radon-222 will be investigated as part of the SRI in RUs 19 (slag pile) and 22b (former ponds) where radon control may be a design criterion for the cap/cover for these RUs.

It should be noted that radium-226, lead-210, and polonium-210 have half-lives of 1,600 years, 22.3 years, and 138 days, respectively. After a period of four years (over 10 half-lives for polonium-210), the concentrations of polonium-210 would no longer be detectable above background, due to the decay of the polonium-210 to stable lead-206. Therefore, polonium-210 that was concentrated in process waste streams would no longer be detectable above background, because the FMC Plant OU has not operated for the past five years.

In summary, the only radionuclides present at the FMC Plant OU that have the potential to be of concern from a risk perspective are uranium-238, the daughters of uranium-238 (i.e., uranium-234, radium-226, lead-210, and polonium-210) and potassium-40.

1.2.5.2 Radioactive Parameters for Analysis

Radioactive parameters selected for analysis during the SRI are based upon the findings of the risk analysis performed using available isotope-specific data for the various source materials historically processed at the FMC Plant OU. The data, methods, assumptions and findings of this analysis are presented in Appendix B. Specifically, external exposure to gamma radiation was shown to be the primary risk driver, although risks associated with ingestion of lead-210 and inhalation of polonium-210 are also potentially significant for any workers exposed to precipitator dust/phossy solids. While risks associated with ingestion and inhalation of other radionuclides were shown to be insignificant in the RI Update Memorandum (BEI, 2004b), additional isotope-specific data will be collected during the SRI to confirm this finding. In summary, the following radiological parameters will be evaluated during the SRI:

- total gamma radiation, including the decay of potassium-40, uranium-238 and its daughters (including radium-226) in soils, by-products, and waste materials, to characterize potential external exposure to outdoor workers;

- lead-210 and polonium-210, to ensure that worker risks from ingestion and inhalation exposures to any residual precipitator dust/phossy solids are adequately characterized;

- uranium-238, radium-226, and potassium-40, to confirm that potential ingestion and inhalation risks associated with worker exposure to these radionuclides is insignificant relative to external exposure to gamma radiation; and,

- radon-222 flux to determine if the shale unloading, crushing, and stockpile area (RU 7), slag pile (part of RU 19), bull rock pile (part of RU 19) and old phossy ponds (RU 22b) are already below the Uranium Mill Tailings Radiation Control Act (UMTRCA) guideline or if remedial alternatives for radon control may need to be addressed.

1.2.5.3 Gamma Radiation Measurement

Due to the large areas requiring gamma measurement, the SRI Work Plan approach is to perform a surface radiation survey utilizing a sodium iodide detector (NaI) supported by quantitative gamma dose-rate measurements as determined using a PIC. In order to support the risk assessment data collection needs associated with each candidate RU for NFA, the following gamma radiation data collection activities will be conducted:

- Perform a one-point calibration of the sodium iodide (NaI) detector with a PIC instrument at or near the gamma dose CV to establish a count rate equivalent to the CV dose rate.

- Perform a high-density, global positioning system (GPS)-based radiation surface survey utilizing the NaI detector. Create radiation maps of each surveyed area to depict RUs (or sub-areas) where the count rate is above the gamma dose CV for a future commercial/industrial worker, based upon the one-point calibration. For those RUs (or sub-areas) above the gamma dose CV for the commercial/industrial worker, the RU will be carried forward to the SFS and will no longer meet the remediation vision of NFA.

- If the radiation surface survey is not above the gamma dose CV for the commercial/industrial worker, then surface PIC measurements will be made to confirm the screening-level measurements. Note that all measurements to support the risk calculation will be based upon the PIC measurements.

- In RUs (or sub-areas) where the surface PIC is not above the gamma dose CV for the commercial/industrial worker, subsurface sampling will be performed and the samples will be analyzed in a fixed laboratory for uranium-238, radium-226, lead-210, polonium-210 and potassium-40. These subsurface samples will initially be

compared to the background levels that have been developed for this site. Demonstration that the subsurface samples contain radioisotope constituents of concern at levels less than EPA's calculated background levels will also demonstrate that there is no increased risk to commercial/industrial workers. A 0-2' below ground surface (bgs) sample will be taken to characterize risks to a surface worker from pathways other than external exposure to gamma radiation (e.g., incidental soil ingestion and fugitive dust inhalation). Also, a 0-to-10 feet bgs sample will be taken to show that subsurface radionuclide levels could not result in future exposures above a level of concern if fill materials were later surfaced during construction activities.

- A PIC measurement will be taken at a depth of five feet (the depth below which shoring, such as a trench box, would be required and would thus shield workers) in both slag and ore to demonstrate that worst-case gamma exposure does not exceed the gamma dose CV for construction or utility workers.

Further information and detail on the gamma risk exposure sampling is included in Sections 2.5 and 2.6.

1.2.5.4 Measurement of Radionuclides in Soil

Determination of the concentration of potassium-40 in soil is a straightforward process. Potassium-40 emits a prominent, energetic (1,461 kilo electron volts [keV]) gamma ray that can be easily measured by gamma spectrometry. Thus, chemical separation is not necessary to quantify potassium-40 activity.

Gamma spectrometry has limited value for the measurement of uranium-238 and its daughters in soil samples. The decay modes and gamma rays having energies greater than 100 keV for uranium-238 and its daughters are summarized in Table 1-4. Most members of the uranium-238 decay chain emit few gamma rays with energies greater than 100 keV.

The concentration of uranium-238 can be estimated by measuring either lead-214 or bismuth-214 by gamma spectrometry with the implicit assumption that these daughters are in known radioactive equilibrium with uranium-238. The only unambiguous way to measure the amount of uranium and radium in soil requires chemical separation. This makes measurement of members of the uranium-238 decay series more difficult; however, it is the only way to be certain that the measurements are valid.

Uranium-235 emits a 185-keV gamma ray that is indistinguishable from the 186-keV gamma ray of radium-226. In samples of natural uranium isotopic composition with the decay chain in radioactive equilibrium, gamma spectrometry cannot provide useful information about the concentrations of either radium-226 or uranium-235. In the case of normal uranium enrichment and radioactive equilibrium, radium-226 will contribute 57 percent and uranium-235 will contribute 43 percent to the measured 185-keV gamma ray.

1.2.5.5 Measurement of Radon Flux

Targeted radon measurements will be taken to support the SFS, although these data are inconsequential to outdoor-worker risk exposure. Radon measurements will be performed using EPA Method 115. This method prescribes that 100 samples be collected per decision unit. Radon flux measurements will be performed in RUs 7, 19 and 22b as described below:

- RU 7 consists of the former shale unloading, crushing, screening, and ore stockpile areas. RU 7 will be measured as one decision unit for radon measurement as the fill material is primarily ore.

- RU 19 consists of the slag pile and the bull rock pile. Bull rock is the reject, oversized material created from screening of phosphate ore. Therefore, the bull rock pile is an ore-related material and is significantly different from slag. As such, RU 19 will be separated into two separate decision units, the slag pile and the bull rock pile, for radon measurement. If radon measurements of the RU 19 slag pile are above the UMTRCA guideline, then the test soil cover on the slag pile will also be measured as a decision unit for radon.

- RU 22b consists of all historic phossy ponds, excluding the RCRA-capped ponds. RU 22b consists of four separate parcels, separated by the RCRA-capped ponds. These four parcels will be measured as two decision units, an eastern and a western portion, for radon. The two decision units will be geographically delineated, with the single parcel in the eastern portion as one decision unit and the three parcels in the western portion as the second decision unit.

1.2.5.6 Recommended Methods of Analysis

As discussed in Appendix K of the RI Update Memorandum (BEI, 2004b), the primary radiological risk driver at the FMC Plant OU is external exposure to gamma radiation. A direct measurement of gamma exposure is best achieved using a radiation dosimeter, sometimes called a micro-r-meter. The micro-r-meter proposed for use in this program is the PIC. There has been the suggestion to relate the external exposure to the concentration of measured radionuclides in soil. This comparison is impractical, if not unachievable. The radionuclides are distributed throughout the soil. The gamma rays emitted from deeper in the soil are attenuated by the soil. The calculation of radiation exposure from such a distributed source is extremely complex, requiring information on the distribution profile and composition of the soil. These calculations do not always agree with the measured radiation exposure.

Radionuclide-specific data will also be collected to evaluate radiological risks from pathways other than external exposure to gamma radiation. To ensure the collection of data with sufficient accuracy and sensitivity, chemical separation procedures are being proposed for all radionuclides of concern except potassium-40. Chemical separation procedures typically require the soil sample to be completely dissolved, usually in an acid mixture. Recommended procedures that provide levels of specific isotopes are detailed in Section 3.4.3 and are summarized as follows:

- uranium will be determined by chemical separation using ion exchange chromatography followed by measurement by alpha spectrometry;
- after chemical separation, radium-226 can be measured either by alpha spectrometry or by the emanation of its radon daughter followed by scintillation counting;
- lead-210 will be determined by chemical separation using anion exchange chromatography followed by liquid scintillation counting;
- polonium-210 will be determined by spontaneous deposition followed by alpha spectrometry; and,
- potassium-40 can reliably be determined by gamma spectrometry without dissolution and chemical processing.

1.2.6 Chemical Constituents of Concern

Non-radiological COCs and COPCs described in the RI Update Memorandum (BEI, 2004b) include a specific list of inorganics and a focused list of volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PAHs) as shown on Tables 1-5 and 1-6. For all of the COCs and COPCs, methods of analysis are provided in Section 3.

1.2.6.1 Elemental Phosphorus (P4)

Elemental phosphorus (P4) was the primary product manufactured at the FMC Plant OU during operation. However, because P4 oxidizes spontaneously and burns vigorously when in contact with air, P4 was managed only in certain areas of the facility and was stored under water to prevent contact with air and thus oxidation. Areas of the FMC Plant OU where P4 was managed included:

- The furnace building where P4 was manufactured and temporarily stored (RU 1). This area has a remediation vision of capping. Visual analysis and analytical sampling for P4 will be used to delineate the extent of the cap for RU 1.
- The phos dock where P4 was stored, processed, and loaded into railcars (RU 1).
- The secondary condenser where the furnace off-gas was further cooled to condense and collect remaining P4 (RU 1). Note that the flare pit in RU 8 (which has a remediation vision of capping) was at the tail-end of the furnace off-gas piping where excess carbon monoxide (CO) was burned. During certain processing conditions, the CO piping was allowed to heat up thus melting any P4 frozen on the inside of the CO piping. This P4 was carried to the flare pit, where in the presence of high temperatures and excess oxygen, the P4 would burn to phosphorus pentoxide and discharge to the atmosphere. No P4 was observed or would be expected to accumulate in the flare pit under these conditions. In addition, the flare pit lining material (silica and slag) was excavated during 2000 to clear the area in advance of

construction of the excess CO (XSCO) combustor. No P4 was evident at the bottom of the excavated flare pit area. The excavation was then backfilled and a concrete slab and motor control center building was constructed over the former flare pit area. As such, no investigation of P4 within RU 8 is warranted or included in the SRI.

- Phossy water (water that came into contact with P4 and therefore could contain some suspended particles of P4) was processed at the phos dock (RU 1) and pumped to the phossy ponds (in RU 22b, which has a remediation vision of capping) where suspended particles were allowed to settle. Then the phossy water was returned to the process. The piping that carried phossy water (SWMU #64) traversed underground through RU 24, RU 12, RU 13 and ultimately RU 22b. Some phossy water also discharged to the slag pit (RU 2), where it was collected in a sump (the slag pit sump) and pumped to the phossy ponds (RU 22b). P4 investigations will be proposed at RUs 12, 13 and 24, if they remain NFA candidates, to determine whether phossy water was released from the pipelines that traverse those RUs. If these RUs are forwarded to the SFS as result of any SRI results, then the information compiled on underground piping will be forwarded to the SFS for consideration during evaluation of remedial alternatives.

- Because RU 2 received phossy water from the furnace building, RU 2 also has a remediation vision of capping. Visual analysis and analytical sampling for P4 will be used to delineate the extent of the cap for RU 2.

- Phossy water often escaped the phos dock and flowed either through storm sewers or via overland flow (through RU 3) to the railroad swale (RU 22c). P4 investigation will be performed at RU 3 to determine if P4 contamination exists as a result of the overland flow of phossy water. Visual analysis and analytical sampling for P4 will be used to delineate the extent of the cap at RU 22c. Note that potential P4 contamination that may have resulted from storm sewer leakage will be addressed by investigation for P4 if RU 3 remains an NFA candidate. If RU 3 is forwarded to the SFS as result of any SRI results, then the information compiled on underground piping will be forwarded to the SFS for consideration during evaluation of remedial alternatives.

1.2.6.2 Metals

Phosphate ore contains elevated concentrations of many metals. As such, any location on the FMC Plant OU where ore and ore-related materials, slag, processing by-products, or waste streams were processed, stored, or disposed, may have concentrations of metals above background. As such, a full suite of metals analyses (see Table 1-6) will be performed in RUs 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 20 23, and 24 to define total risk levels under the risk assessment data type. In addition, a full suite of metals analyses will be performed for specific investigation areas within RUs 3, 6, and 10. A full suite of metals analyses will also be performed for cap delineation studies in RUs 8, and 22b. At RUs 15 and 16 a full suite of metals analyses will be performed to determine the leaching potential and threat to groundwater from the materials stockpiled in those areas.

Based upon historical sampling and analyses during the RI, migration of metals from ore/ore-related materials or from slag to underlying soils does not appear to be likely. However, reference studies will be performed at RU 7 (to represent ore leaching potential) and at RU 20 (to represent slag leaching potential) to determine if these materials have leached metals into underlying soils. This information will be used to design the SFS data collection studies at other RUs that contain slag and/or ore found to exceed the gamma dose CV.

1.2.6.3 Fluorides

The phosphate-bearing mineral in phosphate ore is a fluorapatite and as such contains 2.5 to 3.0 percent fluorine. Thus, locations on the FMC Plant OU may have levels of fluoride above background. Fluoride analysis will be performed in RUs 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 20, 23, and 24 as a part of defining total risk levels under the risk assessment data type. In addition, fluoride analysis will be performed for specific investigation areas in RUs 3, 6, and 10. Fluoride analysis will also be performed for cap delineation studies in RUs 8, and 22b. For RUs 15 and 16 fluoride will be analyzed to determine the leaching potential and threat to groundwater from the materials stockpiled in those areas.

1.2.6.4 Organics

Organic COCs and COPCs (see Table 1-5) are associated with specific investigation areas. The specific analytes for each investigation area were established based upon: 1) known use of a solvent on site (i.e., toluene, benzene, and methylene chloride), 2) process knowledge of process materials (i.e., coke), 3) IDEQ-published lists for fuel release investigations (IDEQ, 2002), and 4) compounds reported as detected in soil samples collected during the RI. Area-specific organic analytes to be investigated are as follows.

Lab-Related Solvents

Lab-related solvents include: benzene, carbon disulfide, chloroform, methylene chloride, tetrachloroethene (PCE), toluene, trichloroethene (TCE), and 1,1,1-trichloroethane, (1,1,1-TCA) and 2-butanone. These analytes will be addressed at specific investigation areas in RUs 4 and 5. RU 5 contained the FMC Plant OU process control laboratory. There are two SWMUs located within the RU 5 specific investigation area, including:

- SWMU # 39: Chemical Lab Drain Pit
- SWMU # 61: Disposal Area Behind Laboratory

The lab-related solvents are either known or suspected of having been used in the lab, or were detected during the RI.

Shop-Related Solvents

Shop-related solvents include: chloroform, methylene chloride, PCE, TCE, 1,1,1-TCA and 2-butanone. These analytes will be addressed at specific areas within RUs 12 and 20 where shop-related solvents are suspected to have been used or released. While there are no specific

SWMUs in either RU with known or suspected solvent releases, both of these RUs had maintenance shops. Shop-related solvents are either known or suspected of having been used in these shops, or were detected during the RI.

Fuels-Related VOCs/PAHs

Fuels-related VOC/PAHs include: benzene, ethylbenzene, toluene, xylene (collectively referred to as BTEX), acenapthene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorene, fluoranthene, naphthalene, phenanthrene, and pyrene. These analytes will be addressed at specific investigation areas within RUs 12 and 20 where fuels were known to have been stored, dispensed, or released. While there were no specific SWMUs in either RU associated with fuels, both of these RUs had gasoline and diesel fuel storage tanks, fuel dispensing areas, and known fuel spills to the ground surface.

Coke-Related PAHs

Coke-related PAHs will include: acenapthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene,and pyrene. Soil samples will be analyzed for these PAHs in specific investigation areas of RUs 7 and 20, where coke was unloaded, stored, and/or processed.

PCBs

PCBs include all chlorinated biphenyl congeners (Method 1668A). PCB investigations are only included at RU 12 in the area of SWMU # 57, the transformer salvage area.

1.3 PROGRAM/TASK DESCRIPTIONS

This Work Plan addresses the data collection tasks needed to meet the objective of providing data of sufficient quality and quantity to support either a no action anticipated to be necessary or remedial alternative analyses in the SFS and, as necessary, remedial design for each RU.

Specific tasks will include sampling, field measurements, fixed-laboratory analyses, data review and evaluation, and report preparation. Tasks for various RUs are summarized in Table 1-2 and the following data types will be collected for purposes of supporting this Work Plan:

- visual determination of the presence of phosphorus in soil samples, for defining the perimeters of caps to be installed;
- total gamma radiation levels, for the purpose of establishing external gamma dose rates;

- radon flux data, to support the SFS;
- reference area data[2], to support the SFS
  - metals, fluoride, uranium-238, radium-226, lead-210, polonium-210, and potassium-40 to evaluate leaching potential from slag (RU 20);
  - metals, fluoride, uranium-238, radium-226, lead-210, polonium-210, and potassium-40 to evaluate leaching potential from ore (RU 7); and,
  - specific PAHs associated with coke to evaluate leaching potential from coke (RU 20)
- speciated radiometric levels by a fixed laboratory, to calculate worker risks associated with the inhalation and ingestion exposure pathways, for inclusion within the overall risk model; specifically, isotopes identified with the greatest risk contribution (uranium-238, radium-226, lead-210, polonium-210, and potassium-40); and,
- collection of samples and analysis by a fixed laboratory for the following:
  - specific VOCs as identified in the RI Update Memorandum (BEI, 2004b), as well as VOCs known to have been used on site, and IDEQ underground storage tank site assessment criteria (IDEQ, 2002);
  - specific PAHs as identified in the RI Update Memorandum (BEI, 2004b), as well as PAHs known to have been associated with fuels and process materials on site, and IDEQ underground storage tank site assessment criteria (IDEQ, 2002);
  - PCBs;
  - elemental phosphorus (P_4);
  - fluoride; and,
  - specific metals as identified in the RI Update Memorandum (BEI, 2004b).

It is anticipated that mobilization for the SRI Work Plan scope of work will begin during 2007. FMC currently estimates that the field work will require four to six months including mobilization. Data analysis and presentation will be performed concurrent with and subsequent to field activities, and results will be presented in the SRI Report. Field work will begin approximately four to six weeks after EPA's approval of the SRI Work Plan and work will proceed through the 2007 construction season. Any remaining field work will begin in April of the following year.

[2] Reference area studies generate data from investigation and evaluation of a selected area which contains generally uniform, homogenous deposits of a particular fill material, e.g., slag, ore, or coke. Data collected in that area will be referenced in the evaluation of other areas which contain these materials.

Mobilization will entail one or more drill rig(s), a backhoe, a sampling team, and personnel to collect PIC and radon flux measurements. A data input/data management specialist will input and organize all data generated during on-site activities. Prior to initiating field work a minimum of one day will be required for safety training. A detailed schedule of planned activities will be prepared after EPA approves this Work Plan. This schedule will be provided to EPA for inspection-planning purposes.

1.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The overall quality of tasks performed for the SRI will be assured by conformance to protocols established for sample collection, analytical procedures, and data management. A summary of the QA/QC protocols that will be implemented throughout the investigation is provided in this section. These protocols are detailed in Section 3.

Field data will be reported in units consistent with those of other agencies and organizations to allow comparability of databases. Standardized field measurement protocols will be used to the extent possible to maintain consistency and to obtain results that can be verified or validated. Calibration and maintenance of field equipment and instrumentation will be in accordance with manufacturers' specifications or applicable test specifications and will be documented.

Laboratory analysis will provide sample-specific data according to EPA specifications. The risk-based criteria, i.e., CVs, including SSLs, background, etc., identified for the site directly affect data measurement requirements. Therefore, the analytical technique chosen will have method detection limits (MDLs) at or below the applicable CV (to the extent practicable). Regardless of the specified MDL, the actual detection limit may be sample-specific, especially in the case of soil samples, samples with complex matrices, or samples that contain numerous analytes at widely different concentration ranges. The data measurement objective is to obtain data with reporting detection limits (target reporting limits) that are approximately 10 percent less than the background values or the SSLs. Reporting limits for organic and inorganic (including radionuclides) parameters are presented in Tables 1-5 and 1-6, respectively.

The data validation process consists of a systematic assessment and verification of data quality. Data validation procedures will incorporate the following guidelines:

- EPA guidance for the Contract Laboratory Program (CLP),
- EPA QA/G-8 Guidance on Environmental Data Verification and Data Validation (EPA 1240/R-02/004, November 2002), and
- EPA QA/G-9 Guidance for Data Quality Assessment, Practical Analysis of Data (EPA/600/R-96/084, July 2000).

Data validation is detailed in Section 5.

1.5 SPECIAL TRAINING/CERTIFICATION

All personnel directly involved in sample collection, handling, analysis, and data evaluation will be provided with a copy of this Work Plan and any subsequent revisions or attachments. The management of the participating laboratories and contractors will establish personnel qualifications and training requirements for the program. Each person participating in the program will have the education, skills, training, technical knowledge, and experience, or a combination thereof, to enable that individual to perform assigned functions. Training will be provided for each staff member as necessary to perform his or her functions properly and safely. Personnel qualifications will be documented in terms of education, experience, and training, and periodically reviewed to ensure adequacy to perform current responsibilities. Examples of topics for which training is required, as applicable to the position, include the following:

- safety (Health and Safety Plan [HASP]),
- SRI Work Plan,
- Standard Operating Procedures (SOPs),
- standards preparation,
- general field sampling techniques,
- specific sampling protocols,
- general laboratory techniques,
- laboratory sub-sampling techniques for obtaining a representative sub-sample,
- specific test methods,
- sample preparation and analysis procedures,
- instrument standardization,
- equipment calibration and maintenance,
- QC corrective action,
- data reduction and validation,
- reporting, and
- records management and database administration.

Additionally, personnel involved in field sampling and measurements will be required to have current Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations

and Emergency Response (HAZWOPER) training and certification. In addition, all site personnel will be given site-specific hazard training, such as training on sampling, handling, and disposal of P4-contaminated materials.

Chemists and laboratory technicians engaged in the preparative extraction of elemental phosphorus and its chromatographic analysis, and the decontamination of phosphorus-contaminated equipment, will be trained in the SOPs for these practices. Applicable SOPs will be freely available for use by the analysts and training records on the use of the SOPs will be maintained. The Quality Manager at each laboratory is responsible for maintaining the laboratory's training records. The Quality Manager is responsible for ensuring the maintenance of the training records by all project team members. All personnel responsible for handling and analyzing samples and for QC and sample documentation will be familiar with this plan.

1.6 DOCUMENTATION

The following sections describe required documentation and records for training, field, and laboratory activities.

1.6.1 Training Activities

Training will be documented and records kept on file and readily available for review. Documentation of training may be accomplished by an attendance sheet that includes a listing of attendees, a summary of the training and the topics covered, and/or a copy of the slides, handouts, and other materials used in the training session.

Copies of OSHA and HAZWOPER training certificates will be maintained in the project files. All contractors/subcontractors will prepare a HASP that will be submitted to FMC prior to beginning any field activities. Any deficiencies in these plans must be addressed prior to beginning fieldwork, and all field personnel will be required to demonstrate that they have read and understand the HASP prepared by their respective organization.

Personnel performing specific field sampling activities will have the requisite training (on-the-job, or formal) to perform the activities specified in this Work Plan. Senior personnel will closely supervise field activities to ensure that they are conducted safely and properly, and that each measurement or sample taken is properly documented.

1.6.2 Field and Laboratory Activities

Records provide direct evidence and support for the necessary technical interpretations, judgments, and discussions concerning program activities. These records will directly support decisions regarding whether or not remedial actions are necessary or will be used for SFS alternative evaluation. Records will be legible, identifiable, retrievable and be protected against damage, deterioration, or loss. This subsection outlines procedures for record keeping. Organizations that conduct sampling and analyses will develop appropriate record-keeping procedures that satisfy relevant technical and legal requirements.

Procedures for reviewing, approving, and revising records will be clearly defined. All documentation errors will be corrected by drawing a single line through the error so it remains legible and will be initialed by the responsible individual, along with the date of change. If appropriate, the reason for the document change will also be indicated. The correction will be written adjacent to the error. If electronic records are used, similar procedures for documenting corrections will be employed. The Field Sampling Plan (FSP) will describe types of records that will be developed. Records will include but will not be limited to the following:

1.6.2.1 Sample Collection

To ensure maximum utility of the sampling effort and resulting data, documentation of the sampling protocol, as performed, is essential. Sample collection records will contain, at a minimum, the names of persons conducting the activity, sample number, sample location, equipment used, ambient conditions, and other pertinent field observations. The actual sample collection record may consist of any of the following: a bound field notebook with pre-numbered pages, a preprinted form, or digitized information on computer media. A more detailed discussion of sample documentation is provided in Section 3.

1.6.2.2 Chain-of-Custody Records

The chain-of-custody, which involves the possession of samples from the time they are obtained until they are disposed, will be documented and will include the following information: 1) the program name; 2) name and signature of sampler(s); 3) the sample number, date, and time of collection, grab or composite sample designation, and requested analysis; 4) name and signature of individuals involved in sample transfer; and 5) if applicable, the airbill or other shipping number. Chain-of-custody records are further discussed in Section 3.

1.6.2.3 Drawings

The final, approved drawings will have a file name/revision number and date and will be subject to the same controls as other program records.

1.6.2.4 QC Samples

Documentation will be maintained for the identification of QC samples such as equipment rinsate blanks, matrix spikes, matrix spike duplicates or duplicate and field collocated samples.

1.6.2.5 Data Verification, Deviations and Nonconformances

The field data will be subject to verification by the appropriate personnel. As recommended by EPA, the person originating the field data will not be the person assigned to verify the data (EPA 2002). All field forms will be checked for completeness in the field on a daily basis. Prior to demobilizing, all nonconformances and deficiencies will be reviewed with the Quality Manager and the FMC Project Manager. Usability of the nonconforming items will be evaluated regarding acceptability in supporting the associated DQOs. Corrective actions required to ensure that data of acceptable quality are obtained for the study will be implemented. Root causes will be identified and follow-up actions to prevent recurrence will be documented and implemented.

This will allow the field teams to collect additional data if it is determined that the original data do not meet the quality standards to support the decision (e.g., key relevant information was not recorded, forms are missing, key entries are illegible, samples were lost or custody documents were destroyed, GPS equipment was not calibrated properly, or measurements did not meet the initial specifications for accuracy and/or reproducibility).

1.6.2.6 Field Reports

A copy of all reports issued and any supporting documentation will be retained. Field reports and other documentation will be organized on a RU-by-RU basis, as appropriate, for ease of access. Reports pertaining to overall site conditions or generic reports will be kept in a separate file. An "as-executed" schedule will be maintained. This schedule will permit a graphical display of activities that were conducted at a specific RU during the SRI, and an overall roll-up of activities conducted at the entire FMC Plant OU during the SRI. The FSP describes types of reports that will be developed.

The laboratory documentation required for each sample delivery group will be adequate to perform the necessary level of data validation to support a CERCLA RI. A list of these requirements is presented in Section 3. Section 5 presents the various levels of data review and associated documentation evaluated for each.

1.6.2.7 Data Validation

Laboratory documentation will be organized into sample delivery groups of 20 samples or less, with discrete samples submitted for each specific analytical procedure (e.g., total metals, VOCs, PAHs), as recommended in EPA guidance (USEPA, 2002). The documentation for each sample delivery group will be sufficient to support all levels of validation as described in Section 5.

1.6.2.8 Verification of Software

All data reduction software used in this program, including spreadsheets, will be verified in accordance with the following statement from EPA SW-846:

> "Data resulting from the analyses of samples should be reduced according to protocols described in the laboratory procedures. Computer programs used for data reduction should be validated before use and verified on a regular basis... Spot checks should be performed on computer calculations to verify program validity…"

1.6.2.9 Electronic Audit Trails and Corrections to Electronic Data

Program personnel will develop and implement a program that will meet the EPA SW-846 criteria listed below.

- All information used in the calculations (e.g., raw data, calibration files, tuning records, results of standard additions, interference check results, and blank- or background-correction protocols) shall be recorded in order to enable reconstruction

of the final result at a later date. Information on the preparation of the sample (e.g., weight or volume of sample used, percent dry weight for solids, extract volume, dilution factor used) shall also be maintained in order to enable reconstruction of the final result at a later date.

- Procedures for reviewing, approving, and revising laboratory records shall be clearly defined, with the lines of authority specified.

- Any documentation errors to originally recorded data shall be corrected by drawing a single line through the error so that it remains legible and shall be initialed by the responsible individual, along with the date of change. The correction will be written adjacent to the error.

- The person who performed the instrumental analysis shall sign printouts. If corrections need to be made in computerized originally recorded data, a system parallel to the corrections for handwritten data shall be in place.

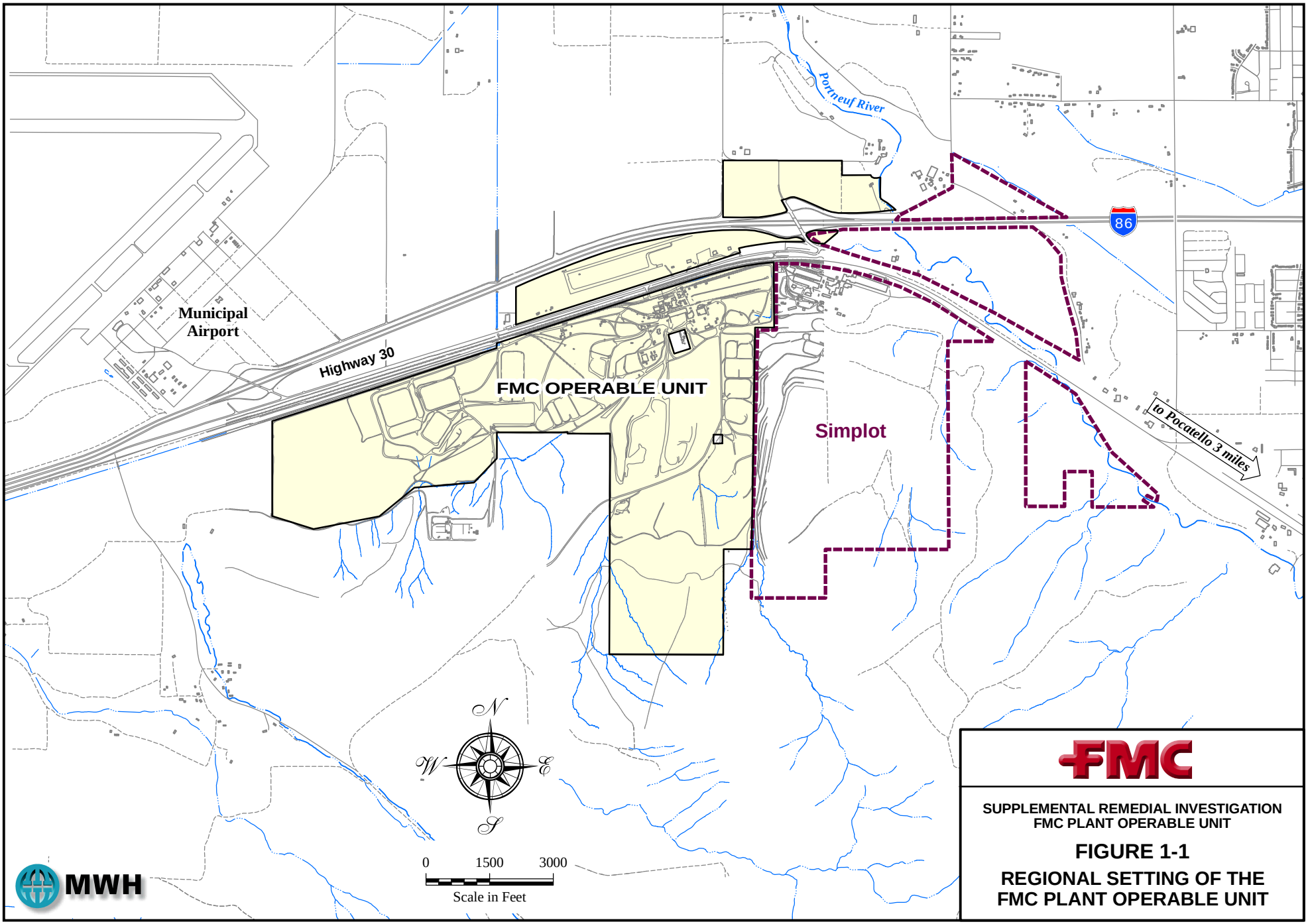
The data report package will contain the following information and records:

- operation records;
  - sample collection records showing that the proper sampling protocol was used
  - chain-of-custody records
  - QC sample records such as blanks and duplicate samples
  - general procedures record
  - corrective action reports indicating methods used when general practices or other standard procedures were violated
- laboratory records;
  - sample data (times that the samples were analyzed to verify holding time requirements, number of samples, sample locations, time, date, etc.)
  - sample management records (sample receipt, handling, and storage, and analysis schedule)
  - test methods (describing sample preparation and analysis, instrument standardization, detection and reporting limits, etc.)
  - QA/QC reports (general QC records and program-specific QC records)
- data-handling records documenting protocols used in data reduction, verification, and validation.

Records of the analyses and evaluations developed under this Work Plan will be maintained by FMC. These records will include all QA/QC reports and raw data sheets and will be available in the program files and for inspection by EPA.

Electronic deliverables to be loaded into the data management system will also be submitted in CD format. Electronic copies of all field and boring logs as well as all original electronic data will be preserved.

FILE *Fig 1-01 Regional Setting_307.mxd* *3/15/07*

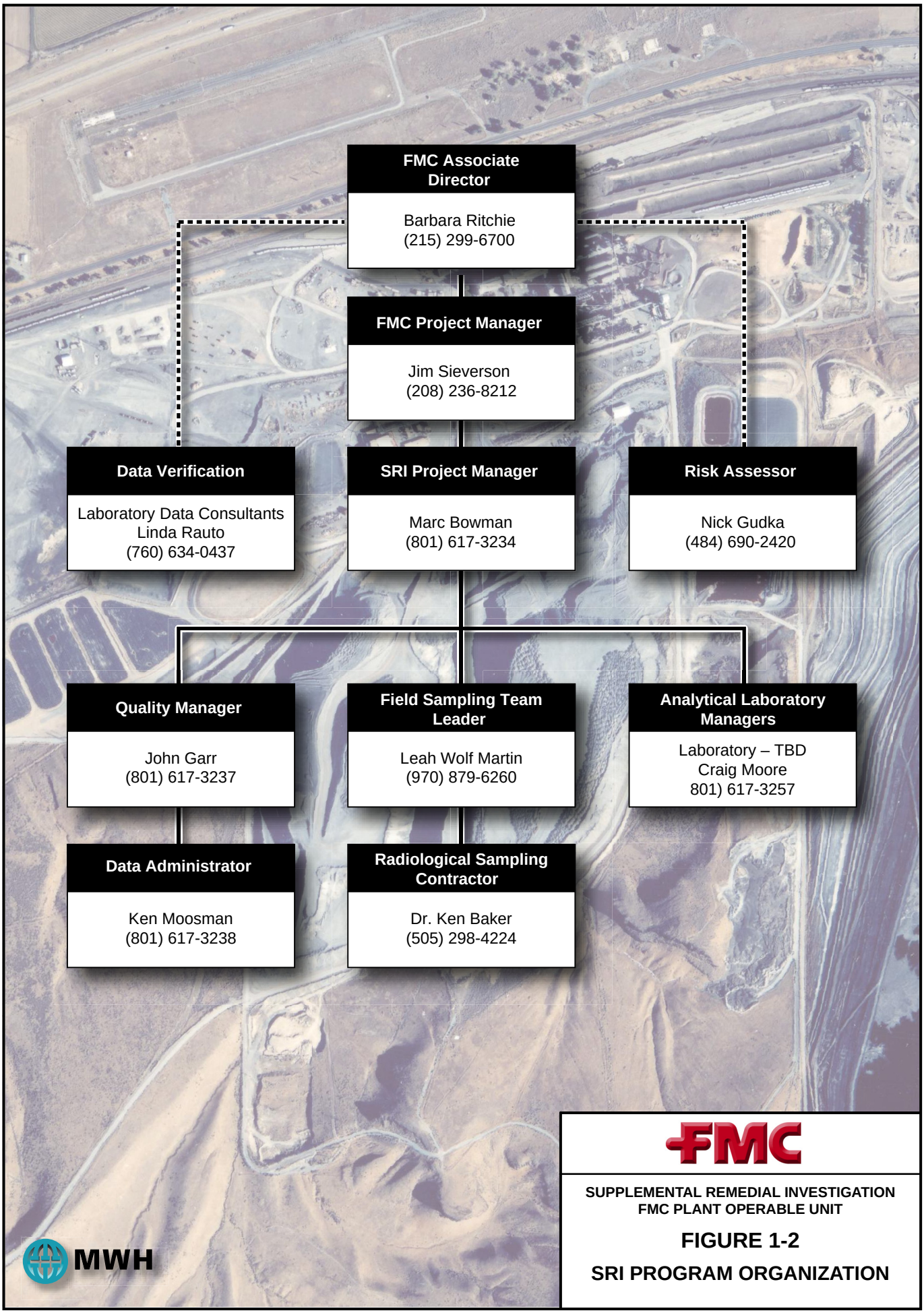


FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-1

REGIONAL SETTING OF THE FMC PLANT OPERABLE UNIT



SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-2

SRI PROGRAM ORGANIZATION

FILE *Fig 1-02 SRI Program Org_507.ai* 5/02/07

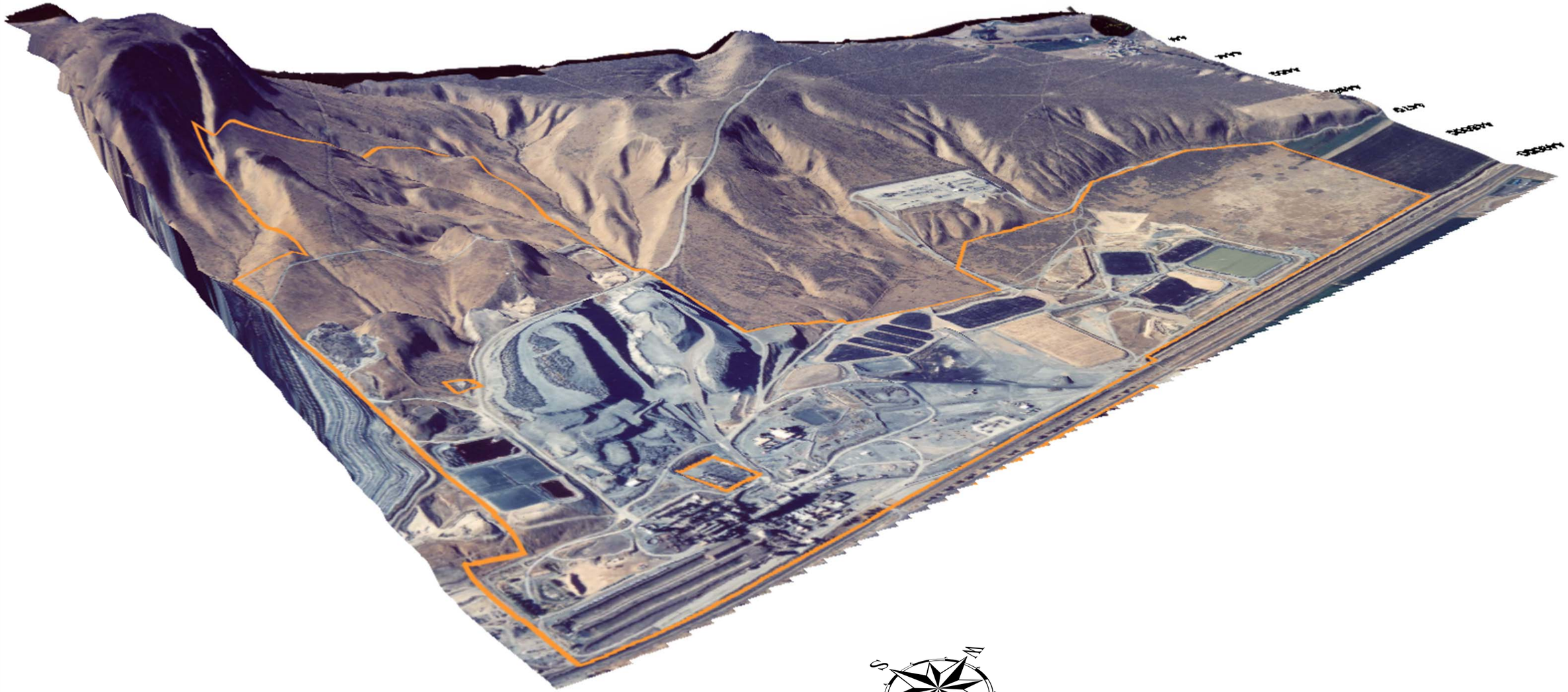
FMC

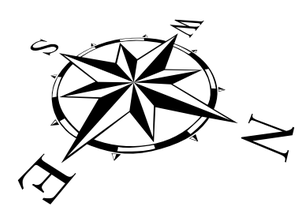
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-3

RU BOUNDARIES AT FMC PLANT OU AND 2003 AERIAL PHOTO

FILE *Fig 1-3 RU Bndries at FMC Plant_307.mxd* *3/14/07*





VERTICAL EXAGGERATION IS 2X HORIZONTAL

FILE Fig 1-4 Digital Elev Model_307.ai 3/15/07

MWH

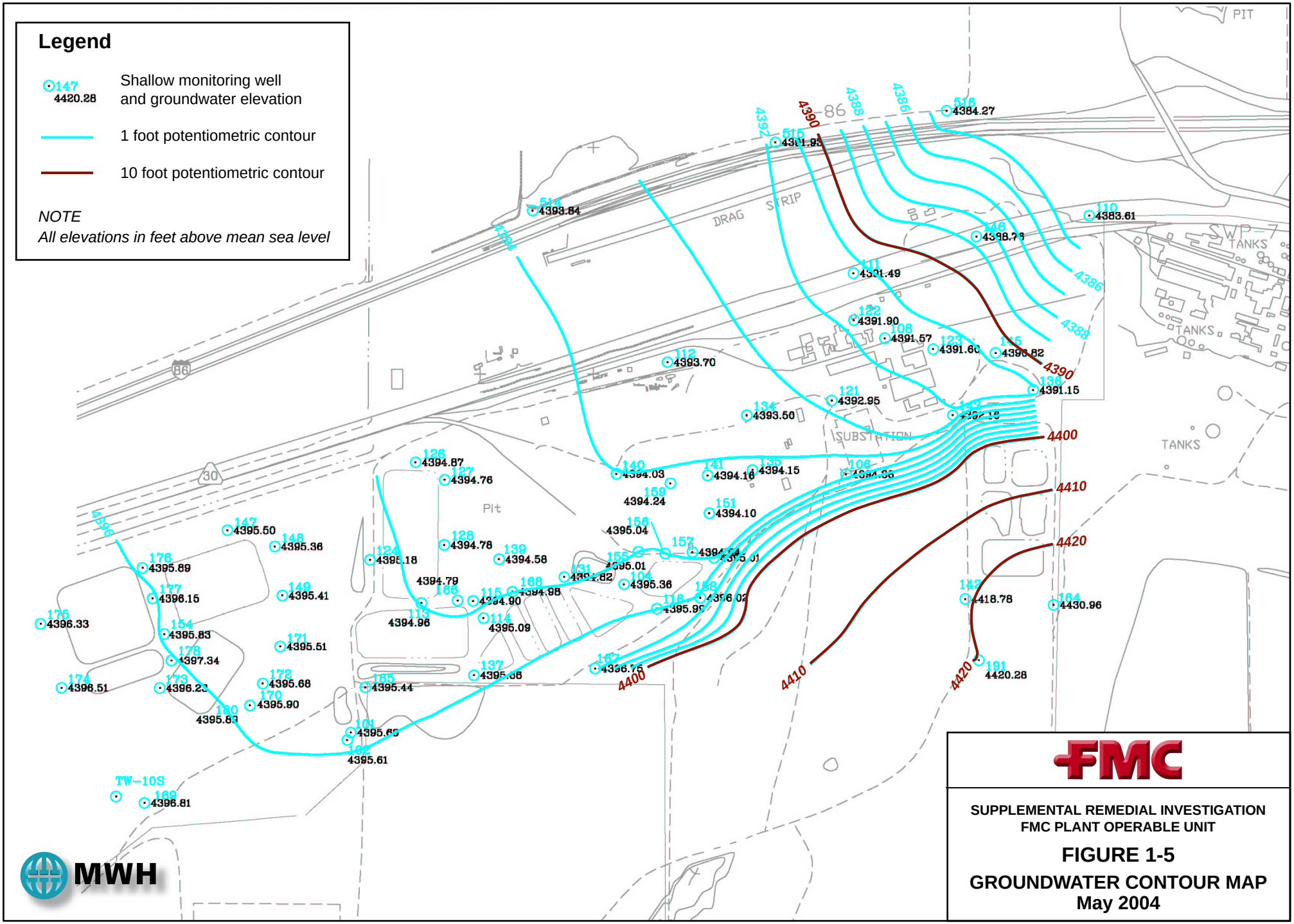
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

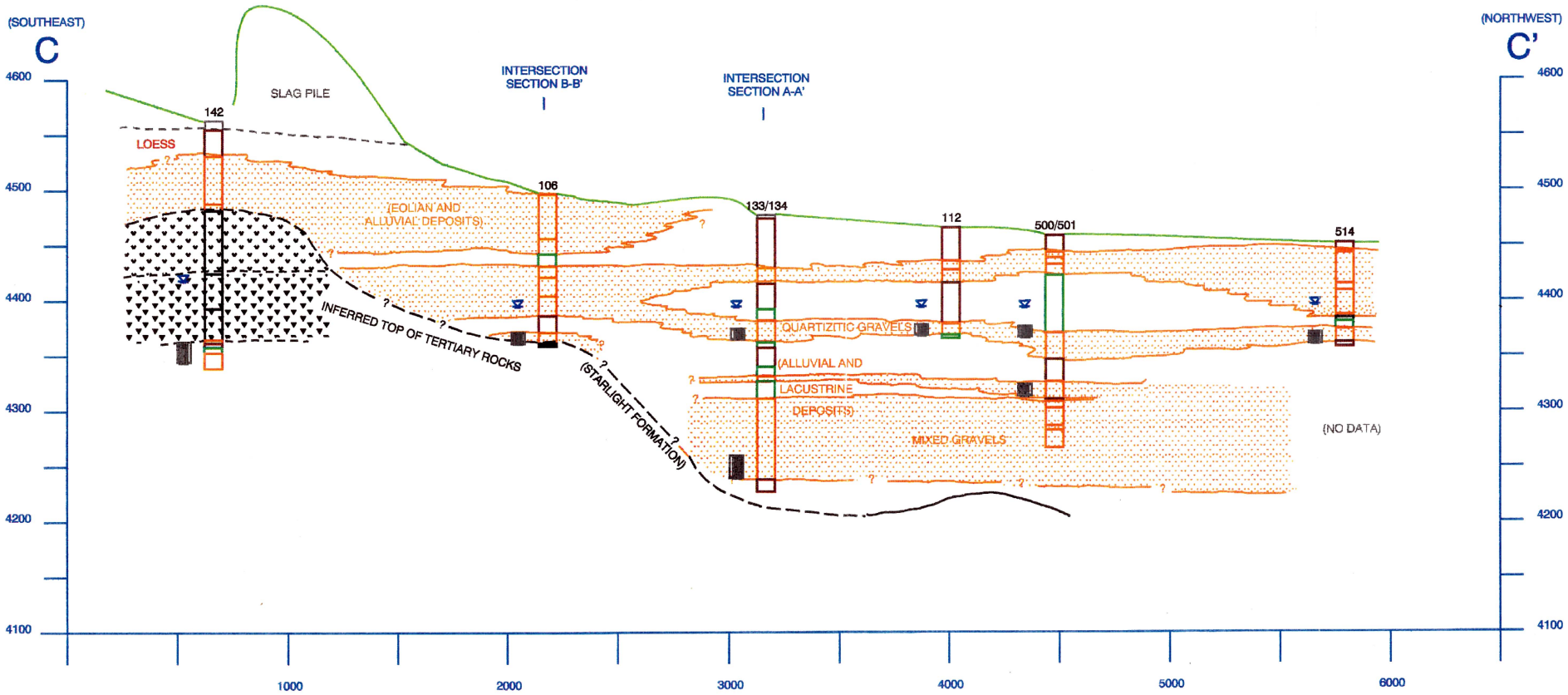
FIGURE 1-4

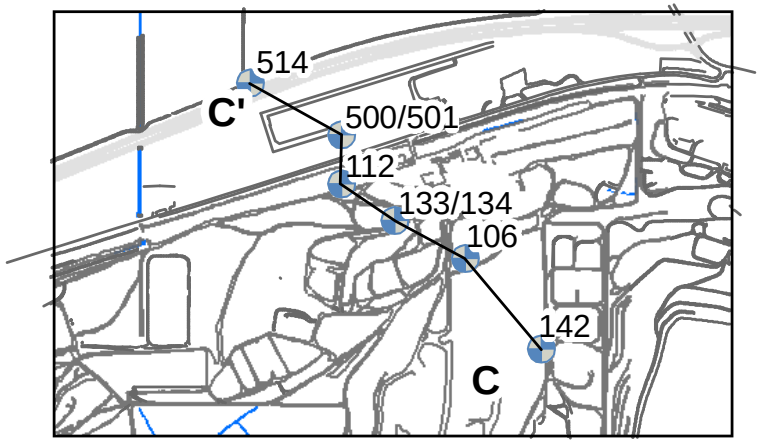
DIGITAL ELEVATION MODEL

FILE *Fig 1-5 Groundwater Contour Map_May2004_206ill.ai 2/16/06*



FILE *Fig 1-06 Hydro Cross Section C-C_307.ai 3/15/07*





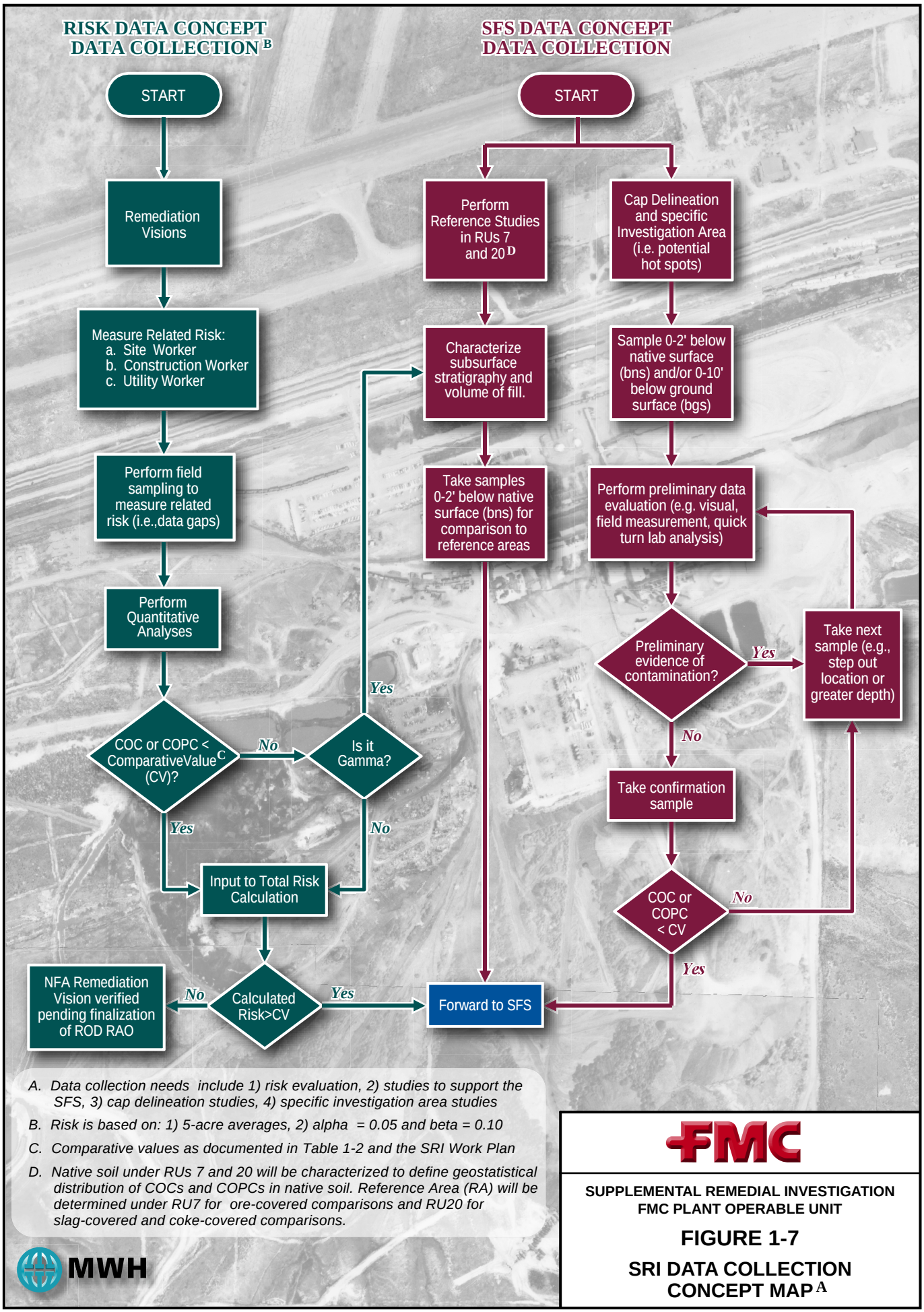
MWH

FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-6

HYDROGEOLOGIC CROSS SECTION C-C′



A. Data collection needs include 1) risk evaluation, 2) studies to support the SFS, 3) cap delineation studies, 4) specific investigation area studies

B. Risk is based on: 1) 5-acre averages, 2) alpha = 0.05 and beta = 0.10

C. Comparative values as documented in Table 1-2 and the SRI Work Plan

D. Native soil under RUs 7 and 20 will be characterized to define geostatistical distribution of COCs and COPCs in native soil. Reference Area (RA) will be determined under RU7 for ore-covered comparisons and RU20 for slag-covered and coke-covered comparisons.

MWH

FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-7

SRI DATA COLLECTION CONCEPT MAP A

FILE Fig 1-07 SRI Data Collection Concept_307.ai 3/27/07

TABLE 1-1

SRI PROGRAM KEY PERSONNEL

Name	Organization Affiliates	Title	Contact Information
Ms. Barbara Ritchie	FMC	FMC Associate Director	Office Phone: (215) 299-6700 Cell Phone: (b) (6) Email: barabara_ritchie@fmc.com
Mr. Jim Sieverson	FMC	FMC Project Manager	Office Phone: (208) 236-8212 Cell Phone: (b) (6) Email: jim_sieverson@fmc.com
Mr. Marc Bowman	MWH	SRI Project Manager	Office Phone: (801) 617-3234 Cell Phone:(b) (6) Email: marc.e.bowman@mwhglobal.com
Ms. Leah Wolf Martin	MWH	Field Sampling Team Leader	Office Phone: (970) 879-6260 Cell Phone: (b) (6) Email: leah.wolf.martin@mwhglobal.com
Mr. John Garr	MWH	Quality Manager	Office Phone: (801) 617-3237 Cell Phone: (b) (6) Email: john.garr@mwhglobal.com
Mr. Nick Gudka	Hanna and Associates	Risk Assessor	Office Phone: (484) 690-2420 ext 102 Cell Phone: (b) (6) Email: (b) (6)
Ms. Linda Rauto	Laboratory Data Consultants	Data Verification	Office Phone: (760) 634-0437 Cell Phone: None Email: lrauto@lab-data.com
Ms. Linda Meyer	EPA Region X	Remedial Project Manager	Office Phone: (206) 553-8509 MS WCM-121 U.S. Environmental Protection Agency, Region 10 1200 Sixth Avenue Seattle, WA 98101 Email: MEYER.LINDA@epamail.epa.gov
Mr. Douglas Tanner	Idaho Department of Environmental Quality	Regional Environmental Manager	Office Phone: (208) 236-6160 Cell Phone: None Email: dtanner@deq.state.id.us
Mr. Kelly Wright	Shoshone Bannock Tribe	Environmental Waste Management Program Manager	Office Phone: (208) 478-3904 Cell Phone: (b) (6) Email: kwright@shoshonebannocktribes.com

Table 1-2

SRI Work Plan Summary
(Page 1 of 16)

Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 1: Furnace Building, Phos Dock and Secondary Condenser (SRI Work Plan Figures: 2-1, 2-2, 2-3, 2-11 & 2-14)	Leave existing concrete slabs in-place, grade to design subgrade elevation and construct a RCRA-engineered cap over entire footprint of these areas.	1. Cap Delineation[viii] SRI WP Sections 2.1.1 and 2.2.1.1	1. Confirm cap/cover extent for P4 and evaluate future worker risk outside of the cap/cover boundary.	1. Drill 7 auger borings around the perimeter of RU 1. Visually evaluate cuttings for the presence of P4. Step out as required. Collect samples for fixed-laboratory analysis from 0-2' bgs and 0-10' bgs from outermost step-out locations.	1. Applicable SSLs: Table 1-6	1. P4: FMC Method Q-15 or 7580	1. If P4 is evidenced by smoking or burning, drill step-out borings to groundwater. If P4 is not evidenced by smoking or burning, collect samples from 0-2' bgs and 0-10' bgs to evaluate future worker risk. If P4 > SSLs in 0-2' bgs or 0-10' bgs, step-out borings required. If P4 < SSLs in 0-2' bgs and 0-10' bgs, no action associated with investigation area is required.	1. See P4 Handling Procedure in HASP	Page 6-4 Page 6-13 to Page 6-16 Page 7-2 Figure 6-1 Figure 6-11 Figure 6-12 Table 6-1 Table 7-1 Table C-1 to C-4 Table A-1
		2. Underground Piping SRI WP Section 2.1.1 and 2.3.9.3	2. Compile information on underground piping, sumps and structures in RU to provide the information for an SFS evaluation.	2. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping, sumps and structures.	2. NA	2. NA	2. Forward data to SFS.	2. NA	
RU 2: Slag Pit (SRI Work Plan Figures: 2-1, 2-2, 2-3, 2-11 & 2-14)	Grade to design subgrade elevation and cap entire slag pit consistent with RCRA cap design for slag pit sump (SWMU #5) in Closure Plan (June 1998, revised April 2000)	1. Cap Delineation[viii] SRI WP Sections 2.1.1 and 2.2.1.1	1. Confirm cap/cover extent for P4 and evaluate future worker risk outside of the cap/cover boundary.	1. Drill 7 auger borings around the perimeter of RU 2. Visually evaluate cuttings for the presence of P4. Step out as required. Collect samples for fixed-laboratory analysis from 0-2' bgs and 0-10' bgs from outermost step-out locations.	1. Applicable SSLs : Table 1-6	1. P4: FMC Method Q-15 or 7580	1. If P4 is evidenced by smoking or burning, drill step-out borings to groundwater. If P4 is not evidenced by smoking or burning, collect samples from 0-2' bgs and 0-10' bgs to evaluate future worker risk. If P4 > SSLs in 0-2' bgs or 0-10' bgs, step-out borings required. If P4 < SSLs in 0-2' bgs and 0-10' bgs, no action associated with investigation area is required.	1. See P4 Handling Procedure in HASP	Page 6-4 Page 6-13 to Page 6-16 Page 7-2 Page C-2 Figure 6-1 Figure 6-11 Figure 6-12 Table 6-1 Table 7-2 Table A-2
		2. Underground Piping SRI WP Sections 2.1.1and 2.3.9.3	2. Compile information on underground piping, sumps and structures in RU to provide the information for an SFS evaluation.	2. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping, sumps and structures.	2. NA	2.NA	2. Forward data to SFS.	2. NA	

Table 1-2

SRI Work Plan Summary
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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 3: Receiving Stores, Paint Shop and P4 Decon (SRI Work Plan Figures: 2-1, 2-9 2-10, 2-11, 2-13, 2-15, & 2-16)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.2 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk**: Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha apectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-4 Page 6-29 Page C-2 Figure 6-1 Figure 6-24 Figure 6-25 Table 6-1 Table 7-3 Table A-3
		2. Specific Investigation Area SRI WP Sections 2.1.2 and 2.3.7.1	2. Investigate potential for P4 contaminated water surface flow to impact soil along the drainage from RU 1 to RU 22c.	2. Drill 15 sample locations in the area of the surface flow path. Collect one sample from each boring for fixed laboratory analysis from 0-2' bns.[v]	2. Applicable SSLs and/or background: Table 1-6	2. P4: FMC Method Q-15 or 7580 Metals: 6020/7471A Fluoride: 9214	2. Compare to SSLs/background. If concentrations above SSLs/background, forward to SFS. If concentrations below SSLs/background, no action associated with investigation area is required.	2. See P4 Handling Procedure in HASP	
		3. Underground Piping Investigation SRI WP Sections 2.1.2 and 2.3.9.1	3a. Phase 1: Compile information on underground piping in RU to provide the information for an SFS evaluation. 3b. Phase 2: evaluate SRI data for RU 3, if necessary design sampling and collect additional samples in phase 2.	3. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping.	3. NA	3. NA	3. If RU 3 is a candidate for NFA after phase 1 investigation, assess potential risk for underground piping. If RU 3 is forwarded to the SFS, during the SRI investigation, forward existing data to the SFS.	3. See P4 Handling Procedure in HASP	
RU 4: Office Buildings and Training Center (SRI Work Plan Figures: 2-1, 2-4, 2-9, 2-13, 2-17, & 2-18)	No further action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.3 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha apectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-3 Page 6-4 Page 6-30 to 6-31 Page 6-40 Page C-2 Figure 6-1 Figure 6-25 Figure 6-26 Figure 6-27 Table 6-1 Table 7-4 Table C5 to C8 Table A-4

Table 1-2

SRI Work Plan Summary
(Page 3 of 16)

Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 4: Office Buildings and Training Center (continued)		2. Specific Investigation Area SRI WP Sections 2.1.3 and 2.3.1.1	2. Investigate organic releases for lab-related solvents around boring F028.	2a. Phase 1: Drill 14 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed laboratory analysis. 2b. Phase 2: Evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater. [v]	2. Worker and groundwater SSLs Lab-related solvents: Table 1-5	2. Lab-related solvents: 5035A/8260B	2. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	2. See Drilling Procedure in HASP	
RU 5: Lab and Old Drainfield (SRI Work Plan Figures: 2-1, 2-4, 2-9, 2-13, 2-19, & 2-20)	No further action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.4 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha apectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 2-8 Page 2-10 Page 2-12 Page 2-14 Page 6-3 Page 6-31 Page C-2 Figure 2-10 Figure 6-1 Figure 6-25 Figure 6-27 Table 6-1 Table 7-5 Table A-5

Table 1-2

SRI Work Plan Summary
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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 5: Lab and Old Drainfield (continued)		2. Specific Investigation Area SRI WP Sections 2.1.4 and 2.3.1.2	2. Investigate organic releases for lab-related solvents around the Chemical Lab Drain Pit and Disposal Area Behind Laboratory.	2a. Phase 1: Drill 24 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed-laboratory analysis. 2b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater.[v]	2. Worker and groundwater SSLs Lab-related solvents: Table 1-5	2. Lab-related solvents: 5035A/8260B	2. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	2. See Drilling Procedure in HASP	
RU 6: Former Long-Term Phos Storage Tanks (SRI Work Plan Figures: 2-1, 2-9 2-10, 2-13, 2-21 & 2-22)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.5 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha apectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 3-7 Page 6-16 to 6-17 Page 7-2 Page C-2 Figure 6-1 Figure 6-14 Figure 6-15 Table 6-1 Table 7-6 Table A-6
		2. Specific Investigation Area SRI WP Sections 2.1.5 and 2.3.7.2	2. Investigate potential for P4 impact to soils near the rail loading/unloading area and long-term storage tanks.	2. 20 borings/test pits around former tanks and railspurs, 12 borings beneath the former tanks. Visually evaluate cuttings for the presence of P4. Move as required. Collect one sample from each boring for fixed laboratory analysis from 0-2' bns.	2. Applicable SSLs and/or background: Table 1-6	2. P4: FMC Method Q-15 or 7580 Metals: 6020/7471A Fluoride: 9214	2. Compare to SSLs/background. If concentrations above SSLs/background, forward to SFS. If concentrations below SSLs/background, no action associated with investigation is required.	2. See P4 Handling Procedure in HASP	

Table 1-2

SRI Work Plan Summary
(Page 5 of 16)

Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 7: Shale Unloading, Crushing and Stockpile (SRI Work Plan Figures: 2-1, 2-6, 2-9, 2-12, 2-13, 2-23, 2-24)	Following sale and removal of ore inventory, no action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.6 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7). [iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha apectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 2-8 Page 6-31 to 6-32 Page 6-37 Figure 6-1 Figure 6-28 Figure 6-29 Table 6-1 Table 7-7 Table A-7 Table C-9 to C-13
		2. Specific Investigation Area SRI WP Sections 2.1.6 and 2.3.3.1	2. Investigate potential PAH releases from coke	2. Evaluate data from RU 20 Coke Reference Area	2. Evaluate data from RU 20 Coke Reference Area	2. See COCs and analytical methods for RU 20.	2. Compare RU 20 data to applicable SSLs. If RU 20 data is above SSLs, forward the RU 7 Coke Investigation Area to the SFS. If RU 20 data below SSLs, no action associated with migration of coke into underlying soils is required.	2. See Sampling Procedure in HASP	
		3. Ore Reference Area Study SRI WP Sections 2.1.6 and 2.7	3. Characterize native soil to define geostatistical distribution of COCs/ COPCs	3. Drill 20 auger borings. Collect a sample in each boring from 0-2' bns for fixed laboratory analysis.	3. Site, construction and utility worker SSLs and/or background: Table 1-6	3. Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	3. Compare to applicable SSLs and/or background for use in other RUs that compare to the reference area.	3. See Drilling Procedure in HASP	
		4. Radon Flux Measurements SRI WP Sections 2.1.6 and 2.4.2	4. Characterize radon flux to evaluate radon emanation from ore	4. Collect 100 radon flux measurements using electret ion chamber	4. Compare measured radon fluxes to UMTRCA guideline of 20 pCi/m^2/sec.	4. Radon Flux: Method 115	4. Compare to UMTRCA guideline. If radon flux above guideline, forward to SFS. If radon flux below guideline, no action associated with radon is required.	4. See Radiological Procedure in HASP	
RU 8: Former Kiln Scrubber Ponds and Calciners (SRI Work Plan Figures: 2-1, 2-2, 2-3, 2-9, & 2-25)	Leave existing concrete slabs in-place, grade to design subgrade elevation and construct soil cover (cap) over entire footprint of these areas.	1. Cap Delineation[viii] SRI WP Sections 2.1.7 and 2.2.2	1. Confirm cap/cover extent to prevent exposure to kiln scrubber pond sediments around the boundary of RU 8 and into RU 9	1. Visually evaluate cuttings for the presence of pond sediments down to native soil. 14 initial borings. Step out 10' as required and collect a sample from 0-2' bns in final step-out borings for fixed laboratory analysis. [v]	1. Applicable SSLs and/or background: Table 1-6	1. Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. Compare to applicable SSLs and/or background. If above SSLs and/or background, then additional delineation borings. If below SSLs and/or background, cap has been delineated.	1. See Drilling Procedure in HASP	Pages 6-9 to 6-10 Page 6-32 Page 7-2 Page C-2 Figure 6-1 Figure 6-6 Figure 6-7 Table 6-1 Table 7-8 Table A-8

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 9: Silica Stockpiles and Former Kiln Scrubber Overflow Pond (SRI Work Plan Figures: 2-1, 2-9, 2-13, 2-25, 2-26, & 2-27)	No further action anticipated to be necessary.	1. Future Worker Risk Exposure SRI WP Sections 2.1.8 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-32 to 6-33 Page C-2 Figure 6-1 Figure 6-30 Figure 6-31 Table 6-1 Table 7-9 Table A-9 Table C-14 to C-17
RU 10: IWW Pond and Ditch (SRI Work Plan Figures: 2-1, 2-9, 2-10, 2-13, 2-28, & 2-29)	Backfill with silica, no further action anticipated to be necessary. .	1. Future Worker Risk Exposure SRI WP Sections 2.1.9 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-33 to 6-36 Page A-5 Page C-2 Figure 6-1 Figure 6-31 Figure 6-32 Table 6-1 Table 7-10 Table A-10
		2. Specific Investigation Area SRI WP Sections 2.1.9 and 2.3.8	2. Investigate potential for P4 impact to soils in the ditch and pond	2. 20 borings/test pits. Visually evaluate cuttings for evidence of P4. Move borings as required. Collect one sample from each boring for fixed-laboratory analysis from 0-2' bns for the ditch and 0-2' bgs for the pond.	2. Applicable SSLs and/or background: Table 1-6	2. P4: FMC Method Q-15 or 7580 Metals: 6020/7471A Fluoride: 9214 Po-210: alpha spectroscopy Pb-210: liquid scintillation	2. Compare to SSLs/background. If concentrations above SSLs/background, forward to SFS. If concentrations below SSLs/background, no action associated with investigation is required.	2. See P4 Handling Procedure in HASP	
RU 11: Equipment Area South of Calciners (SRI Work Plan Figures: 2-1, 2-9, 2-13, 2-30, & 2-31)	No further action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.10 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go o SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS:** Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-35 to 6-35 Page C-2 Figure 6-1 Figure 6-33 Figure 6-34 Table 6-1 Table 7-11 Table A-11

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 12: Former RP&S Area and Mobile Shop (SRI Work Plan Figures: 2-1, 2-4, 2-5, 2-7, 2-9, 2-11, 2-13, 2-32, & 2-33)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.11 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7). [iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS**: Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 2-8 Page 6-35 to Page 6-36 Figure 6-1 Figure 6-35 Figure 6-36 Table 6-1 Table 7-12 Table A-12 Table C-18 to C-21
		2. Specific Investigation Area (Fuel Islands and Mobile Shop) SRI WP Sections 2.1.11, 2.3.1.3, and 2.3.2.1	2. Investigate potential releases for shop-related solvents and liquid petroleum fuels around the Mobile Shop and Fuel Islands.	2a. Phase 1: Drill 42 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed-laboratory analysis. 2b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater. [v]	2. Worker and groundwater SSLs Shop-related solvents: Table 1-5 Liquid petroleum fuels: Table 1-5	2. Shop-related solvents: 5035A/8260B Liquid petroleum fuels: 5035A/8260B/8270C	2. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	2. See Drilling Procedure in HASP	

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 12: Former RP&S Area and Mobile Shop (continued)		3. Specific Investigation Area (Steam Cleaner Area) SRI WP Sections 2.1.11 and 2.3.2.1	3. Investigate potential releases for liquid petroleum fuels around the steam cleaning area	3a. Phase 1: Drill 8 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed-laboratory analysis. 3b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater.[v]	3. Worker and groundwater SSLs Liquid petroleum fuels: Table 1-5	3. Liquid petroleum fuels: 5035A/8260B/8270C	3. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	3. See Drilling Procedure in HASP	
		4. Specific Investigation Area (Transformer Storage) SRI WP Sections 2.1.11 and 2.3.4	4. Investigate potential releases of PCBs around the Transformer Storage Area	4. Drill 33 borings. Collect a discrete sample at surface, every 2.5' to native soil, native soil and 2' bns for fixed-laboratory analysis.	4. Applicable SSLs PCBs: Table 1-5	4. PCBs: 1668A	4. Compare to applicable SSLs. If above SSLs, evaluate lateral extent and/or vertical extent. If below SSLs, no action associated with investigation is required.	4. See Drilling Procedure in HASP	
		5. Underground Piping Investigation SRI WP Sections 2.1.11 and 2.3.9.2	5a. Phase 1: Compile information on underground piping in RU to provide the information for an SFS evaluation. 5b. Phase 2: evaluate SRI data for RU 12 data, if necessary design sampling and collect additional samples in phase 2.	5. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping.	5. NA	5. NA	5. If RU 12 is a candidate for NFA after phase 1 investigation, assess potential risk for underground piping. If RU 12 is forwarded to the SFS, during the SRI investigation, forward existing data to the SFS.	5. See Drilling Procedure in HASP	

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area (SRI Work Plan Figures: 2-1, 2-3, 2.9, 2-11, 2-13, 2-34, & 2-35)	No further action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.12 and 2.5	1. Characterize for: surface radiological risks [i] metals [ii, iii] fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS**: Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-3 Page 6-8 Page 6-36 to 6-37 Page 7-2 Figure 6-1 Figure 6-37 Figure 6-38 Table 6-1 Table 7-13 Table A-13 Table C-22 to C-25
		2. Underground Piping Investigation SRI WP Sections 2.1.12 and 2.3.9.2	2a. Phase 1: Compile information on underground piping in RU to provide the information for an SFS evaluation. 2b. Phase 2: evaluate SRI data for RU 13 data, if necessary design sampling and collect additional samples in phase 2.	2. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping.	2. NA	2. NA	2. If RU 13 is a candidate for NFA after phase 1 investigation, assess potential risk for underground piping. If RU 13 is forwarded to the SFS, during the SRI investigation, forward existing data to the SFS.	2. See Drilling Procedure in HASP	
RU 15: Oversize Ore, Used Electrode, Baghouse Dust Area (SRI Work Plan Figures: 2-1, 2-2, 2-8, & 2-36)	Consolidate material into minimal footprint, grade to design subgrade elevation and construct soil cover (cap) over area.	1. Leaching Potential SRI WP Sections 2.1.13 and 2.3.5	1. Characterize depth of impacted soils assess potential transport of metals in vadose zone.	1. Drill 5 borings. Collect samples at 0-2' bns and a discrete sample every 10' bns to refusal or groundwater for fixed-laboratory analysis.[v]	1. Groundwater SSLs and/or background: Table 1-6	1. Metals: 6020/7471A Fluoride: 9214	1. Compare to groundwater SSLs and/or background. Forward to SFS.	1. See Drilling Procedure in HASP	Page 6-37 to 6-38 Page 7-2 Page C-2 Figure 6-1 Figure 6-39 Figure 6-40 Table 6-1 Table 7-15 Table A-15

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 16: Calciner Solids Stockpile (SRI Work Plan Figures: 2-1, 2-2, 2-8, & 2-37)	Calciner solids will be remediated per the ROD (June 1998).	1. Leaching Potential SRI WP Sections 2.1.13 and 2.3.5	1. Characterize depth of impacted soils assess potential transport of metals in vadose zone.	1. Drill 8 borings. Collect sample at 0-2' bns and a discrete sample every 10' bns to refusal or groundwater for fixed-laboratory analysis. [v]	1. Groundwater SSLs and/or background: Table 1-6	1. Metals: 6020/7471A Fluoride: 9214	1. Compare to groundwater SSLs and/or background. Forward to SFS.	1. See Drilling Procedure in HASP	Page 2-8 Page 2-14 Page 6-6 Page 6-10 to Page 6-13 Page 7-1 Page A-4 Page C-2 Figure 6-1 Figure 6-9 Figure 6-10 Table 6-1 Table 7-16 Table A-16
RU 17: Recyclable Material Landfill (Figure 2-2)	Implement EPA's Presumptive Remedy for Municipal CERCLA Landfills.	1. Presumptive Remedy Technical Areas have been considered	1. NA	1. NA	1. NA	1. NA	1. SRI Report will present a discussion of groundwater flow and chemistry as it relates to the presumptive remedy.	1. NA	Page 2-8 Page 2-14 Page 6-17 to 6-23 Page A-4 Figure 6-1 Figure 6-16 Figure 6-17 Table 6-3 Table 6-5 Table 6-6 Table 7-17 Table A-17
RU 18: Plant Landfill (Figure 2-2)	Implement EPA's Presumptive Remedy for Municipal CERCLA Landfills.	1. Presumptive Remedy Technical Areas have been considered	1. NA	1. NA	1. NA	1. NA	1. SRI Report will present a discussion of groundwater flow and chemistry as it relates to the presumptive remedy.	1. NA	Page 2-14 Page 6-17 to 6-23 Figure 6-1 Figure 6-16 Figure 6-17 Table 6-3 Table 6-5 Table 6-6 Table 7-18 Table A-18

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 19: Slag Pile (SRI Work Plan Figures: 2-1, 2-2, 2-12, & 2-38)	Reclaim in-place; shape external slopes to approximately 3H:1V slope, place topsoil over slag and revegetate with native grasses and shrubs.[vi]	1. Radiation survey over soil cover area SRI WP Sections 2.1.14 and 2.4.1	1. Collect data to support cap design.	1. Perform surface radiation scan over soil cover area	1. Initial comparison to gamma dose CV	1. NA	1. Forward data to the SFS	1. See Radiological Procedure in HASP	Page 2-14 Page 6-17 to 6-23 Page 7-2 Page A-4 Figure 6-1 Figure 6-16 Figure 6-17 Table 6-1 Table 6-3 Table 6-5 Table 6-6 Table 7-19 Table A-19
		2. Radon Flux Measurements SRI WP Sections 2.1.14 and 2.4.1	2. Characterize radon flux to evaluate design of the cap/cover.	2. Collect 100 radon flux measurements using electret ion chamber from each: slag pile, bull rock pile and test soil cover area, if required.	2. Compare measured radon fluxes to UMTRCA guideline of 20 pCi/m^2/sec.	2. Radon Flux: Method 115	2. Forward data to the SFS	2. See Radiological Procedure in HASP	
		3. Old Landfill and Railcar Areas: Presumptive Remedy has been considered	3. NA	3. NA	3. NA	3. NA	3. SRI Report will present a discussion of groundwater flow and chemistry as it relates to the presumptive remedy.	3. NA	
RU 20: Former Bannock Paving Area (SRI Work Plan Figures: 2-1, 2-4, 2-5, 2-6, 2-9, 2-13, 2-39, & 2-40)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.15 and 2.5	1. Characterize for: surface radiological risks [i] Metals [ii, iii] Fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7).[iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS**: Reference Areas in RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 2-8 to 2-9 Page 2-13 Page 2-14 Page 2-15 Page 3-8 Page 6-3 Page 6-27 to 6-29 Page 7-2 Page A-4 Figure 2-10 Figure 6-1 Figure 6-22 Figure 6-23 Table 6-1 Table 7-20 Table A-20 Table C-27 to C-30

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 20: Former Bannock Paving Area (continued)		2. Specific Investigation Area (Hot Batch Plants) SRI WP Sections 2.1.15 and 2.3.2.2	2. Investigate potential releases for liquid petroleum fuels around the Hot Batch Plant areas.	2a. Phase 1: Drill 43 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed-laboratory analysis. 2b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater.[v]	2. Worker and groundwater SSLs Liquid petroleum fuels: Table 1-5	2. Liquid petroleum fuels: 5035A/8260B/8270C	2. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	2. See Drilling Procedure in HASP	
		3. Specific Investigation Area (Maintenance Shop) SRI WP Sections 2.1.15, 2.3.1.4, and 2.3.2.2	3. Investigate potential releases for shop-related solvents and liquid petroleum fuels around the Maintenance and Equipment Shop	3a. Drill 30 borings. Collect a discrete sample in each boring from native soil interface, 2' bns, 10' bns and/or 10' bgs for fixed-laboratory analysis. 3b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater[v]	3. Worker and groundwater SSLs Shop-related solvents: Table 1-5 Liquid petroleum fuels: Table 1-5	3. BTEX: 5035A/8260B PAH: 8270C Solvents: 5035A/8260B	3. Compare to worker and groundwater SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	3. See Drilling Procedure in HASP	
		4. Specific Investigation Area/Reference Study (Coke Handling area) SRI WP Sections 2.1.15 and 2.3.3.2	4. Investigate potential PAH releases from coke – Reference Study for coke in RU 7 and RU 20	4. Drill 20 borings. Collect a sample in each boring from 0-2' bns for fixed-laboratory analysis.	4. Applicable SSLs Coke PAHs: Table 1-5	4. Coke PAHs: 8270C	4. Compare to applicable SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	4. See Drilling Procedure in HASP	

Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 20: Former Bannock Paving Area (continued)		5. Specific Investigation Area (Coke Settling Basins) SRI WP Sections 2.1.15 and 2.3.3.3	5. Investigate potential migration to ground water of releases from coke constituents from the sediments in the basin.	5a. Drill 3 borings to 10' below the bottom of the basins. Collect a discrete sample from each boring at 0', 2' and 10' below the basin. 5b. Phase 2: evaluate phase 1 data, present to Agency, if necessary design sampling program and collect additional samples to evaluate migration to groundwater.[v]	5. Applicable SSLs Metals and Coke PAHs: Table 1-6	5. Metals: 6020/7471A Coke PAHs: 8270C	5. Compare to applicable SSLs. If above SSLs, evaluate lateral extent and/or potential for migration to groundwater. If below SSLs, no action associated with investigation is required.	5. See Drilling Procedure in HASP	
		6. Specific Investigation Area (Coke characterization) SRI WP Sections 2.1.15 and 2.3.3.4	6. Determine characterization of coke for handling purposes.	6. Collect 1 composite sample at the coke handling area and a composite sample from sediments in each of the three settling basins.	6. Regulatory Level of the Maximum Concentration of Contaminants for the Toxicity Characteristic: Table 1-7	6. TCLP: 1312 Metals: 6020/7471A Semi volatiles: 8270C	6. Compare to Maximum Concentration Levels. Forward data to the SFS.	6. See Sampling Procedure in HASP	
		7. Slag Reference Area SRI WP Sections 2.1.15 and 2.7	7. Characterize native soil to define geostatistical distribution of COCs/COPCs	7. Drill 20 borings. Collect a sample from 0-2' bns in each boring for fixed-laboratory analysis.	7. Site, construction and utility worker SSLs and/or background: Table 1-6	7. Metals: 6020/7471A Fluoride: 9214 Ra-226: Radon Emanation U-238: Alpha Spectroscopy K-40: Gamma Spectroscopy Po-210: Alpha Spectroscopy Pb-210: Liquid Scintillation	7. Compare to applicable SSLs and/or background for use in other RUs that compare to a reference area.	7. See Drilling Procedure in HASP	
RU 21: Other Onsite Railspurs (SRI Work Plan Figures: 2-1, 2-13, & 2-41)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.16 and 2.5	1. Characterize surface radiological risk	1. Perform surface radiation scan.	1. Initial comparison to gamma dose CV	1. NA	1. If the railways or a portion of the railways pass the surface radiation scan, perform PIC measurements. If railways fail surface radiation scan, forward to SFS.	1. See Radiological Procedure in HASP	Page 6-38 to 6-39 Page C-2 Figure 6-1 Figure 6-41 Figure 6-42 Table 6-1 Table 7-21 Table A-21

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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 22b: Old Ponds (SRI Work Plan Figures: 2-1, 2-2, 2-3, 2-9, 2-12, 2-42)	Old phossy ponds will be remediated per the ROD (June 1998).	1. Radon Flux Measurements SRI WP Sections 2.1.17 and 2.4.1	1. Characterize radon flux to evaluate design of the cap/cover.	1. Collect 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.	1. Compare measured radon fluxes to UMTRCA guideline of 20 pCi/m^2/sec.	1. Radon Flux: Method 115	1. Forward data to the SFS	1. See Radiological Procedure in HASP	Page 6-3 Page 6-7 to 6-8 Page 6-12 Page 7-1 Figure 6-1 Figure 6-2 Figure 6-3 Table 6-1 Table 7-22b Table A-22b
		2. Cap Delineation[viii] SRI WP Sections 2.1.17 and 2.2.3	2. Confirm cap/cover extent around boundaries of RU 22b to prevent exposure to old phossy pond sediments and phossy solids	2. Trench 6 locations in RU 13. Drill 16 borings around rest of RU 22b. Visually evaluate cuttings for the presence of pond sediments down to native soil. Collect sample for fixed-laboratory analysis from either or 0-2' bgs and 0-10'bgs or 0-2' bns based upon presence of fill material.	2. Applicable SSLs and/or background: Table 1-6	2. Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Pb-210: liquid scintillation Po-210: alpha spectroscopy	2. Compare to SSLs and/or background. If above SSLs and/or background, then additional delineation locations. If below SSLs and/or background, cap has been delineated.	2. See Test Pit and Drilling Procedure in HASP	
		3. Underground Piping SRI WP Section 2.1.17 and 2.3.9.3	3. Compile information on underground piping in the RU to provide the information for an SFS evaluation.	3. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping,	3. NA	3. NA	3. Forward data to SFS.	3. NA	
RU 22c: Railroad Swale (SRI Work Plan Figures: 2-1, 2-2, 2-3, & 2-43)	Cap the Railroad Swale in lieu of lining. Divert storm water run-off from area	1. Cap Delineation[viii] SRI WP Sections 2.1.18 and 2.2.1.2	1. Confirm upstream and downstream cap/cover extent to prevent exposure to fill/soil impacted by phossy water	1. Investigate 4 to 7 locations. Visually evaluate for the presence of P4. Visually evaluate cuttings for the presence of P4. Step out as required. Collect samples for fixed-laboratory analysis from 0-2' bgs and 0-10' bgs from outermost step-out locations.	1. Applicable SSLs: Table 1-6	1. P4: FMC Method Q-15 or 7580	1. If P4 is evidenced by smoking or burning, step-out locations are required. If P4 is not evidenced by smoking or burning, collect samples from 0-2' bgs and 0-10' bgs to evaluate future worker risk. If P4 > SSLs in 0-2' bgs or 0-10' bgs, step-out locations required. If P4 < SSLs in 0-2' bgs and 0-10' bgs, no action associated with investigation area is required.	1. See Test Pit Procedure in HASP	Page 2-2 Page 6-1 Page 6-3 Page 6-6 Page 6-8 to 6-9 Figure 6-1 Figure 6-4 Table 6-1 Table 7-22c

Table 1-2

SRI Work Plan Summary
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Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
RU 23: Road Segments not within RU Boundaries (SRI Work Plan Figures: 2-1, 2-9, 2-13, 2-44, & 2-45)	No action anticipated to be necessary	1. Future Worker Risk Exposure SRI WP Sections 2.1.19 and 2.5	1. Characterize for: surface radiological risks [i] Metals [ii, iii] Fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii]	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7). [iv]	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS**: Reference Areas in RU 7 and/or RU 20	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options	1. See Radiological Procedure in HASP	Page 6-39 to 6-40 Page C-2 Figure 6-1 Figure 6-43 Table 6-1 Table 7-23
RU 24: Plant Areas not within RU Boundaries (SRI Work Plan Figures: 2-1, 2-9, 2-11, 2-13, 2-46, & 2-47)	To be evaluated using the same approach as other RUs for which no further action is anticipated to be necessary [vii]	1. Future Worker Risk Exposure SRI WP Sections 2.1.20 and 2.5 2. Underground Piping Investigation SRI WP Sections 2.1.20 and 2.3.9.2	1. Characterize for: surface radiological risks [i] Metals [ii, iii] Fluoride [ii, iii] Ra-226 [ii, iii] U-238 [ii, iii] K-40 [ii, iii] Pb-210 [ii, iii] Po-210 [ii, iii] 2a. Phase 1: Compile information on underground piping in RU to provide the information for an SFS evaluation. 2b. Phase 2: evaluate SRI data for RU 24 data, if necessary design sampling and collect additional samples in phase 2.	1. Perform surface radiation scan. If radiation scan passes, follow gamma decision tree (Fig. 2-50). If radiation scan fails go to SFS Data Collection (Figure 1-7). [iv] 2. Compile existing drawings, construction records, operation logs, and plant personnel knowledge for underground piping.	1. Initial comparison to gamma dose CV **Risk:** Site, construction and utility worker SSLs and/or background: Table 1-6 **SFS**: Reference Areas in RU 7 and/or RU 20 2. NA	1. Surface radiation scan PIC measurements Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation 2. NA	1. **Risk:** Do worker risk levels support Remediation Vision of NFA **SFS:** Evaluate remedial options 2. If RU 24 is a candidate for NFA after phase 1 investigation, assess potential risk for underground piping. If RU 24 is forwarded to the SFS, during the SRI investigation, forward existing data to the SFS.	1. See Radiological Procedure in HASP 2. See Drilling Procedure in HASP	NA
Other Studies Figure 2-48	NA	1. Southern and Western Undeveloped Area Gamma Measurements SRI WP Sections 2.1.21 and 2.6.1	1. Characterize surface for gamma dose rate.	1. Collect 100 PIC measurements from each area.	1. Comparison to established background	1. PIC Measurements	1. Compare to established background. If above background, forward to the SFS. If below background, no action associated with investigation is required.	1. See Radiological Procedure in HASP	NA

Table 1-2

SRI Work Plan Summary
(Page 16 of 16)

Remediation Unit Number, Name and Figures	Remediation Vision from RI Update Memo	Studies	Study Objectives	Data Collection Summary	Comparative Value	COCs/COPCs and Analytical Methods	Evaluation	Health & Safety	RI Update Memo References
Other Studies (continued) Figure 2-49		2. Specific Investigation Area (Precipitator Dust/Phossy Solids Distribution Along Roadways) SRI WP Sections 2.1.22 and 2.3.6	2. Investigate precipitator dust/phossy solids presence against the southern reference area	2. Investigate 6 locations and reference location. Collect 10 soil samples from 0-2' bgs at each location for fixed-laboratory analysis.	2. Comparison to southern road reference area.	2. Pb-210: liquid scintillation	2. Compare central tendency and extremes to the road reference area to evaluate whether to forward to the SFS.	2. See Drilling Procedure in HASP	
Figure 2-49		3. Specific Investigation Area (PCDT Distribution on Roadways) SRI WP Sections 2.1.22 and 2.3.10	3. Investigate PCDT water presence against a reference area	3. Investigate worst-case segment and reference road segment. Collect 10 soils samples at each area from 0-0.5' bgs for fixed-laboratory analysis	3. Comparison to road reference area.	3. Metals: 6020/7471A Fluoride: 9214 Ra-226: radon emanation U-238: alpha spectroscopy K-40: gamma spectroscopy Po-210: alpha spectroscopy Pb-210: liquid scintillation	3. Compare central tendency and extremes to the road reference area to evaluate whether to forward to the SFS.	3. See Drilling Procedure in HASP	

[i] Surface radiological risk is based on pressurized ionization chamber (PIC) data.
[ii] These parameters will only be sampled and analyzed if the gamma survey is less than the surface worker risk level for the surface (0') measurements.
[iii] These constituents are being evaluated to evaluate the subsurface for the redistributed fill model associated with worker exposure.
[iv] Subsurface stratigraphy includes:
1) Determining the depth of fill
2) Obtaining a sample in the 0-2' below native surface (bns) to analyze for metals, fluoride, U-238, Ra-226, K-40, Pb-210, and Po-210
[v] Sampling design for RUs that are being investigated as a potential source of impacts to groundwater
[vi] Remediation Vision is from Table 3-2 of Scoping and Planning Memorandum (BEI, 2004c)
[vii] Remediation Vision as stated in item 3 of February 2, 2007 meeting notes.
[viii] Confirmation step-out fill samples will be collected in accordance with the protocol in Section 2.2.
bns – below native surface
bgs – below ground surface
SSL – soil screening level
HASP – Health and Safety Plan

Table 1-3

Remediation Units and Descriptions
(Page 1 of 9)

Remediation Unit Number and Name	Description
RU 1: Furnace Building, Phos Dock and Secondary Condenser	RU 1 encompasses the furnace building, secondary condenser, and Phos Dock. These are the primary P_4 production, storage, and handling areas within the FMC OU. Four electric arc furnaces with condensers, P_4 sumps, scrubbers and ancillary equipment are in the furnace building. The Phos Dock was the storage and railcar loading facility and the secondary condenser was used to recover additional P_4 from the furnace off-gas. The following SWMUs are included in RU-1: • SWMU# 13 Andersen Filter Media (AFM) Washing Unit • SWMU# 41 (partial) Stacks and Vents • SWMU# 54 Phos Dock Area • SWMU# 36 & 55 Rail Car Loading and Unloading Areas; Paved Area North of Furnace Bldg. Incl Phos Dock • SWMU# 60 Secondary Condenser/Former Fluid Bec Dryer Area • SWMU# 68 Railroad Spurs (portion within RU 1) • 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 Phosphorus Loading Dock, Andersen Scrubber Blowdown Sump, and North Solid Tank • SWMU# 78 Washdown Collection Sumps--Furnace Building Area • 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 (Phossy Water and Precipitator Slurry) [portion of pipeline network within RU #1 footprint] • 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# 104 #3 P4 Sump • SWMU# 38 Road segments within RU 1

Table 1-3

Remediation Units and Descriptions
(Page 2 of 9)

Remediation Unit Number and Name	Description
RU 2: Slag Pit	Pit on south side of furnace building for tapping slag from furnaces. Operated with standing water, then water spray to cool slag. In 1999/2000, FMC converted to slag ladling and slag was no longer in contact with bottom surface of pit. The following SWMUs are included in RU-2: • SWMU# 5 Slag Pit Wastewater Collection Sump (RCRA closure completed Oct. 2005 per EPA approved closure plan) • SWMU#102 Former Slag Pit (prior to slag handling) • SWMU# 82 (partial) Facility-Wide Waste Water Piping System (Phossy Water and Precipitator Slurry) [portion of pipeline network within RU 2 footprint] • SWMU# 38 Road segments within RU 2
RU 3: Receiving Stores, Paint Shop and P_4 Decon	Located in the Northern part of the FMC OU. It is a relatively flat-lying area, with several buildings and paved areas. It is north of the Phos Dock and furnace building and south of the Railroad Swale. RU 3 consists of storage buildings and shops. It was a P_4 decon area used to clean and decon equipment containing P_4. The following SWMUs are included in RU-3: • SWMU# 66 Boiler Fuel Tank and Pipeline Area • SWMU# 72 Former Satellite Storage Area for Waste Paint Solvents • SWMU# 92 P4 Maintenance Cleaning Facility (Decon Building) • SWMU# 38 Road Segments within RU 3
RU 4: Office Buildings and Training Center	RU 4 is immediately to the west of RU 3 and north of RU 5. Several buildings are within RU 4 including the change house, administrative office buildings, and training center. It is relatively flat-lying with a gentle slope to the north. The following SWMUs are included in RU-4: • Boring FO28 area • SWMU# 99 Drum Storage Area at Training Center • SWMU# 68 Railroad Spurs • SWMU# 38 Road segments within RU 4

Table 1-3

Remediation Units and Descriptions
(Page 3 of 9)

Remediation Unit Number and Name	Description
RU 5: Lab and Old Drainfield	Lab used for assays and product QC. Drainfield used to dispose fluids generated from analyses, now closed. The lab disposed various solutions and organic solvents in the seepage pit and in 1980 that practice was ceased. In 1995 the seepage pit was grouted. The following SWMUs are included in RU-5: • SWMU# 1 Drum Storage Unit (RCRA closure completed Apr. 2003 per EPA approved closure plan) • SWMU# 39 Chemical Lab Drain Pit • SWMU# 70 Satellite Storage Area for Spent Laboratory Solvents • SWMU# 68 Railroad Spurs • SWMU# 38 Road segments within RU 5 • SWMU # 61 Laboratory Chemical Disposal Area
RU 6: Former Long-Term Phos Storage Tanks	Twelve steel phos storage tanks with railcar loading facility. The tanks were 104,000 gallons. Tanks were filled by transporting P_4 in Railcars from the Phos Dock, so there is no underground P_4 piping leading to RU 6. Tanks were removed in 1990's. The RU is located on a fairly level area of the FMC Plant, and it is bounded by roads to the south and east and a railroad spur line on the northeast. The following SWMUs are included in RU-6: • SWMU# 63 Long-Term Phosphorus Storage Tanks (former) • SWMU# 68 Railroad Spurs (portion within RU 6) • SWMU# 101 Railcar Loading Overflow Tank
RU 7: Shale Unload, Crushing and Stockpile	RU 7 is located in the Northeast portion of the FMC OU, adjacent to the JR Simplot facility. Historic and air photos show this area has been used for ore handling since the plant began operation in 1949. Other materials handled within RU 7 include coke, which was unloaded from the railcars and placed on conveyors to the furnace building. Railcar dumper, ore handling equipment, crushing and sieving equipment, and ore stockpiles were present. The following SWMUs are included in RU-7: • SWMU# 37 Shale Ore Handling Areas • SWMU# 105 Coke Unloading Building • SWMU# 68 Railroad Spurs • SWMU# 38 Road segments within RU 7

Table 1-3

Remediation Units and Descriptions
(Page 4 of 9)

Remediation Unit Number and Name	Description
RU 8: Former Kiln Scrubber Ponds and Calciners	Calciners built over the footprint of the former kiln scrubber ponds in the 1960's. The former kiln scrubber ponds operated from 1949 through the late 1960's and were dredged prior to back filling the ponds to grade in preparation for the construction of the calciners. The former kiln scrubber ponds were used to clarify kiln scrubber water before recirculation to scrubbers. The calciners were used to dry and harden ore briquettes before processing. The following SWMUs are included in RU-8: • SWMU# 12 Wastewater Treatment Unit • SWMU# 35 Three kiln Scrubber Ponds • SWMU# 67 Former Flare Pit for Carbon Monoxide • SWMU# 41 Stacks and Vents (i.e., calciner system) • SWMU# 103 New Horizontal Flare Pit • SWMU# 38 Road Segments within RU 8
RU 9: Silica Stockpiles and Former Kiln Scrubber Overflow Pond	The silica stockpile area was expanded over the footprint of the kiln scrubber overflow pond in the 1960's. Overflow pond was used when there was excess water in the kiln scrubber ponds. After conversion to calciners, all kiln scrubber ponds were filled/covered with silica. The following SWMUs are included in RU-9: • SWMU# 51 Kiln (scrubber) Overflow Pond (under nodule fines pile) • SWMU# 106 Nodule Pile • SWMU# 38 Road segments within RU 9
RU 10: IWW Pond and Ditch	IWW pond received non-contact cooling water, and the ditch conveyed water to a pipe at the FMC/Simplot boundary. The ditch and basin were backfilled with surplus silica, and the pipe has been plugged and abandoned. The following SWMUs are included in RU-10: • SWMU# 49 Industrial Wastewater Basin • SWMU# 50 Industrial Wastewater Ditch
RU 11: Equipment Area South of Calciners	RU 11 is located at the northern edge of the slag pile. It slopes to the north toward the calciners. It is a bare area, formerly used for equipment storage and staging. The following SWMUs are included in RU-11: • SWMU# 38 Road segments within RU 11

Table 1-3

Remediation Units and Descriptions
(Page 5 of 9)

Remediation Unit Number and Name	Description
RU 12: Former RP&S Area and Mobile Shop	RU 12 is located in the central portion of the FMC OU. A Mobile shop was used for heavy equipment maintenance and included parts washing/degreasing station, waste oil tank and underground fuel tanks. The former LDR facility, PCB Storage Shed (removed in 2000), and the Mobile Shop are the buildings located in RU 12. These SWMUs are included in RU-12. • SWMU# 57 Transformer Salvage Area • SWMU# 58 PCB Storage Shed (removed 2000) • SWMU# 71 Satellite Storage Areas for Waste Degreasing Solvents • SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas and Intervals • SWMU# 65 (partial) Precipitator Slurry Pipeline Cleanout Areas and Intervals • SWMU# 82 (partial) Facility-wide Wastewater Piping System (Phossy Water and Precipitator Slurry) [portion of pipeline network within RU# 12 footprint • SWMU# 83 High-pressure steam cleaning Station • SWMU# 84 Used Oil Collection Tank • SWMU# 38 Road Segments within RU 12
RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area	RU 13 is located in the south-central portion of the FMC OU. It is immediately south-west of RU 12, and is adjacent to several old ponds. This area contained the former process facility for recovering P_4 from phossy pond sediments. The metal scrap preparation area was used to prepare scrap metal prior to shipment to off-site recycling. Former underground pipes for handling phossy water and precipitator slurry are located within RU 13. The Pond 8S Recovery Process facilities were previously located in RU 13; these facilities were closed and dismantled under a RCRA Closure Plan. The following SWMUs are included in RU-13: • SWMU# 4 Former 8S Recovery Process (RCRA closure completed 1993 per EPA approved closure plan) • SWMU# 64 Phossy Waste Pipeline Cleanout Areas and Intervals • SWMU# 65 Precipitator Slurry Pipeline Cleanout Areas and Intervals • SWMU# 82 (partial) Facility-wide Wastewater Piping System (Phossy Water and Precipitator Slurry) [portion of pipeline network within RU# 13 footprint • SWMU# 38 Road segments within RU 13 • SWMU# 107 Portable Storage Tanker for Dielectric Fluid

Table 1-3

Remediation Units and Descriptions
(Page 6 of 9)

Remediation Unit Number and Name	Description
RU 15: Oversize Ore, Used Electrode, Baghouse Dust Area	RU 15 is located south of the calciner ponds in the Bannock Range area. It is south of the main plant area, and east of the slag pile, near the FMC property boundary with Simplot. Area to the south of the former calciner ponds used to store oversize ore (periodically reclaimed), baghouse dust for ore-handling facilities, and used electrodes (the majority have now been sold). The following SWMUs are included in RU-15: • SWMU# 69 Oversize Ore, Broken and Used Electrode, Baghouse Dust Storage and Recycling, and Used Conveyor Belt Area • SWMU# 38 Road segments within RU 15
RU 16: Calciner Solids Stockpile	Area south of the calciner ponds (RU 15) where FMC placed solids from the calciner ponds as these ponds filled with scrubber water solids. As the material in the calciner scrubber water settled out and accumulated in the ponds, it was removed from the ponds and stockpiled within the boundaries of RU 16. The following SWMUs are included in RU-16: • SWMU# 16 Calciner Solids Pile • SWMU# 17 Calciner Pond Sediment Areas South of Calciner Ponds [SWMU 17= "Storage Area B"] • SWMU# 38 Road segments within RU 16
RU 17: Recyclable Material Landfill	Area to the south of the slag pile used for disposal of non-salvageable construction materials. Wastes may include scrapped building materials (concrete, steel and wood) and furnace dig-out material. The following SWMUs are included in RU-17: • SWMU# 89 Roadway Landfill (also referred to as Construction Debris and/or Recycle Landfill) • SWMU# 38 Road segments within RU 17
RU 18: Plant Landfill	Southernmost remediation unit. Used by FMC for disposal of office waste, etc. Wastes may include scrapped building materials, filter media, asbestos insulation, furnace dig-out material, and minor amounts of spent solvents and oily residuals. The following SWMUs are included in RU-18: • SWMU# 45 Landfill (also referred to as Solid Waste Landfill) • SWMU# 38 Road segments within RU 18

Table 1-3

Remediation Units and Descriptions
(Page 7 of 9)

Remediation Unit Number and Name	Description
RU 19: Slag Pile, Bull Rock Pile	Largest RU within the FMC Plant OU. The vast majority of the volume is slag. The bull rock pile is distinct from the slag pile and consists of reject oversized ore. The former plant landfill and buried railcars are included within this RU. Wastes in the old landfill may have included scrapped building materials, filter media, asbestos insulation, furnace dig-out material, and minor amounts of spent solvents and oily residuals. The following SWMUs are included in RU-19: • SWMU# 42 Slag Pile • SWMU# 44 Landfill (old) • SWMU# 38 Segment of FMC surface road network
RU 20: Former Bannock Paving Area	Large, relatively flat-lying RU that was leased by BAPCO for asphalt production, slag crushing and sales of slag, coke receiving and drying, and ferrophos crushing and loading. BAPCO began operations at RU 20 in 1969 and vacated the leased area in 1996. The following SWMUs are included in RU-20: • SWMU# 46 Railcar Loading and Unloading Area-BPC • SWMU# 47 Bannock Paving Areas • SWMU# 47 (incl. in # 47) Coke Settling Pond (former BAPCO Unit) • SWMU# 48 Surface roads Bannock Paving Company • SWMU# 68 Railroad Spurs
RU 21: Other Onsite Railspurs	Several thousand feet of rail spurs served the FMC plant. The rail spurs are generally located near the northern plant boundary, and were used to deliver coke, ore, and heavy equipment. FMC used the rail spurs to load and transport P4 product. These are rail spurs that are not included within the boundaries of other RUs. Some were built with a slag base. The following SWMUs are included in RU-21: • SWMU# 68 Railroad Spurs

Table 1-3

Remediation Units and Descriptions
(Page 8 of 9)

Remediation Unit Number and Name	Description
RU 22b: Old Ponds	Old ponds that were used to receive phossy water from the furnace building that ceased operation before RCRA permit requirements became effective. The location and extent of each pond is well-documented by plant data and historic air photos. All old ponds have had hydraulic head removed. The following SWMUs are included in RU-22b: • 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# 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# 43 Ferrophos Storage Areas • SWMU# 52 Pond 7E • SWMU# 53 Old Pond 7S Tree-Line Area

Table 1-3

Remediation Units and Descriptions
(Page 9 of 9)

Remediation Unit Number and Name	Description
RU 22b (continued)	• SWMU# 56 Drum Storage Area for other Nonhazardous Wastes [see SWMU 59] • SWMU# 59 Waste Oil Storage Area • SWMU# 62 Area West of Mobile Shop • SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas and Intervals • SWMU# 65 (partial) Precipitator Slurry Pipeline • SWMU# 82 Facility-Wide Wastewater Piping System (phossy Water and Precipitator Slurry) [portion of pipeline network within RU# 22b footprint] • SWMU# 38 Road Segments within RU 22b
RU 22c: Railroad Swale	Low-lying, narrow swale adjacent to the railroad track north of the phos dock area. It received releases of phossy water from spills within the RU 1 area. It was partially lined in 1993. The following SWMUs are included in RU-22c: • SWMU# 18 Railroad Swale
RU 23: Road Segments not within RU Boundaries	This RU accounts for road segments that are not included within the boundaries of other RUs. Many plant roads were built with slag base to handle the heavy equipment (slag haulers, etc.). Many of these roads were paved during the 1990's to reduce fugitive dust emissions. The following SWMUs are included in RU-23: • SWMU# 38 Surface Roads – FMC
RU 24: Plant Areas not within RU Boundaries	This RU includes disturbed areas of the plant site that are not associated with other RUs or SWMUs. This RU does not include areas of the plant site that were not disturbed or that contain only non-impacted native soils (e.g., the southern and western undeveloped areas). • SWMU# 38 Road Segments within RU 24 • SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas and Intervals • SWMU# 65 (partial) Precipitator Slurry Pipeline Cleanout Areas and Intervals • SWMU# 82 (partial) Facility-wide Wastewater Piping System (Phossy Water and Precipitator Slurry) [portion of pipeline network within RU# 24 footprint

Note:
The December 2004 RI Update Memorandum (BEI, 2004b) contains a much more comprehensive and detailed description of the RUs (except for RU 24), historical uses, and materials stored, used, or handled within the RU boundaries

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 1-4

Gamma Energies

Radionuclide	Half-life	Decay mode	Gamma Rays With Energies Above 100 keV	
			Energy (keV)	Abundance
Uranium-238	4.47×10^9 years	alpha	—	LT
Thorium-234	24 days	beta	—	LT
Protactinium-234	1 month	beta	—	LT
Uranium-234	2.4×10^5 years	alpha	—	LT
Thorium-230	7.7×10^4 years	alpha	—	LT
Radium-226	1600 years	alpha	186	0.033
Radon-222	3.8 days	alpha	—	LT
Polonium-218	3 months	alpha	—	LT
Lead-214	27 months	beta	352	0.37
Bismuth-214	20 months	beta	609	0.46
Polonium-214	>1 second	alpha	—	LT
Lead-210	22 years	beta	—	LT
Bismuth-210	5 days	beta	—	LT
Polonium-210	123 days	alpha	—	LT
Lead-206	Stable		—	—
Potassium-40	1.3×10^9years	gamma	1,461	—

Acronyms/Abbreviations:
keV=kiloelectron volt
LT = gamma abundance is less than 0.01 percent

Table 1-5

Soil Screen Levels and Reporting Limits for Organics in Soil
(Page 1 of 2)

Compound	Commercial/ Industrial Worker SSL[a] (mg/kg)	Construction Worker SSL[a] (mg/kg)	Utility Worker SSL[a] (mg/kg)	SSL Protective of Groundwater[a, b] (mg/kg)	Reporting Limit (mg/kg)
Organic Compounds for Liquid Petroleum Fuels					
Benzene	2	5	17	0.03	0.005
Ethylbenzene	390	390	400	13.0	0.005
Toluene	650	650	650	12.0	0.005
Xylenes, total	300	300	300	220	0.01
Acenapthene	37,000	260,000	1,000,000	570	0.01
Anthracene	180,000	1,000,000	1,000,000	12,000	0.01
Benzo(a)pyrene	0.2	4	34	8	0.01
Benzo(b)fluoranthene	2	41	340	5	0.01
Benzo(k)fluoranthene	23	410	3,400	49	0.01
Benzo(a)anthracene	2	41	340	2	0.01
Benzo(g,h,i)perylene	18,000	13,000	110,000	110,000	0.01
Chrysene	230	4,100	34,000	160	0.01
Fluorene	24,000	170,000	1,000,000	560	0.01
Fluoranthene	24,000	170,000	1,000,000	4,300	0.01
Napthalene	12,000	260,000	1,000,000	59	0.01
Phenanthrene	18,000	13,000	110,000	840	0.01
Pyrene	18,000	130,000	1,000,000	4,200	0.01
Organic Compounds for Laboratory-Related Solvents					
Benzene	2	5	17	0.03	0.005
Carbon disulfide	720	160	590	32	0.005
Chloroform	200	120	450	0.5	0.005
Methylene Chloride	22	72	260	0.02	0.005
Tetrachloroethylene (PCE)	1	6	21	0.06	0.005
Toluene	650	650	650	12.0	0.005
Trichloroethene (TCE)	0.1	0.4	1	0.06	0.005
1,1,1-trichloroethane (1,1,1-TCA)	1,200	1,200	1,200	2	0.005
2-butanone	26,000	14.000	27,000	91	0.005
Organic Compounds for Shop-Related Solvents					
Chloroform	200	120	450	0.5	0.005
Methylene Chloride	22	72	260	0.02	0.005
Tetrachloroethylene (PCE)	1	6	21	0.06	0.005
Trichloroethene (TCE)	0.1	0.4	1	0.06	0.005
1,1,1-trichloroethane (1,1,1-TCA)	1,200	1,200	1,200	2	0.005
2-butanone	26,000	14,000	27,000	91	0.005

Table 1-5

Soil Screen Levels and Reporting Limits for Organics in Soil
(Page 2 of 2)

Compound	Commercial/ Industrial Worker SSL[a] (mg/kg)	Construction Worker SSL[a] (mg/kg)	Utility Worker SSL[a] (mg/kg)	SSL Protective of Groundwater[a, b] (mg/kg)	Reporting Limit (mg/kg)
Polynuclear Aromatic Hydrocarbons for Coke					
Acenaphthene	37,000	260,000	1,000,000	570	0.01
Anthracene	180,000	1,000,000	1,000,000	12,000	0.01
Benzo(a)anthracene	2	41	340	2	0.01
Benzo(a)pyrene	0.2	4	34	8	0.01
Benzo(b)fluoranthene	2	41	340	5	0.01
Benzo(k)fluoranthene	23	410	3,400	49	0.01
Chrysene	230	4,100	34,000	160	0.01
Dibenzo(a,h)anthracene	0.2	4	34	2	0.01
Fluoranthene	24,000	170,000	1,000,000	4,300	0.01
Fluorene	24,000	170,000	1,000,000	560	0.01
Indeno(1,2,3-cd)pyrene	2	41	340	14	0.01
Naphthalene	12,000	260,000	1,000,000	59	0.01
Pyrene	18,000	130,000	1,000,000	4,200	0.01
Polychlorinated biphenyls					
Total monochlorinated biphenyls	24	420	3,400	0.9	0.0002
Total dichlorinated biphenyls	24	420	3,400	0.9	0.0005
Total trichlorinated biphenyls	24	420	3,400	0.9	0.001
Total tetrachlorinated biphenyls	24	420	3,400	0.9	0.002
Total pentachlorinated biphenyls	0.8	15	120	0.9	0.002
Total hexachlorinated biphenyls	0.8	15	120	0.9	0.002
Total heptachlorinated biphenyls	0.8	15	120	0.9	0.001
Total octachlorinated biphenyls	0.8	15	120	0.9	0.001
Total nonachlorinated biphenyls	0.8	15	120	0.9	0.0005
Decachlorinated biphenyl	0.8	15	120	0.9	0.0002

Notes:

[a] Soil screening levels (SSLs) developed using the methods presented in EPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* EPA (2002), supplemented with current toxicological data.

[b] The SSLs protective of groundwater incorporate a dilution-attenuation factor (DAF) of 20.

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 1-6

Soil Screening Levels and Reporting Limits for Inorganics in Soil

Parameter	Background* (mg/kg)	Commercial Industrial Worker SSL (mg/kg)	Construction Worker SSL (mg/kg)	Utility Worker SSL (mg/kg)	SSL Protective of Groundwater[c] (mg/kg)	Reporting Limit (mg/kg)
Antimony	2.2	454	104	1,360	5	0.2
Arsenic	7.7	7.7[a]	14.6	173	7.7[d]	0.8
Barium	188	61,700	8,360	109,000	1,600	20
Beryllium	1	645	61.0	792	63	0.1
Boron	12.8	223,000	5,210	67,800	450	1
Cadmium	1.9	860	81.3	1,060	8	0.2
Chromium	27.5	1,000,000[b]	551,000	1,000,000[b]	38	3
Cobalt	7.6	553	52.2	679	630	0.8
Copper	12.6	42,000	22,000	286,000	9,400	1
Fluoride	600	68,100	33,000	430,000	12,000	60
Lead	29.1	800[e]	800[e]	800[e]	800[e]	3
Lead-210	3.03 pCi/g	3.03 pCi/g[a]	7.44 pCi/g	96.7 pCi/g	3.03 pCi/g[d]	0.2 pCi/g
Lithium	16.1	22,700	11,900	155,000	4,200	2
Manganese	482	23,500	77,100	1,000,000	390	50
Mercury	0.16	340	464	6,030	2	0.02
Molybdenum	2.15	5,670	2,750	35,800	81	0.2
Nickel	15.5	6,450	404	5,250	130	2
Phosphorus	NA	22.7	117	1,000	NA	
Polonium-210	3.58 pCi/g	269 pCi/g	43.3 pCi/g	563 pCi/g	3.58 pCi/g[f]	0.2 pCi/g
Potassium-40	20.5 pCi/g	20.5 pCi/g[a]	20.5 pCi/g[a]	136 pCi/g	20.5 pCi/g[f]	2 pCi/g
Radium-226	3.88 pCi/g	3.88 pCi/g[a]	3.88 pCi/g[a]	12.3 pCi/g	3.88 pCi/g[d]	0.2 pCi/g
Selenium	1.36	5,670	2,750	35,800	5	0.1
Silver	1.9	5,670	2,750	35,800	34	0.2
Thallium	0.27	77.2	374	4,870	.7	0.03
Uranium	NA	3,400	491	6,390	900	
Uranium-238	3.88 pCi/g	3.88 pCi/g[a]	20.6 pCi/g	267 pCi/g	3.88 pCi/g[d]	0.2 pCi/g
Vanadium	45.4	7,950	3,500	45,500	6,000	5
Zinc	52.8	340,000	165,000	1,000,000[b]	12,000	5

Note:

[*] background from EMF ROD (EPA/541/R-98/034), Table 11

[a] default to background since the Site Worker SSL is less than background

[b] default to 1E+06 since SSL is greater than 1E+06

[c] A dilution-attenuation factor (DAF) of 20 is incorporated into the SSLs protective of groundwater

[d] default to background since the SSL protective of groundwater is less than background

[e] SSLs for lead are based on the value cited by EPA's Adult Lead Methodology Workgroup as being protective at commercial/industrial sites (www.epa.gov/superfund/programs/lead/almfaq.htm)

[f] Default to background because insufficient data exist to derive an SSL protective of groundwater for this constituent.

Table 1-7

Toxicity Characteristics Maximum Concentration Levels for Metals and Semi-Volatile Organic Compounds

Parameter	Maximum Concentration Level (mg/L)	Reporting Limit (mg/L)
Arsenic	5	0.50
Barium	100.0	10.0
Cadmium	1.0	0.1
Chromium	5.0	0.50
Lead	5.0	0.50
Mercury	0.2	0..02
Selenium	1.0	0.1
Silver	5.0	0.5
o-cresol	200.0	20.0
m-cresol	200.0	20.0
p-cresol	200.0	20.0
cresol	200.0	20.0
1,4-Dichlorobenzene	7.5	0.075
2,4-Dinitrotoluene	0.13	0.013
Hexachlorobenzene	0.13	0.013
Hexachlorobutadiene	0.5	0.05
Hexachloroethane	3.0	0.30
Nitrobenzene	2.0	0.20
Pentachlorophenol	100.0	10.0
Pyridine	5.0	0.50
2,4,5-Trichlorophenol	400.0	40.0
2,4,6-Trichlorophenol	2.0	0.20

Section 2
DATA QUALITY OBJECTIVES

The data generation and acquisition performed during the SRI will follow the EPA's DQO process. The DQO process comprises the following seven steps. A brief description of each step from the EPA guidance is discussed below.

1. **State the problem**. Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem. Identify the planning team members, including the decision-makers.
   For each data gap category, the problem statement is presented. Planning team members and decision-makers are the same for each data collection activity.

2. **Identify the decision**. Identify what questions the study will attempt to resolve and what actions may result from each decision. Develop a decision statement.

3. **Identify the decision inputs**. Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.

4. **Define the study boundaries**. Specify the time periods and spatial boundaries to which decisions will apply. Determine when and where data should be collected. Define the target population of interest.

5. **Develop the decision rules**. Define the statistical parameter of interest, specify the action level, and integrate the previous DQO outputs into a single statement that describes the logical basis for choosing among alternative actions. Define an "if... then..." statement.

6. **Specify tolerance limits on decision errors**. Define the decision-makers' tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.

7. **Optimize the sampling design**. Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets all DQOs.

A summary of the DQO from the RI Update Memorandum, Revised December 2004 (BEI, 2004b) is presented in Table 2-1. As stated in the RI Update Memorandum (BEI, 2004b) the optimization of the sampling design for the identified data gaps will be addressed in the SRI Work Plan as discussed in Section 2.1 on an RU-by-RU basis. Step 7, Optimize the Sampling Design, documents all sampling and data collection activities for each RU. If an RU will involve multiple studies (e.g., specific investigation areas or future worker risk evaluation) then all sampling activities are shown.

A summary of the DQOs for the SRI is contained in Table 2-2. Details associated with Steps 1 through 6 of the overall SRI DQOs are presented sequentially in Sections 2.2 through 2.7.

Individual DQOs associated with specific data collection needs (e.g., specific investigation areas or worker risk evaluation) are also presented in Sections 2.2 through 2.7.

2.0.1 State the Problem

The overall problem statement for the SRI is: Insufficient soil data exist to conclude that the current remediation vision for each RU is verified. A sampling and analysis plan that optimizes the data collection activities to verify the remediation vision and provide information needed for the SFS is required. The remediation visions associated with this SRI are described in the RI Update Memorandum (BEI, 2004b) and in Table 1-2.

Multiple remediation units have been defined for the FMC Plant OU, as shown in Figure 2-1. The definition of RUs (i.e., lateral boundaries) was based on knowledge of past activities and materials handled within the RU. In many cases, the RU can be easily defined because it is bounded by roads, structures, or other features. A limited number of activities occurred within the defined RUs and known materials were associated with these activities. A number of RUs also contain areas that require differing data collection (i.e., sampling) designs based upon the SWMUs present in an RU as identified in the RI Update Memorandum (BEI, 2004b). The initial purpose of the SRI sampling will be to collect data suitable to assess risks to potential workers under a future redevelopment scenario. However, based on the results of the risk assessment data that will be obtained in this SRI, it may be necessary to collect additional data to support the activities of the SFS. The following sections address the specific problem statements and related DQO steps.

2.0.2 Identify the Decision

The overall decisions to be addressed in this SRI are:

- For RUs that are candidates for NFA, if existing data in combination with data generated during the SRI are sufficient to verify the remediation vision then no further action is anticipated.

- If the SRI data do not verify the remediation vision for candidate NFA RUs, then those RUs will be reclassified for further action.

- For RUs with remediation visions that are not NFA as well as those reclassified from NFA, additional data will be collected during the SRI to support the SFS for those RUs. However, it must be noted that the collection of data to support the SFS during the SRI will not preclude the need for additional data collection during the SFS.

2.0.3 Identify the Decision Inputs

2.0.3.1 Previous Studies

This is a supplemental program to augment the RI and other studies identified in Section 1.2. These previous studies are included in the inputs to the decision. Some examples of the studies utilized in the preparation of this SRI include:

- The 1998 EMF Site ROD.
- RUs 17, 18, and 19 contain landfills. The Presumptive Remedy for CERCLA Municipal Landfill Sites (Directive 9355.0-49FS, EPA, 1993) will be considered for these landfills.
- Updated SSLs presented in Section 4 of the RI Update Memorandum (BEI, 2004b).
- Changes in operations since the 1998 ROD.
- Evaluation of spills/releases of process materials that occurred subsequent to the EMF RI (BEI, 1996).

2.0.3.2 EPA Cleanup Levels for CERCLA Sites with Radioactive Contamination

Risk-based CVs will be used during the SRI to inform field data collection activities; in particular, for determining whether a candidate NFA RU should follow the risk assessment path or preliminary SFS data collection path (per Figure 1-7). Previous investigations have shown that risks at the FMC Plant OU are primarily driven by radiological exposures. As discussed in EPA's OSWER Directive 9200.4-18 (Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination), EPA generally sets site-specific remediation levels for carcinogens (including radionuclides) at a level that represents an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}. However, the OSWER Directive further notes that "the upper boundary of the risk range is not a discrete line at 1×10^{-4}…." and that "[a] specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions." EPA stated in the OSWER Directive that a 15 mrem/yr dose, with an equivalent risk of 3×10^{-4}, is at the upper end of remediation levels that have been selected at radioactively contaminated CERCLA sites.

For purposes of informing the field data collection activities, a 3×10^{-4} increased lifetime cancer risk (i.e., above background) will be used as a guideline for characterizing the screening radiological CV in the SRI. For RUs (or potions of RUs) found to exceed this CV, the current NFA remedial vision will no longer be considered valid and additional data will be collected during the SRI to support the SFS. For RUs below this CV, SRI data sufficient to perform a comprehensive risk assessment will be collected. The findings of the risk assessment will subsequently be used to make final risk management decisions for these RUs (i.e., the upper bound CV used in the SRI will be used to make SRI data collection decisions, not final risk management decisions).

2.0.3.3 SFS Data Needs Regarding Potentially Revised Remedial Visions

Based on an outcome analysis of the various RUs and site or process knowledge, the two most likely scenarios will be addressed in this SRI. One is that the original remediation vision is verified. The other is that data collected during the SRI (e.g., radiation surface survey) could determine that an RU will require a revised remediation vision. In these cases, the RU will be forwarded to the SFS and an alternate pre-defined sampling scheme, as shown in Figure 1-7 and described in Sections 2.6 and 2.7, will be followed to support the SFS.

2.0.3.4 Definition of Data Needs (e.g., Data Concept Map)

The overall concept map (see Figure 1-7) delineates the four types of data needs that have been identified for this site and the general scheme for collecting the data.

A summary of the FMC remediation vision for each RU, as described in the RI Update Memorandum (BEI, 2004b), is contained in Table 1-2. The data concept map shown on Figure 1-7 will be followed to evaluate whether or not the remediation vision for each RU is supported. As illustrated in these tables and figures, four types of data needs have been identified. These data types include:

- Cap delineation studies,
- Specific investigation area studies,
- Studies to define the potential risk to a future worker within an RU, and
- Studies to support the SFS based on the outcomes of the data collected in support of defining worker exposure[1].

Studies will be conducted to obtain data for supporting the decisions associated with the remediation visions as follows:

- Delineation of the extent of a cap/cover for RUs that have a cap/cover remediation vision (Figures 2-2 and 2-3) regarding:
  - P4
  - Kiln solids
  - Phossy solids
- Evaluation of specific investigation areas to:
  - determine the potential for subsurface migration to groundwater concerning:
    - Organic solvents (Figure 2-4),
    - Liquid petroleum fuels (Figure 2-5),
    - Polynuclear aromatic hydrocarbons from the coke stockpile area and polynuclear aromatic hydrocarbons and metals from the coke settling basins (Figure 2-6),
    - PCBs (Figure 2-7),

[1] Note: as described in Section 1.3, the data collected in support of the SFS is not intended to supplant the SFS described in the AOC.

        - Metals (Figure 2-8),
        - Fluoride (Figure 2-8),
    - determine the potential risk to site workers from exposure to impacted native soil and the potential for migration to underlying soils:
        - Polynuclear aromatic hydrocarbons (Figure 2-6),
        - PCBs (Figure 2-7),
        - Lead-210 and polonium-210 (precipitator dust/phossy solids) (Figure 2-9).
    - determine the extent of P4, metals and fluoride in soil in selected RUs (Figure 2-10)
    - compile existing information on underground piping, sumps, and structures remaining after the plant decommissioning (Figure 2-11)
- evaluation of radon flux (Figure 2-12)
- evaluation of risk to a future worker (Figure 2-13) - filling data gaps as identified in the RI Update Memorandum to allow for calculating the risk to a future worker regarding:
    - Radiation,
    - Metals
    - Fluoride

Additional studies may be performed based on the outcomes of data collected to determine the risk to a future worker. These SFS support data collection activities include:

- Determining the depth and volume of fill material.
- Determining the extent to which COCs and COPCs may have migrated into the native soil underlying the fill.

2.0.3.5 Definition of Decision Units

The term "decision unit" varies depending on the study being performed. When evaluating the potential risk to a future site worker, the initial definition of a decision unit is an area no greater than five acres, within which a future worker could potentially be exposed within an RU. If an RU is five acres or less, the decision unit will be the entire RU. For the specific area investigation studies, the decision unit is the area associated with each individual study. For purposes of collecting data to support the SFS, the decision unit is the RU. It may be that based on preliminary data to be collected (e.g. gamma screening data in support of assessing future

worker risk in an RU), if a sub-area is of sufficient size and meets the criteria for further investigation while the remainder of the RU does not, the area that requires further investigation could become a decision unit.

2.0.4 Define the Boundaries

2.0.4.1 Lateral Boundaries for RUs

The lateral boundaries for each RU were selected based on knowledge of past activities and materials handled within the RU. In many cases, the RU can be easily defined laterally because it is bounded by roads, structures, or other features. A limited number of activities occurred within these spatial boundaries and known materials were associated with these activities. The lateral boundaries for RUs that require additional data collection activities are shown in Figure 2-1.

The lateral boundaries for SWMUs located within specific RUs are based upon historical process knowledge of people familiar with the site, aerial photographs, current observation and past sampling, and are depicted in Figures 6-2 through 6-43 of the RI Update Memorandum (BEI, 2004b).

2.0.4.2 Vertical Boundaries for RUs

Vertical boundaries associated with an RU will include one or more of the following:

- 0-to-2 feet and 0-to-10 feet bgs associated with the worker exposure based on a future redevelopment scenario. In accordance with EPA's SSL guidance (EPA 2002), 0-2 feet bgs is the depth interval over which it is assumed potential future outdoor commercial/industrial workers could be exposed to site-related contaminants. Similarly, 0-to-10 feet bgs is the depth interval over which it is assumed future construction and/or utility workers could potentially be exposed.

- 0-to-2 feet below native surface (bns) to demonstrate the extent of potential migration into underlying soils from fill. It should be noted that for purposes of this SRI Work Plan, bns shall refer to a depth at which native soil is encountered that has not been impacted by or mixed with fill materials. For example, when native soil is encountered during boring, trenching, or test pitting, and the Work Plan calls for sampling bns, a visual check of the native soil will be made to ensure that other fill materials, such as slag, ore, silica, phossy solids, precipitator dust, etc., are not present in the native soil prior to sampling. If other fill materials are present, the boring, trench or test pit will be advanced deeper until such fill materials are not present to define the bns interface.

- Native soil interface, 2 feet bns, 10 feet bgs, and 10 feet bns to determine if additional, deeper sampling is needed to evaluate the potential for subsurface migration to groundwater within specific investigation areas for VOCs, SVOCs and PAHs.

- Surface-to-groundwater to evaluate the potential of COCs and COPCs to migrate through the subsurface to groundwater.

2.0.5 Develop the Decision Rules

The null hypothesis will be that the true mean of the measured analyte is greater than the CV for that analyte as defined below. The alternative hypothesis will be that the true mean of the measured analyte is less than the associated CV. The hypotheses will be tested using statistical methods consonant with the assumptions supported by the data. All statistical estimators (e.g. means, regression parameters and estimates of constants in mathematical functions) will have acceptable confidence limits.

CVs may include the following:

- Risk thresholds stated in EPA's OSWER Directive 9200.4-18 (Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination),

- SSLs for metals, fluoride, and organics,

- Background concentrations for metals, fluoride and specific radioisotopes.

Regarding the measurement of total gamma exposure under future worker scenarios, the CV will be a defined level above background that is equivalent to the upper end of remediation levels that have been selected at radioactively contaminated CERCLA sites (i.e., $3x10^{-4}$ incremental risk above background). As discussed in Section 2.0.3.2, for RUs found to exceed this CV, the current NFA remedial vision will no longer be considered valid and no further risk data will be collected. Additional data will then be collected during the SRI to support the SFS. For RUs below this CV, SRI data sufficient to perform a comprehensive risk assessment will be collected. The findings of the risk assessment will subsequently be used to make final risk management decisions for these RUs (i.e., the upper-bound CV used in the SRI will be used to make SRI data collection decisions, not final risk management decisions).

There are a number of CVs included in studies that are based on visual observations and/or field screening techniques. Such data collection activities will have different measurement errors than the quantifiable measurements obtained from other sources (e.g., fixed-laboratory analysis). In addition, decision rules based on visual observation and/or field screening will not be used to determine outcomes of the future worker risk scenarios. These scenarios will be based on laboratory analyses and PIC measurements.

2.0.6 Specify the Tolerance on Decision Errors

All statistical significance tests will be conducted at the 95% confidence level (i.e., a false positive rate or Type I error of 5%) and a nominal Type II error of 10% unless otherwise specified in the DQO discussions in Sections 2.2 through 2.7. Stated otherwise all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1 for those studies <u>not</u> associated with a screening method. Screening methods include: radiation surface scans, visual tests (e.g., P4 ignition or lack of presence of fill). The Type II error rate, which

characterizes the risk of performing unnecessary remediation, may be adjusted to reflect the relative costs of remediation versus additional sampling.

The statistical techniques used to conduct significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment, as discussed in Section 5.

2.0.7 Optimize the Sampling Design

As stated above, data collection activities will be designed to support the individual DQOs identified with each type of data need. After all sample collection activities have been defined, the combined sampling program will be evaluated for each RU. Where applicable, based on the project data quality needs, the sampling design will be optimized to reduce the number of borings or test pits needed to obtain the proposed samples. It should be noted that the remainder of this document lists the initially-preferred sampling method (i.e., test pit or boring) based on information available to-date. However, these preferences will be modified in the field as needed based on the field conditions encountered. For example, if a backhoe can only excavate down to 15 feet and additional depth of sampling is needed after initiating the sample collection with a backhoe, then a boring would be drilled. The actual method used to collect the sample will be recorded in the field documentation. Additionally, estimates of the number of samples needed to provide a high likelihood of making the proper decision will be derived based on the historical data collected in previous studies described in Section 1.

For convenience of the reader, the optimized sampling approach on an RU-by-RU basis is presented in Section 2.1. Details associated with Steps 1 through 6 of the overall SRI DQOs are presented sequentially in Sections 2.2 through 2.7.

2.1 SRI OPTIMIZED SAMPLING DESIGN – RU-BY-RU BASIS

This subsection describes the sampling designs developed to meet the final step of the DQO process (i.e., Step 7) to address data gaps presented in the RI Update Memorandum (BEI, 2004b) and described in Steps 1-6 (Sections 2.2 through 2.7). This section will combine all of the sampling activities for each RU. Section 2.1 is organized as follows with the applicable DQO section referenced:

- Section 2.1.1 presents the sampling design to address data gaps associated RUs 1 and 2
  - Cap Delineation Studies (DQO reference Section 2.2.1.1)
  - Underground Piping Specific Investigation Area (DQO reference Section 2.3.9.3)

- Section 2.1.2 presents the sampling design to address data gaps associated with RU 3
  - Phossy Water Specific Investigation Area (DQO reference Section 2.3.7.1)
  - Underground Piping Specific Investigation Area (DQO reference Section 2.3.9.1)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.3 presents the sampling design to address data gaps associated with RU 4
  - Solvent Specific Investigation Area (DQO reference Section 2.3.1.1)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.4 presents the sampling design to address data gaps associated with RU 5
  - Solvent Specific Investigation Area (DQO reference Section 2.3.1.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.5 presents the sampling design to address data gaps associated with RU 6
  - Phossy Water Specific Investigation Area (DQO reference Section 2.3.7.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.6 presents the sampling design to address data gaps associated with RU 7
  - PAH Potential Migration to Soil Specific Investigation Area (DQO reference Section 2.3.3.1)
  - Evaluation of Radon Flux Study (DQO reference Section 2.4.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
  - Ore Reference Area (DQO reference Section 2.7)
- Section 2.1.7 presents the sampling design to address data gaps associated with RU 8
  - Kiln Pond Cap Delineation (DQO reference Section 2.2.2)
- Section 2.1.8 presents the sampling design to address data gaps associated with RU 9
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)

- Section 2.1.9 presents the sampling design to address data gaps associated with RU 10
  - P4 and Phossy Solids Investigation (DQO reference Section 2.3.8)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.10 presents the sampling design to address data gaps associated with RU 11
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.11 presents the sampling design to address data gaps associated with RU 12
  - Solvent Specific Investigation Area (DQO reference Section 2.3.1.3)
  - Liquid Petroleum Fuel Specific Investigation Area (DQO reference Section 2.3.2.1)
  - PCB Specific Investigation Area (DQO reference Section 2.3.4)
  - Underground Piping Investigation (DQO reference Section 2.3.9.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.12 presents the sampling design to address data gaps associated with RU 13
  - Underground Piping Investigation (DQO reference Section 2.3.9.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.13 presents the sampling design to address data gaps associated with RU 15 and RU 16
  - Leaching Potential Investigation (Metals and Fluoride) – (DQO reference Section 2.3.5)
- Section 2.1.14 presents the sampling design to address data gaps associated with RU 19
  - Evaluation of Radon Flux Study (DQO reference Section 2.4.1)

- Section 2.1.15 presents the sampling design to address data gaps associated with RU 20
  - Solvent Specific Investigation Area (DQO reference Section 2.3.1.4)
  - Liquid Petroleum Fuel Specific Investigation Area (DQO reference Section 2.3.2.2)
  - PAH Potential Migration to Soil Specific Investigation Area Reference Study (DQO reference Section 2.3.3.2)
  - Coke Settling Basins Specific Investigation Area (DQO reference Section 2.3.3.3)
  - Coke Characterization (DQO reference Section 2.3.3.4)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
  - Slag Reference Area (DQO reference Section 2.7)
- Section 2.1.16 presents the sampling design to address data gaps associated with RU 21
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.17 presents the sampling design to address data gaps associated with RU 22b
  - Cap Delineation Associated with Former Phossy Ponds (DQO reference Section 2.2.3)
  - Underground Piping Specific Investigation Area (DQO reference Section 2.3.9.3)
  - Evaluation of Radon Flux Study (DQO reference Section 2.4.1)
- Section 2.1.18 presents the sampling design to address data gaps associated with RU 22c
  - P4 Cap Delineation (DQO reference Section 2.2.1.2)
- Section 2.1.19 presents the sampling design to address data gaps associated with RU 23
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)
- Section 2.1.20 presents the sampling design to address data gaps associated with RU 24

  - Underground Piping Investigation (DQO reference Section 2.3.9.2)
  - Evaluation of Future Worker Risk (DQO reference Section 2.5)

- Section 2.1.21 presents the sampling design to address surface gamma studies in the undeveloped areas of the FMC Plant OU.
  - Southern and Western undeveloped area Gamma Measurements (DQO reference Section 2.6.2)

- Section 2.1.22 presents the sampling design to address the data gaps for Precipitator Dust/Phossy Solids distribution along roadways and Pond Closure Decant Treatment (PCDT) water application to roadways.
  - Precipitator Dust/Phossy Solids Distribution Along Roads Specific Investigation Area (DQO reference Section 2.3.6.)
  - PCDT System Roadway Study (DQO reference Section 2.3.10)

The following sections provide detailed sampling designs on an RU-by-RU basis. The figures associated with each sampling design within an RU are also referenced in the following section. To facilitate depicting the different investigation locations on each figure, general types of analyses are referenced on each figure as summarized below:

- PIC – pressurized ionization chamber
- P4 – elemental phosphorus
- Metals – (see list of metals on Table 1-6)
- Fluoride – fluoride
- Rads – uranium-238, radium-226, potassium-40, lead-210, and polonium-210
- Po-210 – polonium-210
- Pb-210 – lead-210
- Fuels – (see list of fuels on Table 1-5)
- Solvents – (see list of solvents on Table 1-5)
- Coke PAHs – (see list of coke PAHs on Table 1-5)
- TCLP – metals and semi-volatile organic compounds (see list on Table 1-7)

2.1.1 RUs 1 and 2: Furnace Building, Phos Dock and Secondary Condenser and Slag Pit

Figure 2-14 shows proposed soil boring locations around the perimeter of the preliminary RU 1 and RU 2 cap/cover area.

Description

RU 1 is 4.1 acres in size and encompasses the site of the former furnace building, secondary condenser, and phos dock. These were the primary P4 production, storage, and handling areas within the FMC Plant OU. The furnace building had four electric arc furnaces, primary condensers, P4 sumps, and various tanks. The secondary condenser was downstream of the furnaces and provided a final recovery of P4 that was collected in a single P4 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.

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 to the slag pile where it was poured down the face of the slag pile and allowed to cool and solidify.

Process Knowledge

Elemental phosphorus was produced within the four electric arc furnaces in the furnace building, which is included in RU 1. The P4 was condensed from the furnace offgas, collected in subsurface, brick-lined concrete sumps, and maintained above the melting point of 44°C. The P4 was pumped by displacement with water through above-ground piping to the phos dock (also within RU 1), located directly north of the furnace building. Offgas from the furnace proceeded to the secondary condenser area where an additional condenser was used to remove remaining P4 from the furnace offgas. At both the phos dock and secondary condenser, the P4 was stored in concrete subgrade tanks or sumps. P4 was ultimately displaced with water in above-ground piping to railcars for shipment. Releases of P4 from the process were typically captured in secondary containment. Releases from leaking tanks or sumps typically remained immediately under the tanks or sumps once the P4 cooled to below the P4 melting temperature. Because of the pyrophoric nature of the P4, the P4 was contained within a closed system, i.e., piping, pumps, tanks, etc. and covered with water to prevent the P4 from contacting air.

However, phossy water (any water that had come into contact with P4 and therefore contained some P4) was allowed to flow from the furnace building and the phos dock to the railroad swale (RU 22c). This flow occurred through underground storm drain piping or across the surface along a paved roadway. This activity ceased in 1991 as result of modified operational procedures.

The slag pit is located directly south of the furnace building and is included within RU 2. Molten slag was tapped from the four furnaces into the slag pit where the slag pooled on the ground and cooled. Phossy water from the furnace building, generated from process leaks,

washwater, etc. often flowed out the back of the furnace building into the slag pit. This water was collected in the slag pit sump and pumped to the phossy waste ponds. FMC used underground piping to carry the slag pit sump water to the phossy water ponds until new above-ground piping was installed. The underground piping was phased out from 1995 through 1998. However, the underground piping remained in place as shown on Figure 2-11.

Although the above-ground buildings and equipment have been removed as part of the decommissioning of the FMC plant, historic aerial photos show the location of the furnace building, phos dock, slag pit, and secondary condenser. The outlines of these areas also are clearly visible on the surface as building foundations remain in place.

Throughout the FMC Plant OU history, the furnace building, phos dock, and secondary condenser have remained in their original locations, although expansions did occur. Therefore, investigation in other areas of the FMC Plant OU for historic activities similar to those that took place at RUs 1 and 2 is not necessary.

Remediation Vision

For RU 1 and RU 2, leave existing concrete slabs in-place, grade to design subgrade elevation and construct a RCRA-engineered cap over the entire footprint of these areas.

2.1.1.1 Reference to DQO Section

Cap Delineation Studies – Section 2.2.1.1.

Underground Piping Specific Investigation Area – Section 2.3.9.3

2.1.1.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.1.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme for these RUs.

2.1.1.2.2 Cap Delineation

Problem Statement

Liquid phosphorus was managed at RU 1 and RU 2. A study to verify that significant concentrations of phosphorus have not migrated outside the RU 1 and RU 2 boundaries is needed for purposes of defining the extent of the RCRA cap that is proposed for these RUs. Additionally, the potential risk to future workers from acute and chronic exposure to phosphorus that may be present outside the boundaries designated for capping has not been defined.

Sampling Design

The number and placement of borings are judgmental and were based on the following considerations:

- Accessibility. Proposed soil boring locations were restricted to areas deemed accessible by a drill rig. Potential drilling sites around RU 1 and RU 2 were identified by field inspection.

- Distance from areas where P4 was handled in sumps and other areas as well as distance from the 44 °C region (i.e., the subsurface area under the slag pit heated from historic slag pit operations). In order to reduce the possibility of encountering P4 during drilling, boring locations were placed beyond the areas where P4 was handled in RUs 1 and 2 and beyond the lateral boundary of the 44 °C isotherm as calculated from the thermal model.

A total of 14 primary borings will be drilled around RUs 1 and 2, combined, each drilled to the groundwater surface. The 14 proposed borings were selected based on spatial coverage around the perimeter in combination with plant operational knowledge (e.g., office buildings to north, Idaho Power Don substation to south where there were no plant processes) and physical access constraints such as building foundations. Although the area has undergone dismantling activities and most of the power lines and buildings are gone, the foundations still remain and present an obstacle to drilling at some locations. It is not expected that P4 will be present in the 14 proposed cap delineation borings based on the distance (several tens to hundreds of feet) from the isotherm. Therefore, the proposed extent of the cap as delineated by the 14 borings will provide for a conservative cap boundary.

If no P4 is encountered at a level of acute health concern, as evidenced by a lack of smoking or burning, in a given primary boring, then no step-out borings down to groundwater will be drilled. If P4 is encountered at a level of acute health concern in a given initial boring, then step-out sampling down to groundwater at a secondary location must be undertaken, with the location of those step-outs to be determined in the field. Step-out borings will be approximately 40 feet from the previous boring. If P4 is encountered at a step-out sampling location at a level of acute health concern, then subsequent step-out sampling down to groundwater must continue until P4 is no longer encountered. The RU boundaries and cap extent must be adjusted to include the area up to which P4 (as evidenced by smoking or burning) is no longer encountered. When visual observation indicates that P4 is not present, samples will be collected in the 0-to-2 foot and 0-to-10 foot[1] intervals and analyzed for P4. Samples in the 0-to-2 foot bgs and 0-to-10 foot bgs intervals will be compared to future site worker SSLs. If concentrations in the 0-to-2 foot bgs and 0-to-10 foot bgs intervals exceed the applicable SSLs, then additional borings to 10 feet will be required to define the lateral extent of P4 above the future site worker SSLs. Additional confirmation sampling will be performed as part of the cap delineation studies described in the introduction to Section 2.2.

[1] A 0-to-2 ft bgs sample and a 2-to-10 ft bgs sample will be numerically averaged to form the 0-to-10 ft bgs sample.

A hollow-stem auger rig will be used to drill to the maximum depth in each boring. This drilling method was selected because it will not cause aerial spreading of P4 as would an air drilling rig (percussion or air rotary). Additionally, it will allow subsurface P4, present at sufficient concentrations, to ignite as the cuttings are exposed to the atmosphere. If P4 is encountered during drilling, as evidenced by smoking or igniting cuttings, the drilling will cease immediately, the augers will be carefully removed, the borehole will be plugged and abandoned, and the rig will move to a step-out location.

Due to the hazards of P4 sampling, a site safety supervisor will monitor site access during field operations. The number of individuals allowed in the exclusion zone will be kept to a minimum. Entry into the exclusion zone during drilling will be restricted to workers who have the necessary personal protective equipment and training as required in the Health and Safety Plan.

2.1.1.2.3 Specific Investigation Area

No specific investigation area study is required at these RUs.

2.1.1.2.4 SFS Data Needs

Underground Piping Problem Statement

The portion of the piping and sump system within RU 1 and RU 2 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures (i.e., foundations) left behind in these RUs after decommissioning is needed to support the SFS.

Sampling Design

The decision whether to remove, decontaminate, or abandon underground piping, sumps and other structures will be an SFS decision based on the detailed analysis of alternatives. To provide the SFS process with sufficient information to evaluate potential remedial alternatives for underground piping, sumps and other structures, FMC proposes an SRI task to identify available information regarding remaining subsurface piping/sumps/structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding residual constituents that may remain in the pipes/sumps/structures. This task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. These data will be forwarded to the SFS to be evaluated as part of the cap design for RU 1 and RU 2.

2.1.2 RU 3: Receiving Stores, Paint Shop and P4 Decon

Figure 2-15 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-16 shows the proposed sampling locations for the SFS data collection scheme, including specific investigation areas. It should be noted that a building with a basement was excluded from the sampling parcels.

Description

RU 3 is 1.4 acres in size and is located in the northern part of the FMC Plant OU. It is a relatively flat area, and was the site of several buildings and paved areas. RU 3 is north of the phos dock and furnace building (RU 1) and south of the railroad swale (RU 22c).

Process Knowledge

RU 3 contained maintenance shops, receiving and stores, and office buildings. There were no P4 production process activities within RU 3. However, the phos dock (located in RU 1) was used to store, process, and load P4 into railcars. Phossy water (water used to prevent P4 contacting air and thus becoming contaminated with particles of P4) often flowed over the surface from the phos dock, along a roadway through RU 3 to the railroad swale (RU 22c). Most of this overland flow was over an asphalt-paved surface. However, given the potential for P4 to be in the phossy water and the fact that the road surface was not impermeable, there is a potential for P4 to have migrated to the subsurface soils.

In addition, there was approximately 1,000 feet of underground storm drain piping running from RU 1 through RU 3. The pipe was installed to carry stormwater from the plant operating areas to the railroad swale (RU 22c). However, the storm drain piping also carried spilled phossy water from the furnace building and phos dock to the railroad swale. The phossy water was generated as result of process leaks, washwater, and other spills. The underground piping was reported to have been constructed of concrete drain pipes. As such, the piping has joints which are not sealed, and can therefore leak.

Although the buildings in RU 3 have been removed as part of the plant decommissioning, roadways and building foundations remain that help identify the location of underground piping, sumps and other structures and the path of overland phossy water flows.

Remediation Vision

No action anticipated to be necessary.

2.1.2.1 Reference to DQO Section

Phossy Water Specific Investigation Area – Section 2.3.7.1

Underground Piping Investigation – Section 2.3.9.1

Evaluation of Future Worker Risk – Section 2.5

2.1.2.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.2.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

This RU is less than five acres in size (1.4 acres). Therefore, the RU constitutes the decision unit for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, a total of 24 surface PIC measurements will be made within the RU. *Visual Sampling Plan, v.4.3.* (VSP) software was used to place the 24-location square grid on a random origin across the entire RU. VSP is a software tool for selecting the correct number and location of environmental samples so that the results of statistical tests performed on the data collected as result of this Work Plan have the required confidence for decision making.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of six increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.2.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.2.2.3 Specific Investigation Area

Phossy Water Specific Investigation Area Problem Statement

The impact to underlying soils due to drainage of phossy water across RU 3 has not been determined, and thus a decision to either remediate the specific investigation areas or to take no further action cannot be determined.

Phossy Water Specific Investigation Area Sampling Design

A total of 15 samples will be collected in the area shown on Figures 2-15 and 2-16. The samples will be located on a 30-foot square grid cast on a random origin as determined in VSP. If the residual P4 concentration is greater than a level of acute health concern, as evidenced by smoking or burning when drilling/excavating to native soil, then the borings/test pits will be

stopped, the sampling location moved and this part of the study repeated. If P4 is not observed at a given location a level of acute health concern, as evidenced by a lack of smoking or burning, a sample will be collected from 0-to-2 feet bns and vertically composited at each location. Samples will be submitted to the laboratory for the following analyses: P4, metals, and fluoride.

Underground Piping Investigation Problem Statement

The storm drain and underlying soil may contain P4, metals and fluorides from storm water collected from the furnace and phos dock area. This portion of the piping within RU 3 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

Underground Piping Investigation Sampling Design

During the SRI, the phase one task for the underground piping investigation in RU 3 is to identify available information regarding remaining piping, sumps and structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data collection activities in RU 3 conducted during the SRI, i.e., whether RU 3 remains designated as NFA or proceeds to the SFS.

If RU 3 remains designated as NFA, FMC will propose a phase two study that would further evaluate the buried piping/sumps/structures and present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation will proceed only upon EPA approval of the SRI Work Plan addendum. If RU 3 is forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures will be forwarded to the SFS and a phase two study during the SRI would not be required.

2.1.2.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.3 RU 4: Office Buildings and Training Center

Figure 2-17 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-18 shows the proposed sampling locations for

the SFS data collection scheme including specific investigation areas. The training center building and the decon building were excluded from the sampling design. The training center was not demolished and remains active. The decon building, while demolished, was designed and constructed as a RCRA Subpart DD building and as such has a lined foundation.

Description

RU 4 is immediately west of RU 3 and north of RU 5. Several buildings were located within RU 4, including the change house, office buildings, and training center. The ground surface is relatively planar with a gentle slope to the north.

Process Knowledge

There were no P4 production process operations within RU 4. During the EMF RI (BEI, 1996), toluene was detected at low concentrations in all samples collected from boring F028B to a depth of 70 feet bgs. F028B is located in the parking lot immediately in front of the former administration building. Although the EMF RI concluded that there was no indication of a VOC source to groundwater, there is some uncertainty as to the source and additional characterization is needed.

Although all the buildings in RU 4 other than the training center have been removed as part of the plant decommissioning, roadways and building foundations remain.

Remediation Vision

No further action is anticipated to be necessary.

2.1.3.1 Reference to DQO Section

Solvent Specific Investigation Area – Section 2.3.1.1

Evaluation of Future Worker Risk – Section 2.5

2.1.3.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.3.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

This RU is less than five acres in size (2.5 acres). Therefore, the RU constitutes the decision unit for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, a total of 40 surface PIC measurements will be made within the RU. VSP was used to place the 40-location square grid on a random origin across the entire RU (except the training center, which remains in use, and the foundation of decon building, which has a liner that would have prevented any subsurface impacts).

If the results of the PIC measurements are below the CV, four composite samples, each consisting of ten increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.3.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.3.2.3 Specific Investigation Area

Solvent Specific Investigation Area Problem Statement

Confirmation sampling is needed to delineate the lateral and vertical extent of solvents in the vicinity of boring F028B.

Solvent Specific Investigation Area Sampling Design

A solvent specific investigation area was identified around Boring F028B in the parking lot north of the office building. The chemical lab drain pit and disposal areas in RU 5 have been proposed as potential sources of this contamination, however, the exact source has not been identified. Proposed boring locations have been laid out as a 30-foot grid with a random origin using VSP. A 30-foot grid is appropriate in this area considering the types of waste management operations that may have occurred in RU 4 and RU 5.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum.

During phase one, 14 borings will be completed in RU 4 and samples will be collected from each boring. The sampling design requires samples to be collected at the native soil interface, two

feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within two feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample. If the fill/native soil interface is greater than 10 feet bgs, the boring will be advanced to native soil and samples will be collected immediately below the native soil interface, 2–feet bns, and 10 feet bns.

The analytical results for the organic COCs or COPCs will be compared to applicable SSLs. The results of the phase one study will be presented to the EPA and the need for additional data to determine the vertical extent of organic COCs or COPCs beyond phase one will be determined. If additional sampling is required it will be performed during a phase two study per an EPA-approved SRI Work Plan addendum.

Samples during phase one will be collected in accordance with Method 5035A and will be analyzed for the laboratory related solvents: benzene, carbon disulfide, chloroform, methylene chloride, PCE, toluene, TCE, 1,1,1-trichloroethane and 2-butanone.

2.1.3.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 sample locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.4 RU 5: Lab and Old Drainfield

Figure 2-19 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-20 shows the proposed sampling locations for the SFS data collection scheme including specific investigation areas. It should be noted that a portion of the laboratory building was excluded from the sampling design due to the presence of a basement.

Description

RU 5 is 0.6 acres in size and contains the site of the former FMC laboratory and its associated drainfield or seepage pit. The laboratory was used to analyze ore and product samples. The laboratory disposed various solutions and organic solvents in the seepage pit. In 1980 that practice ceased. In 1995, the seepage pit was grouted, and a closure report was submitted to EPA in 2002.

Process Knowledge

Although there were no P4 production process operations within RU 5, the process control laboratory did analyze small quantities of process materials for quality control. The laboratory chemical disposal area (SWMU # 61) to the west of the laboratory will be investigated for solvents based on prior practices at the plant process control laboratory. At the chemical laboratory seepage pit (in RU 5), toluene was detected at two of the depth horizons sampled (1 and 20 feet) and xylenes and ethylbenzene were detected at a depth of 70 feet in boring F029B. The coordinates for F029B are N 452,076.0 E 555,703.0. Based on the bore log for F029B there is approximately 1-foot of asphalt on top of 10 feet of gravely silt (possible silica fines). The next 8 feet of depth consist of slag that is on top of native soil.

Although the buildings in RU 5 have been removed as part of the plant decommissioning, roadways and building foundations remain.

Remediation Vision

No further action anticipated to be necessary.

2.1.4.1 Reference to DQO Section

Solvent Specific Investigation Area – Section 2.3.1.2

Evaluation of Future Worker Risk – Section 2.5

2.1.4.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.4.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

This RU is less than five acres in size (0.6 acre). Therefore, the RU constitutes the decision unit for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, a total of 16 surface PIC measurements will be made within the RU. VSP was used to

place the 16-location square grid on a random origin across the entire RU (excluding the basement).

If the results of the PIC measurements are below the CV, four composite samples, each consisting of four increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.4.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.4.2.3 Specific Investigation Area

Solvent Specific Investigation Area Problem Statement

Based on knowledge of past plant practices and analytical results associated with boring F029B the determination of the presence or absence of solvents at SWMU 61 and the Chemical lab seepage pit is needed to support a decision to either remediate the solvent specific investigation area or to take no further action.

Solvent Specific Investigation Area Sampling Design

A specific investigation area was identified around Boring F029B west of the laboratory building. The chemical lab drain pit and disposal areas in RU 5 have been identified as a potential source of this contamination. The boring locations have been laid out as a 30-foot grid with a random origin using VSP. A 30-foot grid is appropriate in this area considering the types of waste management operations that may have occurred in RU 5.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum.

During phase one, 24 borings will be completed in RU 5 and samples will be collected from each boring. The sampling design requires discrete samples to be collected at the native soil interface, two feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample. If the fill/native soil interface is greater than 10 feet bgs, the

boring will be advanced to native soil and samples will be collected immediately below the native soil interface, 2-feet bns, and 10-feet bns.

The analytical results of the samples for the organic COCs or COPCs will be compared to the applicable SSLs. The results of the phase one study will be presented to the EPA and the need for additional data to determine the vertical extent of organic COCs or COPCs beyond phase one will be determined. If additional sampling is required it will be performed during a phase two study per an EPA-approved SRI Work Plan addendum.

Samples during phase one will be collected in accordance with Method 5035A and will be analyzed for the laboratory-related solvents: benzene, carbon disulfide, chloroform, methylene chloride, PCE, toluene, TCE, 1,1,1-trichloroethane and 2-butanone.

2.1.4.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four composited samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.5 RU 6: Former Long-Term Phos Storage Tanks

Figure 2-21 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-22 shows the proposed sampling locations for the SFS data collection scheme, including specific investigation areas.

Description

RU 6 is 1.4 acres in size and is located in the northern part of the FMC Plant OU. RU 6 is the location of the former long-term phosphorus storage tanks and loading/unloading railspur. It is a relatively flat area, slag-covered, with no remaining surface features except a railroad spur that passes through the northern portion of the RU. RU 6 is west of RUs 4 and 5.

Process Knowledge

Over a period of years in the late 1970s and early 1980s, FMC installed 12 underground steel storage tanks for long-term storage of P4, all of which were 104,000 gallons in size. The tanks (which were approximately 14 feet in diameter) were only half buried, i.e., the tanks were placed about 7 feet below the original grade with fill material piled up around the exposed top of each tank. Phossy water spills occurred during transfer operations. FMC removed the P4 from the tanks in the early 1990s and the tanks were then removed. Tank removal occurred in two phases with eight tanks removed in 1994 and four tanks removed in 1998. During both phases of tank removal, FMC personnel noted the presence of P4 in surface materials near the tanks. Phossy

water spills were located near the tank fill ports, indicating potential P4 in the near subsurface soil due to spilling of phossy water, rather than P4 product. The tanks were visually inspected after removal and no tank failures were found. The 7-foot-deep depressions left after the removal of the tanks were backfilled with fill material and the area was graded level.

Remediation Vision

No action anticipated to be necessary

2.1.5.1 Reference to DQO Section

Phossy Water Specific Investigation Area – Section 2.3.7.2

Evaluation of Future Worker Risk – Section 2.5

2.1.5.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.5.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

This RU is less than five acres in size (1.4 acres). Therefore, the RU constitutes the decision unit for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, a total of 24 surface PIC measurements will be made within the RU. VSP was used to place the 24-location square grid on a random origin across the entire RU.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of six increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.5.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.5.2.3 Specific Investigation Area

Phossy Water Specific Investigation Area Problem Statement

There is a potential that phossy water spills may have occurred during loading and unloading of railcars and filling tanks with phossy water. Shallow soil samples near the spur line and in the area of the former storage tanks are needed to evaluate the potential for constituents associated with phossy water in the underlying soils. In addition, soil samples will also be collected beneath the former tanks in order to evaluate the potential for constituents associated with phossy water in the soil immediately beneath the tank.

Phossy Water Specific Investigation Area Sampling Design

A specific investigation area has been identified at RU 6 pertaining to phossy water surface spills associated with the long-term storage tanks and the railcar loading/unloading area. For the P4 specific investigation area associated with phossy water spills to the surface, a total of 20 samples will be collected for the area that includes the long term tank storage and railcar loading area. A 20-foot interval on a standard square grid with a random origin as determined in VSP will be used for the rail loading area. A standard grid of 50 feet will be used for the former tank specific investigation area. If the residual P4 concentration is greater than a level of acute health concern, as evidenced by smoking or burning when drilling/excavating to native soil, then the boring/test pit will be stopped, the sampling location moved and this part of the study repeated. If P4 is not observed at a level of acute health concern at as visually evidenced by a lack of smoking or burning, a sample will be collected from 0-to-2 feet bns and vertically composited at each location. Samples will be submitted to the laboratory for the following analyses: P4, metals, and fluoride.

For the P4 investigation beneath the former phossy tanks, one sample will be collected in the center below each of the 12 tanks. The locations of the 12 former tanks have been determined from historical georeferenced aerial photographs. The sample points were located in the center of each tank footprint based on the aerial photographs. It is anticipated that the 0-to-2 foot bns samples will be collected at depths of at least seven feet bgs in order to be below the tank and in native soil. If the residual P4 concentration is greater than a level of acute health concern , as evidenced by smoking or burning when drilling/excavating to native soil, then the boring/test pit will be stopped, and no sample will be collected. If P4 is not observed at a level of acute health concern, as visually evidenced by a lack of smoking or burning, a sample will be collected from 0-to-2 feet bns and vertically composited at each location. Samples will be submitted to the laboratory for the following analyses: P4, metals, and fluoride.

2.1.5.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation

areas studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four composite samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.6 RU 7: Shale Unloading, Crushing and Stockpile

Figure 2-23 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-24 shows the proposed sampling locations for the SFS data collection scheme including specific investigation areas.

Description

RU 7 is about 25 acres and is located in the northeastern portion of the FMC Plant OU, adjacent to the JR Simplot facility. Historic aerial photos and plant records show this area has been used for ore handling since the plant began operation in 1949.

Coke, another raw material used in the P4 production process, was also handled within RU 7. Coke was unloaded from railcars and carried by conveyors to the furnace building.

Process Knowledge

Phosphate ore was brought into the plant via railcar and unloaded to an ore stockpile/reclaim system. When reclaimed from the stockpile, the ore was crushed and screened and then conveyed to the briquetting process. In addition to phosphate minerals, phosphate ore typically contained numerous metals and uranium-238 in secular equilibrium with its decay daughters. The ore typically contained 19 to 30 pCi/g of radium-226 (a decay daughter of uranium-238) which decays to radon-222.

RU 7 has been built up from original grade, possibly because of ore stockpiling and material handling requirements at the plant. A portion of the ore stockpile has been sold and shipped off site. The remaining ore has been leveled to grade and remains within RU 7.

The coke handling area in RU 7 consists of a former building (approx. 80 feet long, 19 feet wide, and 27 feet high) in which coke was unloaded from single railcars. Coke was bottom dropped from cars onto a hopper and conveyor belt within the building. This coke unloading building was constructed and placed into service circa 1996. Operation ended in December 2001 with the cessation of P4 manufacturing. The building and coke handling systems have been removed.

Analytical data for coke was reported to EPA in FMC's September 17, 2002 response to EPA's July 8, 2002 information request. Coke contained approximately 86.5% fixed carbon, 3.4% volatiles, 2.7% silica, 2.3% water, 1.3% Al2O3, 1.2% CaO, 1.2 % S, 0.5% Fe2O3, 0.46% MgO, and 0.05% K2O. Also, a TCLP analysis of coke from FMC's Kemmerer, WY coke plant was supplied to EPA at that time. This plant supplied 70% of the coke used by FMC.

Remediation Vision

Following sale and removal of ore inventory, no action anticipated to be necessary.

2.1.6.1 Reference to DQO Section

PAH Potential Migration into Soil Specific Investigation Area – Section 2.3.3.1

Evaluation of Radon Flux Study – Section 2.4.2

Evaluation of Future Worker Risk – Section 2.5

Ore Reference Area – Section 2.7

2.1.6.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.6.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

Because RU 7 is greater than five acres in size (25 acres) it will be subdivided into five decision units, each five acres in size, for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, 80 surface PIC measurements will be collected within each decision unit, for a total of 400 measurements within the RU. VSP was used to place the 80-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of 20 increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples) within each decision unit. The sample increments will be collected at the same locations as the PIC measurements. A total of 40 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.6.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.6.2.3 Specific Investigation Area

Evaluation of Radon Flux Study Problem Statement

Radon emission rates from the shale ore handling area have not been quantified. Evaluation of the radon flux from RU 7 is required in order to determine if the level of radon flux requires RU 7 to be forwarded to the SFS.

In addition, these data along with other radon measurements (e.g, RU 19 Slag Pile) will be used to evaluate the potential for radon flux to be an issue of concern at other RUs that contain residual fill material.

Radon Flux Study Sampling Design

The primary goal for the RU 7 investigation is to quantify the radon flux emission rates from the ore storage and handling area. The measured radon flux will be compared against the UMTRCA guideline of 20 pCi/m^2/sec. Secondary inputs to the decision are the detection limits of the radon flux chambers and the variability of radon emissions (see Section 3).

Radon flux measurements at RU 7 will be carried out at 100 locations across RU 7 based on an evenly-spaced grid. Measurements will be made for a period of up to 48 hours at each location. Locations were selected to provide a reasonable assessment of the spatial distribution of the radon emission fluxes. The mean radon flux will be calculated as outlined in EPA Method 115.

The mean radon flux for the entire pile will be calculated and reported as follows:

1) The individual radon flux calculations shall be made as provided in EPA Method 115. The mean radon flux for each region of the pile shall be calculated by summing all individual flux measurements for the region and dividing by the total number of flux measurements for the region.

2) The mean radon flux for the total pile shall be calculated as follows:

$$J_s = \frac{J_1 A_1 + J_2 A_2 + \ldots J_i A_i}{A_t}$$

where:

J_s = mean flux for the total pile (pCi/m^2/sec)

J_i = mean flux measured in region i (pCi/m^2/sec)

A_i = area of region i (m^2)

A_t = total area of the pile (m^2)

The mean radon flux will be calculated as described above, and the mean flux will be compared to the UMTRCA guidelines.

PAH Specific Investigation Area Problem Statement

Dry coke was unloaded from railcars in RU 7 for use in the P4 production process. Coke unloading and handling activities resulted in a release of coke to the ground surface in RU 7 at the coke unloading building. Although coke is no longer visible at the surface, characterization of the soils beneath for the coke handling area is needed to support the remediation vision.

PAH Specific Investigation Area Sampling Design (Coke Reference Study)

A specific investigation area was identified for residual coke that collected at the coke unloading area in RU 7. Since the coke in RU 7 would have the same chemical characteristics as the coke managed in RU 20 and since the areal extent of coke within RU 7 is much smaller than its areal extent in RU 20, it is proposed to conduct a coke reference study in RU 20 as described in Section 2.1.15.2.3. The coke reference study in RU 20 will be utilized to address the potential release of PAHs into the underlying soils at RU 7.

2.1.6.2.4 SFS Data Needs

RU 7 Ore Reference Area Study

A reference area study is planned for RU 7 with the overall purpose of determining the leaching potential of ore and ore-related materials (such as nodule fines) into the native soils beneath the ore materials. This will be done by examining certain ore constituents in the native soil beneath the ore materials on the surface. Although this is an SFS data type, the reference area study will be performed regardless of the outcome of the risk data collection. This reference area study will involve sampling 20 locations in RU 7 on a standard square grid using a random origin. These sample locations will not be placed within a specific investigation area and will be in the same locations as the SFS data collection described below. The samples will be vertically composited in the 0-to-2 foot bns interval for each boring, but will not be composited with other sample locations. The samples will be collected from 0-to-2 feet bns and submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

Other SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.7 RU 8: Former Kiln Scrubber Ponds and Calciners

Figure 2-25 shows the proposed sampling locations for the cap delineation investigation.

Description

RU 8 is 6.7 acres in size and was the location of the calcining operation (consisting of two gas-fired traveling grate calciners and associated scrubbing equipment) used to heat-harden ore briquettes. RU 8 is located south of RU 7, north of RU 11, and east of RU 2. The calciners were installed in 1968. Prior to 1968, a rotary kiln was used to heat ore. Three former kiln scrubber ponds were identified on historic aerial photos and delineated on site maps as part of the EMF RI. These ponds operated from 1949 through the late 1960's. Kiln scrubber pond solids were dredged when the ponds filled and the solids were placed in the Former Plant Landfill (RU 19). The ponds were backfilled to grade in preparation for the construction of the calciners. Since the late 1960's, the calciners occupied this location until decommissioning in 2006.

Process Knowledge

Process knowledge of the kiln process (rotary kilns were used before calciners were installed) indicates that residual sediments from the former kiln scrubber ponds within RU 8 contain materials with COCs similar to those contained in calciner solids. Calciner solids, and by inference kiln pond solids, exceed SSLs for cadmium, arsenic, and/or lead-210 and polonium-210. Additional characterization of the material is therefore not warranted.

The former kiln scrubber ponds within RU 8 are included in this grouping for the following reasons:

1. The kiln scrubber ponds contain materials with COCs and COPCs similar to the calciner ponds. The similarity of material is due to the similarity between the kiln and calcining processes.

2. The 1998 ROD selected capping or covering for the calciner pond solids, and the kiln scrubber solids contained in the former kiln scrubber ponds are of a similar nature.

The kiln scrubber overflow pond in RU 9 received clarified water from the kiln scrubber ponds in RU 8 via the kiln scrubber overflow ditch. Therefore, significant accumulation of solids may have occurred in this ditch or the overflow pond. Also, the clarified water had a low pH and thus could have transported dissolved metals to the overflow scrubber pond and into the subsurface. Upon closure, the kiln scrubber overflow pond was filled with silica fines.

Although all of the calcining equipment and associated buildings have been removed as part of the plant decommissioning process, the building and equipment foundations remain. A 1965 aerial photo, which illustrates the former kiln scrubber ponds when they were in operation, was geo-referenced and the pond outlines were drawn to show actual locations and extent of the three ponds in RU 8. This information will be used during the SRI to define the kiln scrubber pond boundaries, the initial step-out borings for RU 8 and the cap/cover extension into RU 9 (overflow pond boundary).

Remediation Vision

Leave existing concrete slabs in-place, grade to design subgrade elevation and construct soil cover (cap) over entire footprint of these areas.

2.1.7.1 Reference to DQO Section

Kiln Scrubber Pond Cap Delineation – Section 2.2.2

2.1.7.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.7.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme is proposed for this RU.

2.1.7.2.2 Cap Delineation

Problem Statement

The RI Update Memorandum (BEI, 2004b) identified confirmation of the lateral extent of kiln scrubber pond sediments as a data gap. Confirmation sampling along the exterior boundary of RU 8 and in the southern portion of RU 9 (around the scrubber overflow pond) is needed to ensure that the area covered by the cap/cover encompasses the lateral extent of residual kiln scrubber solids.

Sampling Design

Around the RU 8 boundary, nine initial borings/test pits will be drilled and sampled down to native soils. The locations were selected to provide a level of confidence that residual pond sediments do not extend into areas that will not be capped/covered as a remedial action. The western boundary of RU 8 is adjacent to RU 1 (Furnace Building), and these areas will likely have a cap; therefore, it is not critical to delineate pond sediments to the west of RU 8.

The planned cap at RU 8 will be extended to any portions of the former kiln scrubber overflow pond and ditch at RU 9 that contain residual kiln scrubber pond sediments. An investigation will be conducted to identify these areas. Five borings/test pits will be evaluated to determine the boundary of the cap extension into RU 9.

Kiln scrubber pond sediments are very similar to the calciner solids: very fine-grained with a brownish gray color. This will allow field personnel to distinguish between kiln scrubber pond sediments, fill materials (commonly ore, slag and silica), and native soils (yellowish-brown loess).

Based on visual observations, if the material associated with kiln scrubber pond sediments is observed, the location will be abandoned and a step-out location will be installed approximately

10 feet outward from the original location, as shown on Figure 2-25. In the final step-out location, kiln scrubber pond sediments will not be visually observed and a soil sample will be collected from 0-to-2 feet bns and vertically composited at each location. The extent of kiln scrubber pond sediments, as identified from the soil logs, will be used in the SFS and RD to define the perimeter of any cover or cap over the former kiln scrubber ponds in RU 8 and RU 9. Samples submitted to the laboratory will be analyzed for the following constituents: metals, fluoride, U-238, Ra-226, K-40, Po-210, and Pb-210. Additional confirmation sampling will be performed as part of the cap delineation studies as described in the introduction to Section 2.2

2.1.7.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.7.2.4 SFS Data Needs

No additional SFS data collection is required at this RU.

2.1.8 RU 9: Silica Stockpiles and Former Kiln Scrubber Overflow Pond

Figure 2-26 shows the proposed sampling locations under the risk data collection scenario including cap delineation investigations. Figure 2-27 shows the proposed sampling locations for the SFS data collection scheme, including the cap investigations.

Description

RU 9 is 12.9 acres in size and is located immediately south of RU 7 at the east end of the FMC Plant OU. The silica stockpile area is at the eastern end of RU 9 and is a relatively planar area south of the ore stockpile. FMC has always used most of the area within RU 9 for silica handling, although other fill materials are present within the RU. The former kiln scrubber overflow pond was located in this area, and is being investigated as part of RU 8. The pond was backfilled with silica in the late 1960's after the kilns were replaced with calciners.

Remediation Vision

No further action anticipated to be necessary (note that the remediation vision of capping for RU 8 will apply to the overflow pond located within RU 9).

2.1.8.1 Reference to DQO Section

Evaluation of Future Worker Risk – Section 2.5

2.1.8.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.8.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

RU 9 is 12.9 acres in size. However, subtracting the area to be investigated for the RU 8 cap extension into this RU (the kiln scrubber overflow pond and ditch) effectively reduces the RU 9 area to 10.1 acres. Because the size of the remaining area in this RU is greater than five acres in size (10.1 acres), it will be subdivided into two 5-acre decision units for evaluating risks to potential future workers. If the results of the radiation surface scan are below the CV, 80 surface PIC measurements will be collected within each decision unit, for a total of 160 measurements within the RU. VSP was used to place the 80-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of 20 increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples) within each decision unit. The sample increments will be collected at the same locations as the PIC measurements. A total of 16 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.8.2.2 Cap

A complete description of the RU 8 cap delineation into RU 9 is located in Section 2.1.7.2.2.

2.1.8.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.8.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four

samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.9 RU 10: IWW Pond and Ditch

Figure 2-28 shows the proposed sampling locations under the risk data collection scenario including the specific investigation areas. Figure 2-29 shows the proposed sampling locations for the SFS data collection scheme, including the specific investigation areas.

Description

The IWW pond and ditch (RU 10) is 1.3 acres in size and is located east of RUs 7 and 9 along the eastern boundary of the FMC Plant OU. The pond is approximately 100 feet in diameter, and the ditch runs east from the pond for 350 feet, then turns and runs north for 1200 feet along FMC's eastern property boundary.

Process Knowledge

The IWW pond and ditch were put into operation in 1977 for the discharge of non-contact cooling water from the calciners and furnaces to the Portneuf River. FMC operated the IWW system under an NPDES permit. In 2002, FMC requested that EPA terminate the permit because IWW was no longer being discharged.

As documented in the EMF RI Report (BEI, 1996), there were infrequent plant upset conditions where small volumes of phossy water were inadvertently routed to the IWW system. FMC investigated the cause of the releases, and reconfigured plant piping to reduce the potential for phossy water to be released to the IWW system.

The flow of the non-contact cooling water averaged 1,200 gallons per minute (gpm) which resulted in a high-velocity flow through the ditch, and a relatively low-velocity flow through the pond. Sediments, if any, would be expected to be found in the IWW Pond, rather than in the IWW Ditch. After plant closure, the IWW Ditch was backfilled with crushed silica (while the IWW Pond was not backfilled).

Residual P4 may be contained in sediments that remain in the pond and ditch. Sediments in the IWW pond and ditch and sediments that were dredged and placed at the pond and ditch edges likely no longer contain P4 due to the oxidation of P4 as these sediments dried.

Remediation Vision

Backfill with silica, no further action anticipated to be necessary.

2.1.9.1 Reference to DQO Section

P4 and Phossy Solids Investigation – Section 2.3.8

Evaluation of Future Worker Risk – Section 2.5

2.1.9.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.9.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

This RU is less than five acres in size (1.3 acres). Therefore, the RU constitutes the decision unit for evaluating potential future worker risks. If the results of the radiation surface scan are below the CV, a total of 24 surface PIC measurements will be made within the RU. VSP was used to place the 24-location square grid on a random origin across the entire RU.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of six increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.9.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.9.2.3 Specific Investigation Area

IWW Pond and Ditch Specific Investigation Area Problem Statement

The extent of constituents associated with phossy water in RU 10 has not been adequately characterized to support a decision to either remediate the IWW Pond and Ditch specific investigation area or to take no further action.

IWW Pond and Ditch Specific Investigation Area Sampling Design

For the P4 specific investigation area, a total of 20 samples will be collected on a standard square grid with a random origin as determined in VSP. Samples from the ditch will be collected from

0-to-2 feet bns (below silica fill material in the ditch) and vertically composited at each location. Samples from the pond will be collected from 0-to-2 feet bgs. These samples will be vertically composited at each location. If the residual P4 concentration is greater than a level of acute health concern, as visually evidenced by smoking or burning when drilling/excavating to native soil, then the boring/test pit will be stopped, the sampling location moved and this part of the study repeated. If P4 is not observed at a level of acute health concern at a given location, as visually indicated by a lack of smoking or burning, a sample will be collected from 0-to-2 feet bns and vertically composited at each location. Samples from both the pond and ditch will be submitted to the laboratory for the following analyses: P4, metals, fluoride, Pb-210 and Po-210.

2.1.9.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.10 RU 11: Equipment Area South of Calciners

Figure 2-30 shows the proposed sampling locations under the risk data collection scenario. Figure 2-31 shows the proposed sampling locations for the SFS data collection scheme.

Description

RU 11 is 8.4 acres in size and is located north of the northeastern corner of the slag pile. The ground surface slopes to the north, toward the former calciners (RU 8). This area is covered in slag and was historically used as a staging area for used equipment. There were no P4 production process operations in RU 11.

Remediation Vision

No further action anticipated to be necessary.

2.1.10.1 Reference to DQO Section

Evaluation of Future Worker Risk – Section 2.5

2.1.10.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.10.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

Because RU 11 is greater than five acres in size (8.4 acres), it will be subdivided into two decision units, each 4.2 acres in size, for evaluating risks to potential future workers. If the results of the radiation surface scan are below the CV, 64 surface PIC measurements will be collected within each decision unit, for a total of 128 measurements within the RU. VSP was used to place a 64-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of 16 increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples) within each decision unit. The sample increments will be collected at the same locations as the PIC measurements. A total of 16 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.10.2.2 Cap

No cap delineation investigations are required for this RU.

2.1.10.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.10.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.11 RU 12: Former RP&S Area and Mobile Shop

Figure 2-32 shows the proposed sampling locations under the risk data collection scenario including specific investigation areas. Figure 2-33 shows the proposed sampling locations for the SFS data collection scheme including specific investigation areas.

Description

RU 12 is 11.6 acres in size and is located in the central portion of the FMC Plant OU. The ground surface is gently sloping to the northwest, and several buildings were formerly located within the RU boundaries. Buildings in RU 12 included the LDR facility, the PCB storage shed (removed in 2000), and miscellaneous storage sheds. There was also a fueling island located within RU 12, with two associated underground fuel storage tanks. These gasoline and diesel underground fuel tanks were removed from RU 12 during 2006 in accordance with the RCRA UST program.

Process Knowledge

Mobile Shop

The Mobile Shop formerly located in RU 12 was used for large mobile equipment maintenance activities. Degreasing was performed as necessary for mobile equipment parts using brush on/wipe off techniques. No large-scale degreasing operations were used, (i.e., no vapor degreasers). A small 20-gallon degreasing station supplied and recycled by Safety Kleen was also used. The Mobile Shop was constructed with a concrete floor, which would substantially limit migration of solvents through the floor. Although no known releases were reported, solvents may have been released to the ground surface immediately outside the shop.

Soils in the shallow subsurface in the vicinity of the Mobile Shop consist primarily of fill materials. Native soil was not encountered at the 2-foot bgs mark.

Fuel Islands

There have been three reported releases of diesel fuel from the fueling station in RU 12. These have been above-ground releases, ranging from 40 gallons to 572 gallons. FMC personnel responded by placing sand berms around the spill areas, and cleaning up free-phase diesel pooled on the asphalt areas. Some of the diesel may have run off the paved areas and infiltrated the adjacent fill and soils; however, this has not been adequately investigated. During the EMF RI, twelve samples were collected and analyzed for TPH from depths of 0 to 2 feet in six different locations (F060B, F061B, F105B, F111R, F112R, and F122R). TPH concentrations ranged from 30.1 mg/kg to 9,025.2 mg/kg.

High Pressure Steam Cleaning Station

A high-pressure steam cleaning station was located west of the mobile equipment shop. A small metal shed on a concrete pad housed only cleaning equipment. Washing was conducted in the open outside area adjacent to the station. The station was operated from June 1981 until plant closure in 2001. Hazardous wastes were never managed at the steam cleaning station.

Transformer Storage Area

The southern portion of RU 12 was used for used equipment storage, including at times for the storage of large transformers. Prior to the mid-1980s, transformers may have contained dielectric fluid with greater than 50 ppm PCBs. During the 1980s, transformers were either treated or transfilled to reduce PCB concentrations to below regulated levels (i.e., 50 ppm). No releases of transformer oil were documented, but some leakage may have occurred in the form of drips from the equipment.

There was also a small PCB storage shed located at the western edge of RU 12. This small shed was covered, equipped with an impermeable floor and berm, and was specifically designed to meet the long-term PCB storage requirements of 40 CFR Part 761, including weekly inspection of the shed and contents. There were no reported leaks or spills in this storage shed. The shed was removed during construction of the LDR treatment facility.

The EMF RI (BEI, 1996) investigated the potential for PCB releases, and no significant PCB levels were identified (EMF RI Report, pages 4.2-97 through 4.2-99). Fifteen soil samples were collected during the EMF RI and analyzed for PCBs (Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260). Six of the Aroclors were not detected (at 0.65 mg/kg detection level) in any of the samples. Aroclor 1260 was detected at 0.58J mg/kg or less in 3 of the 15 samples. These samples were not directly associated with the PCB storage shed which was removed in 2000 prior to construction of the LDR Treatment System.

Fill materials were found in all three boreholes ranging from 7.5 feet to 17 feet deep. Native soils sampled beneath the fill indicated that little to no migration of trace metals, radionuclides, or other inorganics into the native soils had occurred. Low levels of PCBs were detected in three of 15 soil samples (in fill materials) taken in the subsurface at the former transformer salvage area. There was no evidence of movement into the native soils below the fill.

Buried Pipelines

The EMF RI investigated the pipeline cleanouts located in RU 12. These pipelines transported phossy water and precipitator slurry to the ponds, where the solids were allowed to settle and the water, referred to as Industrial Clarified Water, was returned to the process via other underground lines that paralleled the waste lines out to the ponds. Cleanouts were placed to access these pipes in the event they became clogged with solids. Inorganics and radionuclides were analyzed from soil samples collected around the pipeline cleanouts. The typical suite of phossy water constituents were detected in the shallow soil samples (cadmium, fluoride, zinc, orthophosphate, arsenic, and several trace metals). Borings were drilled to depths ranging from 7 to 25 feet bgs. A detailed review of the results of this investigation is presented in the EMF RI Report (BEI 1996), Section 4.2, pages 97-106

After the EMF RI Report (BEI, 1996) was completed, FMC replaced the underground piping with an above-ground pipe system. During the construction of the LDR, P4 was encountered in the shallow soils and fill. The source of the P4 is believed to be the former underground piping that crosses RU 12.

Remediation Vision

No action anticipated to be necessary.

2.1.11.1 Reference to DQO Section

Solvent Specific Investigation Area – 2.3.1.3

Liquid petroleum Fuel Specific Investigation Area – Section 2.3.2.1

PCB Specific Investigation Area – Section 2.3.4

Underground Piping Investigation – Section 2.3.9.2

Evaluation of Future Worker Risk – Section 2.5

2.1.11.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.11.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

Because this RU is greater than five acres in size (11.6 acres), it will be subdivided into three decision units for evaluating potential risks to future workers. The southern decision unit is five acres, the central decision unit is 4.0 acres, and northern decision unit is 2.6 acres. If the results of the radiation surface scan are below the CV, 80, 64, and 40 surface PIC measurements in the southern, central, and northern decision units, respectively, will be made. A total of 184 PIC measurements will be made within the RU. VSP was used to place the sample location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four multi-increment composite samples will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples) within each decision unit. Based on the size of the decision units (5, 4, and 2.6 acres), each of the composites will be comprised of 20, 16, and 10 increments in the southern,

central, and northern decisions units, respectively (with one sample increment taken per surface PIC location). A total of 24 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.11.2.2 Cap Delineation

A complete description of the RU 22b cap delineation into RU 12 is set forth in Section 2.1.17.2.2.

2.1.11.2.3 Specific Investigation Area

Solvent Specific Investigation Area Problem Statement

Based on knowledge of past plant practices at the Mobile Shop, the determination of the presence, absence and concentrations of solvents is needed to support a decision to either remediate the solvent specific investigation area or to take no further action.

Liquid Petroleum Fuel Specific Investigation Area Problem Statement

Sufficient sampling has not been conducted to determine potential impacts from the diesel fuel releases. The determination of the presence, absence, and concentrations of liquid petroleum fuels is needed to support a decision to either remediate the specific investigation area or to take no further action.

Solvent and Liquid Petroleum Fuel Specific Investigation Sampling Design

Two areas have been identified within and adjacent to RU 12 where releases of organic compounds, primarily fuel hydrocarbons, may have occurred, and one area where PCBs may have been released to the soil. These three areas are illustrated along with proposed sampling locations on Figures 2-32 and 2-33.

For the specific investigation area related to the mobile shop, fuel islands and reported spills, boring locations have been laid out on a 50-foot grid with a random origin using VSP and a shape factor of 0.8. A 30-foot square grid with a random origin has been laid out for the steam cleaning area. Both of these grid sizes are appropriate in these areas, considering that the potential source areas are fairly large and have a history of either surface spills (diesel fuel) or heavy equipment washing (oil and grease).

The investigation will be conducted in a phased approach to determine potential migration of solvents and/or petroleum hydrocarbons to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum.

During phase one, 42 borings will be completed in RU 12 for the Mobile Shop fuel island specific investigation area. Eight borings will be completed in RU 12 for the steam cleaning area. The sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words, when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample. If the fill/native soil interface is greater than 10 feet bgs, the boring will be advanced to native soil and samples will be collected immediately below the native soil interface, 2–feet bns, and 10 feet bns.

During phase one, samples to be analyzed for shop-related solvents and liquid petroleum fuel VOCs will be collected in accordance with Method 5035A. As shown in Figures 2-32 and 2-33, 16 of the borings located within the fuel island and Mobile Shop investigation area will be analyzed for shop-related solvents and liquid petroleum fuel constituents and 26 borings will be analyzed for liquid petroleum fuel constituents only. Samples from the eight borings drilled at the steam cleaning area will be analyzed for liquid petroleum fuel constituents. Borings will be analyzed for VOC and PAH liquid petroleum fuel constituents as listed below.

- shop related solvents: chloroform, methylene chloride, PCE, TCE, 1,1,1-trichloroethane, and 2-butanone
- liquid petroleum fuel VOCs: benzene, ethylbenzene, toluene, m-xylenes, o-xylenes, and p-xylenes.
- liquid petroleum fuel PAHs: acenapthene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorine, fluoranthene, naphthalene, phenanthrene, pyrene.

The results of the phase one study will be presented to the EPA and the need for additional data to determine the vertical extent of organic COCs or COPCs beyond phase one will be determined. If additional sampling is required it will be performed during a phase two study per an EPA-approved SRI Work Plan addendum.

PCB Specific Investigation Area Problem Statement

PCBs in soil must be adequately characterized to support a decision to either remediate PCB specific investigation areas or to take no further action.

PCB Specific Investigation Area Sampling Design

The potential PCB source may be localized to areas around boring F044B and F105b, but the lack of specific information argues for investigating a larger portion of RU 12 for this constituent including the transformer storage area. Thirty-three (33) locations are proposed for the PCB potential specific investigation area. These locations were determined for a 50-foot-square grid using a random origin in VSP. Samples will be collected starting at the surface, every 2.5 feet to

native soil, at the native soil interface and at 2 feet bns. Samples will be submitted to the laboratory and analyzed for PCB congeners by Method 1668. If the analytical results for the 2-foot bns sample reveal that PCBs are detected at levels above the applicable SSL, then additional vertical sampling will be required. Delineation of the lateral extent will be evaluated based on the analytical results. Thirty-three (33) borings will be analyzed for: monochlorinated biphenyls, dichlorinated biphenyls, trichlorinated biphenyls, tetrachlorinated biphenyls, pentachlorinated biphenyls, hexachlorinated biphenyls, heptachlorinated biphenyls, octachlorinated biphenyls, nonachlorinated biphenyls, and decachlorinated biphenyl.

Underground Piping Investigation Problem Statement

The portion of the underground piping, sumps or other structures within RU 12 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

Underground Piping Investigation Sampling Design

During the SRI, the phase one task for the underground piping investigation in RU 12 is to identify available information regarding remaining piping, sumps and structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data collection activities in RU 12 conducted during the SRI, i.e., whether RU 12 remains designated as NFA or proceeds to the SFS.

If RU 12 remains designated as NFA, FMC will propose a phase two study that would further evaluate the buried piping/sumps/structures and present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation would proceed only upon EPA approval of the SRI Work Plan addendum. If RU 12 is forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures will also be forwarded to the SFS and a phase two study during the SRI would not be required.

2.1.11.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.12 RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area

Figure 2-34 shows the proposed sampling locations under the risk data collection scenario including the cap delineation investigation. Figure 2-35 shows the proposed sampling locations for the SFS data collection scheme, including the cap delineation investigation.

Description

RU 13 is 3.6 acres in size and is located in the south-central portion of the FMC Plant OU. 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) and they share a common boundary.

Process Knowledge

Although RU 13 was never 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 (which was within the RU 13 boundaries) was later shut down and removed. Spillage of phossy solids from the Pond 8S recovery process may have occurred.

Borings F058B and F059B, located in RU 13, encountered phossy solids at depths of approximately 5 to 7 feet below current grade. These boring locations are shown in Figures 2-34 and 2-35, as well as in Figure 3-1 of the RI Update Memorandum (BEI, 2004b). These phossy solids may be related to old ponds (RU 22b). As stated in the RI Update Memorandum (BEI, 2004b), RU 22b is anticipated to be remediated in accordance with the 1998 ROD. While the exact source of the phossy solids around borings F058 and F059 is unknown, the investigation to delineate the extent of the cap from RU 22b into RU 13 will address these phossy solids. Confirmation sampling around borings FO58B and FO59B is needed to determine the extent to which the cap for RU 22b is to be extended to cover the phossy solids that have been identified in the western portion of RU 13.

There were several buried pipelines used to transport phossy water and precipitator slurry to the phossy waste ponds that passed through RU 13. Cleanouts were placed along these pipelines to access these pipes in the event they became clogged with solids. Inorganics and radionuclides were analyzed from soil samples collected around the pipeline cleanouts. The EMF RI investigated the pipeline cleanouts located in RU 12 which also pass through RU 13. The typical suite of phossy water constituents were detected in the shallow soil samples (cadmium, fluoride, zinc, orthophosphate, arsenic, and several trace metals). Borings were drilled to depths ranging from 7 to 25 feet bgs. A detailed review of the results of this investigation is presented in the EMF RI Report (BEI 1996), Section 4.2, pages 97-106

Remediation Vision

No further action anticipated to be necessary.

2.1.12.1 Reference to DQO Section

Underground Piping Investigation - Section 2.3.9.2

Evaluation of Future Worker Risk - Section 2.5

2.1.12.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.12.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

RU 13 is 3.6 acres in size; however, excluding the area to be investigated for cap delineation reduces the area to 2.7 acres. Because the remaining size of this RU is less than five acres, the RU constitutes the decision unit for evaluating potential risks to future workers. If the results of the radiation surface scan are below the CV, a total of 40 surface PIC measurements will be made within the RU. VSP was used to place a 40-location square grid on a random origin across the entire RU.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of 10 increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples). The sample increments will be collected at the same locations as the PIC measurements. These eight composited samples (four from 0-to-2 feet bgs and four from 0-to-10 feet bgs) will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.12.2.2 Cap Delineation

A complete description of the RU 22b cap delineation into RU 13 is located in Section 2.1.17.2.2.

2.1.12.2.3 Specific Investigation Area

Underground Piping Investigation Problem Statement

This portion of the piping within RU 13 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in

this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

Underground Piping Investigation Sampling Design

During the SRI, the phase one task for the underground piping investigation in RU 13 is to identify available information regarding remaining piping, sumps and structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data collection activities in RU 13 conducted during the SRI, i.e., whether RU 13 remains designated as NFA or proceeds to the SFS.

If RU 13 remains designated as NFA, FMC will propose a phase two study that would further evaluate the buried piping/sumps/structures and present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation would proceed only upon EPA approval of the SRI Work Plan addendum. If RU 13 is forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures will also be forwarded to the SFS and a phase two study during the SRI would not be required.

2.1.12.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data types, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.13 RUs 15 and 16: Oversize Ore, Used Electrode, Baghouse Dust Area and Calciner Solids Stockpile

Figures 2-36 and 2-37 show the proposed sampling locations for metals and fluoride investigation at RU 15 and RU 16.

Description

RU 15 is 11.7 acres in size and is located south of the calciner ponds (RU 14). It is south of the main plant area, and east of the slag pile, against the eastern FMC property boundary.

RU 16 is 15.1 acres in size and is located south of RU 15. RU 16 contains dried calciner pond solids.

Neither RU 15 nor 16 ever contained P4 production process operations. They were historically used for the waste pile storage as described above.

Process Knowledge

RU 15 was used since the 1970's for storage of oversize ore, baghouse dust from ore handling facilities within the plant, and used/broken carbon electrodes from the furnaces. Periodically, FMC would reclaim some of the oversize ore and larger pieces of carbon electrodes were periodically reclaimed for use as refractory in the furnace operation (slag runner block). After plant shutdown, FMC has sold most of the electrodes from this area.

RU 16 contains calciner solids, dried materials that have been removed from the calciner scrubber ponds and consist primarily of precipitates of calcium fluoride, ore dust, and potentially elevated levels of metals, polonium-210 and lead-210. Although these materials are currently dried, they contained a significant moisture content (to the extent that the materials would flow) when placed in RU 16. A concern has been expressed about the potential impact to groundwater. The materials placed on the stockpile after the 1996 Remedial Investigation were essentially the same as those materials placed before that date. Although the volume and areal extent (footprint) of materials has increased since the 1998 ROD, the materials themselves have remained consistent in terms of their chemical and physical characteristics.

Remediation Vision

For RU 15, consolidate material into minimal footprint, grade to design subgrade elevation and construct soil cover (cap) over area.

For RU 16, calciner solids will be remediated per the ROD (June 1998).

2.1.13.1 Reference to DQO Section

Leaching Potential Investigations (Metals and Fluoride) – Section 2.3.5

2.1.13.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.13.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme is proposed for this RU.

2.1.13.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.13.2.3 Specific Investigation Area

Problem Statement

Current soil conditions in the vadose zone beneath the stockpiles in RUs 15 and 16 have not been fully characterized. Additional data are needed to determine the potential for metals and fluoride migration into the subsurface and the potential for metals and fluoride migration to groundwater at RUs 15 and 16.

Sampling Design

A total of five soil borings will be advanced within RU 15. In the southern portion of the RU, where reject ore and baghouse dust deposits are located, two borings will be drilled through the ore. In the northern portion of the RU, the materials may be more heterogeneous (coarse reject ore, baghouse dust, and possibly calciner solids), and three borings will be drilled in this region.

Samples will be collected at the interface between the waste pile and native soil. Thereafter, samples will be collected at 10-foot intervals until refusal or groundwater is encountered, whichever comes first. Samples will be submitted to the laboratory for the analysis of metals and fluoride.

At the northern end of the RU 16, three soil borings will be advanced to groundwater. In the southern portion of the RU, five soil borings will be advanced near the perimeter of the stockpile to groundwater. Samples will be collected at the interface between the waste pile and native soil. Thereafter, samples will be collected at 10-foot intervals until refusal or groundwater is encountered, whichever comes first. Samples will be submitted to the laboratory for the analysis of metals and fluoride.

2.1.13.2.4 SFS Data Needs

No additional SFS data collection is required at this RU.

2.1.14 RU 19: Slag Pile, Bull Rock Pile

Figure 2-38 shows the proposed sampling locations for radon flux measurements at RU 19.

Description

RU 19, at 151.5 acres, is the largest RU within the FMC Plant OU and contains the slag pile and bull rock pile. The former plant landfill (used prior to the development of the current landfill designated as RU 18) and buried railcars are included within this RU. Wastes may include scrapped building materials, filter media, asbestos insulation, furnace dig-out material, and minor amounts of spent solvents and oily residuals.

Process Knowledge

Slag Pile and Bull Rock Pile

RU 19 consists of the slag pile and bull rock pile. These two piles are made of different materials. Obviously, the slag pile is composed primarily of slag while the bull rock pile is made of reject ore materials (primarily oversize rock). As such, the potential for radon emanation is different between the slag pile and the bull rock pile.

Slag Pile Test Cap Soil Cover

The RU 19 test cap soil cover was constructed on the northwest corner of the RU 19 slag pile in 2001. The original purpose of the test cap was to determine the minimum depth of soil required in a soil cap on the slag pile to support plant survival and growth. The slag pile was first graded to a slope of 3:1. Soil from the southern, undisturbed portion of the FMC Plant OU was used as soil cover. The test plot area is approximately 2 acres. The 2-acre plot is divided into four relatively equal areas with differing soil cover thicknesses. One area was designed with an 8-inch thick soil layer, two areas were designed with a 12-inch thick soil layer, and one area was designed with an 18-inch thick soil layer. Plants survived similarly on all four test sections.

The test plot is still in place and intact. While the test cap soil cover was not installed for use as part of a radon flux test, the opportunity to test the effectiveness of the soil cover at reducing radon flux from the slag pile would appear to be worthwhile. However, the test is only worthwhile if the slag is shown to be above the average radon flux of 20 $pCi/m^2/sec$.

Remediation Vision

Reclaim in-place; shape external slopes to approximately 3H:1V slope, place topsoil over slag and revegetate with native grasses and shrubs.

2.1.14.1 Reference to DQO Section

Evaluation of Radon Flux Study – Section 2.4.1

2.1.14.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.14.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme is proposed for this RU.

2.1.14.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.14.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.14.2.4 SFS Data Needs

Radon Flux Study Problem Statement

Radon emission rates from the uncovered slag pile, bull rock pile and old phossy ponds have not been quantified. Determination of the radon flux is required in order to evaluate remedial alternatives for the slag pile and bull rock pile within RU 19 in the SFS as well as the former phossy waste ponds at RU 22b. These flux rates may be relevant to the design of caps/covers for these areas to meet the UMTRCA guidelines for radon in the event these guidelines are identified as an ARAR in the SFS.

In addition, these data along with other radon measurements (e.g, RU 7) will be used to evaluate the potential for radon flux to be a concern at other RUs that contain residual fill material.

Radon Flux Study Sampling Design

The primary goal for the RU 19 investigation is to quantify the radon flux emission rates from the slag pile and bull rock piles to support cap design. The measured radon flux will be compared against the UMTRCA guideline of 20 $pCi/m^2/sec$. Secondary inputs to the decision are the detection limits of the radon flux chambers and the variability of radon emissions (see Section 3).

Radon flux measurements at RU 19 will be carried out at 100 locations on the slag pile and 100 locations on the bull rock pile laid out on an evenly-spaced grid for a period of up to 48 hours per location. Locations were selected to provide a reasonable assessment of the spatial distribution of the radon emission fluxes. The mean radon flux will be calculated as outlined in EPA Method 115.

If the radon flux measurements from the slag pile exceed the UMTRCA guideline of 20 $pCi/m^2/sec$, then radon flux measurements will be made on the northwestern portion of RU 19 where FMC has installed a soil test cover to evaluate re-vegetation on the slag pile. These test plots have soil cover thicknesses ranging from 8 to 18 inches. The data collected at these locations will be used to evaluate the effectiveness of soil covers for reducing radon emissions as compared to the measurements made on exposed slag. The mean radon flux from the soil covered areas will be calculated, as described above in Section 2.1.6.2.3, and the mean flux will be compared to the UMTRCA guidelines.

2.1.15 RU 20: Former Bannock Paving Area

Figure 2-39 shows the proposed sampling locations under the risk data collection scenario including specific investigation area and reference area investigations. Figure 2-40 shows the proposed sampling locations for the SFS data collection scheme, including the specific investigation area and reference area investigations.

Description

RU 20 is 61.6 acres in size and is located east of RU 6 and north of RU 22c along the northern plant boundary. RU 20 was leased from FMC by Bannock Paving Company (BAPCO) for the crushing and sales of slag, ferrophos crushing and loading, coke loading and unloading, drying coke for FMC, production of asphalt, and equipment maintenance. RU 20 was never used for P4 production process operations.

Process Knowledge

BAPCO Operations

Bannock Paving had a maintenance shop within RU 20 that was primarily used for mobile equipment and general maintenance activities on BAPCO equipment. Degreasing is presumed to have been performed as necessary for equipment parts using brush on/wipe off techniques. No large-scale degreasing operations were used (i.e., no vapor degreasers). The BAPCO equipment shop was equipped with a concrete floor that would limit migration of solvents through the floor. Although no known releases were reported, solvents may have been released to the ground surface immediately outside the shop. In November 2006 an accidental fire destroyed the former BAPCO shop.

BAPCO also operated an asphalt batch-plant operation on site and an equipment fueling area with above-ground storage tanks. All fuel tanks and asphalt production equipment have been removed from RU 20.

Coke Operations

Coke was a raw material used in the manufacture of P4. Although there were numerous sources for the coke used, 70% of the coke came from FMC's Kemmerer, WY coke plant. Other types of coke included metallurgical coke and petroleum coke. Coke was typically transported to the FMC site by railcar and was unloaded near the ore stockpile (in RU 7) into an underground hopper where it was transferred to the process via conveyors.

Kemmerer coke typically was dry enough to feed directly into the process, while other forms of coke contained enough moisture that drying was required prior to use. Wet coke was transported via railcar to the coke drying operation at the Bannock Paving area (RU 20) where it was unloaded, stockpiled, dried, and transported back to the FMC operations in RU 7. The coke drying operation was equipped with a wet scrubber, including a series of three coke settling basins. Scrubber water was recycled through these basins to allow suspended particulates to settle.

Remediation

No action anticipated to be necessary

2.1.15.1 Reference to DQO Section

Solvent Specific Investigation Area – Section 2.3.1.4

Liquid Petroleum Fuel Specific Investigation Area – Section 2.3.2.2

PAH Potential Migration into Soil Specific Investigation Area Reference Study – Section 2.3.3.2

Coke Settling Pond Specific Investigation Area – Section 2.3.3.3

Coke Characterization – Section 2.3.3.4

Evaluation of Future Work Risk – Section 2.5

Slag Reference Area - Section 2.7

2.1.15.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.15.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

Because RU 20 is greater than five acres in size (61.6 acres), it will be subdivided into 12 decision units, each five acres in size, for evaluating potential risks to future workers. If the results of the radiation surface scan are below the CV, 80 surface PIC measurements will be collected within each decision unit, for a total of 960 measurements within the RU. VSP was used to place the 80-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four composite samples, each consisting of 20 increments, will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals (i.e., a total of eight samples) within each decision unit. The sample increments will be collected at the same locations as the PIC measurements. A total of 96 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.15.2.2 Cap Delineation

A complete description of the RU 22b cap delineation into RU 20 is set forth in Section 2.1.17.2.2.

2.1.15.2.3 Specific Investigation Area

Solvent Problem Statement

Solvent VOCs must be adequately characterized to support a decision to either remediate specific investigation areas or to take no further action.

Liquid Petroleum Fuel Specific Investigation Area Problem Statement

Sampling has not been conducted to determine potential impacts from the diesel fuel releases. The determination of the presence, absence, and concentration of liquid petroleum fuels is needed to support a decision to either remediate liquid petroleum fuel specific investigation areas or to take no further action.

Solvent and Liquid Petroleum Sampling Design

Three areas within and adjacent to RU 20 will be investigated for potential releases of organic compounds and/or petroleum hydrocarbons. In these areas, boring locations have been laid out on a 75-foot square grid with a random origin using VSP. The footprint of the asphalt batch plant is approximately 0.5 acres, and the above-ground fuel storage tanks occupied a similar area. The 75-foot grid is acceptable for determining the presence of organic compounds at these specific investigation areas.

The investigation will be conducted in a phased approach to determine potential migration of solvents and/or petroleum hydrocarbons to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum.

During phase one, a total of 73 borings will be completed in RU 20 (30 around the BAPCO shop area and 43 between the two hot batch plant specific investigation areas). The sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample. If the fill/native soil interface is greater than 10 feet bgs, the boring will be advanced to native soil and samples will be collected immediately below the native soil interface, 2–feet bns, and 10 feet bns.

The results of the phase one study will be presented to the EPA and the need for additional data to determine the vertical extent of organic COCs or COPCs beyond phase one will be determined. If additional sampling is required it will be performed during a phase two study per an EPA-approved SRI Work Plan addendum.

Samples to be analyzed for shop-related solvents and liquid petroleum fuel VOCs during phase one will be collected in accordance with Method 5035A. As shown in Figures 2-39 and 2-40, 30 borings will be located within the BAPCO shop investigation area and analyzed for shop-related solvents. Forty-three (43) borings around the hot batch plant area and BAPCO shop will be analyzed for VOC and PAH liquid petroleum fuel constituents. The constituents for each VOC and PAH lists are the following:

- shop related solvents: chloroform, methylene chloride, PCE, TCE, 1,1,1-trichloroethane, and 2-butanone
- liquid petroleum fuel VOCs: benzene, ethylbenzene, toluene, m-xylenes, o-xylenes, and p-xylenes.
- liquid petroleum fuel PAHs: acenapthene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorine, fluoranthene, naphthalene, phenanthrene, pyrene.

PAH Specific Investigation Area Problem Statement

Wet and dry coke was stored in RU 20 as part of the coke drying process. This process included a coke dryer scrubber and coke settling basins that contained a sustained hydraulic head as described above. Characterization of the soils beneath the coke handling area is needed to support the remediation vision.

PAH Specific Investigation Area Sampling Design (Coke Reference Study)

A specific investigation area was identified for residual coke that exists at the former BAPCO area. This includes a former coke unloading and storage area, coke drying facility (now removed), and concrete lined coke settling basins. Twenty (20) borings will be located in the coke handling area for investigation of potential migration of PAHs associated with coke to underlying soils. For the investigation, 20 samples will be collected on a standard square grid with a random origin as determined in VSP. A sample will be collected from 0-to-2 feet bns and vertically composited at each location. As discussed in Section 2.1.6.2.3, the results from this investigation in RU 20 will also be used as a reference to evaluate the potential for PAHs associated with coke in RU 7 to have impacted underlying soils.

Samples collected in the former coke handling area will be analyzed for the coke-related PAHs: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene , benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, pyrene.

Coke Characterization Problem Statement

Waste characterization of the coke present on the FMC Plant OU has not been performed per 40 CFR Part 262.11

Coke Characterization Sampling Design

The coke sediments in the settling basins and the coke in the former unloading and storage area will be sampled for TCLP analysis in accordance with EPA guidance for sampling storage bins, roll-off boxes, or collection hoppers (U.S. EPA, 2002). Each area will be divided it into four approximately equal sections. One sample location will then be randomly selected within each quadrant. A hand auger or shovel will be utilized at each random quadrant location to bore or scoop through the vertical extent of the coke and coke sediments. The four aliquots from each quadrant will be composited. One composite sample will be generated from each of the three basins within the coke settling pond and one sample will be collected from the former unloading and storage area and sent to the laboratory for TCLP analysis of the following metals and semi-volatile organic compounds:

- TCLP Metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver.
- TCLP SVOCs: o-cresol, m-cresol, p-cresol, cresol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, nitrobenzene, pentachlorophenol, pyridine, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol.

Coke Settling Basins Specific Investigation Area Problem Statement

Wet and dry coke was stored in RU 20 as part of the coke drying process. This process included coke settling basins that had a sustained hydraulic head. The potential migration to groundwater for the concrete-lined coke settling basins needs to be investigated to support the remediation vision.

Coke Settling Basins Specific Investigation Sampling Design

The soils beneath the coke settling basins will also be investigated for potential migration of metals and PAHs associated with coke. The investigation will be conducted in a phased approach to determine potential migration of metals and PAHs to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum.

Three (3) borings will be drilled through the basins. The boring locations have been laid out on a 50-foot square grid with a random origin using VSP. The sampling design requires samples to be collected immediately below the bottom of the basin, 2 feet below the bottom of the basin,

and 10 feet below the bottom of the basin. In the event that fill material rather than native soil exists below the bottom of the basin, the samples will be collected at 0 feet, 2 feet, and 10 feet bns. The grab samples will be sent to the laboratory for analysis of the following.

- Metals: see Table 1-6.
- Coke-related PAHs: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, pyrene.

The analytical results for the metals and coke-related PAHs will be compared to the applicable SSLs. The data will be presented to the EPA and the need for additional data to determine the vertical extent of these COCs or COPCs will be performed during a phase two study, if necessary, per an EPA-approved SRI Work Plan addendum.

2.1.15.2.4 SFS Data Needs

RU 20 Slag Reference Area Study

A reference area study is planned for RU 20 with the overall purpose of determining the leaching potential of slag into the native soils below the slag materials. This will be done by examining certain slag constituents in the native soil beneath slag on the surface. Although this is an SFS data type, the reference area study will be performed regardless of the outcome of the risk data collection. This reference area study will involve sampling 20 locations in RU 20 on a standard square grid using a random origin. These sample locations will not be placed within a specific investigation area and will be in the same locations as the SFS data collection described below. The samples will be vertically composited in the 0-to-2-foot interval for each boring, but will not be composited with other sample locations. The samples will be collected from 0-to-2 feet bns and submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

Other SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data collection, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.16 RU 21: Other Onsite Rail Spurs

Figure 2-41 shows the onsite rail spurs that need to be evaluated.

Description

Several thousand feet of rail spurs served the FMC plant. These rail spurs are located primarily along the northern plant boundary, although individual rail spurs pass through RUs 1, 5, 6, 7, 20, 22b, and 24. The rail spurs were used to deliver coke, ore, and heavy equipment and to transport P4, slag, and ferrophos products. As it is desirable to leave the rail spurs intact for potential future site industrial use, rail spurs are likely to have investigation and remediation needs independent from the RUs in which they are located. Therefore, RU 21 investigations will remain separate from the other RU investigations.

Remediation Vision

No action anticipated to be necessary.

2.1.16.1 Reference to DQO Section

Evaluation of Future Worker Risk - Section 2.5

2.1.16.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.16.2.1 Data Collection for Risk Evaluation

A radiation surface scan will be performed at the onsite rail spurs not already addressed in an RU. If the results of the radiation surface scan are below the gamma CV, then surface PIC measurements will be performed. As stated in the RI Update Memorandum, rail spurs are significant assets for future redevelopment and are not anticipated to be removed. Therefore, no subsurface samples will be collected through the rail spurs.

2.1.16.2.2 Cap Delineation

No cap delineation investigations are required for this RU.

2.1.16.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.16.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data type then the RU will be forwarded to the SFS without further subsurface characterization.

2.1.17 RU 22b: Old Ponds

Figure 2-42 shows the proposed sampling locations for radon flux measurements at RU 22b.

Description

RU 22b is 37.7 acres in size and consists of four separate parcels in the western portion of the FMC Plant OU. The parcels are separated by RCRA-capped ponds that are not part of the SRI investigation. While individual ponds within RU 22b vary in size, the location and extent of each pond is well-documented by plant data and historic aerial photos. All old ponds have had hydraulic head removed through solar evaporation, although their volume of dried material and/or P4 is not known.

Process Knowledge

Early in the FMC Plant OU history, waste streams that contained P4, (i.e., phossy water and precipitator slurry) were slurried and pumped to a series of ponds west of the furnace building. Ponds that accepted phossy water were designated with an "S" and ponds that accepted precipitator slurry were designated with an "E". As the "S" ponds filled with settled solids, they typically contained P4 and thus were covered with slag to prevent oxidation. The E ponds were typically allowed to dry in order to reclaim the dried solids. New ponds were dug to replace the filled ponds such that a series of ponds was expanded to the west of the older ponds. In the early 1970s, a fluid bed dryer was installed to manage the precipitator slurry, thus eliminating the need for further "E" ponds. With the shutdown of the fluid bed dryer in the mid-1980s, new lined "E" ponds were constructed to again manage precipitator slurry.

Over the history of ponds utilized in RU 22b, the phossy water and precipitator slurry were conveyed to the ponds via pipelines from the furnace building (RU 1) and slag pit (RU 2). FMC used underground piping to carry the slag pit water to the phossy water ponds until 1996 when the piping was moved to above-ground. However, the underground piping remained in place as shown on Figure 2-11.

RU 22b extends over areas of known historic phosphorus ("phossy") waste ponds. These areas were extensively investigated and the results reported in the Remedial Investigation Report (Bechtel, 1996). The 1998 ROD selected a capping remedy for the old phossy pond area (now RU 22b).

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 was later shut down. Spillage of phossy solids from the Pond 8S recovery process may have occurred. While the exact source of the phossy solids around borings F058 and F059 is unknown, they will be addressed in the investigation that will delineate the extent of the cap extension from RU 22b into RU 13 .

FMC considers it likely that the phossy solids encountered in borings F058 and F059 were deposited from dredging one or more of the old phossy ponds or from excavating dried phossy solids from nearby ponds. Subsequent activities resulted in the sediments being buried with slag fill. Therefore, the area of RU 13 that contains these dredged sediments should be delineated so this area can be incorporated in the final cap/cover design for the old phossy ponds (RU 22b).

Borings F058 and F059 are located south and east of RU 22b within RU 13. Therefore, sampling should start directly to the east of borings F058 and F059 and continue across RU 13 until the extent of the phossy solids in RU 13 is defined.

It is likely that the same activities that deposited phossy solids in RU 13 also account for the phossy solids encountered in RU 12 (borings F035, F036, and F077) and in other borings in and around RU 22b. Therefore, sampling should occur in step-out borings and continue across other RUs (i.e., RUs 12, RU 20, and RU 24) until the extent of phossy solids is defined.

Remediation Vision

Old phossy ponds will be remediated per the ROD (June 1998).

2.1.17.1 Reference to DQO Section

Cap Delineation Associated with Former Phossy Ponds – Section 2.3.3

Underground Piping Specific Investigation Area – Section 2.3.9.3

Evaluation of Radon Flux Study – Section 2.4.1

2.1.17.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.17.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme is proposed for this RU.

2.1.17.2.2 Cap Delineation

Problem Statement

Per the RI Update Memorandum (BEI, 2004b), sufficient information exists for the old phossy ponds (RU 22b) to determine the extent of the cap/cover specified in the 1998 ROD. However, more information is needed to determine whether phossy solids were deposited outside the pond boundaries and need to be encompassed by the RU 22b cap.

Sampling Design

Around the boundary of RU 22b, an investigation is required to determine the extension of the cap into RU 12, RU 13, RU 20, and RU 24 and beyond the western and southern boundaries of RU 22b. Trenches and borings will be used to determine the extent of the cap.

A total of 16 borings will be drilled in RUs 12, 20, and 24, and locations along the western and southern boundaries of RU 22b. Six (6) trenches are proposed for excavation into RU 13 beginning near the locations of F058B and F059B to determine the extent of the cap. Trenches

will be excavated in approximately 12-inch depth increments to ensure that residual pond sediment layers can be readily identified in the backhoe or on the fill pile. After the initial phossy solids layer has been exposed and logged, trenching will continue to the depth of native soils (approximately 5 to 8 feet below current grade). As trenching progresses, visual evidence of phossy solids will be monitored by observing the backhoe bucket material and the trench sidewalls.

Based on visual observations, if the fill material associated with the phossy solids is observed in the trench or boring, then the trench will be extended or a step-out boring of 10 ft will be drilled. Based on visual observations, if the fill material associated with phossy solids is not observed at the end of the trench or within the step-out boring and there is no other fill on the surface, then confirmation samples from 0-to-2 foot bgs and 0-to-10 foot bgs will be collected. Based on visual observations, if fill material associated with phossy solids is not observed at the end of the trench or in the step-out boring and there is some type of other fill on the surface (e.g., slag), then confirmation samples from 0-to-2 foot bns will be vertically composited at each location. Additional confirmation sampling will be performed as part of the cap delineation studies as described in the introduction to Section 2.2.

This information will be used in the SFS to refine the size of the covers or caps that are likely to be required at the former phossy waste ponds in RU 22b. Samples submitted to the laboratory will be analyzed for the following constituents: metals, fluoride, U-238, Ra-226, K-40, Po-210, and Pb-210.

2.1.17.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.17.2.4 SFS Data Needs

Underground Piping Problem Statement

The underground piping within RU 22b was not evaluated during the remedial investigation. Sufficient information regarding underground piping left behind in this RU after decommissioning is needed to support the SFS.

Sampling Design

The decision whether to remove, decontaminate, or abandon underground piping will be an SFS decision based on the detailed analysis of alternatives. To provide the SFS process with sufficient information to evaluate the alternatives for underground piping, FMC proposes an SRI task to identify available information regarding remaining subsurface piping/sumps/structures, including their size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding residual constituents that may remain in the pipes. This task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. These data will be forwarded to the SFS to be evaluated as part of the likely cap design for RU 22b. Additional confirmation sampling will be performed as part of the cap delineation studies as described in the introduction to Section 2.2.

Radon Flux Study Problem Statement

Radon emission rates from the uncovered old phossy ponds have not been quantified. Determination of the radon flux is required in order to evaluate remedial alternatives for the former phossy waste ponds at RU 22b. These flux rates may be relevant to the design of caps/covers for these areas to meet the UMTRCA guidelines for radon in the event these guidelines are identified as ARARs in the SFS.

Radon Flux Study Sampling Design

The primary goal for the RU 22b investigation is to quantify the radon flux emission rates from the area surrounding the former phossy ponds. The radon flux rate will be compared to the UMTRCA guideline of 20 $pCi/m^2/sec$.

The electret ion chamber will be utilized to obtain a measure of radon emissions over the time of exposure. Measurements will be conducted using criteria defined in EPA Method 115. EPA Method 115 requires 100 measurements for each identified region; therefore 100 measurement locations will be distributed on the combined three western-most parcels and 100 measurements will be distributed across the eastern-most parcel.

Radon flux measurements at RU 22b will be conducted on an evenly spaced grid with a random origin for a period of up to 48 hours per location. These measurements will provide a reasonable assessment of the spatial distribution of the radon emission fluxes. The mean radon flux from the areas will be calculated, as described above in Section 2.1.6.2.3, and the mean flux will be compared to the UMTRCA guidelines.

2.1.18 RU 22c: Railroad Swale

Figure 2-43 shows the proposed sampling locations for cap delineation at RU 22c.

Description

RU 22c is 2.4 acres in size and is located to the north of the P4 production areas along the northern boundary of the plant site. The Railroad Swale was designed as a stormwater collection pond but also received releases of phossy water from spills within the RU 1 area. It was partially lined in 1993, during the performance of the EMF RI.

Process Knowledge

Historically, phossy water releases from the furnace building and phos dock (RU 1) resulted in probable P4 releases to the railroad swale area. Phossy water spills since the EMF RI may have introduced additional P4 above the liner in the railroad swale and/or to the unlined area east of the lined portion of the railroad swale. As with the old ponds, historic aerial photos will be used to delineate the extent of ponded water in the railroad swale east of the lined area, which should ensure that past spills of process materials will be characterized.

Remediation Vision

Cap the Railroad Swale in lieu of lining. Divert storm water run-off from area.

2.1.18.1 Reference to DQO Section

P4 Cap Delineation – Section 2.2.1.2

2.1.18.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.18.2.1 Data Collection for Risk Evaluation

No future worker risk data collection scheme is proposed for this RU.

2.1.18.2.2 Cap Delineation

Problem Statement

During the SRI, FMC will collect confirmation soil samples along the length of the railroad swale to delineate the extent of released P4. These data will be used to confirm the area to be capped. Additionally, the potential risk to future workers from acute and chronic exposure to P4 that may be present outside the boundaries designated for capping has not been defined.

Sampling Design

The lateral boundaries of RU 22c are shown in Figure 2-43. A liner was installed in the western portion of RU22c and an extension of the liner was selected in the 1998 ROD as a remedial action for the railroad swale. The first step-out trench will be to the east of the existing liner and the total depth will be down to 10 feet bgs. If P4 is encountered during sampling above a level of acute health concern, as evidenced by smoking or burning, then sampling locations will be stepped out a distance of approximately 200 feet in an easterly direction from the existing liner, taking into account practical constraints that include worker safety and access. The RU boundaries and cap extent must be adjusted to include the area up to which potentially acutely hazardous levels of P4, as evidenced by smoking or burning, are no longer encountered. When P4 is not present as smoking or burning, a sample will be collected in the trench from 0-to-2 feet bgs and 0-to-10 feet bgs. Samples will be submitted to the laboratory for analyses of P4. Samples in the 0-to-2 foot and 0-to-10 foot intervals will be compared to the chronic future site worker SSLs. If concentrations in the 0-to-2 foot and 0-to-10 foot intervals exceed SSLs, additional step-out locations to 10 feet will be required to define the lateral extent of P4 above the potential future worker SSLs. Additional confirmation sampling will be performed as part of the cap delineation studies as described in the introduction to Section 2.2.

2.1.18.2.3 Specific Investigation Area

No specific investigation area study is required at this RU.

2.1.18.2.4 SFS Data Needs

No additional SFS data collection is required at this RU.

2.1.19 RU 23: Road Segments not within RU Boundaries

Figure 2-44 shows the decision units under the risk data collection scenario; sampling locations are further described in Section 2.1.19.2.1. Figure 2-45 shows the proposed sampling locations under the SFS data collection scheme.

Description

RU 23 includes all road segments not included within an existing RU boundary. Roads which fall within an RU will be investigated as part of that RU. Most roads within the FMC Plant OU were constructed on a base of crushed and graded slag. Many of these roads were paved during the 1990's to reduce fugitive dust emissions.

Process Knowledge

Plant roads are constructed primarily of slag, placed upon native soils or upon fill materials existing on the surface at the time of road construction. Roads that were paved were constructed of a slag base and asphalt with a slag aggregate.

Remediation Vision

No action anticipated to be necessary

2.1.19.1 Reference to DQO Section

Evaluation of Future Worker Risk – Section 2.5

2.1.19.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.19.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

Because RU 23 is greater than five acres in size and comprises 23.0 acres, it will be subdivided into six decision units for evaluating potential risks to future workers. As shown on Figure 2-44, the RU has been divided into decision units as follows:

- RU23a – 1.7 total acres, 32 PIC measurements
- RU 23b – 3.5 total acres, 56 PIC measurements
- RU 23c – 3.8 total acres, 64 PIC measurements
- RU 23d – 3.9 total acres, 64 PIC measurements
- RU 23e – 5.0 total acres, 80 PIC measurements
- RU 23f – 5.0 total acres, 80 PIC measurements

If the results of the radiation surface scan are below the CV, 80 surface PIC measurements will be collected within each decision unit, for a total of 376 measurements within the RU. VSP was used to place the 80-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four multi-increment composite samples will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals within each decision unit. Based on the size of the decision units, each of the composites will be comprised of sample increments (with one sample increment taken per surface PIC location) as follows:

- RU 23a – 8 increment composite
- RU 23b – 14 increment composite
- RU 23c – 16 increment composite
- RU 23d – 16 increment composite
- RU 23e – 20 increment composite
- RU 23f – 20 increment composite

A total of 48 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.19.2.2 Cap

No cap delineation investigations are required for this RU.

2.1.19.2.3 Specific Investigation Area

No specific investigation areas are required for this RU.

2.1.19.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data types, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.20 RU 24: Plant Areas not within RU Boundaries

Figure 2-46 shows the proposed sampling locations under the risk data collection scenario and specific investigation area and reference area investigations. Figure 2-47 shows the proposed sampling locations for the SFS data collection scheme, and for the specific investigation area and reference area investigations.

Description

This RU includes disturbed areas of the plant site that are not associated with other RUs or SWMUs. This RU does not include areas of the plant site that were not disturbed or that contain only non-impacted native soils (e.g., the southern and western undeveloped areas). Examples of areas included in RU 24 are those where slag or other fill material has been placed. Examples of areas not included in RU 24 are soil borrow areas and associated soil stockpiles.

Process Knowledge

Many areas of the plant site were not directly used for P4 production and were not included in the original RU identification. However, these areas may contain fill materials such as slag, phosphate ore, silica or other debris. Typically these are graded level and were used for access throughout the plant site.

The EMF RI investigated the pipeline cleanouts located in RU 12, which also passed through RU 24. These pipelines transported phossy water and precipitator slurry to the ponds, where the solids were allowed to settle. The decant water from the ponds, referred to as Industrial Clarified Water, was returned to the process via other underground lines that paralleled the waste lines out to the ponds. Cleanouts were placed to access these pipes in the event they became clogged with solids. Inorganics and radionuclides were analyzed from soil samples collected around the pipeline cleanouts. The typical suite of phossy water constituents was detected in the shallow soil samples (cadmium, fluoride, zinc, orthophosphate, arsenic, and several trace metals). Borings were drilled to depths ranging from 7 to 25 feet bgs. A detailed review of the results of this investigation is presented in the EMF RI Report (BEI, 1996), Section 4.2, pages 97-106.

Remediation Vision

RU 24 is to be evaluated in the same manner as other RUs with a current NFA remedial vision.

2.1.20.1 Reference to DQO Section

Underground Piping Investigation – Section 2.3.9.2

Evaluation of Future Worker Risk - Section 2.5

2.1.20.2 Sampling

These subsections describe the sampling designs developed to address data gaps as part of Step 7 of the DQO process.

2.1.20.2.1 Data Collection for Risk Evaluation

The risk data collection will initially consist of a radiation surface survey. Based on the results of that survey, the following studies may also be performed per Figure 2-50:

- Surface PIC measurements
- 0-to-2 foot bgs composite samples
- 0-to-10 foot bgs composite samples

The first step in the risk data collection will be to perform a high-density, GPS-based radiation surface survey. This survey will be performed using a sodium iodide detector with an output in counts per minute. The results of the survey will be plotted to create a radiation map of the RU.

Because RU 24 (made up of four parcels) is greater than five acres in size (52.5 acres), it will be subdivided into 12 decision units for evaluating potential risks to future workers. As shown on Figure 2-46, the four parcels have been divided into decision units as follows:

- RU24a – 3.6 total acres, 1 decision unit of 3.6 acres, 56 PIC measurements per unit
- RU 24b – 9.6 total acres, 2 decision units of 4.8 acres, 72 PIC measurements per unit
- RU 24c – 6.3 total acres, 2 decision units of 3.15 acres, 48 PIC measurements per unit
- RU24d – 33.0 total acres, 7 decision units of 4.7 acres, 72 PIC measurements per unit

If the results of the radiation surface scan are below the CV, 80 surface PIC measurements will be collected within each decision unit, for a total of 800 measurements within the RU. VSP was used to place the 80-location square grid on a random origin in each of the decision units.

If the results of the PIC measurements are below the CV, four multi-increment composite samples will be collected from the 0-to-2 foot bgs and 0-to-10 foot bgs intervals within each

decision unit. Based on the size of the decision units, each of the composites will be comprised of sample increments (with one sample increment taken per surface PIC location) as follows:

- RU 24a – 14 increment composite
- RU 24b – 18 increment composite
- RU 24c – 12 increment composite
- RU 24d – 18 increment composite

A total of 96 composited samples from the RU will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.20.2.2 Cap Delineation

A complete description of the RU 22b cap delineation into RU 24 is set forth in Section 2.1.17.2.2.

2.1.20.2.3 Specific Investigation Area

Underground Piping Investigation Problem Statement

The portion of the underground piping, sumps or other structures within RU 24 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

Underground Piping Investigation Sampling Design

During the SRI, the phase one task for the underground piping investigation in RU 24 is to identify available information regarding remaining piping, sumps and structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data collection activities in RU 24 conducted during the SRI, i.e., whether RU 24 remains designated as NFA or proceeds to the SFS.

If RU 24 remains designated as NFA, FMC will propose a phase two study that would further evaluate the buried piping/sumps/structures and present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation would proceed only upon EPA approval of the SRI Work Plan addendum. If RU 24 is forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures will also be forwarded to the SFS and a phase two study during the SRI would not be required.

2.1.20.2.4 SFS Data Needs

Based on the concept flow map in Figure 1-7, if the data collection activities shift to the SFS data types, the following sampling scheme will be performed in addition to the specific investigation area studies described above. VSP was used to place the 20 locations on a standard square grid using a random origin for the RU. At each location, the depth of the fill material will be visually determined down to 10 feet bgs. If native soil is encountered within the first 10 feet bgs, a sample will be collected from 0-to-2 feet bns and five locations will be composited. Four samples will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210.

2.1.21 Other Gamma Studies

Figure 2-48 shows the proposed sampling locations for the Southern and Western Undeveloped Area Gamma Measurements. For the southern and western undeveloped areas 100 sampling points will be identified by a standard grid cast on a random origin. Twenty (20) minute PIC measurements will be made at each location.

2.1.22 Other Roadway Studies

Figure 2-49 shows the proposed sampling locations for precipitator dust/phossy solids and PCDT water delineation along roads.

Precipitator Dust/Phossy Solids Distribution along Roadways Study

Until approximately 1992, precipitator dust/phossy solids may have been occasionally applied to roads during winter months for traction (as an alternative to salt) at the FMC Plant OU. The worst-case scenario locations (the most likely places where precipitator dust/phossy solids may have been used on roads for traction) are identified in Section 2.3.6.4. These road segments within the FMC Plant OU are either close to the precipitator dust/phossy solids storage area or were high traffic-hazard areas where traction materials would have been needed for safe operations. Precipitator dust/phossy solids and slag have elevated levels of metals, and polonium-210 and lead-210. For this investigation, lead-210 will be used as an indicator for distinguishing precipitator dust/phossy solids from slag is lead-210.

The purpose of this study is to determine if precipitator dust/phossy solids were applied on roads. Road segments identified as most likely to have had precipitator dust/phossy solids applied and the comparative roadway in the southern region of the FMC Plant OU will be sampled as follows.

- The road segments, paved or unpaved, will be trenched or drilled to 2 feet bgs.
- 10 discrete samples will be collected.

A boring or a trench will be dug across the road at the sampling points as shown on Figure 2-49. Ten discrete samples will be collected from the 0-to-2 foot bgs interval. These ten (10) samples per location will be submitted to the laboratory for analysis of Pb-210. Once the analytical data

have been reviewed, these data will be forwarded to either the risk assessment (if the RU is still an NFA candidate) or the SFS (if the RU is no longer an NFA candidate).

PCDT System Roadways Study

As shown on Figure 2-49, two segments of roadway, the worst-case slag road segment in RU 20 and the slag road reference segment in RU 19, were selected for this study. Along each segment, 10 locations are placed along the centerline of the roadway based on a random origin. Samples will be collected from 0 to 0.5 feet and will be submitted to the laboratory for the following analyses: metals, fluoride, Ra-226, U-238, K-40, Pb-210, and Po-210. See Section 2.3.10 for the PCDT System Roadway Study DQOs.

2.2 CAP/COVER DELINEATION STUDIES

The RI Update Memorandum (BEI, 2004b) identified data gaps associated with RUs where an engineered cap/cover was identified as the remediation vision (Figure 2-2). Specifically, data gaps were identified in RUs, where there are insufficient data to confidently delineate the specific limits of the areas required to be covered or capped (Figure 2-3).

RUs that require refinement of the RU boundary for an engineered cap/cover design include the following and fall into three categories 1) delineation of P4 cap boundaries, 2) delineation of cap boundaries associated with former kiln scrubber ponds, and 3) delineation of cap boundaries associated with former phossy waste ponds. These are described below[1].

- Delineation of P4 Cap/Cover Boundaries:
  - RU 1: Furnace Building, Phos Dock and Secondary Condenser
  - RU 2: Slag Pit
  - RU 22c: Railroad Swale
- Delineation of Boundaries Associated with Former Kiln Ponds
  - RU 8: Former Kiln Scrubber Ponds and Calciners, extending into RU 9 (Former Kiln Scrubber Overflow Pond)
- Delineation of Boundary Associated with Phossy Solids in Old Ponds
  - RU22b: Old Ponds, potentially extending into RUs 12, 13, 20, and 24 and beyond the southern and western boundaries of RU 22b

Following completion of the studies designed to define the lateral boundaries of the engineered caps to be placed on RUs 1, 2, 8, 22b and 22c (as described in Section 2.2.1 through 2.2.3

[1]Cap delineation information is not required for RU 15, 16, 17, 18 and 19 to support SFS evaluation of remedial alternatives at this time. Cap delineation in these RUs would be performed in conjunction with remedial construction and confirmation, if the remedial vision of capping is selected as a remedial alternative.

below), 0-to-2 foot and 0-10 foot fill samples will be taken at the engineered cap boundary for evaluating potential worker risks within the adjacent RU under the risk data collection path. Specifically, if the final step-out cap delineation sample is located in fill within an adjacent RU that is still envisioned to be NFA, then the 0-to-2 foot and 0-to-10 foot fill samples will be collected at the cap boundary. These data will be used in conjunction with the 0-2 foot and 0-10 foot composite samples collected under the risk assessment data collection scheme (Section 2.5) to evaluate potential risks to future workers within the adjacent RU.

The 0-to-2 foot and 0-to-10 foot fill samples will not immediately be collected at the cap boundary if the adjacent RU has already been forwarded to the preliminary SFS data collection path (i.e., risks associated with gamma exposure exceed the radiological CV). If the SFS ultimately identifies excavation of fill from the adjacent RU as the remedial approach, then post-remedial action verification samples will be collected at 0-to-2 foot and 0-to-10 foot at the cap boundary. These data will be used in conjunction with any other post-remedial action samples as a part of the post-remedial action verification of the adjacent RU. Alternatively, if the SFS identifies capping as the remedial approach in the adjacent RU, then post-remedial action verification sampling will not be collected at the engineered cap boundary. However, post-remedial action investigations at the boundaries of the cap covering the adjacent RU will be collected for purposes of post-remedial action verification.

2.2.1 Delineation of P4 Cap Boundaries

This section presents the first six steps of the DQO process for former P4 working areas where P4 is presumed to be present in subsurface soils. These include the following RUs:

- RU 1: Furnace Building, Phos Dock and Secondary Condenser
- RU 2: Slag Pit
- RU 22c: Railroad Swale

2.2.1.1 RUs 1 and 2 P4 Cap Delineation

2.2.1.1.1 State the Problem

RUs 1 and 2 Conceptual Site Model

White P4 freezes (and is immobile in the subsurface) at temperatures below 44 °C. Elemental phosphorus was typically handled in the phosphorus areas (RUs 1 and 2) as a liquid at temperatures between 60 °C and 66 °C. Molten slag was tapped almost continuously into the slag pit for 50 years. As a result, heat from these operations transferred via convection into the underlying strata. With the ground being heated above the melting point of P4, there is a potential that any P4 released into the subsurface in the areas of RUs 1 and 2 could remain a liquid and mobile while within this thermal plume area. Given the physical and chemical properties of P4, it is important to evaluate the extent of P4 migration in the subsurface, which in turn would delineate the lateral boundary of an engineered cap to cover areas where P4 is presumptively present in the subsurface.

The RI Update Memorandum (BEI, 2004b) identified RUs 1 and 2 as former P4 working areas in which P4 was likely to have been released to the subsurface, through both documented and suspected historic spills or leaks from process equipment such as sumps. These RUs are shown in Figure 2-3. RU 1 contains the Furnace Building, Phos Dock and Secondary Condenser. RU 2 is the former Slag Pit. RUs 1 and 2 are considered together because of their proximity, their potential as sources of P4, and the documented occurrence of P4 in the subsurface within their boundaries.

As discussed above, the furnace working areas were heat sources that may have facilitated the migration of liquid P4 in the subsurface by creating a thermal plume in the soil and groundwater beneath the slag pit and furnace building. By calculating the maximum lateral extent of the 44 °C subsurface isotherm from a thermal model with a continuous heat source (the slag pit) for a period of 50 years, the overall extent of potential P4 migration can be modeled. The 44 °C isotherm can help define the appropriate area of the RU 1 and RU 2 cap (i.e., the 44 °C isotherm boundary should be well within the outer boundary of the cap).

RUs 1 and 2 Problem Statement

Liquid phosphorus was managed at RU 1 and RU 2. A study to verify that significant concentrations of phosphorus have not migrated outside the RU 1 and RU 2 boundaries is needed for purposes of defining the extent of the RCRA cap that is proposed for these RUs. Additionally, the potential risk to future workers from acute and chronic exposure to phosphorus that may be present outside the boundaries designated for capping has not been defined.

2.2.1.1.2 Identify the Decision

RU 1 and RU 2 Decisions

There are two decisions associated with P4 beyond the boundaries of RUs 1 and 2.

1. Has the extent to which P4 is present at a level of acute health concern, as evidenced by visual observation of smoking or burning in the subsurface, been identified for purposes of delineating the cap boundaries? To address this question the following decisions apply.

    - If when drilling to groundwater, a P4 acute health concern is present, as evidenced by visual smoking or burning, then the borings will have to be moved further out and this part of the study repeated.

    - If when drilling to groundwater, a P4 acute health concern is not present, as evidenced by a lack of visual smoking or burning, then the extent of the proposed cap will have been delineated.

2. Does the area outside of the cap perimeter contain an increased chronic health risk to future workers from exposure to P4? To address this question the following decisions apply.

- If the residual P4 concentration in the 0-to-2 foot bgs or 0-to-10 foot bgs sample is greater than the applicable worker SSL, then additional step-out sampling is required.

- If the residual P4 concentration in the 0-to-2 foot bgs and 0-to-10 foot bgs sample is less than the applicable SSL, then no further action with regards to P4 will be required in this area.

2.2.1.1.3 Identify the Decision Inputs

RUs 1 and 2 Decision Inputs

The results of the EMF RI (BEI, 1996) and this SRI will be used as inputs to answer the questions in the preceding subsection. The RI Update Memorandum (BEI, 2004b) also presented and discussed the inputs and practical constraints of the RI/FS for the former P4 working areas, including worker hazards, delineation of P4 in the subsurface, mobility of P4 in the subsurface, and existing cover over P4 areas. These discussions need not be restated here.

RU 1 and 2 initial Cap Boundaries

The RU 1 and RU 2 boundaries were initially drawn to include processing areas where liquid P4 was managed at the FMC Plant OU. Additionally, the maximum lateral extent of the 44 °C subsurface isotherm, as determined by thermal modeling, was used as an input in the development of the lateral extent of the proposed RU 1 and RU 2 cap. The thermal modeling was used to validate that the proposed boundaries of RU 1 and RU 2 were sufficient to adequately cover the phosphorus process areas including the area where liquid phosphorus may have migrated laterally in the subsurface.

Information Supportive of a RCRA Cap Remedy

The Technology Innovation Program (TIP) (USEPA, 2003) report examined six technologies as potentially applicable to soils and sludges at the FMC Plant OU contaminated with P4, heavy metals, and radionuclides. The TIP report concluded that:

- No technology has been used at full-scale to treat waste materials similar to that found on the FMC Plant OU.

- No new technologies have emerged as potentially applicable.

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

- Minimal performance data currently exist for use of the six examined technologies to treat similar waste materials.

- Additional testing would be necessary to assess whether examined treatment technologies could perform adequately across the range of contaminant concentrations and properties of the waste materials.

Although not directly applicable, the report conclusions are relevant to the former P4 working areas within the FMC Plant OU. The highly variable content and irregular distribution of P4 in subsurface soils and the variability of soil types in RU 1 and RU 2 are the kinds of site conditions the TIP report found were not amenable to available treatment technologies.

SSLs Associated with Future Worker Scenarios

SSLs for the various site worker exposures were developed in Sections 4.2 through 4.6 of the RI Update Memorandum (BEI, 2004b). The SSLs for P4 are:

- Commercial/Industrial Worker Scenarios: 22.7 mg/kg
- Construction Worker Scenarios: 117 mg/kg
- Utility Worker Scenarios: 1,000 mg/kg

Process Knowledge RUs 1 and 2

See Section 2.1.1.

Risks Addressed by RU 1 and 2 Cap Delineation

For areas that will be delineated for capping by this study, the risks of concern are associated with potential worker exposure to P4 levels of acute health concern, as evidenced by visible smoking or burning. For areas designated outside the cap, the risks of concern are those associated with potential chronic and/or sub-chronic future site worker exposure to P4.

2.2.1.1.4 Define the Boundaries

RUs 1 and 2 Cap Delineation Boundaries

Lateral Boundaries for RU 1 and RU2 Cap Delineation for Visual Determination of P4 for RU1 and RU 2 Cap Delineation

The initial lateral study boundary will be just beyond the current limit of the proposed cap. Judgmental sampling (USEPA, 2002b) will be used to confirm the adequacy of the areal extent of the cap. If, during sampling, P4 is observed to be present above a level of concern for acute exposure, as is evidenced by visual observation of burning or smoking, then sampling locations will be stepped out a distance of approximately 40 feet from the RU boundary, taking into account practical constraints that include worker safety and rig access.

Vertical Boundaries for Visual Determination of P4 for RU1 and RU 2 Cap Delineation

The vertical study boundaries were defined in the thermal modeling study, which showed the maximum vertical extent of the 44 ^{o}C isotherm at a depth of approximately 80 feet bgs (approximately 10 to 15 feet below static groundwater levels). However, the 44 °C isotherm is well within the RU boundary. Therefore, the lateral boundaries for cap delineation will be well outside the 44 °C isotherm. Given this fact, the vertical boundary is defined from ground surface to the depth of groundwater.

Lateral Boundaries For Evaluating Potential Chronic Worker Risk at the RU 1 and RU2 Cap Delineation Boundary.

The initial lateral boundary will be the last step-out boring associated with the visual determination of P4. If P4 is reported at levels above the applicable SSL in the 0-2 foot and the 0-10 foot intervals, based on fixed-laboratory analyses, then additional step-out borings as described above will be required.

Vertical Boundaries for *Evaluating Potential Chronic Worker Risk at the RU 1 and RU2 Cap Delineation Boundary.*

The vertical boundaries for evaluating potential chronic worker risk are the 0-to-2 foot bgs and 0-to-10 foot bgs intervals.

2.2.1.1.5 Develop the Decision Rules

The following decision rules apply to RUs 1 and 2.

The decision for each boring associated with cap delineation is to determine whether P4 is present at a level of acute health concern, as evidenced by smoking or burning of P4. Therefore, the null and alternative hypotheses are:

- H_0: single boring concentration > level at which smoking or burning occurs
- H_A: single boring concentration < level at which smoking or burning occurs

The decision for each boring associated with potential future chronic worker exposure to P4 are addressed by the following null and alternative hypotheses:

- H_0: 0-to-2 foot bgs P4 concentration or 0-to-10 foot bgs P4 concentration > applicable SSL
- H_A: 0-to-2 foot bgs P4 concentration and 0-to-10 foot bgs P4 concentration < applicable SSL

The decision rules associated with the visual determination of P4 sampling at RUs 1 and 2 are as follows:

- If P4 at a level of acute health concern is present in the boring, as evidenced by smoking or burning, then additional step-out borings down to groundwater are needed.

- If P4 at a level of acute health concern is not present in the boring, as evidenced by a lack of smoking or burning, then no further action regarding P4 cap delineation is needed.

The decision rules associated with the evaluation of chronic worker exposure are as follows:

- If P4 is above the applicable SSL, then additional step-out borings to 10 feet bgs are needed.

- If P4 is less than all applicable SSLs then no further action with regards to P4 will be required in this area.

2.2.1.1.6 Specify the Tolerance Limits of Decision Errors

RU 1 and RU2 Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.2.1.1.7 Optimize the Sample Design

See Section 2.1.1.

2.2.1.2 RU 22c P4 Cap Delineation

2.2.1.2.1 State the Problem

RU 22c Conceptual Site Model

RU 22c (railroad swale), is an area identified for remedial action in the 1998 ROD. The ROD selected an extension of or replacement (with extension) of the existing lining system for this RU. Following plant shutdown in 2001, FMC has proposed a cap/cover remediation vision rather than extending the lining in the swale. FMC anticipates recording land use restrictions to prevent intrusion through any cap/cover at the railroad swale if capping is the selected remedy for RU 22c. Spills that occurred from 1994 through 2002 were relatively small volumes of phossy water from the furnace building and phos dock area. These spills were likely contained within the low-lying areas of the railroad swale.

The remediation vision for the railroad swale is a cap of similar design to the cap for RUs 1 and 2. Given that the COC is the same as for the cap delineation at RUs 1 and 2, the decisions will again be based upon the visual determination of P4 as evidenced by smoking or burning.

RU 22c Problem Statement

During the SRI, FMC will collect confirmation soil samples along the length of the railroad swale to delineate the extent of released P4. These data will be used to confirm the area to be capped. Additionally, the potential risk to future workers from acute and chronic exposure to P4 that may be present outside the boundaries designated for capping has not been defined.

2.2.1.2.2 Identify the Decision

RU 22c Decisions

There are two decisions associated with P4 in RU 22c.

1. Has the extent to which P4 is present at a level of acute health concern, as evidenced by visual observation of smoking or burning in the subsurface, been identified for purposes of delineating the cap boundaries? To address this question the following decisions apply.

    - If a P4 acute health concern is present, as evidenced by visual smoking or burning when trenching, then the trenches will have to be moved further out and this part of the study repeated.

    - If a P4 acute health concern is not present, as evidenced by a lack of visual smoking or burning when trenching, then the extent of the proposed cap will have been delineated.

2. Does the area outside of the cap perimeter pose an increased chronic health risk to future workers from exposure to P4? To address this question the following decisions apply.

    - If the residual P4 concentration in the 0-to-2 foot bgs or 0-to-10 foot bgs sample is greater than the applicable worker SSL, then additional step-out sampling is needed.

    - If the residual P4 concentration in the 0-to-2 foot bgs and 0-to-10 foot bgs is less than the applicable SSL, then no further action with regards to P4 will be required in this area.

2.2.1.2.3 Identify the Decision Inputs

RU 22c Decision Inputs

Process Knowledge RU 22c

See Section 2.1.18.

Risks Addressed By Railroad Swale Capping

For areas that will be delineated for capping by this study, the risks of concern are associated with potential worker exposure to P4 levels of acute health concern, as evidenced by visible smoking or burning. For areas designated outside the cap, the risks of concern are associated with potential chronic and/or sub-chronic future site worker exposure to P4.

2.2.1.2.4 Define the Boundaries

RU 22c Cap Delineation Boundaries

Lateral Boundaries for RU22c Cap Delineation for Visual Determination of P4

The lateral boundaries for RU 22c are shown in Figure 2-2. A liner was installed in the western portion of RU22c. The first step-out trench will be to the east of the existing liner. If P4, as evidenced by visual observation of smoking or burning, is encountered during sampling, then sampling locations will be stepped out a distance of approximately 200 feet in an easterly direction from the existing liner, taking into account practical constraints that include worker safety and access. Step-out sampling for the purpose of cap delineation will continue until P4 concentrations are less than the level that can be visually evidenced.

Vertical Boundaries for RU 22c Cap Delineation for Visual Determination of P4

The vertical study boundary for RU22c is 0-to-10 feet bgs for visual determinations of P4.

Lateral Boundaries for Potential Future Worker Exposure to P4

The initial lateral boundary will be the last step-out trench associated with the visually based sampling activities. If P4 is reported at levels above the applicable chronic worker SSL based on fixed-laboratory analyses, then additional step-out trenches as described above will be required.

Vertical Boundaries for Potential Future Worker Exposure to P4

The vertical boundaries for confirmation sampling are 0-to-2 feet bgs and 0-to-10 feet bgs.

2.2.1.2.5 Develop the Decision Rules

The following decision rules apply to RU 22c. The decision for each location associated with cap delineation is to determine whether P4 is present at a level of acute health concern, as evidenced by smoking or burning of P4. Therefore, the null and alternative hypotheses are:

- H_0: single boring concentration > level at which smoking or burning occurs
- H_A: single boring concentration < level at which smoking or burning occurs

The decision for each boring associated with potential future chronic worker exposure to P4 are addressed by the following null and alternative hypotheses:

- H_0: 0-to-2 foot bgs P4 concentration or 0-to-10 foot bgs P4 concentration > applicable SSL

- H_A: 0-to-2 foot bgs P4 concentration and 0-to-10 foot bgs P4 concentration < applicable SSL

The decision rules associated with the visual determination of P4 at a level of acute health concern at RU 22c are as follows:

- If P4 is present in the boring as evidenced by smoking or burning, then additional step-out borings to 10 feet bgs are needed.

- If P4 is not present in the boring as evidenced by a lack smoking or burning, then no further action regarding P4 cap delineation is needed.

The decision rules associated with the evaluation of potential chronic worker exposure are as follows:

- If P4 is above the applicable worker SSL, then additional step-out borings to 10 feet bgs are needed.

- If P4 is less than all applicable SSLs then no further action with regards to P4 will be required in this area.

2.2.1.2.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.2.1.2.7 Optimize the Design

See Section 2.1.18.

2.2.2 Delineation of Boundaries Associated with Former Kiln Ponds

This section presents the first six steps of the DQO process for RUs that require the delineation of boundaries for a cap/cover design associated with the former kiln scrubber ponds. The former kiln scrubber ponds are contained within RU 8, Former Kiln Scrubber Pond and Calciners. In addition, the former kiln scrubber overflow pond is located in the southern portion of RU 9 and will also be considered in the boundary delineation study.

Description of Conceptual Site Model for RU 8 and 9

The former kiln scrubber ponds are located in RU 8. The former kiln scrubber overflow pond is located in RU 9. The former kiln scrubber overflow ditch conveyed clarified water from the former kiln scrubber ponds in RU 8 to the former kiln scrubber overflow pond in RU 9. The kiln scrubber overflow pond was operated as an overflow pond that received clarified water from the primary kiln scrubber ponds. As documented in Table 1-2, the remediation vision for RU 8 is to

leave existing concrete slabs in-place, grade to design subgrade elevation and construct a soil cover (cap) over entire footprint of these areas and the remediation vision for RU 9 is no further action is anticipated to be necessary (NFA). This remedial vision for RU 9 assumes the cap/cover from RU 8 will be extended over the area that encompasses the former kiln scrubber overflow ditch and former kiln scrubber overflow pond in RU 9, thus effectively subdividing RU 9. Therefore, the remediation vision of NFA would still apply to the remainder of RU 9.

2.2.2.1 State the Problem

RU 8 Problem Statement

The RI Update Memorandum (BEI, 2004b) identified confirmation of the lateral extent of kiln scrubber pond sediments as a data gap. Confirmation sampling along the exterior boundary of RU 8 and in the southern portion of RU 9 (around the scrubber overflow pond) is needed to ensure that the area covered by the cap/cover encompasses the lateral extent of residual kiln scrubber solids.

2.2.2.2 Identify the Decision

RU 8 Decisions

For RU 8 the decisions associated with determining the lateral extent of the cap are:

Visual Observations

- If the presence of pond solids or pond fill is observed based on visual observations in a step-out boring/test pit, then additional step-out borings/test pits will be performed.

- If the presence of pond solids or pond fill is not observed based on visual observations in the step-out boring/test pit, then confirmation sampling will be performed.

The decision rules associated with confirmation sampling at RU 8 are as follows:

- If the concentration of selected COCs and COPCs in the confirmation sample is greater than the applicable SSL or background, then additional step-out borings/test pits will have to be performed.

- If the concentration of selected COCs and COPCs in the confirmation sample is less than the applicable SSL or background, the lateral extent of the cap has been defined.

  Note: COCs and COPCs for this study include metals, fluoride, uranium-238, radium-226, potassium-40, lead-210 and polonium-210.

2.2.2.3 Identify the Decision Inputs

RU 8 Decision Inputs

Process Knowledge RU 8

See Section 2.1.7.

Pond Sediment Characteristics

This section addresses the physical and chemical characteristics of kiln scrubber pond sediments. Pond sediments can be distinguished from fill and native soil based on the following characteristics associated with each material.

- Native soils are light tan and finely divided.
- Ore is dark brown and typically coarser material than native soil.
- Slag is dark gray angular material ranging in size from ¼ inch to large boulders.
- Kiln pond sediments consist primarily of fine-grained ore and precipitates (such as calcium fluoride) of dark brown or gray color. The kiln scrubber pond sediments in RU 8 would be slightly coarser than the sediments found in the kiln scrubber overflow pond in RU 9 as the coarser suspended particulates would be expected to settle out in the kiln scrubber ponds in RU 8 prior to the overflow to the kiln scrubber overflow pond in RU 9.
- The kiln scrubber overflow pond was backfilled with silica. Therefore, the presence of silica, an orange, angular, crystalline material ranging in size from –1/8” to –2” is a strong indicator of being within the pond boundaries.

Risk Addressed by Residual Pond Sediments

As stated in the RI Update Memorandum (BEI, 2004b) there is no indication the kiln scrubber ponds contain or stored P4; however, there is evidence from the RI (BEI, 1996) that the ponds were a source of heavy metals to groundwater. In addition, without capping, future site workers could potentially be exposed to the COCs and COPCs associated with residual pond sediments.

Variability of the Stratigraphy

The silt aquitard beneath RU 8 and RU 9 was characterized as part of the overall hydrogeologic investigation of the EMF RI (see sections 3.1, 3.3, 4.4, 5, and Appendix K of the EMF RI, BEI, 1996). In the area of RUs 8 and 9, the aquitard is generally planar, with a vertical permeability of approximately 10-6 cm/s.

2.2.2.4 Define the Boundaries

Lateral Boundaries for RU 8 Associated with Kiln Scrubber Ponds and Kiln Scrubber Pond Ditch

The initial lateral boundaries for the former kiln scrubber ponds and kiln scrubber overflow ditch were delineated from the 1965 geo-referenced air photo. The lateral boundaries for cap delineation will be based on the analytical results associated with the outermost borings/test pits.

Vertical Boundaries for RU 8

The vertical boundary for RU 8 and the cap extension into RU 9 will be the 0-to-2 foot bns interval to demonstrate that the underlying native soil is less than the applicable SSLs.

2.2.2.5 Develop the Decision Rules

RU 8 Decision Rules

The following decision rules apply to RU 8 visual observations. The decision for each boring/test pit is to determine whether the kiln solids are present. Therefore, the null and alternative hypotheses are:

- H_0: kiln solids observed in single boring/test pit
- H_A: kiln solids not observed in a single boring/test pit

The decision rules associated with visual observations at RU 8 are as follows:

- Based on visual observations if the fill material associated with the kiln scrubber ponds is observed in a step-out boring/test pit then additional step-out borings/test pits will be performed.
- Conversely, based on visual observations, if the fill material associated with the kiln scrubber ponds is not observed in a step-out boring/test pit then confirmation samples will be collected.

The following decision rules apply to RU 8 confirmation sampling. The decision for each boring/test pit is to determine whether the kiln solids are present. Therefore, the null and alternative hypotheses are:

- H_0: 0-to-2 foot bns composite COC or COPC > applicable SSL or background
- H_A: 0-to-2 foot bns composite COC or COPC < applicable SSL or background

The decision rules associated with confirmation sampling at RU 8 are as follows:

- If the concentration of COCs and COPCs associated with the step-out boring/test pit from the kiln scrubber ponds is greater than the applicable SSL or background, then additional step-out borings/test pits will be performed.

- Conversely, if the concentration of COCs and COPCs associated with the step-out borings/test pit from the kiln scrubber ponds is less than the applicable SSL or background, then the lateral extent of the cap has been delineated.

2.2.2.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.2.2.7 Optimize the Design

See Section 2.1.7.

2.2.3 Delineation of Boundaries Associated with Former Phossy Waste Ponds – RUs 22b

2.2.3.1 State the Problem

Delineation of Phossy Waste Ponds Conceptual Site Model

Borings located in RU 12, RU 13, and near the boundaries of RU 22b encountered phossy solids at depths of approximately 5 to 7 feet below current grade. As stated in the RI Update Memorandum (BEI, 2004b), it is anticipated that RU 22b will be remediated in accordance with the 1998 ROD through placement of a cap/cover. Confirmation sampling around the boundaries of RU 22b is needed to determine the extent to which the cap for RU 22b is to be extended into RU 12, RU 13, RU 20, RU 24, and to delineate the RU 22b cap around the western portions of RU 22b. The historic and proposed SRI borings are discussed in Section 2.1.17. As documented in Table 1-2, the remediation vision for RU 12, RU 13, RU 20, and RU 24 is NFA. The remediation vision for these RUs assumes the cap/cover from RU 22b will be extended over the area that encompasses the phossy solids in these RUs. Therefore, the remediation vision of NFA would still apply to the remainder of RU 12, RU 13, RU 20, and RU 24.

RU 22b Problem Statement

Per the RI Update Memorandum (BEI, 2004b), sufficient information exists for the old phossy ponds (RU 22b) to determine the extent of the cap/cover specified in the 1998 ROD. However, more information is needed to determine whether phossy solids were deposited outside the pond boundaries and need to be encompassed by the RU 22b cap.

2.2.3.2 Identify the Decision

RU 22b Decisions

- If the concentration of selected COCs and COPCs in the step-out boring/test pit is greater than the applicable SSL or background, then additional step-out borings/test pits will have to be performed.

- If the concentration of selected COCs and COPCs in the step-out boring/test pit is less than the applicable SSL or background, then additional borings/test pits are not required.

  Note: COCs and COPCs for this study include metals, fluoride, uranium-238, radium-226 potassium-40, lead-210, and polonium-210.

2.2.3.3 Identify the Decision Inputs

Process Knowledge RU 22b

See Section 2.1.17.

Risk Addressed by Residual Pond Sediments

The risk addressed at the boundaries of RU22b concern migration of constituents to groundwater. In addition, without capping, future site workers could potentially be exposed to the COCs and COPCs associated with residual pond sediments.

2.2.3.4 Define the Boundaries

Lateral Boundaries

While the lateral boundaries for ponds within RU 22b can be delineated per historic aerial photos and plant drawings, the delineation of phossy solids around RU22b is bounded to the south by the property boundary and by capped ponds. Otherwise the lateral extent will be determined by the step-out borings/test pits. The lateral boundaries for RU 22b are shown in Figures 2-2 and 2-3.

Vertical Boundaries

The vertical boundaries associated with RU 22b are the 0-to-2 feet bns interval to determine the potential impact to groundwater. The 0-to-2 feet bgs and 0-to-10 feet bgs intervals are associated with evaluating potential worker risk in the adjacent area or RU.

2.2.3.5 Develop the Decision Rules

RU 22b Decision Rules

The following decision rules apply to RU 22b visual observations. The decision for each boring/test pit location is to determine whether phossy solids are present. Therefore, the null and alternative hypotheses are:

- H_0: phossy solids observed in the boring/test pit
- H_A: phossy solids not observed in the boring/test pit

The decision rules associated with visual observations at RU 22b are as follows:

- Based on visual observations, if the fill material associated with the phossy solids is observed in a step-out boring/test pit, then additional step-out borings/test pits will be performed.

- Based on visual observations, if the fill material associated with phossy solids is not observed in a step-out boring/test pit and there is no other fill on the surface, then confirmation samples from the 0-to-2-foot bgs and 0-to-10-foot bgs will be collected.

- Based on visual observations, if the fill material associated with phossy solids is not observed in a step-out boring/test pit and there is some type of other fill on the surface (e.g., slag), then confirmation samples from the 0-to-2-foot below native surface will be collected.

The following decision rules apply to RU 22b confirmation sampling. The decision for each boring/test pit is to determine whether phossy solids are present. Therefore, the null and alternative hypotheses are:

- H_0: 0-to-2-foot bgs or 0-to-10-foot bgs composite COC or COPC > applicable SSL or background

- H_A: 0-to-2-foot bgs and 0-to-10-foot bgs composite COC or COPC < applicable SSL or background

- H_0: 0-to-2-foot bns composite COC or COPC > applicable SSL or background

- H_A: 0-to-2-foot bns composite COC or COPC < applicable SSL or background

The decision rules associated with confirmation sampling at RU 22b are as follows:

- If the concentrations of COCs and COPCs associated with the boring/test pit from RU 22b in the 0-to-2-foot bgs or 0-to-10 foot bg interval are is greater than the applicable SSLs or background values, then the data will be forwarded to the SFS.

- If the concentrations of COCs and COPCs associated with the boring/test pit from RU 22b in the 0-to-2-foot bgs and 0-to-10 foot bg interval are less than the applicable SSLs or background values, then no further data are required.

- If the concentrations of COCs and COPCs associated with the step-out boring/test pit from RU22b in the 0-to-2 foot bns interval are greater than the applicable SSLs or background values, then additional step-out sampling will be performed.

- Conversely, if the concentrations of COCs and COPCs associated with the boring/test pit from RU 22b in the 0-to-2 foot bns interval are less than the applicable SSLs or background values, then the lateral extent of the cap has been delineated.

2.2.3.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.2.3.7 Optimize the Design

See Section 2.1.17.

2.3 SPECIFIC INVESTIGATION AREAS

This section provides the first six steps of the DQO process for each of the specific investigation areas listed below. Step 7 of the DQO process, Optimize the Sampling Design, is presented in Section 2.1.

2.3.1 Organic Solvents

The need for organic solvent specific investigation area studies has been identified in the following RUs:

- RU 4: Office Building and Training Center - Boring F028B
- RU 5: Lab and Old Drain Field – the disposal area behind the laboratory (SWMU #61) and the Chemical Lab Seepage Pit (SWMU #39)
- RU 12: Former RP & S Area and Mobile Shop - Area West of the Mobile Shop (SWMU #62) (note: the Mobile Shop is actually in RUs 22b and 12. Only that portion of the shop that is associated with RU 12 will be investigated).
- RU 20: Former Bannock Paving Area - Office - Shop Complex

2.3.1.1 RU 4 Solvent Specific Investigation Area

2.3.1.1.1 State the Problem

RU 4 Solvent Specific Investigation Area Conceptual Site Model

During the EMF RI (BEI, 1996) solvents were detected in Boring F028B located within RU 4. This boring is located in the parking lot in front of the office building. A source has not been identified that would explain the presence of solvents at this boring location. Therefore, a specific area investigation study delineating the extent of the solvent contamination is required.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed

only upon EPA approval of the SRI Work Plan addendum. All decisions will be based upon fixed laboratory data.

The specific investigation areas within RU 4 may have a fill thickness of a few inches to several feet. Therefore, the depth of the native soil interface may vary. The optimization of the sampling design (Section 2.7) requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 4 Solvent Specific Investigation Area Problem Statement

Confirmation sampling is needed to delineate the lateral and vertical extent of solvents in the vicinity of boring F028B.

2.3.1.1.2 Identify the Decision

RU 4 Solvent Specific Investigation Area Decisions

For the RU 4 solvent specific investigation area study, the decisions associated with determining the extent of the solvent contaminated soil are:

- If the concentration of solvent COCs and COPCs in the soil is detected at levels above the applicable SSL, then additional vertical and/or lateral sampling may be required.

- If the concentration of solvent COCs and COPCs in the soil is less than the applicable SSL, then the extent of the specific investigation area contamination has been defined.

  Note: The list of compounds to be evaluated is provided in Table 1-5 Volatile Organic Compounds for Laboratory-Related Solvents.

2.3.1.1.3 Identify the Decision Inputs

RU 4 Solvent Specific Investigation Area Decision Inputs

Process Knowledge RU 4

See Section 2.1.3.

Risk addressed by the RU 4 Solvent Specific Investigation Area Study

A solvent investigation is being performed at RU 4 to investigate the potential release of organic solvents around the F028B boring. If the presence of solvents is confirmed, then the risk is that

associated with the potential impact to future site workers and the potential impact to groundwater.

2.3.1.1.4 Define the Boundaries

Boundaries Associated with the RU 4 Solvent Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the solvent specific investigation area in RU 4 will be defined based on the analytical results associated with the outermost borings.

Vertical Boundaries

The initial vertical boundary for the solvent specific investigation area in RU 4 is 0-to-10 feet bns. If solvents are detected at the 10-foot bns level, then the vertical boundary is from ground surface to groundwater.

2.3.1.1.5 Define the Decision Rules

Decision Rules for the RU 4 Solvent Specific Investigation Area

The following decision rules apply to the RU 4 solvent specific investigation area study. The decision for each boring is to determine whether the concentration of solvent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: Solvent constituent concentration > applicable SSL
- H_A: Solvent constituent concentration < applicable SSL

The decision rules associated with confirmation sampling at RU 4 for the solvent specific investigation area study are as follows:

- If the concentration of solvent COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.
- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has solvent COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.
- If the concentrations of solvent COCs and COPCs are less than the applicable SSLs, then the lateral and vertical extent of the solvent contamination has been delineated.

2.3.1.1.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.1.1.7 Optimize the Design

See Section 2.1.3.

2.3.1.2 RU 5 Solvent Specific Investigation Area

RU 5: Lab and Old Drain Field consists of the disposal area behind the laboratory (SWMU #61) and the Chemical Lab Seepage Pit (SWMU #39)

2.3.1.2.1 State the Problem

RU 5 Solvent Specific Investigation Area Conceptual Site Model

SWMU #61, the disposal area behind the laboratory, is located within RU 5. This area has been identified as a potential source for solvents. There may have been some disposal of free liquids in this area, which is now covered with sidewalks and a parking area. The EMF RI (BEI, 1996) targeted the laboratory seepage pit at RU 5 as a potential source of solvents. The seepage pit received laboratory solvents used in the preparation of ore or product samples for analysis. In 1980, the disposal of laboratory waste ceased, and in 1995 FMC permanently abandoned the seepage pit by subsurface pressure grouting of the pit area.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based upon fixed laboratory data.

The specific investigation areas within RU 5 may have a fill thickness of a few inches to several feet. Therefore, the depth of the native soil interface may vary. The optimization of the sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 5 Solvent Specific Investigation Area Problem Statement

Based on knowledge of past plant practices and analytical results associated with boring F029B the determination of the presence or absence of solvents at SWMU 61 and the Chemical lab seepage pit is needed to support a decision to either remediate the solvent specific investigation area or to take no further action.

2.3.1.2.2 Identify the Decision

RU 5 Solvent Specific Investigation Area Decisions

For the RU5 solvent specific investigation area study, the decisions associated with determining the extent of solvent contamination are:

- If the concentration of solvent COCs or COPCs in the soil is detected at levels above the applicable SSL, then additional lateral and/or vertical sampling may be required.
- If the concentration of solvent COCs and COPCs in the soil is less than the applicable SSL, then the extent of the solvent specific investigation area contamination has been defined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Volatile Organic Compounds for Laboratory-Related Solvents.

2.3.1.2.3 Identify the Decision Inputs

RU 5 Solvent Specific Investigation Area Decision Inputs

Process Knowledge RU 5

See Section 2.1.4.

Risks Addressed by RU 5 Solvent Investigation

A solvent investigation is being performed at RU 5 to investigate the potential release of organic solvents around the Laboratory Chemical Disposal Area and the Laboratory Seepage Pit. If the presence of solvents is confirmed the risk is associated with the potential impact to future site workers and the potential impact to groundwater.

2.3.1.2.4 Define the Boundaries

Boundaries Associated with the RU 5 Solvent Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the solvent specific investigation area in RU 5 will be defined based on the analytical results associated with the outermost borings.

Vertical Boundaries

The initial vertical boundary for the solvent specific investigation area in RU 5 is 0-to-10 feet bns. If solvents are detected at the 10-foot bns level, then the vertical boundary is from ground surface to groundwater.

2.3.1.2.5 Define the Decision Rules

Decision Rules for the RU 5 Solvent Specific Investigation Area

The following decision rules apply to the confirmation samples for the RU 5 solvent specific investigation area study. The decision for each boring is to determine whether the concentration of solvent constituent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: Solvent constituent concentration > applicable SSL
- H_A: Solvent constituent concentration < applicable SSL

The decision rules associated with RU 5 for the solvent specific investigation area study are as follows:

- If the concentration of solvent COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.
- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has solvent COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.
- If the concentration of solvent COCs and COPCs is less than the applicable SSLs, then the lateral and vertical extent of the solvent contamination has been delineated.

2.3.1.2.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.1.2.7 Optimize the Design

See Section 2.1.4.

2.3.1.3 RU 12 Solvent Specific Investigation Area

2.3.1.3.1 State the Problem

RU 12 Solvent Specific Investigation Area Conceptual Site Model

The Mobile Shop is primarily located in RU 22b as the shop was built upon an old phossy pond. The remediation vision for RU 22b is capping. Therefore, the determination as to the extent of solvent contamination is not needed in RU 22b. The east end of the shop extends into RU 12 and the extent to which the soil in RU 12 may be impacted by solvents utilized at the Mobile Shop is not known.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based on fixed-laboratory data.

The specific investigation areas within RU 12 may have a fill thickness of a few inches to several feet. Therefore, the depth of the native soil interface may vary. The optimization of the sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 12 Solvent Specific Investigation Area Problem Statement

Based on knowledge of past plant practices at the Mobile Shop, the determination of the presence, absence and concentrations of solvents is needed to support a decision to either remediate the solvent specific investigation area or to take no further action.

2.3.1.3.2 Identify the Decision

RU 12 Solvent Specific Investigation Area Decisions

For the RU 12 solvent specific investigation area study, the decisions associated with determining the extent of solvent contamination are:

- If the concentration of solvent COCs or COPCs in the soil is detected at levels above the applicable SSL, then additional lateral and/or vertical sampling may be required.
- If the concentration of solvent COCs and COPCs in the soil is less than the applicable SSL, then the extent of the solvent specific investigation area contamination has been defined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Volatile Organic Compounds for Shop-Related Solvents.

2.3.1.3.3 Identify the Decision Inputs

RU 12 Solvent Specific Investigation Area Decision Inputs

Process Knowledge RU 12

See Section 2.1.11.

Risk Addressed by the RU 12 Solvent Specific Investigation Area

A solvent specific investigation area study is being performed at RU 12 to investigate the potential release of organic solvents at the Mobile Shop. If the presence of solvents is confirmed the risk is associated with the potential impact to future site workers and the potential impact to groundwater.

2.3.1.3.4 Define the Boundaries

Boundaries Associated with the RU 12 Solvent Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the specific investigation area at RU 12 will be defined based on the analytical results associated with the outermost borings.

Vertical Boundaries

The initial vertical boundary for the solvent specific investigation area in RU 12 is 0-to-10 feet bns. If solvents are detected at the 10-foot bns level, then the vertical boundary is from ground surface to groundwater.

2.3.1.3.5 Define the Decision Rules

Decision Rules for RU 12 Solvent Specific Investigation Area

The following decision rules apply to the confirmation samples for the RU 12 solvent specific investigation area study. The decision for each boring is to determine whether the concentration of solvent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: solvent constituent concentration > applicable SSL
- H_A: solvent constituent concentration < applicable SSL

The decision rules associated with RU 12 for the solvent specific investigation area study are as follows:

- If the concentration of solvent COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.

- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has solvent COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.

- If the concentrations of solvent COCs and COPCs are less than the applicable SSLs, then the lateral and vertical extent of the solvent contamination has been delineated.

2.3.1.3.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.1.3.7 Optimize the Design

See Section 2.1.11.

2.3.1.4 RU 20 Solvent Investigation

2.3.1.4.1 State the Problem

RU 20 Solvent Conceptual Site Model

The shop in RU 20 was used to maintain and repair BAPCO paving and construction equipment. This area was not previously evaluated for potential solvent contamination.

The investigation will be conducted in a phased approach to determine potential migration of solvents to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based on fixed-laboratory data.

The specific investigation areas within RU 20 may have a fill thickness of a few inches to several feet. Therefore, the depth of the native soil interface may vary. The optimization of the sampling design (Section 2.1) requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words

when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 20 Solvent Problem Statement

Solvent VOCs must be adequately characterized to support a decision to either remediate specific investigation areas or to take no further action.

2.3.1.4.2 Identify the Decision

RU 20 Solvent Decisions

For the RU20 solvent specific investigation area study, the decisions associated with determining the extent of solvent contamination are:

- If the concentration of solvent COCs or COPCs in the soil is detected at levels above the applicable SSL, then additional lateral and/or vertical sampling may be required.
- If the concentration of solvent COCs and COPCs in the soil is less than the applicable SSL, then the extent of the solvent specific investigation area contamination has been defined.

  Note: The list of compounds to be evaluated is provided in Table 1-5 Volatile Organic Compounds for Shop-Related Solvents.

2.3.1.4.3 Identify the Decision Inputs

RU 20 Solvent Specific Investigation Area Decision Inputs

Process Knowledge RU 20

See Section 2.1.15.

Risk Addressed by the RU 20 Solvent Specific Investigation Area Study

A solvent specific investigation area study is being performed at RU 20 to investigate the potential release of organic solvents at the shop. If the presence of solvents is confirmed the risk is associated with the potential impact to future site workers and the potential impact to groundwater.

2.3.1.4.4 Define the Boundaries

Boundaries Associated with RU 20 Solvent Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the solvent specific investigation area at RU 20 will be defined based on the analytical results associated with the outermost borings.

Vertical Boundaries

The initial vertical boundary for the solvent specific investigation area in RU 20 is 0-to-10 feet bns. If solvents are detected at the 10-foot bns level then the vertical boundary is from ground surface to groundwater.

2.3.1.4.5 Define the Decision Rules

Decision Rules for RU 20 Solvent Specific Investigation Area

The following decision rules apply to the confirmation samples for the RU 20 solvent specific investigation area study. The decision for each boring is to determine whether the concentration of solvent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: solvent constituent concentration > applicable SSL
- H_A: solvent constituent concentration < applicable SSL

The decision rules associated with RU 20 for the solvent specific investigation area study are as follows:

- If the concentration of solvent COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.
- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has solvent COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.
- If the concentration of solvent COCs and COPCs is less than the applicable SSLs, then the lateral and vertical extent of the solvent contamination has been delineated.

2.3.1.4.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.1.4.7 Optimize the Design

See Section 2.1.15.

2.3.2 Liquid Petroleum Fuels

The need for liquid petroleum fuels specific investigation area studies has been identified in the following RUs:

- RU 12: Former RP & S Area and Mobile Shop - Fuel Islands (SWMU #84), High Pressure Steam Cleaning Station (SWMU # 83) and Area West of Mobile Shop (SWMU # 82).

- RU 20: Former Bannock Paving Area - Shop and Hot Batch Plant.

2.3.2.1 RU 12 Liquid Petroleum Fuel Specific Investigation Area

2.3.2.1.1 State the Problem

RU 12 Liquid Petroleum Fuel Specific Investigation Area Conceptual Site Model

There was a fueling station located within RU 12, with two associated underground fuel tanks (SWMU #84). As detailed below there were three reported releases of fuel from the fueling station. There are no reported fuel releases associated with the high pressure steam cleaning station, however, per the RI Update Memorandum (BEI, 2004b) this area will be sampled to determine if diesel fuel is present in the soil. The Mobile Shop used to store and maintain equipment and store fuel, motor oil, and lubricants. The sampling associated with the fuel island will be extended to the Mobile Shop for liquid petroleum fuel specific investigation area studies.

The investigation will be conducted in a phased approach to determine potential migration of liquid petroleum fuels to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based on fixed-laboratory data.

The specific investigation areas within RU 12 may have a fill thickness of a few inches to several feet. Therefore the depth of the native soil interface may vary. The optimization of the sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 12 Liquid Petroleum Fuel Specific Investigation Area Problem Statement

Sufficient sampling has not been conducted to determine potential impacts from the diesel fuel releases. The determination of the presence, absence, and concentrations of liquid petroleum fuels is needed to support a decision to either remediate the specific investigation area or to take no further action.

2.3.2.1.2 Identify the Decision

RU 12 Liquid Petroleum Fuel Specific Investigation Area Decisions

For the RU 12 liquid petroleum fuel specific investigation area study, the decisions associated with determining the extent of the fuel-contaminated soil are:

- If the concentration of liquid petroleum fuel constituents in the soil are detected at levels above the applicable SSL, then additional lateral and/or vertical sampling may be required.

- If the concentration of liquid petroleum fuel constituents in the soil is less than the applicable SSL, then the extent of the liquid petroleum fuel contamination has been defined.

  Note: The list of compounds to be evaluated is provided in Table 1-5 Organic Compounds for Liquid Petroleum Fuels

2.3.2.1.3 Identify the Decision Inputs

RU 12 Liquid Petroleum Fuel Specific Investigation Area Decision Inputs

Process Knowledge RU 12

See Section 2.1.11.

Risk Addressed by the RU 12 Liquid Petroleum Fuel Specific Investigation Area

A liquid petroleum fuel specific investigation area study is being performed at RU 12 to investigate the potential risk to future site workers and the potential release of liquid petroleum fuels at the three locations identified above. If the presence of liquid petroleum hydrocarbons is confirmed, the risk is associated with the potential impact to future site workers and the potential impact to groundwater.

2.3.2.1.4 Define the Boundaries

Boundaries Associated with the RU 12 Liquid Petroleum Fuel Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the liquid petroleum fuel specific investigation area at RU 12 will be defined based on the analytical results associated with the outermost borings. Soil samples should be collected and analyzed in low-lying areas downgradient from the fuel pumps to characterize potential impacts from the past diesel spills, recognizing that diesel fuel is within the CERCLA petroleum exclusion.

Vertical Boundaries Associated with the RU 12 Liquid Petroleum Fuel Specific Investigation Area

The initial vertical boundary for the liquid petroleum fuel specific investigation area in RU 12 is 0-to-10 feet bns. If liquid petroleum fuels are detected at 10 feet bns, then the vertical boundary is from ground surface to groundwater.

2.3.2.1.5 Define the Decision Rules

Decision Rules for RU 12 Liquid Petroleum Fuel Specific Investigation Area

The following decision rules apply to the RU 12 liquid petroleum fuel specific investigation area study. The decision for each boring is to determine whether the concentration of the liquid petroleum fuel constituent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: liquid petroleum fuel constituent concentration > applicable SSL
- H_A: liquid petroleum fuel constituent concentrations < applicable SSL

The decision rules associated with sampling at RU 12 for the liquid petroleum specific investigation area study are as follows:

- If the concentration of liquid petroleum fuel COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.
- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has liquid petroleum fuel COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.
- If the concentration of solvent COCs and COPCs is less than the applicable SSLs, then the lateral and vertical extent of the liquid petroleum fuel contamination has been delineated.

2.3.2.1.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.2.1.7 Optimize the Design

See Section 2.1.11.

2.3.2.2 RU 20 Liquid Petroleum Fuel Specific Investigation Area

2.3.2.2.1 State the Problem

RU 20 Liquid Petroleum Fuel Specific Investigation Area Conceptual Site Model

Petroleum fuels were stored in several above-ground fuel oil and diesel storage tanks at RU 20, and potential releases from these hydrocarbon storage facilities have not been fully investigated. At this time, the CSM recognizes that the operation of fuel storage facilities may have impacted soils and groundwater. Additional activities associated with liquid petroleum fuels include the production of asphalt (hot batch plant).

The investigation will be conducted in a phased approach to determine potential migration of liquid petroleum fuels to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based on fixed-laboratory data.

The specific investigation areas within RU 20 may have a fill thickness of a few inches to several feet. Therefore the depth of the native soil interface may vary. The optimization of the sampling design requires samples to be collected at the native soil interface, 2 feet below the native soil interface, 10 feet below ground surface and 10 feet below the native soil interface. In the event that the 10-foot bgs and 10-foot bns samples are within 2 feet of each other, the 10-foot bgs sample will be utilized for the 10-foot bns sampling point. In other words when the surface fill material thickness is two feet or less, the 10-foot bgs and 10-foot bns sample will be the same sample.

RU 20 Liquid Petroleum Fuel Specific Investigation Area Problem Statement

Sufficient sampling has not been conducted to determine potential impacts from the diesel fuel releases. The determination of the presence, absence, and concentrations of liquid petroleum fuels is needed to support a decision to either remediate the specific investigation area or to take no further action.

2.3.2.2.2 Identify the Decision

RU 20 Liquid Petroleum Fuel Specific Investigation Area Decisions

For the RU 20 liquid petroleum fuel specific investigation area study, the decisions associated with determining the extent of the fuel contaminated soil are:

- If the liquid petroleum fuel constituent concentrations in the soil are detected at levels above the applicable SSL, then additional vertical sampling may be required.

- If the liquid petroleum fuel constituent concentrations in the soil are less than the applicable SSL, then the extent of the liquid petroleum fuel contamination has been defined.

  Note: The list of compounds to be evaluated is provided in Table 1-5 Organic Compounds for Liquid Petroleum Fuels.

2.3.2.2.3 Identify the Decision Inputs

RU 20 Liquid Petroleum Fuel Decision Inputs

Process Knowledge RU 20

See Section 2.1.15.

Other Studies at RU 20

In 1997, BAPCO conducted an investigation into the alleged release of "oily sludge" from a railcar. The investigation identified TPH and BTEX compounds at a depth of 2.5 feet in one test pit. EPA notified the Jack B. Parson Company, owner of BAPCO, that no further investigation was needed based on the results of the investigation.

Fill Characteristics for RU 20

The fill material at RU 20 associated with fuel tanks and asphalt production equipment is expected to be native soil overlain with slag. Slag depth on the surface may range from 1 to 10 feet. The area within RU 20 was not known to have been used for phossy water, precipitator slurry, or other plant waste accumulation.

Risk Addressed by the RU 20 Liquid Petroleum Fuel Specific Investigation Area

A liquid petroleum fuel specific investigation area study is being performed at RU 20 to investigate the potential risk to future site workers and the potential release of liquid petroleum fuels at the two locations identified above. If the presence of liquid petroleum hydrocarbons is confirmed the risk is associated with the potential impact to future workers and the potential impact to groundwater.

2.3.2.2.4 Define the Boundaries

Boundaries Associated with RU 20 Liquid Petroleum Fuel Specific Investigation Area

Lateral Boundaries

The lateral boundaries associated with the liquid petroleum fuel specific investigation area at RU 20 will be defined based on the analytical results associated with the outermost borings.

Vertical Boundaries

The initial vertical boundary for the liquid petroleum fuel specific investigation area in RU 12 is 0-to-10 feet bns. If liquid petroleum fuels are detected at the 10-foot bns level then the vertical boundary is from ground surface to groundwater.

2.3.2.2.5 Define the Decision Rules

Decision Rules for the RU 20 Liquid Petroleum Fuel Specific Investigation Area

The following decision rules apply to the RU 20 liquid petroleum fuel specific investigation area study. The decision for each boring is to determine whether the concentration of the liquid petroleum fuel constituent is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: liquid petroleum fuel constituent concentration > applicable SSL
- H_A: liquid petroleum fuel constituent concentrations < applicable SSL

The decision rules associated with sampling at RU 20 for the liquid petroleum specific investigation area are as follows:

- If the concentration of liquid petroleum fuel COCs or COPCs associated with the potential migration to groundwater (i.e., 10 feet bns) is greater than the applicable SSLs, then the additional vertical sampling needed to address the migration from 10 feet below native soil to groundwater will be performed in phase two.
- If a sample (i.e., from native soil interface, 2 feet bns, 10 feet bgs or 10 feet bns intervals) from one or more of the outermost borings has liquid petroleum fuel COC and COPC concentrations above the applicable SSLs, then additional lateral delineation of the solvent specific investigation area will be addressed in phase two.
- If the concentration of solvent COCs and COPCs is less than the applicable SSLs, then the lateral and vertical extent of the liquid petroleum fuel contamination has been delineated.

2.3.2.2.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.2.2.7 Optimize the Design

See Section 2.1.15.

2.3.3 Constituents Associated with Coke

The need for specific investigation area studies associated with coke has been identified as:

- RU 7: subsurface migration of PAHs into underlying soil associated with the Shale Unloading, Crushing and Stock Pile – Coke Railcar Unloading Building (SWMU #105).
- RU 20: subsurface migration of PAHs into underlying soil associated with the Former Bannock Paving Area – Coke Handling Area and Settling Basins (included in SWMU #47)
- RU 20: potential migration of coke constituents to groundwater associated with the Coke Settling Basins (included in SWMU #47)
- RU 20: characterization of coke associated with the Former Bannock Paving Area – Coke Handling Area and Settling Basins (included in SWMU #47)

FMC has determined that evaluating the risk associated with PAHs in coke, which exists within the future worker risk scenario conceptual model, will be addressed by the SFS. Specifically, this would be the exposure of future site workers to coke that exists in the 0-2 foot and 0-10 foot exposure intervals.

2.3.3.1 RU 7 PAH Potential Migration into Soil Specific Investigation Area

2.3.3.1.1 State the Problem

RU 7 PAH Specific Investigation Area Conceptual Site Model

A reference study to determine the impact of coke with regards to the migration of PAHs into native soil will be performed as described in Section 2.2.3.2 at RU 20 where visible coke still exists on the surface. The information from the RU 20 coke reference study will be used to support the risk assessment activities in RU 7. The reference study area from RU 20 will be utilized for evaluating the potential for PAH migration with regards to SWMU # 105. Based upon the combined information of process knowledge, historical photos delineating the lateral boundaries of SWMU # 105, and the data collected in RU 7, the need for additional information related to this issue will be addressed in the SFS.

RU 7 PAH Problem Statement

Dry coke was unloaded from railcars in RU 7 for use in the P4 production process. Coke unloading and handling activities resulted in a release of coke to the ground surface in RU 7 at the coke unloading building. Although coke is no longer visible at the surface, characterization of the soils beneath the coke handling area is needed to support the remediation vision.

2.3.3.1.2 Identify the Decision

RU 7 PAH Specific Investigation Area Decisions

For the RU 7 PAH specific investigation area study, the decisions associated with determining the extent of PAH contaminated soil are:

- If the PAH concentrations in the soil are detected at levels above the applicable SSL, as indicated by the reference study in RU 20, then the area will be forwarded to the SFS.
- If the PAH concentrations in the soil are less than the applicable SSL, as indicated by the reference study in RU 20, then the migration of PAHs into Soil at RU 7 has been defined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Polynuclear Aromatic Hydrocarbons for Coke

2.3.3.1.3 Identify the Decision Inputs

RU 7 PAH Specific Investigation Area Decision Inputs

Process Knowledge RU 7

See Section 2.1.6.

Fill Characteristics

The fill material at the RU 7 PAH specific investigation area is expected to be native soil overlain with ore materials and to a lesser extent, slag.

Risk Addressed by RU 7 PAH Specific Investigation Area

A PAH specific investigation area study is being performed at RU 20 regarding the potential release of PAHs into the underlying soils from coke. This reference study will be utilized to address the potential release of PAHs into the underlying soils at RU 7. Based on the RU 20 reference study, the confirmed presence of PAHs above SSLs in native soil would pose a risk to future site workers, in accordance with the original CSM as defined in the RI Update Memorandum (BEI, 2004b), and to groundwater quality.

2.3.3.1.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for the coke handling building in RU 7 will be the length of the coke handling building and 10 feet on each side of the railroad tracks within the coke handling building. The area between the railroad tracks is not included.

Vertical Boundaries

The vertical boundary associated with the coke handling building is the same as for the RU 20 reference study, 0-to-2 feet bns.

2.3.3.1.5 Develop the Decision Rules

The following decision rules apply to the confirmation samples for the RU 7 PAH specific investigation area study. The decision to determine whether the concentrations of the PAHs are greater than the applicable SSL in the 0-to-2 foot bns interval is:

- H_0: PAH concentration in RU 20 reference study 0-to-2 foot bns interval > applicable SSL
- H_A: PAH concentration in RU 20 reference study 0-to-2 foot bns interval < applicable SSL

The decision rules associated with confirmation sampling at RU 7 for the PAH specific investigation area study are as follows:

- If the PAH constituent concentrations, as indicated by the RU 20 reference study are greater than the applicable SSLs, then the specific investigation area will be forwarded to the SFS. The need for additional vertical and/or lateral sampling will be determined as a part of the SFS activities.
- If the PAH constituent concentrations, as indicated by the RU 20 reference study are less than the applicable SSL value, then additional characterization of potential PAH migration into soil will not be required for RU 7.

2.3.3.1.6 Specify the Tolerance Limits of Decision Errors

The tolerance limits for RU 20 are located in Section 2.3.3.2.6.

2.3.3.2 RU 20 Potential Migration into Soil PAH Specific Investigation Area Reference Study

2.3.3.2.1 State the Problem

RU 20 PAH Specific Investigation Area Conceptual Site Model

The RU 20 PAH specific investigation area consists of the former coke handling and storage area which also contains the concrete lined coke settling basins located in RU 20. Wet coke (high moisture but not free water) was dried in a natural gas-fired coke dryer equipped with an air pollution scrubber system. Scrubber blowdown liquor was recycled through these concrete coke settling basins. Wet coke was also stockpiled in this area before the coke was dried prior to introduction into FMC's production process. Residual coke and coke fines remain on the ground surface near the coke drying facility. It is not anticipated that PAHs associated with coke stored on the surface migrated into the subsurface. However, the concrete lined coke settling basins did have a sustained hydraulic head. Therefore, a potential for migration of coke related PAHs into

the subsurface exists. Studies addressing the potential migration of coke constituents to groundwater at the coke settling basins are addressed in Section 2.3.3.3.

The determination of the lateral and vertical extent of coke can be achieved with visual observation of coke materials. To evaluate if coke in RU 20 poses a risk to underlying soil, sampling will be conducted at 0-to-2 feet bns.

RU 20 PAH Specific Investigation Area Problem Statement

Wet and dry coke was stored in RU 20 as part of the coke drying process. This process included a coke dryer scrubber and coke settling basins that contained a sustained hydraulic head as described above. Characterization of the soils beneath the coke handling area is needed to support the remediation vision.

2.3.3.2.2 Identify the Decision

For the RU 20 PAH specific investigation area, the decisions associated with determining the extent of PAH contaminated soil are:

- If the PAH concentrations in the soil are detected at levels above the applicable SSL in the 0-to-2 foot bns sample, then RU 20 will be forwarded to the SFS.
- If the PAH concentrations in the soil are less than the applicable SSL in the 0-to-2 foot bns sample, then the extent of the PAH contamination has been defined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Polynuclear Aromatic Hydrocarbons for Coke.

2.3.3.2.3 Identify the Decision Inputs

RU 20 PAH Specific Investigation Area Decision Inputs

Fill Characteristics

The fill material at RU 20 is expected to be native soil overlain with slag. Slag depth on the surface may range from 1 to 10 feet. The area within RU 20 was not known to have been used for phossy water, precipitator slurry, or other plant waste accumulation. The coke drying area is where coke was stored and dried. Aerial photographs indicate that this area has some coke materials on the surface as well as slag.

Risk Addressed by the RU 20 PAH Specific Investigation Area Study

A PAH specific investigation area study is being performed at RU 20 to investigate the potential release of PAHs into the underlying soils and to be utilized as a reference area for evaluating the coke specific investigation area of RU 7. The confirmed presence of PAHs in underlying soils above SSLs would pose a risk to future site workers in accordance with the original CSM as defined in the RI Update Memorandum (BEI, 2004b). Additionally, if PAHs have migrated into the underlying soil then a potential risk to groundwater must be evaluated.

2.3.3.2.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for the RU 20 coke PAH specific investigation area will be defined based on historical areal photographs and visual observations. The initial lateral extent is shown on Figure 2-6.

Vertical Boundaries

The vertical boundary for the PAH specific investigation areas in RU 20, not including the concrete coke settling basin, is 0-to-2 feet below the native soil interface.

2.3.3.2.5 Develop the Decision Rules

The following decision rules apply to the samples for the RU 20 PAH specific investigation areas. The decision for each boring/test pit is to determine whether the concentration of the PAHs is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: PAH constituent concentration at 0-to-2 foot bns > applicable SSL
- H_A: PAH constituent concentration at 0-to-2 foot bns < applicable SSL

The decision rules associated with sampling at RU 20 for the PAH specific investigation areas, except the concrete lined coke settling basins are as follows:

- If the PAH concentrations are greater than the applicable SSLs, then the area will be forwarded to the SFS.
- If one or more of the outermost borings have PAH concentrations above the SSL, then additional lateral delineation of the specific investigation area will be required.
- If the PAH concentrations are less than the applicable SSL value, then the lateral and vertical extent of coke PAH constituents have been delineated.

2.3.3.2.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.3.3.2.7 Optimize the Design

See Section 2.1.15.

2.3.3.3 RU 20 Coke Settling Basins Specific Investigation Area

2.3.3.3.1 State the Problem

RU 20 Coke Settling Basins Specific Investigation Area Conceptual Site Model

The RU 20 PAH specific investigation area consists of the former coke handling and storage area which also contains the concrete lined coke settling basins located in RU 20. Wet coke (high moisture but not free water) was dried in a natural gas-fired coke dryer equipped with an air pollution scrubber system. Scrubber blowdown liquor was recycled through these concrete coke settling basins. Wet coke was also stockpiled in this area before the coke was dried prior to introduction into FMC's production process. Residual coke and coke fines remain on the ground surface near the coke drying facility. It is not anticipated that PAHs associated with coke stored on the surface migrated into the subsurface. However, the concrete lined coke settling basins did have a sustained hydraulic head. Therefore, a potential for coke related PAHs to have migrated into the subsurface exists.

The investigation will be conducted in a phased approach to determine potential migration of coke PAHs and metals to groundwater. The first phase will investigate the potential migration into the upper 10 feet of native soil. After completion of the first phase, the study results and an evaluation of the results will be presented to the EPA. If indicated by the results of the phase one study, FMC will propose a phase two study that would further evaluate potential migration to groundwater and present that proposal in a draft SRI Work Plan addendum. The phase two study would proceed only upon EPA approval of the SRI Work Plan addendum. All decisions will be made based on fixed-laboratory data.

RU 20 Coke Settling Basins Specific Investigation Area Problem Statement

Wet and dry coke was stored in RU 20 as part of the coke drying process. This process included coke settling basins that had a sustained hydraulic head. The potential migration to groundwater for the concrete-lined coke settling basins needs to be investigated to support the remediation vision.

2.3.3.3.2 Identify the Decision

For the RU 20 PAH specific investigation area, the decisions associated with determining the extent of PAH contaminated soil are:

- If the PAH or metals concentrations in the soil are detected at levels above the applicable SSL in the samples, then RU 20 will be forwarded to the SFS.
- If the PAH and metals concentrations in the soil are less than the applicable SSL in the 10-foot below the coke settling basin sample, then the vertical extent of the PAH and metals contamination has been defined.
- If the PAH or metals concentrations in the soil are detected at levels above the SSL in the 10-foot below the coke settling basin sample then the data will be presented to the EPA and the need for a second phase that includes sampling to groundwater will be determined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Polynuclear Aromatic Hydrocarbons for Coke and Table 1-6 Metals.

2.3.3.3.3 Identify the Decision Inputs

RU 20 Coke Settling Basins Specific Investigation Area Decision Inputs

Fill Characteristics

The coke drying area is where coke was stored and dried. Aerial photographs indicate that this area has some coke materials on the surface as well as slag.

Risk Addressed by the RU 20 Coke Settling Basins Specific Investigation Area Study

A coke settling basins specific investigation area study is being performed at RU 20 to investigate the potential release of PAHs and metals into the underlying soils. The confirmed presence of PAHs or metals above SSLs would pose a risk to future site workers in accordance with the original CSM as defined in the RI Update Memorandum (BEI, 2004b). Additionally, if PAHs have migrated into the underlying soil at 10 feet below the coke settling basin then the potential migration of coke-related constituents to groundwater must be evaluated.

2.3.3.3.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for the RU 20 coke settling basins specific investigation area will be defined visually. The coke settling basins are shown on Figure 2-6.

Vertical Boundaries

The vertical boundary for the concrete lined coke settling basins is from ground surface to groundwater.

2.3.3.3.5 Develop the Decision Rules

The following decision rules apply to the samples for the RU 20 coke settling basins specific investigation areas. The decision for each boring is to determine whether the concentration of the PAHs or metals is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: PAH or metals constituent concentration in the soil below the coke settling basin > applicable SSL

- H_A: PAH or metals constituent concentration in the soil below the coke settling basin < applicable SSL

The decision rules associated with sampling at RU 20 for the PAH specific investigation areas, the concrete lined coke settling basins are as follows:

- If the PAH or metals concentrations are greater than the applicable SSLs in the soil samples below the coke settling basins, then RU 20 will be forwarded to the SFS.

- If the PAH and metals concentrations are less than the applicable SSLs, then the lateral and vertical extent of coke PAH constituents have been delineated.

- If the PAH or metals concentrations are greater than the applicable SSLs in the 10-foot below coke settling basin samples, then the area will be forwarded to the SFS and the need for a second phase investigation regarding soil concentrations of PAHs and metals down to groundwater will be evaluated with EPA input.

2.3.3.3.6 Specify the Tolerance Limits of Decision Errors

For the coke settling basins specific investigation area, a grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.3.4 Coke Characterization

2.3.3.4.1 State the Problem

Coke Characterization Conceptual Site Model

As stated in the RI Update Memorandum (BEI, 2004b) a data gap regarding the characterization of coke exists. Per the FMC conceptual model, total PAHs in coke as listed in Table 1-5 may exceed the SSLs for the coke material and could present an unacceptable risk to future outdoor workers based on ingestion, adsorption, or inhalation exposure pathways. Coke materials do not warrant testing since their PAH levels and resulting risk to future outdoor workers are already known. However, the coke needs to be evaluated to determine whether it exhibits any RCRA hazardous waste characteristic since that would affect how it would need to be managed if it were excavated and placed elsewhere as part of the FMC Plant OU remedial action. The waste characterization will involve testing the coke in RU 20 to determine if it exhibits the RCRA toxicity characteristic using the Toxicity Characteristic Leaching Procedure (TCLP). Waste characterization will be documented per 40 CFR Part 262.40(c). These results will be forwarded to the SFS. As discussed above, coke is presumed present in RU 7 at the coke unloading building (SWMU #105) and is known to be present in RU 20 at the coke handling area and coke settling basins (included in SWMU #47). However, waste characterization will be performed only at RU 20. The results from the RU 20 waste characterization and process knowledge will be used to characterize the coke at RU 7, if required.

Coke Characterization Problem Statement

The coke that remains at the FMC Plant OU has not been evaluated to determine whether it exhibits a RCRA hazardous waste characteristic, specifically the toxicity characteristic.

2.3.3.4.2 Identify the Decision

The decisions associated with determining the waste characterization of excavated coke are:

- If any constituent in the coke TCLP leachate exceeds a regulatory maximum concentration established under the RCRA toxicity characteristic, then the coke would be classified as a hazardous waste for purposes of evaluating disposal options.

- If all the constituents in the coke TCLP leachate are less than the regulatory maximum concentrations established under the RCRA toxicity characteristic, then the coke would not be classified as a hazardous waste for purposes of evaluating disposal options.

  Note: The list of compounds to be evaluated is provided in Table 1-7 Toxicity Characteristics Maximum Concentration Levels for Metals and Semi-volatile Organic Compounds.

2.3.3.4.3 Identify the Decision Inputs

Coke Characterization Decision Inputs

Process Knowledge

See Section 2.1.15.

Coke Characteristics

Analytical data for coke was reported to EPA in FMC's September 17, 2002 response to EPA's July 8, 2002 information request. Coke contained approximately 86.5% fixed carbon, 3.4% volatiles, 2.7% silica, 2.3% water, 1.3% Al2O3, 1.2% CaO, 1.2 % S, 0.5% Fe2O3, 0.46% MgO, and 0.05% K2O. Also, a TCLP analysis of coke from FMC's Kemmerer, WY coke plant was supplied to EPA at that time.

2.3.3.4.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries of the coke-related investigations in RUs 7 and 20 are discussed in Sections 2.3.3.1, 2.3.3.2.and 2.3.3.3.

Vertical Boundaries

The vertical boundaries of the coke-related investigations in RUs 7 and 20 are discussed in Sections 2.3.3.1, 2.3.3.2 and 2.3.3.3.

2.3.3.4.5 Develop the Decision Rules

The following decision rules apply to the coke characterization.

- H_0: contaminant concentrations in the coke TCLP leachate > the regulatory level of the maximum concentration established under the RCRA toxicity characteristic

- H_A: contaminant concentrations in the coke TCLP leachate < the regulatory level of the maximum concentration established under the RCRA toxicity characteristic

The decision rules associated with coke characterization are as follows:

- If the final ROD selects excavation and removal of coke in RU 7 and/or RU 20 as part of the FMC Plant OU remedial action, then the TCLP results and process knowledge will be used to determine the appropriate waste management for that material.

2.3.3.4.6 Specify the Tolerance Limits of Decision Errors

For the coke characterization investigation, sampling locations will be used to provide a 95 percent confidence that the sample exhibits the average properties of the waste.

2.3.3.4.7 Optimize the Design

See Section 2.1.15.

2.3.4 PCBs

A PCB specific investigation area has been identified for RU 12: Former RP&S Area and Mobile Shop - Transformer Storage Area. This is the only PCB specific investigation area identified.

2.3.4.1 State the Problem

RU 12 PCB Specific Investigation Area Conceptual Site Model

The PCB sampling pattern at RU 12 in the EMF RI (BEI, 1996) was too sparse to perform a specific investigation area study analysis that would support a reasonable decision regarding the need for remediation.

RU 12 PCB Specific Investigation Area Problem Statement

PCBs in soil must be adequately characterized to support a decision to either remediate PCB specific investigation areas or to take no further action.

2.3.4.2 Identify the Decision

RU 12 PCB Specific Investigation Area Decisions

For the RU 12 PCB specific investigation area study, the decisions associated with determining the extent of PCBs in soil are:

- If the PCB concentrations in the soil/fill material are detected at levels above the applicable SSL in the outer most borings, then additional definition of the lateral extent is required.

- If the PCB concentrations in the soil are detected at levels above the applicable SSL at 2 feet bns, then the additional vertical sampling is required.

- If the PCB concentrations in the soil are less than the applicable SSL, then the extent of the PCB contamination has been defined.

Note: The list of compounds to be evaluated is provided in Table 1-5 Polychlorinated biphenyls.

2.3.4.3 Identify the Decision Inputs

RU 12 PCB Specific Investigation Area Decision Inputs

Process Knowledge

See Section 2.1.11.

Risk Addressed by the RU 12 PCB Specific Investigation Area Study

The RU 12 PCB investigation will determine the risk posed to future site workers for PCBs.

2.3.4.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for the areas around the PCB storage shed and transformer salvage area in RU 12 will be defined by the analytical results from the borings/test pits. The initial lateral extent is shown in Figure 2-7.

Vertical Boundaries

The vertical boundary will be from ground surface to 2 feet below the native soil interface.

2.3.4.5 Develop the Decision Rules

The following decision rules apply to the confirmation samples for the RU 12 PCB specific investigation area study. The decision for each boring/test pit is to determine whether the concentration of PCBs is greater than the applicable SSL. Therefore, the null and alternative hypotheses are:

- H_0: PCB concentration at surface, every 2.5 ft to native, native surface interface, or 2 ft bns > applicable SSL

- H_A: PCB concentration at surface, every 2.5 ft to native, native surface interface, or 2 ft bns < applicable SSL

The decision rules associated confirmation sampling at RU 12 for the PCB specific investigation area study are as follows:

- If the PCB concentrations are greater than the applicable SSLs in the 0-to-2 foot bns sample, then additional vertical sampling will be performed.

- If one or more of the outermost borings have PCB concentrations above the SSL, then additional lateral delineation of the PCB specific investigation area will be required.

- If the PCB concentrations are less than the applicable SSL value, then the lateral and vertical extent of the PCB contamination has been delineated.

2.3.4.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.4.7 Optimize the Design

See Section 2.1.11.

2.3.5 Leaching Potential Investigations (Metals and Fluoride)

The need for metals and fluoride specific investigation area studies has been identified in the following RUs:

- RU 15: Oversized Ore, Used Electrodes, Baghouse Dust Area

- RU 16: Calciner Solids Stockpile

2.3.5.1 State the Problem

RU 15 and RU 16 Description of Conceptual Site Model

In the 1998 ROD, EPA selected a soil cover as the remedial action for the old calciner solids storage area, now known as RU 16. Consistent with the remedy selected for RU 16, FMC's remediation vision of consolidating, grading, and capping RU 15 is focused on reducing direct exposure to constituents in oversized ore and baghouse dust and controlling run-on/run-off to prevent migration via surface water runoff. EMF RI (BEI, 1996) data from the RU 7 area and ore feedstock indicates the material in RU 15 (ore and baghouse dust from ore handling facilities) exceed the SSLs for arsenic and possibly cadmium.

Although RUs 15 and 16 never had ponded materials, (i.e., a sustained hydraulic head), free liquids may have been present in calciner solids stockpiled at RUs 15 and 16. Free liquids, if present in the solids removed from the calciner ponds and placed in RUs 15 or 16, may have seeped into underlying soils. As discussed in the RI Update Memorandum (BEI, 2004b), a deep soil boring was completed at the Calciner Solids Stockpile (RU 16) during the EMF RI. Although samples from this boring indicated some contaminant migration in the soils, there was

no indication of groundwater contamination emanating from RUs 15 and 16 using FMC's monitoring well network.

RU 15 and RU 16 Problem Statement

Current soil conditions in the vadose zone beneath the stockpiles in RUs 15 and 16 have not been fully characterized. Additional data are needed to determine the potential for metals and fluoride migration into the subsurface and the potential for metals and fluoride migration to groundwater at RUs 15 and 16.

2.3.5.2 Identify the Decision

RU 15 and RU 16 Leaching Potential Decisions

For the RU 15 and RU 16 leaching potential investigation, the decisions associated with determining the extent of metals and fluoride migration in the soil are based on having collected sufficient information to allow for the design of the cap/cover. Therefore:

- If sufficient information exists to adequately characterize the soils in the vadose zone for purposes of cap/cover design, then additional sampling is not required.
- If sufficient information does not exist to adequately characterize the soils in the vadose zone for purposes of supporting cap/cover design, then additional SFS sampling may be required.

Note: The list of compounds to be evaluated for the reference studies consists of metals and fluoride, as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.5.3 Identify the Decision Inputs

RUs 15 and 16 Leaching Potential Decision Inputs

Process Knowledge

See Section 2.1.13.

Risk Addressed by RU 15 and RU 16 Leaching Potential

As stated above a cap/cover remedy has been selected for RU 16 and proposed for RU 15. The risk associated with RU 15 and RU 16 is from the potential migration of metals and fluoride to groundwater.

2.3.5.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for RU 15 and RU 16 leaching potential investigation are based upon aerial photographs and actual observation. These boundaries are shown in Figure 2-8.

Vertical Boundaries

The vertical boundaries for the RU 15 and RU 16 leaching potential investigation are from the surface to groundwater.

2.3.5.5 Develop the Decision Rules

The following decision rules apply to the data collection activities for the RU 15 and RU 16 leaching potential investigations. The decision for each RU is to determine whether the sufficient data have been gathered to characterize the vadose zone. Therefore, the null and alternative hypotheses are:

- H_0: constituent concentration at the 10-foot interval sample > applicable SSL or background
- H_A: constituent concentration at the 10-foot interval sample < applicable SSL or background
- H_0: sufficient samples were collected and analyzed to characterize the vadose zone.
- H_A: sufficient samples were not collected and analyzed to characterize the vadose zone.

The decision rules associated confirmation sampling at RU 15 and RU 16 for the leaching potential investigation are as follows:

- If a sufficient number of samples were collected, then additional sampling will not be performed.
- If the collected samples are not sufficient for characterization of the vadose zone, then additional sampling will be performed.

2.3.5.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.3.5.7 Optimize the Design

See Section 2.1.13.

2.3.6 Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Areas

Several roads are captured within specific RUs. In addition, RU 23 consists of road segments not within other RU boundaries. This study includes roadway segments both within other RUs and within RU 23 and is a separate study from the worker risk evaluation for RU 23 discussed in Section 2.5. Road locations selected within the FMC Plant OU for this investigation are either close to the precipitator dust/phossy solids storage area or were high traffic-hazard areas where

traction materials would have been needed for safe operations. Four of locations in the study are located in RU 24, one area is in RU 3, one area is in RU 23, and the comparative region is in the southern undeveloped area.

2.3.6.1 State the Problem

Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Area Conceptual Site Model

This RU accounts for road segments that are not included within the boundaries of other RUs. Plant roads are constructed primarily of slag, placed upon native soils or upon fill materials existing on the surface at the time of road construction. Roads that were paved were constructed of a slag base and asphalt with a slag aggregate. Until approximately 1992, precipitator dust/phossy solids may have been occasionally applied to roads during winter months for traction (as an alternative to salt) at the FMC Plant OU.

Both slag and precipitator dust/phossy solids contain constituents at levels above the applicable SSLs or background levels. However, the concentrations of these constituents in slag and precipitator dust/phossy solids are significantly different from each other (e.g., the concentration of Pb-210 in precipitator dust/phossy solids is at least ten times greater than the concentration in slag). Therefore, analyzing for the presence of constituents above the applicable CV will not provide adequate data to support a decision regarding constituents related to the presence of precipitator dust/phossy solids. However, the comparison of sample results from road segments potentially impacted by precipitator dust/phossy solids to road segments where precipitator dust/phossy solids was not utilized will provide data to support the decisions identified below.

Due the complexity of comparing the distributions of several constituents simultaneously for purposes of determining differences in two identified populations, Pb-210 has been selected for identifying the presence of precipitator dust/phossy solids in the roadway investigation. If precipitator dust/phossy solids are determined to be present, based on the analysis of Pb-210, then additional constituents will be analyzed.

To evaluate the potential presence of precipitator dust/phossy solids along the roadways FMC has identified six areas that are worst case scenarios in which precipitator dust/phossy solids would have been applied for traction purposes. These are either high traffic areas or areas with a steeper grade wherein the precipitator dust/phossy solids would have been needed. A comparative roadway has been identified in the remote southern region of the FMC Plant OU. This roadway is a slag based, unpaved road not used in the winter and had very little traffic during the remainder of the year. The section of roadway to be evaluated is located in a relatively level area that would not have required the use of any traction materials, even if used during the winter months.

Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Area Problem Statement

The purpose of this study is to determine if precipitator dust/phossy solids were applied on roads.

2.3.6.2 Identify the Decision

Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Area Decisions

- If the statistical distribution of precipitator dust/phossy solids in the worst case scenario location(s), as measured by Pb-210, is greater in central tendency and/or frequency of extremes than that exhibited in the slag based road in the southern area, then the worst case scenario locations(s) will have been impacted by precipitator dust/phossy solids.

- If the statistical distribution of precipitator dust/phossy solids in the worst case scenario location(s), as measured by Pb-210, is no greater in central tendency and/or frequency of extremes than that exhibited in the slag based road in the southern area, then the worst case scenario section(s) will not have been impacted.

Questions to be resolved are:

- If precipitator dust/phossy solids as measured by Pb-210 is present in a worst case scenario area above the level associated with the comparative roadway, then forward this information to the risk assessment (if the RU is still an NFA candidate) or the SFS (if the RU is no longer an NFA candidate).

- If precipitator dust/phossy solids as measured by Pb-210 is not present in the worst case scenario areas the roadways are not impacted due to precipitator dust/phossy solids.

2.3.6.3 Identify the Decision Inputs

Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Area Decision Inputs

Process Knowledge

See Section 2.1.22.

Risk Addressed by Precipitator Dust/Phossy Solids Distribution along Road Specific Investigation Areas

The risks addressed by investigating the presence of precipitator dust/phossy solids are those posed to site workers under the future redevelopment scenarios.

2.3.6.4 Define the Boundaries

Lateral Boundaries

Initially, the study boundaries are identified as those roads where precipitator dust/phossy solids are most likely to be found (i.e., worst case scenarios). The locations where precipitator dust/phossy solids on roadways will be investigated are:

- slag pit -haul road intersection with plant roadway (the intersection with the greatest safety concern),
- contractor access road at the contractor gate area (historically, a congested traffic area),
- near the northeast corner of the furnace building (most congested traffic area in this part of the plant),
- pond access road (precipitator dust/phossy solids were hauled over this road),
- east slag pile access road (routine heavy truck traffic), and
- road to contractor's yard (most congested traffic area in this part of the plant).

Vertical Boundaries

The vertical boundaries will be from the surface to 2 feet bgs.

2.3.6.5 Develop the Decision Rules

The decision associated with the each roadway segment is to determine if precipitator dust/phossy solids is present on the roads. Therefore, the null and alternative hypotheses are:

- H_0: The statistical distribution of Pb-210 in the worst case scenario location(s) is the same as that in the southern, low traffic road location
- H_A: The statistical distribution of Pb-210 in the worst case scenario locations(s) is greater in central tendency and/or extremes than that in the southern, low traffic road location.

The decision rules for the worst case scenario location(s) are as follows:

- If the statistical distribution of Pb-210 exceeds that of the southern low traffic road location in central tendency and/or extremes, then forward this information to the risk assessment (if the RU is still an NFA candidate) or the SFS (if the RU is no longer an NFA candidate).
- If the statistical distribution of Pb-210 does not exceed that of the southern low traffic road location in central tendency and/or extremes, then the area has not been impacted by precipitator dust/phossy solids.

2.3.6.6 Specify the Tolerance Limits of Decision Errors

The statistical significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and a nominal Type II error of 10%. Stated otherwise all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1.

The statistical techniques used for the conduct of the significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment as discussed in Section 5.

2.3.6.7 Optimize the Design

See Section 2.1.22.

2.3.7 Determination of Phossy Water Contamination in Soils in Selected RUs

The need for phossy water specific investigation area studies has been identified in the RUs listed below. Section 2.3.9 outlines additional studies regarding phossy water from underground piping.

- RU 3: Receiving Stores, Paint Shop, and P4 Decon – Surface water drainage flowing overland from RU 1 (Furnace Building, Phos Dock, and Secondary Condenser) to RU 22c (Railroad Swale)

- RU 6: Former Long Term Phos Storage Tanks (SWMU # 63)

2.3.7.1 RU 3 Phossy Water Specific Investigation Area

2.3.7.1.1 State the Problem

Description of Conceptual Site Model

Phossy water generated at the phos dock (RU 1) drained across the surface, primarily on paved roadway surfaces (in RU 3), to the railroad swale (RU 22c). Furnace operations ceased in December 2001 and the drainage stopped at that time. P4 that may have been present in the phossy water probably has oxidized.

RU 3 Phossy Water Specific Investigation Area Problem Statement

The impact to underlying soils due to drainage of phossy water across RU 3 has not been determined, and thus a decision to either remediate the specific investigation areas or to take no further action cannot be determined.

2.3.7.1.2 Identify the Decision

RU 3 Phossy Water Specific Investigation Area Decisions

For the RU 3 phossy water specific investigation area study, the decisions associated with determining the extent to which soils were impacted are:

- If the underlying soil has been impacted by the phossy water, then RU 3 will be forwarded to the SFS.

- If the underlying soil has not been impacted by the phossy water, then no further action is necessary with regards to constituents associated with phossy water.

  Note: The list of compounds to be evaluated for phossy water investigations consists of P4, metals and fluoride as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.7.1.3 Identify the Decision Inputs

RU 3 Phossy Water Specific Investigation Area Decision Inputs

Process Knowledge RU 3

See Section 2.1.2.

Fill Characteristic

The fill characteristics are assumed to be asphalt paving, with roadbase materials (which may include slag) under the paving.

Risk Addressed by the RU 3 Phossy Water Specific Investigation Area Study

The risks from the constituents associated with phossy water in RU 3 are those associated with the potential migration into the underlying soil.

2.3.7.1.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for the RU 3 phossy water drainage specific investigation areas will be defined by the analytical results from the boring/test pit. The initial lateral extent is the alignment of the surface flow.

Vertical Boundaries

The vertical boundary associated with the phossy water drainage in RU 3 is 0-to-2 feet bns.

2.3.7.1.5 Develop the Decision Rules

Given there is a possibility of encountering P4 at a level of acute health concern, as visually evidenced by smoking or burning, there are two decisions associated with the delineation of the P4 in RU 3.

1. Is P4 present at a level of acute health concern, as evidenced by smoking or burning? To address this question the following decisions apply:

   - If the residual P4 is present at a level of acute health concern, as evidenced by smoking or burning when drilling/excavating to native soil, then the borings/test

pits will be stopped, the sampling location moved and this part of the study repeated.

- If the residual P4 concentration is not present at level of acute health concern, as evidenced by a lack of smoking or burning when drilling/excavating to native soil, then confirmation samples will be collected in the 0-to-2 foot bns interval.

2. The decision associated with the confirmation sample to be collected in RU 3 is to determine if the underlying soils have been impacted by phossy water. Therefore, the null and alternative hypotheses are:

   - H_0: phossy water constituent concentration in 0-to-2 foot bns sample > applicable SSL or background

   - H_A: phossy water constituent concentration in 0-to-2 foot bns sample < applicable SSL or background

The decision rules associated with sampling at RU 3 for the constituents associated with phossy water are as follows:

- If the constituent concentrations are above the applicable SSLs or background levels in the underlying soil, the data will be forwarded to the SFS.

- If the constituent concentrations are below the applicable SSLs or background levels then no further action is required in regards to constituents associated with phossy water.

2.3.7.1.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.7.1.7 Optimize the Design

See Section 2.1.2.

2.3.7.2 RU 6 Long Term Phos Storage and Phossy Water Specific Investigation Area

2.3.7.2.1 State the Problem

RU 6 Description of Conceptual Site Model

As noted below, P4 was observed at low levels in surface soils around the tank filling points. This P4 has not been delineated within RU 6 and therefore additional confirmation sampling is needed. Phossy water spills at RU 6 would be limited to the area immediately surrounding the former underground storage tanks and the railcar loading/unloading area. P4 would most likely have been immediately oxidized during tank removal, and therefore, there should be no potential

for P4 migration. Inspection of the tanks after removal did not find evidence of tank failure. However, the soil beneath the tanks also needs to be evaluated. The railcar spur at the site where P4 was transferred to/from the former long-term P4 storage tanks (SWMU 63) is a potential source given absence of containment and potential for phossy water leakage.

RU 6 Phossy Water Specific Investigation Area Problem Statement

There is a potential that phossy water spills may have occurred during loading and unloading of railcars and filling tanks with phossy water. Shallow soil samples near the spur line and in the area of the former storage tanks are needed to evaluate the potential for constituents associated with phossy water in the underlying soils. Soil samples also will be collected beneath the former tanks to determine if phossy water constituents are present in the soil immediately beneath the tanks.

2.3.7.2.2 Identify the Decision

RU 6 Phossy Water Specific Investigation Area Decisions

For the RU 6 phossy water specific investigation area, the decisions associated with determining the extent to which soils were impacted are:

- If the underlying soils have been impacted by the phossy water, then RU 6 will be forwarded to the SFS.
- If the underlying soils have not been impacted by the phossy water, then no further action is necessary for constituents associated with phossy water.

Note: The list of compounds to be evaluated for phossy water investigations consists of P4, metals and fluoride as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.7.2.3 Identify the Decision Inputs

RU 6 Phossy Water Specific Investigation Area Decision Inputs

Process Knowledge RU 6

See Section 2.1.5.

Fill Characteristics

Soil borings drilled in RU 6 during the RI did not encounter P4. Some inorganics were detected at above-representative levels. The maximum depth investigated was 7 feet. Borings did not encounter slag, ore, or precipitator dust/phossy solids. However, slag has since been placed on the surface of RU 6.

Risk Addressed by RU 6 Phossy Water Specific Investigation Area

The risks addressed by the phossy water specific investigation areas in RU 6 are those associated with the potential migration into the underlying soil.

2.3.7.2.4 Define the Boundaries

Lateral Boundaries for Rail Spur in RU 6

The lateral boundaries for the RU 6 phossy water investigation along the rail spurs is from the edge of the rail spur to the foot print of the building, as determined from historical aerial photographs, for the length of the building.

Vertical Boundaries for Rail Spur in RU 6

The vertical boundary for the RU 6 phossy water investigation along the rail spurs is the 0-to-2 foot bns interval.

Lateral Boundaries for the Former Tank Storage Area in RU 6

The lateral boundaries for the RU 6 phossy water investigation at the former tank storage area will be delineated from the historical aerial photographs.

Vertical Boundaries for the Former Tank Storage Area in RU 6

The vertical boundary for the RU 6 phossy water investigation at the tank storage area is from 0-to-2 feet bns. This should ensure sampling below the fill material and the bottom of the tanks, given the voids remaining after tank removal was backfilled with fill material.

2.3.7.2.5 Develop the Decision Rules

Given there is a possibility of encountering P4 at a level of acute health concern, as visually evidenced by smoking or burning, there are two decisions associated with the delineation of the P4 in RU 6.

1. Is P4 present at a level of acute health concern, as evidenced by smoking or burning? To address this question the following decisions apply:

    - If the residual P4 is present at a level of acute health concern, as evidenced by smoking or burning when drilling/excavating to native soil, then the borings/test pits will be stopped, the sampling location moved and this part of the study repeated.

    - If the residual P4 concentration is not present at a level of acute health concern, as evidenced by a lack of smoking or burning when drilling/excavating to native soil, then confirmation samples will be collected in 0-to-2 foot bns interval.

2. The decision associated with confirmation sample in RU 6 is to determine if the underlying soils have been impacted by phossy water. Therefore, the null and alternative hypotheses are:

   - H_0: phossy water constituent concentration in 0-to-2 foot bns sample > applicable SSL or background

   - H_A: phossy water constituent concentration in 0-to-2 foot bns sample < applicable SSL or background

The decision rules associated with sampling at RU 6 for the constituents associated with phossy water are as follows:

- If the constituent concentrations are above the applicable SSLs or background levels in the underlying soil, the data will be forwarded to the SFS.

- If the constituent concentrations are below the applicable SSLs or background levels then no further action is required in regards to constituents associated with phossy water.

2.3.7.2.6 Specify the Tolerance Limits of Decision Errors

At the railspurs and tank storage area, a grid network of sampling locations will provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk. Beneath the former tanks, judgmental samples will be collected. Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.3.7.2.7 Optimize the Design

See Section 2.1.5.

2.3.8 Determination of Phossy and Precipitator Solids in Soils in RU 10 IWW Pond and Ditch

The IWW pond and ditch specific investigation within RU 10 (IWW Pond and Ditch) address two areas as follows:

- The Industrial Wastewater Pond (SWMU # 49), and

- The Industrial Wastewater Ditch (SWMU # 50).

2.3.8.1 State the Problem

RU 10 Industrial Wastewater (IWW) Pond (SWMU # 49) Description of Conceptual Site Model

The sediments within the pond and ditch as well as dredged sediments at the edge of the pond and ditch may contain minor levels of P4 related to inadvertent discharges of phossy water to the

IWW system in the furnace building. In this section, sediments refer to soil and materials that were deposited in the pond and ditch.

RU 10 IWW Ditch (SWMU # 50) Description of Conceptual Site Model

The sediments below the silica backfill in the former ditch and dredged sediments along the ditch route may contain minor levels of P4 related to inadvertent discharges of phossy water to the IWW system. Sediments were periodically excavated and stockpiled along the length of the ditch (to keep the channel flowing).

RU 10 IWW Pond and Ditch Specific Investigation Area Problem Statement

The extent of constituents associated with phossy water in RU 10 has not been adequately characterized to support a decision to either remediate the IWW Pond and Ditch specific investigation area or to take no further action.

2.3.8.2 Identify the Decision

RU 10 IWW Pond and Ditch Decisions

For the RU 10 IWW Pond and Ditch investigation, the decisions associated with determining the extent to which soils were impacted are:

- If the underlying soil has been impacted by the phossy water, then RU 10 will be forwarded to the SFS.
- If the underlying soils have not been impacted by the phossy water, then no further action is necessary in regards to constituents associated with phossy water.

Note: The list of compounds to be evaluated for phossy water and phossy solids investigations consists of P4, metals, fluoride, Po-210 and Pb-210 as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.8.3 Identify the Decision Inputs

RU 10 IWW Pond and Ditch

Process Knowledge RU 10

See Section 2.1.9.

Risk Addressed by RU 10 Phossy Water and Phossy Solids Investigation

The risks from the constituents associated with phossy water in RU 10 are those associated with the potential migration into the underlying soil.

2.3.8.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries for RU 10 are shown on Figure 2-10 and are defined by historical aerial photographs and by actual observation.

Vertical Boundaries

The vertical boundary for the RU 10 IWW Pond (SWMU # 49) investigation is from 0-2 feet bgs. The vertical boundary for the RU 10 IWW Ditch (SWMU # 30) investigation is from 0-to-2 feet bns.

2.3.8.5 Develop the Decision Rules

Given there is a possibility of encountering P4 at a level of acute health concern, as evidenced by smoking or burning, there are two decisions associated with the delineation of the P4 in RU 10.

1. Is P4 present at levels of acute health concern, as evidenced by smoking or burning? To address this question the following decisions apply:

    - If the residual P4 is present at a level of acute health concern, as evidenced by smoking or burning when drilling/excavating to native soil, then the borings/test pits will be stopped, the sampling location moved and this part of the study repeated.

    - If the residual P4 concentration is not present at a level of acute health concern, as evidenced by a lack of smoking or burning when drilling/excavating to native soil, then confirmation samples will be collected in the 0-to-2 foot bns or bgs interval, as applicable.

2. The decision associated with the confirmation sample in RU 10 is to determine if the underlying soils and sediments have been impacted. Therefore, the null and alternative hypotheses are:

    - H_0: constituent concentration in 0-to-2 foot bgs pond sample > applicable SSL or background

    - H_A: constituent concentration in 0-to-2 foot bgs pond sample < applicable SSL or background

    - H_0: constituent concentration in 0-to-2 foot bns ditch sample > applicable SSL or background

    - H_A: constituent concentration in 0-to-2 foot bns ditch sample < applicable SSL or background

The decision rules associated with sampling at RU 10 for the constituents associated with phossy water, sediments and phossy solids are as follows:

- If the constituent concentrations are above the applicable SSLs or background level in the underlying material (soils and sediments), then the data will be forwarded to the SFS.
- If the constituent concentrations are below the applicable SSLs or background level, then no further action is required for constituents associated with phossy water.

2.3.8.6 Specify the Tolerance Limits of Decision Errors

A grid network of sampling locations will be used to provide a 95 percent chance of locating a contiguous area of concentration above an applicable SSL of sufficient size so as to pose an unacceptable risk.

2.3.8.7 Optimize the Design

See Section 2.1.9.

2.3.9 Potential Leakage from Underground Piping Investigation

The need for determining the potential leakage from underground piping has been identified in the RUs listed below. Section 2.3.7 outlines additional studies regarding surficial releases of phossy water.

- RU 3: Receiving Stores, Paint Shop, and P4 Decon
- RU 12: Former RP & S Area and Mobile Shop
- RU 13: Pond 8S Recovery Process and Metal Scrap Preparation Area
- RU 24: Plant Areas not within RU Boundaries
- RU 1: Furnace Building, Phos Dock and Secondary Condenser
- RU 2: Slag Pit
- RU 22b: Old Ponds

2.3.9.1 RU 3 Underground Piping Investigation

2.3.9.1.1 State the Problem

RU 3 Underground Piping Investigation Conceptual Site Model

The decision whether to remove, decontaminate, or abandon underground piping, sumps or other structures will be an SFS decision based upon an analysis of alternatives. In order to provide the

SFS process with the appropriate information to evaluate the alternatives for underground piping/sumps/structures in RU 3, FMC proposes a phased approach. During the SRI, the phase one task for the underground piping investigation in RU 3 is to identify available information regarding remaining piping, sumps and structures, including the piping/sump/structure size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data collection activities in RU 3 conducted during the SRI, i.e., whether RU 3 remains designated as NFA or proceeds to the SFS.

If RU 3 remains designated as NFA, FMC will propose a phase two study that would further evaluate the buried piping/sumps/structures and present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation would proceed only upon EPA approval of the SRI Work Plan addendum. If RU 3 is forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures will also be forwarded to the SFS and a phase two study during the SRI would not be required.

RU 3 Underground Piping Investigation Problem Statement

The storm drain and underlying soil may contain P4, metals and fluorides from storm water collected from the furnace and phos dock area. This portion of the piping within RU 3 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

2.3.9.1.2 Identify the Decision

RU 3 Underground Piping Decisions

For the RU 3 underground piping investigation, the decisions associated with determining the need for remediation are:

- If RU 3, with the exception of underground piping, meets the criteria for a NFA designation then the risk associated the underground piping will be addressed in phase two.
- If it is determined that RU 3 is not a candidate for NFA, regardless of the risk associated with underground piping, then the RU will be forwarded to the SFS.

Note: The list of compounds to be evaluated for phossy water investigations related to the underground piping consists of P4, metals and fluoride as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.9.1.3 Identify the Decision Inputs

RU 3 Underground Piping Investigation Decision Inputs

Process Knowledge RU 3

See Section 2.1.2.

Fill Characteristics

The fill materials around the underground storm drain piping is likely to consist of native soils, although other fill materials (i.e., slag) may be present.

Risk Addressed by RU 3 Underground Piping Investigation

The risks addressed by the phossy water specific investigation areas related to the underground piping in RU 3 are those associated with the potential migration into the underlying soil.

2.3.9.1.4 Define the Boundaries

Lateral Boundaries for RU 3 Underground Piping Investigation

The lateral boundaries for the RU 3 underground piping will be the length and width of the underground piping and the area impacted by any leaks associated with the underground piping as defined by phase two.

Vertical Boundaries for RU 3 Underground Piping Investigation

The vertical extent for the RU underground piping investigation in phase two will include the potential vertical migration into the underlying fill/soil.

2.3.9.1.5 Develop the Decision Rules

Phase One Decision Rules:

The decision associated with phase one is concerned with performing the phase two study.

- H_0: RU 3, except for underground piping > Applicable CVs
- H_A: RU 3, except for underground piping < Applicable CVs

The decision rules associated with phase one at RU 3 for the underground piping investigation are as follows:

- If after evaluating the risk to future site workers for all other data collected in RU 3, except for the underground piping, it is determined that RU 3 will be NFA, then phase two will be designed to incorporate all new relevant data to evaluate the potential risk associated with the underground piping.

- If after evaluating the risk to future site workers for all other data collected in RU 3, except for the underground piping, it is determined that RU 3 will be forwarded to the SFS, then no additional sampling will be required in the SRI with regards to the underground piping in RU 3.

Phase Two Decision Rules

Phase two decision rules will be established during the design of the phase two study.

2.3.9.1.6 Specify the Tolerance Limits of Decision Errors

Tolerance limits of decision errors are not applicable to phase one.

2.3.9.2 RU 12, RU 13, and RU 24 Underground Piping Investigation

2.3.9.2.1 State the Problem

RU 12, RU 13, and RU 24 Underground Piping Conceptual Site Model

An underground piping system that was abandoned circa 1998 carried phossy water and precipitator slurry from the furnace building and phos dock and traversed RU 12, RU 13, and RU 24 to the pond area. This pipeline system is included in the following SWMUs:

- SWMU #64 partial: historical releases from underground segments of the former pipeline system, while undocumented, are suspected.

- SWMU # 65 partial: historical releases from underground segments of the former pipeline system, while undocumented, are suspected.

- SWMU # 82 partial: The above-grade portion of the pipeline system is not a potential source. In addition to the documented June 1996 release of phossy water/slurry as described in the RI Update Memorandum (BEI 2004), undocumented historical releases from underground segments of the former pipeline system are suspected, making the underground segments a potential source.

The decision whether to remove, decontaminate, or abandon underground piping, sumps or other structures will be an SFS decision based on an analysis of alternatives. In order to provide the SFS process with the appropriate information to evaluate the alternatives for underground piping/sumps/structures, FMC proposes a phased approach. During the SRI, the phase one task for the underground piping investigation in RUs 12, 13, and 24 is to identify available information regarding remaining piping, sumps and structures, including their size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding the residuals expected to be remaining in the pipes/sumps/structures. The phase one task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. The need to collect additional data concerning remaining pipes/sumps/structures will be based on the outcome of all other data

collection activities conducted during the SRI in RUs 12, 13, and 24, i.e., whether these RUs remain designated as NFA or proceeds to the SFS.

If any of these RUs remain designated as NFA, FMC will propose a phase two study for those RUs remaining as NFA that would further evaluate the buried piping/sumps/structures. FMC would then present that proposal to EPA in a draft SRI Work Plan addendum. The phase two investigation would proceed only upon EPA approval of the SRI Work Plan addendum. If any of these RUs are forwarded to the SFS as result of this or any other investigation, the information compiled during the phase one study on piping/sumps/structures for that RU will also be forwarded to the SFS and a phase two study during the SRI would not be required for that RU.

RU 12, RU 13, and RU 24 Underground Piping Problem Statement

The portion of the underground piping, sumps or other structures within RU 12, RU 13, and RU 24 was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in this RU after decommissioning is needed to support a decision to further remediate the specific investigation area or to take no further action.

2.3.9.2.2 Identify the Decision

RU 12, RU 13, and RU 24 Underground Piping Decisions

For the RU 12, RU 13, and RU 24 underground piping investigation, the decisions associated with determining need for remediation are:

- If an RU, with the exception of underground piping, meets the criteria for an NFA designation then the risk associated the underground piping will be addressed in phase two.
- If it is determined that an RU is not a candidate for NFA, regardless of the risk associated with underground piping, then the RU will be forwarded to the SFS.

Note: The list of compounds to be evaluated for phossy water and phossy solids investigations associated with the underground piping consists of P4, metals, fluoride, Po-210 and Pb-210 as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.3.9.2.3 Identify the Decision Inputs

RU 12, RU 13, and RU 24 Underground Piping Decision Inputs

Process Knowledge RUs 12, 13, and 24

See Sections 2.1.11, 2.1.12, and 2.1.20.

Risk Addressed by RU 12, RU 13, and RU 24 Underground Piping Investigation

For areas determined to be impacted in RU 12, RU 13, and RU 24 the risk posed would be that related to the underground piping in RUs 12, 13, and 24 are those associated with the potential migration into the underlying soil.

2.3.9.2.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries associated with the RU 12, RU 13, and RU 24 underground piping investigation are shown in Figure 2-11. The lateral boundaries for the underground piping and the area impacted by any leaks associated with the underground piping will be defined by phase two.

Vertical Boundaries

The vertical boundaries associated with the RU 12, RU 13, and RU 24 underground piping investigation in phase two will include the vertical migration into the underlying fill/soil.

2.3.9.2.5 Develop the Decision Rules

Phase One Decision Rules:

The decision associated with phase one is concerned with performing the phase two study.

- H_0: RUs 12, 13, and 24, except for underground piping > Applicable CVs
- H_A: RUs 12, 13, and 24, except for underground piping < Applicable CVs

The decision rules associated with phase one at RUs 12, 13, and 24 for the underground piping investigation are as follows:

- If after evaluating the risk to future site workers for all other data collected in RUs 12, 13, and 24, except for the underground piping, it is determined that RUs 12, 13, and 24, will be NFA, then phase two will be designed to incorporate all new relevant data to evaluate the potential risk associated with the underground piping.
- If after evaluating the risk to future site workers for all other data collected in RUs 12, 13, and 24, except for the underground piping, it is determined that RUs 12, 13, and 24, will be forwarded to the SFS, then no additional sampling will be required in the SRI with regard to the underground piping in RUs 12, 13, and 24.

Phase Two Decision Rules:

Phase two decision rules will be established during the design of the phase two study.

2.3.9.2.6 Specify the Tolerance Limits of Decision Errors

Tolerance limits of decision errors are not applicable to phase one.

2.3.9.2.7 Optimize the Design

See Sections 2.1.11, 2.1.12, and 2.1.20.

2.3.9.3 RU 1, RU 2 and RU 22b Underground Piping Investigation

2.3.9.3.1 State the Problem

RU 1, RU 2, and RU 22b Underground Piping Conceptual Site Model

RU 1 encompasses the furnace building, secondary condenser, and Phos Dock. These were the primary P4 production, storage, and handling areas within the FMC Plant OU. The furnace building had four electric arc furnaces, and associated primary condensers, P4 sumps, various tanks and piping. The secondary condenser had a single P4 sump. P4 from the sumps was pumped to the Phos Dock for storage and loading onto railcars. The slag pit (RU 2) is south of the former furnace building and consists of a pit where slag from the furnaces was accumulated, cooled, broken, and loaded onto slag haul trucks to be placed on the slag pile. RU 22b consists of the area containing old ponds (closed before RCRA requirements applied) within four parcels to the west of RU 12. These ponds historically received phossy water and precipitator slurry and were taken out of service and allowed to dry before RCRA was enacted or its requirements became effective.

During plant decommissioning, all above-ground tanks, equipment, and piping were removed. The plant has now been fully decommissioned and most buildings, including the furnace building, have been dismantled and removed. The furnace building foundation currently is primarily a level concrete slab with below grade sumps and launders. The sumps and below grade features have been backfilled and the fill material was graded to manage run-on/run-off and prevent water accumulation in these areas. An inventory of the furnace building foundation, sumps, piping and other structures is needed for the final cap/cover design.

Underground piping in RU 1, RU 2, and RU 22b is primarily mild steel pipe, with diameters of four to six inches. These pipes carried phossy water and precipitator slurry to the ponds. The underground piping system that was abandoned circa 1998 carried phossy water and precipitator slurry from the furnace building and phos dock and traversed RUs 1 and 2 to and through the pond area, RU 22b. This pipeline system and other sumps, tanks, or structures in RUs 1, 2, and 22b are included in the following SWMUs:

- SWMU #77: Phosphorus Loading Dock, Andersen Scrubber Blowdown Sump, and North Solid Tank: The above-grade P4 storage tanks were contained within a concrete vault. Overflow from these tanks was directed to a launder that returns the flow to the process. Prior to approximately 1970, product storage tank was a large in-ground covered concrete sump. It is a potential source due to historical spills of phossy water.

- SWMU #78: Washdown Collection Sumps: These seven concrete sumps (flow-through process tanks) and connecting launders in Furnace Building were used to collect phossy wastewater generated from furnace washdown. Sumps had pumps to transfer wastewater to Tank V-3600. If one sump overflowed due to pump problems, wastewater would drain into an adjacent sump. It is a potential source due to historical spills of phossy water.

- SWMU #79 Northeast Collection Sump – Furnace Building Area: This 6x6x7 foot stainless steel-lined sump was used for collection of phossy wastewater. Wastewater was pumped to the phosphorus loading dock for further use in the process. If the sump overflowed, wastewater flowed to one of the furnace washdown sumps. It is a potential source prior to containment system upgrades.

- SWMU #80: Southeast Collection Sump – Furnace Building Area: This 10,000-gallon capacity sump was used for collection of nonhazardous storm water runoff and tapping floor washwater from east side of No. 1 Furnace. It is a potential source due to historical spills of phossy water.

- SWMU # 104: Sump accumulated P4 product stream from the #3 Furnace condenser and directed the P4 product to the Phos Dock. A stainless steel tank was installed within the sump in August 1999 after excavation beneath the floor of the Furnace Building revealed P4 in soil. Each furnace had a similar in ground, brick-lined, concrete product sump.

- SWMU # 82 partial: The above-grade portion of the pipeline system is not a potential source. In addition to the documented June 1996 release of phossy water/slurry as described in the RI Update Memorandum, undocumented historical releases from underground segments of the former pipeline system are suspected, making the underground segments a potential source within RUs 1, 2, and 22b.

- SWMU #5: RCRA Interim Status Closure Subpart K Surface Impoundment. Pit cooling water and furnace wash down wastewater was historically drained to the unlined Slag Pit collection sump, which is about 10 feet by 10 feet in southeast corner of the slag pit. It was replaced in 1991 by a furnace wastewater collection tank. SWMU #5 was closed in accordance with an approved EPA Closure Plan.

- SWMU #64: Phossy Water Pipeline Cleanout Areas and Intervals. This includes the underground phossy water pipeline and cleanout areas for that section of the pipeline that lies with RU 22b.

- SWMU #65: Precipitator Slurry Pipeline. This includes that section of the underground precipitator slurry pipeline that lies within RU 22b.

The decision whether to remove, decontaminate, or abandon underground piping will be an SFS decision based on the detailed analysis of alternatives. To provide the SFS process with sufficient information to evaluate the alternatives for underground piping, FMC proposes an SRI task to identify available information regarding remaining subsurface piping/sumps/structures,

including their size, material of construction, methods of closure at plant shut-down (i.e., capped, cleaned, removed, etc.), and any process knowledge regarding residual constituents that may remain in the pipes. This task will be based upon existing drawings, construction records, operational logs, and plant personnel knowledge. This data will be forwarded to the SFS to be evaluated as part of the cap design for RUs 1, 2, and 22b.

RU 1, RU 2, and RU 22b Underground Piping Problem Statement

The portion of the piping and sump system within RUs 1, 2, and 22b was not evaluated during the remedial investigation. Sufficient information regarding underground piping, sumps, and other structures left behind in these RUs after decommissioning is needed to support the SFS.

2.3.9.3.2 Identify the Decision

RU 1, RU 2, and RU 22b Underground Piping Decisions

The decision whether to remove, decontaminate, or abandon underground piping will be an SFS decision based on the detailed analysis of alternatives.

2.3.9.2.3 Identify the Decision Inputs

RU 1, RU 2, and RU 22b Underground Piping Decision Inputs

Process Knowledge RU 1, RU 2, and RU 22b

See Sections 2.1.1 and 2.1.17

Risk Addressed by RU 1, RU 2, and RU 22b Underground Piping Investigation

For areas determined to be impacted in RU 1, RU 2, and RU 22b the risk posed would be that related to the underground piping in RU 1, RU 2, and RU 22b are those associated with the potential migration into the underlying soil.

2.3.9.2.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries associated with the RU 1, RU 2, and RU 22b underground piping investigations are shown in Figure 2-11.

Vertical Boundaries

The vertical boundaries associated with the RU 1, RU 2, and RU 22b underground piping investigation will be the depths at which the piping is reported to be located.

2.3.9.2.5 Develop the Decision Rules

The decision whether to remove, decontaminate, or abandon underground piping will be an SFS decision based on the detailed analysis of alternatives.

2.3.9.2.6 Specify the Tolerance Limits of Decision Errors

Tolerance limits of decision errors are not applicable this task

2.3.9.2.7 Optimize the Design

See Sections 2.1.1 and 2.1.17

2.3.10 Pond Closure Decant Treatment (PCDT) System Roadway Study

2.3.10.1 State the Problem

PCDT Water Application along Road Specific Investigation Area Conceptual Site Model

This investigation includes plant roads within RUs. Many plant roads were built with a slag base to handle heavy equipment (slag haulers, etc.). Slag has been analyzed for uranium-238, uranium-234, thorium-230, radium-226, potassium-40, lead-210, polonium-210, thorium-232, and radium-228. The activities of these isotopes in slag are presented in Table B-1 of Appendix B. During 2004 and 2005 treated effluent water from Ponds 8E, 15S, 16S, 18, 17 and Phase IV ponds was utilized for general dust control (i.e., roads) and dust control in the pond closure construction area. The potential mass loading or depositing of contaminants onto the roadways was addressed in Appendix I of the RI Update Memorandum (BEI, 2004b). As shown in Appendix I, the PCDT water contained low concentrations of the same suite of constituents in slag, thus making an investigation of PCDT water on slag roadways difficult.

PCDT water used for dust suppression on roads was most heavily applied on a slag road within RU 20 starting at the water treatment facility and running north and then west toward RU 20. Therefore, evaluation of a road segment in RU 20 should represent a worst case scenario (i.e., road with the greatest application of water treated at PCDT). Dust suppression was never applied to many road segments within the plant, including the slag haul road running north-south in the center of RU 19. Therefore, a road segment in RU 19 would be considered a reference area (i.e., a slag covered road with no PCDT water application).

PCDT Water Application along Road Specific Investigation Area Problem Statement

The potential impact of PCDT water application along roads within the FMC Plant OU has not been adequately characterized.

2.3.10.2 Identify the Decision

- If the statistical distribution of constituents in the worst case scenario slag-based road segment is greater in central tendency and/or frequency of extremes than that

exhibited in the slag-based reference road, then the worst case scenario will have been impacted by PCDT water.

- If the statistical distribution of constituents in the worst case road segment is no greater in central tendency and/or frequency of extremes than that exhibited in the slag based reference road, then the worst case scenario road segment will not have been impacted.

Note: The list of compounds to be evaluated for the PCDT study consists of metals, fluoride, U-238, Ra-226, K-40, Pb-210, Po-210, as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

Questions to be resolved are:

- If PCDT water constituents in a worst case scenario area are above the level associated with the comparative roadway, then forward the study results either to the risk assessment (if the RU is still potentially NFA) or the SFS (if the RU is no longer potentially NFA).

- If PCDT water constituents are not present in the worst case scenario areas, the roadways are not impacted due to PCDT water.

2.3.10.3 Identify the Decision Inputs

Process Knowledge

During 2004 and 2005 treated effluent water from Ponds 8E, 15S, 16S, 18, 17 and Phase IV ponds was utilized for general dust control (i.e., roads) and dust control in the pond closure construction area. The water was applied to slag roads starting in RU 20 and out to the pond area in RU 22a by two or three water trucks. Additional information on the PCDT water constituents, application rates and the potential mass loading or depositing of contaminants onto the roadways was provided in Appendix I of the RI Update Memorandum (BEI, 2004b).

2.3.10.4 Define the Boundaries

2.3.10.4.1 Lateral boundaries:

The lateral boundaries of the worst case road segment potentially impacted by the application of PCDT water for dust control and the reference road segment are shown in Figure 2-44.

2.3.10.4.2 Vertical boundaries:

The vertical boundaries of the roads potentially impacted by the application of PCDT water for dust control are 0-0.5 feet.

2.3.10.5 Develop the Decision Rules

The decision associated with the worst case road segment and the reference roadway segment is to determine if PCDT water constituents are present on the roads compared to a reference area. Therefore, the null and alternative hypotheses are:

- H_0: The statistical distribution of constituents in the worst case scenario road segment is the same as that in the slag haul road reference segment.

- H_A: The statistical distribution in the worst case scenario locations(s) is greater in central tendency and/or extremes than that in the southern, low traffic road location.

The decision rules for the PCDT water study are as follows:

- If the statistical distribution exceeds that of the reference road location in central tendency and/or extremes, and the roadway is located in an RU that is still NFA, then that road segment and other road segments that received PCDT water as dust suppressant will be forwarded to the risk assessment along with the results of the PCDT water application study.

- If the statistical distribution exceeds that of the reference road location in central tendency and/or extremes and the roadway is located in an RU that has been forwarded to the SFS, then the results of the PCDT water application study will be forwarded to the SFS.

- If the statistical distribution does not exceed that of the reference road location in central tendency and/or extremes, then no further consideration of PCDT water application is required.

2.3.10.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

2.3.10.7 Optimize the Sampling Design

See Section 2.1.22.

2.4 EVALUATION OF RADON FLUX STUDY

RUs with the greatest potential for radon flux exists, based solely on the radium-226 content of contained source materials, include the following:

- RU 19: Slag Pile

- Test Cap Soil Cover – radon flux will be measured if the slag pile is above the levels defined below.

- RU 19: Bull Rock Pile
- RU 22b: Old Phossy Ponds
- RU 7: Shale Unload, Crushing and Stockpile

2.4.1 RU 19 and RU 22b Radon Flux Study

2.4.1.1 State the Problem

Evaluation of Radon Flux Study Conceptual Site Model

FMC's remedial vision for RU 19 (slag and bull rock piles) is a soil cover (Figure 2-12). A soil cover at the slag pile will shield future site workers from gamma emissions at the slag pile. Although the slag contains radium-226, which decays to radon, a radioactive gas[1], FMC's assessment is that slag has a vitrified matrix and radon gas flux is significantly inhibited. RU 19 has a test cap soil cover that will undergo evaluation of radon flux measurements if the RU 19 slag pile average radon flux exceeds the CV to assist in evaluating the effectiveness of soil cap/cover designs in reducing radon flux from the slag pile.

The bull rock pile primarily consists of reject oversized ore in which the radium-226 originates. As the ore has not been vitrified, the bull rock pile area of RU 19 will be evaluated separately from the slag pile to determine if controlling radon flux is relevant in developing cap/cover design criteria.

Radon flux from old phossy pond sediments will be considered in developing cover design criteria. Therefore, radon flux measurements from the former phossy waste ponds (RU 22b) will be obtained during the SRI. The RU will be divided into two decision units for the radon flux tests. A radon flux test will be performed at the largest, eastern-most parcel of RU 22b, which contains historic precipitator slurry ponds and phossy water ponds. The three western-most parcels of RU 22b only contained precipitator slurry ponds and, therefore, will be evaluated separately from the eastern-most parcel.

RUs 19 and 22b Evaluation of Radon Flux Study Problem Statement

Radon emission rates from the uncovered slag pile, bull rock pile and old phossy ponds have not been quantified. Determination of the radon flux is required in order to evaluate remedial alternatives for the slag pile and bull rock pile within RU 19 in the SFS as well as the former phossy waste ponds at RU 22b. These flux rates may be relevant to the design of caps/covers for these areas to meet the UMTRCA guidelines for radon in the event these guidelines are identified as an ARAR in the SFS.

In addition, these data along with other radon meaurements (e.g,, at RU 7 and RU 19) will be used to evaluate the potential for radon flux to be an issue of concern within other RUs that contain residual fill material.

[1] Radon (^{222}Rn) is a noble gas derived from the radioactive decay of an isotope of radium (^{226}Ra).

2.4.1.2 Identify the Decision

Evaluation of Radon Flux Study Decisions

For the evaluation of radon flux study, the decisions associated with determining the radon flux over a defined area are:

- If the average radon flux is above the UMTRCA guidelines, then additional studies will be needed.
- If the average radon flux is below the UMTRCA guidelines, then the remediation vision with respect to radon will have been confirmed.

2.4.1.3 Identify the Decision Inputs

Evaluation of Radon Flux Study Decision Inputs

The primary inputs to the decision are EPA Method 115 and the UMTRCA guidelines for radon emission rates from mine tailings and mine wastes. UMTRCA specifies that radon fluxes not exceed 20 pCi/m^2/sec. EPA Method 115 is discussed in Section 3. Secondary inputs to the decision are the detection limits of the radon flux chambers and the variability of radon emissions. The variability can be spatial, seasonal, or related to short-term weather events (e.g., rising or falling barometric pressure, wind, soil moisture, relative humidity).

Process Knowledge for RU 19 and Test Cap Soil Cover

See Section 2.1.14.

RU 22b Process Knowledge

See Section 2.1.17.

Electret Ion Chambers

The detection limits of the radon flux chambers and the variability of radon emissions are addressed in Section 3.

Risks Addressed by Evaluation of Radon Flux Study

This study will address the potential that the cap/cover proposed for the slag pile, bull rock pile and old phossy ponds may need to be designed to control radon emissions.

In addition, these data along with other radon measurements (e.g,, at RU 7 and RU 19) will be used to evaluate the potential for radon flux to be an issue of concern at other RUs that contain residual fill material.

2.4.1.4 Define the Boundaries

Lateral Boundaries

Figure 2-12 illustrates the boundaries associated with the slag pile, the bull rock pile, and RU 22b area designated for radon flux measurements. The lateral boundaries for the RU 19 Test Cap Soil Cover are illustrated in Figure 2-38. Lateral boundaries will also be based upon actual observation.

Vertical Boundaries

The vertical boundaries are defined as the depth of fill that could contribute to radon emanation to the atmosphere. This depth is not defined because it depends on the gradation of fill, soil moisture, and other factors that are temporally and spatially variable. The upper boundary is the slag/atmosphere interface because this constitutes the point where radon fluxes are quantified.

2.4.1.5 Develop the Decision Rules

The decision associated with the radon flux studies is to compare the results with the UMTRCA guidelines. Therefore, the null and alternative hypotheses are:

- H_0: average radon flux > 20 pCi/m^2/sec
- H_A: average radon flux < 20 pCi/m^2/sec

The decision rules for radon flux measurements for the RU 19 slag pile are as follows:

- If the average radon flux from the slag pile is above the UMTRCA guideline, then the results from the soil test cover will be evaluated.
- If the average radon flux from the slag pile is below the UMTRCA guideline, then the control of radon flux is not a relevant cap/cover design criterion for the slag pile.

The decision rules for radon flux measurements in the RU 19 soil test cover are as follows:

- If the average radon flux from the soil test cover is above the UMTRCA guideline, then the soil cover may need to be further evaluated in the SFS with respect to controlling radon flux.
- If the average radon flux from the soil test cover is below the UMTRCA guideline, then radon flux control does not need to be further evaluated in the SFS.

The decision rules for radon flux measurements in the RU 19 the bull rock pile and RU 22b are as follows:

- If the average radon flux from the pile is above the UMTRCA guideline, then radon flux control may be a cover/cap design criterion in the SFS.

- If the average radon flux from the pile is below the UMTRCA guideline, then radon flux control does not need to be further evaluated in the SFS.

2.4.1.6 Specify the Tolerance Limits of Decision Errors

The statistical significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and a nominal Type II error of 10%. Stated otherwise all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1. The Type II error rate, which characterizes the risk of performing unnecessary remediation, may be adjusted to reflect the relative costs of remediation versus additional sampling.

The statistical techniques used for the conduct of the significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment as discussed in Section 5.

2.4.1.7 Optimize the Design

See Section Sections 2.1.14 and 2.1.17.

2.4.2 RU 7 Radon Flux Study

2.4.2.1 State the Problem

Evaluation of Radon Flux Study Conceptual Site Model

The original Remediation Vision for RU 7 as stated in the RI Update Memo (BEI, 2004b) was no action anticipated to be necessary, following the sale and removal of the ore inventory. The RI Update Memorandum did not identify radon as a data gap for RU 7. However, since the time of the RI Update Memo, only a portion of the ore inventory was sold and removed. Since radium-226 levels in ore are elevated above background, and ore remains at the plant site, radon flux has been identified as a data gap.

RU 7 Evaluation of Radon Flux Study Problem Statement

Radon emission rates from the shale ore handling area have not been quantified. Evaluation of the radon flux from RU 7 is required in order to determine if the level of radon flux requires RU 7 to be forwarded to the SFS.

In addition, these data along with other radon measurements (e.g,, at RU 19) will be used to evaluate the potential for radon flux to be an issue of concern at other RUs that contain residual fill material.

2.4.2.2 Identify the Decision

Evaluation of Radon Flux Study Decisions

For the evaluation of radon flux study, the decisions associated with determining the radon flux over a defined area are:

- If the average radon flux is above the UMTRCA guidelines, then RU 7 will be forwarded to the SFS and additional radon studies may be necessary in other RUs.
- If the average radon flux is below the UMTRCA guidelines, RU 7 will continue to proceed down the appropriate risk or SFS data collection pathway, with no further consideration of the need for radon mitigation measures anticipated to be necessary.

2.4.2.3 Identify the Decision Inputs

Evaluation of Radon Flux Study Decision Inputs

The primary inputs to the decision are EPA Method 115 and the UMTRCA guidelines for radon emission rates from mine tailings and mine wastes. UMTRCA specifies that radon fluxes not exceed 20 pCi/m^2/sec. EPA Method 115 is discussed in Section 3. Secondary inputs to the decision are the detection limits of the radon flux chambers and the variability of radon emissions. The variability can be spatial, seasonal, or related to short-term weather events (e.g., rising or falling barometric pressure, wind, soil moisture, relative humidity).

Process Knowledge for RU 7

See Section 2.1.6.

Electret Ion Chambers

The detection limits of the radon flux chambers and the variability of radon emissions are addressed in Section 3.

Risks Addressed by Evaluation of Radon Flux Study

This study will address the potential need for radon emission control to be considered in the SFS for RU 7.

In addition, these data along with other radon measurements (e.g,, at RU 19) will be used to evaluate the potential for radon flux to be an issue of concern at other RUs that contain residual fill material.

2.4.2.4 Define the Boundaries

Lateral Boundaries

Figure 2-12 illustrates the boundaries associated with RU 7, Shale Unload, Crushing, Stockpile. Lateral boundaries will also be based upon actual observation.

Vertical Boundaries

The vertical boundaries are defined as the depth of fill that could contribute to radon emanation to the atmosphere. This depth is not defined because it depends on the gradation of fill, soil moisture, and other factors that are temporally and spatially variable. The upper boundary is the ore/atmosphere interface because this constitutes the point where radon fluxes are quantified.

2.4.2.5 Develop the Decision Rules

The decision associated with the radon flux studies is to compare the results with the UMTRCA guidelines. Therefore, the null and alternative hypotheses are:

- H_0: average radon flux > 20 pCi/m^2/sec
- H_A: average radon flux < 20 pCi/m^2/sec

The decision rules for radon flux measurements for RU 7 are as follows:

- If the average radon flux from RU 7 is above the UMTRCA guideline, then RU 7 will be forwarded to the SFS.
- If the average radon flux from RU 7 is below the UMTRCA guideline, then RU 7 will continue down the appropriate risk or SFS data collection pathway, with no further consideration of the need for radon mitigation measures anticipated to be necessary.

2.4.2.6 Specify the Tolerance Limits of Decision Errors

The statistical significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and a nominal Type II error of 10%. Stated otherwise, all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1. The Type II error rate, which characterizes the risk of performing unnecessary remediation, may be adjusted to reflect the relative costs of remediation versus additional sampling.

The statistical techniques used for the conduct of the significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment as discussed in Section 5.

2.4.2.7 Optimize the Design

See Sections 2.1.6.

2.5 EVALUATION OF FUTURE WORKER RISK

The RUs where the FMC remediation vision is NFA will be evaluated for potential radiological and inorganic risk drivers. There are two categories of radiological risk drivers associated with

these RUs: 1) gamma radiation, and 2) gamma radiation in combination with the inhalation and ingestion risk associated with precipitator dust/phossy solids as listed below.

RUs with Gamma Radiation As The Primary Risk Driver

- RU 3 – Receiving Stores, Paint Shop and P_4 Decon
- RU 4 – Office Buildings and Training Center
- RU 5 – Lab and Old Drainfield
- RU 6 – Former Long-Term Phos Storage Tanks
- RU 7 – Shale Unload, Crushing and Stockpile
- RU 9 – Silica Stockpiles and Former Kiln Scrubber Overflow Pond
- RU 11 – Equipment Area South of Calciners
- RU 20 – Former Bannock Paving Area
- RU 21 – Other Onsite Rail Spurs
- RU 23 – Road Segments Not within RU Boundaries
- RU 24 – Plant Areas not within RU Boundaries

RUs with Gamma Radiation and Inhalation and Ingestion of Precipitator Dust/Phossy Solids Constituents As The Primary Risk Driver

- RU 10 – IWW Pond and Ditch
- RU 12 – Former RP&S Area and Mobile Shop
- RU 13 – Pond 8S Recovery Process and Metal Scrap Preparation Area

2.5.1 State the Problem

Evaluation of Future Worker Risk Conceptual Site Model

As discussed in the RI Update Memorandum (BEI, 2004b) external gamma radiation makes up over 90% of the incremental cancer risk associated with ore, calcined nodules, slag, and calciner pond sediment. With respect to precipitator dust/phossy solids, incidental soil ingestion and fugitive dust inhalation of lead-210 and polonium-210, in conjunction with exposure to external gamma radiation, accounts for over 98% of the future worker risk to any future worker exposed to this media. The risk to future site workers that is not associated with radiation measurements is due to metals and fluoride.

Due to gamma radiation comprising a significant amount of the future worker risk, FMC will determine the rate associated with a decision unit prior to performing any other measurement. If, based on the gamma data, the remedial vision of no action anticipated to be necessary is not realized, the data collection activities, following a predefined sampling scheme to support the SFS will be performed as shown in Figure 1-7.

Provided the gamma data determine the remedial vision of no action anticipated to be necessary is realized concerning gamma exposure to the future site worker, then the remainder of the data collection activities defined in this section will be implemented. A surface radiation scan will first be performed to determine areas that potentially meet the remedial vision. The gamma dose rate associated with these areas will then be quantified with a PIC.

Based on input from EPA during review of the RI Update Memorandum (BEI, 2004b), FMC will also evaluate a potential future exposure scenario that considers the potential for fill material to be redistributed to the surface during site redevelopment. To evaluate the potential exposure based upon redistributed fill (i.e., those scenarios that address worker risks from exposure pathways other than external gamma radiation) FMC will analyze samples collected from the 0-to-2 foot and 0-to-10 foot below ground surface intervals that will be compared with the applicable SSLs or background values. In the event that any COC concentrations exceed applicable SSLs and background values, a comprehensive risk assessment will be performed to fully evaluate potential risks to future workers from all relevant exposure pathways. The total worker incremental risk will be derived by combining the calculated risks from external exposure to gamma radiation (to be derived from gamma dose PIC measurements) with risks from the inhalation and ingestion exposure pathways (to be derived from speciated radiometric data as well as metals and fluoride data).

All risk data will be evaluated based on the upper confidence limit of the average concentration or dose rate for the decision unit. The maximum size of a decision unit will be five acres. The five acres is not dependent on significant figures (i.e., the proposed 5.1-acre decision units within RU 20 still meet the five-acre definition). RUs greater than five acres will be divided into decision units of five acres or less. For example, an RU of seven acres could be divided into 1) one five-acre and one two-acre decision unit or 2) two units of less than five acres based on factors such as identified release mechanisms associated with each area. For RUs with an area of less than five acres, the RU will be the decision unit.

Regarding the number of composite samples and increments per composite sample for each decision unit:

- Four multi-increment composite samples will be collected for each decision unit with the objective that each of the four multi-increment samples is representative of the entire area of the decision unit.

- For five-acre decision units a total of twenty-increments will be incorporated into each of the four composite samples collected.

- For decision units less than five acres the number of increments per composite will be based on the ratio of the decision unit area to the five acre sampling density. For

example, based on collecting 20 increments per composite for a five-acre decision unit, 16 increments would be collected for each of the four composite samples collected across a four-acre decision unit.

- The maximum distance that should exist between any two sample increments for any sized decision unit will be 55 feet.

- To ensure that an adequate number of increments per composite are collected for very small decision units (e.g., 0.5 acres), each composite sample must consist of a minimum of four increments.

The sampling locations for each of the four multi-increment samples will be determined by using a standard grid cast on a random origin over the entire decision unit. Once the sampling points have been determined, the sampling points will be assigned a composite sample identifier (i.e., a number between 1 and 4). The sample composite identifiers will be assigned on a random basis such that there are an equal number of increments in each of the four composite samples.

The sampling design has been optimized to account for each decision unit's total area. The total areas for each RU and decision unit are listed on Table 2-5.

As presented to the EPA in the meeting of February 7, 2006, to evaluate the gamma dose rate potential to construction and utility workers, a worst case gamma scenario PIC study will be performed in slag and ore. To confirm that the subsurface slag and ore PIC measurements represent worst case gamma exposures, the radium-226 concentrations (the primary gamma radiation risk driver) in the 0-10 foot composite samples will be compared to historical site data documenting the levels of this COC in pure slag and ore (shown in Appendix B). Provided the radium-226 levels in the 0-10 foot samples are lower than those in pure slag and ore, the PIC measurements in slag and ore will be utilized in calculating the future worker risk associated with these worker scenarios.

2.5.2 Identify the Decision

The decisions associated with the future worker risk measurements are the same for RUs with gamma radiation as the primary risk driver and RUs with gamma radiation and precipitator dust/phossy solids as the primary risk driver. In both instances, the same suite of constituents (SCs) will be analyzed once it has been determined that the surface of the RU (or a sub area of the RU) is below the gamma dose rate CV on a quantifiable basis (i.e., PIC measurements)

Risk Decisions

Figures 1-7 and 2-50 describe the process for collecting risk assessment based data. Figure 1-7 describes the overall data collection concepts and Figure 2-50 describes the data collection concepts associated with the gamma surface scan and collecting the data to assess the redistributed fill scenarios (i.e., those scenarios that address worker risks from exposure pathways other than external gamma radiation).

Radiation Surface Survey

As described in Section 1.2.5.3, a high-density, GPS-based radiation surface survey will be performed. The decisions associated with the radiation surface survey are:

- If an RU (or sub-area) exceeds the gamma dose rate CV for the site worker, then the remediation vision of no action anticipated to be necessary will require revision and the predefined sampling activities to support the SFS will be performed as discussed in Sections 2.6 and 2.7.

- If the radiation surface survey is below the gamma dose rate CV for the site worker, then surface PIC measurements will be made to quantify the rate. Note that all measurements to support the risk calculation will be based upon the PIC measurements.

  Note: The gamma dose rate CVs for each worker type are contained in Table 2-3. The CVs are based on a 3x10-4 increased lifetime risk which corresponds to the upper bound of EPA's potentially acceptable risk range for CERCLA sites with radioactive contamination (OSWER Directive 9200.4-18). The allowable dose rates also meet the OSHA exposure limits for ionizing radiation for general industry and construction as specified in 29 CFR 1910.1096 and 29 CFR 1926.53, respectively.

Surface PIC Measurements

For those RUs (or sub areas) that appear to be less than the gamma dose rate CV based upon the radiation surface scan, PIC measurements will be made to quantify the actual gamma dose rate for each decision unit.

- If the decision unit is above the gamma dose rate CV for the site worker, then the remediation vision of no action anticipated to be necessary will require revision and the predefined sampling activities to support the SFS will be performed.

- If the decision unit is below the gamma dose rate CV for the site worker, then 0-to-2 feet bgs and 0-to-10 feet bgs samples will be collected to evaluate worker risks from exposure pathways other than external gamma irradiation (e.g., ingestion and inhalation).

  Note: The CV for the gamma dose rates are contained in Table 2-3. The initial CVs for the SC are contained in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

Redistributed Fill Scenario Measurements

For those RUs (or sub areas) wherein the quantified gamma dose rate is less than the Outdoor Commercial/Industrial Worker, Construction Worker or Utility Worker thresholds as defined in Table 2-3, the decisions associated with the redistributed fill samples are:

- If the calculated total risks for a RU (or sub area) are above the applicable CVs then the decision unit is forwarded to the SFS.

- If the calculated total risks for all worker exposure scenarios in a RU (or sub area) are below the applicable CVs then the remediation vision of no action anticipated to be necessary remains valid, pending final risk management decisions.

2.5.3 Identify the Decision Inputs

2.5.3.1 Description of Slag

Homogeneity of Slag Materials

FMC used slag as fill materials within many of the RUs that will be investigated for SCs. This material is relatively homogeneous in terms of inorganic constituent concentrations because of the uniform quality of furnace feed needed to produce P4 of known quality.

Physical Characteristics

Slag is dark gray, angular, gravel-like material that is very hard.

Radiological Characteristics

Slag has been analyzed for uranium-238, uranium-234, thorium-230, radium-226, potassium-40, lead-210, polonium-210, thorium-232, and radium-228. The activities of these isotopes in slag are presented in Table B-1 of Appendix B. The EPA 1987 aerial gamma survey of the FMC Plant OU showed elevated gamma dose rate levels associated with areas covered by slag (Figure 2-51). PIC measurements performed during the EMF RI (BEI, 1996) indicate external gamma rates are measurably above background (BEI 1996, Appendix O-2) (Figure 2-52).

Chemical Characteristics

Table H-3 of the RI Update Memorandum (BEI, 2004b) (Appendix H) presents total metals and fluoride concentrations in slag.

2.5.3.2 Description of Ore

Ore was managed on site primarily in the front end of the process located at the northeastern most area of the FMC Plant OU. Ore was unloaded from railcars, stockpiled, reclaimed from the stockpile, crushed, and screened all within RU 7. When plant operation ceased, some ore remained on the ore stockpile in RU 7. Some of the ore inventory was sold and shipped off-site. The remaining ore has been leveled to grade. Ore also remains on the surface within most of the RU 7 surface area. Ore, ore by-products such as bull rock, and calcined ore would be expected to be found in RU 2 (briquetting operation), RUs 8 and 9 (kiln/calciner operations), RU 15 (oversized ore, used electrodes and baghouse dust area), and RU 19 (slag and bull rock pile).

Physical Characteristics

Ore is a brown, silty soil. The phosphate-bearing mineral is calcium fluorapatite.

Radiological Characteristics

Ore has been analyzed for uranium-238, uranium-234, thorium-230, radium-226, lead-210, polonium-210, thorium-232, and radium-228 and potassium-40. The activities of these isotopes in ore are also presented in Table B-1 of Appendix B. The 1987 EPA aerial gamma survey of the FMC Plant OU showed elevated gamma dose rate levels associated with ore pile areas (Figure 2-51). PIC measurements performed during the EMF RI (BEI, 1996) indicate external gamma rates are measurably above background (BEI 1996, Appendix O-2) for ore (Figure 2-52).

Chemical Characteristics

Table H-1 of the RI Update Memorandum (Appendix H) (BEI, 2004b) presents total metals and fluoride concentrations in slag.

2.5.3.3 Description of Native Soils

Homogeneity of Soils

The loess soils underlying areas of slag fill are relatively homogeneous. The variability of inorganic constituent concentrations was evaluated by E&E during their derivation of soil background concentrations for each inorganic constituent (E&E 1996). Table 6-11 of the RI Update Memorandum (BEI, 2004b) presents characteristic concentrations of metals in native soil.

Radiological Characteristics

Some gamma-producing radioisotopes exist in the native soils at the FMC Plant OU. The background level in the Michaud Flats area underlain by native soils has been established at 13 μR/hr and includes cosmic contributions.

2.5.3.4 Mixing of Materials

It is likely that some combination of ore, slag, and native soils are mixed in varying proportions within most areas of the RUs to be evaluated in the SRI. This was documented in the EMF RI (BEI, 1996), where over 80 borings were advanced through the fill and into native soils with samples analyzed from different depths. A summary of this information is included in Table 2-4. Normal and log normal distributions of metals concentrations were identified in samples from the same materials.

2.5.3.5 Description of Precipitator Dust/Phossy Solids

Physical Characteristics

Precipitator dust/phossy solids are a fine-grained, dark-gray-to-black material.

Radiological Characteristics

Precipitator dust/phossy solids have been analyzed for uranium-238, thorium-230, radium-226, potassium-40, lead-210, polonium-210, thorium-232, and radium-228. The activities of these isotopes in precipitator dust/phossy solids are presented in Table B-1 of Appendix B. Elevated levels of lead-210 and polonium-210 are associated with precipitator dust/phossy solids (labeled "Precipitator Slurry/Phossy Wastes" in Table B-1).

Chemical Characteristics

Table H-2 of the RI Update Memorandum (Appendix H) presents total metals and fluoride concentrations in precipitator dust/phossy solids.

Extent of Distribution

Until approximately 1992, precipitator dust/phossy solids were used sporadically for traction (as an alternative to salt) on roads during winter months at the FMC Plant OU. Therefore, the testing of lead-210 and polonium-210 from precipitator dust/phossy solids is limited to the roads within the FMC Plant OU. Precipitator dust/phossy solids may also have impacted RUs 12, 13 and 20 during materials-handling operations associated with RU 22b. Testing for lead-210 and polonium-210 will also be conducted in these RUs.

2.5.3.6 Updated SSLs

In Section 4 of the RI Update Memorandum (BEI, 2004b), updated Site Worker, Construction Worker, and Utility Worker SSLs were developed. These SSLs are the values against which decision unit-specific data will initially be compared to evaluate risks from exposure pathways other than external gamma radiation. However, in the event that an applicable worker SSL for a COC is lower than background (e.g., arsenic SSL for commercial/industrial workers is below the background level for this COC), the decision unit-specific data will initially be compared to the background level. If any of the applicable SSLs are exceeded, then a comprehensive risk assessment will be performed.

2.5.3.7 Incremental Cancer Risk Associated with Radiation

Radionuclide Risk Model (Appendix F of the RI Update Memorandum)

The available data from the 1977 EPA study (USEPA, 1977) and the EMF RI (BEI, 1996) were evaluated for incremental cancer increase (ICR) for each exposure pathway and the relative ICR contribution from nine radionuclides. The potassium, uranium, and thorium decay chains were evaluated. The data indicate that uranium-238 and radium-226 are associated with ore and, when ore was processed, the uranium-238 and radium-226 became incorporated into slag.

Data in Appendix B indicate that, for all feedstocks, by-products and waste materials (with the exception of precipitator dust/phossy solids), over 90 percent of the ICR is due to external gamma exposure and over 90 percent of this gamma radiation has been attributed to the activities of uranium-238, radium-226, and potassium-40. The remaining ICR (<10 percent) that is not accounted for by external gamma radiation exposure is due to the inhalation/ingestion pathways

for all radionuclides (gamma, beta, and alpha emitters). For precipitator dust/phossy solids, approximately 80 percent of the ICR is attributed to lead-210 and polonium-210. The nine radionuclides evaluated in the RI Update Memorandum HHRA were: potassium-40, uranium-238 plus daughters, uranium-234, thorium-230, radium-226 plus daughters, lead-210 plus daughters, polonium-210, thorium-232 and radium-228.

2.5.3.8 CVs

This SRI is concerned with collecting data that are appropriate for evaluating the remediation vision for each study area (i.e., RU). As discussed in Section 2.0.3.2, risk-based CVs will be used during the SRI to inform field data collection activities; in particular, for determining whether a candidate NFA RU should follow the risk assessment or preliminary SFS data collection path (per Figure 1-7). Regarding the measurement of total gamma exposure under future worker scenarios, the CV will be a defined level above background that is equivalent to the upper end of remediation levels that EPA has selected at radioactively contaminated CERCLA sites (i.e., 3x10-4 above background). Total gamma screening levels equivalent to this risk threshold for each of the worker scenarios are summarized in Table 2-3.

2.5.3.9 Total Gamma Background Levels

As described in Appendix G of the RI Update Memorandum (BEI, 2004b), an aerial radiation survey that included the FMC Plant OU site was conducted by EPA (USEPA, 1987). This survey shows large areas of the Michaud Flats emitting gamma radiation at rates between 11 and 17 μR/hr. This survey was performed at 150 feet above the ground surface. At this altitude, the detector had a field of view of approximately 300 feet and took a reading once every second. At the typical speed of flight, approximately 1 acre is transversed in this time period. A review of Figure 2-51 shows that the RUs associated with this portion of the study have average readings above 30 μR/hr and RU 20 has average readings of greater than 50 μR/hr.

As discussed in the HHRA, EPA reviewed this study and concluded that background in the FMC Plant OU is 12.9 μR/hr (E&E 1996). Other studies, including the PIC measurements made during the EMF RI (BEI, 1996) and IDEQ's INL Oversight Monitoring Program indicate that an appropriate background level is 13 μR/hr for many areas within the FMC Plant OU. The EMF RI data and the EPA aerial survey also indicate that background levels in the Bannock Range (14.5 uR/hr to 30 uR/hr) are higher than those measured in the Michaud Flats area. This is due to geologic factors associated with exposed volcanic material in the Bannock Range contributing to higher background levels than the loess and quartzitic gravel deposits in the Michaud Flats.

2.5.3.10 Gamma Study

As described in Appendix O of the EMF RI Report (BEI, 1996), additional surface gamma measurements were made at the FMC Plant OU. These demonstrated that total gamma dose rates varied from 10 μR/hr to 52 μR/hr. The higher reading of 52 μR/hr was obtained at the slag pile. This level of activity is consistent with the aerial survey, which indicates the average dose rate of the slag pile is between 50 and 100 μR/hr. Figure 2-51 shows the gamma measurement locations from this study (superimposed over all RUs) and lists the associated μR/hr values.

2.5.3.11 Description of New Data Requirements

Background Values

The background levels within the Bannock Range have not been adequately characterized to define an appropriate background value and associated variance for statistical purposes.

Gamma Scan

A radiation surface scan will be conducted to identify surface areas that are potentially below the associated worker gamma CV. A description of this study in contained in Section 1.2.5.3.

PIC Measurements

The instrument utilized for quantifying total gamma dose rates is mounted on a tripod that is approximately 3 feet high. Surface measurements will be made with this device at all identified sampling locations. Additionally, PIC measurements will be taken at a depth of 5 feet in both slag and ore to demonstrate that worst-case exposures do not exceed the gamma dose CV for construction or utility workers. As discussed in Section 2.5.1, the radium-226 concentrations (the primary gamma radiation risk driver) in the 0-10 foot composite samples will be compared to historical site data documenting the levels of this COC in pure slag and ore (shown in Appendix B) to confirm that the subsurface slag and ore PIC measurements represent worst case gamma exposures to subsurface workers.

Study Constituents

Metals, radium-226, uranium-238, potassium-40, lead-210, polonium-210 and fluoride analyses will be measured utilizing fixed-laboratory analyses. The specific analytical methods to be employed are described in Section 3. Only potassium-40 will be quantified using gamma spectroscopy.

2.5.4 Define the Boundaries

Lateral Boundaries

The study area is defined as those RUs where insufficient data exist to make a decision regarding the potential need for remedial action. Figure 2-13 shows the RUs where the future worker risk to future site workers will be measured.

Vertical Boundaries

The vertical boundary is the surface for the surface radiation scan and the PIC measurements.

The vertical boundaries for the future redevelopment scenario are:

- 0-to-2 feet bgs for the Outdoor Commercial/Industrial Worker, and
- 0-to-10 feet bgs for the Construction worker and Utility Worker

2.5.5 Develop the Decision Rules

The decision for each RU is to determine whether the risk associated with an RU (or sub area) is greater than the applicable CVs. Therefore, the null and alternative hypotheses are:

- H_0: calculated risk based on sufficient data from SRI study > applicable CV
- H_A: calculated risk based on sufficient data from SRI study < applicable CV

In order to determine when calculation of the risk is necessary, COC and COPCs identified in the RI Update Memorandum (BEI, 2004b) as having data gaps will initially be evaluated against SSLs and background levels, as appropriate. If the null hypothesis for a given COC or COPC is true, then the incremental cancer risk for the RU will be calculated and tested as described above. If the alternative hypothesis for the COCs and COPCs is true then further evaluation is not required.

2.5.6 Specify the Tolerance Limits of Decision Errors

The statistical significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and a nominal Type II error of 10%. Stated otherwise all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1. The Type II error rate, which characterizes the risk of performing unnecessary remediation, may be adjusted to reflect the relative costs of remediation versus additional sampling.

The statistical techniques used for the conduct of the significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment as discussed in Section 5.

2.6 OTHER GAMMA STUDIES

Other gamma studies needed to complete the SRI include:

- Southern undeveloped area on FMC property (Figure 2-48)
- Western undeveloped area on FMC property (Figure 2-48)

Based on previous studies as discussed in the RI Update Memorandum (BEI, 2004b) the background associated with the northern and western regions of the FMC plant is 13 uR/hr. As described in Appendix G of the RI Update Memorandum (BEI, 2004b) background exposure rates in the Pocatello area range from 11 to 17 µR/hr (C-D levels); however, a review of the maps included in the survey report shows that the background levels in the flats and valley floor areas, where most people live and work, is predominantly ‘C’ (11 uR/hr to 14.5 uR/hr). By contrast, background levels in the Bannock Range, within which the southern portion of the FMC plant is located, is predominantly “D” (14.5 to 17 uR/hr). The background level associated with the southern undeveloped area of the FMC property will be characterized by the mid-point of this range (15.75 uR/hr); however, the potential for natural geological features (e.g., rock

outcroppings) within this area to cause site-specific exceedances of this level will be explicitly considered in the SRI.

2.6.1 Southern and Western Undeveloped Area Gamma Measurements

2.6.1.1 State the Problem

Undeveloped Area Gamma Conceptual Site Model

The surface of the undeveloped areas on the FMC OU has not been disturbed, was never used for operational process areas, for storage of materials or waste, or as a traffic way. The southern undeveloped area is in the Bannock Range and due to the differences in geological formations may have higher levels of background gamma radiation. The western undeveloped region is expected to be consistent with Michaud Flat background levels.

Undeveloped Area Gamma Problem Statement

The gamma dose rate associated with the southern and western undeveloped regions of the Plant OU has not been adequately characterized.

2.6.1.2 Identify the Decision

Undeveloped Area Gamma Decisions

The decisions associated with the undeveloped area gamma study are:

Southern Undeveloped Region

- If the surface radiation levels in the southern undeveloped area, as measured by the PIC, are above the midpoint of the "D" range (15.75 uR/hr), site-specific exceedances associated with natural geological features (e.g., rock outcroppings) will be considered and then areas that have been impacted will be forwarded to the SFS.

- If the surface radiation levels in the southern undeveloped area, as measured by the PIC, are below the midpoint of the "D" range (15.75 uR/hr), then the area will not have been impacted.

Western Undeveloped Region

- If the surface radiation levels in the western undeveloped area, as measured by the PIC, are above the established background (13 µR/hr), then the area will have been impacted and will be forwarded to the SFS.

- If the surface radiation levels in the western undeveloped area, as measured by the PIC, are below the established background, then the area will not have been impacted.

2.6.1.3 Identify the Decision Inputs

Process Knowledge Undeveloped Areas

The western undeveloped area is located on the far western portion of the FMC Plant OU. The southern undeveloped area is located on the far southern portion of the FMC Plant OU. Both of these undeveloped areas are undisturbed in that they were never used for operational process areas, raw material or waste storage/accumulation, or as a traffic way. The only potential impact from EMF site operations would have been from deposition of FMC and Simplot emissions.

2.6.1.4 Define the Boundaries

Lateral Boundaries

Figure 2-48 shows the RUs and undeveloped areas where total gamma dose rate measurements will be made.

Vertical Boundaries

The vertical boundaries are the existing surface of the study area.

2.6.1.5 Develop the Decision Rules

The decisions for the undeveloped areas are associated with the potential for past plant emissions to have impacted the undeveloped surface. Therefore, the null and alternative hypotheses are:

- For the Southern undeveloped area:
  - H_0: Undeveloped area radiation rate (µR/hr) > midpoint of the "D" range (15.75 µR/hr)
  - H_A: Undeveloped area radiation rate (µR/hr) < midpoint of the "D" range (15.75 µR/hr)
- For the Western undeveloped area:
  - H_0: Undeveloped area radiation rate (µR/hr) > 13 µR/hr
  - H_A: Undeveloped area radiation rate (µR/hr) < 13 µR/hr

The decision rules for the Southern undeveloped area are as follows:

- If the mean surface measurement exceeds the midpoint of the "D" range (15.75 µR/hr), site-specific exceedances associated with natural geological features (e.g., rock outcroppings) will be considered and then areas that have been impacted will be forwarded to the SFS.

- If the mean surface measurement is below the midpoint of the "D" range (15.75 μR/hr), then the area has not been impacted.

The decision rules for the Western undeveloped area are as follows:

- If the mean surface measurement exceeds 13 μR/hr, then the area will be forwarded to the SFS.
- If the mean surface measurement is below 13 μR/hr, then the area has not been impacted.

2.6.1.6 Specify the Tolerance Limits of Decision Errors

The statistical significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and a nominal Type II error of 10%. Stated otherwise all significance tests will have a significance level, α, equal to 0.05 and a Type II error, β, equal to 0.1.

The statistical techniques used for the conduct of the significance tests will be chosen such that their underlying assumptions are supported by the data. Evaluation of the data support and the selection of the appropriate statistical testing procedure will be made during the Data Quality Assessment as discussed in Section 5.

2.7 ADDITIONAL SFS DATA NEEDS BASED ON OUTCOMES FROM EVALUATION OF TOTAL WORKER RISK EXPOSURE

2.7.1 State the Problem

SFS Data Needs Conceptual Site Model

As discussed in Section 1.2.4 and shown in Figure 1-7, the data collection activities may shift from those to support the risk assessment to a predefined data collection scheme to support the SFS.

It is important to note that while the investigation within a given RU with a remediation vision of no action anticipated to be necessary may change from risk data collection to SFS data collection, this SRI Work Plan is not intended to supplant Task 3 of the AOC as identified in Section 1. As part of Task 3 of the AOC, an SFS Work Plan will be developed to address SFS data needs as determined in the SFS process. However, there are certain SFS data needs that can be identified and addressed during the SRI; specifically, determination of the depth/volume of fill materials (consisting primarily of ore and slag) overlaying native soils and the extent of contaminant migration into native soils from fill materials.

The site conceptualization model as described in Section 2.2.4 - Potential Receptors and Routes of Exposure, of the RI Update Memorandum (BEI, 2004b) specifies that the utility and construction workers could be exposed to contaminants in the upper 10 feet of soil. A task within the SFS is to evaluate remedial alternatives. If the fill or overlaying material is removed,

the future site workers would be exposed to the newly revealed surface. Based on inputs from the SFS Project Team, it was determined that the probability of removing material with a thickness of greater than 10 feet was unlikely. Therefore, determining the depth of fill up to 10 feet meets the initial needs of the SFS Team.

To evaluate the potential for constituents to migrate into the native soil that is underlying the fill, three reference studies will be performed. Each study will define the extent to which a fill material of concern (ore, slag or coke) has leached constituents into the native soil. Other RUs which may also require a revised remediation vision will be evaluated for potential subsurface migration of constituents by comparing the underlying native soil to the applicable reference study. For example if an RU is covered with slag, the underlying soil would be compared to the slag reference study. The three reference studies that will be conducted are:

- Ore reference study: RU 7 excluding the coke handling building
- Slag reference study: RU 20 excluding specific investigation areas
- Coke reference study: RU 20 excluding specific investigation area

Additional SFS Data Needs Problem Statement

For those RUs where the remedial vision will need to be revised, additional data to delineate: 1) the depth and volume of fill, and 2) the extent to which constituents may have migrated into the underlying native soil are needed.

2.7.2 Identify the Decision

SFS Data Needs Decision

For the additional SFS data needs, the decisions associated with determining the depth and volume of fill and the impact to underlying soils are:

- If the remediation vision requires change based upon the data collected to support risk, then borings/test pits to determine the depth/volume of fill will be performed and impacts to underlying soil investigated.

  Note: The list of compounds to be evaluated for the reference studies consists of metals, fluoride, uranium-238, radium-226, potassium-40, lead-210, and polonium-210 as provided in Table 1-6 - Soil Screening Levels and Reporting Limits for Inorganics in Soils.

2.7.3 Identify the Decision Inputs

Data collected in support of determining the risk to future workers serves as the input to following the predefined SFS sampling scheme. These predefined data collection activities will assist the SFS group in determining the proper remedy based upon the revised remedial vision.

2.7.4 Define the Boundaries

Lateral Boundaries

The lateral boundaries will be for those candidate NFA RUs that are designated for further action based on gamma studies. Boundaries of candidate NFA RUs are shown on Figure 2-13.

Vertical Boundaries

The vertical boundaries will be 10 feet below ground surface or 0-to-2 feet bns whichever is encountered first.

2.7.5 Develop the Decision Rules

The decisions for the SFS Data Collection Scheme are associated with obtaining the 0-to-2 foot bns sample. Therefore, the null and alternative hypotheses are:

- H_0: fill material depth ≥ 10 feet
- H_A: fill material depth <10 feet

The decision rules for SFS Data Collection scheme are as follows:

- If native soil is detected at 10 feet below ground surface or less, then collect a 0-to-2 foot below native soil sample.
- If native soil is not detected in the first 10 feet below ground surface, then no other sampling is required at that sampling point.

2.7.6 Specify the Tolerance Limits of Decision Errors

Judgmental sampling, guided by site specific knowledge, does not allow quantification of a level of confidence. Judgmental sampling was selected based on EPA guidance (USEPA, 2002b).

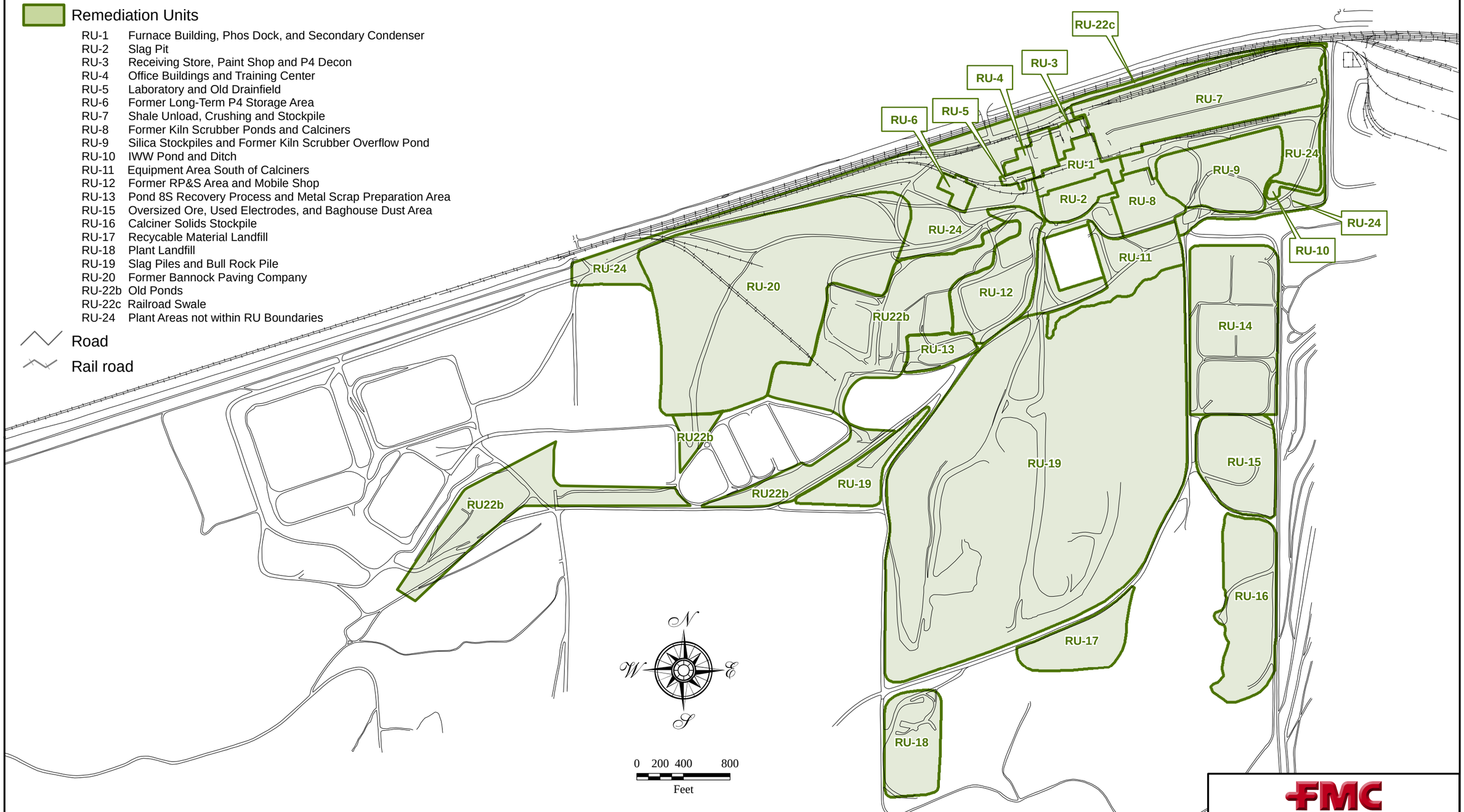
Legend

Remediation Units

RU-1	Furnace Building, Phos Dock, and Secondary Condenser
RU-2	Slag Pit
RU-3	Receiving Store, Paint Shop and P4 Decon
RU-4	Office Buildings and Training Center
RU-5	Laboratory and Old Drainfield
RU-6	Former Long-Term P4 Storage Area
RU-7	Shale Unload, Crushing and Stockpile
RU-8	Former Kiln Scrubber Ponds and Calciners
RU-9	Silica Stockpiles and Former Kiln Scrubber Overflow Pond
RU-10	IWW Pond and Ditch
RU-11	Equipment Area South of Calciners
RU-12	Former RP&S Area and Mobile Shop
RU-13	Pond 8S Recovery Process and Metal Scrap Preparation Area
RU-15	Oversized Ore, Used Electrodes, and Baghouse Dust Area
RU-16	Calciner Solids Stockpile
RU-17	Recycable Material Landfill
RU-18	Plant Landfill
RU-19	Slag Piles and Bull Rock Pile
RU-20	Former Bannock Paving Company
RU-22b	Old Ponds
RU-22c	Railroad Swale
RU-24	Plant Areas not within RU Boundaries

Road

Rail road



Also included:
RU-21 Other Railroad Spurs
RU-23 Road not within RU Boundaries

MWH

FMC

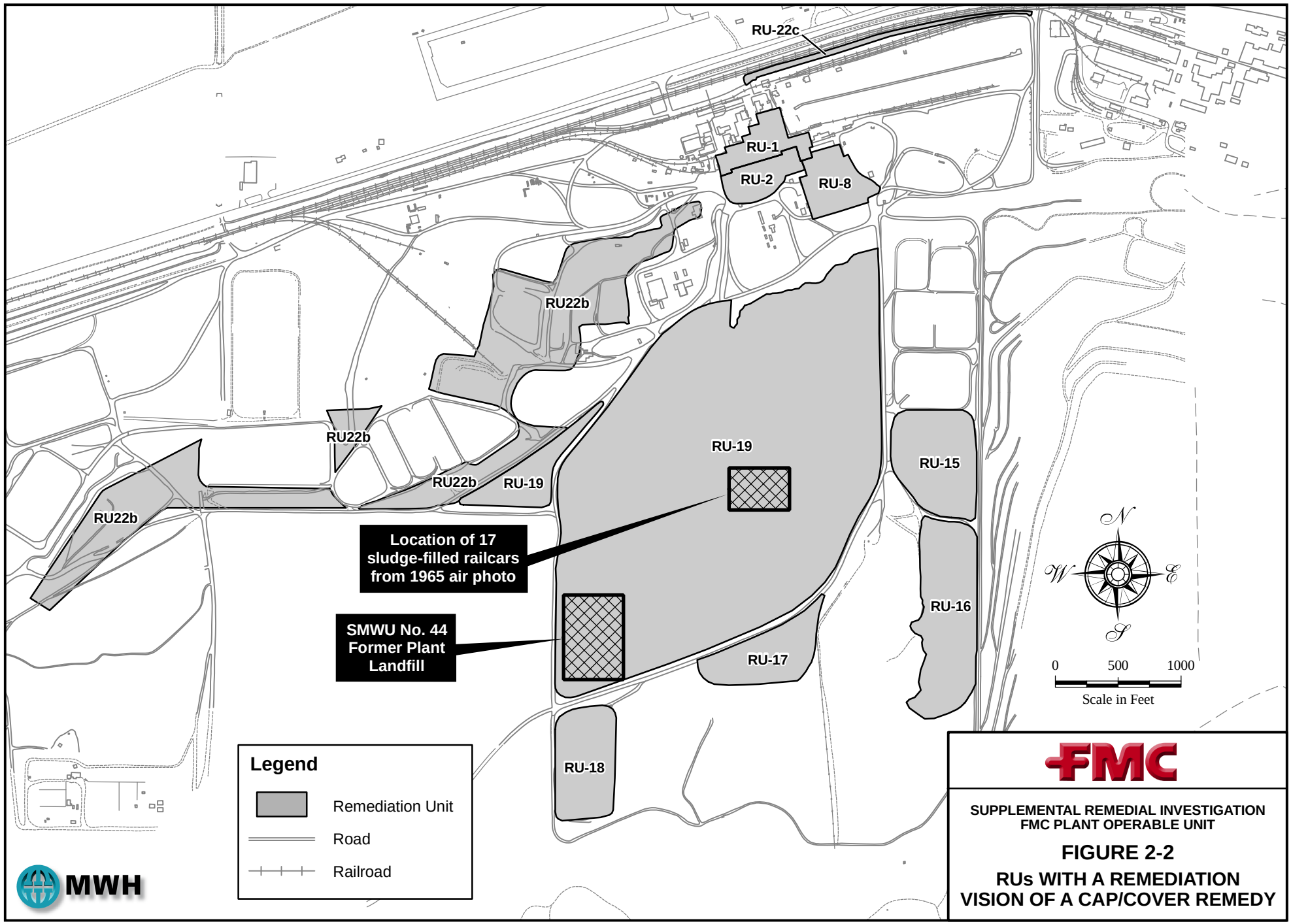
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-1

RUs IDENTIFIED FOR SUPPLEMENTAL REMEDIAL INVESTIGATION

FILE *Fig 2-01 RUs Ident Supp Rem Invest_307.mxd* 3/15/07

FILE *Fig 2-02 RUS with remed capcover_307.mxd* *3/15/07*



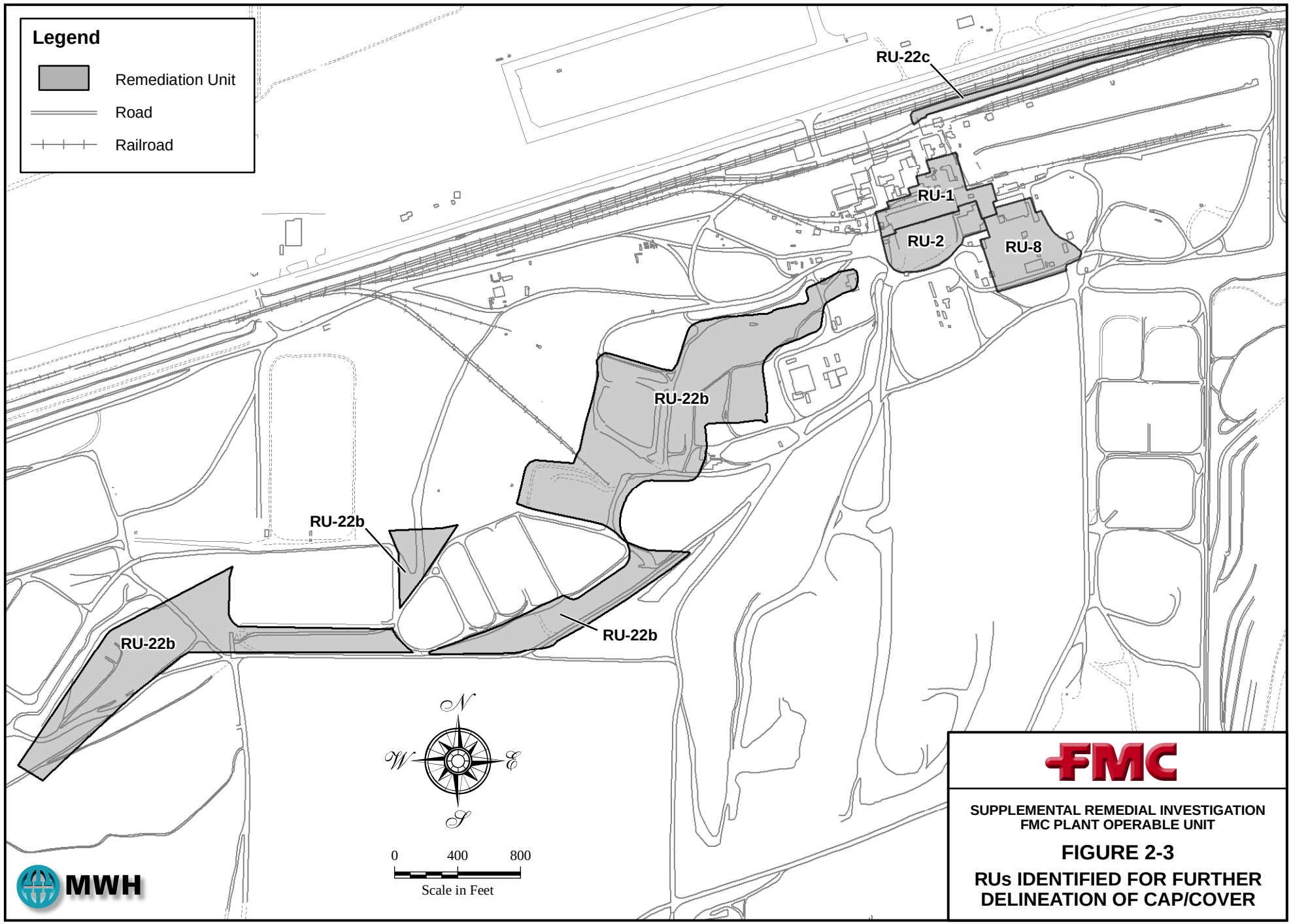
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-2

RUs WITH A REMEDIATION VISION OF A CAP/COVER REMEDY

FILE *Fig 2-03 RUs for further Delin_307.mxd* *3/15/07*

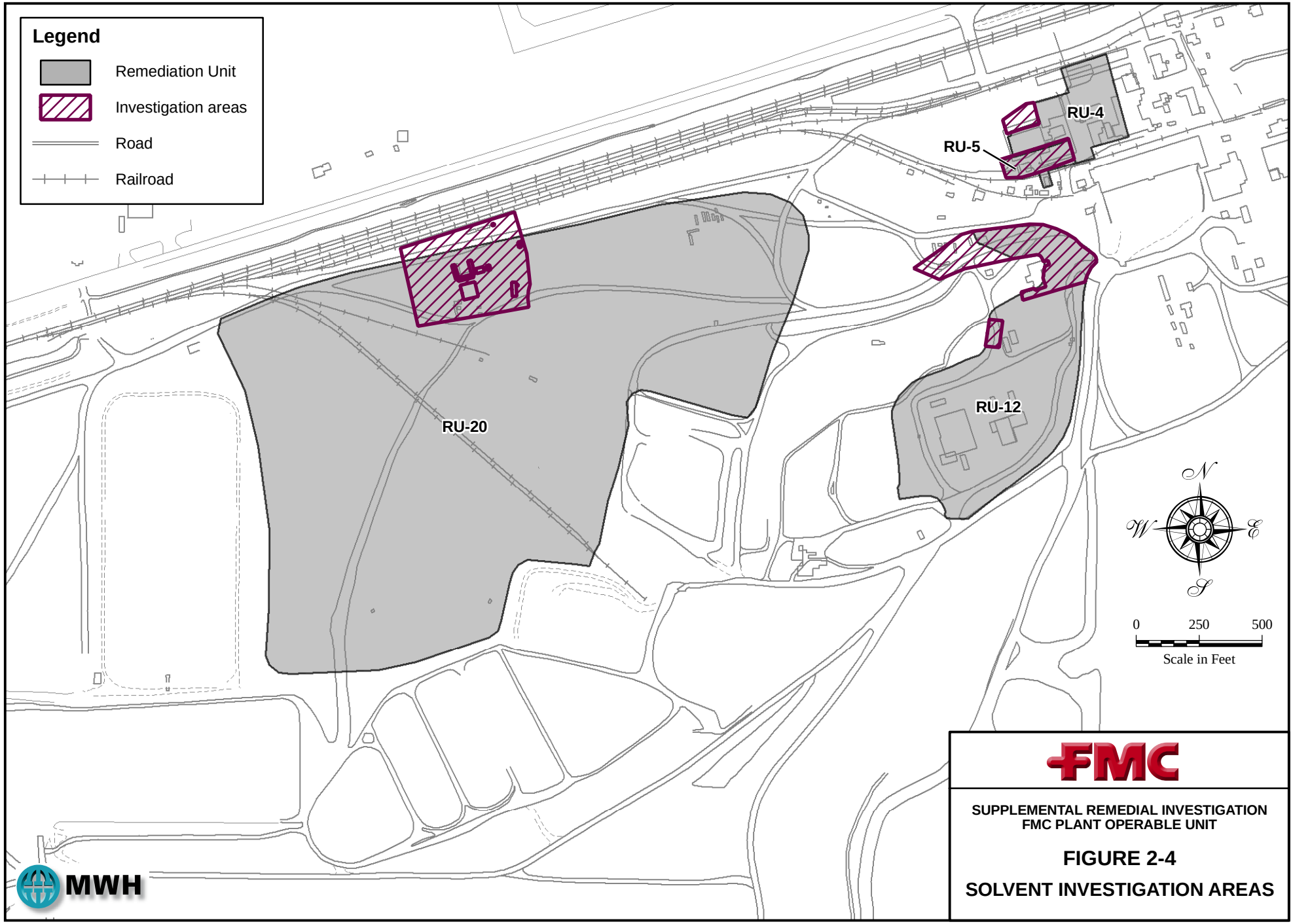


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

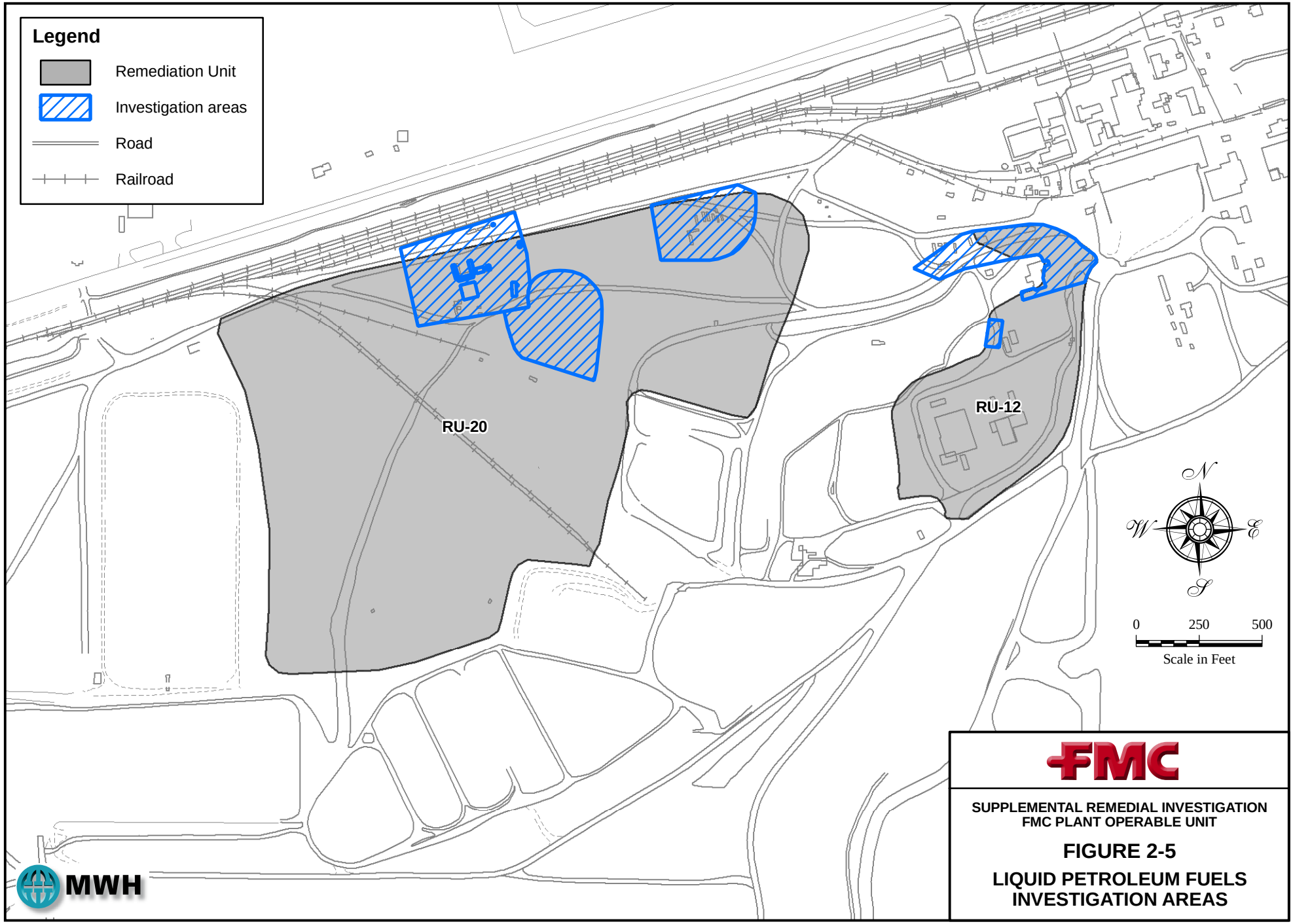
FIGURE 2-3

RUs IDENTIFIED FOR FURTHER DELINEATION OF CAP/COVER

FILE *Fig 2-04 Solvent areas_307.mxd 3/15/07*



FILE *Fig 2-05 Liquid pet fuels_307.mxd* *3/16/07*

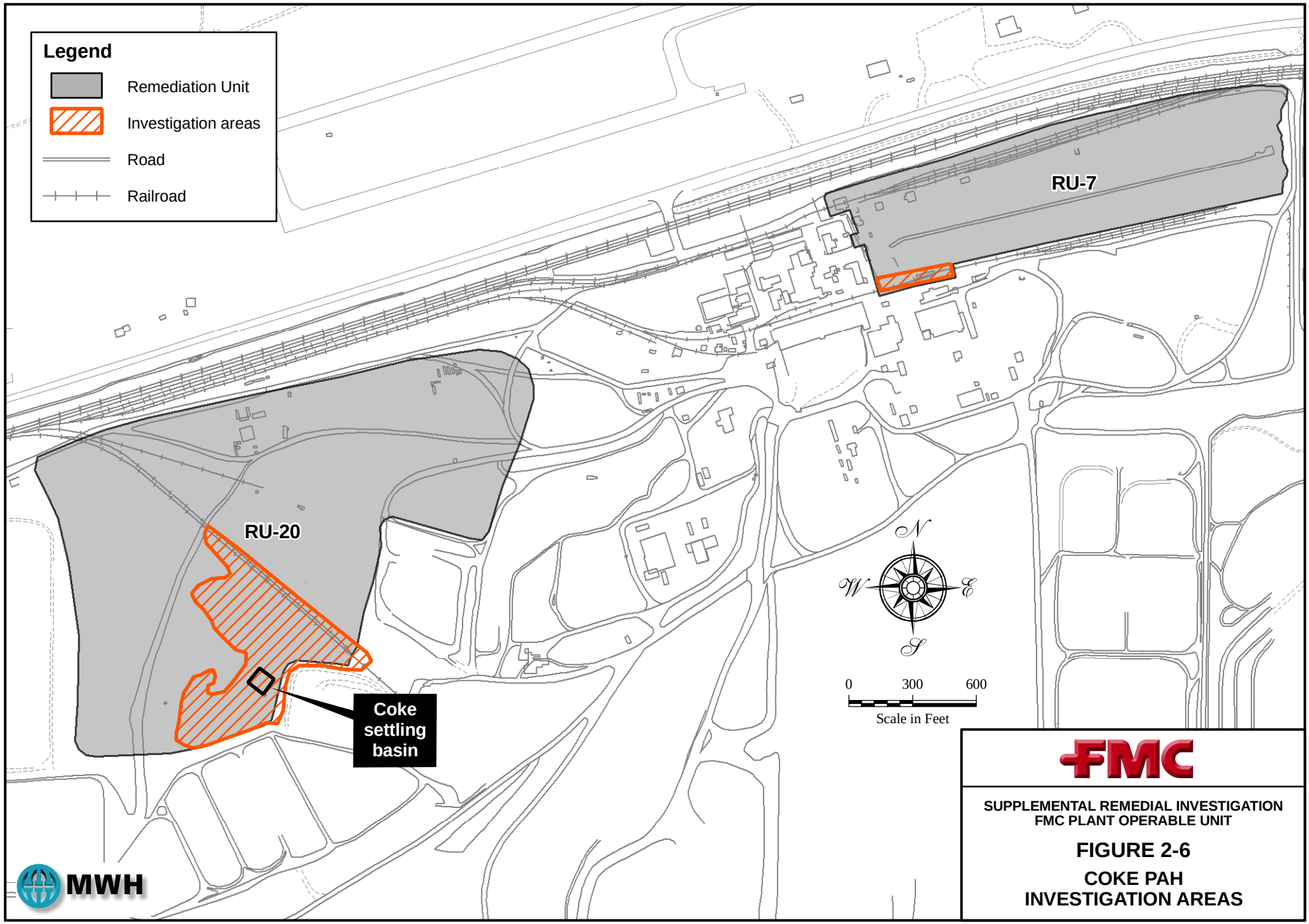


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-5

LIQUID PETROLEUM FUELS INVESTIGATION AREAS

FILE *Fig 2-06 Coke PAH_307.mxd 3/15/07*

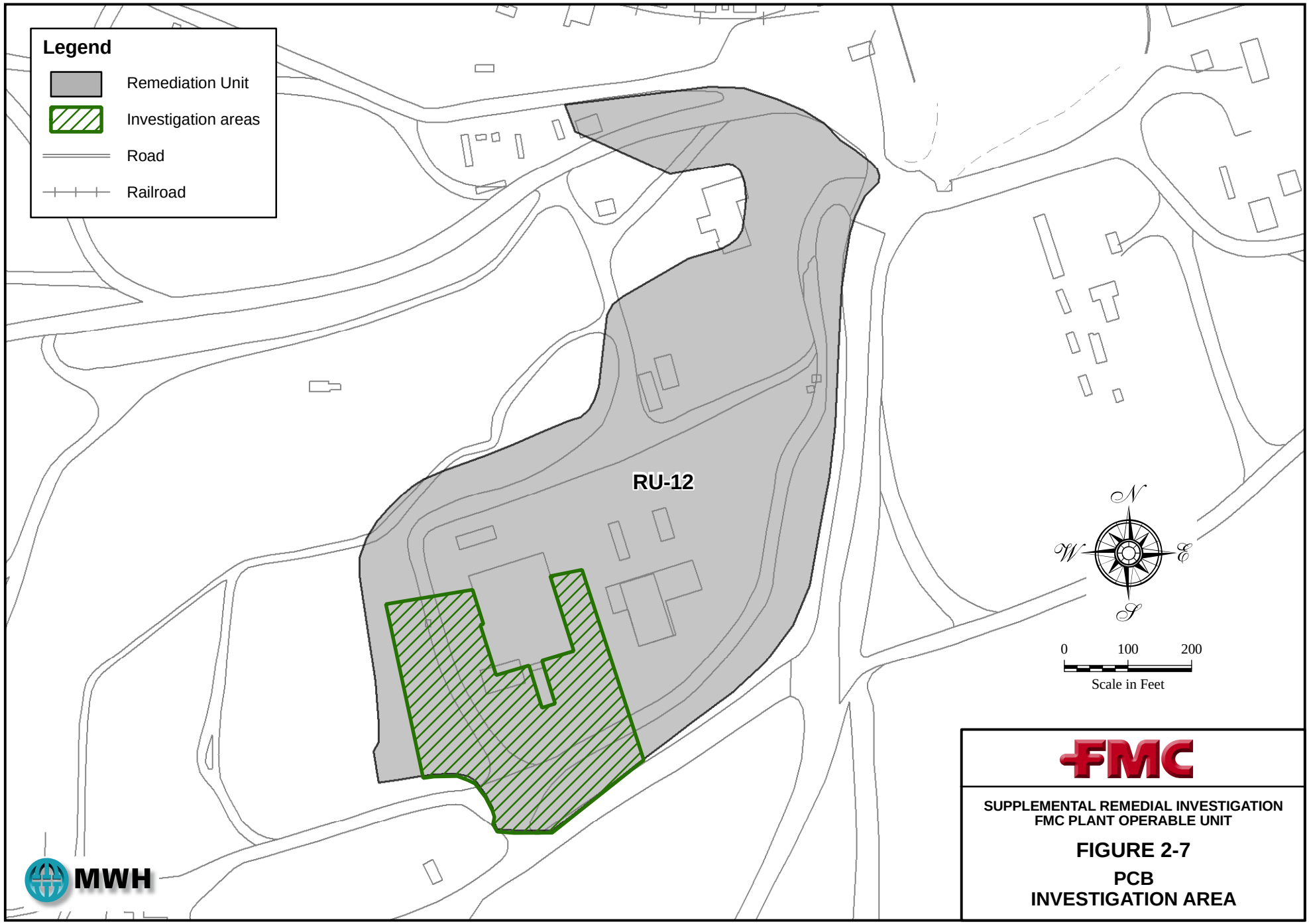


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-6

COKE PAH INVESTIGATION AREAS

FILE *Fig 2-07 PCB_307.mxd* *3/15/07*



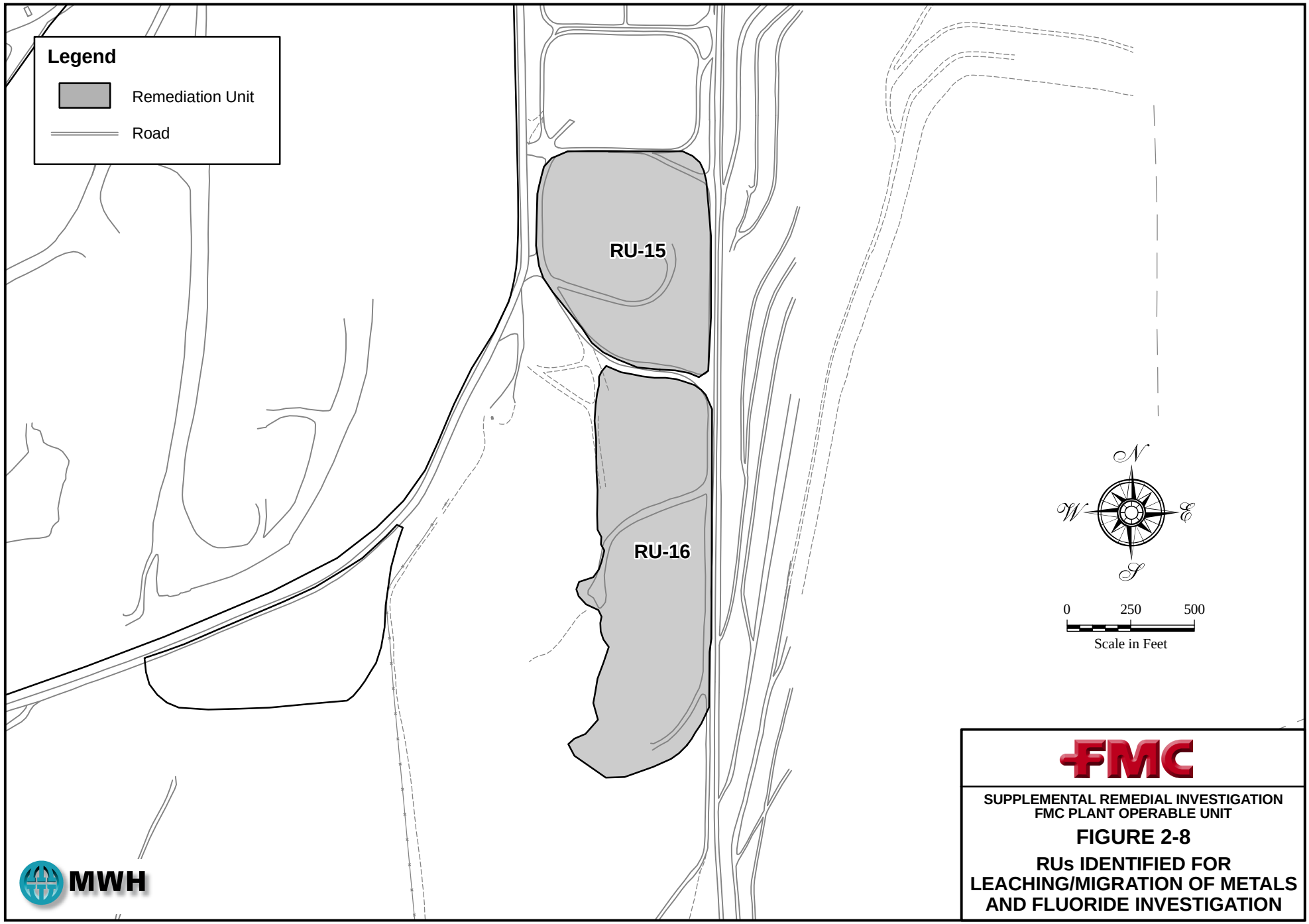
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-7

PCB INVESTIGATION AREA

FILE *Fig 2-08 Leaching_307.mxd* *3/15/07*



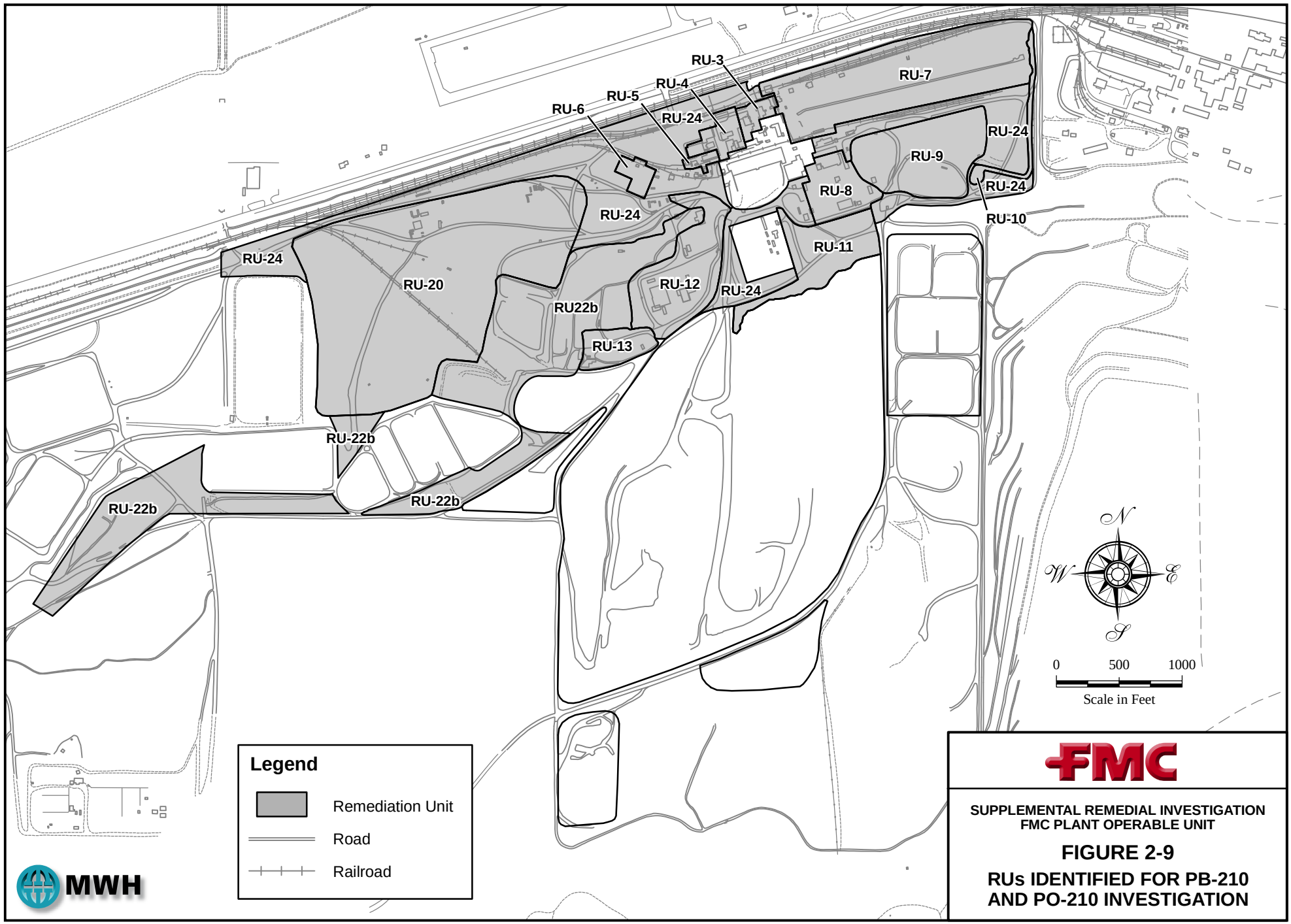
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-8

RUs IDENTIFIED FOR LEACHING/MIGRATION OF METALS AND FLUORIDE INVESTIGATION

FILE *Fig 2-09 PB210PO210_307.mxd* *3/26/07*



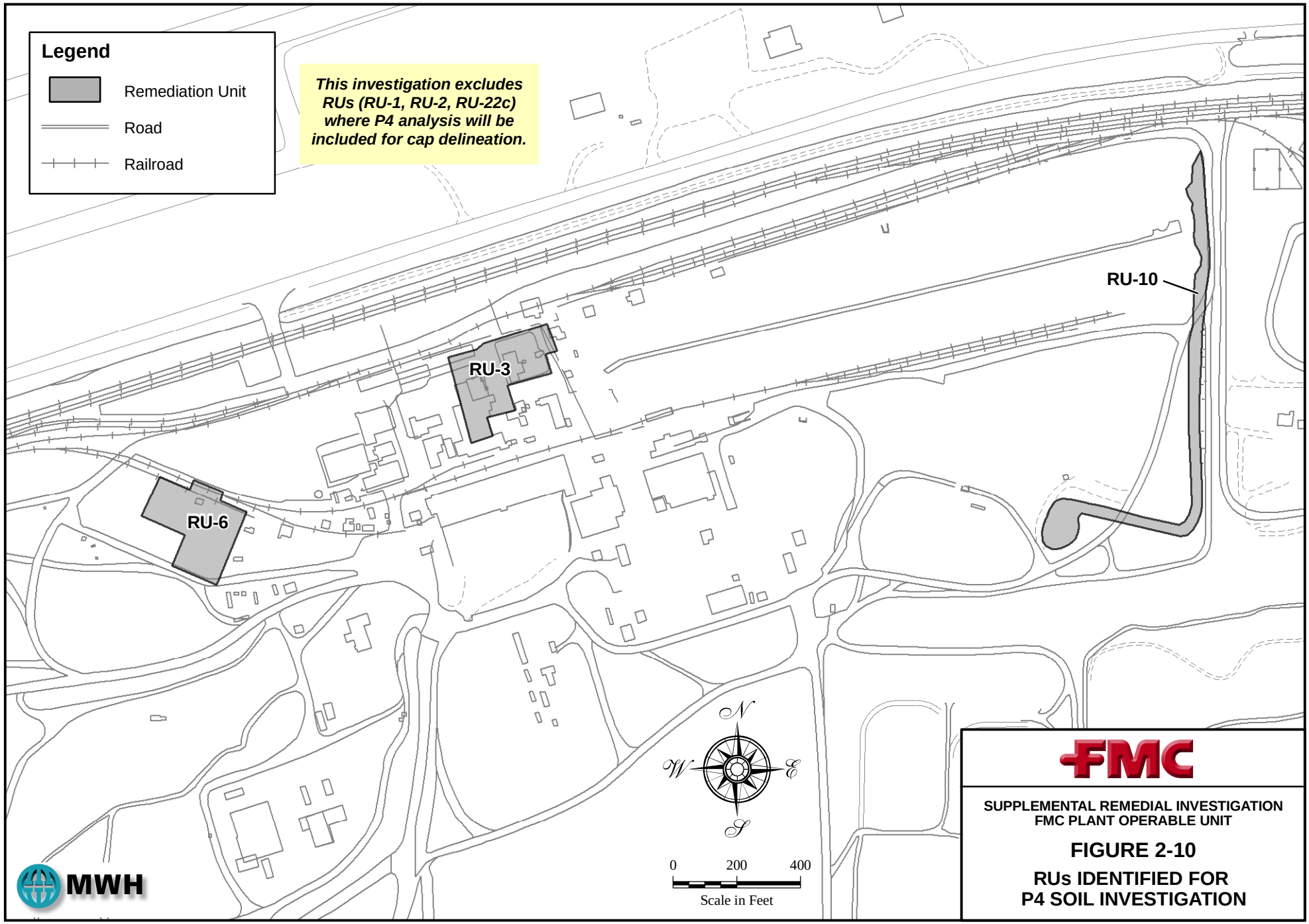
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-9

RUs IDENTIFIED FOR PB-210 AND PO-210 INVESTIGATION

FILE *Fig 2-10 P4 soil_307.mxd* *3/15/07*



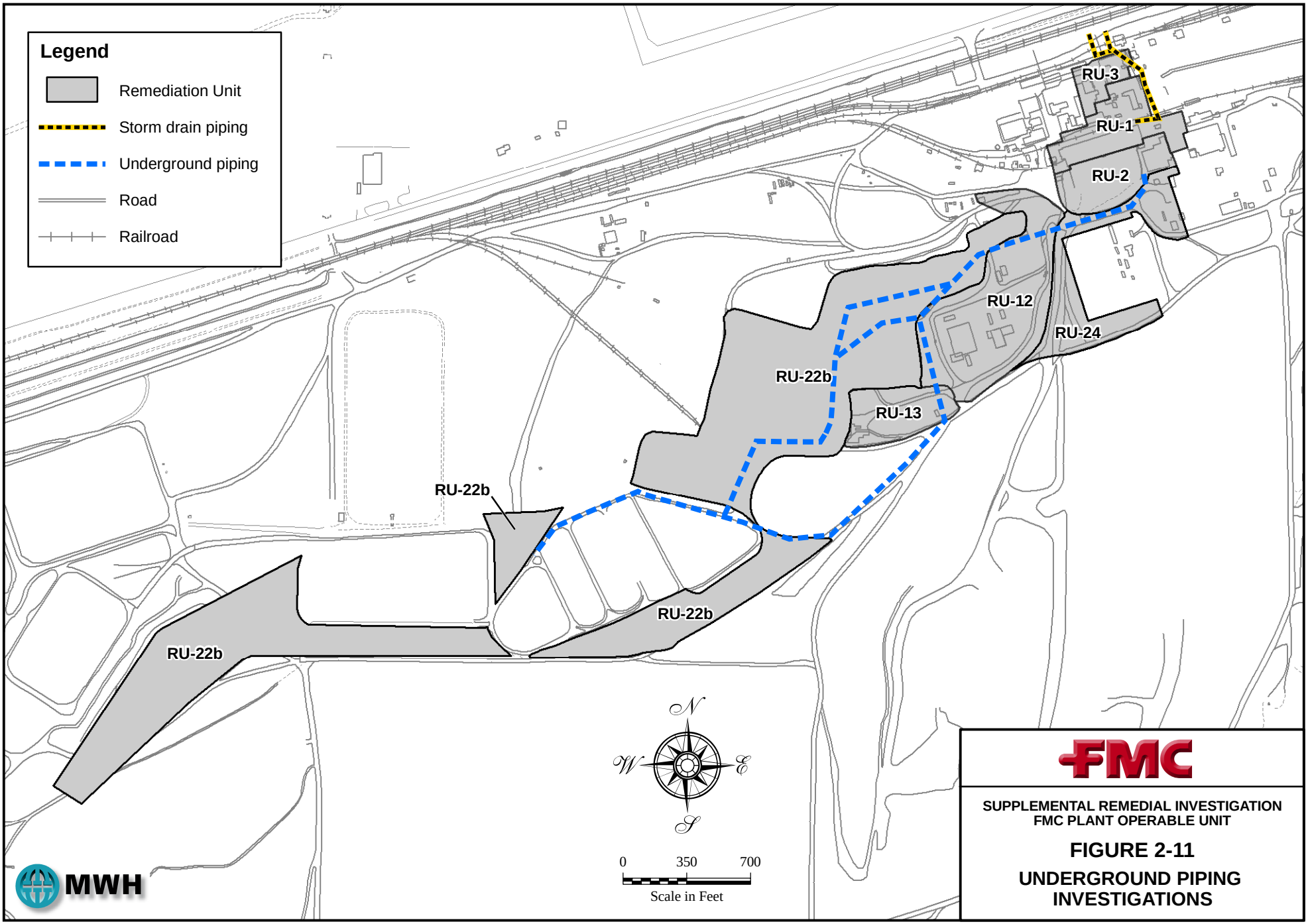
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-10

RUs IDENTIFIED FOR P4 SOIL INVESTIGATION

FILE *Fig 2-11 Underground piping_307.mxd* *3/26/07*

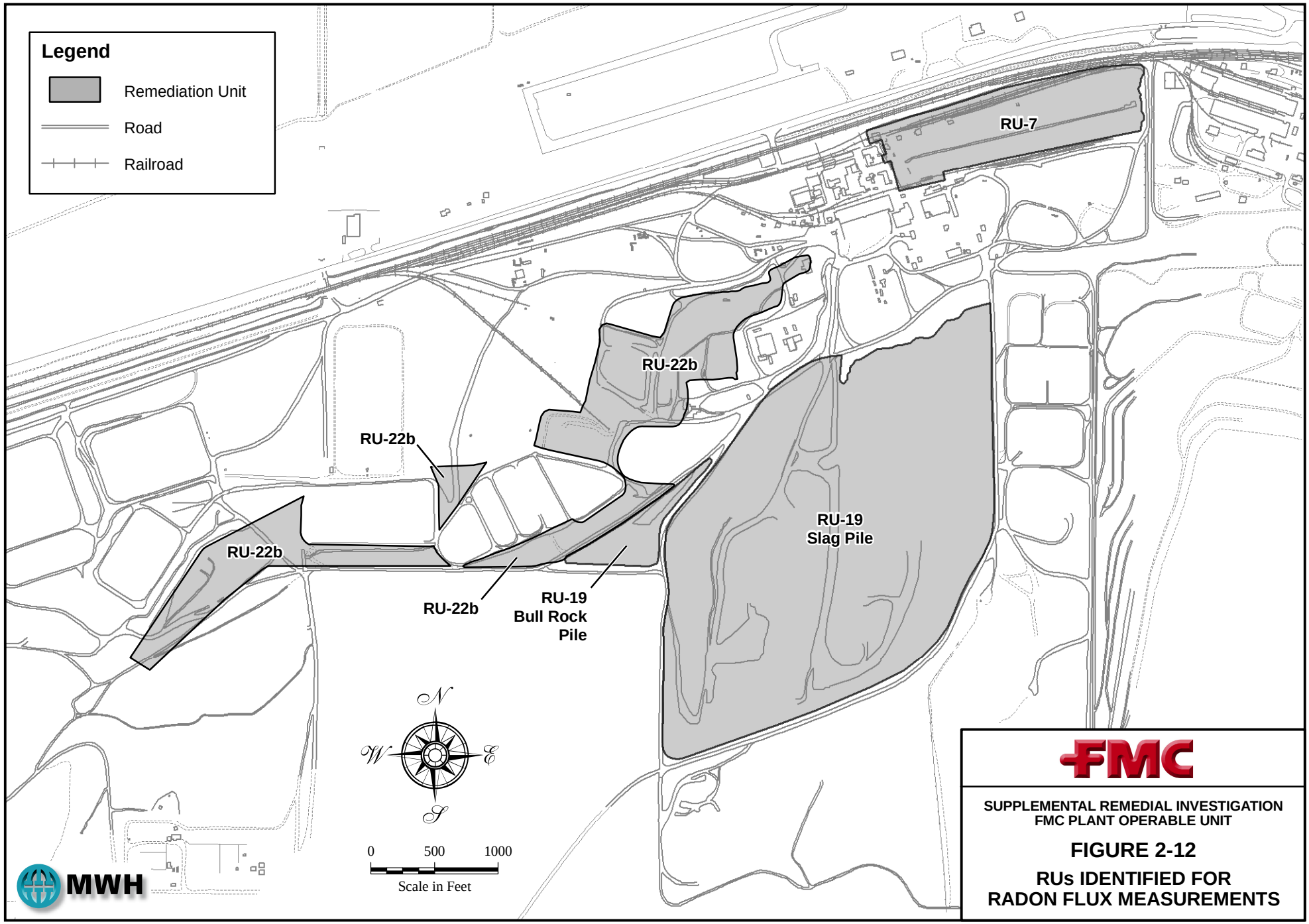


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-11

UNDERGROUND PIPING INVESTIGATIONS

FILE *Fig 2-12 Radon Flux_307.mxd* *3/15/07*

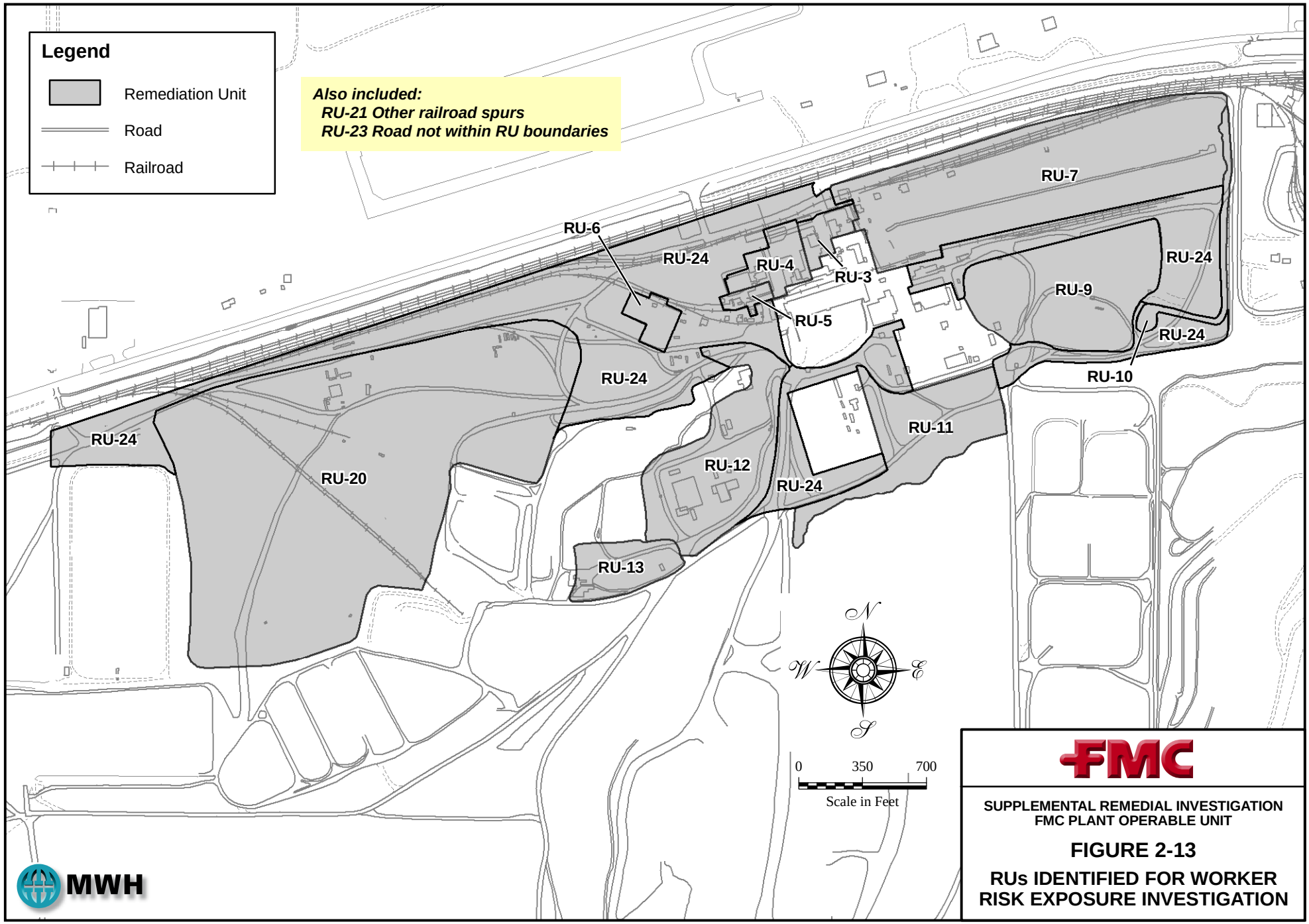


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-12

RUs IDENTIFIED FOR RADON FLUX MEASUREMENTS

FILE *Fig 2-13 Risk Exposure_307.mxd* *3/15/07*

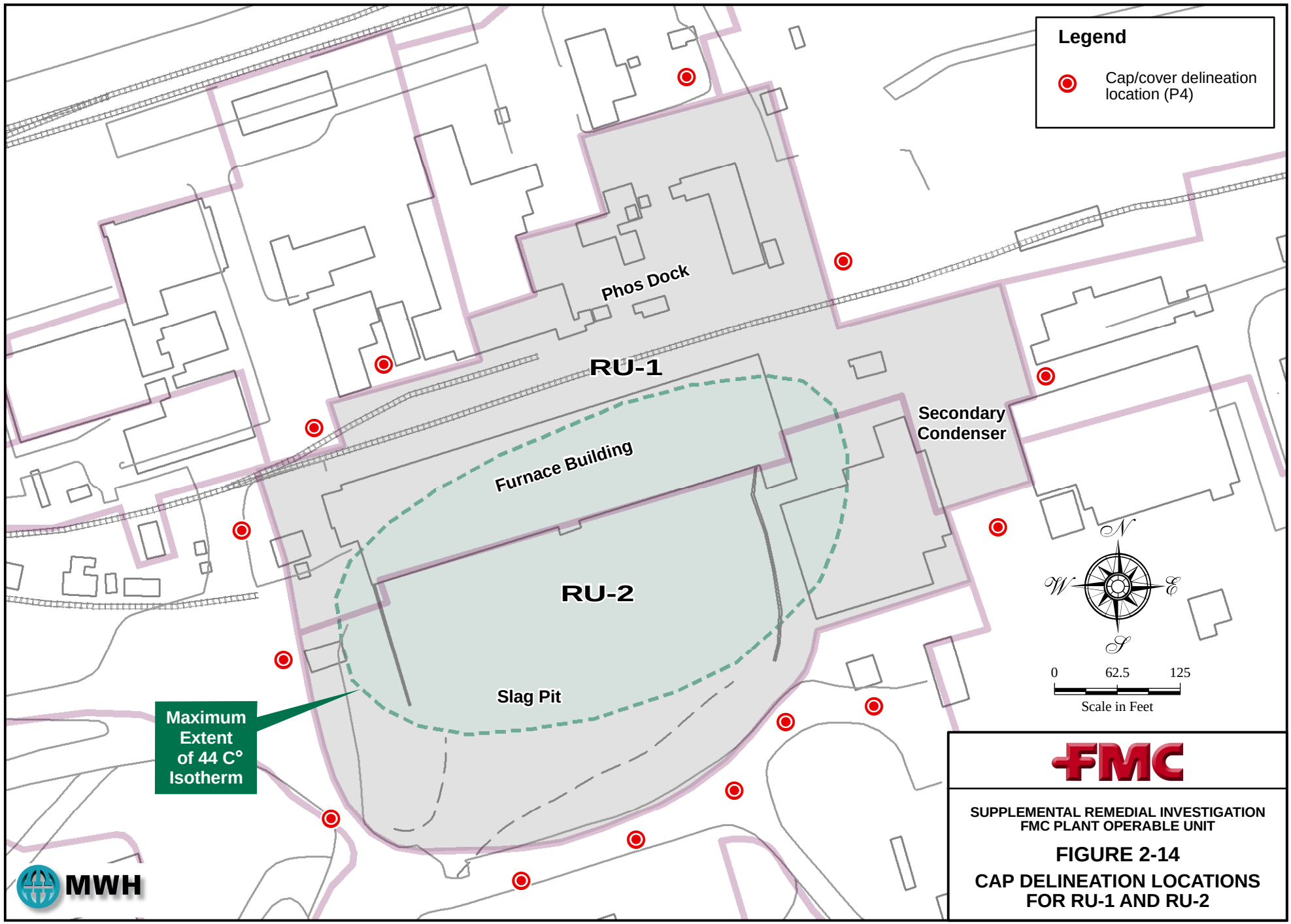


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-13

RUs IDENTIFIED FOR WORKER RISK EXPOSURE INVESTIGATION

FILE *Fig 2-14_Cap DelineationRU1RU2_307.mxd* *3/15/07*

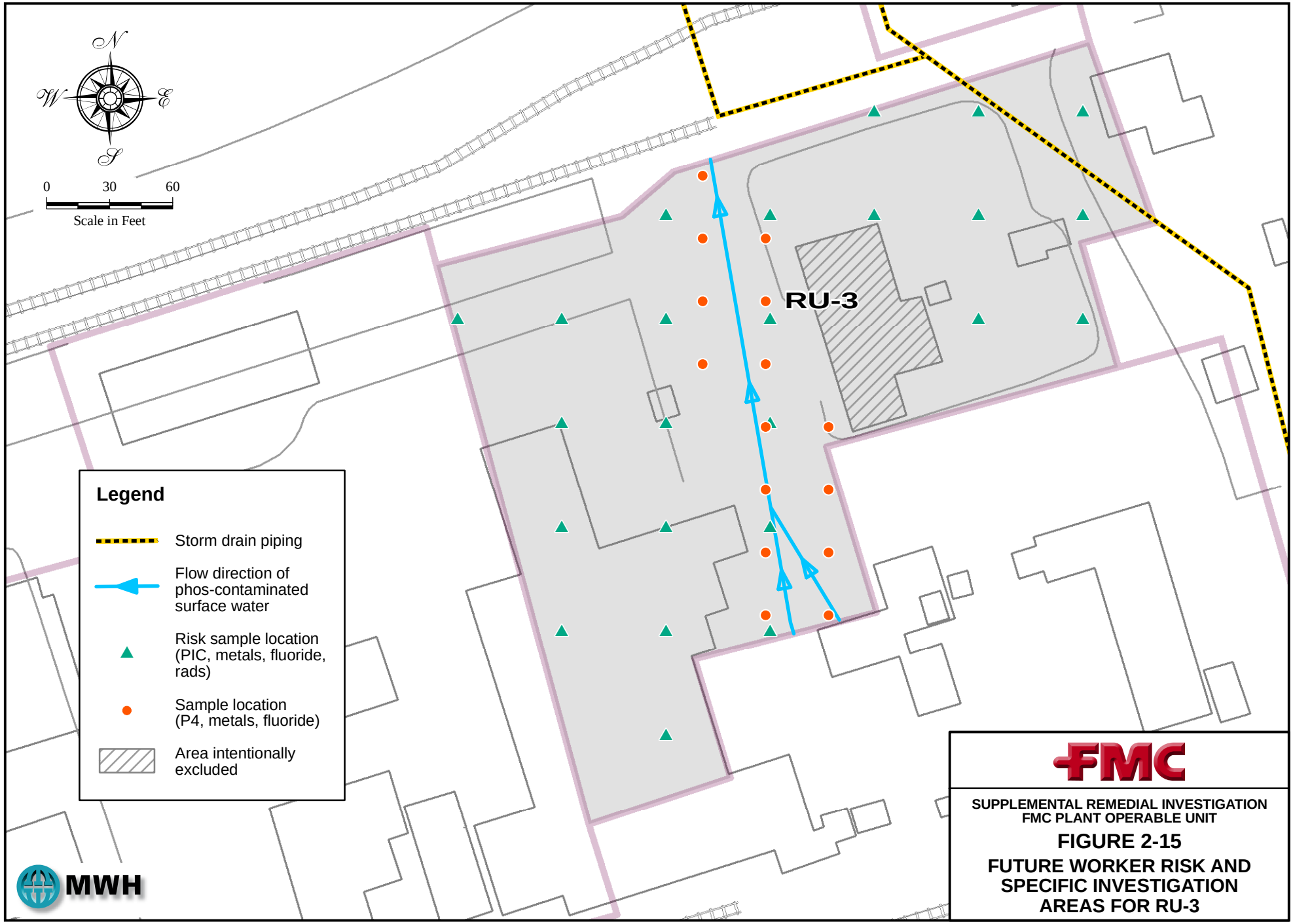


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-14

CAP DELINEATION LOCATIONS FOR RU-1 AND RU-2

FILE *Fig 2-15_Risk Hotspot_RU3_307.mxd* *3/24/07*



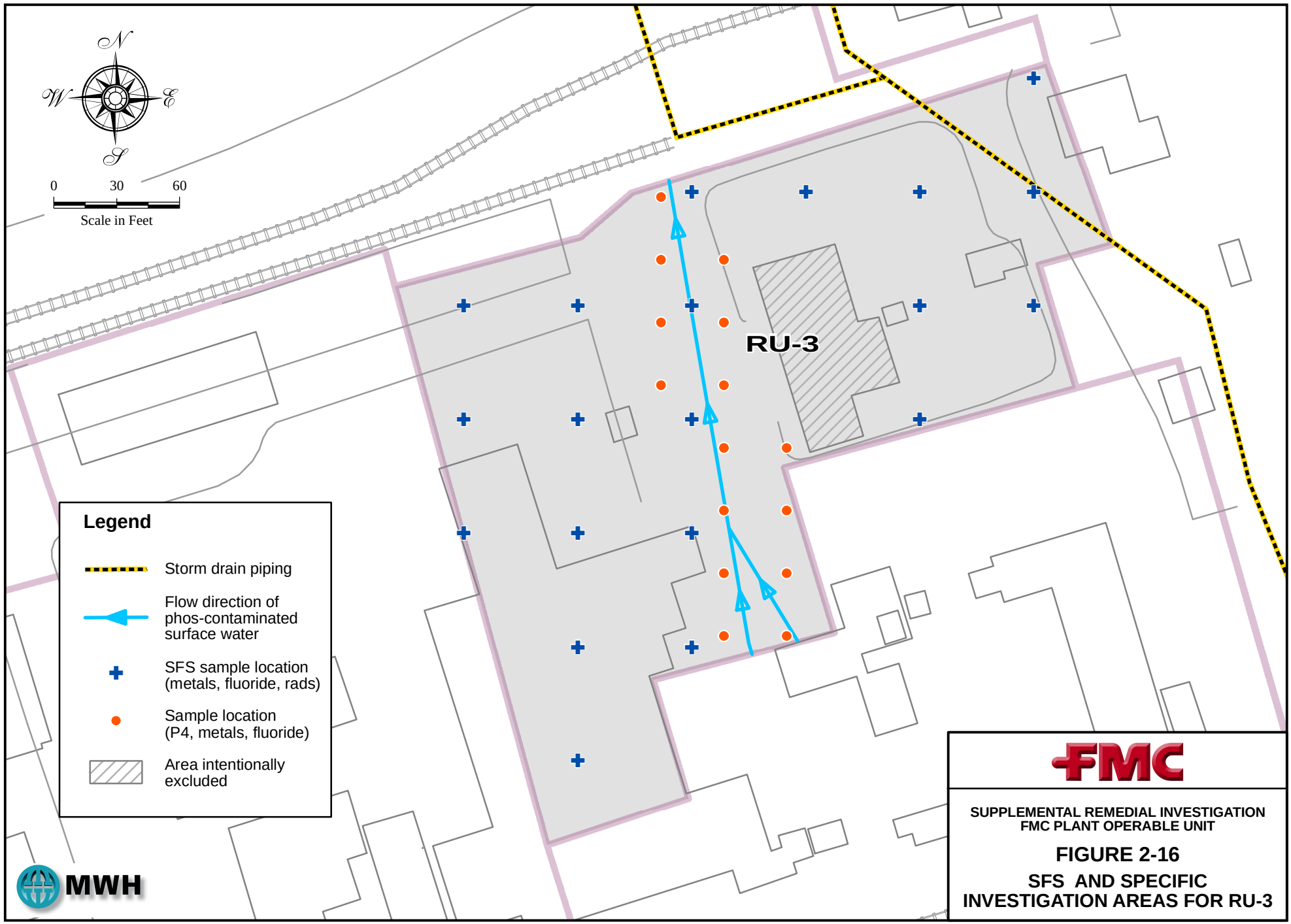
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-15

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-3

FILE *Fig 2-16_SFS Hotspot_RU3_307.mxd* *3/26/07*



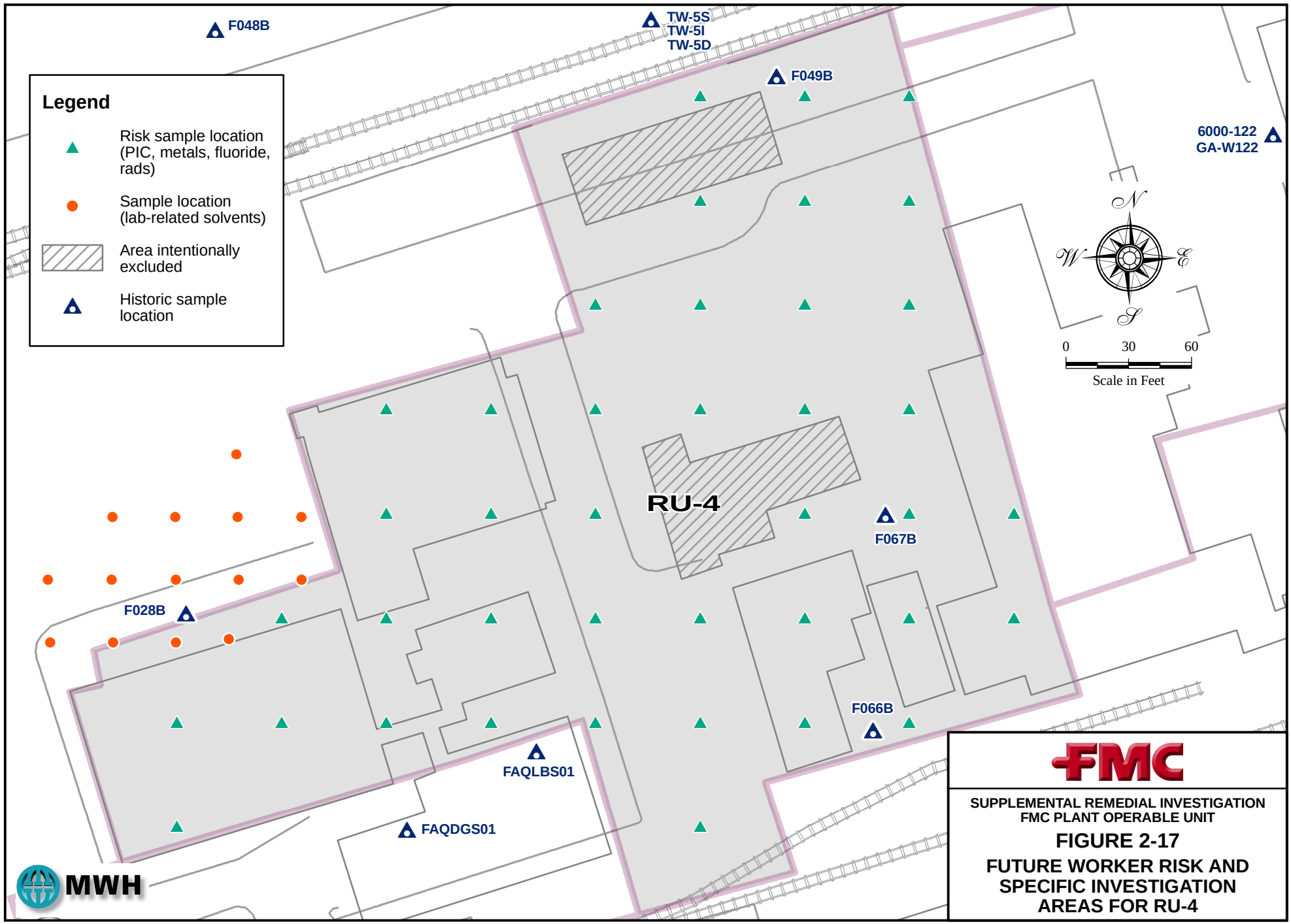
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-16

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-3

FILE *Fig 2-17_Risk Hotspot_RU4_307.mxd* *3/15/07*



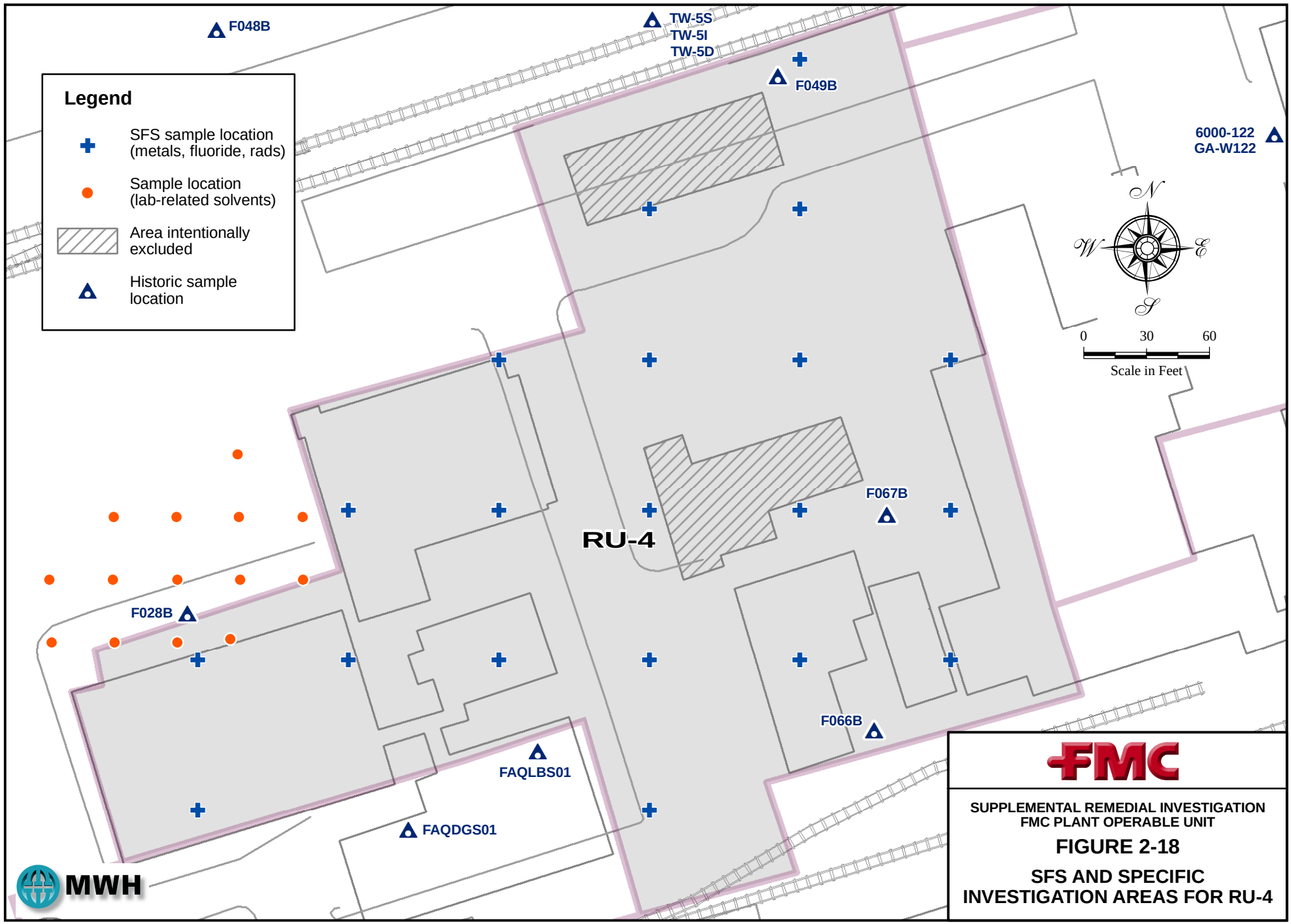
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

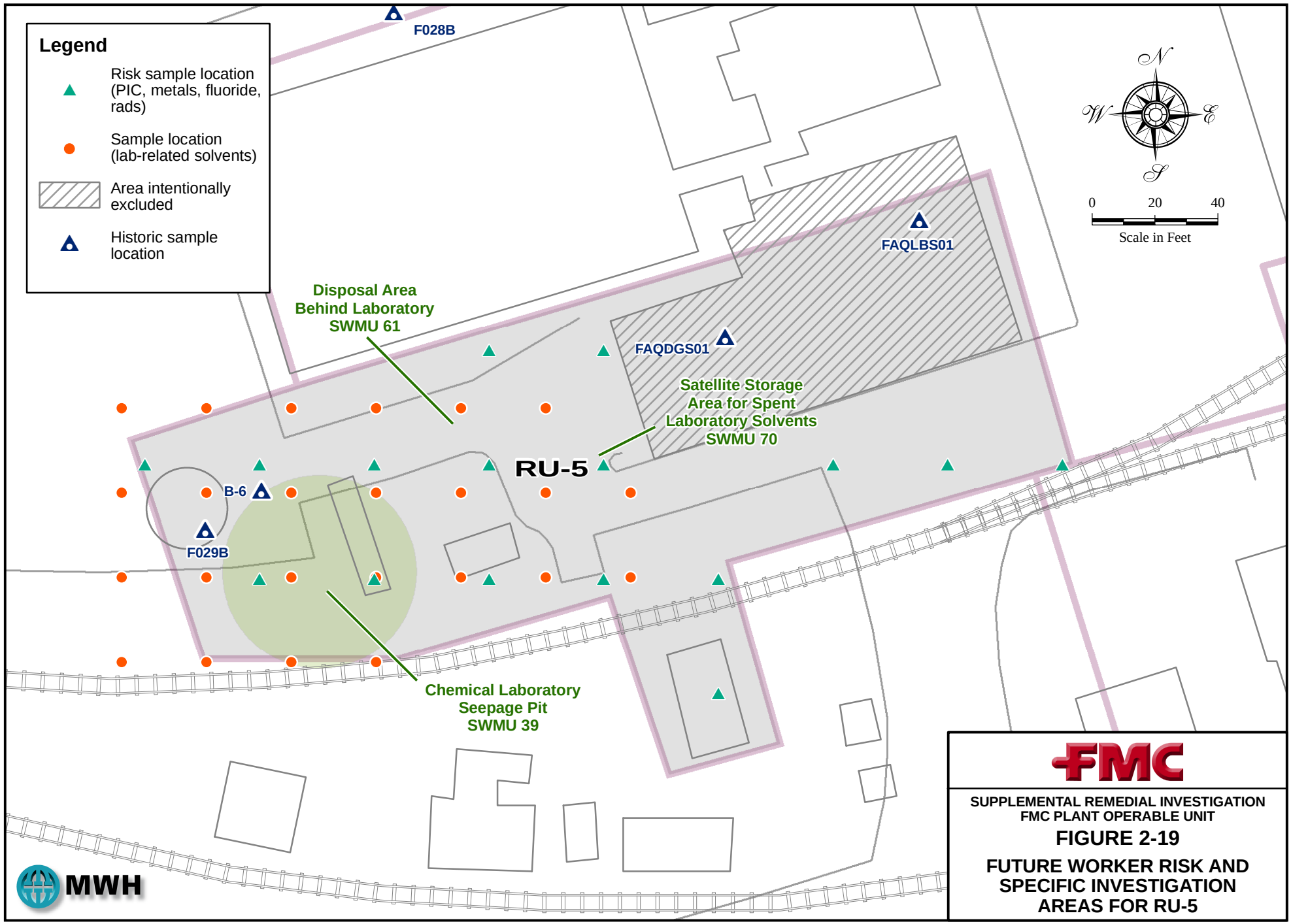
FIGURE 2-17

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-4

FILE *Fig 2-18_SFS Hotspot_RU4_307.mxd* *3/15/07*



FILE *Fig 2-19_Risk Hotspot_RU5_307.mxd* *3/26/07*



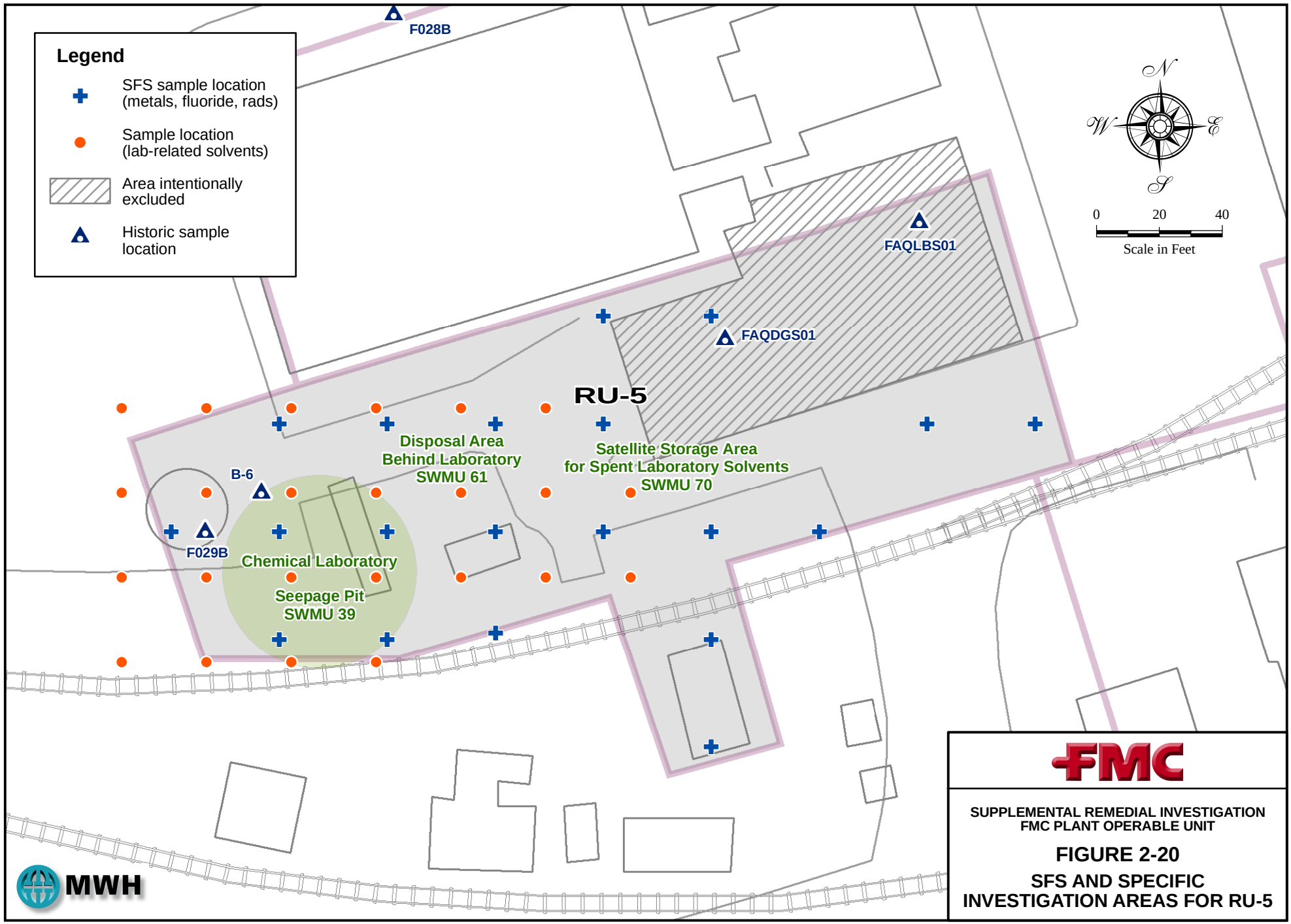
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-19

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-5

FILE *Fig 2-20_SFS Hotspot_RU5_307.mxd* *3/26/07*



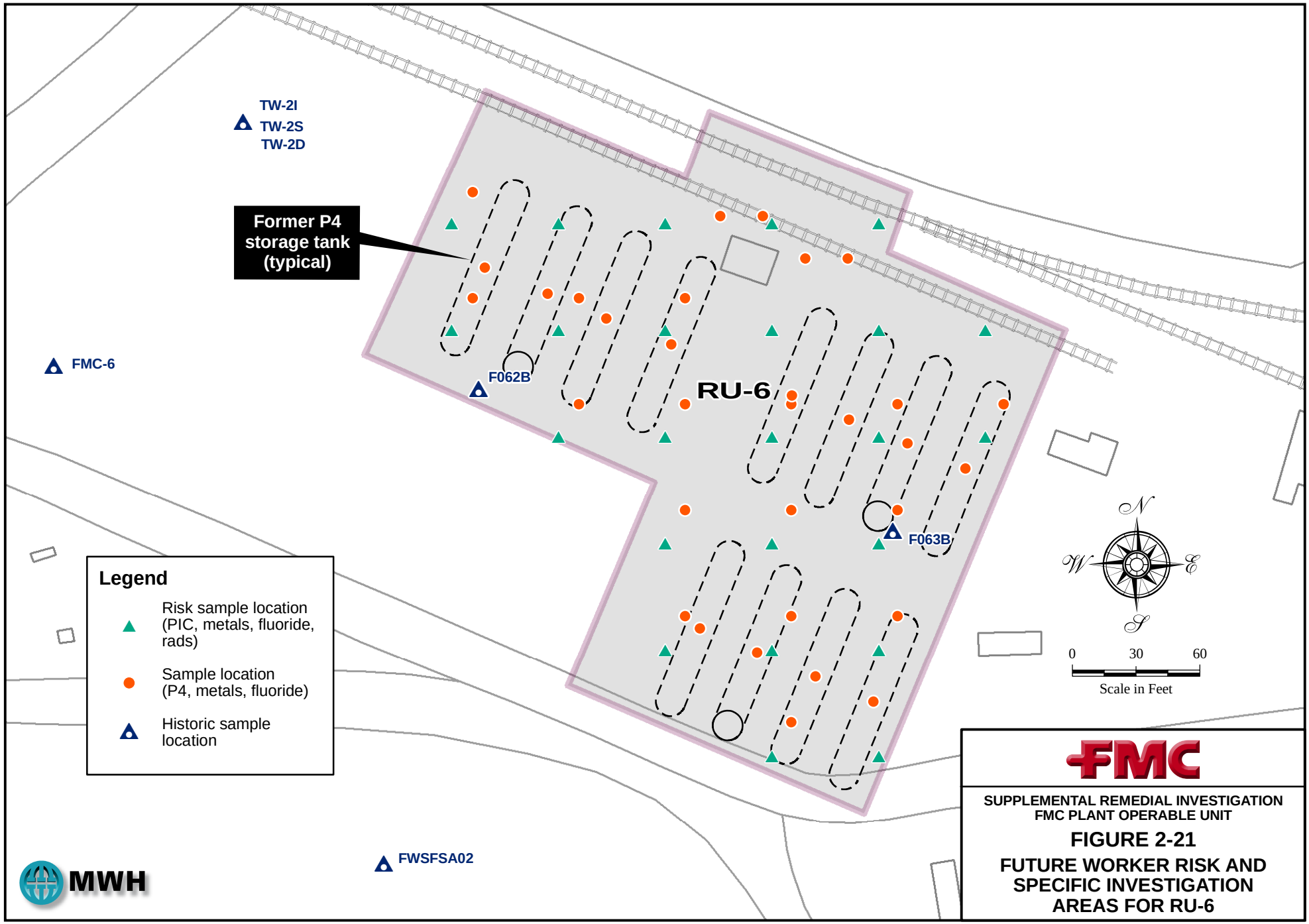
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-20

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-5

FILE *Fig 2-21_Risk Hotspot_RU6_307.mxd* *3/26/07*

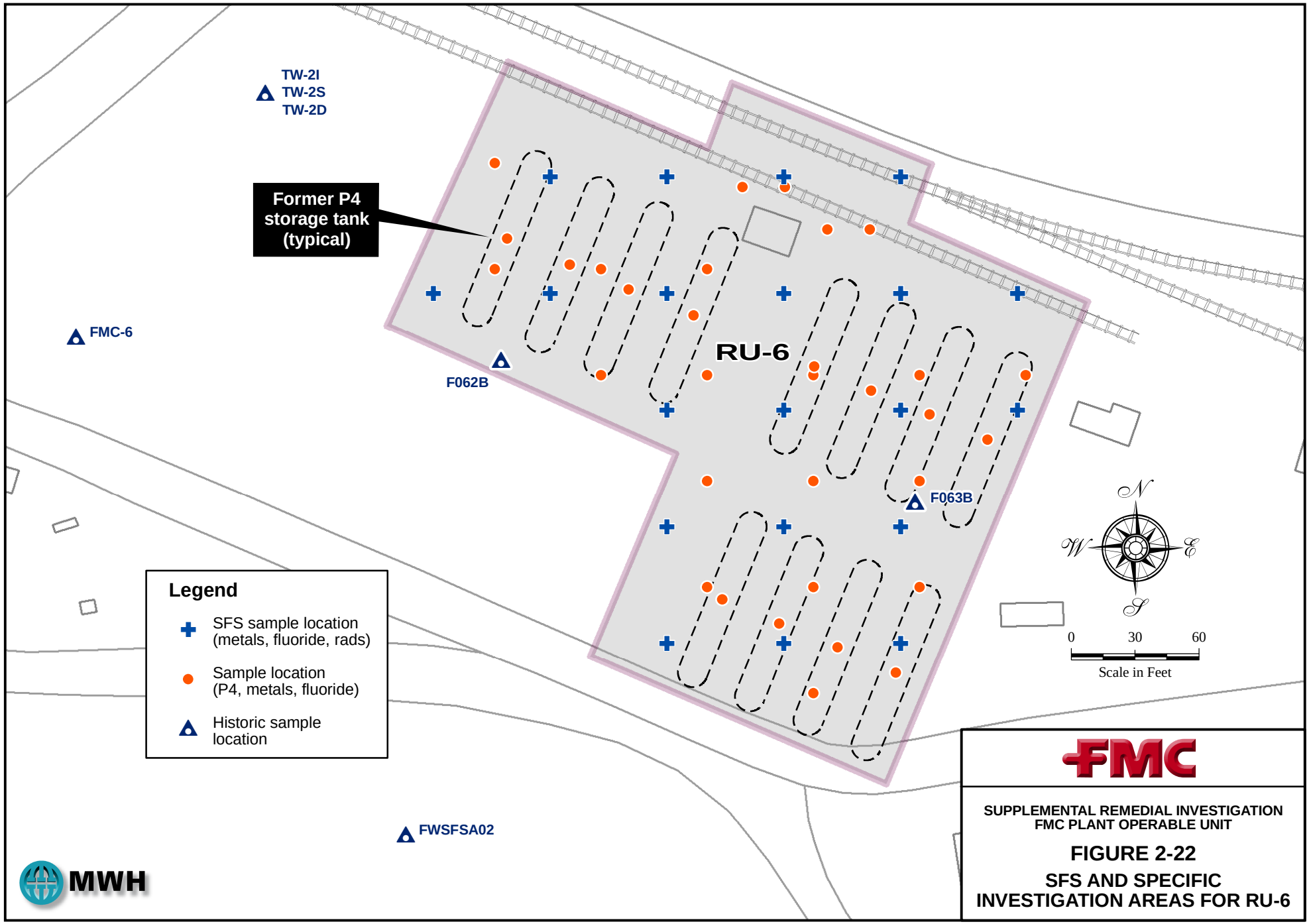


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-21

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-6

FILE *Fig 2-22_SFS Hotspot_RU6_307.mxd* *3/26/07*



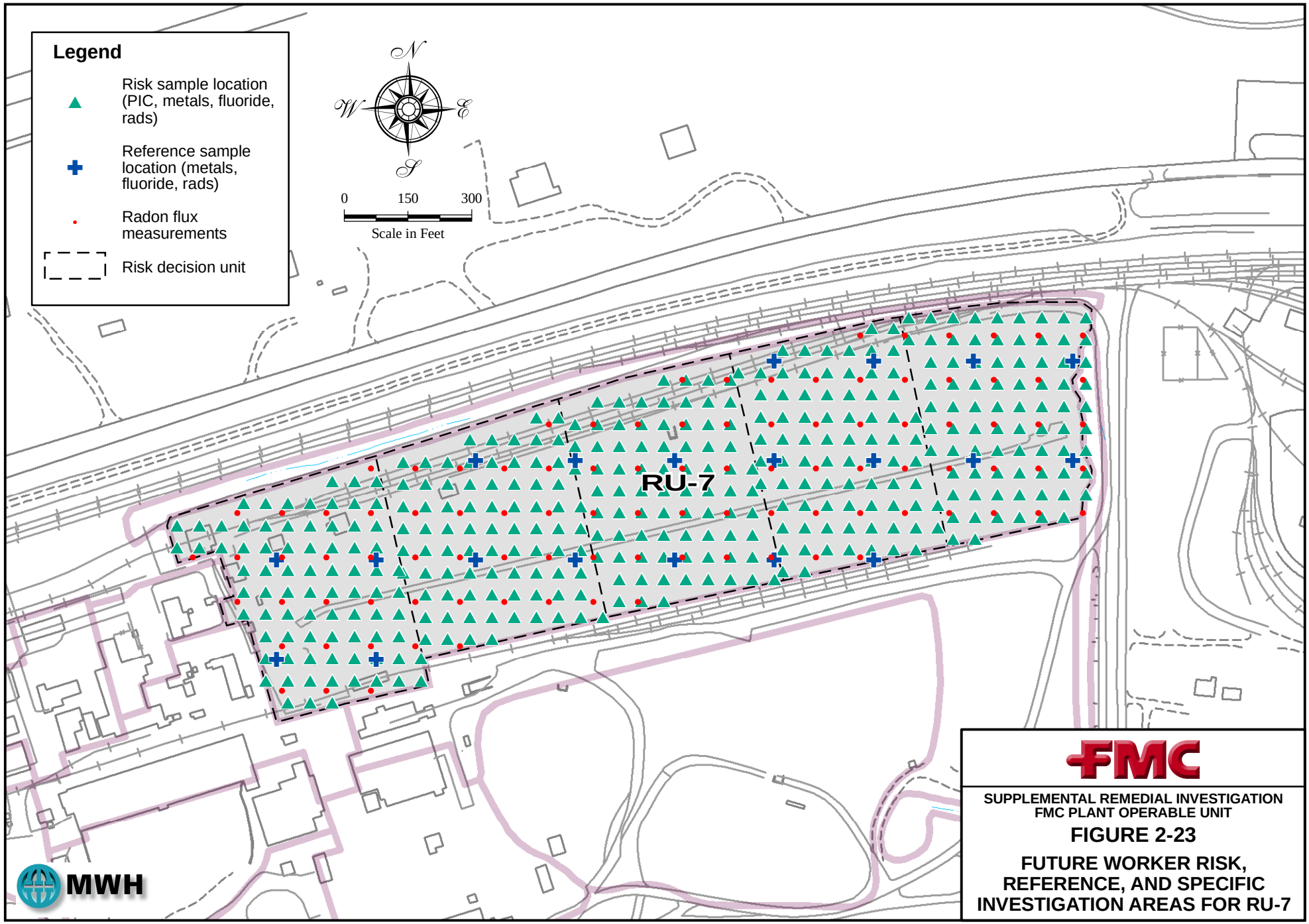
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-22

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-6

FILE *Fig 2-23_Risk Hotspot_RU7_307.mxd* *3/15/07*



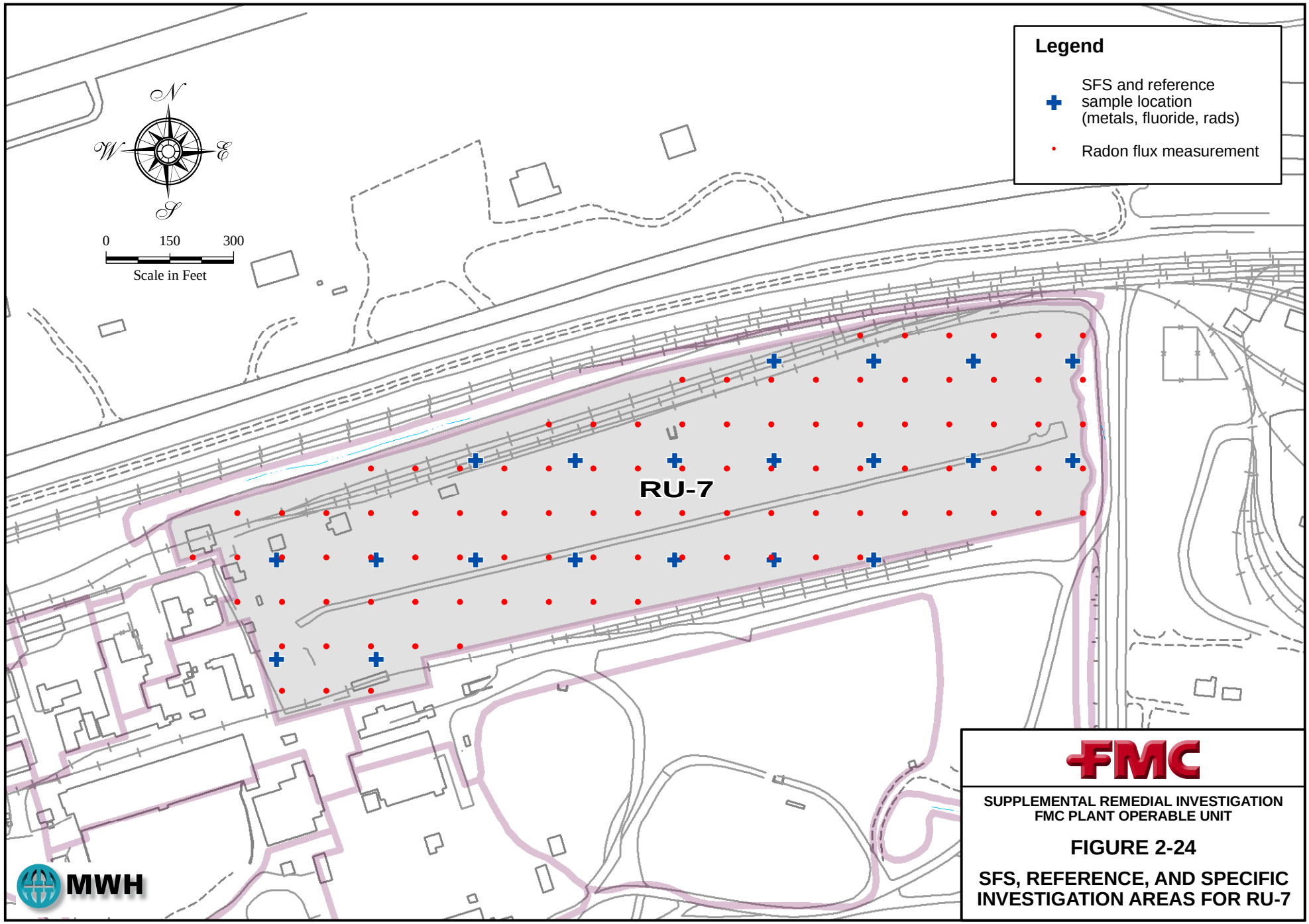
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-23

FUTURE WORKER RISK, REFERENCE, AND SPECIFIC INVESTIGATION AREAS FOR RU-7

FILE *Fig 2-24_SFS Hotspot_RU7_307.mxd* *3/15/07*



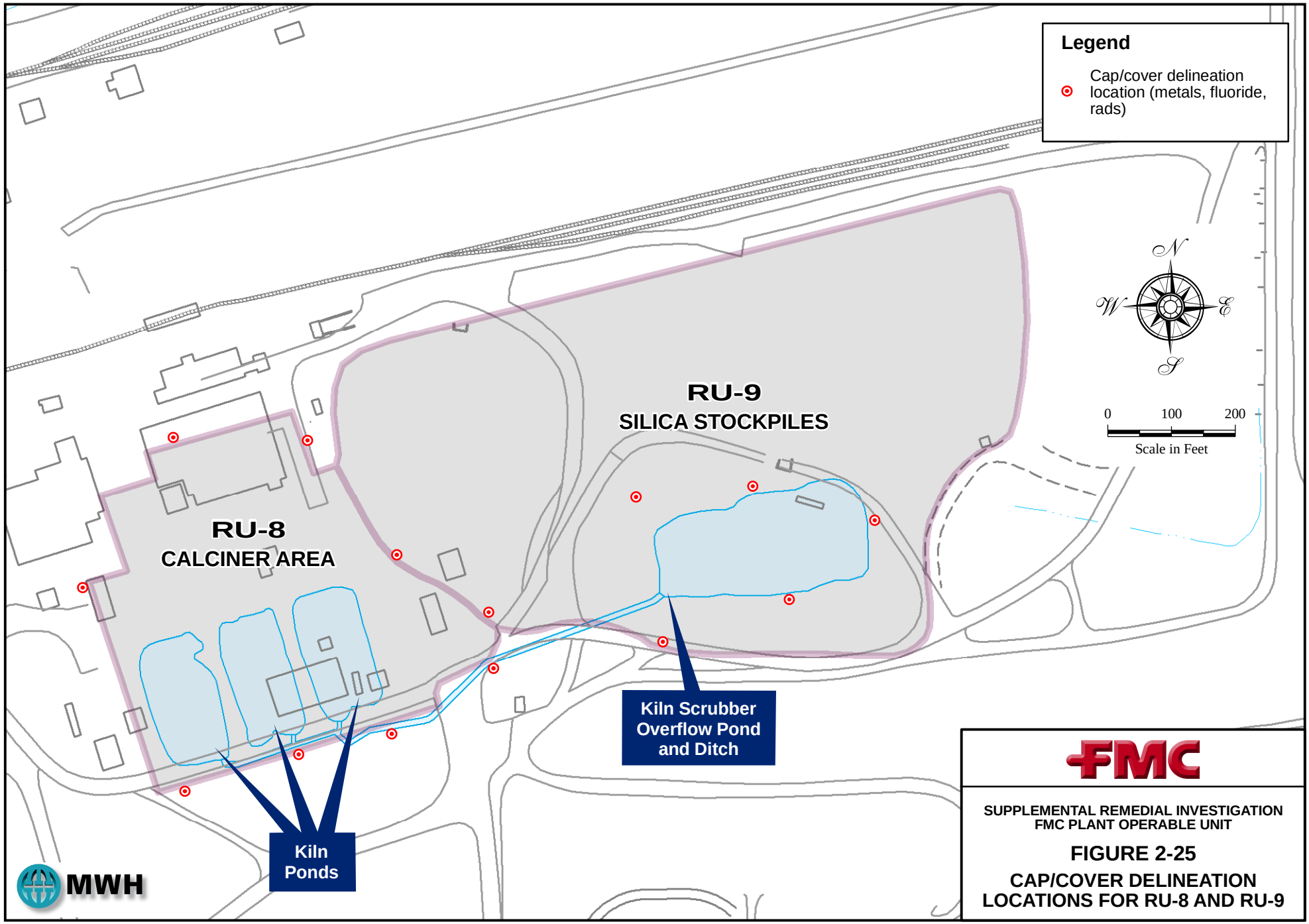
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-24

SFS, REFERENCE, AND SPECIFIC INVESTIGATION AREAS FOR RU-7

FILE *Fig 2-25 Cap Delin RU8RU9_307.mxd* *3/15/07*



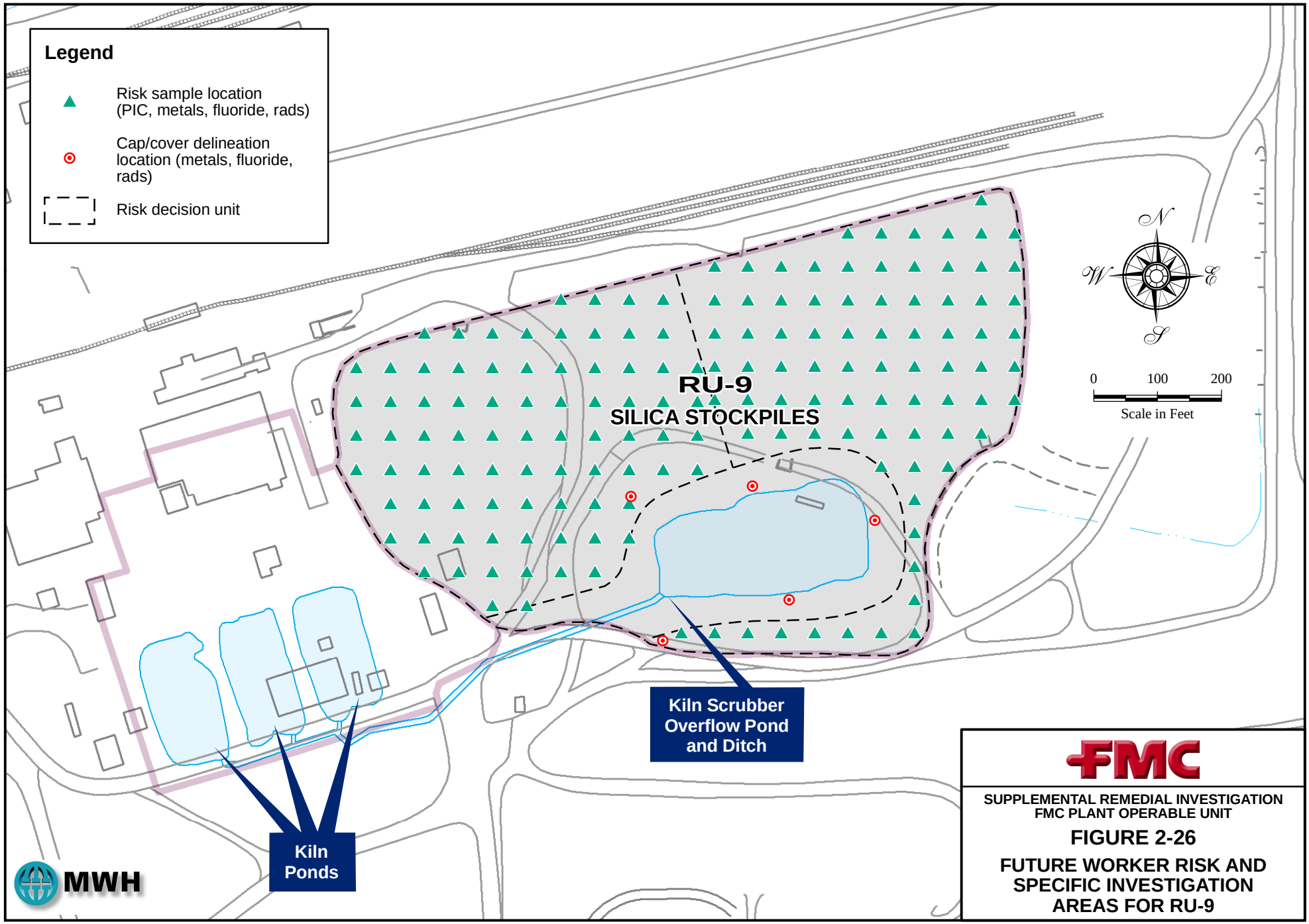
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-25

CAP/COVER DELINEATION LOCATIONS FOR RU-8 AND RU-9

FILE *Fig 2-26_Risk_RU9_307.mxd* *3/15/07*



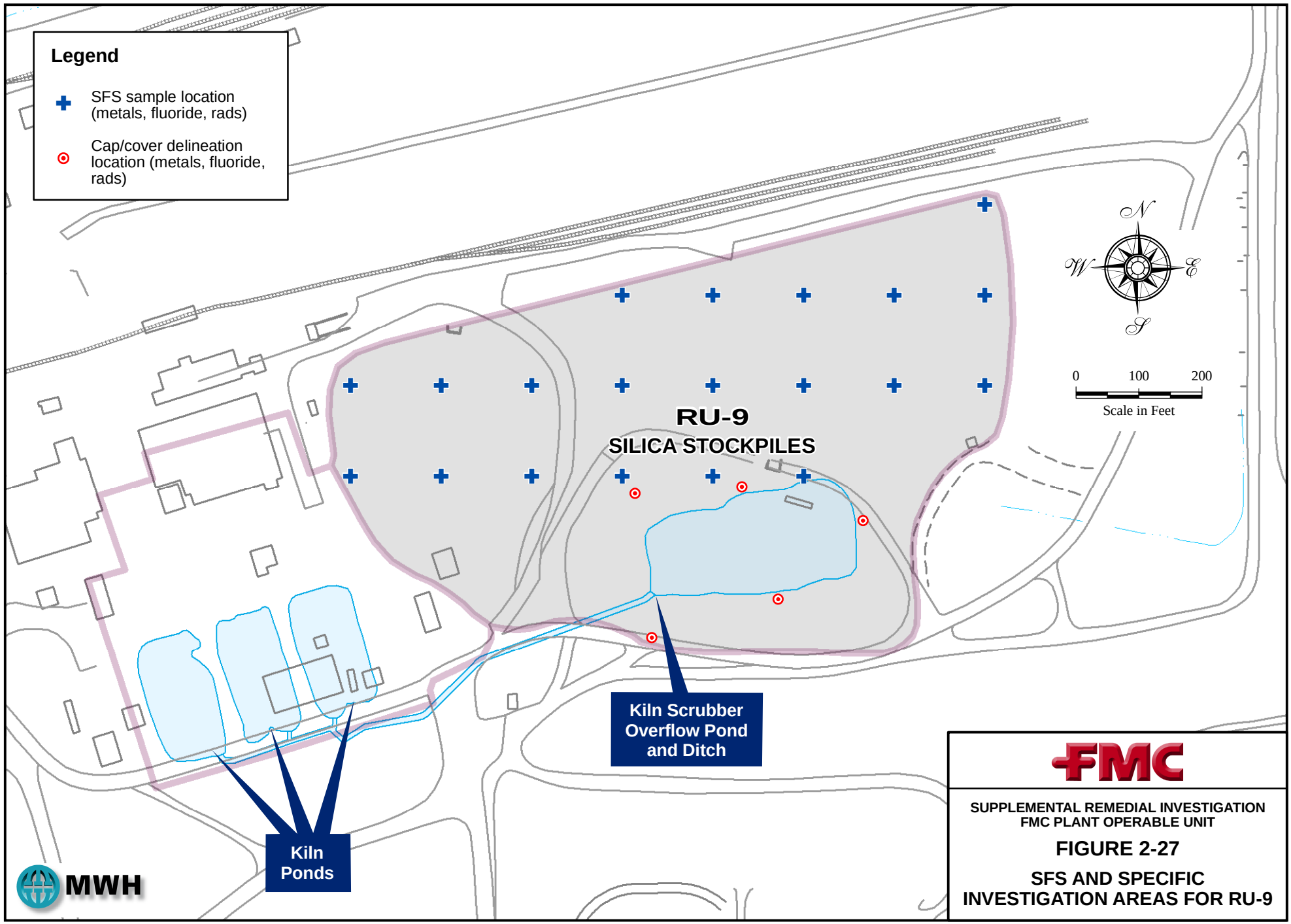
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-26

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-9

FILE *Fig 2-27_SFS_RU9_307.mxd* *3/15/07*

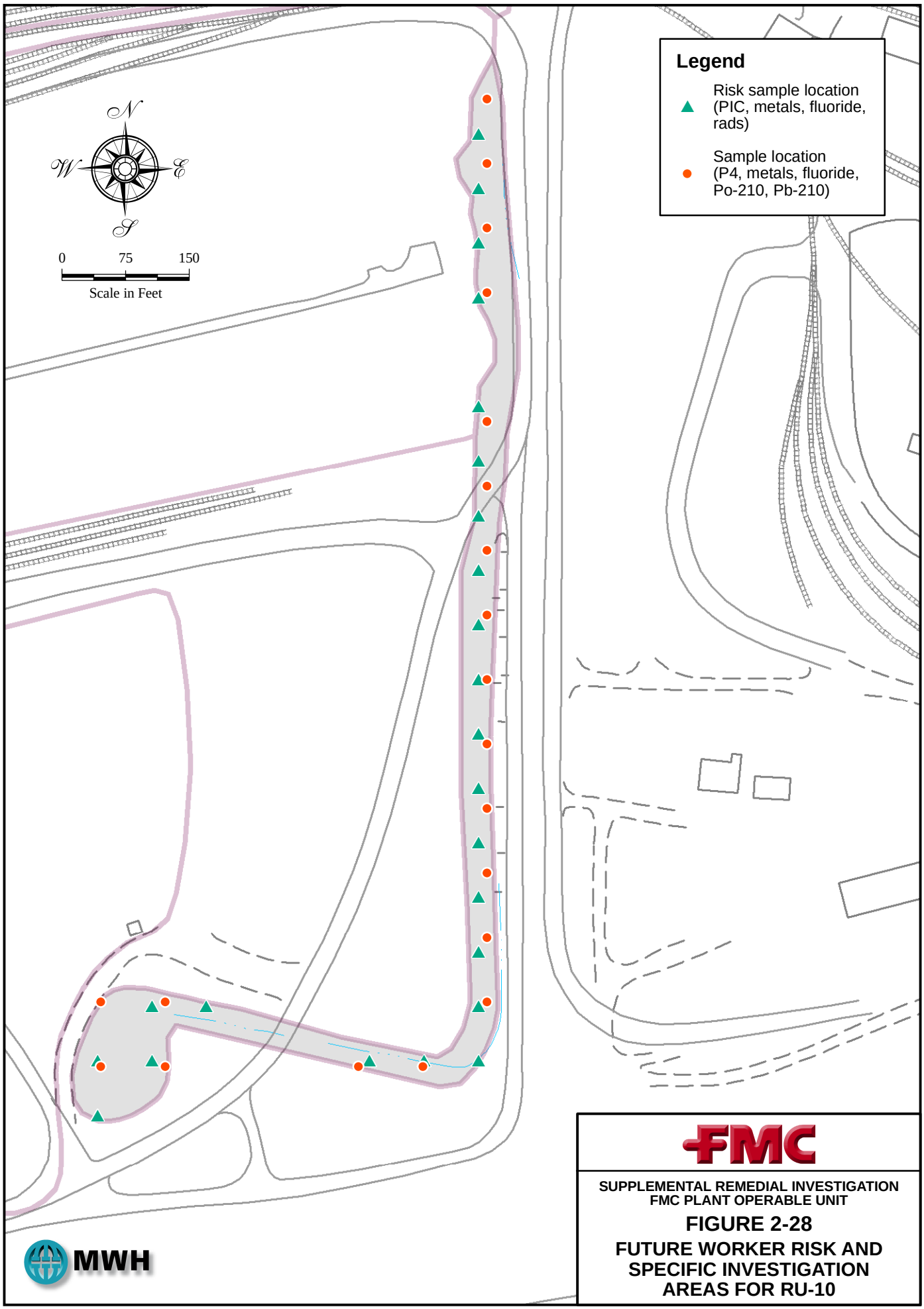


FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-27

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-9



FMC

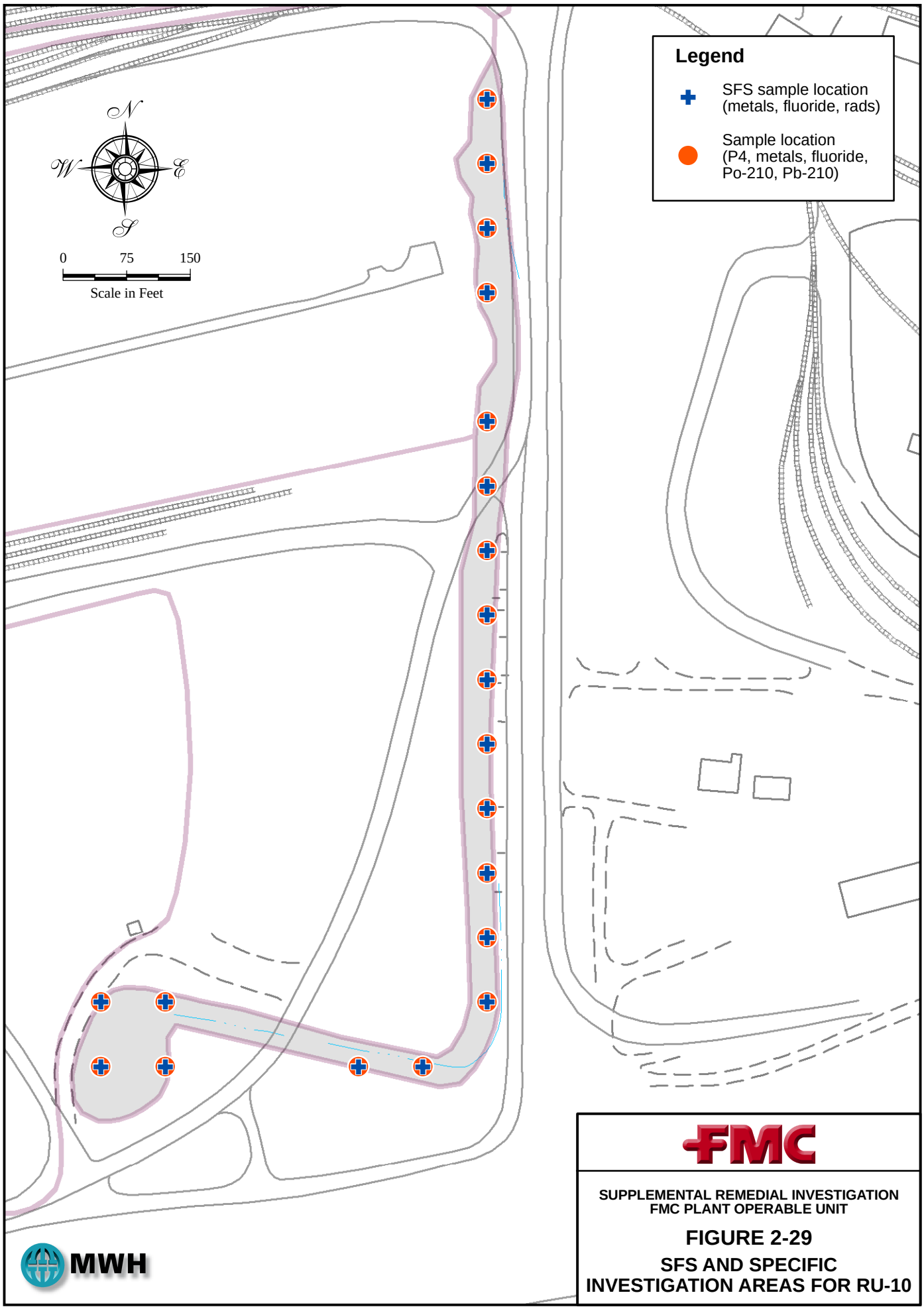
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-28

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-10

MWH

FILE *Fig 2-28_Risk Hotspot_RU10_307.mxd* *3/26/07*



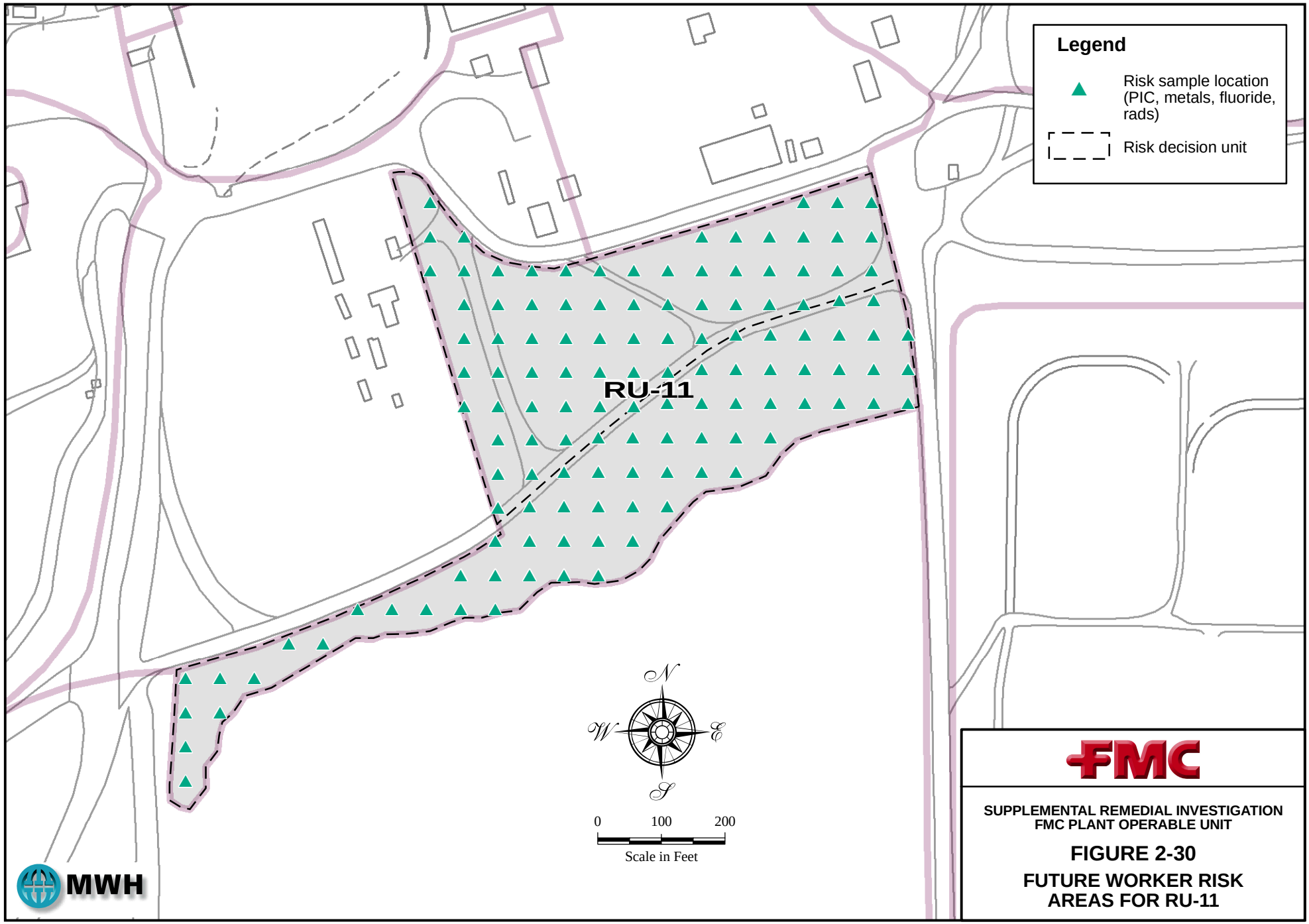
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-29

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-10

FILE Fig 2-29_SFS Hotspot_RU10_307.mxd 3/26/07

FILE *Fig 2-30_Risk_RU11_307.mxd* *3/15/07*



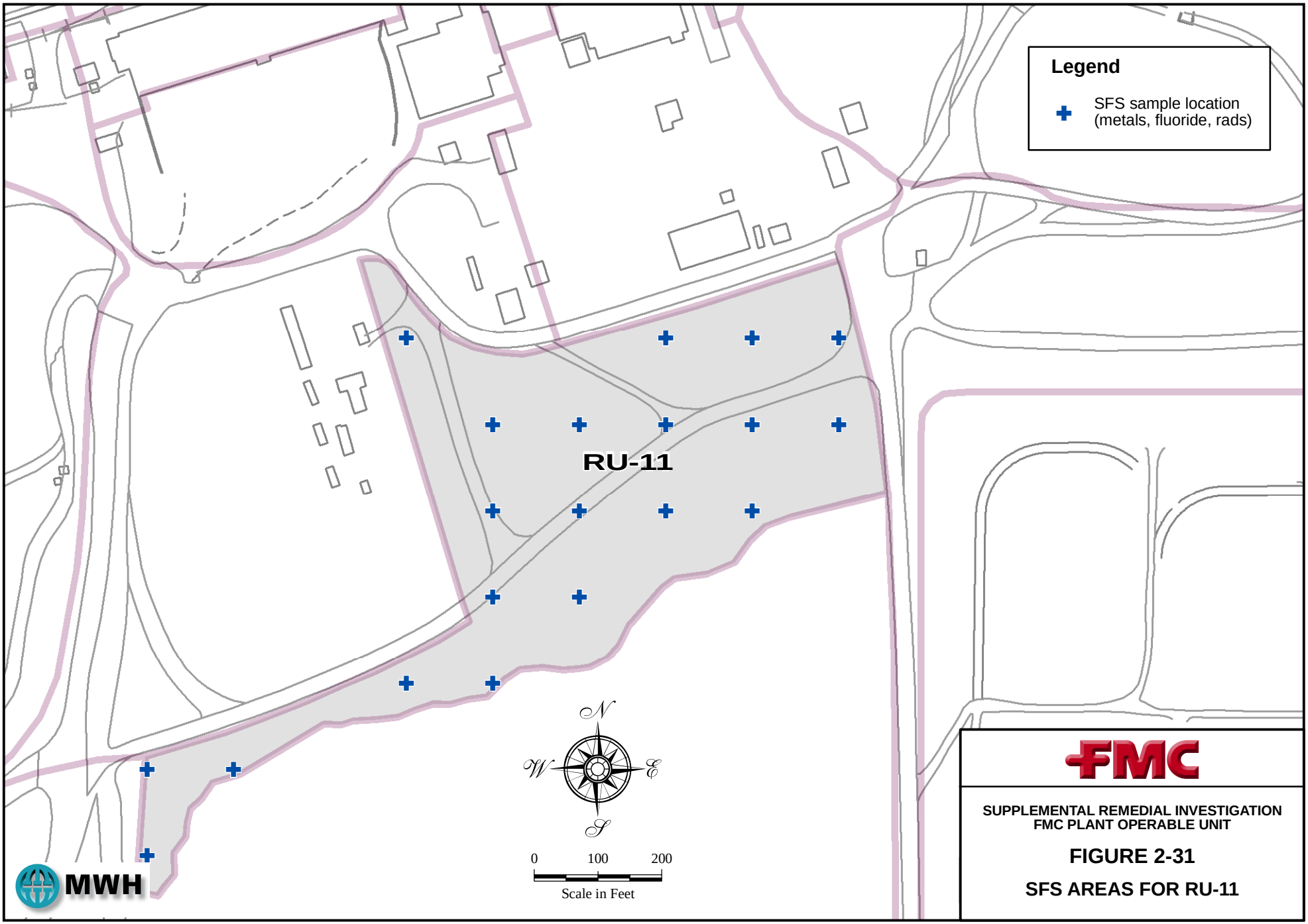
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-30

FUTURE WORKER RISK AREAS FOR RU-11

FILE *Fig 2-31_SFS Hotspot_RU11_307.mxd* *3/15/07*

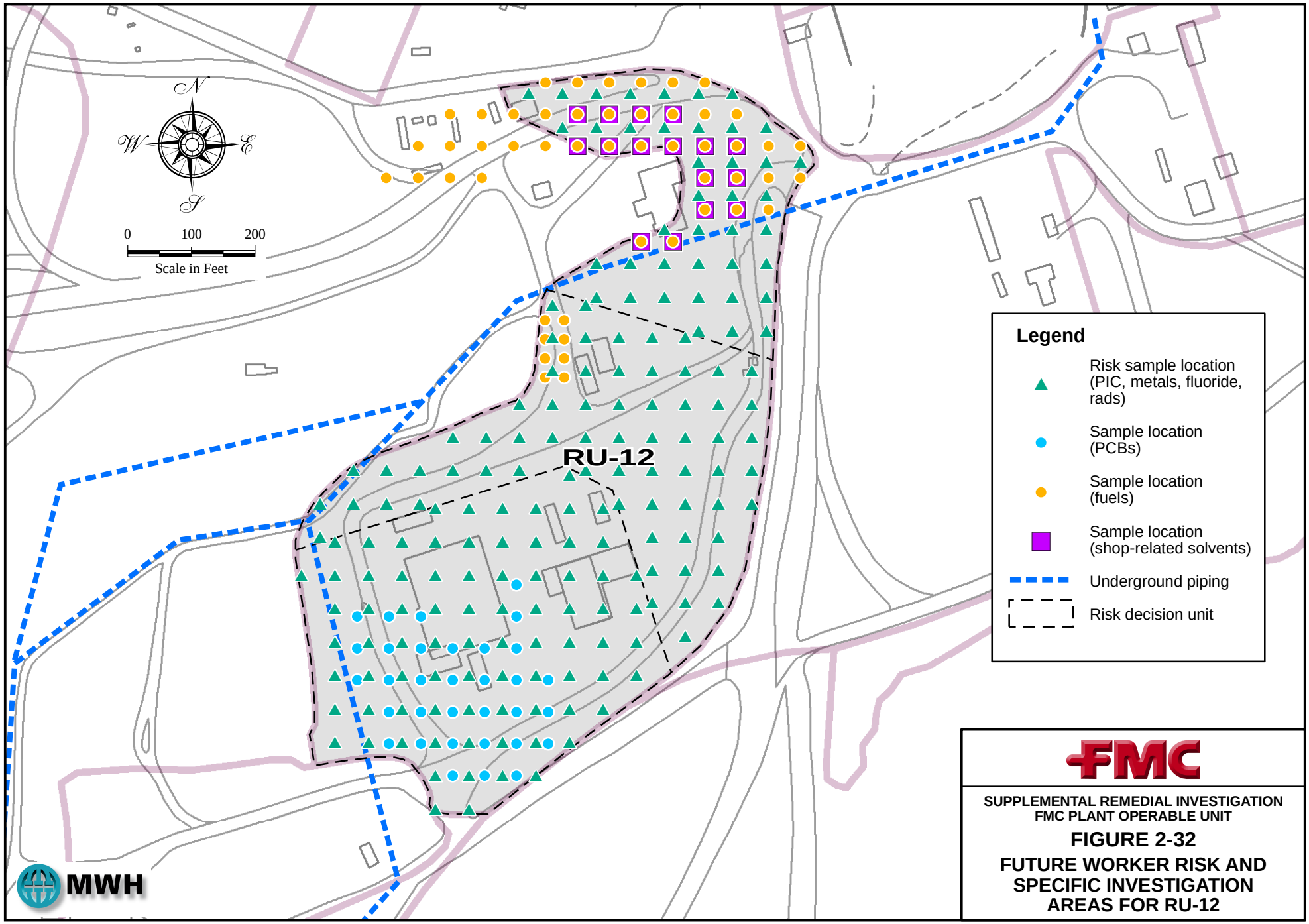


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-31

SFS AREAS FOR RU-11

FILE *Fig 2-32_Risk Hotspot_RU12_307.mxd* *3/27/07*



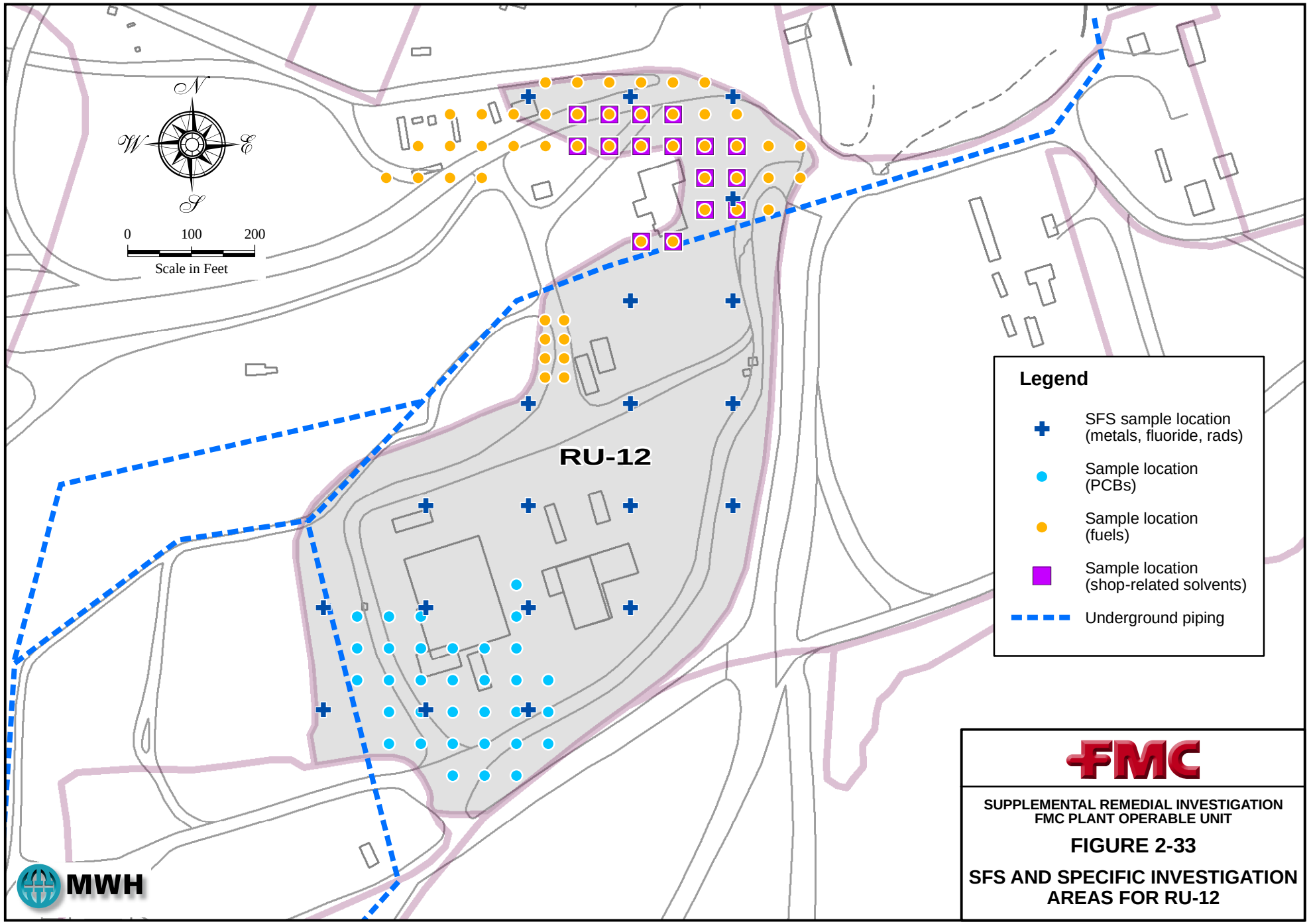
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-32

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-12

FILE *Fig 2-33_SFS Hotspot_RU12_307.mxd* *3/27/07*

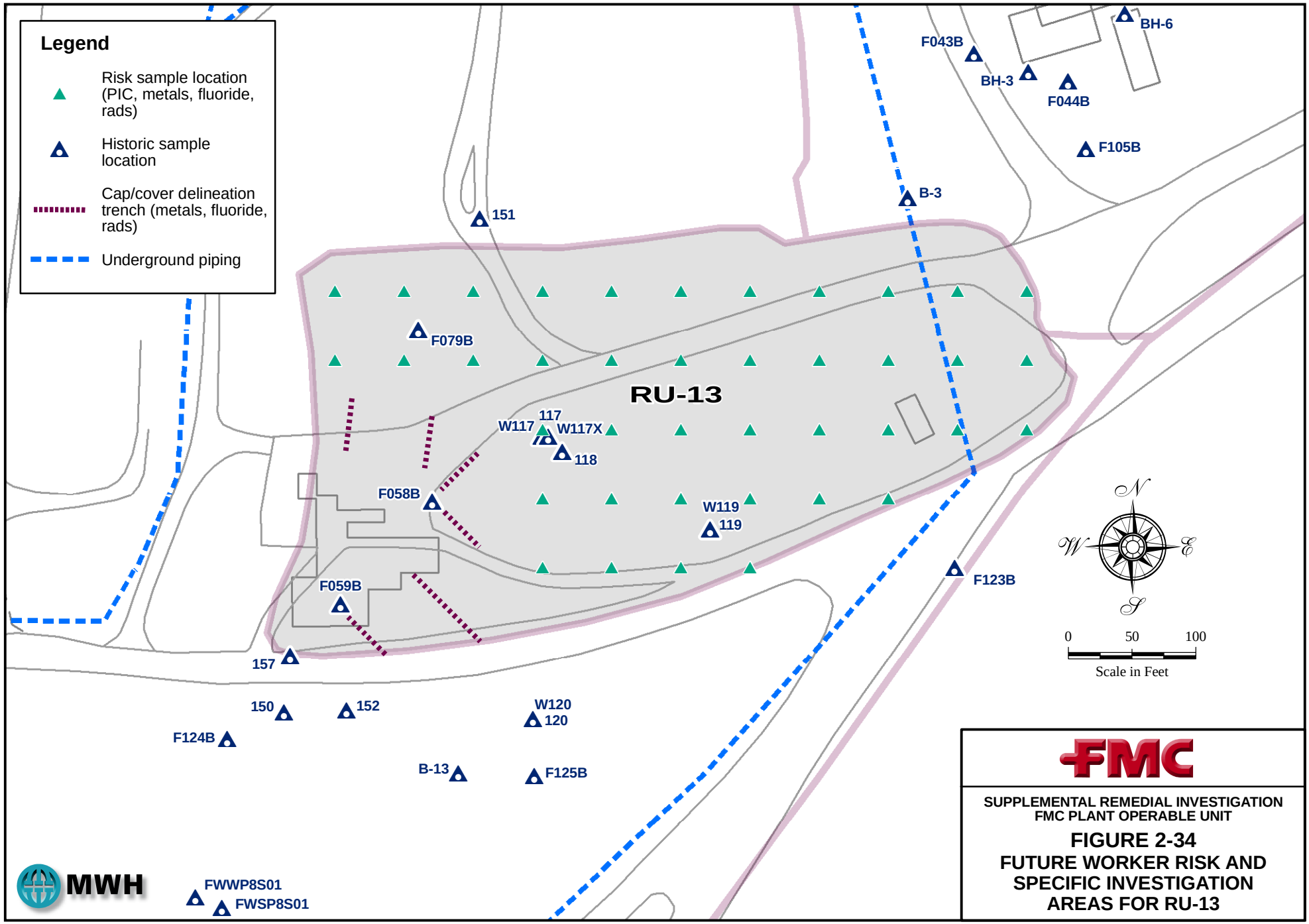


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-33

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-12

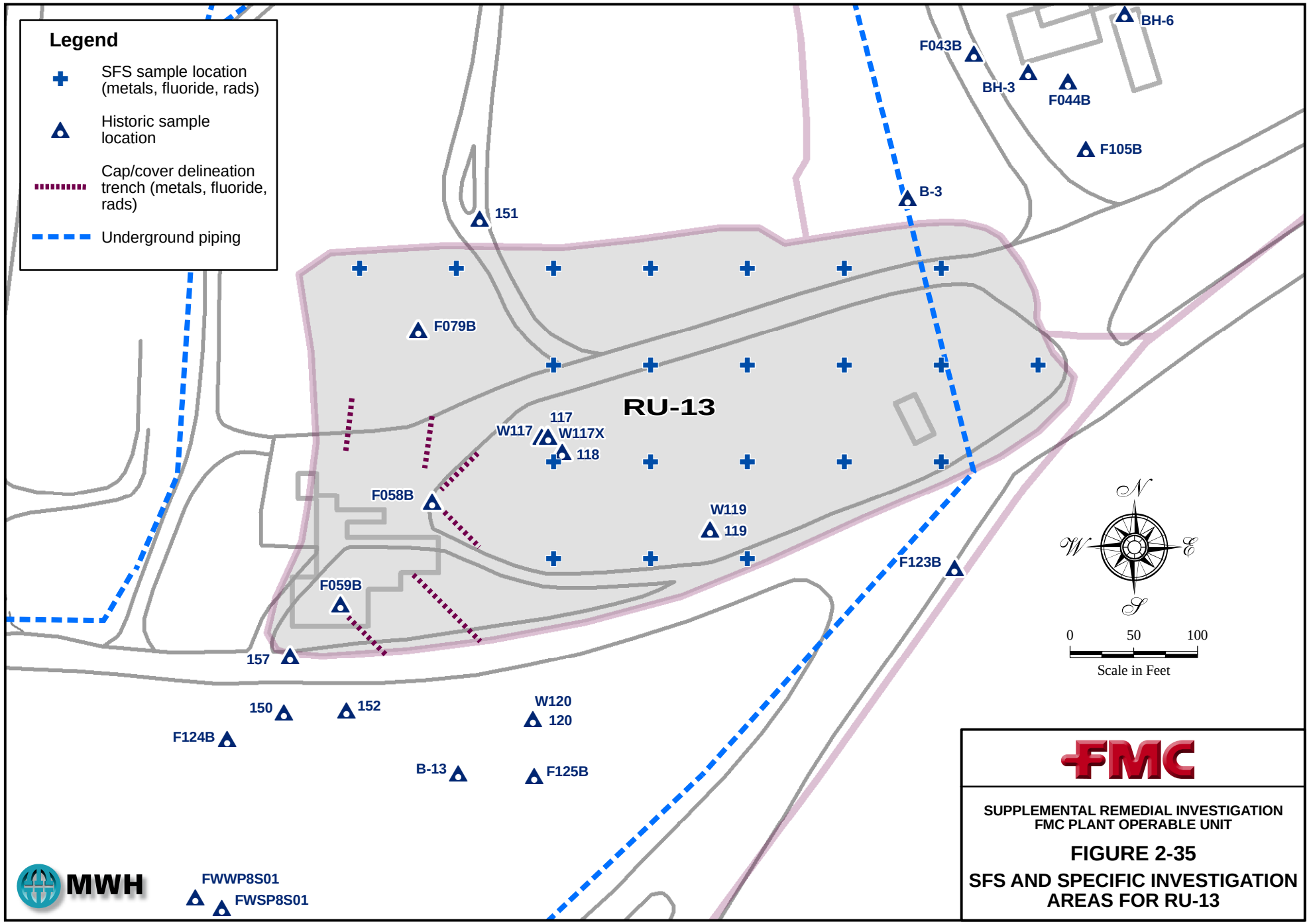
FILE *Fig 2-34_Risk Hotspot_RU13_307.mxd 3/27/07*



SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-34
FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-13

FILE *Fig 2-35_SFS Hotspot_RU13_307.mxd* *3/27/07*

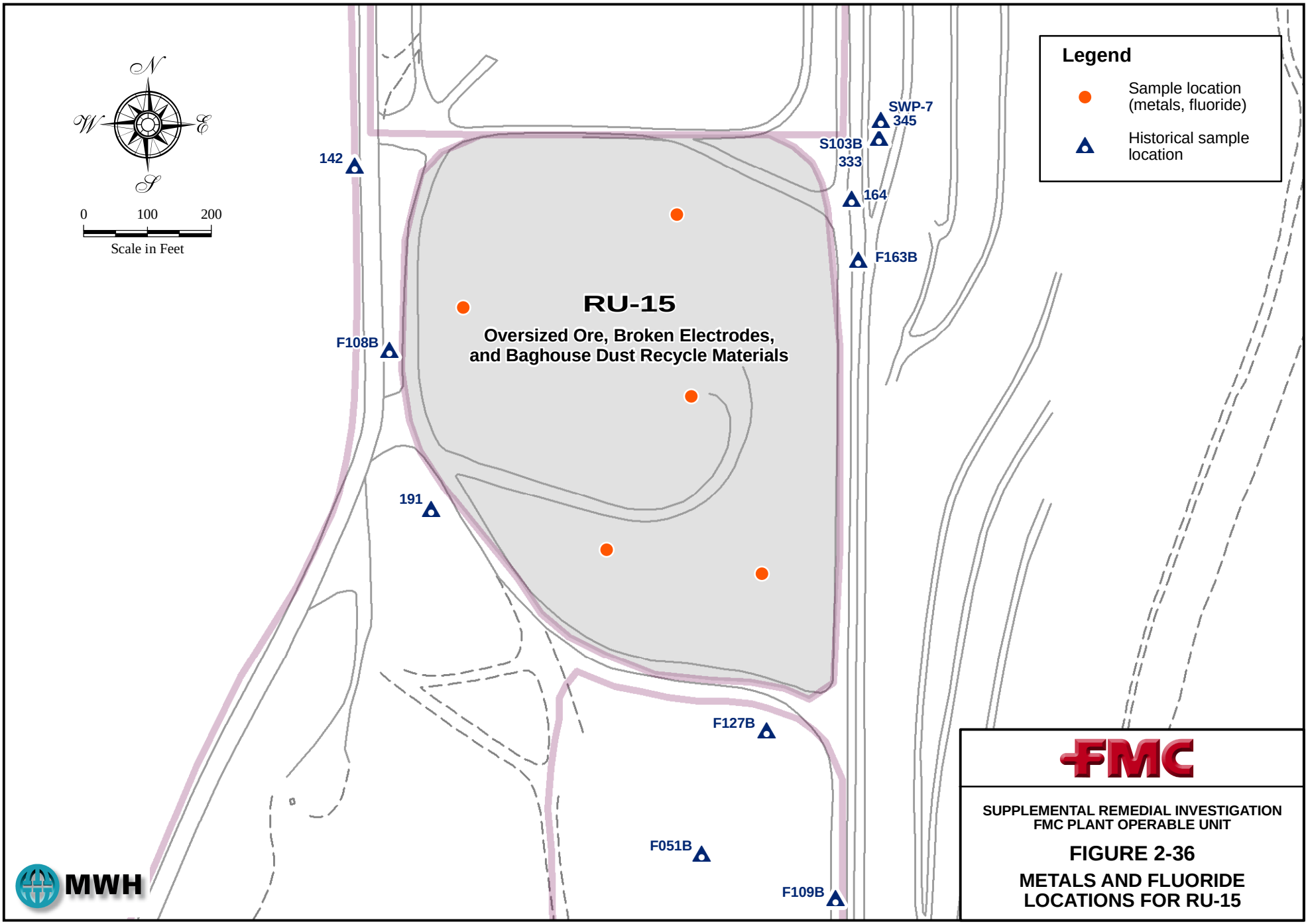


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-35

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-13

FILE *Fig 2-36_Metals_FluorideRU15_307.mxd* *3/16/07*



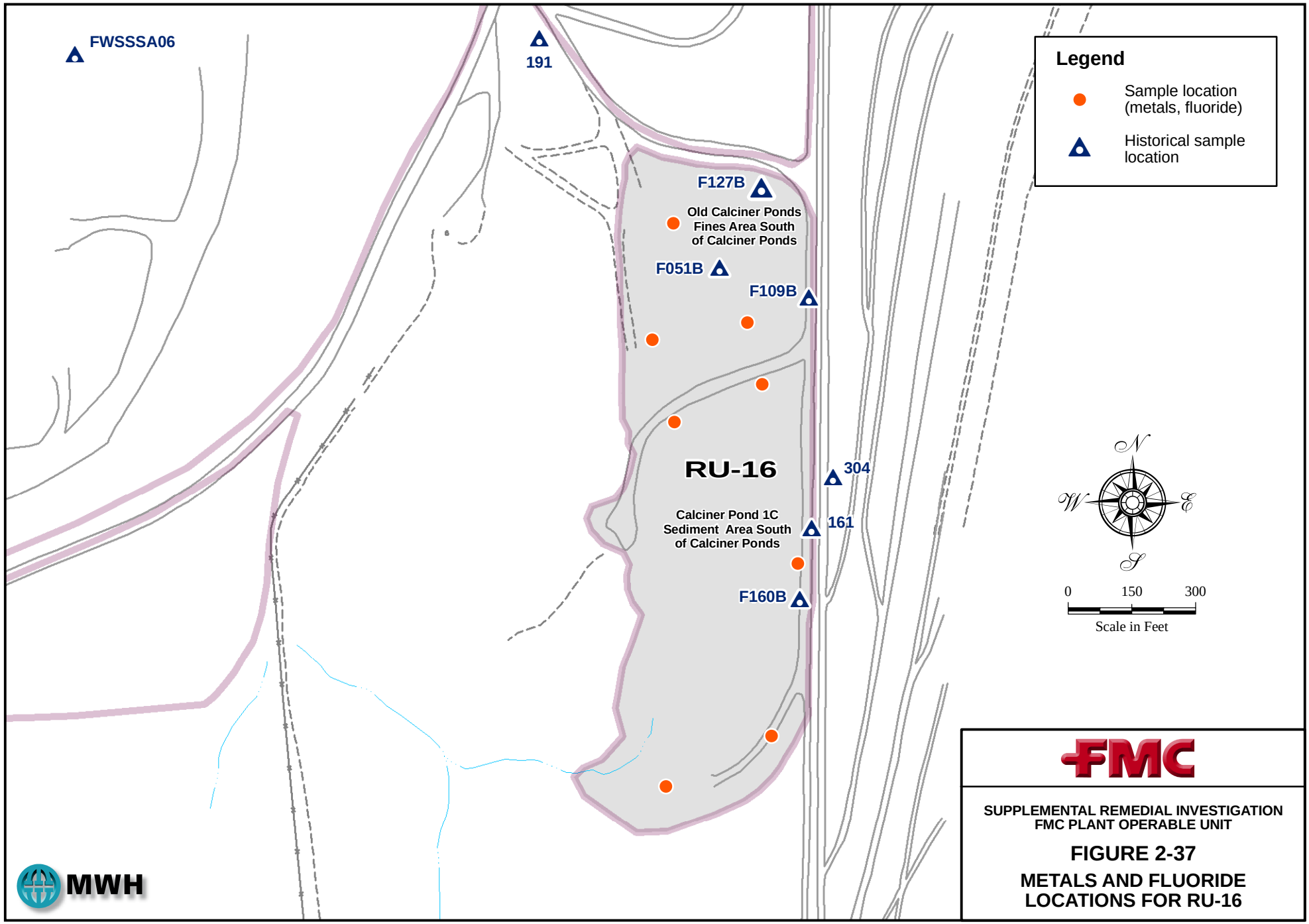
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-36

METALS AND FLUORIDE LOCATIONS FOR RU-15

FILE *Fig 2-37_Metals_FluorideRU16_307.mxd* *3/16/07*



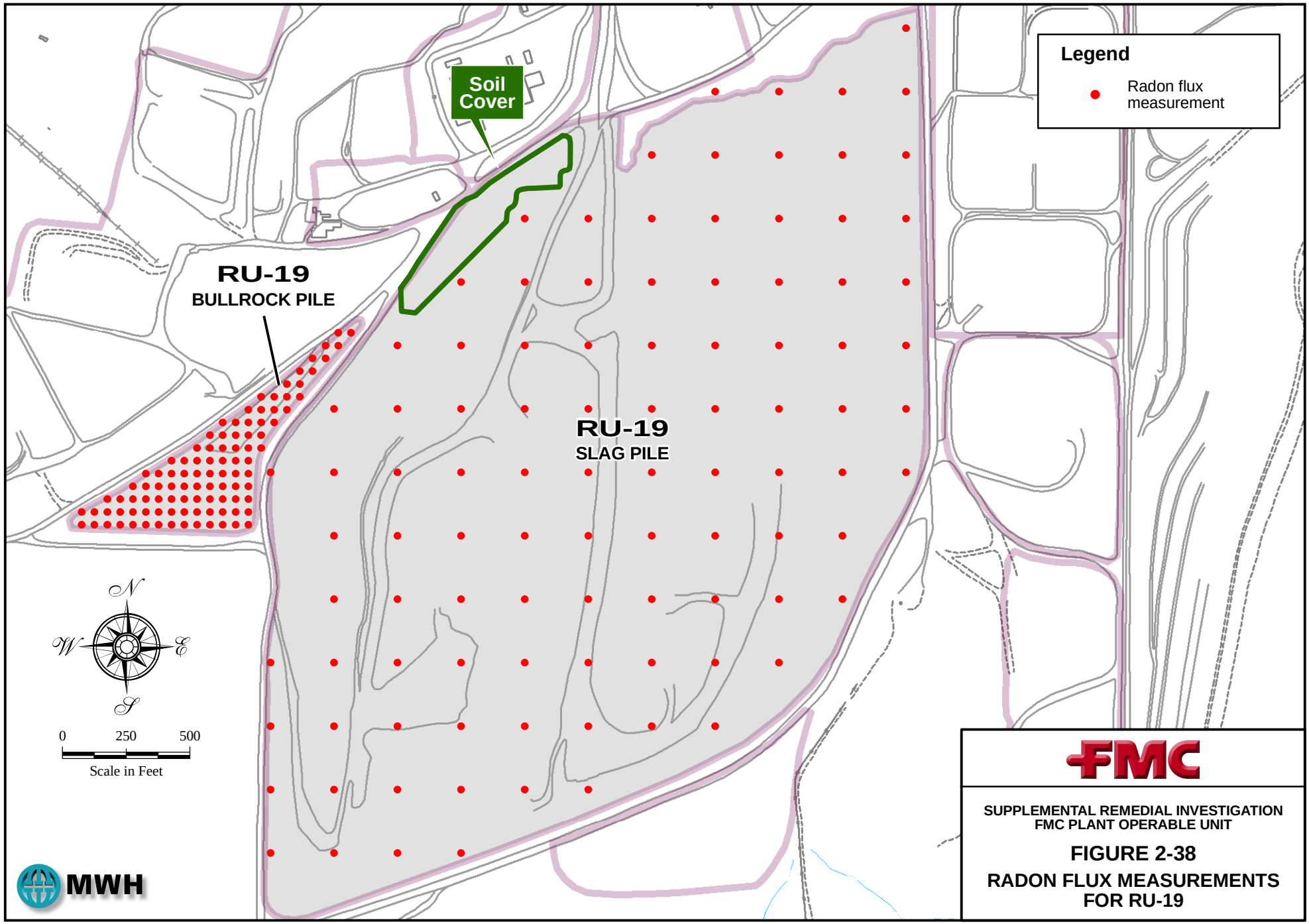
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

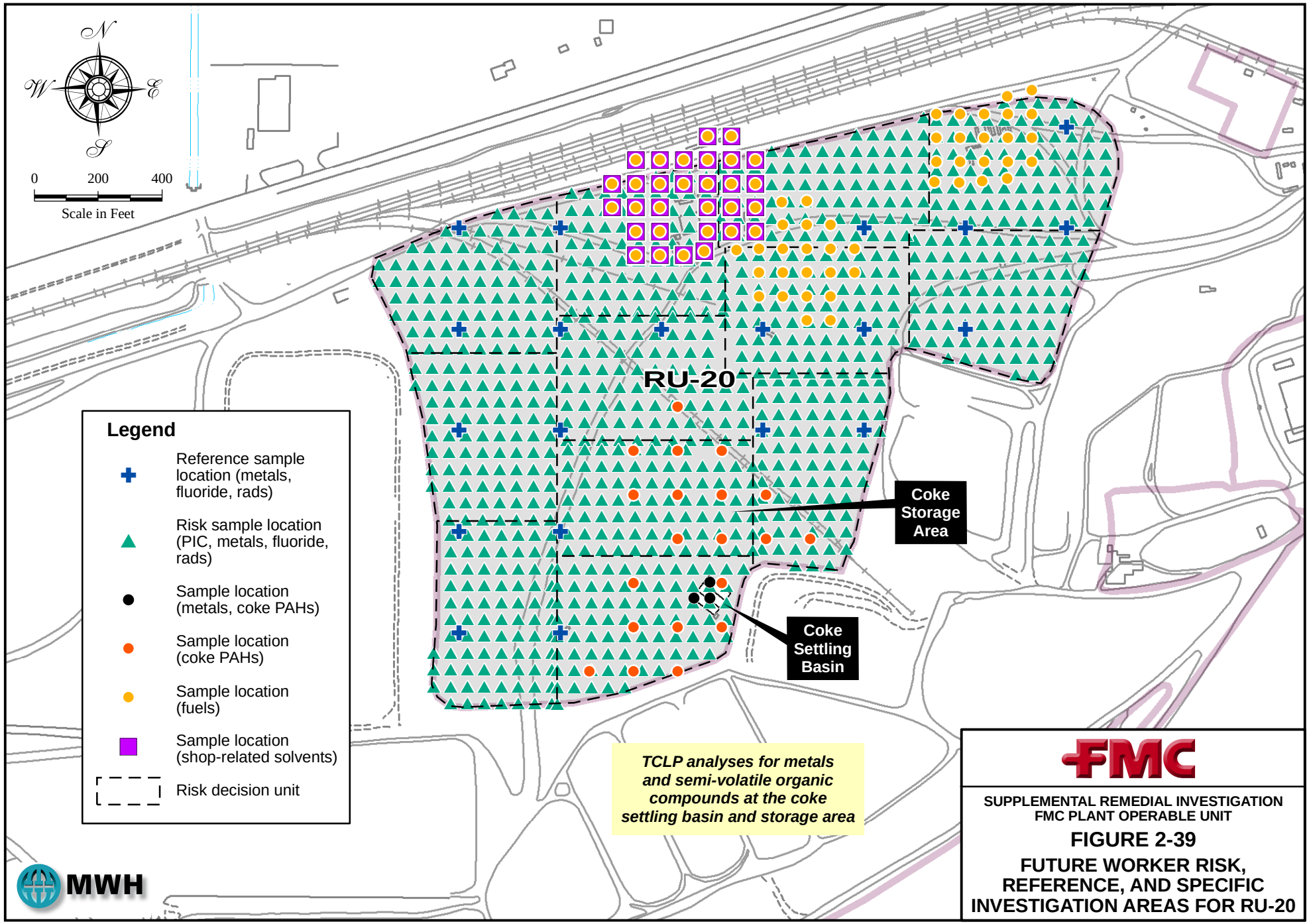
FIGURE 2-37

METALS AND FLUORIDE LOCATIONS FOR RU-16

FILE *Fig 2-38_Radon FluxRU19_307.mxd* *3/16/07*



FILE *Fig 2-39_Risk Hotspot_RU20_307.mxd* *3/16/07*

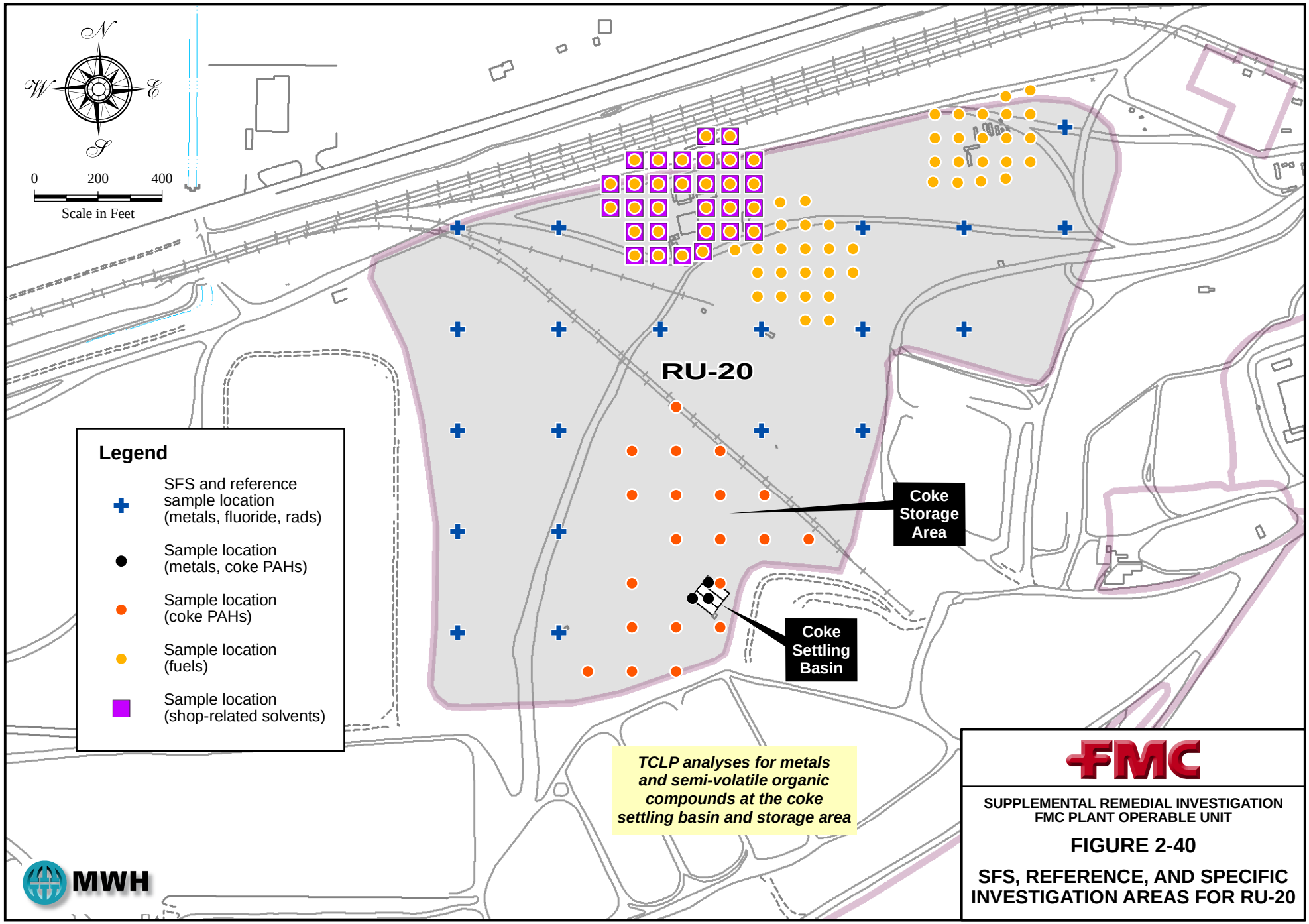


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-39

FUTURE WORKER RISK, REFERENCE, AND SPECIFIC INVESTIGATION AREAS FOR RU-20

FILE *Fig 2-40_SFS Hotspot_RU20_307.mxd* *3/16/07*



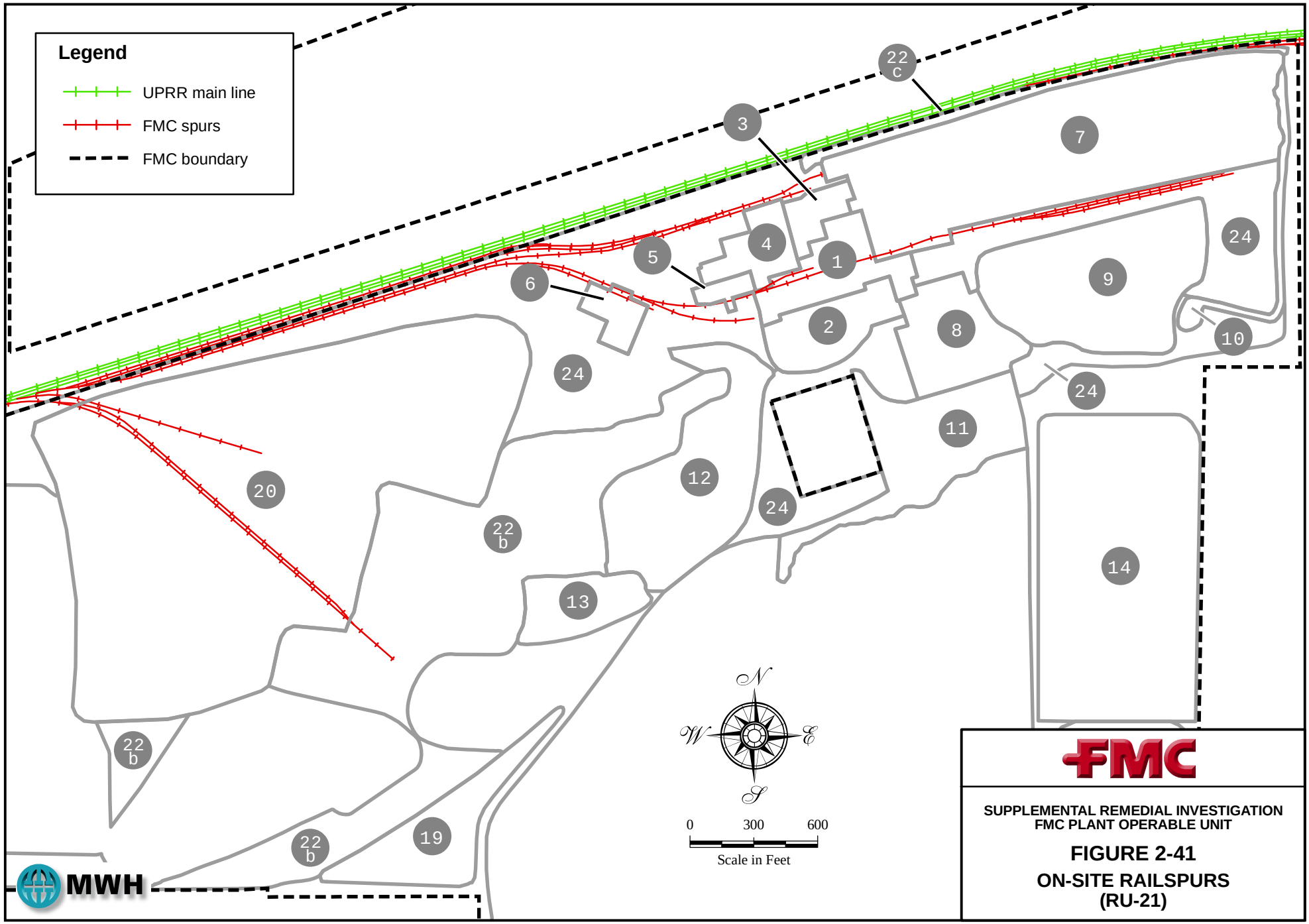
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-40

SFS, REFERENCE, AND SPECIFIC INVESTIGATION AREAS FOR RU-20

FILE *Fig 2-41 Onsite Railspurs R21_307.mxd* *3/27/07*

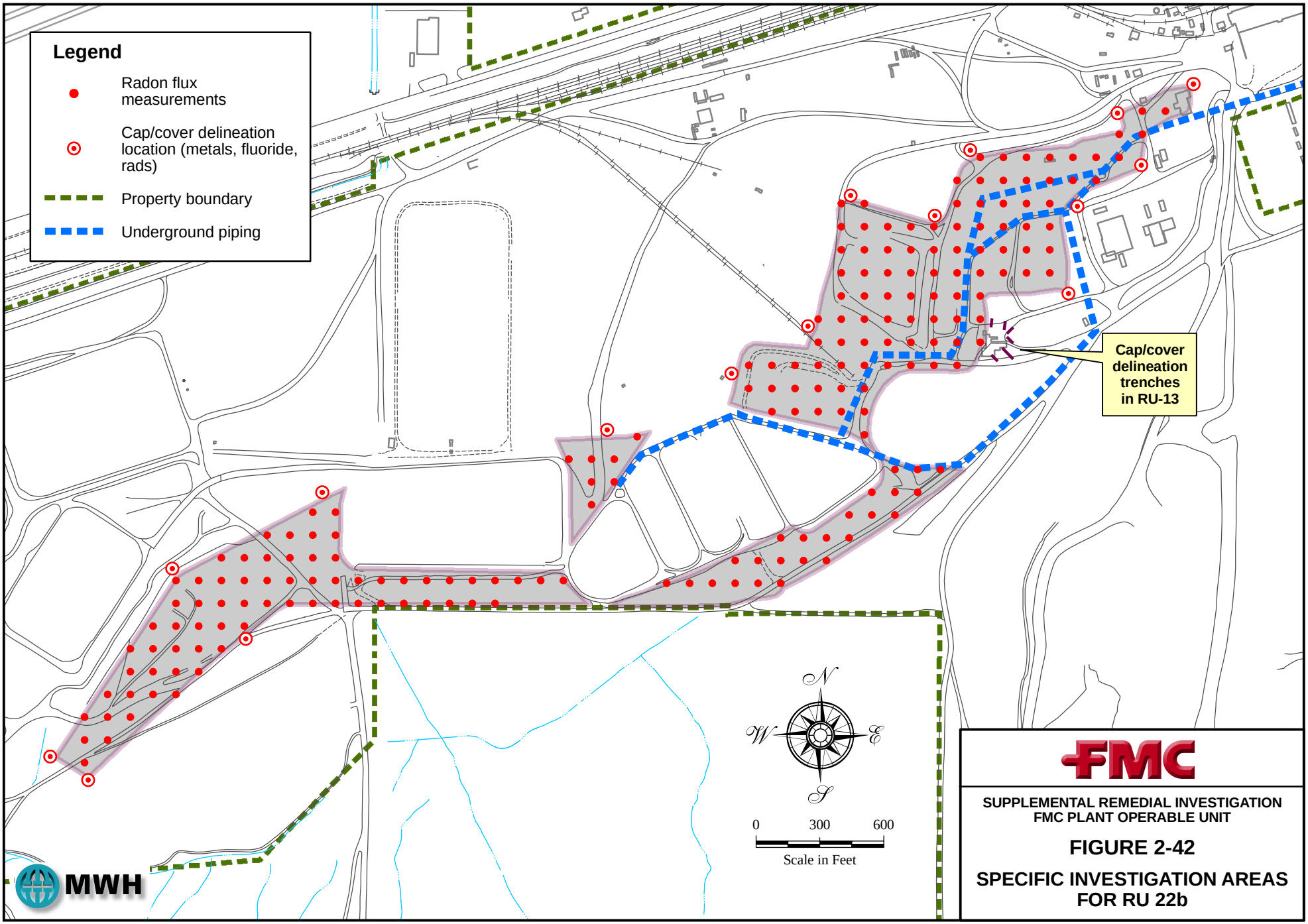


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-41

ON-SITE RAILSPURS (RU-21)

FILE *Fig 2-42_Radon FluxRU22b_307.mxd 3/26/07*

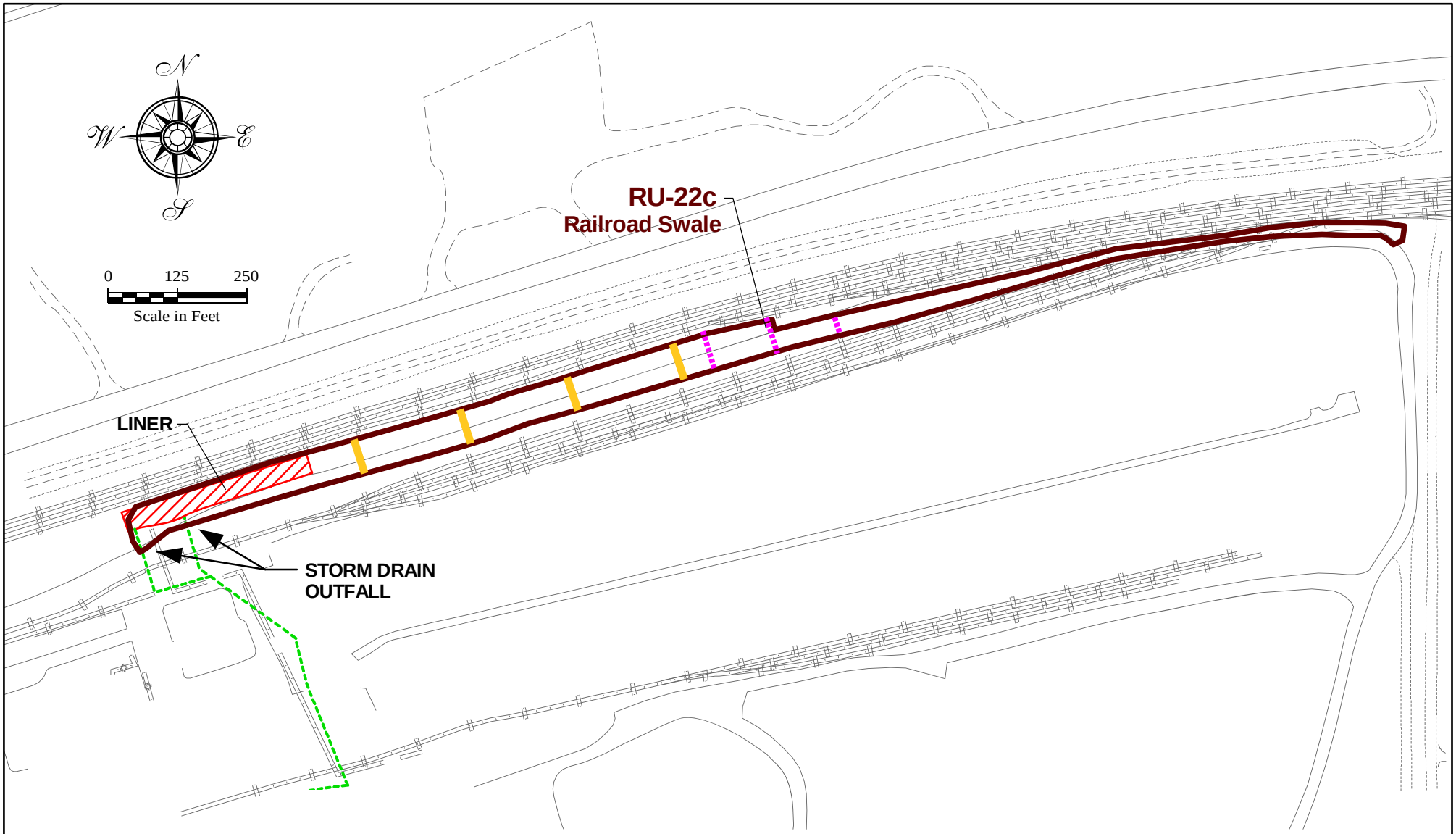


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-42

SPECIFIC INVESTIGATION AREAS FOR RU 22b

FILE *Fig 2-43_Cap Delin RU22c_307.ai 3/16/07*



Legend

- Trench location (P4)
- Contingent trench location (P4)
- RU-22c boundary
- Storm drain
- Paved road
- Gravel road
- Railroad

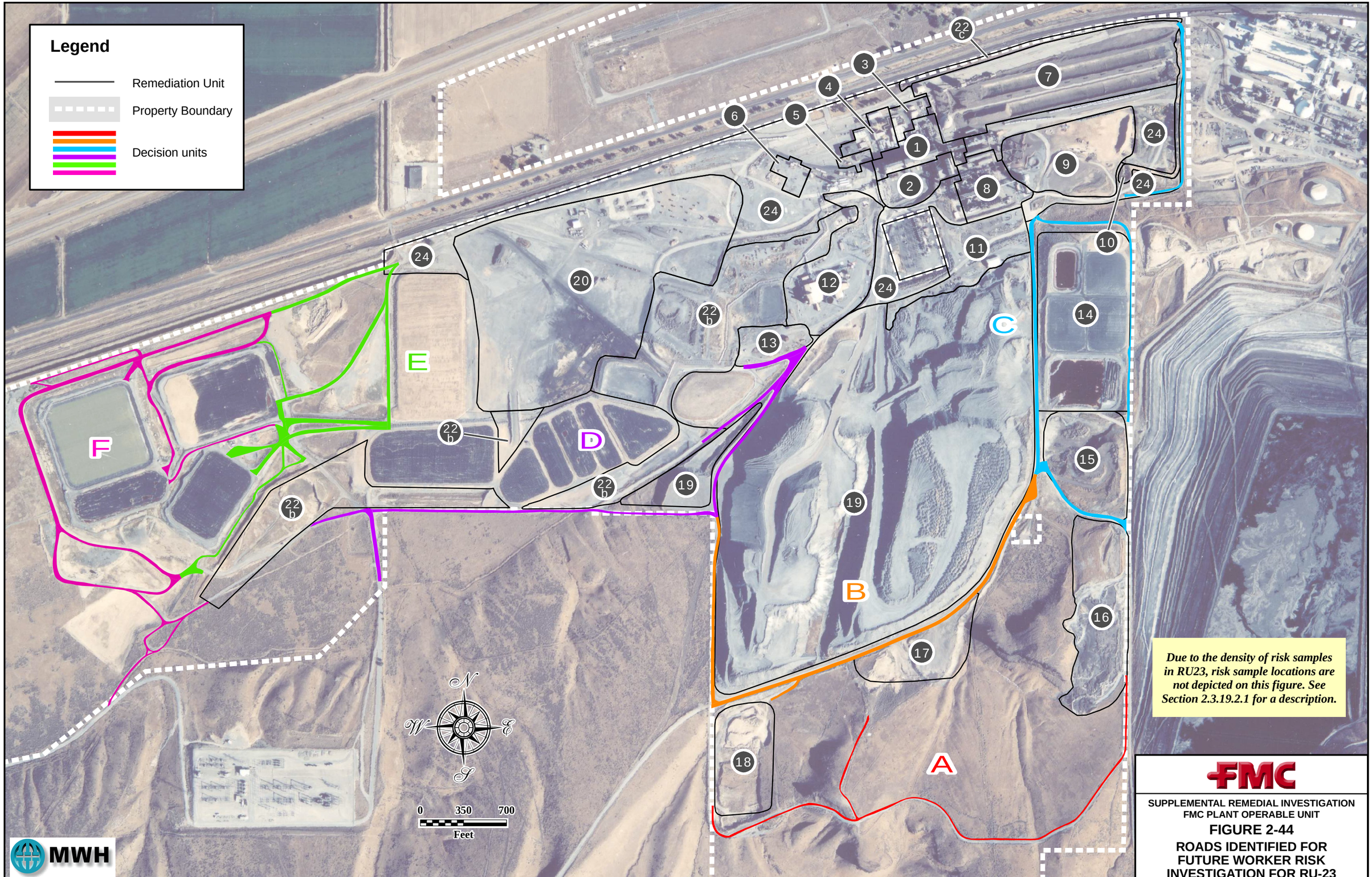
MWH

FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-43

CAP/COVER DELINEATION LOCATIONS FOR RU-22c



FILE Fig 2-44 RU23Roads_RISK.mxd 4/26/07

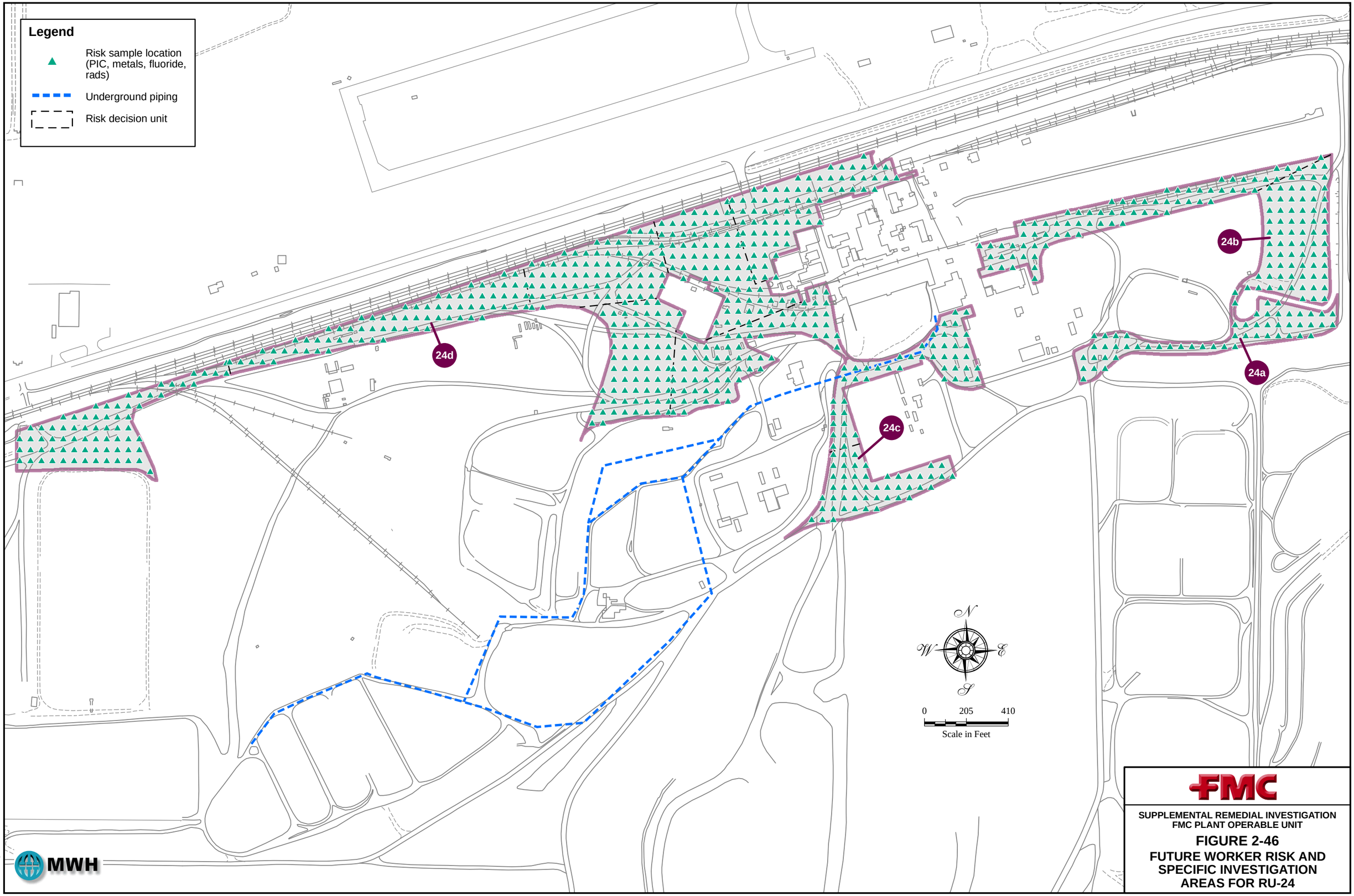
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-45

ROADS IDENTIFIED FOR SFS INVESTIGATION FOR RU-23

FILE Fig 2-45 RU23Roads_SFS407.mxd 4/26/07



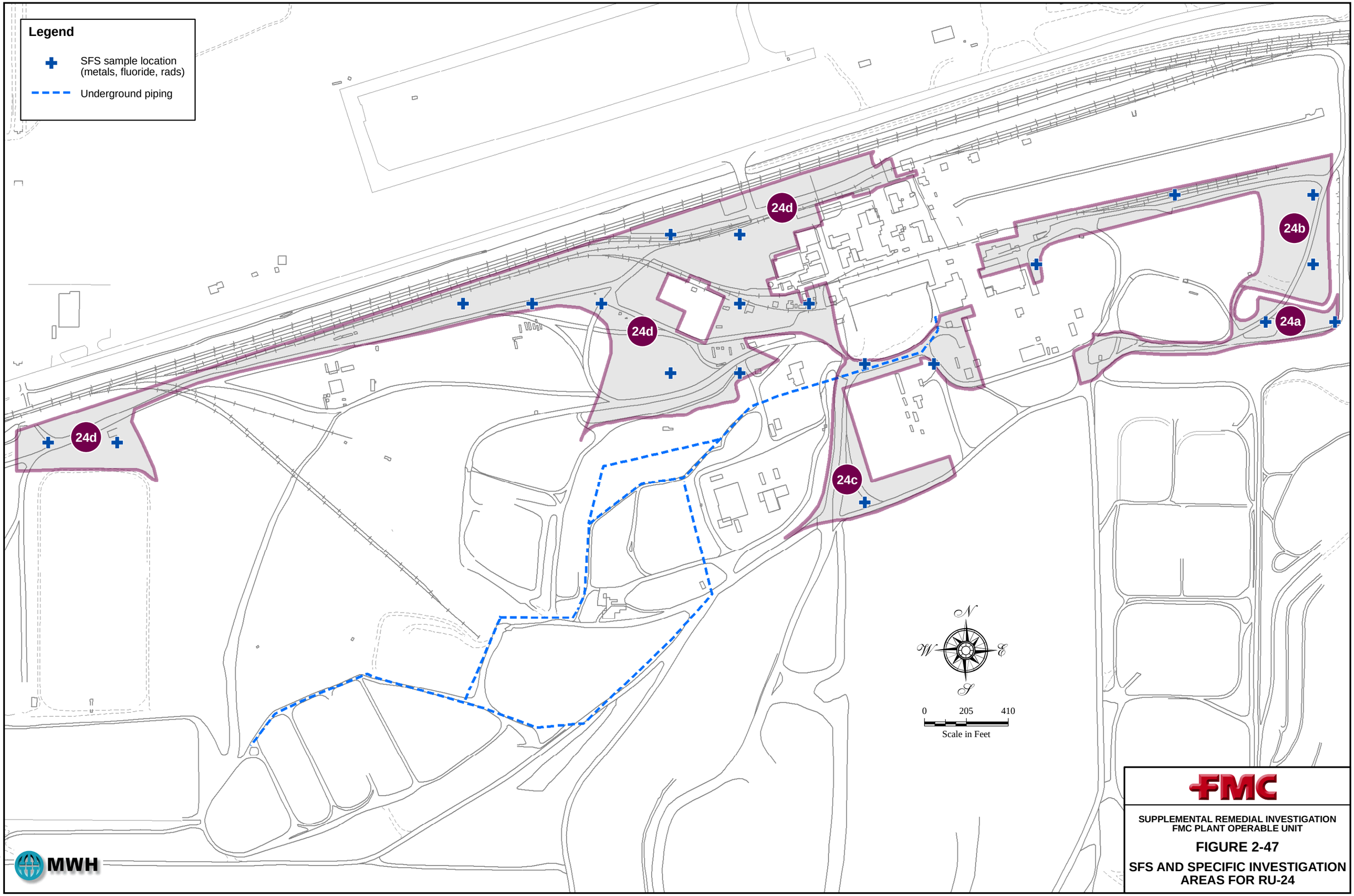
FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-46

FUTURE WORKER RISK AND SPECIFIC INVESTIGATION AREAS FOR RU-24

FILE Fig 2-46 Risk_RU24_507.mxd 5/01/07



FMC

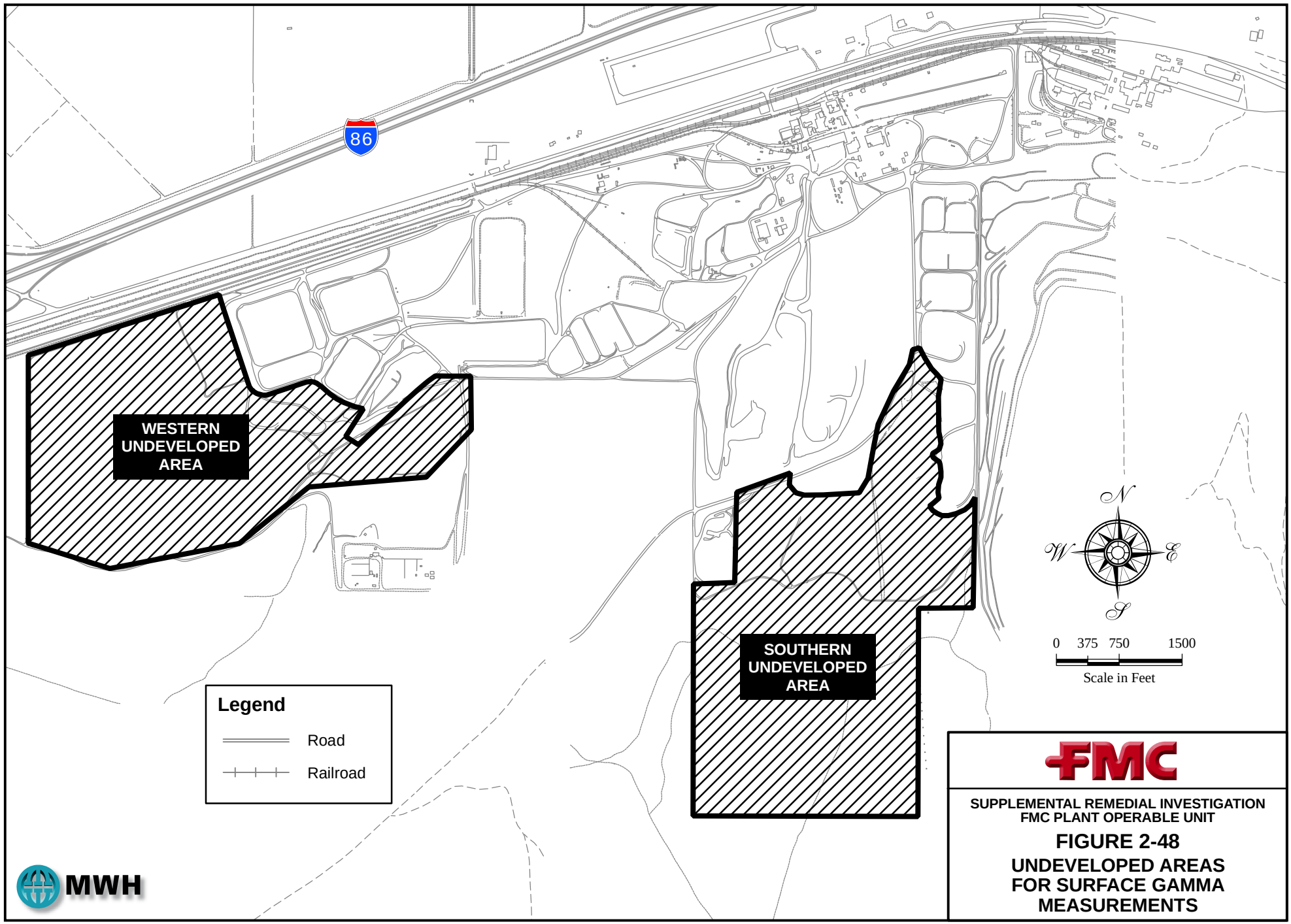
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-47

SFS AND SPECIFIC INVESTIGATION AREAS FOR RU-24

FILE Fig 2-47 SFS_RU24_507.mxd 5/01/07

FILE *Fig 2-48 Undev Area Surf Gamma_307.mxd* *3/15/07*

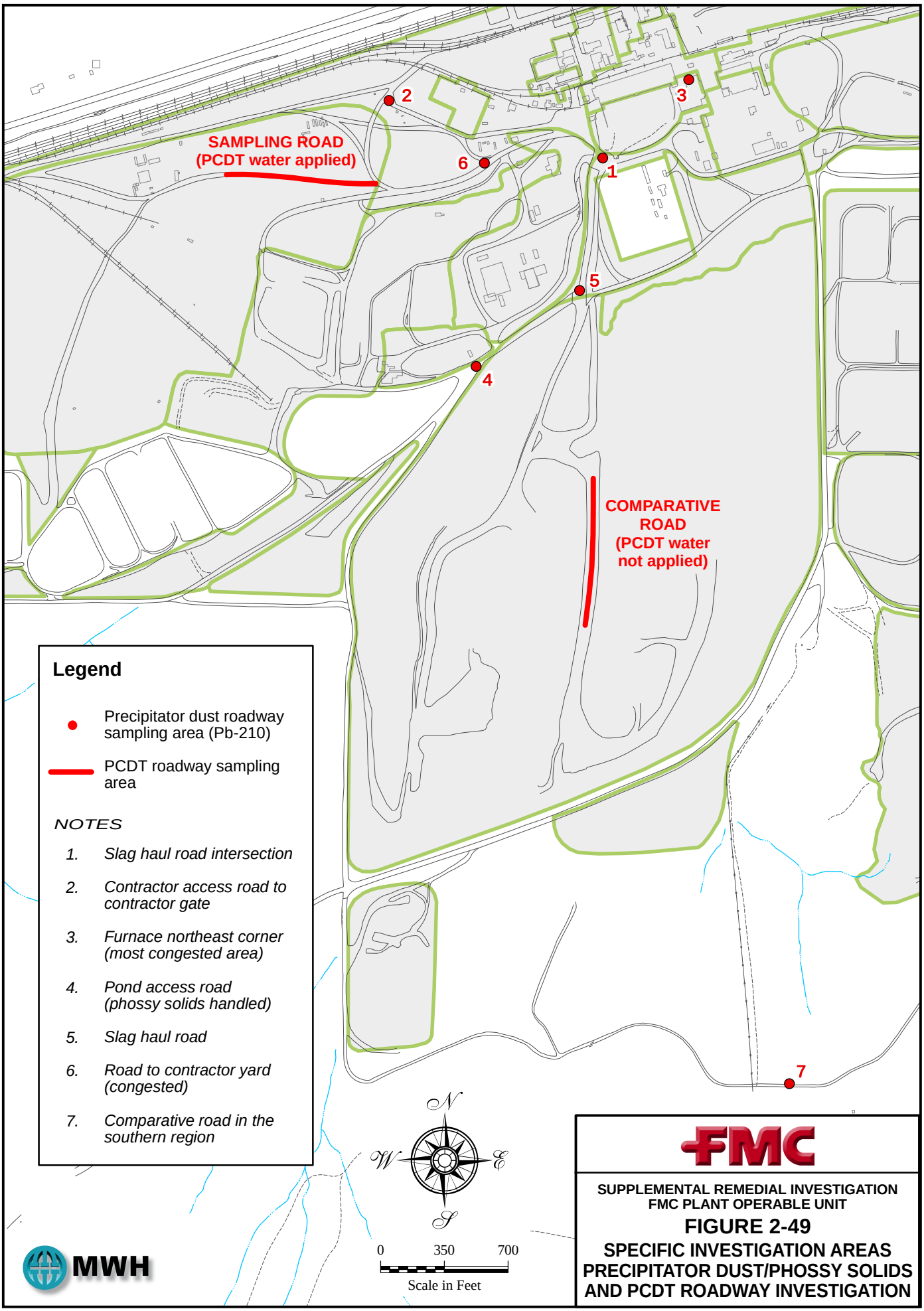


FMC

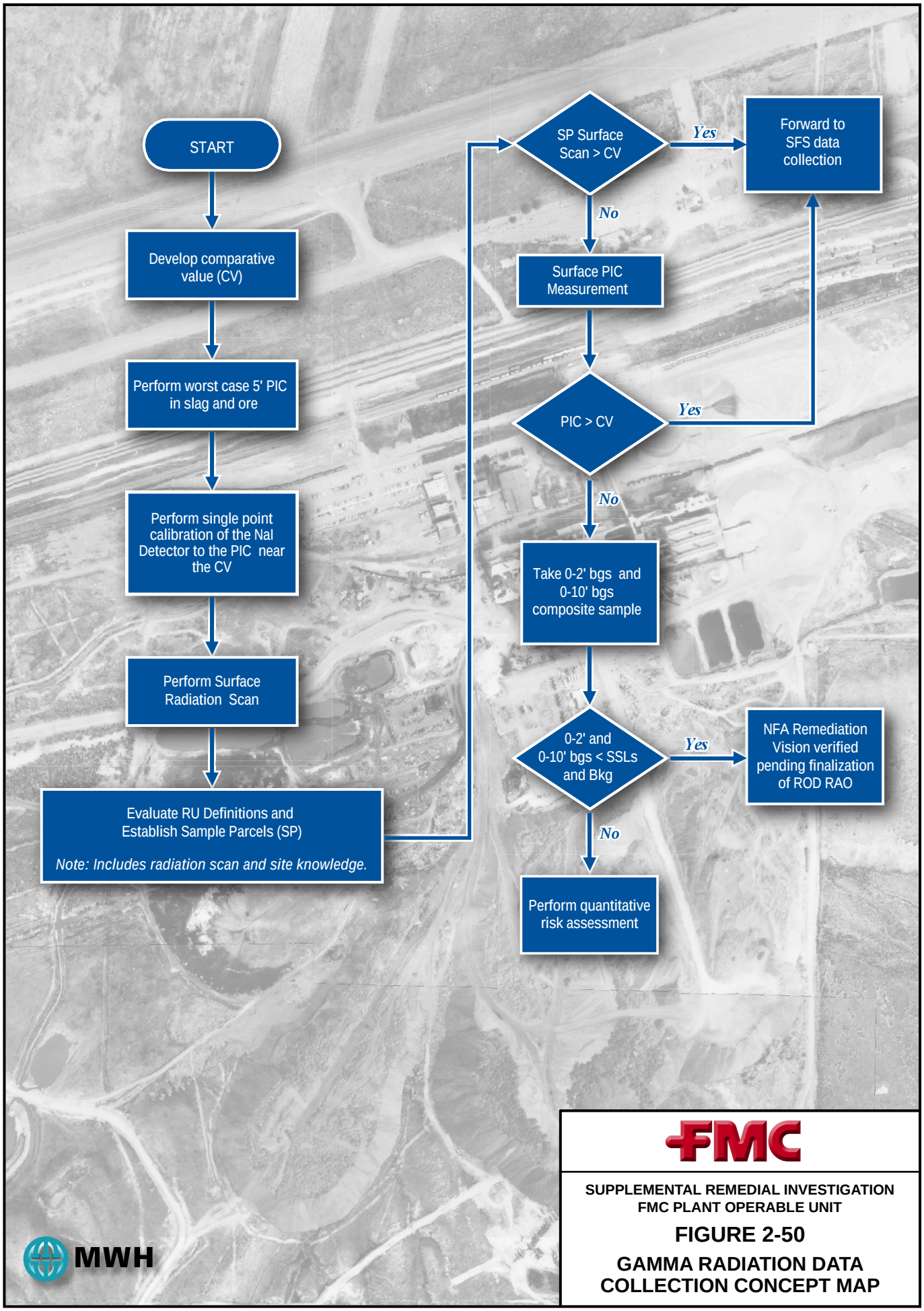
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-48

UNDEVELOPED AREAS FOR SURFACE GAMMA MEASUREMENTS



FILE Fig 2-49_Specific Invest Areas RU23_507.mxd 5/01/07

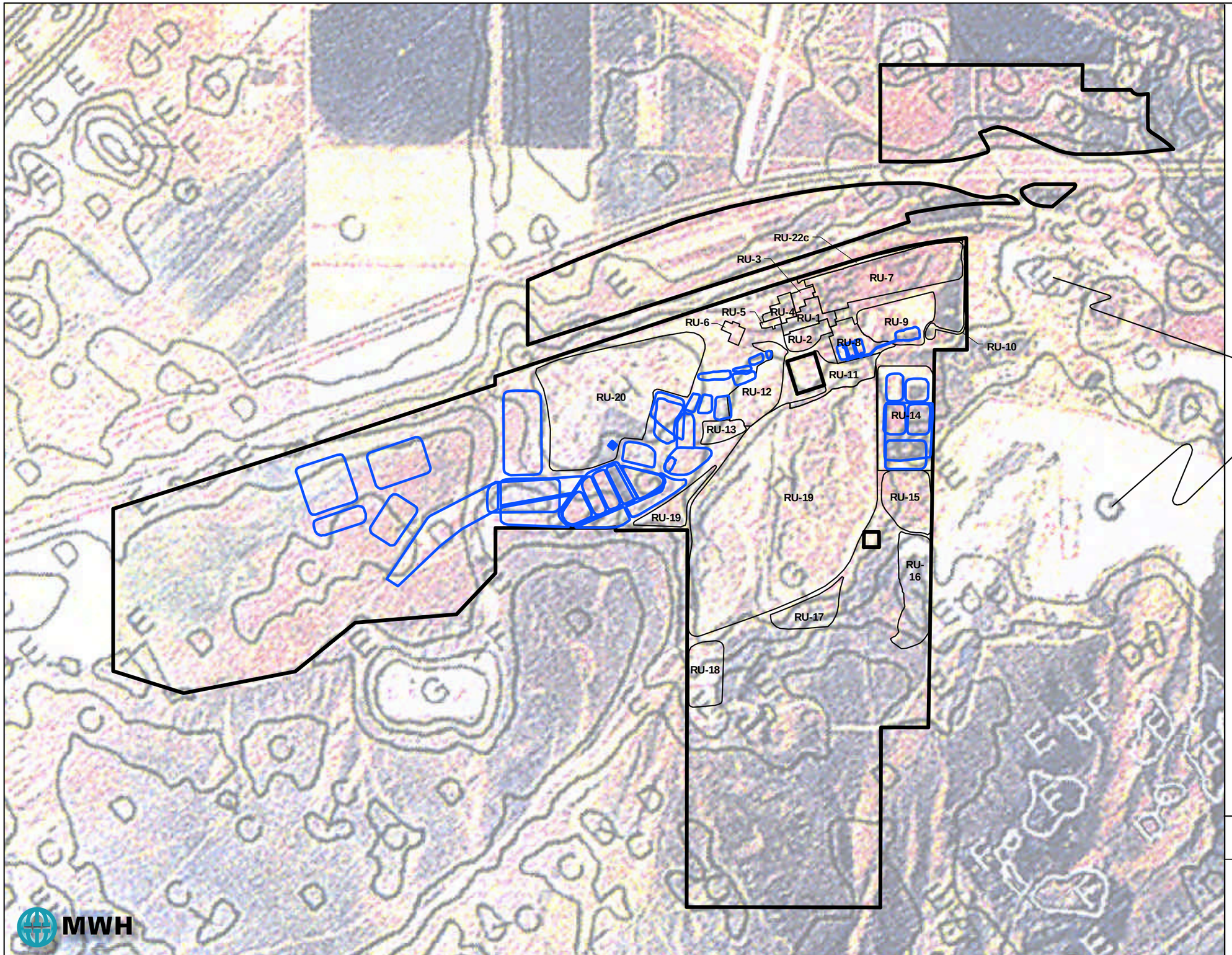


SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-50

GAMMA RADIATION DATA COLLECTION CONCEPT MAP

FILE *Fig 2-50 Gamma Radiation Data_507.ai* *5/01/07*



Legend

- FMC OPERABLE UNIT BOUNDARY
- REMEDIATION UNIT BOUNDARY
- FORMER POND

CONVERSION SCALE	
LETTER LABEL	TERRESTRIAL GAMMA EXPOSURE RATE AT 1 METER (µR/h)
A	< 9
B	9 - 11
C	11 - 14.5
D	14.5 - 17
E	17 - 22
F	22 - 30
G	30 - 50
H	50 - 100

N
W E
S

0 650 1300
Scale in Feet

FMC

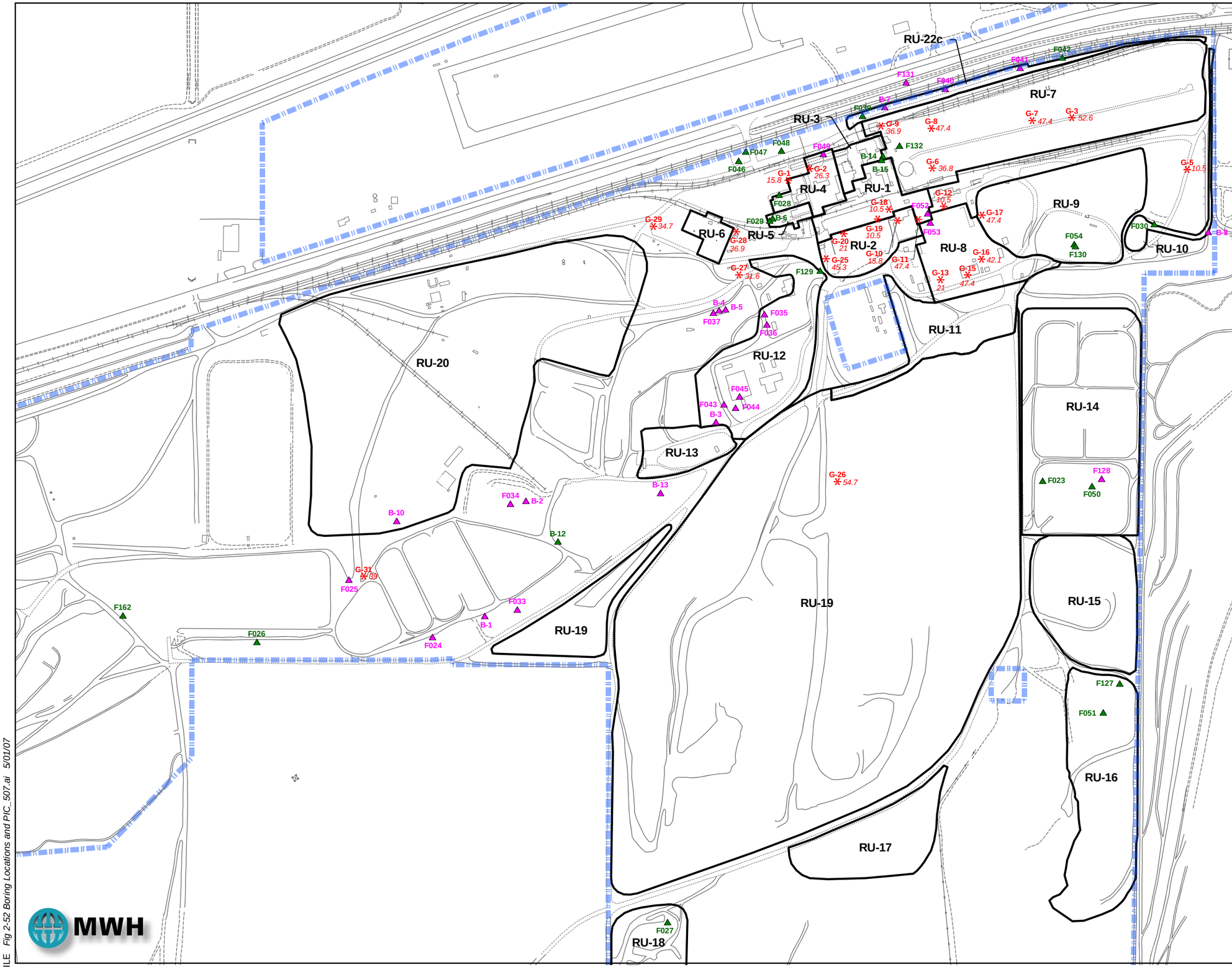
SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-51

EPA 1987 AERIAL GAMMA SURVEY

MWH

FILE Fig 2-51 EPA 1987 Aerial Gamma Survey_507.ai 5/01/07



LEGEND

- SOIL BORING LOCATION WITH SURFACE SLAG
- SOIL BORING LOCATION, NO SLAG ON SURFACE
- PIC MEASUREMENT LOCATION (1995) AND MAXIMUM EXPOSURE RATE IN µR/hr (NO SHIELDING)
- FMC OPERABLE UNIT BOUNDARY
- REMEDIATION UNIT
- BUILDING OR STRUCTURE
- PAVED ROAD
- GRAVEL ROAD
- RAILROAD

N W E S

0 300 600

Scale in Feet

FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 2-52

BORING LOCATIONS AND PIC MEASUREMENTS

MWH

FILE Fig 2-52 Boring Locations and PIC_507.ai 5/01/07

Table 2-1

DQO Summary from RI Update December 2004[1]
(Page 1 of 2)

Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**
State the Problem	Identify the Decision	Identify the Decision Inputs	Define the Boundaries	Develop the Decision Rules	Specify the Tolerance Limits of Decision Errors	Optimize the Sampling Design
Areas within the FMC Plant OU have been used for waste disposal, some areas are former working areas with the potential for P4 occurrence in the subsurface, and other areas have had multiple uses through the operational history of the plant. Characterization data may or may not be sufficient for evaluating the future exposure scenarios, or for conducting the SFS.	The decision that must be made is to classify RUs within one of the following categories: 1) No Further Action – RU does not contain materials or environmental media that exceed RBCs for the relevant exposure pathways, or 2) RU contains materials or environmental media with constituent concentration(s) that exceed RBCs, and no additional data are needed to support an evaluation of remedial action alternatives under the SFS process, or 3) Collect additional data to: (a) evaluate classification of No Further Action or (b) support the SFS analyses of remedial action alternatives[2]. The decision is to be made based upon the RU mean exposure level consonant with the Risk Assessment Paradigm.	1) The 1998 EMF Site ROD 2) RUs 17, 18, and 19 are landfills; FMC will consider application of the Presumptive Remedy for CERCLA Municipal Landfill Sites (Directive 9355.0-49FS, EPA 1993) for these landfills. 3) Updated RBCs presented in Section 4 of RI Update, 4) Changes in operations since the 1998 ROD, 5) Evaluation of spills/releases of process materials that occurred from 1994 6) RAOs from ROD[3]	The lateral boundaries for each RU were selected based on knowledge of past activities and materials handled within the RU. Vertically, the study boundaries are from existing grade to a depth of 10 feet (see updated Conceptual Site Model in Section 2 or RI Update). These vertical boundaries were selected because they encompass the exposure pathways for the various future commercial/industrial land use exposure scenarios identified in the updated CSM.[4]	The statistical comparison between site data and RBCs or other identified criteria as defined in the RAOs must show that sufficient data are available to support the decisions for all COPCs. Hypothesis for comparing values specific level (e.g., RBC or SSL): H_0: 95 UCL of Mean ≥ comparative level. H_A: 95 UCL of Mean < comparative level. Hypothesis for comparing values specific level to background values: H_0: Constituent mean exceeds or is equal to background mean. H_A: Constituent mean does not exceed background mean .	All significance tests will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and Type II error of 10%. The statistical techniques used for the conduct of the significance test will be chosen such that their underlying assumptions are supported by the data. Thus the specified decision errors will be achieved.	This is to be addressed in the SRI work Plan. It is not a part of the RI Update Memorandum. The statistical sampling design for each RU will be designed to achieve the desired level of the tolerable decision errors.

Table 2-1

DQO Summary from RI Update December 2004[1]
(Page 2 of 2)

1 Reference pages 6-1 to 6-6 Remedial Investigation Update Memorandum For The FMC Plant Operable Unit, December 2004 Revision Of June 2004 Draft

2 Are there sufficient data to statistically compare the constituents of concern with RBCs or other relevant screening criteria? If yes, decide whether the RU can be classified as "No Further Action – RBCs are not exceeded in environmental media" or "RBCs are exceeded, RU is not eligible for NFA and the RU should proceed to the SFS." If no, forward the RU to the SRI process for additional sampling and/or analyses.

3 Remedial Action Objectives

1) Reduce the exposure to radon that would occur in future buildings constructed within the plant areas under a future industrial scenario
2) Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risks greater than 1x10-4, or site specific background levels where that is not practicable.
3) Prevent ingestion or inhalation of soil containing contaminants of concern at levels that pose estimated cancer risk above 1 x 10-4, a noncancer quotient higher than 1, or above the site specific background levels where that is not practicable
4) Reduce the release and migration of COC to groundwater from facility Sources that may result in concentrations in groundwater exceeding RBC or chemical specific applicable or relevant and appropriate requirements (ARARS), specifically maximum containment levels (MCLs)

4 Deeper soils have not been included in the study boundaries at this time because there is no evidence of an active source (i.e., source with sustained hydraulic head) of contamination to groundwater, and because exposure to these soils is not anticipated under future commercial/industrial exposure scenarios. In addition, groundwater was not included in the study boundaries because the 1998 EMF ROD selected land use restrictions on the future use of groundwater at the FMC Plant OU. Each RU was evaluated to ensure that sources that could impact groundwater were identified and that the existing groundwater monitoring network would be sufficient to demonstrate achievement of the following 1998 ROD RAOs: 1) Prevent potential ingestion of ground water containing COCs having concentrations exceeding RBCs or MCLs (chemical-specific ARARs) and 2) Restore ground water that has been impacted by site sources to meet RBCs or MCLs for the COCs

Table 2-2

Overall SRI DQO Summary

Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**
State the Problem	Identify the Decision	Identify the Decision Inputs	Define the Boundaries	Develop the Decision Rules	Specify the Tolerance Limits of Decision Errors	Optimize the Sampling Design
Insufficient data exists to conclude that the current remediation vision for each RU will meet the comparative values (CVs). A sampling and analysis plan that optimizes the data collection activities to verify the remedial vision and provide information needed for the supplemental feasibility study is required.	If sufficient data exists to verify the remedial vision from the RI Update and Draft SRI then no further action is anticipated. If sufficient data does not exist to verify the remedial vision for the RI Update and Draft SRI then the remedial vision may require revision and additional data will be collected to support the SFS	1) All inputs from Table 1. 2) Additional information obtained since last SRI revision 3) Economical impacts for total project cost based on anticipated remedial visions or changes to remedial visions. 4) Data needs from FS team regarding potentially revised remedial visions. 5) Development of individual DOQs for data gaps identified in RI Update. 6) Definition of data needs developed as a result of latest iteration of DQO process (i.e., data concept maps).	Lateral and vertical boundaries generally as stated in Table 1. Additional refinements on specific individual data gap DQOs will be detailed as needed to meet the CVs.	The null hypothesis will be that the measured parameter mean is greater than the associated level that causes the risk to exceed the applicable CV. The alternative hypothesis will be that the measured parameter mean is less than the associated level that causes the risk to exceed the CV. The hypotheses will be tested utilizing statistical methods incorporating assumptions that are supported by the data. All statistical estimators (e.g. means, regression parameters and estimates of constants in mathematical functions) will have acceptable confidence limits.	All significance test will be conducted at the 95% confidence level (i.e. a false positive rate or Type I error of 5%) and Type II error of 10%.	The sampling design will be optimized for each parameter within a given Remediation Unit (RU) that requires demonstration of the associated risk level. The design will simultaneously address technical, statistical and economic aspects of the program.

Table 2-3
Worker Classifications and Gamma Dose Rate CVs Based on a Risk Threshold[a]

Worker Classification	Soil Exposure Scenarios	Gamma Dose Rate CV (µR/hour) Equivalent to Risk Threshold[b]	Total Number of Exposure Hours Worked at FMC Plant OU
Outdoor Commercial/Industrial Worker	Surface soil, 0-2', 0-10'soil redistributed fill	8.3 + Background[c]	45,000[d]
Construction Worker	Subsurface soil, 0-10'	359 + Background[c]	1,040[e]
Utility Worker	Subsurface soil, 0-10'	4670 + Background[c]	80[f]

Notes:

[a] The gamma dose rate CVs are equivalent to a $3x10^{-4}$ increased lifetime risk above background, which corresponds to the upper bound of EPA's potentially acceptable risk range for CERCLA sites with radioactive contamination (OSWER Directive 9200.4-18).

[b] Gamma dose rate CVs also meet the OSHA exposure limits for ionizing radiation for general industry and construction as specified in 29 CFR 1910.1096 and 29 CFR 1926.53, respectively.

[c] The background gamma dose rate in areas of the FMC Plant OU within the Michaud Flats is 13 µR/hour. The background gamma dose rate in areas of the FMC Plant OU within the Bannock Range (i.e., the undeveloped southern portion of the site) is 15.75 µR/hour.

[d] Per EPA 2002 and RI Update Memorandum (BEI, 2004b) SSL calculations, assumes outdoor commercial/industrial worker is exposed 8 hours/day, 225 days/year for 25 years.

[e] Per RI Update Memorandum (BEI, 2004b) SSL calculations, assumes construction worker is exposed 8 hours/day, 5 days/week for 26 weeks.

[f] Per RI Update Memorandum (BEI, 2004b) SSL calculations, assumes a utility worker is exposed 8 hours /day for 10 days.

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Derivation of Gamma Dose Rate CVs:

$$\text{Gamma CV} = \frac{CF \times EF \times ED \times SF}{TR}$$

Where:

Gamma CV = Gamma exposure rate (uR/hr) equivalent to a 3E-04 target cancer risk
CF = Conversion factor (0.95 urad/uR),
EF = Exposure frequency (hours/year)
1800 hours/year for commercial/industrial workers,
1040 hours/year for construction workers,
80 hours/year for utility workers
ED = Exposure duration (years)
25 years for commercial/industrial workers,
1 year for construction workers
1 year for utility workers
SF = External gamma radiation slope factor (8.46E-10/urad - Table 7.6 of *Federal Guidance Report No. 13: Cancer Risk Coefficients for Environmental Exposure to Radionuclides*).
TR = Target cancer risk from external gamma radiation exposure (unitless)
3E-04, consistent with Monsanto ROD RAO

Commercial/Industrial Worker:
0.95 urad/Ur x 1800 hr/yr x 25 yr x 8.46E-10/urad / 3E-04 = 8.3 uR/hr
Construction Worker:
0.95 urad/Ur x 1040 hr/yr x 1 yr x 8.46E-10/urad / 3E-04 = 359 uR/hr
Utility Worker:
0.95 urad/Ur x 80 hr/yr x 1 yr x 8.46E-10/urad / 3E-04 = 4670 uR/hr

Table 2-4

Slag and Silt Stratigraphy at Selected Boring Locations
(Page 1 of 3)

RU	Boring ID	Depth (ft)	Description	Location Note
1	B-15	0-5	gravelly silt	very close to RU-3 border
1	B-15	5-30	silt	
1	F052	0-0.5	concrete	
1	F052	0.5-10	slag	
1	F052	10-22	silt	
4	F028	0-1.2	asphalt	
4	F028	1.2-36	silt	
4	F049	0-0.5	blacktop	
4	F049	0.5-1.5	slag	
4	F049	1.5-5	silt	
4	F049	5-13	silt	
5	F029	0-1	asphalt	
5	F029	1-10	gravelly silt	
5	F029	10-18	slag gravel	
7	B-14	0-5	silt	very close to RU-3 border
7	B-14	5-12	silt/sand	
7	B-14	12-30	silt/sand	
7	F132	0-5.5	gravelly silt	
7	F132	5.5-13	silt	
8	F053	0-0.5	concrete	
8	F053	0.5-10	slag	
8	F053	10-22	silt	
9	F054	0-40	silica	
9	F130	0-30	sandy gravel - silt	
10	B-8	0-2	slag	
10	B-8	2-14	silt/sand	
10	F030	0-30	gravelly silt	
12	B-3	0-5	slag fill w/ 40% sand and 10% silt	
12	B-3	5-12	sand	
12	B10	0-12	slag	
12	B10	12-26	silt	
12	F035	0-2.5	slag	
12	F035	2.5-15.5	silt	
12	F036	0-1	slag	
12	F036	1-12.5	silt	
12	F043	0-17	slag	
12	F043	17-25.5	silt	
12	F044	0-2	slag	
12	F044	2-6.5	silt w/ traces of slag	
12	F044	6.5-8	silt	
12	F044	8.5-15	silt	

Table 2-4

Slag and Silt Stratigraphy at Selected Boring Locations
(Page 2 of 3)

RU	Boring ID	Depth (ft)	Description	Location Note
12	F045	0-5	slag	
12	F045	5-14	silt	
12	F045	6.5-7	green rubber trash	
12	F045	8.5-9	void	
12	F045	11-11.5	trash	
12	F129	0-0.5	asphalt	
12	F129	0.5-4	gravelly sand fill (angular)	
12	F129	4-20	silty sand	
14	F023	0-40	clayey silt	
14	F050	0-10	clay w/silt	
14	F128	0-8	gravelly silt, some slag	
14	F128	8-30	silt	
15	F127	0-4	sludge (pond sediment)	
15	F127	0-5	gravel placement	
15	F127	5.2-21	silt	
16	F051	0-5	fill	
16	F051	5-17	silty sand	
18	F027	0-21	silt	
22a	B-12	0-1	organic clay fill	north of former Pond 1E
22a	B-12	1-5	sandy silt	
22a	B-12	5-10	sandy silt	
22a	B-12	10-12	gravelly clay	
22a	B-12	12-50	silt	
22a	B-13	0-2	slag	former Pond 8S
22a	B-13	2-12	sandy silt	
22b	B-1	0-4	slag fill w/ 20% silt	former Pond 1E
22b	B-1	4-30	silt	
22b	B-2	0-2	slag fill w/ 20% silt	former Pond 9S
22b	B-2	2-5	slag fill w/ 20% silt, 10% sand	
22b	B-2	5-15	silt	
22b	B-4	0-7	slag w/ 0-20% silt	north of former Pond 2S
22b	B-5	0-6	slag w/ 0-20% silt	north of former Pond 2S
22b	B-6	0-0.3	asphalt	north of former Pond 2S
22b	B-6	0.3 - 29	silty gravel	
22b	F024	0-0.5	slag	along roadside near old ponds
22b	F024	0.5 -12	silt	
22b	F026	0-20	silt	along roadside near old ponds
22b	F033	0-4.5	slag	former Pond 1E
22b	F033	4.5-21	silt	
22b	F025	0-5	slag	along roadside near old ponds
22b	F025	5-18	silt	

Table 2-4

Slag and Silt Stratigraphy at Selected Boring Locations
(Page 3 of 3)

RU	Boring ID	Depth (ft)	Description	Location Note
22b	F034	0-5	slag	former Pond 9S
22b	F034	5-15	silt	
22b	F037	0-20	slag	near former Pond 2S
22b	F037	20-24	silt	
22b	F037	23.5	phos in sample	
22b	F162	0-9	silt	road in former Pond 7E
22b	F162	9-15	basalt	
22c	B-7	0-10	slag w/ 20% sand	
22c	F039	0-6	silty gravel	
22c	F039	6-7.5	sandy gravel	
22c	F039	7.5-11.5	silt	
22c	F040	0-14	slag	
22c	F040	14-17	silt	
22c	F040	17-18	sandy gravel	
22c	F041	0-8	slag	
22c	F041	8-13.5	silt w/tan trash and organic material	
22c	F041	13.-19	sandy gravel	
22c	F042	0-2	sand, silt and gravel	
22c	F042	2-7.5	slag	
22c	F042	7.5-15	silt	
22c	F042	15-18.5	sandy gravel	
23	F046	0-1	top soil	northwest of RU-4
23	F046	1-2	silt	
23	F046	2-8	slag	
23	F046	8-11.5	silt	
23	F047	0-1	top soil	northwest of RU-4
23	F047	1-11.5	silt	
23	F048	0-1	top soil	northwest of RU-4
23	F048	1-2	silt and gravel	
23	F048	2-11.5	silt	
—	F131	0-18	slag gravel	on road north of RU-7

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 2-5

Areal Extent of FMC Remediation Units

RU Label	RU Name	Area in Acres	Number of Risk Decision Units	Size of Risk Decision Units in Acres
RU 1	Phos Dock and Secondary Condenser	4.1	na	na
RU 2	Slag Pit	3.7	na	na
RU 3	Receiving Stores, Paint Shop and P_4 Decon	1.4	1	1.4
RU 4	Office Buildings and Training Center	2.5	1	2.5
RU 5	Lab and Old Drainfield	0.6	1	0.6
RU 6	Former Long-Term Phos Storage Tanks	1.4	1	1.4
RU 7	Shale Unload, Crushing and Stockpile	25.0	5	5.0
RU 8	Former Kiln Scrubber Ponds and Calciners	6.7	na	na
RU 9	Silica Stockpiles and Former Kiln Scrubber Overflow Pond	12.9[1]	2	5.0
RU 10	IWW Pond and Ditch	1.3	1	1.3
RU 11	Equipment Area South of Calciners	8.4	2	4.2
RU 12	Former RP&S Area and Mobile Shop	11.6	3	2.6-5.0
RU 13	Pond 8S Recovery Process and Metal Scrap Preparation Area	3.6[2]	1	2.7
RU 15	Oversize Ore, Used Electrode, Baghouse Dust Area	11.7	na	na
RU 16	Calciner Solids Stockpile	15.1	na	na
RU 17	Recyclable Material Landfill	8.1	na	na
RU 18	Plant Landfill	9.4	na	na
RU 19	Slag Pile, Bull Rock Pile	151.5	na	na
RU 20	Former Bannock Paving Area	61.6	12	5.0
RU 21	Other Onsite Railspurs	(tbd)	(tbd)	(tbd)
RU 22A	RCRA Waste Management Units	na	na	na
RU 22B	Old Ponds	37.7	na	na
RU 22C	Railroad Swale	2.4	na	na
RU 23	Road Segments not within RU Boundaries	23.0	6	1.7-5.0
RU 24	Plant Areas not within RU Boundaries	52.5	12	3.2-4.8

1. Area for RU 9 risk data collection is no greater than 10.0 acres after removing the minimum area that will be capped from RU 8.
2. Area for RU 13 risk data collection is no greater than 2.7 acres after removing the minimum area that will be capped from RU 9

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Section 3
MEASUREMENT/DATA ACQUISITION

This section of the Work Plan describes those elements and activities associated with data generations, data acquisition and management activities. This section presents the sampling design, describes methods and procedures that will be used in the field and laboratory, and describes how the resultant data will be managed.

3.1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

Section 2 provides the SRI data quality objectives, which include the rationale for selecting specific sampling locations and the analytes that will be determined. Section 2 also provides figures that illustrate the locations where samples will be collected for the specified analyses.

The Field Sampling Plan (FSP) in Appendix A provides details on the total number of samples, types/matrices or test runs/trials expected and needed; discussions on what to do if sampling sites become inaccessible, identification of sources of variability and how this variability should be reconciled with project information: and project activity schedules.

3.2 SAMPLING PROCEDURES

Sampling methods specified in this section will be used to collect soil samples for submission to selected laboratories for analysis. Sampling SOPs detailing how sampling activities will be performed are contained in the FSP. This section describes the methodology for sampling, sampling equipment that will be used, and decontamination procedures. Also described are utility and land survey activities that will be performed. Table 3-1 is a summary of the types of samples to be collected, the analyses to be performed, and the sampling methods.

3.2.1 Utility Survey

Underground utility clearance will be completed before subsurface investigation activities begin. The area within a five-foot radius of each subsurface sampling location will be cleared using the following protocol.

- Review available facility utility maps provided by FMC.
- Mark the proposed sampling locations and the utility lines in the immediate vicinity using a marker, stakes or flags.
- Verify proposed sampling locations with FMC plant employees to avoid potential for subsurface obstructions prior to drilling activities.
- Notify the local utility clearance service and schedule a meeting with all interested parties who potentially may be affected by off-site drilling activities.

- Utilize a magnetic locator or a hand auger to probe down to four or five feet bgs when facility maps or historic knowledge of subsurface utilities are not available.

3.2.2 Land Survey

Once samples have been collected, the sample location will be determined with a GPS. A Sokkia Axis, Trimble GEO Explorer, Trimble Pathfinder GPS or similar instrument will be used to map the test pit, borehole, PIC or other sampling locations. This level of accuracy usually ranges between sub-foot and sub-meter, depending on the model. The accuracy of the GPS unit will be documented and evaluated by locating surveyed benchmarks at the Site and recording the GPS coordinates. The GPS coordinates must have an accuracy of 1 meter of less. The GPS unit will be compared to a surveyed benchmark once each day. All measurements will be referenced to the State Plane Coordinate System, North American Datum 1983 and the North American Vertical Datum 1988.

3.2.3 Surface Soil Grab Samples for PCBs

Surface soil grab samples will be collected by carefully removing the top layer of soil or debris to the desired sample depth with a precleaned spade, shovel, or equivalent. If a composite sample is required, samples will be placed into a precleaned stainless steel or other appropriate container. Unless instructed otherwise, samples received by the laboratory will be analyzed "as received." Therefore, extraneous material (e.g., rocks, leaves, sticks) should be removed at the time of sample collection. Each sample will be homogenized in the field prior to shipment to the laboratory. Homogenization will be performed utilizing a quartering and coning or equivalent process as described in the FSP. After obtaining a representative subsample, the samples will be placed into new, appropriately sized sample jars provided by the laboratory. One soil jar will be submitted per soil sample. Samples will be labeled and handled following the sample preservation and chain-of-custody protocols described in Section 3.3. Sampling equipment will be decontaminated as described in Section 3.2.12.

3.2.4 Subsurface Soil Sampling by Drill Rig with Split-Spoon Sampler

To collect subsurface samples, borings will be advanced using dual-wall casing percussion equipment with reverse air circulation, or with a hollow-stem auger drill rig where applicable. Samples will be retrieved with split-spoon samplers. During drilling and sampling activities, the sampling team will continually monitor the auger cuttings visually and with an organic vapor analyzer. This method has been used successfully at the site to collect subsurface samples.

The dual-wall casing percussion and hollow-stem auger methods involve truck-mounted drill rigs. If necessary, pavement will be cored or sawed to allow access to the soil surface. After the pavement is cored or sawed (where paved areas are present), a hand auger or a geotechnical density probe may be advanced to four to five feet bgs to help decrease the risk of impacting underground utilities. The casing or boring will be advanced to the desired interval, where a soil sample will be collected in a split-spoon sampler fitted with brass sleeves.

When the desired sample interval is reached, the split-barrel sampler will be driven 18 inches with blows from a140-pound hammer in general accordance with ASTM D 1586. The number of blow counts in the first 12 inches will be recorded on the boring log.

If refusal is met before the targeted sampling depths are achieved, the borehole will be backfilled and relocated up to two times per location within a five-foot radius of the original sampling location. Sampler refusal is generally indicated if more than 50 blows are required to advance the sampler 6 inches. If any samples are successfully collected prior to refusal, these samples will be retained.

Once the sample interval has been retrieved, soil samples will be collected for the required analyses. The sample will be placed in an appropriately-sized container for field compositing or into the appropriate container for discrete samples. Samples for VOC analysis will be collected immediately upon retrieval of the sample interval, using the procedures described in Section 3.2.5. The samples will be labeled and handled for transport to a laboratory following sample preservation and chain-of-custody protocols described in Section 3.3.

Remaining soil not submitted for analysis will be used to log the soil in accordance with the Unified Soil Classification System. Samples not used for analysis will be discarded and disposed as investigation-derived waste (IDW) as described in Section 3.2.13.

After completion of sample collection, boreholes will be backfilled completely. For boreholes deeper than 10 feet, the borehole will be sealed with hydrated bentonite chips to ground surface. Shallower boreholes will be backfilled with cuttings. Drilling equipment will be decontaminated per the SOP in Appendix A between boring locations. Sampling equipment (split-spoons and sleeves) will be decontaminated between samples.

3.2.5 Subsampling for Volatile Organic Compounds

Samples for VOC analysis will be collected immediately upon retrieval of the sample interval, in accordance with U.S. EPA Method 5035A. Using an appropriate sample collection device, approximately 5 grams (g) of sample will be collected and placed in a sample vial that contains preservative solution. The samples will be placed in a cooler with ice and stored at 4°C for transport to a laboratory following chain-of-custody protocol described in Section 3.3.

Soil samples that contain carbonate minerals (either from natural sources or applied as an amendment) may effervesce upon contact with the acidic preservative solution in the sample vial. If the amount of gas generated is very small (i.e., several milliliters [mL]), any loss of volatiles as a result of such effervescence may be minimal if the vial is sealed quickly. However, if larger amounts of gas are generated, not only may the sample lose a significant amount of analyte, but the gas pressure may shatter the vial if the sample vial is sealed. Therefore, when samples are known or suspected to contain high levels of carbonates, a test sample should be collected, added to a vial, and checked for effervescence. If a rapid or vigorous reaction occurs, the sample will be discarded as IDW, and samples will be placed in vials that do not contain the preservative solution.

When practicable, a portable balance will be used to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample are added. The balance will be calibrated in the field using an appropriate weight for the sample containers employed. If a balance is used, the weight of the sealed vial containing the sample will be recorded to the nearest 0.01 gram. Alternatively, several trial samples can be performed using plastic syringes. Each trial sample should be weighed and the length of the soil column in the syringe should be noted. This method can be used to determine the length of soil in the syringe that corresponds to 5.0 ± 0.5 g. Each trial sample will be discarded as IDW as described in Section 3.2.13.

At least two replicate subsamples for VOC analysis will be collected for each targeted soil sample. This will allow the laboratory an additional sample for reanalysis, is necessary. The second subsample should be collected adjacent to the first subsample. A third subsample may be collected in a 60-mililiter (mL) glass vial or a third 40-mL soil sample vial that does not contain preservatives in order to determine dry weight, if needed.

Based on FMC's approval TerraCore^{TM} sampling may be employed. The collection of low concentration soil samples in vials that contain methanol is not appropriate for samples analyzed with the closed-system purge-and-trap equipment described in this method.

3.2.6 Trenching and Subsurface Soil Sampling

Trench and test pit excavation will be carried out by using standard motorized equipment such as a rubber tired backhoe or track mounted excavator. Operators of excavating equipment shall be skilled and experienced in the safe use of the equipment. A typical backhoe with an extending arm can excavate to a depth of approximately 15 feet. If investigations are required to penetrate beyond 15 feet, trenching and test pits may not be the most appropriate method of investigation and the use of other methods (e.g., soil borings) will be considered. A detailed description of trenching, excavations and safety considerations is found in the FSP.

At selected locations, subsurface soil samples are collected from the 0-to-2-foot bns or bgs depth, and the 0-to-10-foot bgs depth intervals. If the depth to the 0-to-2-foot bns sample is less than three ft bgs, soil samples will be extracted by using a hand auger within the test pit as described in the FSP. If the depths are greater than three feet, and drilling is not selected, and fill can be entirely removed or separated from native soil, soil samples will be extracted from the excavation using the bucket of the backhoe or excavator. Soil from the excavation will be placed in piles on clean plastic or other material as described in the FSP. A representative sub sample will be obtained in accordance with Section 3.2.9 and the FSP by compositing and splitting multiple core samples. In some instances, such as cap delineation investigation, a test pit will be used to visually identify material and a boring adjacent to the test pit will be used to collect a native soil sample. Discrete and composited samples will be labeled and handled following the sample handling protocols described in Section 3.3.

After sampling and logging has been completed the excavation will be backfilled with soil from the spoils pile. Soil will be replaced in roughly the order it was removed with any fill material replaced last. Replacing the soil will be completed in 1 to 2 foot lifts with each lift being compacted using the backhoe or excavator bucket.

3.2.7 Electret Canisters for Radon Flux Measurements

An electret ion canister consists of an electrically charged disk (electret) placed inside an air-filled chamber. Ionization events within the air-filled chamber partially discharge the electret, and the decrease in electret voltage is proportional to the exposure. Electret measurements will be made at the surface. Each electret ion canister will include two ion chambers; one of the chambers will be covered with Mylar film to prevent entrance of radon and provide a background value for each measurement location. Canisters will be deployed during periods of low barometric pressure to estimate radon flux during the time of year when higher flux would be expected. Canisters may be deployed for up to 48 hours, as described in Method 115, at which time they will be collected for on-site or laboratory reading of the electret voltages. Canisters will be deployed over consistent time intervals (e.g., from 8:00 a.m. on day 1 until 8:00 p.m. on day 2).

3.2.8 Composite Sampling

Composite samples will be collected for:

- 0-to-2-foot bgs interval associated with worker exposure studies
- 0-to-10-foot bgs interval associated with worker exposure studies
- 0-to-2-foot bns samples associated with SFS support data collection
  - Vertical composites
  - Spatial composites

Sample compositing associated with estimating worker risk exposure is based on DOQs that support decisions based on five-acre average values. Therefore field compositing and subsampling schemes that result in a representative subsample being submitted to the laboratory will be performed as described in the FSP. There are several subparts to SOPs in the FSP that outline the methods for compositing based on the sample collection method and analytes of interest such as waste pile sampling, split-spoon sampling, and P4 sampling.

Subsampling considerations as described by EPA, and based on Pierre Gy's sampling theory, will be utilized in selecting the appropriate compositing scheme for each identified sample collection type and matrix. Representative subsamples submitted to the laboratory will be further processed as appropriate to the analytical process, so that representative samples for analysis are obtained. Compositing SOPs in the FSP are divided into the following categories based on the analytical suite and sample collection method:

- 0-to-2-foot cores for metals, fluoride, and radionuclides
- 2–to-10-foot cores for metals, fluoride, and radionuclides
- 0-to-2-foot test pits/trenches for metals, fluoride, and radionuclides

- 2-to-10-foot test pits/trenches for metals, fluoride, and radionuclides
- 0-to-2-foot and 0-to-10-foot cores for elemental phosphorus
- 0-to-2-foot and 0-to-10-foot cores for elemental phosphorus, metals, fluoride, and radionuclides
- 0–to-2-foot test pits/trenches for elemental phosphorus, metals, fluoride, and radionuclides

For samples that require spatial compositing, field and laboratory compositing of the sample will be performed and a representative subsample will be submitted to the laboratory for analysis. The 0-to-10-foot composite for risk assessment data collection will be obtained by mathematically averaging the 0-to-2-foot and 2-to-10-foot intervals.

For 0-to-2-foot samples that require vertical compositing only, the entire sample will be placed in an appropriate sample container, mixed, and submitted to the laboratory for analysis.

3.2.9 Pile Sampling

At selected locations, subsurface soil samples from the 0-to-2-foot bgs depth, the 0-to-10-foot bgs depth interval or the 0-to-2-foot bns depth will be collected by using a backhoe to dig to the appropriate depth and create a sampling pile. The pile sampling strategy will be used when a drilling method is not selected, sample depths are greater than three feet and fill can be entirely removed or separated from native soil. It is important for the 0-to-2-foot bns sample that fill material is not present in the sample.

The practices employed for obtaining a representative sample of a pile will follow the guidance of Pierre Gy's sampling theory and ASTM Method D 6009, *Standard Guide for Sampling Waste Piles*. A representative sample is defined as sample collected such that it encompasses all of the characteristics of interest of the population from which it was collected.

As described in SOPs in the FSP, the trench sample will be placed on cardboard and plywood centered on a plastic tarp. The pile will be leveled with the aid of sampling guides and a 30- increment grid will be placed on the pile. A total of 30 increments will be collected using a 1-inch diameter corer that vertically penetrates the lift at randomly chosen sampling locations within each grid cell. The multiple core samples will be collected in the field, homogenized and subsampled in the laboratory and a representative sample will then be collected according to SOPs in the FSP.

The sampling device to be used for pile sampling at FMC is the thin-walled tube sampler. As described in the SOPs in the FSP, a 1 inch diameter core sampler, which collects relatively undisturbed core samples in soil-like solids or sludges will be utilized. All sampling equipment will be decontaminated prior to use and stored in clean plastic bags until use. The multi-increment samples will be labeled and handled following the sample handling protocols described in Section 3.3.

3.2.10 Pressurized Ionization Chamber Measurements

PIC measurements will be performed in the field to quantify total gamma dose rate. After assembling the instrument, checking the batteries, and allowing the PIC to stabilize for approximately 10 minutes, the background level and response to the gamma check source will be performed. The PIC will be placed at the sampling location, allowed to stabilize for approximately five minutes, and an integrated measurement will then be taken over a 20-minute interval

3.2.11 Decontaminating Sampling Equipment

Sampling equipment will be cleaned and decontaminated as follows.

- Large equipment such as drill rig augers will be decontaminated using a pressure washer capable of delivering water at a minimum temperature of 180 degrees Fahrenheit.
- Smaller equipment will be decontaminated between samples as follows:
  - Wash the equipment in detergent (e.g., Alconox® or Liqui-Nox® solutions made as directed by the manufacturer).
  - Rinse with potable water
  - Rinse twice with deionized or distilled water
  - Rinse water will be handled as IDW

3.2.12 Disposal of Investigation-Derived Waste

Generation of IDW such as equipment decontamination wastewater, rinsate, soil cuttings, sample containers, personal protective equipment (PPE) will be minimal. Based on EMF Site RI data for similar sampling areas, IDW is not expected to exhibit the characteristics of hazardous waste. IDW will be managed in accordance with the SOP contained in the FSP and applicable federal and state laws and regulations.

3.2.13 Coke Characterization

As described in Section 2.3.3 and Section 2.1, characterization of the coke material will be performed. The coke characterization will be documented per 40 CFR Part 262.40(c). The coke in RU 20 at both the coke handling area and in the coke settling basins will be evaluated for characteristics as described in the following subsections.

3.2.13.1 TCLP Sampling of Coke Settling Basins

The coke sediments in the settling basins will be sampled for TCLP analysis in accordance with EPA guidance for sampling storage bins, roll-off boxes, or collection hoppers (USEPA, 2002). The settling basins will be divided into four approximately equal sections. One sample location

will then be randomly selected within each quadrant of the sediment basin. A hand auger or shovel will be utilized at each location in order to bore or scoop through the sediments in the coke settling basins. The sediments are anticipated to range in thickness from a few inches to approximately 3 feet. Coke sediments will be collected with the bucket of the hand auger or shovel from the surface to the base of the concrete ponds and will be placed into clean, stainless steel bowls for mixing with clean stainless steel spoons (one vertical composite aliquot will be generated from each quadrant of the settling pond). All four aliquots will then be placed into a clean stainless steel mixing bowl and mixed with a clean stainless steel spoon in order to produce a single composite sample for analysis. One composite sample will be generated from each of the three areas of the coke settling basins and sent to the laboratory for analysis of TCLP metals and SVOCs as listed in Table 1.7.

3.2.13.2 TCLP Sampling of Surface Coke

The coke at the surface of the coke handling area will be sampled for TCLP analysis in accordance with EPA guidance for sampling storage bins, roll-off boxes, or collection hoppers (USEPA, 2002). The area will be subdivided into four approximately equal quadrants. One sample location will then be randomly selected within each quadrant of the coke handling area. A shovel will be utilized at each location in order to determine the approximate thickness of the coke and to scoop through the coke. Coke will be collected with the shovel to the maximum depth of the coke, assuming that the maximum depth is no greater than two feet. The coke will be placed into clean, stainless steel bowls for mixing with clean stainless steel spoons (one vertical composite aliquot will be generated from each quadrant of the coke handling area). All four aliquots will then be placed into a clean stainless steel mixing bowl and mixed with a clean stainless steel spoon in order to produce a single composite sample for analysis. One composite sample will be generated from the coke handling area and sent to the laboratory for analysis of TCLP metals and SVOCs as listed in Table 1.7.

3.3 SAMPLE HANDLING AND CUSTODY

This section describes sample container and preservation requirements, required records, and sample handling and packaging procedures.

3.3.1 Sample Handling, Preservation, and Storage

After collection, samples will be properly stored to prevent degradation of the integrity of the sample prior to its analysis. As applicable, this includes adding the appropriate chemical preservative in the sample, storing the sample in a refrigerated environment, and analyzing the sample within prescribed holding times. Table 3-2 summarizes the preservation and holding time requirements for specific analyses. Where practicable, FMC may electronically document sample handling, preservation, and storage. Sample preservation and holding times are to be maintained from the time of sampling until the time of analysis.

Based on visual confirmation, it is not anticipated that elemental phosphorus will be present in samples collected for shipment. However, in order to ensure the health and safety of all project personnel, specific procedures for shipping, handling, and analyzing the samples will be

followed. Health and safety precautions will take precedence over approved methodologies that might result in the exposure of elemental phosphorus to oxygen.

All samples designated for off-site laboratory analysis will be packaged and shipped in accordance with applicable U.S. Department of Transportation regulations. Samples will be sealed in the appropriate sampling container. A chain-of-custody seal will be placed on the sample container. The samples will be packed securely in an ice chest and samples will be preserved in accordance with the specifications set forth in Table 3-2. For those samples requiring preservation at 4 °C, the samples will be placed on ice in coolers in the field. Sufficient water ice (not "blue ice" or similar products) will be utilized to cool the samples during shipment. Sufficient ice shall be placed in each cooler such that: 1) some ice is still present upon arrival at the laboratory, and 2) the samples are cooled to 4 °C or below.

3.3.2 Sample Documentation and Custody

Each sample and/or measurement will be properly documented to facilitate timely, correct, and complete analysis of data. The documentation system is used to identify, track, and monitor each sample from the point of collection through final data reporting. Where practicable, this documentation system may be electronic. Chain-of-custody protocol will be implemented and followed for all samples. A sample is considered to be in a person's custody if it is: 1) in a person's physical possession, 2) in view of the person after taking possession, or 3) secured by that person so that no one can tamper with it.

3.3.2.1 Field Sample Custody and Documentation

Sample custody and documentation are necessary to demonstrate the integrity of the sample from time of collection until delivery to the laboratory. The documentation required includes logbooks, sample labels, custody seals, and chain-of-custody forms or their electronic equivalent**.**

Location

The characteristics of the sampling location must be documented in accordance with ASTM D 5911, *Standard Practice for Minimum Set of Data Elements to Identify a Soil Sampling Site*. The required characteristics are as follows:

- planar coordinates
- coordinate precision
- elevation
- elevation precision
- location map
- project identification

- source company and address
- unique location identification
- date
- type of soil sampling site (e.g., trench)

Logbooks

Logbooks (or the electronic equivalent) will document where, when, how, and from whom any vital program information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. At a minimum, the following sampling information will be recorded:

- sample location, station location, and description
- sample depth
- sample number
- sampler's name(s)
- date and time of sample collection
- designation of sample as composite or grab, including locations of composite increments
- sample matrix (soil, groundwater, etc.)
- type of sampling equipment used
- type of sample preservation
- shipping arrangements and airbill number (as applicable)
- recipient laboratory(ies)
- weather conditions (temperature, windy or calm, precipitation)

If a paper logbook is used, it will be bound, ruled, and paginated. All entries in logbooks will be in indelible ink. All corrections will be made by drawing a line through the erroneous information and initialing the change. "White-out" or its equivalent will not be used.

If electronic record-keeping systems are employed, procedures will ensure that:

- All original entries recorded are sufficiently backed up to avoid loss.
- A system that preserves both the original record and any changes to the record, inclusive of the identification of the individual making the change exists, and will be implemented.
- An archived record of all data entries will be protected to prevent unauthorized access or amendment of the electronic data.
- Entries will be complete enough to allow for the historical reconstruction of all records.
- The review of the records will be documented.

Labeling

All samples will be labeled in a clear, precise way for proper identification in the field and for tracking in the laboratory. The samples will have identifiable and unique numbers. At a minimum, the sample labels will contain the following information:

- facility name
- sample number
- sample depth
- date of collection
- time of collection
- analytical parameter(s)
- method of sample preservation

Sample Designation

A coding system will be used to uniquely identify each sample collected. The system will allow for quick data retrieval and tracking to account for all samples. The sample designation will be recorded on the sample label and logbook, and will comprise three parts or fields.

- Samples will be numbered sequentially within each RU for each type of sample collected (i.e., surface sampling, soil boring, PIC measurement).
- Part 1 will be a field of up to 5 characters corresponding to the RU and will be designated “RU” followed by up to three alphanumeric characters (e.g., RU22c will refer to Remediation Unit 22c).

- Part 2 will be a field that begins with alphabetic characters that identify the type of sample (e.g., "SB" for soil boring, "ER" for equipment rinsate blank). Three digits will follow the alphabetic character(s) and will be sequential (e.g., "001" for the first sample location collected, "002" for the second sample location collected, "003" for the third sample collected). In the case of a soil boring, Part 2 will end with depth interval in parentheses. As an example, sample designation RU12-SB004(2-4')-02 is the second container of the 4th sample collected in RU 12 from two to four feet bgs.

  Sample-type codes include the following:

  - ER = equipment rinsate blank
  - IDW = investigation-derived waste
  - S = solid (e.g., soil or slag)
  - SS = surface soil
  - SB = soil boring
  - SW = source water blank
  - TB = trip blank
  - PIC = PIC measurement

- Part 3 is a 2-digit sequential container number.

The individual sample designations that make up a composite sample will be recorded and a new sample designation will be given to the composited sample. The composited sample designation will include the RU number, the alphabetic character "C", a three-character depth interval, three-character sample type and a two digit, sequential number. For example, a composite sample for RU 12 from 0-to-2 feet below the native surface would be "RU12C-002-BNS-01."

Depth interval and sample designations include:

- Depth interval designations:
  - 000 = surface
  - 002 = 0-2 foot interval
  - 010 = 0-10 foot interval

- Sample designations:
  - BGS = below ground surface
  - BNS = below native surface
  - SUR = surface
  - PIC = PIC measurement

Custody Seals

Custody seals will be used to preserve the integrity of each sample container and cooler from the time the sample is collected until it is opened by the laboratory. Custody seals will be placed on each sample container after collection such that it must be broken to open the container. Two or more custody seals will be signed, dated, and placed on the front and back of the sample cooler prior to transport.

Chain-of-Custody Records

Chain-of-custody forms will be used to ensure that the integrity of the samples is maintained. Each form will include the following information:

- sample number
- date of collection
- time of collection
- sample depth
- analytical parameter
- method of sample preservation
- number of sample containers
- shipping arrangements and airbill number, as applicable
- recipient laboratories
- signatures of parties relinquishing and receiving the sample at each transfer point

Whenever a change of custody takes place, both parties will sign and date the chain-of-custody form, with the relinquishing person retaining a copy of the form. The party that accepts custody will inspect the custody form and all accompanying documentation to ensure that the information is complete and accurate. Any discrepancies will be noted on the chain-of-custody form.

3.3.2.2 Laboratory Sample Custody

Laboratory sample custody procedures in laboratory SOPs will be detailed enough to ensure that the procession of the sample in the laboratory is traceable from the time the sample is received by the laboratory until the sample is exhausted or returned to storage, the residue properly disposed, and data reported.

The laboratory will document all transfers of each sample within the laboratory system (e.g., the transfer of the sample from the sample custodian to the analyst for obtaining a sample aliquot and the transfer of the sample back to the sample custodian). Additionally, all transfers of sample extracts and digests will be recorded. This may be accomplished through the use of a sample preparation sheet with a signature block for documenting the transfer of the samples or by using a separate sample digestion/extraction custody transfer form.

3.4 ANALYTICAL METHODS

Laboratory analytical methods to be used for this SRI are presented in this section and have been outlined in Table 3-3. Methodologies are discussed below. Information concerning the analytical methods was obtained from the *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (U.S. EPA SW-846, Third Edition, and its first, second, and third updates).

3.4.1 Organics

Analyses of samples for organics will include testing for VOCs, PAHs, and PCB congeners. Samples for VOCs were collected in accordance with Method 5035A.

3.4.1.1 Method 8260B – Volatile Organics

This method is used to analyze samples for VOCs using gas chromatography and mass spectrometry (GC/MS). The VOCs are introduced into the gas chromatograph by the purge-and-trap method or by other methods. The analytes are introduced directly to a wide-bore capillary column or cryofocussed on a capillary precolumn before being flash-evaporated to a narrow-bore capillary for analysis. The column is temperature-programmed to separate the analytes, which are then detected with mass spectrometer interfaced to the gas chromatograph.

Analytes eluted from the capillary column are introduced into the mass spectrometer via a jet separator or a direct connection. (Wide-bore capillary columns normally require a jet separator, whereas narrow-bore capillary columns may be directly interfaced to the ion source). Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard using a minimum of a five-point calibration curve.

3.4.1.2 Method 8270C — Polynuclear Aromatic Hydrocarbons

This method will be used to analyze samples for PAHs, a subset of semivolatile compounds. If necessary, to obtain the required detection limits, SIM analysis may be used. The samples are

prepared for analysis by GC/MS using the appropriate sample preparation (refer to Method 3500) and, if necessary, sample cleanup procedures (refer to Method 3600). The semivolatile compounds are introduced into the GC/MS systems by injecting the sample extract into a gas chromatograph with a narrow-bore fused-silica capillary column. The GC column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer connected to the gas chromatograph. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard using a minimum of a five-point calibration curve. The method includes specific calibration and QC steps that supersede the general requirements provided in Method 8000.

3.4.1.3 Method 1668A – Polychlorinated Biphenyls

This method is used to analyze samples for congener-specific PCBs using high-resolution GC/high resolution MS (HRGC/HRMS). The toxic PCBs and the earliest and latest eluted congener at each level of chlorination are determined by the isotope dilution quantitation technique, while the remaining congeners are determined by the internal standard quantitation technique.

After sample preparation and cleanup to reduce possible interferences, sample extract is injected into a gas chromatograph, which separates the analytes and then is detected by an HRMS. Specific isomers for certain congeners are resolved using GC columns.

3.4.2 Inorganics

Analyses of samples for inorganics will include testing for elemental phosphorus, fluoride, metals, and leachability.

3.4.2.1 Method 7580 – Elemental Phosphorus

EPA SW 846 Method 7580 is used to determine the concentration of white elemental phosphorus in wet soil, sediment, and water samples. Soil or sediment samples are analyzed by extracting a 40-g wet-weight aliquot of the sample with a mixture of 10.0 mL of degassed reagent water and 10.0 mL of isooctane. The extraction is performed in a glass jar on a platform shaker for 18 hours. A 1.0 microliter (µL) aliquot of the extract is analyzed by gas chromatograph/ nitrogen phosphorus detector (GC/NPD). This procedure provides sensitivity on the order of 1 microgram per kilogram (µg/kg).

3.4.2.2 FMC Method Q-15

Samples to be analyzed for P4 in support of cap delineation and comparison to SSLs will be analyzed utilizing this FMC method. These samples contain P4 at levels between 10- and 1,000 milligrams per kilogram (mg/Kg) (i.e., 10,000 to 10,000,000 times the sensitivity of Method 7580). This method is applicable to phosphorus-containing waste including phossy water, NOSAP slurry, slurry, sludge, and solid waste. Phossy water and slurry contain elemental phosphorus as part of the suspended solids. To determine the concentration of phosphorus in

samples expected to contain less than 0.1 % P4, a 2 to10 g sample is extracted by refluxing with toluene for 20 to 30 minutes. The sample is then diluted to volume in toluene and analyzed on a GC that is equipped with a NPD. For samples expected to contain greater than 0.1 % P4, a 5 g sample is extracted for a period of 2 to 3 hours with a toluene/carbon disulfide mixture using the soxhlet extraction method followed by GC/NPD analysis.

3.4.2.3 Method 9214 – Fluoride

Soil samples can be prepared by ASTM methods D4646-87, D5233-92 or D3987-85. Method 9214 is for the analysis of simple fluoride ions rather than total fluoride, as analysis using the ion-selective electrode is not preceded by a distillation step. Total solubilized fluoride is determined potentiometrically using a fluoride ion-selective electrode (ISE) in conjunction with a standard single-junction reference electrode, or a fluoride combination ISE, and a pH meter with an expanded millivolt scale or an ISE meter capable of being calibrated directly in terms of fluoride concentration.

3.4.2.4 Method 6020 – Metals

Prior to analysis, samples must be digested by the appropriate digestion method (e.g., EPA Method 3050B for soils). Method 6020 is for multi-element determination of elements by ICP-MS. The method measures ions produced by a radio-frequency inductively-coupled plasma. Analyte species originating in a liquid are nebulized and the resulting aerosol is transported by argon gas into the plasma torch. The ions produced are entrained in the plasma gas and introduced, by means of an interface, into a mass spectrometer. The ions produced are sorted according to their mass-to-charge ratio and quantified with a channel electron multiplier. Interference correction must include compensation for background ions contributed by the plasma gas, reagents, and constituents of the sample matrix.

3.4.3 Radionuclides

Selected samples will be analyzed for radionuclides using alpha spectroscopy (uranium-238 and polonium-210), radon emanation (radium-226), electret ion chamber (radon flux), liquid scintillation (lead-210), gamma spectroscopy (potassium-40), and PIC (total gamma dose rate).

3.4.3.1 Alpha Spectroscopy

Alpha spectroscopy will be used for uranium-238 and polonium-210 analyses. Alpha emissions from radionuclides are detected by a semiconductor silicon chip that transfers the energy deposited into a small electronic pulse for each alpha interaction, where the pulse height is proportional to the incident alpha energy. These electronic data are converted to digital data by an analog-to-digital converter and stored in a multichannel analyzer (MCA). Data collected by the MCA are subsequently interpreted by a complex software program generating count data corresponding to a predefined list of nuclides being sought in the sample fraction. These data are then processed through data reduction and results-reporting routines to generate final reports. This procedure is similar in principle to DOE/EML 4.5.2.1 and easily exceeds the requirements referenced in ASTM D3972.

Paragon was been selected to analyze the radiological samples for the SRI. Paragon Analytical, Inc.'s Environmental Radiochemistry Laboratory utilizes PC-based MCAs for the acquisition of alpha spectra from 600-square-millimeter ion-implanted silicon detectors. The detectors are mounted in vacuum chambers and operated at or below 100 microns of mercury (Hg) absolute pressure to minimize loss of alpha particle energy during the path from sample to the detector. The spectrometers have interlocks between the bias and the vacuum system to prevent application of bias during evacuation or venting, which could damage the detectors. The MCAs are controlled by a personal computer, having a half-slot interface card and MCA display control and software. The MCA operations and subsequent data analysis are controlled through a series of menu-driven batch jobs. Descriptions of preparation methods (specifically, isotopic isolation techniques) are discussed below.

Uranium–238

To analyze for uramium-238, soil samples are first prepared as described in Paragon's SOP 721 (Solids Preparation For Radiochemistry Analysis) and SOP 733 (Dissolution of Solids for the Determination of Actinides), including the addition of a uranium-232 tracer. Uranium is separated by coprecipitation with ferric hydroxide. The ferric hydroxide precipitate is dissolved in hydrochloric acid (HCl). The sample solution is passed through a column containing an anion exchange resin that is equilibrated in 9-normal HCl. The resin retains uranium and plutonium while the other sample constituents pass through. The resin is washed with 9N HCl to complete the isolation of uranium and plutonium from the sample matrix. Plutonium is selectively stripped from the column by washing with 8N HCl/(0.72 g/100 mL) ammonium iodide solution. Finally, uranium is stripped by washing the resin with 0.5 N HCl. The purified uranium is co-precipitated with lanthanum fluoride and mounted on a filter membrane for quantification by alpha spectroscopy.

Polonium-210

To analyze for polonium-210, a tracer is added to the prepared soil samples. Polonium is leached into HCl. The acid concentration is adjusted, ascorbic acid is added, and polonium is spontaneously deposited onto a silver disc. The amounts of polonium-210 and tracer on the disc are measured by alpha spectroscopy.

3.4.3.2 Radon Emanation – Radium-226

Radon emanation is used to analyze for radium-226. Soil samples are dissolved by total digestion in an acid mixture. The dissolved sample is evaporated to dryness, muffled, transferred to a polypropylene beaker, and digested in the presence of strong acids. After digestion, the sample is transferred to a 40-mL volatile organic analysis (VOA) vial, purged of any existing radon-222, and stored to allow ingrowth of radon-222. After ingrowth, the ingrown radon-222 progeny are allowed to come to equilibrium with the parent radon (approximately 4 hours) before the scintillation cell is counted for alpha activity.

3.4.3.3 Electret – Radon Flux

The E-PERM^{TM} H electret ion chamber has a 180-square-centimeter, electrically conducting diffusion window made of a 70-micrometer-thick Tyvek sheet. Four filtered outlets vent the chamber so that it will not accumulate radon. When the flux monitor is placed on a radon-emanating surface, the radon enters through the Tyvek barrier and exits through the vents. The semiequilibrium radon concentration established inside the chamber is representative of the flux from the surface. Because of the equilibrium between the radon from the ground and the radon in the outside air through the vents, the flux emanation from the ground is not disturbed. A measure of the semiequilibrium radon concentration is a measure of the radon flux. The discharge rate of the electret is, in turn, a measure of the radon flux. The discharge rate is simply the voltage drop divided by the exposure time in hours.

Two ion chambers are used for each measurement. The Tyvek window of one of these chambers is covered with a Mylar film to prevent entrance of radon. This chamber provides a background value to be subtracted from the reading on the other chamber

3.4.3.4 Liquid Scintillation – Lead-210

Liquid scintillation will be used to analyze for lead-210. Soil samples are first prepared as described in Paragon's SOP 721 (Solids Preparation For Radiochemistry Analysis). The soil sample is dissolved in an acid mixture. Lead carrier is added. Lead is separated from other constituents by sorption onto an ion exchange column from a nitric acid solution. Lead is eluted from the ion exchange column with HCl. The eluate is evaporated to dryness, and taken up in dilute acid. An aliquot is taken for determination of chemical yield and the lead-210 content is determined by liquid scintillation counting.

3.4.3.5 Gamma Spectroscopy

Gamma spectroscopy will be used to quantify potassium-40 and provide qualitative identification of radioisotopes within the uranium-238 decay chain. Approximately 500 g of prepared soil are placed in the counting container. The sample is placed in a standardized position above the detector. The detectors are intrinsic germanium spectrometers mounted in lead shields. The electrical pulses from the detectors are proportional in height to the incident gamma energy. These pulses are converted to digital data and stored in an MCA. The data are subsequently interpreted by a complex software program that identifies and quantifies each radionuclide detected. The minimum detectable concentration is calculated for specified radionuclides that are not detected. This is a direct measurement without chemical processing, tracers, or carriers.

3.4.3.6 Pressurized Ion Chamber – Total Gamma Dose Rate

Total gamma-ray dose rate is measured in the field using a PIC. Calibration of this equipment is done by the manufacturer. Recalibration is done annually or whenever repairs of the instrument are required.

The detector chamber may be attached to a tripod or used at the ground surface. The exposure rate may be obtained either in analog or integrated integral form. For the analog measurements, the average of a series of ten consecutive readings is used.

3.4.4. Toxicity Characteristics Leaching Procedure

Method 1311 is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphase wastes. This method is usually used to determine the toxicity characteristic of a waste stream for hazardous waste determination. For wastes containing greater than or equal to 0.5% solids, the liquid, if any, is separated from the solid phase and stored for later analysis; the particle size of the solid phase is reduced, if necessary. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A special extractor vessel is used when testing for volatile analytes (see Table 1 for a list of volatile compounds). Following extraction, the liquid extract is separated from the solid phase by filtration through a 0.6 to 0.8 µm glass fiber filter.

3.5 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Both field and laboratory QA/QC checks will be used to evaluate the performance of field and laboratory analytical procedures. QC samples will be used to assess data quality in terms of precision and accuracy and verify that sampling procedures, decontamination, packaging, and shipping are not introducing variables into the sampling chain that could compromise the validity of sample data.

3.5.1 Sampling QA/QC Measures

The following types of field-QC samples will be submitted for analysis:

- equipment rinsate blanks
- source water blanks
- trip blanks
- electret blank for radon-222 flux measurements
- co-located samples

Table 3-4 presents quality goals for field QA/QC samples.

3.5.1.1 Equipment Rinsate Blanks

Equipment rinsate samples will be collected for all soil sampling events. The equipment rinsate blanks will be prepared at the site by passing laboratory-provided distilled water of known quality through decontaminated or factory-sealed sampling equipment. At the end of each day, the sampling team will take one equipment rinsate sample from each set of sampling equipment just before its final use.

The field log will identify the team members, date, and sampling area. This identification procedure will associate the equipment rinsate samples with a specific team's field decontamination procedure on each day. The rinsate sample sets from the team will be submitted each day along with field samples. Equipment rinsates will be collected at a frequency of one each day per analysis type.

3.5.1.2 Source-Water Blanks

There may be one or more sources of water required for sampling purposes. One blank will be collected for each source of water used for sampling equipment decontamination.

3.5.1.3 Trip Blanks

Trip blanks will be prepared by the laboratory using contaminant-free reagent-grade water and will be shipped to the field together with sample containers to detect contamination introduced during sample handling and shipment. They are not opened in the field and are returned to the laboratory in every sample cooler containing samples to be analyzed for VOCs using EPA Method 8260B.

3.5.1.4 Electret Blank Radon-222 Flux Measurements

The electret contains two ion chambers that are used for each measurement. The Tyvek window of one of these chambers is covered with a Mylar film to prevent the entrance of radon. This chamber provides a background value to be subtracted from the reading on the other chamber. After the measurements, each chamber is placed in a storage cover until the electret voltage is read.

3.5.1.5 Co-located Samples

Co-located soil samples will be collected at a frequency of one per ten investigative samples or one per decision unit, whichever is more frequent where samples are collected at random locations. The co-located sample will be collected no more than one foot from the location of the investigative sample.

3.5.2 Laboratory and Laboratory Testing Quality Assurance and Quality Control

FMC will conduct all required analyses of samples in the field or at its contract environmental laboratory. The following sections provide specific requirements for the field and contract laboratory analytical programs.

3.5.2.1 Conventional Environmental Laboratory Measurements

QA/QC sample types and acceptance criteria are presented in Table 3-5. For method-specific QC criteria and samples (e.g., calibration blanks or initial calibrations), the criteria specified in the methods will be used. The methods will be performed as written. Any deviations, if allowed, must be approved by the FMC Project Manager or the Quality Manager [in writing prior to implementation by the laboratory]. Procedures will be in place for demonstrating that

the laboratory is in control during each analytical measurement. Documentation associated with this demonstration may be recorded electronically.

Laboratory Control Samples

The laboratory will be considered in control when data generated by analysis of control samples fall within prescribed limits. Data generated by analysis of control samples that fall outside the established control limits are judged to be generated during an "out-of-control" situation. These data are considered suspect and the analyses shall be repeated. Appropriate laboratory control samples will be analyzed for each analytical method. A laboratory control sample consists of either a control matrix spiked with the analytes of interest for this program or a certified reference material that contains the analytes of interest. Laboratory control sample(s) will be analyzed with each batch of samples processed to verify that the precision and bias of the analytical process are within control limits. The results of the laboratory control sample(s) will be compared to control limits established for both precision and bias to determine usability of the data. In the absence of historical data, the laboratory will be considered in control if the recovery for each analyte is between 70 and 130 percent and when the relative percent difference between laboratory control samples is less than 25 percent. Precision data will be developed by analysis of laboratory control samples over time. When the laboratory has collected sufficient data (20 to 30 samples), control charts will be developed and the laboratory recovery and precision limits will be defined by the experimental data.

Method Blank

A method blank will be analyzed with each batch of samples processed to assess contamination levels in the laboratory. The laboratory will have guidelines in place for accepting or rejecting data based on the level of contamination in the blank. For a method blank to be acceptable for use with the accompanying samples, the concentration in the blank of any analyte of concern will not be higher than the highest of either:

- the method detection limit (MDL), or
- 5 percent of the regulatory limit for that analyte, or
- 5 percent of the measured concentration in the sample.

Matrix Spike/Matrix Spike Duplicates for Matrix Duplicate Samples

Procedures will be in place for documenting the effect of the sample matrix on method performance. When appropriate for the method, there will be at least one matrix spike and either one matrix spike duplicate or one matrix duplicate per analytical batch. These procedures will include preparation and analysis of matrix spikes and the method of standard additions for metals and inorganics methods. When the concentration of the analyte in the sample is greater than 0.1 percent (1,000 parts per million), no spike is necessary. Procedures will be in place for determining the precision of the method for a specific matrix. These procedures will include analysis of matrix duplicates and/or matrix spike duplicates.

If the concentration of a specific analyte in the sample is being checked against a regulatory concentration limit or action level, the spike will be at or below the limit, or 10 times the background concentration (if historical data are available), whichever concentration is higher. If historical data are not available, a background sample of the same matrix from the site will be submitted for matrix spiking purposes to ensure that high concentrations of target analytes and/or interferences will not prevent calculation of recoveries.

If the concentration of a specific analyte in a sample is not being checked against a limit specific to that analyte, the analyst may spike the sample at the same concentration as the reference sample, at 20 times the estimated quantitation limit in the matrix of interest, or at a concentration near the middle of the calibration range. A background sample of the same matrix from the site will be submitted as a sample for matrix spiking purposes.

Matrix-Specific Detection Limits

Procedures will be in place for determining the MDL for a specific matrix type (e.g., liquid, slurry, solid). FMC matrix-specific detection limits will be determined prior to analysis of samples for each matrix and each analytical method. Elevated detection limits may be reported for samples that contain contaminants or interfering substances. Data from multiple dilutions will be used, as necessary, to quantify target components within the calibrated range. Actual detection limits obtained during analysis will be reported by the laboratory for each parameter in each sample.

The MDL is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. It is determined from analysis of a sample in a given matrix containing the analyte. For operational purposes, when it is necessary to determine the MDL in the matrix, the MDL should be determined by multiplying the appropriate one-sided 99 percent t-statistic by the standard deviation obtained from a minimum of five analyses of a matrix spike containing the analyte of interest at a concentration three to five times the estimated MDL, where the t-statistic is obtained from standard references or from Table 3-6.

To estimate the MDL, obtain the concentration value that corresponds to:

- an instrument signal/noise ratio within the range of 2.5 to 5.0, or
- the region of the standard curve where there is a significant change in sensitivity (i.e., a break in the slope of the standard curve).

Determine the variance (S^2) for each analyte as follows:

$$S^2 = \frac{1}{n-1}\left[\sum_{i=1}^{n}(x_i - \bar{x})^2\right]$$

where x_i = the ith measurement of the variable x and
$\bar{x}$ = the average value of x;

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

Determine the standard deviation(s) for each analyte as follows:

$$s = (S^2)^{1/2}$$

Determine the MDL for each analyte as follows:

$$MDL = t_{(n-1, \alpha = .99)} (s)$$

where t is the one-sided t-statistic appropriate (n-1, α = .99)
for the number of samples used to determine (s), at the 99 percent level.

3.5.2.2 Radiochemical Measurements

Tables 3-7 and 3-8 present the analytical performance criteria for the radiochemical measurements.

Alpha Spectrometry

Weekly energy, efficiency, and background calibrations will be performed on each detector. The counting efficiency is calculated from the peak area obtained from these weekly calibration counts of the standard. Corrective actions to be taken if results exceed the acceptance criteria are listed in Paragon's SOP 714.

Radon Emanation – Radium-226

Per the laboratory SOP, an 18,000 disintegration per minute (dpm) National Institute of Standards and Technology (NIST) traceable thorium source will be counted for 1 minute before and after each batch of samples is counted, bracketing the sample counts, to ensure that the detector and scalar are working properly. The check source is to be counted at least once per day when the detector is in use.

The background count rate of each alpha scintillation cell will be determined prior to emanation of each sample by counting in the associated detector for a duration equal to or longer than the planned sample count. If the sample and background count times differ, the gross background counts should be adjusted to match the sample count time. This adjustment will be recorded on a laboratory Quality Assurance Summary Sheet. The measured count activity of the cell is employed as the background activity in the calculation of sample results.

Electret Ion Canister – Radon Flux

The electret flux monitor from E-PERM™ has been calibrated on radon flux beds at CANMET (Canada). These beds consisted of 776 radon-bearing materials (well-characterized uranium

tailings) 5.5 cm thick and 5 meters in diameter. The bed had been precisely characterized by CANMET to provide a radon flux of 7.7 ± 1.1 pCi/m^2/sec (7.7 flux units [FU]). These beds are no longer in existence; however, the electret calibration should be valid because the design of the electret has not been altered. In addition, the electric voltage readers are calibrated annually and E-PERM^{TM} participates in a third-party blind performance evaluation program. During the SRI, the electret measurements will be performed according to the SOP in Appendix A.

Liquid Scintillation – Lead–210

No calibration check is required for this system. An efficiency calibration is performed at least annually. A blank sample using quartz sand and a laboratory control sample (LCS) of spiked quartz sand will be processed with each batch of samples.

Gamma Spectroscopy

Daily calibration checks will be performed for one of the calibrated counting geometries. This daily check verifies the energy calibration, efficiency calibration and resolution of the detector. Control charts will be maintained for these checks. Warning and control limits will be based on historic performance of the checks. Weekly background measurements will be made on each detector system. The acceptance criteria for background count rate will be based on historic performance.

Pressurized Ion Chamber – Total Gamma Dose

QC checks will be performed prior to sending instruments to the field, at the beginning and end of each day of data acquisition, upon return of the instrument from a field assignment, at any time that instrument factors (e.g., batteries, cables, operating parameters) that could affect the instrument response are altered, and whenever the performance of an instrument is in question.

The baseline check source will be placed in contact with the detector in a reproducible fashion, using a “jig” or marking on the PIC casing. After making sure that the source is placed in the same location for each source check, the analog or integrated digital response will be recorded. The net response will be calculated and compared with the previously established acceptable baseline response range. If the source falls within that range, the instrument may be considered to be operating properly. If the response does not fall within the acceptable range, the instrument should not be used for quantitative measurements unless a thorough evaluation justifies otherwise.

3.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

All equipment used to conduct this work will receive routine maintenance checks to minimize equipment breakdowns. Maintenance checks will generally coincide with calibration checks. Any equipment found to be operating improperly will be taken out of use, and a notation stating the time and date of this action will be made in a logbook. The equipment will be repaired, replaced, or recalibrated, as necessary, and the time and date of its return to service will also be recorded. This applies to both laboratory and field equipment. Documentation of instrument/equipment testing, inspection, and maintenance may be recorded electronically.

3.6.1 Analytical Balance

For this program, the laboratory(ies) will use weights that meet or exceed ASTM Class 2 certification for the calibration of balances. The acceptance criteria for each balance will be set in accordance with ASTM E617-91, *Standard Specification for Laboratory Weights and Precision Mass Standards*, Appendix X1, Suggested Applications, Page 5, Table X1.1.

Balances will be verified prior to setup and initial use at the laboratory and periodically (once per day) thereafter. The weights used for the verification will bracket (i.e., with a minimum of two weights) the torsion range, which includes the weight of the sample and the tare vessel. The acceptance range, as documented in the balance logbook, will accurately depict the acceptance range for the type of balance, as shown in Table 3-9.

3.6.2 Laboratory Reagent Water

Reagent water will be tested at the beginning of the SRI and periodically thereafter to demonstrate that the criteria as referenced in Chapter One of EPA SW-846, Update III (EPA, 1996), or the applicable method meets the performance specifications for ASTM water provided in Table 3-10. This is required for all participating laboratories.

3.6.3 Volumetric Glassware

Glassware will be verified as meeting the appropriate specifications listed in Tables 3-11 and 3-12 as provided by ASTM E1272-95 and E288-94. Verification of autopipeter volumes will be accomplished gravimetrically.

3.6.4 Thermometers or Temperature Measurement Devices

All temperature measurement devices will be calibrated against a NIST-traceable thermometer. This calibration will include the temperature range in which the device will be used (e.g., 0 °C – 100 °C). Thermocouples will be verified by comparison with NIST-traceable mercury thermometers.

3.6.5 Equipment Maintenance

Both field and analytical equipment will be maintained in working order so as not to compromise data quality.

3.6.5.1 Field Equipment

The procedures describing how to ensure that field equipment and instrumentation are in working order will be specified when appropriate instruments have been identified. These will describe calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, and service arrangements for equipment. Calibration and maintenance of field equipment and instrumentation will be in accordance with manufacturers' specifications or applicable test specifications and will be documented in SOPs.

3.6.5.2 Analytical Equipment

The procedures describing how to ensure that laboratory equipment and instrumentation are in working order will be specified in the laboratory quality assurance project plan (QAPP). These procedures will include calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, service arrangements for all equipment, and spare parts available in-house. Calibration and maintenance of laboratory equipment and instrumentation will be in accordance with manufacturers' specifications or applicable test specifications and will be documented in SOPs.

3.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Laboratory equipment will be calibrated in accordance with an established laboratory QAPP, and all calibrations will be performed in accordance with SOPs consistent with the cited methods. Documentation of instrument/equipment calibration and frequency may be recorded electronically.

3.7.1 Multipoint Calibrations

When evaluating which mathematical model is most appropriate for the initial calibrations, the following guidelines are to be used.

- For each analyte and surrogate of interest, prepare calibration standards at a minimum of five different concentrations by adding volumes of one or more stock standards to volumetric flasks and diluting to volume with an appropriate solvent. For gas methods, different masses of gas standards will be delivered to the gas chromatograph by injecting different volumes of the same standard mixture.

- The lowest concentration calibration standard that is analyzed during an initial calibration establishes the method quantitation limit. This limit is based on the final volume of extract (or sample) described in the preparative method or employed by the laboratory.

- The other concentrations will define the working range of the detector or correspond to the expected range of concentrations found in actual samples that are also within the working range of the detector.

- For each analyte, at least one of the calibration standards will correspond to a sample concentration at or below that necessary to meet the DQOs of the program. DQOs may include establishing compliance with a regulatory or action limit.

- Concentration must be plotted on the x-axis and instrument response must be plotted on the y-axis.

3.7.1.1 Calibration Linearity

EPA SW-846 methods allow the use of both linear and nonlinear (1st, 2nd, and 3rd order) models for the calibration data as described below. The option for nonlinear calibration may be necessary to

achieve low detection limits or to address specific instrumental techniques. However, it is not EPA's intent to allow nonlinear calibration to be used to compensate for detector saturation at higher concentrations or to avoid proper instrument maintenance. Whichever calibration model is employed, a unique analyte or surrogate concentration must fall within the calibration range. Samples with concentrations that exceed the calibration range will be diluted to fall within the range.

Linear Models (Relative Percent Difference)

Both the calibration factor (CF) and the response factor (RF) are measures of the slope of the calibration relationship and assume that the curve passes through the origin. Under ideal conditions, the factors will not vary with the concentration of the standard that is injected into the instrument. In practice, some variation is to be expected. However, when the variation, measured as the relative standard deviation (RSD), is less than or equal to 20 percent, the use of the linear model is generally appropriate, and the calibration curve can be assumed to be linear and to pass through the origin.

> NOTE: Linearity through zero is a statistical assumption and <u>not</u> a rationale for reporting results below the calibration range demonstrated by the analysis of the standards.

To evaluate the linearity of the initial calibration, the analyst shall calculate the mean CF (external standard calibration) or RF (internal standard calibration), the standard deviation (SD), and the RSD as follows:

$$\mathrm{CF} = \frac{\mathrm{Response}}{\mathrm{Mass}} \tag{1}$$

$$\mathrm{RF} = \frac{\mathrm{A_s\ x\ C_{is}}}{\mathrm{A_{is}\ x\ C_s}} \tag{2}$$

$$\text{mean CF} = \overline{\mathrm{CF}} = \frac{\sum_{i=1}^{n} \mathrm{CF}_i}{\mathrm{n}} \tag{3}$$

$$\text{mean RF} = \overline{\mathrm{RF}} = \frac{\sum_{i=1}^{n} \mathrm{RF}_i}{\mathrm{n}} \tag{4}$$

$$\mathrm{SD} = \sqrt{\frac{\sum_{i=1}^{n} \left(\mathrm{CF_1} - \overline{\mathrm{CF}}\right)^2}{\mathrm{n}-1}} \quad \text{or} \quad \mathrm{SD} = \sqrt{\frac{\sum_{i=1}^{n} \left(\mathrm{RF_1} - \overline{\mathrm{RF}}\right)^2}{\mathrm{n}-1}} \tag{5}$$

$$\mathrm{RSD} = \frac{\mathrm{SD}}{\overline{\mathrm{CF}}}\ \mathrm{x}\ 100 \quad \text{or} \quad \mathrm{RSD} = \frac{\mathrm{SD}}{\overline{\mathrm{RF}}}\ \mathrm{x}\ 100 \tag{6}$$

where:

A_s = area (or height) of the peak for the target analyte in the sample

A_{is}= area (or height) of the peak for the internal standard

C_s = concentration of the target analyte in the calibration standard

C_{is} = concentration of the internal standard

If the RSD of the calibration or response factors is less than or equal to 20 percent over the calibration range, then linearity through the origin may be assumed, and the average calibration or response factor may be used to determine sample concentrations.

If the RSD of the calibration or response factors is greater than 20 percent over the calibration range, then linearity through the origin cannot be assumed. If this is the case, the analyst may employ a regression equation that does not pass through the origin. This approach may also be employed based on past experience or prior knowledge of the instrument response. Further, at the discretion of the analyst, this approach also may be used for analytes that do meet the RSD limits.

1st Order Regressions

This is most easily achieved by performing a linear regression of the instrument response versus the concentration of the standards. The analyst shall make certain that the instrument response is treated as the dependent variable (y) and the concentration as the independent variable (x). This is a statistical requirement and is not simply a graphical convention. Data submitted with the axis flipped (i.e., concentration as [y] and responses as [x]) will not be accepted and will be returned to the laboratory for recalculation and resubmission of the data package.

The regression will produce the slope and intercept terms for a linear equation in the form:

$$y = ax + b \qquad (7)$$

where:

y = instrument response (peak area or height)

a = slope of the line (also called the coefficient of x)

x = concentration of the calibration standard

b = the intercept

The analyst shall not force the line through the origin, but have the intercept calculated from the five data points. Otherwise, the problems noted with the RSD value will occur, i.e., a line through the origin will not meet the QC specifications. In addition, the analyst shall not include the origin (0,0) as a sixth calibration point. The use of a linear regression may not be used as a rationale for reporting results below the calibration range demonstrated by the analysis of the

lowest nonzero standard. The regression calculation will generate a correlation coefficient (r) that is a measure of the "goodness of fit" of the regression line to the data. A value of 1.00 indicates a perfect fit. In order to be used for quantitative purposes, (r) must be greater than or equal to 0.99.

In calculating sample concentrations by the external standard method, the regression equation is rearranged to solve for the concentration (x), as shown below.

$$x = \frac{y - b}{a} \tag{8}$$

In calculating sample concentrations by the internal standard method, the regression equation is rearranged to solve for the concentration of the target analyte (C_s), as shown below.

$$C_s = \frac{\left[\frac{A_s C_{is}}{A_{is}} - b\right]}{a} \tag{9}$$

2nd and 3rd Order Regressions

In situations where the analyst knows that the instrument response does not follow a linear model over a sufficiently wide working range, or when the other approaches described here have not met the acceptance criteria, a nonlinear calibration model may be employed.

> NOTE: It is not FMC's intent to allow nonlinear calibration to be used to compensate for detector saturation at higher concentrations or to avoid proper instrument maintenance. Thus, nonlinear calibration will not be employed for methods or instruments previously shown to exhibit linear calibration for the analytes of interest.

When using a calibration model for quantitation, the curve must be continuous, continuously differentiable, and monotonic over the calibration range. The model chosen shall have no more than four parameters, i.e., if the model is polynomial, it may be no more than third order, as in the equation:

$$y = ax^3 + bx^2 + cx + d \tag{10}$$

As noted above, the model must be continuous. This also applies to 1st order equations. A curve is continuous when it has consecutive numerical values along the function, whether increasing or decreasing, and has no breaks in the function (i.e., the pen shall never leave the paper from the minimum to the maximum). The model must also be continuously differentiable, such that all derivatives of the function are continuous functions themselves, and monotonic, such that all tangent lines of the derivative to all of the points on the calibration curve have either only positive or only negative slopes.

In estimating model parameters for the calibration data, the instrument response (y) will be treated as the dependent variable, and the calibration of the concentration standard (x) will be the independent variable. The analyst shall not force the line through the origin, i.e., shall not set the intercept as 0, and shall not include the origin (0,0) as a calibration point. Model estimates from the regression will be used as calculated, i.e., if the model is a polynomial, the intercept is d (equation 10) and may not be set to 0.

The statistical considerations in developing a nonlinear calibration model require more data than the more traditional linear approaches described above. Whereas EPA SW-846 methods employ five standards for a linear (first-order) calibration model, a quadratic (second-order) model requires six standards, and a third-order polynomial requires seven standards.

Most curve-fitting programs will use some form of least squares minimization to adjust the coefficients of the polynomial (a, b, c and d, above) to obtain the polynomial that best fits the data. The "goodness of fit" of the polynomial equation is evaluated by calculating the weighted coefficient of the determination (COD). The following equation will be used for determining the COD for 2nd and 3rd order equations used in this program:

$$COD = \frac{\sum_{i=1}^{n}\left(y_{obs} - \bar{y}\right)^{z} - \left(\frac{n-1}{n-p}\right)\sum_{i=1}^{n}\left(y_{obs} - y_{i}\right)^{z}}{\sum_{i=1}^{n}\left(y_{obs} - \bar{y}\right)^{z}} \qquad (11)$$

where:

y_{obs} = observed response (area) for each concentration from each initial calibration standard

$\bar{y}$ = mean observed response from the initial calibration

y_i = calculated (or predicted) response at each concentration from the initial calibration(s)

n = total number of calibration points (i.e., 6 for a quadratic model; 7 for a third-order model)

p = number of adjustable parameters in the polynomial equation (i.e., 3 for a third-order; 2 for a second-order polynomial)

Under ideal conditions, with a "perfect" fit of the model to the data, the COD will equal 1.0. In order to be an acceptable nonlinear calibration, the COD must be greater than or equal to 0.99. If the weighted COD is not used to assess goodness of fit to 2nd or 3rd order equations, then the laboratory will document this nonconformance. The laboratory must provide a rationale for use of an alternative indicator for goodness of fit.

Whichever of these options is employed, a unique analyte or surrogate concentration must fall within the calibration range. Analysts will be advised to check both second- and third-order

calibration models to ensure that this holds true (e.g., no parabolas or repeating functions in the calibration range). Samples with concentrations that exceed the calibration range will be diluted to fall within the range.

3.7.2 Retention-Time Windows for Chromatographic Methods

Retention-time windows are crucial to the identification of target compounds. Absolute retention times will be used for compound identification in all GC and high-performance liquid chromatography methods that do not employ internal standard calibration. Retention-time windows will be established to compensate for minor shifts in absolute retention times as a result of sample loadings and normal chromatographic variability. The width of the retention-time window should be carefully established to minimize the occurrence of both false positive and false negative results. Tight retention-time windows may result in false negatives and/or may cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. Overly wide retention-time windows may result in false positive results that cannot be confirmed upon further analysis.

Before establishing retention-time windows, the analyst shall make sure that the chromatographic system is operating reliably and that the system conditions have been optimized for the target analytes and surrogates in the sample matrix to be analyzed. The analyst shall make three injections of all single-component standard mixtures and multicomponent analytes (such as PCBs) over the course of a 72-hour period. Serial injections or injections over a period of less than 72 hours may result in retention-time windows that are too tight.

The analyst shall record the retention time for each single-component analyte and surrogate to three decimal places (e.g., 0.007). The analyst shall calculate the mean and standard deviation of the three absolute retention times for each single-component analyte and surrogate. For multicomponent analytes, the analyst shall choose three to five major peaks (see the determinative methods for more details) and calculate the mean and standard deviation of those peaks.

If the standard deviation of the retention times for a target compound is 0.000 (i.e., no difference between the absolute retention times), then the laboratory may either collect data from additional injections of standards or use a default standard deviation of 0.01 minutes. (Recording retention times to three decimal places rather than only two should minimize the instances in which the standard deviation is calculated as 0.000.)

The width of the retention-time window for each analyte, surrogate, and major constituent in multicomponent analytes is defined as ± 3 times the standard deviation of the mean absolute retention time established during the 72-hour period. If the default standard deviation is employed, the width of the window will be 0.03 minutes.

> NOTE: The retention-time window study must be performed. It is not acceptable to use a default standard deviation of 0.01 minutes as a default retention time of 0.03 minutes.

The analyst shall establish the center of the retention-time window for each analyte and surrogate by using the absolute retention time for each analyte and surrogate from the calibration verification standard at the beginning of the analytical shift. For samples run during the same shift as an initial calibration, the analyst shall use the retention time of the mid-point standard of the initial calibration.

The laboratory will calculate absolute retention-time windows for each analyte and surrogate on each chromatographic column and instrument. New retention-time windows will be established when a new GC column is installed. The retention-time windows should be reported with the analysis results in support of the identifications made.

If the instrument data system is not capable of employing compound-specific retention-time windows, then the analyst may choose the widest window and apply it to all compounds.

The surrogates will be added to each sample, blank, and QC sample and are also contained in each calibration standard. Although the surrogates may be diluted out of certain sample extracts, their retention times in the calibration standards may be useful in tracking retention-time shifts. Whenever the observed retention time of a surrogate is outside of the established retention-time window, the analyst will be advised to determine the cause and correct the problem before continuing analyses.

3.7.3 Alpha Spectroscopy

Energy calibration, efficiency calibration, and background calibration are performed on each alpha spectrometer weekly. The counting efficiency is calculated from the peak area obtained from these weekly calibration counts of the standard. Specific instruction for performing these instrument measurements are contained in Paragon Analytics Inc.'s SOP 714, Rev 8.

Energy calibrations will be performed on a weekly basis utilizing sources containing americium-241, uranium-234, and uranium-235 activity. The sources will be counted for approximately 35 minutes. When the count is finished, the computer program will compare the locations of the americium-241, uranium-234, and uranium-235 peaks to the primary emissions energies and perform a quadratic fit of the energy per channel data. These data will be stored in the appropriate detector file for reference by the analysis program during sample analysis.

This energy calibration equation will be used to calculate the energy in keV of the alpha peak centroid channel. The initial calibration will be used as baseline and the following control limits will be set:

- warning limits ± 40 keV from the initial value
- control limits ± 50 keV from the initial value

Energy calibration corrective actions are contained in Section 12.2.4 of SOP 714.

As described in Section 12.1.1.6 of Paragon Analytics Inc.'s SOP 714, efficiency calibration will be performed immediately after energy calibration. The efficiency calibration acceptance criteria will be set with the following limits:

- warning limits = 3.3 percent of initial value
- control limits = 5 percent of initial value

Efficiency calibration corrective actions are contained in Section 12.2.6 of SOP 714.

Background calibrations will be performed by placing blank filter papers in numbered planchets that are placed in each detector. The filter paper is counted for 1,000 minutes energy/efficiency. Filter papers and planchets are replaced at least annually. The background acceptance criteria for uranium detectors will be set with the following limits:

- warning limit – 400 counts over the entire spectrum
- control limit – 500 counts over the entire spectrum

Background corrective actions are contained in Section 12.2.2 of SOP 714.

3.7.4 Radon Emanation Radium-226

The calibration constant of each detector-scintillation cell combination will be determined using a NIST-traceable radium-226 solution. A distilled water sample in the VOA vial will be spiked with the standard solution just prior to the helium purge step. The resulting calibration constant will be a composite measure of the emanation efficiency of the system and the counting efficiency of the cell. Each detector-cell combination will be calibrated with standard radium-226 yearly. Specific procedures are contained in Paragon Analytics, Inc.'s SOP 783, Revision 4.

3.7.5 Electret – Radon Flux

The E-PERM™ flux monitor has been calibrated on radon flux beds at CANMET (Canada). These National Reference Standard Flux Beds in Canada are used for calibrating flux monitoring instrumentation. These beds consist of radium-226 bearing material (well characterized uranium tailings) 5.5 cm thick and 5 meters in diameter. The bed has been precisely characterized by CANMET to provide a radon flux of 7.7 +/- 1.1 pCi/m^2/sec (7.7 FU). One pCi/m^2/sec is referred to as one flux unit.

High sensitivity electrets (termed ST) are used for low fluxes and low sensitivity electrets (termed LT) are used for high fluxes. The units were placed on the flux beds for up to 48 hours when the flux monitor was used with ST electrets and placed from 4 to 7 days when flux monitors were used with LT electrets. A similar flux monitor is positioned on the flux bed, separated by a radon barrier (Mylar sheet) to serve as a blank that responds to all the other environmental contributors (gamma and radon in the atmosphere) except flux from the bed. The differential discharge rates were correlated with the reference flux values. The calibration factors based on the data from CANMET are given below:

For ST electrets (high sensitivity electrets), the calibration factor (CF) is given by the equation:

$$CF = 10.4 +/- 1.0 \text{ VPH per unit flux } (pCi/m^2/sec) \quad (1)$$

For LT electrets (low sensitivity electrets), the calibration factor (CF) is given by the equation:

$$CF = 0.60 +/- 0.12 \text{ VPH per unit flux } (pCi/m^2/sec) \quad (2)$$

This means that a discharge rate of 10.4 volts in one hour corresponds to 1 FU when the monitor is used with ST electrets and a discharge rate of 0.60 volt in one hour corresponds to 1 FU when the monitor is used with LT electrets.

3.7.6 Liquid Scintillation – Lead-210

A set of twelve blanks and twelve lead-210 standards will be prepared for calibration of the liquid scintillation spectrometer. The blanks and standards will be quenched with nitromethane in 15 µL increments. The spectrometer calculates a calibration curve of efficiency versus degree of quench from the counts of the series of standards and blanks. This calibration is minimally performed on an annual basis.

3.7.7 Gamma Spectroscopy

A NIST-traceable mixed-gamma standard will be used for energy and efficiency calibration of each detector-geometry combination annually. The standard contains multiple gamma rays over the energy range of interest. The calibration standard will be counted sufficiently long to obtain at least 10,000 counts for each gamma-ray peak. The spectral data will be processed by the spectrometer computer and the output will be a set of calibration equations. One equation calculates counting efficiency as a function of gamma-ray energy and another equation calculates the gamma-ray energy corresponding to each channel. The calibration data will be stored in the computer and used in the processing of sample data.

3.7.8 Pressure Ionization Chamber – Total Gamma-Ray Exposure Rate

Instruments to be used for quantitative measurements will be source-calibrated a minimum of every twelve months. Calibration is to be performed with standards traceable to the NIST or other industry- recognized standards organizations. Records will be maintained for each detector and readout instrument, detailing the calibration and maintenance history. Calibration will be performed by the instrument manufacturer or other outside organization.

Where possible, for an analog readout instrument, the selected scale should provide a reading between half- and full-scale; for an integrating digital readout instrument the count time should result in accumulation of at least 10,000 counts. The gross and net instrument response should be recorded on the Baseline Response record form. For instruments that will be operated in the scalar mode, the determination should be repeated ten times and the average of these measurements should be used. One reading is recorded for instruments to be operated in the ratemeter mode. A range of within 20 percent of that response to the designated source is established as the criterion for evaluating acceptance of other readouts (with properly set operating parameters) with that detector. Each detector/readout combination that satisfies the acceptance criterion for the designated baseline check

source may be assumed to be responding with the efficiency established for the detector. This record is filed with other detector response, calibration, and maintenance information

3.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Sample containers will be precleaned and supplied by the laboratory performing sample analysis. All other consumables will be purchased clean or decontaminated prior to use. Consumables and supplies will be assumed to meet manufacturer's certification and program specifications. Routine testing of supplies will be implemented if it is suspected that supplies do not meet certification and specifications. Documentation of inspection and acceptance of supplies and consumables may be recorded electronically.

Procedures shall be established to ensure that inspections or acceptance testing of supplies and consumables are documented adequately by permanent, dated, and signed records or logs that uniquely identify the critical supplies or consumables, the date received, the date tested, the date to be retested (if applicable), and the expiration date. These records shall be kept by the responsible individual(s). In order to track supplies and consumables, labels containing the information on receipt and testing shall be used.

These or similar procedures shall be established to enable program personnel to 1) verify, prior to use, that critical supplies and consumables meet specified program or task quality objectives, and 2) ensure that supplies and consumables that have not been tested, have expired, or do not meet acceptance criteria are not used for the program or task. Where analyses of blank samples are used to verify the acceptability of consumables and supplies, all manufacturer certification records will be retained and when blank results indicate contamination, data associated with the contaminated materials may be qualified or rejected.

3.9 NONDIRECT MEASUREMENTS

To meet the testing objectives of this SRI, no data are required other than those collected during the sampling and sample analyses described in this plan.

3.10 DATA MANAGEMENT

Data management will include both field and laboratory-generated data. Management of conventional and radiochemistry data are discussed in the following subsections. The FMC Quality Manager will maintain a database of all analytical results.

3.10.1 Environmental Data

Data collected during the SRI will be managed during this program. Data will consist of information recorded in logbooks and chain-of-custody forms or a digital alternative. Logbooks and chain-of-custody forms (or their electronic equivalent) will be retained by the sampling personnel until complete or until the end of the calendar year, then forwarded to the FMC Quality Manager for retention.

All contract laboratories will be required to submit a Category I data package for each Sample Delivery Group (SDG) to document the quality of the analytical data and to support later

validation of the data. The format and detailed content of the laboratory documents must support validation of the data in accordance with EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 540/R-94-013) and EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA540/R-94/012, February 1994. In addition, the laboratory data packages must support a Level I data validation, as defined in Section 5. The Level I documentation provided in Table 3-13 will be provided by the laboratory for each SDG scheduled for validation.

The electronic data deliverable will contain the fields specified in Table 3-14. All contract laboratories will provide two full copies of the data validation package containing all materials specified in Table 3-13 for each SDG. The laboratory will forward Category 1 data packages to the data-validation contractor. Validation will be conducted as specified in Section 5. The standard validation qualifiers specified in Table 3-15 will be assigned as appropriate.

3.10.2 Fixed Laboratory Radiochemical Data

Requirements for hard copy and electronic data deliverables from the radiochemical laboratory are detailed in this section. Electronic deliverables to be loaded into the project database will also be submitted.

The laboratory will be responsible for maintaining supporting documentation in the form of sample preparation logs, instrument run logs, maintenance logs, standards receipt and preparation logs, and instrument printouts. Calculations shall be clearly identified in the sample analysis records or in laboratory SOPs.

3.10.2.1 Hard Copy Data Package

A complete data package capable of supporting the data validation requirements of this project will be prepared by the laboratory, inclusive of all required documentation described in Section 5. The following information is to be included in the data package:

- sample results
- total weight or volume of the sample submitted and analyzed
- identification and documentation of the specific analysis processes and analyst
- specific analytical parameters, (i.e., chemical yields, counting times, decay factors, efficiency of detector used)
- sample receipt information
- QC data demonstrating the quality of the measurement
- control charts
- traceability of standards

- chain-of-custody
- efficiency, calibration curves and instrument background
- spectrometry resolution
- dilution and correction factors
- counts and count time
- result of measurement, uncertainty, minimum detectable concentration, and units
- plots of alpha spectra
- dates and times of counting, start, and end times for ingrowth of radon-222; start and end times for decay of radon-222

3.10.2.2 Organization of Data Package

The laboratory shall submit a CLP-Type Level 4 data package consisting of the following:

- case narrative
- sample receipt documentation and COC
- summary report of sample results, with uncertainties and MDCs
- QC results: lab blanks, LCS, matrix spikes and duplicate
- individual sample results with tracer or chemical yields, aliquot size, etc.
- raw instrument data and instrument logs, including maintenance logs
- instrument performance-check data and summaries
- initial calibration checks and summaries
- laboratory bench sheets and prep notes
- standards traceability information

The laboratory should also ensure that the following information is included in the data report:

- internal COC information
- copies of standards logs

- copies sample preparation logs – include weight or volume of the sample submitted and analyzed
- copies of certificates of analysis for standards
- identification and documentation of the specific analysis processes and analyst
- efficiency, calibration curves and instrument background
- specific analytical parameters, (i.e., chemical yields, counting times, decay factors, efficiency of detector used)
- dilution and correction factors
- counts and count time
- result of measurement, uncertainty, minimum detectable concentration and units
- spectrometry resolution
- plots of alpha spectra
- dates and times of counting, start, and end times for ingrowth of radon-222; start and end times for decay of radon-222
- traceability of standards
- control charts

3.10.2.3 Electronic Data Deliverables

Electronic data may be in two forms. One form of electronic data is a PDF or TIFF file that contains images of each page of the hard copy report. The second form is an electronic file with individual data elements that can be loaded into other software (e.g., databases, spreadsheets). This second form may be a comma delimited file, a spreadsheet, or a database file and is normally referred to as Electronic Data Deliverable (EDD). This applies to conventional data as well as fixed laboratory radiochemical data.

3.10.2.4 Image Files

The preferred form of an image file is the PDF format. PDFs can be prepared in one of two ways: scanning an existing document or printing to a new PDF document. Both forms have advantages. Scanning the existing document ensures that an exact copy of the hard copy document is available for review. Printing to a PDF document results in an electronic file that is searchable and allows for the electronic transfer of information through electronic cutting and pasting functions. However, if the laboratory prints to a PDF, it must ensure that the electronic version is the same as the paper version. Receiving the data report in a PDF format is preferred and assists in

implementing the Paperwork Reduction Act. This applies to conventional data as well as fixed laboratory radiochemical data.

The standard laboratory practice is to retain the hard copy data report, which contains copies of supporting documentation, for approximately 3 months, at which time the report is scanned and the hard copy is disposed. For this project, the hard copy is to be initially sent to the Quality Manager for use in the data validation process. After completion of the data validation process, the Quality Manager will send the hard copy to the FMC Project Manager for inclusion in the project file.

The laboratory is required to ensure that the hard copy of the report matches the PDF version of the report that is sent to the validator. This is to be accomplished by scanning the completed hard copy report and comparing the total number of pages scanned to the number of pages in the hard copy document. In addition, the scanned document is to be reviewed to ensure that all pages are legible and correctly oriented. The laboratory must also ensure that the PDF file has the capability for capturing text and for the cutting and pasting of text.

3.10.2.5 Electronic Data Deliverable Files

Tables 3-16 through 3-20 present templates for reporting laboratory radiochemical raw data. Table 3-14 is the EDD format for reporting radiochemical data.

3.10.3 Field Pressurized Ionization Chamber Data

Field measurements using a PIC will be managed in the same manner as for conventional field measurements. Data will consist of information recorded in logbooks/field forms or a digital alternative. Logbooks/field forms (or their electronic equivalent) will be retained by the sampling personnel until complete or until the end of the calendar year, then forwarded to the FMC Quality Manager for retention.

Table 3-1

Summary of Sample Types and Methods

Sample Type	Analysis	Sampling Method
Surface soil	PCBs	Stainless steel spoon or trowel
Subsurface soil	VOCs	Method 5035A
	PAHs	Stainless steel spoon or trowel
	PCBs	Stainless steel spoon or trowel
	Metals, fluoride, radionuclides	Stainless steel spoon or trowel
	P4	Stainless steel spoon or trowel
Surface coke TCLP	PAHs	Stainless steel spoon or trowel
	Metals	Stainless steel spoon or trowel
Surface Gamma	Pressurized ionization chamber	Not applicable
Surface Radiation	NaI Detector	Not applicable
Radon Flux	Radon-222	*In situ* Electret™

Table 3-2

Summary of Sample Container, Preservation, and Holding Time Requirements (Page 1 of 2)

Parameter	Sample Container	Preservation	Holding Time
Soil			
Elemental Phosphorus	Three 40-mL amber glass vials with screw caps and seals	Cool to 4 °C, store in the dark, keep tightly sealed to prevent loss of moisture. Collect sample as close to zero headspace as possible.	Soil samples do not have an extraction Holding time. When extracted in Isooctane analyze within 30 days of extraction
Metals Radionuclides, and Fluoride	Two 8-ounce plastic jar with screw cap[1]	Ambient temperature Cool to 4 °C for mercury	6-months 28 days for mercury and fluoride
VOCs	Three 40-mL amber glass vials with screw caps, septum seals and stir bars Three 40-mL amber glass vials with screw caps, septum seals and stir bars 2 oz sample jar for percent solids determination	5-mL water[2] Cool to 4 °C 10 mL methanol Cool to 4 °C Cool to 4 °C	7 days to analysis 7 days[3]
PAHs	8-ounce amber glass jar with screw cap	Cool to 4 °C	14 days to extraction, 40 days after extraction to analysis
PCBs	8-ounce amber glass jar with screw cap	Cool to 4 °C	14 days to extraction, 40 days after extraction to analysis
SVOCs and Metals for TCLP	8-ounce amber glass jar with screw cap for SVOCs 8-ounce glass or plastic jar with screw cap for metals	Cool to 4 °C	14 days to extraction, 40 days after extraction to analysis for SVOCs 6-months for metals

[1] This project requires the analysis of boron. Therefore, sample collection and laboratory analysis must performed using non-borosilicate lab ware.
[2] Appendix B: CLP Sample Collection Guidelines for Volatile Organic Analytes (VOAs) in Soil by SW-846 Method 5035A, Option 2, Contract Laboratory Program Guidance for Field Samplers, OSWER 9240.0-35, EPA540-R-00-003, FINAL AUGUST 2004
[3] 40 CFR Part 136.3 Table II

Table 3-2

Summary of Sample Container, Preservation, and Holding Time Requirements (Page 2 of 2)

Parameter	Sample Container	Preservation	Holding Time
Water			
Elemental Phosphorus	Three 40-mL amber glass vials with screw caps and seals	Cool to 4 °C, no head space	5 days to analysis
Metals Radionuclides	Four 1-L poly bottles	Cool to 4 °C; HNO_3 to pH <2	6-months 28 days for Mercury
Fluoride	1-L Poly bottle	No Preservative	28 Days
VOCs	Three 40-mL amber glass vials with Teflon septa	4 °C, HCL, no head space	7 days[3]
PCBs and PAHs	Four 1-L amber glass bottles	Cool to 4 °C	7 days to extraction, 40 days after extraction to analysis

See List of Acronyms and Abbreviations for definitions

Table 3-3

Analytical Methods

Compounds	Analytical Method	Field/Laboratory
Organics		
Volatile organics	EPA Method 5035A/8260B	Laboratory
PAHs	EPA Method 8270C	Laboratory
Polychlorinated Biphenyls	EPA Method 1668A	Laboratory
Inorganics		
Elemental phosphorus	EPA Method 7580/FMC Method Q-15	Laboratory
Fluoride	ASTM Method D3987/EPA Method 9214	Laboratory
Metals	EPA Method 6020	Laboratory
Radionuclides		
Polonium-210	Alpha spectroscopy	Laboratory
Uranium-238	Alpha spectroscopy	Laboratory
Radium-226	Radon emanation	Laboratory
Radon Flux	Electret Ion Chamber	Field
Lead-210	Scintillation counting	Laboratory
Potassium-40, uranium-238 daughters	Gamma spectroscopy	Laboratory
Total gamma-ray dose	Pressurized ionization chamber FMC SOP	Field

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

TCLP for PAHs and metals in surface coke will be performed according to EPA Method 1311

Table 3-4

Field Sampling QA/QC Goals

Field QA/QC Sample Type	Quality Goal
Equipment rinsate blank	The analyte of concern should not be higher than the highest of either: (1) the MDL, (2) five percent of the regulatory limit for that analyte, or (3) five percent of the measured concentration in the sample
Source-water blank	The analyte of concern should not be higher than the highest of either: (1) the MDL, (2) five percent of the regulatory limit for that analyte, or (3) five percent of the measured concentration in the sample
Trip blank	The analyte of concern should not be higher than the highest of either: (1) the MDL, (2) five percent of the regulatory limit for that analyte, or (3) five percent of the measured concentration in the sample
Co-located	RPD less than or equal to 50 when both duplicate pairs are greater than or equal to five times the EQL. If either or both samples are less than five times the EQL then the difference cannot exceed the EQL.

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 3-5

Summary of Laboratory QA/QC Samples and Criteria for Soil Samples

Analytical Group	Laboratory Duplicate[d]		Method Blank		Matrix Spike/Matrix Spike Duplicate		Laboratory Control Sample	
	Frequency	Criteria	Frequency	Criteria	Frequency	Criteria	Frequency	Criteria
Volatile organic compounds[f]	NA	NA	1 per 20[a]	As per the method[b]	1 per 20[a]	As per the Method	1 per 20[a]	[e]
Polychlorinated biphenyls[g]	NA	NA	1 per 20[a]	As per the method[b]	1 per 20[a]	As per the method	1 per 20[a]	[e]
Elemental Phosphorus (P_4)	1 per 20[a]	± 25%	1 per 20[a]	As per the method[b]	NA[c]	NA	NA	NA
Fluoride	1 per 20[a]	± 25%	1 per 20[a]	As per the method[b]	1 per 20[a]	NA	NA	NA
Polynuclear aromatic hydrocarbons[f]	NA	NA	1 per 20[a]	As per the method[b]	1 per 20[a]	As per the method	1 per 20[a]	[e]
Metals	1 per 20[a]	± 20%	1 per 20[a]	As per the method[b]	1 per 20[a]	As per the method	NA	NA

Notes:

[a] One per 20 samples, or one per batch if a batch contains less than 20 samples.

[b] The analyte of concern should not be higher than the highest of either: (1) the MDL, (2) five percent of the regulatory limit for that analyte, or (3) five percent of the measured concentration in the sample.

[c] Matrix spike/matrix spike duplicate analysis not possible on elemental phosphorus. Instead, an extraction completeness check (1 per 20 samples or 1 per day, whichever is greater) and laboratory control sample are used to determine method accuracy.

[d] A control limit of ±20%, unless otherwise specified, for the RPD will be used for original and duplicate sample values greater than or equal to 5x the estimated quantitation limit (EQL). A control limit of ± the EQL will be used if either the sample or duplicate value is less than 5x the EQL. In the case where only one result is above 5x the EQL and the other is below, the ± the EQL criteria applies. If both sample values are less than the instrument detection limit, the RPD is not calculated.

[e] Limit is statistically derived by the laboratory; if not established a control limit of ±30% will be used.

f Surrogates compounds spiked in every sample will also be used to measure accuracy; contract laboratories' statistically derived limits will be used.

[g] Labeled standards spiked in every sample will also be used to measure accuracy. Limits established by the analytical method will be used.

NA = Not applicable.

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 3-6

t-Statistic for Method Detection Limit Estimate

Number of Samples*	t-Statistic
3	6.96
4	4.54
5	3.75
6	3.36
7	3.14
8	3.00
9	2.90
10	2.82

Note:

* This is the number of samples, not the degrees of freedom as specified in standard statistical textbooks.

Table 3-7

Analytical Performance Criteria for Methods with a Chemical Separation

QC Item	Control Criteria			
	Radium-226	**Uranium-238**	**Lead-210**	**Polonium-210**
Efficiency Calibration	Two σ uncertainty less than 5 % of value			
Calibration Checks	Warning Limits ± 2 σ Control Limits ± 3 σ			
Carrier/Tracer Recovery	NA	75% - 110 %	40 - 110 %	30 - 110 %
Reporting Limit	0.2 pCi/g			
MDC	Less than or equal to reporting limit			
Method Blank	Less than reporting limit			
Laboratory Control Sample	Laboratory-derived warning and control limits from control charts			
Duplicate Samples	Warning Limits: DER = 1.43 Control Limits: DER = 2.13			
Matrix Spike Samples	70% - 130%			
Total Propagated Uncertainty	15% (one σ)			
Tracer Counting Uncertainty	NA	1 σ < 5%	NA	1 σ < 5%

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 3-8

Analytical Performance Criteria for Gamma Spectroscopy

QC Item	Control Criteria
Efficiency Calibration	Two σ uncertainty less than 5 % of value
Calibration Checks	Warning Limits ± 2 σ Control Limits ± 3 σ
Carrier/Tracer Recovery	NA
Reporting Limit	Nuclide dependent
MDC	Less than or equal to reporting limit
Method Blank	Nuclide dependent
Laboratory Control Sample	Laboratory-derived warning and control limits from control charts
Duplicate Samples	Warning Limits: DER = 1.43 Control Limits: DER = 2.13
Matrix Spike Samples	NA
Total Propagated Uncertainty	Nuclide dependent
Tracer Counting Uncertainty	NA

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 3-9

Analytical Balance Check Criteria

Comparison of Laboratory Criteria with ASTM Criteria for Analytical Weights					
Weight	No. of Decimal Places on Balance	ASTM Tolerance for Class 1 Weight[a]		Measurable Tolerance of Balance to Demonstrate Acceptance	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
5 grams	2	4.999966	5.000034	5.00	5.00
100 grams	2	99.99975	100.00025	100.00	100.00
5 grams	3	4.999966	5.000034	5.000	5.000
100 grams	3	99.99975	100.00025	99.999[b]	100.001[b]

Notes:

[a] ASTM E617-91, Standard Specification for Laboratory Weights and Precision Mass Standards, Appendix X3. Page 7, Table X3.4, Class 2 - Metric

[b] Assumes the balance is capable of being accurate to 0.5 mg and all errors of the balance and the weight are in the same direction

Table 3-10

Reagent-Grade Water Specification

ASTM Standard Specification for Reagent Water			
Parameter	**Testing Frequency**	**Type I**	**Type II**
Electrical conductivity, maximum, $(\mu ohm/cm)^{-1}$ at 298 K (25 °C)	Once per day	0.056	1.0
Electrical resistivity, min, mega-ohm·cm at 298 K (25 °C)	Once per day	18	1.0
Total organic carbon, maximum, µg/L	Once per month	50	50
Sodium, maximum, µg/L	Once per month	1	5
Chloride, maximum, µg/L	Once per month	1	5
Total silica, maximum, µg/L	Once per month	3	3

Note:

The reference for ASTM Type II water in Chapter 1 of EPA SW-846 is: "ASTM Method D 1129-77, Specification for Reagent Water, 1991 Annual Book of ASTM Standards. Volume 11.01 Water and Environmental Technology." ASTM Method D1129-77 would designate ASTM Method 1129, revised in 1977. Method 1129 is titled "Standard Terminology Relating to Water." This method was originally approved in 1950 and revised in 1988 and 1990. There is no 1977 revision of this method. ASTM Method 1193 is titled "Standard Specification for Reagent Water." This method was originally approved in 1951 and revised in 1977 and 1991. As this method has essentially the same title and also has the same year for the revision, it is our assumption that the EPA SW-846 reference is to ASTM Method 1193-77 – Standard Specification for Reagent Water, and updated in 1999 and 2001.

Acronyms/Abbreviations:

See List of Acronyms and Abbreviations for definitions

Table 3-11

Graduated Cylinder Certification Criteria

Tolerance for Graduated Cylinders		
	Tolerances to Contain or to Deliver ± mL	
Capacity (mL)	Class A	Class B
5	0.05	0.10
10	0.10	0.20
25	0.17	0.34
50	0.25	0.50
100	0.50	1.00
250	1.00	2.00
500	2.00	4.00
1,000	3.00	6.00
2,000	6.00	12.00
4,000	14.50	29.00

Source:
ASTM E1272-95, Standard Specifications for Laboratory Glass Graduated Cylinders, Table 1 – Dimensions and Tolerances

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-12

Volumetric Flask Certification Criteria

Tolerance for Volumetric Flasks		
	Tolerances to Contain or to Deliver ± mL	
Capacity (mL)	Class A	Class B
5	0.02	0.04
10	0.02	0.04
25	0.03	0.06
50	0.05	0.10
100	0.08	0.16
200	0.10	0.20
250	0.12	0.24
500	0.20	0.40
1,000	0.30	0.60
2,000	0.50	1.00

Source:
ASTM E288-94, Standard Specification for Laboratory Glass Volumetric Flasks, Table 1 – Requirements for Volumetric Flasks

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-13

Laboratory Data Deliverable Requirements
(Page 1 of 2)

Data Deliverable
Chain-of-custody (COC)
Sample receipt forms and /or logbook pages
Copies of shipping manifests (e.g., airbills)
Verification of sample temperature on receipt
Copies of temperature logs for storage coolers used to store samples
Internal COC (all documents denoting transfer of sample[s] to an individual)
Sample preparation logs
Standards preparation logs
Instrument operating conditions
Copies of sample analysis logbooks
Instrument run log, including copies of autosampler loading and verification of the autosampler loading
Raw data for instrument – hardcopy
Raw data for instrument –electronic (CD-ROM is preferred medium)
Raw data for LOD or percent solids
Printout of electronic data
Analyst's notes
Data review sheets
Example calculations
Sample data summary forms
Nonconformance and corrective actions
Case narrative
Method blank control charts
Duplicate control charts
Matrix spike control charts
Matrix spike duplicate control charts
MDL/LCS control charts
Surrogate recovery control chart
Standard reference material (LCS) control charts
Documentation of the verification of the water bath temperature used for digestion/extraction
Documentation of oven temperature used for determining percent solids
Standards certificates
Standards reference material certificates
Documentation of thermometers including certificate of NIST-traceable thermometer
Daily verification of autopipeters
Verification of transfer of data to the computerized system
Certificates for weights used to calibrate/verify the balance
Balance calibration logs
Volumetric glassware verifications
Certificate of cleanliness for all sample bottles

Table 3-13

Laboratory Data Deliverable Requirements
(Page 2 of 2)

Data Deliverable
General for all SDGs
Verification package of software used for data calculation
Copy of SOP
MDL studies and supporting documentation
Equipment maintenance records
Consumables acceptance and tracking records
Analyst's demonstration of precision and accuracy

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-14

Database Field Acronyms and Descriptions
(Page 1 of 2)

Database Field Name	Type	Size	Full Name	Description
STA_ID	Text	12	Station ID	Sampling point, etc.
AGENCY	Text	8	Agency	Investigating party (EPA)
SAMP_DATE	Date/Time	8	Sample Date	Date sample was taken
SAMP_ID	Text	8	Sample ID	Unique identification number given to each sample
CHEM_NAME	Text	36	Chemical Name	Name of chemical
CAS_NO	Text	12	Chemical Abstract Service Number	Number that is given to identify a unique chemical by the Chemical Abstract Service
CONC_DET	Number (Double)	8	Concentration Detection	Chemical concentration that was detected
QUAL	Text	4	Qualifier	Laboratory qualifier given to each sample
UNITS	Text	12	Units	Units of measurement
QUAL_VAL	Text	4	Validation Qualifier	Qualifier assigned as a result of data validation
QUAL_CODE	Text	6	Code Qualifier	Code used by validation to indicate why a qualifier was assigned
VAL_LVL	Text	4	Validation Level	Level or extent of validation done
CHEM_NO	Number (Double)	8	Chemical Number	Chemical number given by FMC for database sorting
LAB_NAME	Text	12	Laboratory Name	Name of laboratory that performed the analyses
LAB_ID	Text	12	Laboratory Identification	Identification number given to a sample by laboratory
QUAL_ANAL	Text	4	Analysis Qualifier	Lab-assigned qualifier (see Qualifier Description)

Table 3-14

Database Field Acronyms and Descriptions
(Page 2 of 2)

Database Field Name	Type	Size	Full Name	Description
SAMP_TYPE	Text	4	Sample Type	e.g., gas, slurry, liquid, solid
QUAL_SAM	Text	8	Qualifying Sample	Sample qualifier indicating that sample is not representative (see Qualifier Description)
AN_DATE	Date/Time	8	Analytical Date	Date sample was analyzed for constituents
EXTRACT_DATE	Date/Time	8	Extract Date	Date of laboratory extraction
AN_METHOD	Text	20	Analytical Method	Method used for analyzing chemicals
PKG_NAME	Text	9	Package Name	Laboratory sample delivery group (SDG)
ACTUAL_VAL	Number (Double)	8	Actual Value	Actual value shown for accuracy, used only for radiological
ACCURACY	Number (Double)	8	Accuracy	± Accuracy (for radiological samples)
RPT_LIM	Number (Double)	8	Reporting Limit	Laboratory required reporting limit
FILE_NAME	Text	8	File Name	Chronological name of an event

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-15

Data Validation Qualifiers

U	The parameter was analyzed for but was not detected. The associated numerical value is the laboratory-reported sample quantitation value.
J*	The associated numerical value is estimated.
R*	The result is rejected. Resampling and reanalysis may be necessary for verification.

Note:

* The "J" and "R" qualifiers result from several data quality anomalies; these will be assigned standard codes (i.e., J1 = noncompliant matrix spike, J2 = noncompliant surrogate recovery, J3 = noncompliant calibration stability, R1 = low specific response) for the permanent database record.

Table 3-16

Template for Radium-226 Analyses

Client Sample ID	Lab Sample ID		pCi/unit	Ra-226 Error	Gross Counts	Count Time	Back-ground Counts	Net cpm	Cell Constant	Sample Volume or Mass	Units (L, g)	De-emanation		Time of Counting	Growth Time	Decay Time	Growth Factor	Decay Factor
	Batch ID	Sample ID										Start Time	End Time					

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-17

Template for Uranium-238 Analyses

Client Sample ID	Lab Sample ID		Nuclide	Reported Activity	Reported Error	Gross Counts	Net Counts	Back-ground Counts	Sample Volume or Mass	Units (L, g)	Count Time	Efficiency	Reported Recovery	Tracer Counts	Tracer dpm
	Batch ID	Sample ID													

Acronyms/Abbreviations:
See List of Acronyms and Abbreviations for definitions

Table 3-18

Template for Lead-210 Analyses

	Lead-210						Lead-210												
							22.26	Y	8.5235E-05										
Lab number	**Sample ID**	**Reported Activity**	**Reported Error**	**Reported MDA**	**Qualifier (data flag)**		**Sample Time**	**Separation Time**	**Count Time**	**Gross Counts**	**Bkgnd Counts**	**Count Interval**	**Sample Weight**	**Sample Volume**	**Sample Aliquot**	**Efficiency**	**Recovery**	**Ingrowth Factor**	**Decay Factor**
	Spike	20.80	1.10	0.30			4/24/2001 14:15	4/24/2001 14:15	5/1/2001 14:08	1664	90	60			2.00	0.442	0.936	0.620	0.999
	Blank	0.1	1.5	1.5			4/24/2001 14:15	4/24/2001 14:15	5/1/2001 14:08	106	105	60			0.50	0.442	0.920	0.620	0.999
244/01-1	115-1	1241	17	1.7			3/14/2001 7:00	4/24/2001 14:15	5/1/2001 17:18	20743	105	60	1.498	250	0.50	0.442	0.814	0.627	0.996

Table 3-19

Template for Polonium-210 Analyses

	Polonium-210								Polonium-210							Po-208 half life =		2.898	years
																Po-209 half life =		102	years
											Tracer activity =				32.7	Po-210 half life =		138.376	days
Lab	**Sample**	**Reported**	**Reported**	**Reported**	**Qualifier**		**Sample**		**Net Counts**		**Bkg cts**	**Counting**	**Sample**	**Sample**	**Sample**	**Efficiency**	**Tracer**	**Reported**	**Decay**
number	**ID**	**Activity**	**Error**	**MDA**	**(data flag)**		**Date**	**Date**	**Po-208**	**Po-210**	**Po-210**	**Interval**	**Weight**	**Volume**	**Aliquot**		**Aliquot**	**Recovery**	**Factor**
	Spike	21.9	0.9	0.1			4/30/2001 13:30	4/30/2001 13:30		2259	3	60			2.0000	0.386	1.0000	1	1.0000
	Blank	0.0	0.2	0.2			4/30/2001 13:30	4/30/2001 13:30		3	4	60			0.5000	0.386	1.0000	1	1.0000
244/01-1	115-1	514.0	8.1	2.0			3/14/2001 7:00	4/30/2001 13:30		15599	7	60	1.498	250	100.0000	0.386	1.0000	1	0.7892

Table 3-20

Template for Gamma Spectroscopy Analyses

	Gamma spectroscopy									Gamma spectroscopy						
Lab	**Sample**	**Nuclide**	**Reported**	**Reported**	**Reported**	**Qualifier**		**Sample**	**Count**	**Sample**	**Counting**	**Gamma**	**Gamma**	**Counting**	**Gross**	**Background**
number	**ID**		**Activity**	**Error**	**MDA**	**(data flag)**		**Date**	**Date**	**Weight**	**Interval**	**Energy**	**Abundance**	**Efficiency**	**Counts**	**Counts**

Section 4
ASSESSMENT AND OVERSIGHT

Program assessment and oversight will be performed by the Quality Manager and/or designee and will include assessments and response actions, reports to management, as well as nonconformance and corrective action training.

All personnel are responsible for ensuring that the program is implemented in accordance with this Work Plan and applicable professional standards. All personnel are also expected to stop and take appropriate action when it is determined that conditions adversely affecting the quality of the data have occurred (e.g., an instrument is not working properly). The Quality Manager has the authority to issue a stop work order to allow for determining any further action needed to meet the quality objectives of this study.

Any deviations from the specifications described in this Work Plan, field sampling protocols, field measurement standard operating procedures, or laboratory quality system are to be documented and addressed utilizing the nonconformance and corrective action procedures as described in Section 4.3 of this Work Plan. All nonconformances will be forwarded to the FMC Project Manager and MWH Project Manager, and Quality Manager.

4.1 ASSESSMENTS AND RESPONSE ACTIONS

Program assessment and oversight will include surveillance/audit of field sampling activities, the analytical program, and program records. Surveillance of sampling activities will focus on adherence to procedures outlined in this Work Plan and will include observation of sampling procedures and selected documentation (e.g., field logbooks). At least one sampling audit will be performed within the first four days of each type of field sampling activities to verify that proper protocols are being adhered to. Any issues identified during field audits must be addressed immediately. The sampling audits will be performed by the Quality Manager or designee.

Analytical program assessment and oversight consists of laboratory audits to the specifications set forth in this Work Plan and the laboratory QAPP; review of program records; and the review, verification, and validation of analytical data packages. The audits will be based on referenced analytical methods (e.g., Method 6020), referenced test and measurement data (e.g., ASTM Method E617-91, Standard Specification for Weights and Precision Mass Standards), good laboratory practices, and good analytical practices. For this program, unless otherwise specified in this Work Plan, the quality programs for all methods will meet the guidelines as given in EPA SW-846 (USEPA, 1996), regardless of the origin of the method (e.g., Method 6020 will meet the requirements of the method and Chapter 1 of EPA SW-846, including performance of method detection limit studies, demonstration of precision and accuracy).

Laboratory audits will be performed prior to initiating field sampling activities. This will allow for the identification of any project-specific criteria that the lab will need to address and implement prior to receiving samples (e.g., MDL studies, analyst certification). Issues identified during initial laboratory audits must be resolved prior to the initiation of field activities.

Additional ad-hoc audits may be performed, if needed, to address or follow up on specific quality issues. Laboratory audits will be performed by the Quality Manager or designee.

Review of program records will include both sampling and laboratory records. Review of the laboratory data will serve as verification that the quality program as described in this Work Plan and the laboratory QAPP is being implemented, thus allowing for the collection of data that support the DQOs of the program.

Surveillance reports and laboratory audit reports will be forwarded to the FMC Project Manager, as described in Section 4.2. Audit findings that require corrective action and follow-up will be documented and tracked, and the Quality Manager will verify that the problem has been resolved.

The FMC Project Manager and Quality Manager will work with the data validator, risk assessor, and statistician to determine the extent of corrective action that is required. This may include one or more of the following:

- depending on the variations associated with the production of the data, calculation of the associated total propagated error to assist in determining data usability
- flagging of the data with data-usability restrictions applied
- collection and analysis of new samples once the corrective action(s) from the data source (e.g., field personnel or analytical laboratory) have been implemented and verified
- determining new specifications to be included in future or follow-on work associated with this project
- reassessment of conclusions based on summary (e.g., statistical) calculations of the data and reissue of reports if necessary due to errors identified in calculating the summary results

4.1.1 Field Personnel-Identified Deviations from Program Specifications

For this project, the field personnel are responsible for field observations, sampling, and field measurement activities (e.g., gamma dose measurements utilizing a PIC).

This includes:

- calibration of field instruments (e.g., GPS, pH meters, balances, etc.),
- documentation of field activities,
- recording of instrument responses,
- calculation of field results, and

- sample collection and shipment activities (e.g., homogenization of samples, sample preservation, storage, shipping, chain-of-custody documentation).

4.1.2 Laboratory Internally Identified Deviations from Program Specifications

Deviations include but are not limited to:

- improper documentation of chain-of-custody procedures (i.e., internal laboratory procedures and external procedures);
- samples received without proper preservation;
- samples for which proper preservation is not maintained;
- missed holding times;
- failed calibrations wherein samples cannot be reanalyzed under acceptable calibrations within holding times (includes instrument calibrations, and test and measurement calibrations associated with an analysis [e.g., balance calibrations, volumetric pipette calibrations, thermometer calibrations, etc.]);
- failed laboratory QC (e.g., method blank, LCS, internal standards, surrogates, etc.) that cannot be corrected by sample repreparation and/or sample reanalysis;
- failure to implement the method or FMC-approved equivalent, specified as written or as agreed to in this Work Plan; and
- calculation or reporting errors.

4.1.3 Data Validator Identified Deviations from Program Specifications

During data validation, common deviations from the program that are identified include:

- incomplete or improper documentation of information that may impact data defensibility;
- failure to meet laboratory control quality requirements that were not corrected (e.g., method blank contamination and inability to perform corrective action and reanalyze within holding times);
- Calculation errors, including:
  - improper plotting of the dependent and independent variables for regression analysis,
  - improper application of higher-order regressions or weighting of regressions that are not supported by the analytical instrumentation and method,

  - improper integration of peaks within chromatograms, and
  - improper application of a (0,0) point or the use of a forced zero intercept in regression;

- matrix QC criteria that are outside of the laboratory or project-specified DQO limits that can be attributed to matrix effect; and
- qualification of data based on QC samples that are blind to the laboratory (e.g., co-located samples, trip blanks, field spiked samples, blind PE samples).

Any item identified during the technical verification and validation of the data will be documented in a technical review and validation report, with appropriate qualification of the data and evaluation of data usability. The data verification and validation report is submitted to the FMC Project Manager and Quality Manager, who will determine whether additional measures are needed to address any issues identified in the verification and validation report.

4.1.4 Review of Data Assessments and Statistical Evaluations

For all calculations performed in support of this program, the following must be provided:

- software utilized for performing the calculation
- a concise statement of the purpose of the calculations
- any associated assumptions in utilizing a calculation, include any units used
- a description of the actual calculation performed in sufficient detail to allow for the reproduction of the calculated result by another party
- a reference to the software (if internally established spreadsheet calculations are utilized they should be version controlled and verified), including version and release number
- example calculations that were performed to demonstrate the proper functioning of the computerized program
- the personnel responsible for input of the data into the software
- the personnel responsible for verifying the data input
- for software that entails the use of professional judgment (e.g., the appropriate statistical method to utilize for determining the 95 percent upper confidence limit of the data set and concomitant determination of the underlying distribution of the data set), the name of the professional directing the test to be utilized
- verification of the output of the computerized system

- an electronic copy of all data inputs, including a copy in the form utilized by the software (e.g., if the software stores the data in an internal data base, a copy of the database records is required)

All personnel performing calculations must implement the following practices for utilizing calculated data.

- For each data set, at least one documented result verification must have been performed to establish that the software is functioning properly.

- For any reports or documents that include the use of manually entered data (e.g., the result was calculated utilizing a computer program and then was manually typed into a report), a 100-percent documented review of the data transfer is required.

- In the event that an error is discovered, then a 100-percent review or recalculation is required. A nonconformance report, root cause analysis, and corrective action must be performed, documented, and forwarded to the FMC Project Manager and Quality Manager.

4.2 REPORTS TO MANAGEMENT

Reports to the FMC Associate Director will be compiled by the FMC Project Manager for submission weekly, or less frequently if requested by the FMC Associate Director. The report will include the program progress, a summary of key performance indicators, a summary of the nonconformance and corrective actions, surveillance and audit findings, and data validation reports. Each report, as appropriate, will include a section that provides an overall assessment of the sampling and laboratory programs. Each Task Manager is responsible for providing input to the FMC Project Manager.

4.3 NONCONFORMANCE AND CORRECTIVE ACTION TRAINING

Nonconformance training will be provided to all project personnel. The purpose of the nonconformance and corrective action program is to effectively identify and address quality issues when the issues are first observed and to facilitate the completion of this SRI in a cost-effective manner. In order for the nonconformance and corrective action program to be effective, all personnel will be trained in the identification of root causes.

All of the individuals involved in this program will follow a formalized process for documenting nonconformances. The nonconformance process consists of the following: 1) identification of the nonconformance, 2) determination of the immediate actions to be taken as a result of the nonconformance, 3) root cause analysis and identification of real root cause(s), 4) proposed action to prevent recurrence of the nonconformance and implementation of the correction, and 5) follow-up and verification of the effectiveness of the corrective action. This process is further described as follows.

1. A nonconformance is defined as an unapproved deviation from the regulations, SRI Work Plan, laboratory QAPP, SOPs, approved methodologies, or program-specific scope of work.

2. Immediate action may be required to deal with a problem. Problems may include a failure of sampling equipment, identification of broken sample custody, or data that do not meet specifications. Actions that address the narrow, specific problem (e.g., replacement of faulty equipment or resampling and/or reanalysis) are the result of this step.

3. Identification of the root cause of the nonconformance. There are six basic root causes of quality problems:

   - lack of organization
   - lack of training
   - lack of discipline
   - lack of resources
   - lack of time
   - lack of top management support

   Identification of real root cause(s) will help prevent recurrence of the nonconformance.

4. Proposed corrective action is directed toward eliminating root causes to prevent recurrence. This proposed corrective action is designed to address the root cause that was responsible for allowing the nonconformance to occur. An example of a corrective action may include obtaining additional resources or providing additional training.

5. The FMC Project Manager and the SRI Project Manager are responsible for assuring that the root causes are identified and corrective actions are implemented. These individuals have control over the resources assigned to the project, are in key positions to ensure corrective actions are implemented, and successfully address the root cause of any nonconformance.

6. The Quality Manager is responsible for verifying that the corrective action has been implemented and is effective. This includes tracking nonconformances, approving root cause analyses, and proposed corrective actions. A summary of nonconformances and the effectiveness of the corrective actions undertaken will be included in reports to management. An example Nonconformance/Corrective Action Form is shown on Figure 4-1.

Category: _____ Nonconformance Report Number _____

FMC NONCONFORMANCE AND CORRECTIVE ACTION REPORT

NONCONFORMANCE OBSERVATION:	Signature:_____ (Person Observing Nonconformance) Date:_____ Quality Manager:_____ Date:_____
IMMEDIATE ACTION TAKEN:	Signature:_____ (FMC Project Manager) Date:_____ Quality Manager:_____ Date:_____
ROOT CAUSE* ANALYSIS:	Signature:_____ (FMC Project Manager) Date:_____ Quality Manager:_____ Date:_____
CORRECTIVE ACTION:	Signature:_____ (FMC Project Manager) Date:_____ Quality Manager:_____ Date:_____
FOLLOW-UP and VERIFICATION:	Signature: _____ (Person Observing Nonconformance) Date: _____ Quality Manager:_____ Date:_____

* The six basic root causes are: lack of organization, lack of training, lack of discipline, lack of resources, lack of time, and lack of top management support

Signature authority cannot be delegated.

Figure 4-1
Sample Nonconformance/Corrective Action Form

Section 5
DATA VALIDATION AND USABILITY

The following section presents the requirements for activities that occur after the data collection phase of the program is complete. Data verification is used to ensure that the requirements stated in the planning documents are implemented as prescribed. Data validation is used to ensure that the results of the data collection activities support the objectives of the survey as documented in the QAPP, or permit a determination that these objectives should be modified. Data Quality Assessment (DQA) is the scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support their intended use (See Chapter 8, USEPA, 2000a; USEPA, 2000b; and Appendix E, USEPA, 2000c).

5.1 VERIFICATION AND VALIDATION METHODS

Labs are required to submit a Category 1 or full data package for all data as described in Table 5-1. All levels of validation can be performed on a Category 1 data package. Once received the appropriate level of validation as described below will be performed.

The review of all data from contract laboratories associated with the SRI will be at Level III as specified below by the Quality Manager or designee. Approximately 10 percent of the data generated during the investigation will be validated at Level IV. The initial data package from each laboratory for an analytical method will be reviewed at Level IV. Once the laboratory has demonstrated the ability to produce a Level IV data package the practice of performing a Level III review with 10-percent Level IV reviews will be implemented.

There are four levels of data review and verification.

- Level IV requires: 1) review and cross-check of all required data deliverables; 2) review of all raw data; 3) recalculation of all values, including standards concentration, reagent preparation, percent moisture values, analytical results, etc.; 4) comparison of all recalculated values to the reported values; and 5) flagging of all data that were not produced in accordance with the specifications set forth in the SRI Work Plan and laboratory QAPP. All electronic copy entries will be verified against hard-copy results reported by the laboratory and sampling personnel. If the hard copy is generated by the same information management system used to store the electronic data, then this review is not required.

- Level III consists of a review of all data forms, calibration records, QC results, and raw data. The reviewer is to perform the recalculation of at least one sample for each parameter of interest (e.g., cadmium by inductively-coupled plasma [ICP]).

- Level II consists of a review of all summary forms, but does not include a review of the raw data. This review includes laboratory and field QC sample results to determine whether the analytical process is in control.

- Level I consists of a review of the summary data forms (Form I) for each sample analyzed.

Generally speaking, recalculation of results begins with the appropriate instrument output (e.g., the integrated area under a curve, raw instrument counts). This is combined with additional information, including utilization of the proper data regression model, sample preparation information, dilutions, counting times, etc. Regarding items such as integration practices, the laboratory data will include all integrations performed by the data system. These will be reviewed for correctness prior to recalculating the results based on the integrated areas.

If the person performing the technical review observes a nonconformance in either the production, reduction, or reporting of data, the reviewer will perform the next, more thorough review of the data package. For example, if an error is noted during a Level III review, a Level IV review will be performed.

All data (field and laboratory) generated by this program will be reviewed at Level I by the Quality Manager or designee to evaluate consistency with previous results and previously observed data trends.

The purpose of data validation is to determine the degree to which each data item has met its quality specifications. Validators estimate the potential effect that each deviation from this SRI Work Plan and the laboratory QAPP may have on the usability of the associated data item, its contribution to the quality of the data, and its effect on decisions formed by the data.

Data validation considers how closely a measurement represents the actual environment at a given time and location. Each sample should be checked to ensure that it is the correct matrix collected from the correct location. By noting the deviations in sufficient detail, subsequent data users will be able to determine the data's usability.

Data validation considers details of how a sample is separated from its native time/space location and how these details affect the proper interpretation of the measurement results. The validator considers details that include sampling and ancillary equipment and procedures (including equipment decontamination). Acceptable departures (e.g., alternate equipment) from the SRI Work Plan, and the action to be taken if the specified procedures cannot be satisfied, should be considered and their impacts on the usability of the measurement assessed. Validation activities will note potentially unacceptable departures from the Work Plan. Comments from surveillances on deviations from written plans and procedures will also be noted.

During data validation, details of how a sample is physically treated and handled during relocation from its original site to the actual measurement site will be considered. Correct interpretation of the subsequent measurement results requires that deviations from specifications in this plan and the actions taken to minimize or control the changes will be detailed. Documentation reviewed during validation should indicate events that occur during sample handling that might affect the integrity of the samples. At a minimum, validators will evaluate the sample containers and the preservation methods used and ensure that they are appropriate to the nature of the sample and the type of data generated from the sample. Checks on the identity of the sample (e.g., proper labeling and chain-of-custody records) as well as proper

physical/chemical storage conditions (e.g., chain-of-custody and storage records) should be made to ensure that the sample continues to be representative of its native environment as it moves through the analytical process.

Each sample should be verified during validation to ensure that the procedures used to generate the data were implemented as specified. Data validation activities should determine how much a sample deviated beyond the acceptable limit so that the potential effects of the deviation can be evaluated during data quality assessment.

This plan specifies the QC checks that are to be performed during sample collection, handling, and analysis. These include calibration and analyses of check standards, blanks, spikes, and replicates, which provide indications of the quality of data being produced by specific steps of the measurement process. Data validation should document any corrective actions that were taken, which samples were affected, and the potential effect of the actions on the validity of the data. When issues are identified in the verification and validation process, the validator will make appropriate comments and/or assign data flags to alert the data user to potential limitations on the usability of the data.

5.2 RECONCILIATION WITH USER REQUIREMENTS (DATA QUALITY ASSESSMENT)

Data collected during the SRI will be reconciled with the requirements of the data user. These requirements are established and presented in Section 2.

There are five steps in the DQA Process:

- Review the DQOs and Survey Design.
- Conduct a Preliminary Data Review.
- Select the Statistical Test.
- Verify the Assumptions of the Statistical Test.
- Draw Conclusions from the Data.

These five steps are presented in a linear sequence, but the DQA process is applied in an iterative fashion much like the DQO process. The strength of the DQA process is that it is designed to promote an understanding of how well the data will meet their intended use by progressing in a logical and efficient manner.

5.2.1 Review DQOs and Survey Design

The DQA process begins by reviewing the key outputs from the planning phase of the data life cycle that are recorded in the planning documents (e.g., the QAPP). The DQOs provide the context for understanding the purpose of the data collection effort. They also establish qualitative and quantitative criteria for assessing the quality of the data set for the intended use.

There are three activities associated with this step in the DQA process:

- Translating the data user's objectives into a statement of the hypotheses to be tested using environmental data. These objectives are documented in Section 2, and this activity is reduced to translating these objectives into the statement of hypotheses.

- Reviewing the design for data collection and noting any special features or potential problems which may have affected the data collection activity. Review the survey design documentation (e.g., the QAPP) with the data user's objectives in mind. Look for design features that support or contradict these objectives.

- Review the data collection design to assess whether the specified probability of committing Type I or Type II decision errors is likely to be achieved.

5.2.2 Conduct a Preliminary Data Review

In this step of the DQA process, a preliminary evaluation of the data set is conducted through the calculation of some basic statistical quantities and looking at the data through graphical representations. By reviewing the data both numerically and graphically, the analyst can learn the "structure" of the data and thereby identify appropriate approaches and limitations for their use.

This step includes three activities:

- reviewing quality assurance reports,

- calculating statistical quantities (e.g., relative standing, central tendency, dispersion, shape, and association)

- graphing the data (e.g., histograms, scatter plots, confidence intervals, ranked data plots, quantile plots, stem-and-leaf diagrams, spatial or temporal plots)

5.2.3 Select the Statistical Test

The candidate statistical methods for testing the formulated hypotheses are identified. Several such methods are identified in MARSSIM and various EPA guidance documents. Statistical methods not mentioned in such guidance may also be employed upon consultation with a professional statistician.

5.2.4 Verify the Assumptions of the Statistical Test

In this step, the data analyst assesses the validity of the statistical test by examining the underlying assumptions in light of the data at hand. The key questions to be resolved are: "Do the data support the underlying assumptions of the test?", and: "Do the data suggest that modifications to the statistical analysis are warranted?"

There are three activities included in this step:

- Determine how the assumptions of the hypothesis test will be verified, including assumptions about distributional form, independence, dispersion, type, and quantity of data.
- Perform tests of the assumptions.
- Determining corrective actions (if any). Sometimes the assumptions underlying the hypothesis test will not be satisfied and some type of corrective action should be performed before proceeding. In some cases, the data for verifying some key assumption may not be available and existing data may not support the assumption. In this situation, it may be necessary to collect new data, transform the data to correct a problem with the distributional assumptions, or select an alternate hypothesis test.

5.2.5 Draw Conclusions from the Data

The final step of the DQA process is performing the statistical test and drawing conclusions that address the data user's objectives.

There are two activities associated with this final step:

- Performing the calculations for the statistical hypothesis test.
- Evaluating the statistical test results and drawing the study conclusions. The results of the statistical test will be either accept the null hypothesis, or reject the null hypothesis.

5.2.6 Cap Delineation Studies

Cap delineation studies will rely primarily on visual observations in the field to identify residual pond sediments. These field observations will be supported by confirmation laboratory analyses of fill or native soils that will allow data users to determine the extent of elemental phosphorus and residual pond sediments and delineate the caps/covers that may be required to prevent exposure to these materials by future workers. Furthermore, the data will be reviewed to ensure that a sufficient density of borings and/or trenches/test pits are available to delineate the areas to be covered. The data validation process will focus on the laboratory data and will ensure that the lab results are of suitable quality to determine the extent, if any, of elemental phosphorus and residual pond sediments.

5.2.7 Specific Investigation Area Evaluations for Organic Analyses (Volatile Organic Compounds, Polynuclear Aromatic Hydrocarbons, and Polychlorinated Biphenyls)

Data from field screening techniques will not be validated. They will be verified in the field through a review of calibration records and field records. Sampling locations and depths also will be verified in the field.

The fixed-lab data will be used to describe the nature and extent of VOCs, PAHs, and PCBs in site media, and support interpretations regarding the fate and transport of these constituents in the environment. Further uses of the data will include supporting the SFS to determine if remedial action is required or supporting evaluation of remedial alternatives in the SFS.

To support the data uses described above, laboratory data will be validated to ensure that the QC criteria have been met and the detection limits are below the screening levels.

5.2.8 Specific Investigation Area Evaluations for Inorganic and Radiological Analyses (P4, Metals, Fluoride, Pb-210, Po-210)

The fixed-lab data will be used to describe the nature and extent of P4, metals, fluoride, Pb-210 and Po-210 in site media, and support interpretations regarding the fate and transport of these constituents in the environment. Further uses of the data will include supporting the SFS to determine if remedial action is required or supporting evaluation of remedial alternatives in the SFS.

To support the data uses described above, laboratory data will be validated to ensure that the QC criteria have been met and the detection limits are below the screening levels.

5.2.9 Radon Flux Measurements

Data users will compare the mean radon flux measurements against the UMTRCA guidelines. Data verification will ensure that the field procedures and documentation are complete, and that any deviations from the field procedures will not impact the quality of the data. Validation of the data will ensure that measured emission rates are of sufficient quality to justify comparison with the UMTRCA guidelines.

5.2.10 Risk Based Total Gamma, Radionuclides and Metals

5.2.10.1 Primary Use of the Data

The primary use of the surface radiation scan data is to determine the boundaries of the radiologically impacted and potentially unimpacted areas within the identified RUs. For radiologically impacted areas, the total gamma dose rate is responsible for over 97 percent of the risk in these areas, (except phossy solids); if an area is identified as impacted, then additional data to support SFS will be collected.

The primary use of the data for total gamma dose rate as measured by the PIC is to quantify the gamma dose rate in the areas potentially identified as unimpacted compared to the appropriate worker exposure scenario. The primary use of the specific radioisotope data (e.g., lead-210, polonium-210, radium-226, uranium-238, and potassium-40) is verification of the radiological risk to future workers in the unimpacted areas. The primary use of the metals and fluoride data are to: 1) verify that the individual constituent concentration is less than the applicable SSL or background concentration and 2) to serve as inputs for calculating the incremental risk for comparison to a cumulative risk-based CV.

The primary use of the gamma spectroscopy data is the quantitative determination of potassium-40. The other primary use of this data is to confirm the presence of radionuclides in the uranium-238 decay chain that can be identified utilizing gamma spectroscopy.

5.2.10.2 Proposed Methods of Data Analysis

Data from the surface radiation scan is compared to the screening level established in Section 2 for use in mapping the radiologically impacted and unimpacted areas. The data from the PIC measurements will be compared to background gamma dose rates utilizing the appropriate statistical test. The data for metals, fluoride, lead-210, polonium-210, radium-226, uranium-238, and potassium-40 data will be compared to the thresholds established in Section 2 utilizing the appropriate statistical testing procedures.

5.2.11 Additional Data Acquired to Support the SFS (Metals, Fluoride, U-238, Ra-226, K-40, Pb-210, Po-210).

The fixed-lab data will be used to describe the nature and extent of constituents in site media, and to support interpretations regarding the fate and transport of these constituents in the environment. Further uses of the data will include supporting the SFS to determine if remedial action is required or for supporting evaluation of remedial alternatives in the SFS.

To support the data uses described above, laboratory data will be validated to ensure that the QC criteria have been met and the detection limits are below the screening levels.

5.2.12 Undeveloped Area Gamma Measurements

The primary use of the data for total gamma dose rate as measured by the PIC is to quantify the gamma dose rate in the areas. Data from the undeveloped area will be compared to the applicable background levels.

Table 5-1

Data Deliverables Requirements
(Page 1 of 2)

Item Number	Category 1 Data Deliverable Requirement	Level 1 Data Review	Level 2 Data Review
1	Chain-of-Custody (COC)	✓	✓
2	Sample receipt forms and/or logbook pages	✓	✓
3	Copies of Shipping Manifests	✓	✓
4	Verification of sample temperature on receipt	✓	✓
5	Copies of temperature logs for storage coolers used to store samples	✓	✓
6	Internal COC (all documents denoting transfer of sample[s] to an individual)	✓	✓
7	Sample preparation logs	✓	✓
8	Standard preparation logs	✓	
9	Instrument operating conditions	✓	
10	Copies of analysis logbooks	✓	
11	Instrument run logs including copies of autosampler loading and verification of the autosampler loading.	✓	
12	Raw data for instrument – hardcopy	✓	✓
13	Raw data for instrument - electronic (CD or DVD)	✓	
14	Raw data for LOD percent solids	✓	✓
15	Analyst's notes	✓	
16	Data review sheets	✓	
17	Example Calculations	✓	
18	Sample Data Summary Forms	✓	✓
19	Nonconformance and corrective actions	✓	✓
20	Case Narrative	✓	✓
21	Method Blank control charts	✓	
22	Duplicate control charts	✓	
23	MDL/LCS control charts	✓	
24	Surrogate Recovery Control Charts	✓	
25	Standard Reference Material (LCS) control charts	✓	
26	Documentation of the temperature associated with heating devices for sample preparation (e.g. heat blocks for metals digestion).	✓	
27	Documentation of oven temperatures used for determining percent solids)	✓	
28	Standards Certificates	✓	
29	Standards Reference Material Certificates	✓	
30	Documentation of thermometer calibrations	✓	
31	Certificate of NIST traceable thermometer	✓	
32	Daily verification of auto pipetors	✓	
33	Verification of the transfer of data to the computerized system	✓	
34	Certificate of weights used for balance calibration calibration/verification	✓	
35	Balance Calibration Logs	✓	
36	Volumetric Glassware Calibrations	✓	
37	Certificate of cleanliness for all sample bottles	✓	

Table 5-1

Data Deliverables Requirements
(Page 2 of 2)

Item Number	Category 1 Data Deliverable Requirement	Level 1 Data Review	Level 2 Data Review
38	Verification package of software utilized for data calculation	✓	
39	Copy of standard operating procedure(s)	✓	
40	Method detection limit studies and supporting documentation	✓	
41	Equipment maintenance records	✓	
42	Consumables acceptance and tracking records	✓	
43	Analysts demonstration of precision and accuracy	✓	

Section 6
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APPENDIX A

FIELD SAMPLING PLAN

(To be submitted under separate cover)

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ACRONYMS/ABBREVIATIONS

1,1,1-TCA	1,1,1-Trichloroethane
AOC	Administrative Order of Consent
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BAPCO	Bannock Paving Company
bgs	below ground surface
bns	below native surface
BTEX	benzene, toluene, ethylbenzene, xylene
ºC	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	calibration factor
CFR	Code of Federal Regulations
COC	constituent of concern and chain of custody
COPC	constituent of potential concern
CV	comparative value
DAF	dilution attenuation factor
DCQCR	daily quality control reports
DEM	digital elevation model
DQO	data quality objective
EMF	Eastern Michaud Flats
EPA	Environmental Protection Agency
FU	flux units
FMC	FMC Corporation
FSP	field sampling plan
FTL	field team leader
ft	feet
GPS	Global Positioning System
HASP	Health and Safety Plan
IDEQ	Idaho Department of Environmental Quality
IDW	investigation-derived waste
IWW	industrial waste water

K-40	potassium-40
keV	kilo electron volt
LDR	land disposal restriction
m	meter
MWH	MWH Americas, Inc.
NA	not applicable
NaI	sodium iodide
NCP	National Contingency Plan
NFA	No Further Action
NIST	National Institute of Standards and Technology
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OU	operable unit
P4	elemental phosphorus
PAH	polynuclear aromatic hydrocarbon
Pb-210	lead-210
PCB	polychlorinated biphenyl
pCi	picoCuries
pCi/m^2-sec	picoCuries per square meter per second
PIC	pressurized ionization chamber
PID	photoionization detector
Po-210	polonium-210
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
Precipitator Dust	phossy solids, phossy wastes, precipitator slurry
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Ra-226	radium-226
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Managers
RU	remediation unit
SAP	Sampling and Analysis Plan
SFS	Supplemental Feasibility Study
SOP	Standard Operating Procedures

SOW	Statement of Work
SRI	Supplemental Remedial Investigation
SSL	soil screening level
SVOC	semivolatile organic compounds
SWMU	solid waste management unit
TCE	trichloroetheylene
TPH	total petroleum hydrcarbons
U-238	uranium-238
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
VSP	Visual Sampling Plan
Work Plan	Supplemental Remedial Investigation Work Plan

APPENDIX B

RISK-BASED JUSTIFICATION FOR FMC'S PROPOSED APPROACH TO EVALUATING RADIONUCLIDES DURING THE SUPPLEMENTAL RI/FS

Appendix B

Risk-based Justification for FMC's Proposed Approach to Evaluating Radionuclides During the Supplemental RI/FS

B1 Introduction

During teleconferences held between FMC, EPA, IDEQ and the Tribes on August 3 and September 15, 2004, FMC provided the results of technical analyses performed to support its case that gamma radiation dose rate measurements, in conjunction with targeted radionuclide-specific analyses, are sufficient to evaluate potential radiological risks associated with commercial/industrial worker exposure to surface soils within the Supplemental Remedial Investigation/Feasibility Study (SRI/SFS) of the FMC Plant OU. The Agencies subsequently requested that the methods, assumptions and findings of these analyses be documented in the revised RI Update Memorandum. Amongst other requests, the Agencies also asked that additional analyses be performed to confirm that the proposed approach is appropriate for evaluating potential risks to workers exposed to subsurface soils. The purpose of this appendix is to document the relevant radionuclide data, and the methods, assumptions and findings of the risk analyses. In addition, based on the findings of the risk analyses, an outline of the SRI approach that will be taken to collect data sufficient to evaluate RU-specific radiological risks to potential receptors is also provided. A comprehensive description of the approach will be provided in the SRI Workplan.

The information presented within this appendix is presented as follows: For background informational purposes, Section B2 summarizes the dialogue-to-date between FMC, EPA Region 10, IDEQ and the Tribes concerning the evaluation of radionuclides in the SRI/SFS. Available radionuclide data characterizing the various feedstock and waste stream source materials historically processed at the FMC Plant OU are presented in Section B3. Analyses performed to estimate radionuclide- and exposure pathway-specific contributions to total radiological risk to the receptor most highly exposed to surface contamination (future commercial/industrial worker) from exposure to each potential source material are presented in Section B4. Similarly, analyses performed to document the radionuclide- and exposure pathway-specific contributions to total radiological risk for the receptor most highly exposed to subsurface contamination (construction worker) from exposure to each potential source material are presented in Section B5. Based on the findings of the analyses presented in Sections B4 and B5, Section B6 provides an overview of the approach that will be taken to collect data sufficient to evaluate RU-specific radiological risks to potential receptors during the SRI. The references cited in this appendix are provided in Section B7.

B2 Background

In the June 2004 RI Update Memorandum (FMC, 2004), gamma radiation was identified as the sole measure of radiation-related risk to be considered in the SRI/SFS. This approach was proposed on the basis that the Human Health Risk Assessment (HHRA) of the EMF Site (E&E, 1996) concluded that external gamma radiation contributes the vast majority (over 95%) of the total potential risk associated with radionuclide exposure of future workers in the FMC Subarea (excluding indoor exposure to radon because, per the EMF ROD, future office buildings are to be constructed using radon control measures).

Preliminary EPA, IDEQ and Tribe comments on the draft RI Update Memorandum noted that the HHRA evaluation of radiological risks to future workers in the FMC Subarea was not based on actual measurements of specific radionuclide activities, and that radionuclide data should be obtained during the SRI to identify key risk driving constituents and pathways. Moreover, the Agencies commented that the approach of using gamma radiation dose rate measurements to evaluate radionuclide-related risks is not consistent with EPA guidance, and that radionuclide-specific measurements were necessary to fully characterize risks.

In response to the preliminary draft comments, FMC provided EPA, IDEQ and the Tribes with information regarding the available radionuclide-specific data for the various feedstocks and waste streams historically processed at the FMC Plant OU and how these data support the conclusion that external exposure to gamma radiation drives risks to commercial/industrial workers for all source materials (except phossy solids) at the FMC Plant OU. Moreover, information was provided to demonstrate that the proposed approach of primarily relying upon gamma radiation dose rate measurements to evaluate radiological risks during the SRI/SFS is not unprecedented. Specifically, this information, summarized below, was provided during two teleconferences between technical and managerial representatives of FMC, EPA Region 10, IDEQ and the Tribes that were held on August 3 and September 15, 2004.

During the teleconferences, FMC highlighted several EPA guidance documents that expressly identify circumstances under which it is desirable to collect direct exposure rate measurements of gamma radiation. Specifically, EPA's *Radiation Risk Assessment at CERCLA Sites: Q and A* (EPA, 1999) identifies the merits of collecting gamma radiation dose rate measurements, and deriving cancer risk estimates directly from these data (as discussed in the response to question 33 in EPA, 1999). EPA (1999) notes that this approach eliminates potential modeling uncertainties associated with estimating external gamma radiation exposure and concerns about the shape of the source (e.g., slag pile on the FMC Plant OU).

Illustrative of the Agencies' concerns raised in the preliminary comments on the June 2004 RI Update Memorandum, EPA (1999) also cautions that such data only reflect a sub-set of the radionuclides and exposure pathways of potential concern (e.g., only external exposure from gamma-emitting radionuclides in near-surface soil), and may present an incomplete picture of overall radionuclide-related site risks. EPA (1999) indicates that, in most cases, more accurate estimation of radiation risks will require additional site characterization data, including concentrations of all radionuclides of concern in all pertinent environmental media because of the potential for other pathways to contribute to overall risk. However, as discussed during the teleconferences and documented in Section B3, radionuclide-specific data characterizing the

content of the various feedstocks and waste materials historically processed at the FMC Plant OU are available. Moreover, as discussed during the teleconferences and presented in Sections B4 and B5, analyses of these data demonstrate that exposure pathways other than external exposure to gamma radiation do not contribute significantly to overall worker risk for all source materials of potential concern, with the exception of phossy solids. With respect to phossy solids, incidental ingestion and fugitive dust inhalation of lead-210 and polonium-210, together with external exposure to gamma radiation, contribute virtually all of the risk to workers exposed to this source material. Therefore, analyzing samples for lead-210 and polonium-210, in conjunction with taking gamma dose rate measurements, would adequately address radiological risks in areas found to contain phossy solids.

Further support for FMC's proposed approach is presented in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* which was developed by the Departments of Defense and Energy, EPA, and the Nuclear Regulatory Commission to provide detailed guidance for planning, implementing, and evaluating environmental and facility radiological surveys conducted to demonstrate compliance with a dose- or risk-based regulations (http://www.epa.gov/radiation/marssim/index.html). Specifically, page 4-7 of MARSSIM (EPA et al., 2000) states that measurement of exposure rates may be used as a surrogate for surface or volume activity concentrations for radionuclides that deliver the majority of their dose through the direct radiation pathway. That is, instead of demonstrating compliance with radionuclide-specific soil or surface contamination derived concentration guideline levels (DCGLs) (i.e., cleanup goals) for the direct radiation pathway, compliance is demonstrated by direct measurement of exposure rates. Furthermore, MARSSIM indicates that this surrogate approach may still be possible for sites that contain radionuclides that do not deliver the majority of their dose through the direct radiation pathway, provided that a consistent relative ratio for the radionuclides that do deliver the majority of their dose through the direct radiation pathway can be established. This approach, as described in Section B6, has been adopted for the SRI.

Finally, despite some guidance indicating that dose assessments should generally not be performed to assess risk or to establish cleanup levels, this approach has been applied at sites comparable to the FMC Plant OU. Specifically, one of the remedial action objectives (RAOs) established for off-site soils (property surrounding the plant) at the Monsanto elemental phosphorus production site located in Soda Springs, Idaho is to prevent exposure to radionuclides in soils at levels that pose cumulative estimated risks of 3E-04, by meeting a radiation effective dose equivalent of 15 mrem/year above background (EPA, 1997; EPA, 2003). Consequently, FMC proposed during the teleconferences to use the same target dose threshold in the SRI evaluation of radiological impacts at the FMC Plant OU.

As a result of FMC's August 3 and September 15, 2004 presentations, it was agreed that FMC's proposed approach to evaluating radionuclides in the SRI/SFS could be adopted provided that each of the following issues were satisfactorily addressed:

1. Documentation of the methods and assumptions used in FMC's August and September analyses that found that gamma radiation dose rate measurements could be used to evaluate risks from exposure to surficial deposits of all source materials of potential concern (except phossy solids) in the SRI/SFS, and that gamma dose rate measurements

in conjunction with lead-210 analyses could be used to evaluate risks for areas found to contain surficial phossy solids;

2. Documentation of the basis for evaluating potential radiological risks associated with exposure to subsurface materials (i.e., construction worker, utility worker) during the SRI (Action Item 31 from the September 15 teleconference);
3. Documentation confirming that the sensitivity of gamma survey instruments (e.g., pressurized ionization chamber) is sufficient to observe an increased dose rate of 15 mrem/year above background for the commercial/industrial, construction and utility worker receptors (Action Item 30 from the September 15 teleconference); and
4. Development of an approach to ensure that risks (chemical and radiological) associated with potential redistribution of fill excavated during future site construction or utility trenching will be addressed in the SRI (Action Item 32 from the September 15 teleconference).

The purpose of this appendix is to address the first two followup issues described above (i.e., delineate and provide the technical justification for FMC's proposed approach to evaluating radionuclide risks from exposure to surface and subsurface fill in the SRI/SFS). Documentation of item 3 is provided in Appendix G of this report. Item 4 will be addressed in the SRI Workplan.

B3 Radionuclide-Specific Data

Radionuclide-specific data are available for all of the primary feedstock and waste stream source materials historically handled at the FMC facility. The sources of these data, along with methods and assumptions used to derive exposure point activities for each potential source material for use in the risk evaluation, are described below.

B3.1 Data Sources

The available radionuclide-specific data for the FMC Plant OU, which are presented for both background soils and each potential source material in Table B-1, were developed from the following sources:

EPA's Radiological Surveys of Idaho Phosphate Ore Processing -- The Thermal Process Plant Report (1977)

As part of a radiological survey of the FMC facility (EPA, 1977), EPA collected and analyzed samples of materials input to FMC's thermal process (phosphate ore, calcined nodules, silica, coke and coke supplement) and the products and by-products of the process (phosphorus product, ferrophos, fluid bed prills, and slag). Each of the collected samples was analyzed for radionuclides in the uranium-238 and thorium-232 decay chains. The results of these analyses are presented in Tables 3 and 4 of EPA (1977).

The reported values for phosphate ore, calcined nodules and slag in Tables 3 and 4 of EPA (1977) represent averages of the results of analyses performed on a larger number of individual samples of these materials. Specifically, six samples of phosphate ore, calcined nodules and slag were collected and analyzed as part of the survey. Moreover, as discussed within Appendix C of EPA (1977), each of these samples was split, with one set analyzed at EPA's Environmental Monitoring and Support Laboratory (EMSL), and the other set analyzed at EPA's Eastern Environmental Research Facility (EERF) laboratory. Table C-1 of EPA (1977) provides analytical results for the phosphate ore samples, Table C-2 provides results for the calcined nodule samples, and Table C-3 provides results for the slag samples. It is also noted in Appendix C of EPA (1977) that the lead-210 results for ore, calcined nodules and slag reported by EMSL are erroneous, being found to underestimate actual levels by up to a factor of five for this constituent.

Remedial Investigation for the Eastern Michaud Flats Site (Bechtel, 1996)

Data characterizing the radiological composition of slag, ferrophos, phosphate ore, IWW Ditch discharge and sediment, water and sediment in the railroad swale, phossy pond discharge and sediment, calciner pond discharge and sediment, and coke settling pond sediment were collected during the RI (Bechtel, 1996). Gross alpha and gross beta levels were measured in each of the samples. Uranium-238, lead-210, and potassium-40 analyses were performed on each of the slag, ferrophos, phosphate ore, phossy pond sediment, calciner pond sediment and coke settling pond sediment samples. By contrast, radium-226 and radium-228 analyses were performed on the liquid IWW Ditch discharge, railroad swale water, phossy pond discharge, and calciner pond discharge samples. No data, outside of the gross alpha and gross beta measurements, were

developed from the IWW Ditch and railroad swale sediment samples. These data are discussed in Section 4.2.3.1 and presented in Tables 4.2.3-2 and 4.2.3-3 of the RI report (Bechtel, 1996).

In addition to the radiological data developed from potential source materials at the FMC Subarea, potassium-40, uranium-238, lead-210 and polonium-210 analyses were performed on offsite, subsurface soil samples that were collected from a depth of 2 feet at nearly 100 locations situated along radials extending from the EMF facilities. These data are presented in Table 4.3-1 of the RI report (Bechtel, 1996). EPA subsequently used these data to develop the representative background activities of potassium-40, uranium-238, lead-210, and polonium-210 that are presented in Table 4.2.1-1 of the RI report. These background levels represent the 95th percentile of the offsite, subsurface soil RI data set. The precise approach taken to derive these background levels is described in Section 2.2.4 of EPA's Baseline Human Health Risk Assessment (HHRA) (E&E, 1996).

Rather than present each offsite, subsurface soil RI data point, Table B-1 provides the 95th percentile representative (background) levels developed by EPA for potassium-40, uranium-238, lead-210, and polonium-210.

Astaris' Pre-Start Up LDR Radionuclides Study (2001)

Data characterizing the content of phossy solids were developed by Astaris during the *Pre-Start Up LDR Radionuclides Study* (Astaris, 2001). Specifically, Astaris collected samples of Tank V-3600, V-3700, and V-3800 discharges, and composited these in the proportion expected to be fed to the LDR Waste Treatment System that was under construction in 2001 (V-3600 = 17.6%, V-3700 = 73.8%, and V-3800 = 8.6%). The samples were then dryed and subsequently submitted to Hazen Research, Inc., Golden, Colorado for analysis of potassium-40, radionuclides in the uranium-238 and thorium-232 decay chains, and gross alpha and gross beta.

In total, two sets of grab samples from Tank V-3600, V-3700, and V-3800 discharges were collected within a two week period in February 2001. An additional 2 sets of samples were collected within a two week period in April 2001.

Hazen Report of Analysis for Calciner Sample 2-C 03/12/2003 (2003)

Hazen Research, Inc., Golden, Colorado was contracted to analyze a sample of Pond 2C liquid in March 2003. The sample was analyzed for potassium-40, radionuclides in the uranium-238 and thorium-232 decay chains, and gross alpha and gross beta.

B3.2 Data Treatment

The data for solid matrix samples discussed in Section B3.1 and presented in Table B-1 were treated in accordance with EPA guidance (EPA, 1992) to develop exposure point activities for use in the risk evaluation. Initially, one-half of the detection limit was used to characterize the activity of radionuclides in samples that did not contain levels above the detection limit. However, if one-half of the detection limit for a non-detect sample was found to exceed the maximum detected activity of a radionuclide in a source material, then that non-detect sample was removed from the exposure point activity calculation.

As discussed in Section B3.1, the EMSL results for lead-210 in phosphate ore, calcined nodules and slag were found to be in error by up to a factor of 5 too low in EPA's *Radiological Surveys*

of Idaho Phosphate Ore Processing -- The Thermal Process Plant Report (EPA, 1977). Therefore, none of the EMSL results for lead-210 were included in the exposure point activity calculations. Also, while there is no documentation critiquing the validity of the Bechtel (1996) phosphate ore lead-210 sample result, this data point was also removed from the evaluation because it corresponds closely to the low-biased levels seen in the EMSL data set. Finally, Table B-1 includes the EPA (1977) calculated average activity of each radionuclide in the 6 individual phosphate ore, calcined nodule, and slag samples analyzed in the study. These average activities were removed from the evaluation (i.e., only the results for the six individual samples were retained).

The exposure point activity of each radionuclide within each source material of potential concern was then derived by calculating the 95% upper confidence limit (UCL) on the arithmetic mean of the remaining data points. In the event that the calculated 95% UCL on the arithmetic mean was found to exceed the maximum reported activity in a potential source material (e.g., radium-226 in coke), the maximum activity was used to characterize potential exposures. Also, when only one data point was available for a radionuclide in a source material (e.g., radium-226 in ferrophos), the result for that sample was used to characterize potential exposure.

Data are not available to characterize uranium-234, thorium-230, radium-226, and polonium-210 (i.e., uranium-238 decay series) in calciner pond sediment. For this source material, the exposure point activities of uranium-234, thorium-230, and radium-226 were characterized by the calculated exposure activity of uranium-238 (i.e., secular equilibrium was assumed). Similarly, the exposure point activity of polonium-210 was characterized by the calculated exposure activity of lead-210.

As discussed in Section B3.1, the 95th percentiles of the potassium-40, uranium-238, lead-210 and polonium-210 activities measured in offsite, subsurface soil RI samples were developed by EPA to characterize representative background levels of these constituents. The precise approach taken to derive these background levels is described in Section 2.2.4 of EPA's Baseline Human Health Risk Assessment (HHRA) (E&E, 1996). These values were also used to characterize background exposures and risks in the current evaluation. Additionally, in the absence of data for uranium-234, thorium-230 and radium-226, the background activity of uranium-238 was used to characterize the background levels of these constituents (i.e., secular equilibrium was assumed). Finally, in the absence of data for thorium-232 and radium-228 (thorium-232 decay series), background levels were not assigned to these constituents.

The resulting exposure point activities in background soils and each of the source materials of potential concern at the FMC Plant OU are summarized in Table B-2.

B4 Evaluation of Radiological Risk Drivers for Receptors Exposed to Surface Soil/Fill at the FMC Plant OU

As discussed in greater detail within Section 4 of the RI Update Memorandum, the following receptors have the potential to be exposed to site-related contamination at the FMC Plant OU:

- Outdoor commercial/industrial workers
- Indoor commercial/industrial workers
- Construction workers
- Utility workers
- Nearby off-site residents

From the soil screening level (SSL) calculations performed for inorganic constituents of potential concern in Section 4, the outdoor commercial/industrial worker is identified as the most highly exposed receptor to surface contamination. This finding corresponds with EPA guidance (EPA, 2002), which identifies the outdoor worker as likely to be the most highly exposed receptor in the outdoor environment under commercial/industrial conditions. Thus, identifying the radiological constituents and exposure pathways that drive risks to this chronically exposed (i.e., > 1 year) receptor for each potential source material at the FMC Plant OU is the most relevant approach to determining the appropriate surface radiological data for collection during the SRI.

B4.1 Potential Exposure Pathways of Concern

As defined by EPA (2002), the outdoor commercial/industrial worker is a long-term receptor exposed during the work day who is a full time employee of the company operating on-site and who spends most of the workday conducting maintenance activities outdoors. The activities for this receptor (e.g., moderate digging, landscaping) typically involve on-site exposures to surface and shallow subsurface soils (at depths of zero to two feet).

Under current EPA guidance for deriving preliminary remediation goals (PRGs) for radionuclides (EPA, 2004), the following exposure pathways are identified as being relevant to outdoor workers:

- Incidental ingestion of soil,
- Inhalation of fugitive dust, and
- External exposure to gamma (ionizing) radiation.

With respect to evaluating potential risks to outdoor commercial/industrial workers at the FMC Plant OU, each of the above exposure pathways is considered relevant. No radiological exposure pathways outside of those listed above are considered plausible for potential future outdoor commercial/industrial workers at the FMC Plant OU.

B4.2 Exposure via Soil Ingestion

For the purposes of evaluating the contribution of incidental soil ingestion to the total radiological risk to future outdoor commercial/industrial workers at the FMC Plant OU, the portion of EPA's PRG equation for outdoor workers relevant to the soil ingestion pathway, as presented in Section 4.2 of EPA (2004), was re-arranged to develop a commercial/industrial worker risk estimate (i.e., rather than a PRG) from ingestion of radionuclides for each source material, as follows:

Equation B-1

$$Risk_{si,x,y} = \frac{A_{x,y} \times (1 - e^{[-\lambda_x \times t_w]}) \times EF_{ow} \times ED_{ow} \times SF_{si-x} \times IR_{sow} \times 1E-03}{t_w \times \lambda_x}$$

Where:

$Risk_{si,x,y}$	=	Soil ingestion cancer risk for radionuclide x in source material y (unitless),
$A_{x,y}$	=	Exposure point activity of radionuclide x in source material y (pCi/g),
t_w	=	Time – worker (years),
λ_x	=	Decay constant for radionuclide x (years^{-1})
EF_{ow}	=	Exposure frequency (days/year),
ED_{ow}	=	Exposure duration (years),
SF_{si-x}	=	Soil ingestion slope factor for radionuclide x (risk/pCi),
IR_{sow}	=	Soil ingestion rate (mg/day), and
1E-03	=	Conversion factor (g/mg).

The radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU, along with corresponding background levels in native soils, are presented in Table B-2. The radionuclide-specific soil ingestion cancer slope factors are presented in Table B-3. Per EPA (2004), these slope factors were obtained from EPA's current Health Effects Assessment Summary Tables (HEAST) for radionuclides (EPA, 2001). The radionuclide-specific decay constants, along with their corresponding half-lives, were also obtained from HEAST EPA (2001), and are provided in Table B-4. Finally, the values and reference sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-1 are presented in Table B-5. It should be noted that the values assigned to these parameters are consistent with both the values incorporated into the inorganic SSL calculations within Section 4 of the RI Update Memorandum and the recommended, default values provided in EPA (2004).

The total radiological risk to outdoor commercial/industrial workers at the FMC Plant OU from incidental soil ingestion was calculated for each potential source material by summing the risk estimate for each radionuclide, as follows:

Equation B-2

$$Risk_{si,totaly} = \sum Risk_{si,x,y}$$

Where:

$Risk_{si,total,y}$	=	Total radiological cancer risk from incidental soil ingestion of source material y (unitless), and
$Risk_{si,x,y}$	=	Soil ingestion cancer risk for radionuclide x in source material y (unitless),

The radionuclide-specific and total radiological risk estimates to outdoor commercial/industrial workers at the FMC Plant OU from incidental soil ingestion are presented in Tables B-6, B-7, B-8, B-9, B-10, B-11, B-12, B-13, and B-14 for phosphate ore, calcined nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B4.3 Exposure via Inhalation of Fugitive Dusts

Similar to the approach used to evaluate risks associated with incidental soil ingestion, the portion of EPA's PRG equation for outdoor workers relevant to the fugitive dust inhalation pathway, as presented in Section 4.2 of EPA (2004), was re-arranged to develop a commercial/industrial worker risk estimate from inhalation of radionuclides for each source material, as follows:

Equation B-3

$$Risk_{fdi,x,y} = \frac{A_{x,y} \times (1 - e^{[-\lambda_x \times t_w]}) \times EF_{ow} \times ED_{ow} \times SF_{i-x} \times IR_{iw} \times \frac{1E-03}{PEF} \times \left[ET_{owo} + \left(ET_{owi} \times DF_i\right)\right]}{t_w \times \lambda_x}$$

Where:

$Risk_{fdi,x,y}$	=	Fugitive dust inhalation cancer risk for radionuclide x in source material y (unitless),
$A_{x,y}$	=	Exposure point activity of radionuclide x in source material y (pCi/g),
t_w	=	Time – worker (years),
λ_x	=	Decay constant for radionuclide x ($years^{-1}$)
EF_{ow}	=	Exposure frequency (days/year),
ED_{ow}	=	Exposure duration (years),
SF_{i-x}	=	Inhalation slope factor for radionuclide x (risk/pCi),
IR_{ow}	=	Inhalation rate (m^3/day),
ET_{owo}	=	Exposure time outdoors (hour/hour),
ET_{owi}	=	Exposure time indoors (hour/hour),
DF_i	=	Indoor dilution factor (unitless),
PEF	=	Particulate emission factor (m^3/kg), and
1E+03	=	Conversion factor (g/kg).

The radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU, along with corresponding background levels in native soils, are presented in Table B-2. The radionuclide-specific inhalation cancer slope factors are presented in Table B-3, and the radionuclide-specific decay constants are provided in Table B-4. Finally, the values and reference sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-3 are presented in Table B-5. With the exception of the particulate emission factor (PEF), the values assigned to the non radionuclide-specific exposure parameters are consistent with both the values incorporated into the inorganic SSL calculations within Section 4 of the RI Update Memorandum and the recommended, default values provided in EPA (2004). Because regional-specific meteorological data were used to develop the PEF in the Section 4 SSL calculations, this value was used in preference to the non site-specific default PEF presented in EPA (2004).

The total radiological risk to outdoor commercial/industrial workers at the FMC Plant OU from fugitive dust inhalation was calculated for each potential source material by summing the risk estimate for each radionuclide, as follows:

Equation B-4

$$Risk_{fdi,totaly} = \sum Risk_{fdi,x,y}$$

Where:

$Risk_{fdi,total,y}$	=	Total radiological cancer risk from fugitive dust inhalation of source material y (unitless), and
$Risk_{fdi,x,y}$	=	Fugitive dust inhalation cancer risk for radionuclide x in source material y (unitless).

The radionuclide-specific and total radiological risk estimates to outdoor commercial/industrial workers at the FMC Plant OU from fugitive dust inhalation are presented in Tables B-6, B-7, B-8, B-9, B-10, B-11, B-12, B-13, and B-14 for phosphate ore, calcined nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B4.4 Exposure via External Gamma Radiation

Similar to the approach used to evaluate risks associated with incidental soil ingestion and fugitive dust inhalation, the portion of EPA's PRG equation for outdoor workers relevant to the external gamma radiation exposure pathway, as presented in Section 4.2 of EPA (2004), was re-arranged to develop a commercial/industrial worker risk estimate from external gamma emitting radionuclides within each source material, as follows:

Equation B-5

$$Risk_{ee,x,y} = \frac{A_{x,y} \times (1 - e^{[-\lambda_x \times t_w]}) \times EF_{ow} \times ED_{ow} \times SF_{e-x} \times \frac{1}{365} \times ACF \times [ET_{owo} + (ET_{owi} \times GSF)]}{t_w \times \lambda_x}$$

Where:

$Risk_{ee,x,y}$	=	External gamma cancer risk for radionuclide x in source material y (unitless),
$A_{x,y}$	=	Exposure point activity of radionuclide x in source material y (pCi/g),
t_w	=	Time – worker (years),
λ_x	=	Decay constant for radionuclide x (years^{-1})
EF_{ow}	=	Exposure frequency (days/year),
ED_{ow}	=	Exposure duration (years),
SF_{e-x}	=	External exposure slope factor for radionuclide x (risk/year per pCi/g),
ACF	=	Area correction factor (unitless),
GSF	=	Gamma shielding factor (unitless),
ET_{owo}	=	Exposure time outdoors (hour/hour),
ET_{owi}	=	Exposure time indoors (hour/hour), and
365	=	Conversion factor (days/year).

The radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU, along with corresponding background levels in native soils, are presented in Table B-2. The radionuclide-specific external exposure cancer slope factors are presented in Table B-3, and the radionuclide-specific decay constants are provided in Table B-4. Finally, the values and reference sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-5 are presented in Table B-5. With the exception of the area correction factor (ACF), the values assigned to the non radionuclide-specific exposure parameters are consistent with the recommended, default values provided in EPA (2004). The EPA default ACF (0.9) lowers the assumed extent to which receptors are presumed to be exposed to external gamma radiation to account for the fact that the assumption of an infinitely thick slab is overly conservative. However, due to the large spatial extent of the FMC Plant OU, the most conservative (i.e., health protective) value (1) was assigned to the ACF parameter.

The total radiological risk to outdoor commercial/industrial workers at the FMC Plant OU from external exposure to gamma radiation was calculated for each potential source material by summing the risk estimate for each radionuclide, as follows:

Equation B-6

$$Risk_{ee,totaly} = \sum Risk_{ee,x,y}$$

Where:

$Risk_{ee,total,y}$	=	Total radiological cancer risk from external exposure to gamma radiation from source material y (unitless), and
$Risk_{ee,x,y}$	=	External gamma cancer risk for radionuclide x in source material y (unitless).

The radionuclide-specific and total radiological risk estimates to outdoor commercial/industrial workers at the FMC Plant OU from external exposure to gamma radiation are presented in Tables B-6, B-7, B-8, B-9, B-10, B-11, B-12, B-13, and B-14 for phosphate ore, calcined

nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B4.5 Summary of Risk Estimates: Commercial/Industrial Workers

Table B-15 summarizes both the pathway-specific and total risk estimates for commercial/industrial workers exposed to potential source materials at the FMC Plant OU and background soils. As shown in this table, total cancer risks associated with commercial/industrial worker exposure to silica (8E-05), coke (4.45E-05) and ferrophos (4.45E-5) are 3 to 6 times lower than the corresponding total risk associated with exposure to background soils (2.61E-04) over the same working timeframe (i.e., a worker exposed to background soils for 1,800 hours/year for 25 years would have a higher level of cancer risk than a worker exposed to silica, coke or ferrophos over the same timeframe). Because exposure of future commercial/industrial workers to these silica, coke and ferrophos would pose a lower risk than that associated with exposure to natural background levels, there is no potential for residual, surficial deposits of these materials to result in unacceptable levels of risk to any receptor at the FMC Plant OU. Therefore, there is no need to identify an SRI radiological sampling strategy for these source materials. However, it is still worth noting that, as shown in Table B-15, external gamma radiation is the principal risk driver for all three source materials, contributing between 87 to over 97% of the total radiological risk.

With the exception of phossy wastes, external exposure to gamma radiation contributes approximately 96 to 98.5% of the total radionuclide cancer risk to a potential future commercial/industrial worker exposed to any of the remaining source materials (ore, calcined nodules, slag, and calciner pond sediment). Given both the high degree to which external gamma radiation contributes to total risk, and the relatively consistent ratio of external gamma radiation risk to total risk for each of these source materials, it is reasonable to conclude that, per the approach described in MARSSIM (EPA et al., 2000), direct gamma radiation measurements are sufficient to characterize commercial/industrial worker risks associated with exposure to surficial source materials at the FMC Plant OU that do not contain significant quantities of phossy solids.

With respect to phossy solids, Table B-13 indicates that incidental soil ingestion of lead-210 would contribute approximately 48% of the total risk to commercial/industrial workers exposed to this media. Additionally, external exposure to gamma radiation would contribute a further 51% of the total risk. Thus, given that lead-210 and external gamma radiation contribute a combined total of approximately 99% of the total risk associated with commercial/industrial worker exposure to phossy solids, it is reasonable to conclude that a supplemental remedial investigation strategy targeted on both gamma dose rate measurements and analysis of lead-210 can be implemented in the SRI to evaluate radiological risk in RUs found to contain surficial phossy solids.

B5 Evaluation of Radiological Risk Drivers for Receptors Exposed to Subsurface Soil/Fill at the FMC Plant OU

As discussed in greater detail within Section 4, the following receptors have the potential to be exposed to subsurface site-related contamination at the FMC Plant OU:

- Construction workers
- Utility workers

From the soil screening level (SSL) calculations performed for inorganic constituents of potential concern in Section 4 of the RI Update Memorandum, the construction worker is identified as the most highly exposed receptor to subsurface contamination, a finding which corresponds with EPA guidance (EPA, 2002). Thus, identifying the radiological constituents and exposure pathways that drive risks to this sub-chronically exposed (i.e., <= 1 year) receptor for each feedstock and waste stream source material historically processed at the FMC Plant OU is the most relevant approach to determining the appropriate radiological data to collect from subsurface fill during the SRI.

B5.1 Potential Exposure Pathways of Concern

Current EPA guidance (EPA, 2002) recognizes that construction is likely to occur as part of the redevelopment process at many NPL sites, regardless of the anticipated future land use. Although construction is typically of relatively short duration (a year or less), it may lead to significant exposures to construction workers as a result of soil-disturbing activities that include excavation and vehicle traffic on unpaved roads. EPA's approach to deriving construction worker SSLs is to assume that a short-term adult receptor is exposed to soil contaminants during the work day for the duration of a single construction project (typically a year or less). If multiple non-concurrent construction projects are anticipated, it is assumed that different workers will be employed for each project (EPA, 2002). Construction worker activities typically assume substantial on-site exposures to surface and subsurface soils, particularly with respect to soil ingestion rates.

While the exact nature of any future redevelopment of the FMC OU is unknown, it is reasonable to conclude that building construction would likely be an integral part of any such effort. During construction, workers may be exposed to residual soil contamination to a depth of 4-6 feet (the depth at which building footers have historically been placed at the FMC OU), though exposure to a maximum depth of 10 feet is considered possible on a short-term basis. Consistent with the approach outlined in EPA (2002) and Section 4 of the RI Update Memorandum, potential risks to construction workers are developed herein assuming that a period of six months would be required to complete construction work.

Current EPA guidance for developing PRGs for radionuclides (EPA, 2004) does not identify a construction worker scenario. However, the same exposure pathways by which a future commercial/industrial worker could be exposed to surface fill material are considered relevant to potential exposure of construction workers to surface and subsurface fill material:

- Incidental ingestion of soil,
- Inhalation of fugitive dust, and
- External exposure to gamma (ionizing) radiation.

No radiological exposure pathways outside of those listed above are considered plausible for potential future construction workers at the FMC Plant OU.

B5.2 Exposure via Soil Ingestion

For the purposes of evaluating the contribution of incidental soil ingestion to the total radiological risk to future construction workers at the FMC Plant OU, the portion of EPA's PRG equation for outdoor workers relevant to the soil ingestion pathway was re-arranged to develop a risk estimate from ingestion of radionuclides for each source material. This approach was previously presented in Equation B-1 within Section B4.2.

To characterize construction worker exposures from incidental soil ingestion, the radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU were used, along with corresponding background levels in native soils, as previously presented in Table B-2. Similarly, the radionuclide-specific soil ingestion cancer slope factors were presented in Table B-3, and the radionuclide-specific decay constants were provided in Table B-4. Finally, the values and reference sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-1 are presented in Table B-16. In the absence of default values for a construction worker in EPA's radionuclide PRG guidance, the exposure parameters were assigned to be consistent with the values incorporated into the inorganic construction worker SSL calculations within Section 4 of the RI Update Memorandum.

The total radiological risk to construction workers at the FMC Plant OU from incidental soil ingestion was calculated for each potential source material using Equation B-2. The resulting radionuclide-specific and total radiological risk estimates to future construction workers at the FMC Plant OU from incidental soil ingestion are presented in Tables B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-24, and B-25 for phosphate ore, calcined nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B5.3 Exposure via Fugitive Dust Inhalation

For the purposes of evaluating the contribution of fugitive dust inhalation exposure to the total radiological risk to future construction workers at the FMC Plant OU, the portion of EPA's PRG equation for outdoor workers relevant to the fugitive dust inhalation pathway was re-arranged to develop a risk estimate from inhalation of radionuclides for each source material. This approach was previously presented in Equation B-3 within Section B4.3.

Construction worker exposure via fugitive dust inhalation was calculated using the radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU, as well as the radionuclide-specific activities associated with background levels in native soils. These exposure point activities were previously presented in Table B-2. Estimates of risk relied on the radionuclide-specific inhalation cancer slope factors presented in Table B-3, and the radionuclide-specific decay constants provided in Table B-4. Finally, the values and reference

sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-3 are presented in Table B-16. In the absence of default values for a construction worker in EPA's radionuclide PRG guidance, the values assigned to these parameters were chosen to be consistent with the values incorporated into the inorganic SSL calculations within Section 4 of the RI Update Memorandum.

The total radiological risk to construction workers at the FMC Plant OU from fugitive dust inhalation was calculated for each potential source material using Equation B-4. The resulting radionuclide-specific and total radiological risk estimates to future construction workers at the FMC Plant OU from fugitive dust inhalation are presented in Tables B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-24, and B-25 for phosphate ore, calcined nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B5.4 Exposure via External Gamma Radiation

For the purposes of evaluating the contribution of external gamma radiation to the total radiological risk to future construction workers at the FMC Plant OU, the portion of EPA's PRG equation for outdoor workers relevant to the external gamma radiation pathway was re-arranged to develop a risk estimate from external gamma emitting radionuclides within each source material. This approach was previously presented in Equation B-5 within Section B4.4.

Additionally, a correction factor was applied to account for the increased external gamma radiation exposure that would occur when a worker is surrounded by the walls of an excavated trench. The correction factor was derived by applying the MICROSHIELD 5.05 model to estimate the increased dose rate to a worker standing in a trench excavated from slag. Specifically, the increased dose rate associated with a worker standing in a 1.5 m (5 ft) or 2.75 m (9 ft) deep, 5 m long and 2 m wide trench was modeled for various assumed thicknesses of steel shoring (0, 0.25, 0.5, and 1 inch). As shown in Table B-26, an upperbound correction factor of 1.57 was derived for a 2.75 m (9 ft) deep trench with 0.25 inch steel shoring. This factor was applied to account for the increased risk a worker would experience from external gamma radiation exposure while standing in a trench. A complete discussion of the assumptions and findings of the MICROSHIELD 5.05 modeling is presented in Attachment B1to this appendix.

Characterization of construction worker risk from external gamma radiation exposure to the various fill materials as well as native soils relied on the radionuclide-specific exposure point activities associated with each potential source material at the FMC Plant OU, along with corresponding background levels in native soils, as previously presented in Table B-2. Similarly, the radionuclide-specific external gamma radiation cancer slope factors were presented in Table B-3, and the radionuclide-specific decay constants were provided in Table B-4. Finally, the parameter values and reference sources used to characterize each of the non radionuclide-specific exposure parameters within Equation B-5 are presented in Table B-16. In the absence of default values for a construction worker in EPA's radionuclide PRG guidance, the exposure parameters were chosen to be consistent with the values incorporated into the inorganic SSL calculations within Section 4.

The total radiological risk to construction workers at the FMC Plant OU from external gamma radiation exposure was calculated for each potential source material using Equation B-6. The

resulting radionuclide-specific and total radiological risk estimates to future construction workers at the FMC Plant OU from fugitive dust inhalation are presented in Tables B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-24, and B-25 for phosphate ore, calcined nodules, silica, coke, ferrophos, slag, calciner pond sediments, phossy solids (including precipitator slurry), and background soils, respectively.

B5.5 Summary of Risk Estimates: Construction Workers

Table B-27 summarizes both the pathway-specific and total risk estimates for construction workers exposed to potential source materials at the FMC Plant OU and background soils. As shown in this table, total cancer risks associated with construction worker exposure to silica (3.81E-06), coke (2.54E-06) and ferrophos (4.03E-06) are 3 to 4 times lower than the corresponding total risk associated with exposure to background soils (1.10E-05) over the same working timeframe (i.e., a construction worker exposed to subsurface background soils for 1,040 hours over the course of a construction project would experience a higher level of cancer risk than a worker exposed to silica, coke or ferrophos over the same timeframe). Because exposure of future construction workers to silica, coke and ferrophos would pose a lower risk than that associated with exposure to natural background levels, there is no potential for residual, subsurface deposits of these materials to result in unacceptable levels of risk to any receptor at the FMC Plant OU. Consequently, there is no need to develop an SRI radiological sampling strategy for these materials.

Considering the remaining source materials, i.e. those where total risks are above background, external gamma radiation is the principal risk driver, contributing between 80 to over 88.5% of the total radiological risk, with the exception of phossy solids (Table B-27). Given both the high degree to which external gamma radiation contributes to total risk, and the relatively consistent ratio of external gamma radiation risk to total risk for each of these sources materials, it is reasonable to conclude that, per the approach described in MARSSIM (EPA et al., 2000), direct gamma radiation measurements can be used during the SRI as a surrogate for radionuclide-specific activity data for subsurface areas of the FMC Plant OU that do not contain significant quantities of phossy solids.

With respect to phossy solids, Table B-24 indicates that incidental soil ingestion of lead-210 and polonium-210 would contribute approximately 54% of the total risk to construction workers exposed to this media in the subsurface, with approximately 49% of the total risk attributable to lead-210 and a further 5% attributable to polonium-210. Additionally, inhalation of fugitive dusts contributes another 26% of the total risk, with nearly 21% of the total risk attributable to lead-210 and an additional 5% attributable to polonium-210. External exposure to gamma radiation would contribute a further 18% of the total risk. Thus, lead-210 and polonium-210 determine nearly 80% of the total risk which, when combined with measures of external gamma radiation, captures 98% of the total risk associated with construction worker exposure to phossy solids. Therefore, it is reasonable to conclude that an SRI strategy targeted on gamma dose rate measurements and analyses of lead-210 and polonium-210 can be implemented to evaluate radiological risk in RUs found to contain subsurface phossy waste solid fill.

B6 Overview of FMC's Proposed Approach to Radiological Data Collection and Evaluation During the SRI

As discussed within the summaries to Sections B4 and B5, radiological risks associated with future worker exposure to surface and subsurface fill at the FMC Plant OU will be driven by external gamma radiation for all potential receptors and source materials, except phossy solids. Risks associated with future worker exposure to phossy solid fill material will be driven by incidental ingestion and fugitive dust inhalation of lead-210 (and polonium-210 in the case of subsurface soils) in addition to external gamma radiation.

Based on the above findings, FMC proposes to evaluate radiological risks during the SRI/SFS of the FMC Plant OU through the collection of gamma dose rate measurements, in conjunction with radionuclide-specific analyses targeted on samples collected from areas identified as containing residual phossy solids. The resulting data will be used to develop dose rate estimates above background. These incremental dose rate estimates will subsequently be compared to a target threshold of 15 mrem/year for each receptor. This threshold is equivalent to the remedial action objective (RAO) established for offsite soils at the Monsanto, Soda Springs elemental phosphorus production plant in Soda Springs, Idaho (EPA, 1997; EPA, 2003). The remainder of this section provides an overview of the approach FMC proposes to implement with respect to the collection and evaluation of radiological data within the SRI. A comprehensive presentation of this approach will be provided in the SRI Workplan.

As discussed in the main body of this report, a remedial vision of capping has already been developed for many RUs within the FMC Plant OU. This remedial approach, in conjunction with accompanying land-use restrictions, will prevent future workers at the site from being exposed to source materials of radiological concern via any pathway (including external gamma radiation) at capped RUs. Thus, collection of radiological data during the SRI will be restricted to RUs for which a remedial vision of capping is not currently envisioned (i.e., RUs # 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 20, 21, and 23)Gamma dose rate measurements will be collected at each of the above-referenced RUs using instrumentation described in Appendix G. Surface samples will be collected 3 feet above the ground (i.e., coincident with the mid-point of an exposed worker's body). Subsurface samples will be collected 3 feet above the base of test pits/trenches. The maximum depth of these test pits/trenches will be 5 feet (maximum allowable under OSHA regulations for worker entry without sloping or shoring). The DQO process that will be used to identify both a sampling grid and the total number of surface and subsurface measurements to be made at each RU is discussed in Appendix G, and will be implemented during the SRI.

The potential for phossy solids to be present within the surface and subsurface fill material at each gamma measurement site will be determined based on both visual observation (phossy waste has distinctive visual characteristics) and the use of a portable XRF analyzer to confirm elevated cadmium, zinc and, possibly lead levels (i.e., phossy solid indicator parameters) (see Appendix H). A sample will be taken at each area suspected to contain phossy solid fill material, based on a visual assessment or XRF analytical result, and analyzed for Pb-210 and Po-210 activities. In addition, for RUs in which the presence of phossy solid fill is not identified at any sampling point, an RU-wide composite sample will be analyzed for Pb-210 and Po-210 to confirm that risk levels associated with exposure to these constituents are low relative to the risk

from exposure to gamma radiation (i.e., consistent with the findings of the risk evaluations performed in Sections B4 and B5). The SRI Work Plan will identify sampling locations and analytical protocols for Pb-210 and Po-210 speciation.

Existing background gamma dose rate data for the EMF area (Bechtel, 1996) will be used to account for background within the SRI surface and subsurface gamma dose rate measurements taken within each RU. The incremental dose rate estimates will then be compared to a target threshold of 15 mrem/year for each potential receptor. For locations at which the presence of phossy solids is confirmed, the dose associated with incidental ingestion and fugitive dust inhalation of the measured lead-210 and polonium-210 activities (minus background) will be calculated, combined with the incremental gamma dose rate measurement results and compared to the 15 mrem/yr threshold for each receptor. A comprehensive description of this approach will be provided in the SRI Workplan.

B7 References

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ATTACHMENT B1

MICROSHIELD 5.05 MODELING ANALYSIS

Microshield 5.05 Modeling Analysis
Appendix B– Attachment B1

Calculation of Dose Increase by Walls of a Trench

MICROSHIELD 5.05 was used to calculate the increased dose rate from slag if a person were to stand in a trench. The first case was a trench assumed 2.0 meters wide, at least 5.0 meters long, and at a depth of approximately 1.5 meters (5 feet). The dose rate was calculated at a height of 1 m above the trench floor. The second case was a trench assumed 2.0 meters wide, at least 5.0 meters long, and at a depth of approximately 2.75 meters (9 feet). The dose rate was calculated at a height of 1 m above the trench floor. Both cases were then repeated with 3 thicknesses of steel shoring (shields) along the trench wall.

The conditions were simulated by first determining the dose rate at 1 meter from an infinitely thick slab[1] of infinite extent for the floor of the trench. One trench wall was calculated for an infinitely thick wall, 5 m long and at the two heights (depths). The dose rate point was 1 meter from the wall and 1 meter above the base. The total dose rate was assumed to be the sum of the trench floor and two walls. The material of the floor and walls was assumed to be 20 pCi/g of radium-226, lead-214, and bismuth-214 and of a density of 1.6 (g/cm^3).

Three repetitions of the trench wall dose rate were made for each case with a steel shield against the face as a shoring device. The thicknesses used were 0.635 cm (0.25 inch), 1.27 cm (0.5 inch), and 2.54 cm (1.0 inch). The summed results are show in the following table and the MICROSHIELD results on the following pages.

Scenario	Trench Floor (µR/hr)	Trench Wall (µR/hr)	Total Exposure Rate (µR/hr)	Fractional increase from Trench Walls
Trench w/ No shield (5 ft)	54	26	80	1.48
Trench w/ 0.64 shield (5 ft)	54	21	75	1.39
Trench w/ 1.3 shield (5 ft)	54	17	71	1.32
Trench w/ 2.5 shield (5 ft)	54	11	65	1.20
Trench w/ 0.64 shield (9 ft)	54	31	85	1.57
Trench w/ 1.3 shield (9 ft)	54	24	78	1.45
Trench w/ 2.5 shield (9 ft)	54	15	69	1.27

[1] Infinite thickness was determined by a succession of calculations that showed that there was no increase in dose rate for thicknesses greater than 60 cm. The cases were run for 60 cm depth or thickness.

MicroShield v5.05 (5.05-00134)
Auxier & Associates
Case Title: Case 1, Infinite Slab, soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.309e-002	6.495e-002	3.247e-003	8.651e-006
7	0.08	2.730e-001	4.803e+000	3.842e-001	6.080e-004
8	0.1	1.607e-003	3.533e-002	3.533e-003	5.405e-006
10	0.2	1.275e-001	2.618e+000	5.236e-001	9.242e-004
11	0.3	2.443e-001	4.773e+000	1.432e+000	2.716e-003
12	0.4	4.531e-001	7.867e+000	3.147e+000	6.131e-003
13	0.5	2.025e-002	3.303e-001	1.651e-001	3.242e-004
14	0.6	5.709e-001	8.620e+000	5.172e+000	1.009e-002
15	0.8	1.118e-001	1.608e+000	1.286e+000	2.447e-003
16	1.0	3.707e-001	5.134e+000	5.134e+000	9.464e-003
17	1.5	2.254e-001	3.026e+000	4.539e+000	7.636e-003
18	2.0	3.169e-001	4.364e+000	8.729e+000	1.350e-002
	TOTALS:	2.728e+000	4.324e+001	3.052e+001	5.386e-002

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.309e-002	1.009e-002	5.045e-004	1.344e-006
7	0.08	2.730e-001	3.897e-001	3.118e-002	4.933e-005
8	0.1	1.607e-003	2.710e-003	2.710e-004	4.146e-007
10	0.2	1.275e-001	2.970e-001	5.940e-002	1.048e-004
11	0.3	2.443e-001	6.682e-001	2.004e-001	3.802e-004
12	0.4	4.531e-001	1.395e+000	5.581e-001	1.087e-003
13	0.5	2.025e-002	6.868e-002	3.434e-002	6.740e-005
14	0.6	5.709e-001	2.101e+000	1.261e+000	2.460e-003
15	0.8	1.118e-001	4.709e-001	3.767e-001	7.165e-004
16	1.0	3.707e-001	1.744e+000	1.744e+000	3.215e-003
17	1.5	2.254e-001	1.310e+000	1.964e+000	3.305e-003
18	2.0	3.169e-001	2.142e+000	4.283e+000	6.623e-003
	TOTALS:	2.728e+000	1.060e+001	1.051e+001	1.801e-002

Attenuation Coefficients for Shield Materials

Source	Air Gap
5.838e-01	2.396e-04
3.202e-01	1.969e-04
2.723e-01	1.841e-04
1.998e-01	1.495e-04
1.715e-01	1.297e-04
1.532e-01	1.162e-04
1.396e-01	1.061e-04
1.291e-01	9.810e-05
1.134e-01	8.619e-05
1.019e-01	7.746e-05
8.299e-02	6.305e-05
7.155e-02	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.060e+001	4.324e+001
Photon Energy Fluence Rate	MeV/cm²/sec	1.051e+001	3.052e+001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.801e-002	5.386e-002
Absorbed Dose Rate in Air	mGy/hr	1.572e-004	4.702e-004
	mrad/hr	1.572e-002	4.702e-002

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	1.822e-004	5.562e-004
Opposed		1.541e-004	4.552e-004
Rotational		1.541e-004	4.551e-004
Isotropic		1.379e-004	4.068e-004

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	1.918e-004	5.840e-004
Opposed		1.842e-004	5.563e-004
Rotational		1.842e-004	5.563e-004
Isotropic		1.453e-004	4.303e-004

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	1.629e 004	4.941e 004
Posterior/Anterior		1.487e-004	4.437e-004
Lateral		1.175e-004	3.416e-004
Rotational		1.339e-004	3.977e-004
Isotropic		1.180e-004	3.462e-004

MicroShield v5.05 (5.05-00134)
Auxier & Associates

Case Title: Case 2, Rectangular volume, 5m x 1.5m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, no shielding, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	6.744e-003	3.372e-004	8.982e-007
7	0.08	1.248e+006	3.805e-001	3.044e-002	4.817e-005
8	0.1	7.347e+003	2.943e-003	2.943e-004	4.502e-007
10	0.2	5.831e+005	3.366e-001	6.733e-002	1.188e-004
11	0.3	1.117e+006	6.986e-001	2.096e-001	3.975e-004
12	0.4	2.071e+006	1.352e+000	5.407e-001	1.053e-003
13	0.5	9.259e+004	6.248e-002	3.124e-002	6.132e-005
14	0.6	2.610e+006	1.807e+000	1.084e+000	2.116e-003
15	0.8	5.110e+005	3.718e-001	2.974e-001	5.657e-004
16	1.0	1.695e+006	1.291e+000	1.291e+000	2.379e-003
17	1.5	1.031e+006	8.617e-001	1.293e+000	2.175e-003
18	2.0	1.449e+006	1.307e+000	2.614e+000	4.042e-003
	TOTALS:	1.247e+007	8.478e+000	7.459e+000	1.296e-002

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	3.953e-003	1.977e-004	5.266e-007
7	0.08	1.248e+006	1.509e-001	1.208e-002	1.911e-005
8	0.1	7.347e+003	1.044e-003	1.044e-004	1.597e-007
10	0.2	5.831e+005	1.126e-001	2.253e-002	3.976e-005
11	0.3	1.117e+006	2.510e-001	7.531e-002	1.429e-004
12	0.4	2.071e+006	5.204e-001	2.082e-001	4.056e-004
13	0.5	9.259e+004	2.546e-002	1.273e-002	2.499e-005
14	0.6	2.610e+006	7.748e-001	4.649e-001	9.074e-004
15	0.8	5.110e+005	1.721e-001	1.377e-001	2.618e-004
16	1.0	1.695e+006	6.324e-001	6.324e-001	1.166e-003
17	1.5	1.031e+006	4.671e-001	7.006e-001	1.179e-003
18	2.0	1.449e+006	7.533e-001	1.507e+000	2.330e-003
	TOTALS:	1.247e+007	3.865e+000	3.773e+000	6.477e-003

Attenuation Coefficients for Shield Materials

Source	Air Gap
5.838e-01	2.396e-04
3.202e-01	1.969e-04
2.723e-01	1.841e-04
1.998e-01	1.495e-04
1.715e-01	1.297e-04
1.532e-01	1.162e-04
1.396e-01	1.061e-04
1.291e-01	9.810e-05
1.134e-01	8.619e-05
1.019e-01	7.746e-05
8.299e-02	6.305e-05
7.155e-02	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.865e+000	8.478e+000
Photon Energy Fluence Rate	MeV/cm²/sec	3.773e+000	7.459e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.477e-003	1.296e-002
Absorbed Dose Rate in Air	mGy/hr	5.654e-005	1.131e-004
	mrad/hr	5.654e-003	1.131e-002

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	6.558e-005	1.320e-004
Opposed		5.538e-005	1.103e-004
Rotational		5.537e-005	1.103e-004
Isotropic		4.954e-005	9.861e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	6.901e-005	1.389e-004
Opposed		6.627e-005	1.331e-004
Rotational		6.627e-005	1.331e-004
Isotropic		5.221e-005	1.041e-004

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	5.862e-005	1.178e-004
Posterior/Anterior		5.346e-005	1.068e-004
Lateral		4.219e-005	8.354e-005
Rotational		4.814e-005	9.603e-005
Isotropic		4.237e-005	8.418e-005

Case Title: Case 3 Rectangular volume, 5m x 1.5m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, with 0.635 cm thick steel shield, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	4.232e-007	2.116e-008	5.637e-011
7	0.08	1.248e+006	3.416e-002	2.733e-003	4.325e-006
8	0.1	7.347e+003	8.049e-004	8.049e-005	1.231e-007
10	0.2	5.831e+005	2.290e-001	4.580e-002	8.083e-005
11	0.3	1.117e+006	5.221e-001	1.566e-001	2.971e-004
12	0.4	2.071e+006	1.044e+000	4.177e-001	8.139e-004
13	0.5	9.259e+004	4.914e-002	2.457e-002	4.823e-005
14	0.6	2.610e+006	1.439e+000	8.633e-001	1.685e-003
15	0.8	5.110e+005	3.014e-001	2.411e-001	4.586e-004
16	1.0	1.695e+006	1.061e+000	1.061e+000	1.955e-003
17	1.5	1.031e+006	7.253e-001	1.088e+000	1.830e-003
18	2.0	1.449e+006	1.116e+000	2.232e+000	3.452e-003
	TOTALS:	1.247e+007	6.522e+000	6.133e+000	1.063e-002

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	8.935e-008	4.467e-009	1.190e-011
7	0.08	1.248e+006	4.845e-003	3.876e-004	6.134e-007
8	0.1	7.347e+003	1.164e-004	1.164e-005	1.781e-008
10	0.2	5.831e+005	4.505e-002	9.011e-003	1.590e-005
11	0.3	1.117e+006	1.235e-001	3.706e-002	7.029e-005
12	0.4	2.071e+006	2.814e-001	1.126e-001	2.193e-004
13	0.5	9.259e+004	1.463e-002	7.314e-003	1.436e-005
14	0.6	2.610e+006	4.653e-001	2.792e-001	5.449e-004
15	0.8	5.110e+005	1.102e-001	8.815e-002	1.677e-004
16	1.0	1.695e+006	4.239e-001	4.239e-001	7.814e-004
17	1.5	1.031e+006	3.368e-001	5.053e-001	8.501e-004
18	2.0	1.449e+006	5.661e-001	1.132e+000	1.751e-003
	TOTALS:	1.247e+007	2.372e+000	2.595e+000	4.415e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.372e+000	6.522e+000
Photon Energy Fluence Rate	MeV/cm²/sec	2.595e+000	6.133e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.415e-003	1.063e-002
Absorbed Dose Rate in Air	mGy/hr	3.855e-005	9.276e-005
	mrad/hr	3.855e-003	9.276e-003

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	4.446e-005	1.079e-004
Opposed		3.788e-005	9.057e-005
Rotational		3.788e-005	9.057e-005
Isotropic		3.391e-005	8.096e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	4.681e-005	1.135e-004
Opposed		4.506e-005	1.090e-004
Rotational		4.506e-005	1.090e-004
Isotropic		3.569e-005	8.543e-005

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	3.981e-005	9.631e-005
Posterior/Anterior		3.648e-005	8.756e-005
Lateral		2.899e-005	6.870e-005
Rotational		3.289e-005	7.877e-005
Isotropic		2.904e-005	6.914e-005

Case Title: Case 3a Rectangular volume, 5m x 2.75m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, with 0.635 cm thick steel shield, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	4.471e-007	2.236e-008	5.955e-011
7	0.08	2.246e+006	4.165e-002	3.332e-003	5.272e-006
8	0.1	1.322e+004	1.040e-003	1.040e-004	1.592e-007
10	0.2	1.050e+006	3.187e-001	6.374e-002	1.125e-004
11	0.3	2.011e+006	7.356e-001	2.207e-001	4.186e-004
12	0.4	3.729e+006	1.479e+000	5.918e-001	1.153e-003
13	0.5	1.667e+005	6.985e-002	3.493e-002	6.856e-005
14	0.6	4.698e+006	2.051e+000	1.231e+000	2.402e-003
15	0.8	9.197e+005	4.314e-001	3.451e-001	6.564e-004
16	1.0	3.051e+006	1.523e+000	1.523e+000	2.808e-003
17	1.5	1.855e+006	1.049e+000	1.573e+000	2.647e-003
18	2.0	2.608e+006	1.622e+000	3.244e+000	5.016e-003
	TOTALS:	2.245e+007	9.322e+000	8.830e+000	1.529e-002

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	9.404e-008	4.702e-009	1.253e-011
7	0.08	2.246e+006	5.773e-003	4.619e-004	7.309e-007
8	0.1	1.322e+004	1.457e-004	1.457e-005	2.229e-008
10	0.2	1.050e+006	6.053e-002	1.211e-002	2.137e-005
11	0.3	2.011e+006	1.684e-001	5.052e-002	9.584e-005
12	0.4	3.729e+006	3.866e-001	1.546e-001	3.013e-004
13	0.5	1.667e+005	2.020e-002	1.010e-002	1.983e-005
14	0.6	4.698e+006	6.453e-001	3.872e-001	7.557e-004
15	0.8	9.197e+005	1.538e-001	1.230e-001	2.340e-004
16	1.0	3.051e+006	5.947e-001	5.947e-001	1.096e-003
17	1.5	1.855e+006	4.769e-001	7.153e-001	1.203e-003
18	2.0	2.608e+006	8.064e-001	1.613e+000	2.494e-003
	TOTALS:	2.245e+007	3.319e+000	3.661e+000	6.223e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.319e+000	9.322e+000
Photon Energy Fluence Rate	MeV/cm²/sec	3.661e+000	8.830e+000

Exposure and Dose Rates:

Exposure Rate in Air	mR/hr	6.223e-003	1.529e-002
Absorbed Dose Rate in Air	mGy/hr	5.432e-005	1.335e-004
	mrad/hr	5.432e-003	1.335e-002

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	6.263e-005	1.551e-004
Opposed		5.340e-005	1.303e-004
Rotational		5.340e-005	1.303e-004
Isotropic		4.780e-005	1.165e-004

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	6.594e-005	1.633e-004
Opposed		6.349e-005	1.567e-004
Rotational		6.349e-005	1.567e-004
Isotropic		5.031e-005	1.229e-004

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	5.610e-005	1.385e-004
Posterior/Anterior		5.141e-005	1.260e-004
Lateral		4.089e-005	9.891e-005
Rotational		4.636e-005	1.133e-004
Isotropic		4.095e-005	9.952e-005

Case Title: Case 4 Rectangular volume, 5m x 1.5m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, with 1.27 cm thick steel shield, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	3.192e-011	1.596e-012	4.252e-015
7	0.08	1.248e+006	2.349e-003	1.879e-004	2.974e-007
8	0.1	7.347e+003	1.703e-004	1.703e-005	2.605e-008
10	0.2	5.831e+005	1.389e-001	2.777e-002	4.902e-005
11	0.3	1.117e+006	3.621e-001	1.086e-001	2.061e-004
12	0.4	2.071e+006	7.621e-001	3.048e-001	5.940e-004
13	0.5	9.259e+004	3.685e-002	1.842e-002	3.616e-005
14	0.6	2.610e+006	1.100e+000	6.600e-001	1.288e-003
15	0.8	5.110e+005	2.365e-001	1.892e-001	3.599e-004
16	1.0	1.695e+006	8.477e-001	8.477e-001	1.562e-003
17	1.5	1.031e+006	5.977e-001	8.965e-001	1.508e-003
18	2.0	1.449e+006	9.350e-001	1.870e+000	2.892e-003
	TOTALS:	1.247e+007	5.019e+000	4.923e+000	8.496e-003

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	4.844e-012	2.422e-013	6.452e-016
7	0.08	1.248e+006	2.086e-004	1.669e-005	2.641e-008
8	0.1	7.347e+003	1.530e-005	1.530e-006	2.340e-009
10	0.2	5.831e+005	1.870e-002	3.741e-003	6.602e-006
11	0.3	1.117e+006	6.205e-002	1.862e-002	3.531e-005
12	0.4	2.071e+006	1.543e-001	6.173e-002	1.203e-004
13	0.5	9.259e+004	8.487e-003	4.244e-003	8.330e-006
14	0.6	2.610e+006	2.815e-001	1.689e-001	3.296e-004
15	0.8	5.110e+005	7.081e-002	5.664e-002	1.077e-004
16	1.0	1.695e+006	2.845e-001	2.845e-001	5.244e-004
17	1.5	1.031e+006	2.423e-001	3.635e-001	6.116e-004
18	2.0	1.449e+006	4.236e-001	8.472e-001	1.310e-003
	TOTALS:	1.247e+007	1.546e+000	1.809e+000	3.054e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.546e+000	5.019e+000
Photon Energy Fluence Rate	MeV/cm²/sec	1.809e+000	4.923e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.054e-003	8.496e-003
Absorbed Dose Rate in Air	mGy/hr	2.666e-005	7.417e-005
	mrad/hr	2.666e-003	7.417e-003

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	3.065e-005	8.605e-005
Opposed		2.627e-005	7.253e-005
Rotational		2.627e-005	7.253e-005
Isotropic		2.353e-005	6.485e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	3.227e-005	9.059e-005
Opposed		3.110e-005	8.702e-005
Rotational		3.110e-005	8.702e-005
Isotropic		2.474e-005	6.839e-005

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	2.748e-005	7.689e-005
Posterior/Anterior		2.526e-005	7.004e-005
Lateral		2.018e-005	5.513e-005
Rotational		2.279e-005	6.305e-005
Isotropic		2.018e-005	5.542e-005

Case Title: Case 4a, Rectangular volume, 5m x 2.75m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, with 1.27 cm thick steel shield, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	3.238e-011	1.619e-012	4.313e-015
7	0.08	2.246e+006	2.647e-003	2.118e-004	3.351e-007
8	0.1	1.322e+004	2.047e-004	2.047e-005	3.131e-008
10	0.2	1.050e+006	1.867e-001	3.733e-002	6.589e-005
11	0.3	2.011e+006	4.976e-001	1.493e-001	2.832e-004
12	0.4	3.729e+006	1.058e+000	4.231e-001	8.243e-004
13	0.5	1.667e+005	5.145e-002	2.573e-002	5.050e-005
14	0.6	4.698e+006	1.543e+000	9.259e-001	1.807e-003
15	0.8	9.197e+005	3.341e-001	2.673e-001	5.084e-004
16	1.0	3.051e+006	1.204e+000	1.204e+000	2.219e-003
17	1.5	1.855e+006	8.568e-001	1.285e+000	2.162e-003
18	2.0	2.608e+006	1.349e+000	2.698e+000	4.172e-003
	TOTALS:	2.245e+007	7.083e+000	7.016e+000	1.209e-002

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	4.909e-012	2.455e-013	6.539e-016
7	0.08	2.246e+006	2.316e-004	1.853e-005	2.932e-008
8	0.1	1.322e+004	1.790e-005	1.790e-006	2.739e-009
10	0.2	1.050e+006	2.408e-002	4.816e-003	8.499e-006
11	0.3	2.011e+006	8.173e-002	2.452e-002	4.651e-005
12	0.4	3.729e+006	2.057e-001	8.227e-002	1.603e-004
13	0.5	1.667e+005	1.141e-002	5.703e-003	1.119e-005
14	0.6	4.698e+006	3.807e-001	2.284e-001	4.458e-004
15	0.8	9.197e+005	9.671e-002	7.737e-002	1.472e-004
16	1.0	3.051e+006	3.915e-001	3.915e-001	7.216e-004
17	1.5	1.855e+006	3.380e-001	5.071e-001	8.531e-004
18	2.0	2.608e+006	5.961e-001	1.192e+000	1.844e-003
	TOTALS:	2.245e+007	2.126e+000	2.514e+000	4.238e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.126e+000	7.083e+000
Photon Energy Fluence Rate	MeV/cm²/sec	2.514e+000	7.016e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.238e-003	1.209e-002
Absorbed Dose Rate in Air	mGy/hr	3.700e-005	1.056e-004
	mrad/hr	3.700e-003	1.056e-002

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	4.251e-005	1.224e-004
Opposed		3.648e-005	1.033e-004
Rotational		3.648e-005	1.033e-004
Isotropic		3.267e-005	9.235e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	4.475e-005	1.289e-004
Opposed		4.315e-005	1.238e-004
Rotational		4.315e-005	1.238e-004
Isotropic		3.435e-005	9.738e-005

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	3.812e-005	1.094e-004
Posterior/Anterior		3.506e-005	9.971e-005
Lateral		2.803e-005	7.855e-005
Rotational		3.164e-005	8.976e-005
Isotropic		2.802e-005	7.894e-005

MicroShield v5.05 (5.05-00134)
Auxier & Associates
Results With Buildup

Case Title: Case 5, Rectangular volume, 5m x 1.5m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 1.6 g/cm^3, with 2.54 cm thick steel shield, dose at height of 1 meter from center.

Dose Point # 1 - (162.54100250) cm

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	2.200e-019	1.100e-020	2.931e-023
7	0.08	1.248e+006	1.059e-005	8.473e-007	1.341e-009
8	0.1	7.347e+003	6.858e-006	6.858e-007	1.049e-009
10	0.2	5.831e+005	4.603e-002	9.207e-003	1.625e-005
11	0.3	1.117e+006	1.607e-001	4.821e-002	9.144e-005
12	0.4	2.071e+006	3.800e-001	1.520e-001	2.962e-004
13	0.5	9.259e+004	1.964e-002	9.819e-003	1.927e-005
14	0.6	2.610e+006	6.145e-001	3.687e-001	7.196e-004
15	0.8	5.110e+005	1.409e-001	1.128e-001	2.145e-004
16	1.0	1.695e+006	5.280e-001	5.280e-001	9.732e-004
17	1.5	1.031e+006	3.997e-001	5.995e-001	1.009e-003
18	2.0	1.449e+006	6.508e-001	1.302e+000	2.013e-003
	TOTALS:	1.247e+007	2.940e+000	3.130e+000	5.352e-003

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	5.984e+004	2.360e-020	1.180e-021	3.143e-024
7	0.08	1.248e+006	5.176e-007	4.141e-008	6.553e-011
8	0.1	7.347e+003	3.268e-007	3.268e-008	5.000e-011
10	0.2	5.831e+005	3.539e-003	7.078e-004	1.249e-006
11	0.3	1.117e+006	1.679e-002	5.036e-003	9.553e-006
12	0.4	2.071e+006	4.922e-002	1.969e-002	3.836e-005
13	0.5	9.259e+004	3.010e-003	1.505e-003	2.954e-006
14	0.6	2.610e+006	1.080e-001	6.477e-002	1.264e-004
15	0.8	5.110e+005	3.044e-002	2.435e-002	4.632e-005
16	1.0	1.695e+006	1.327e-001	1.327e-001	2.447e-004
17	1.5	1.031e+006	1.291e-001	1.936e-001	3.258e-004
18	2.0	1.449e+006	2.432e-001	4.864e-001	7.522e-004
	TOTALS:	1.247e+007	7.160e-001	9.288e-001	1.547e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.160e-001	2.940e+000
Photon Energy Fluence Rate	MeV/cm²/sec	9.288e-001	3.130e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.547e-003	5.352e-003
Absorbed Dose Rate in Air	mGy/hr	1.351e-005	4.672e-005
	mrad/hr	1.351e-003	4.672e-003

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	1.546e-005	5.396e-005
Opposed		1.337e-005	4.585e-005
Rotational		1.337e-005	4.585e-005
Isotropic		1.199e-005	4.102e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	1.627e-005	5.683e-005
Opposed		1.571e-005	5.467e-005
Rotational		1.571e-005	5.467e-005
Isotropic		1.258e-005	4.320e-005

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	1.389e-005	4.830e-005
Posterior/Anterior		1.282e-005	4.417e-005
Lateral		1.033e-005	3.501e-005
Rotational		1.159e-005	3.981e-005
Isotropic		1.030e-005	3.511e-005

Case Title: Case 5A, Rectangular volume, 5m x 2.75m x 0.6m volume of soil 60 cm thick Ra-226, Pb-214, and Bi-214 at 20 pCi/g with a density of 2.54 g/cm^3, with 2.54 cm thick steel shield, dose at height of 1 meter from center.

Results With Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	2.203e-019	1.101e-020	2.934e-023
7	0.08	2.246e+006	1.115e-005	8.916e-007	1.411e-009
8	0.1	1.322e+004	7.599e-006	7.599e-007	1.163e-009
10	0.2	1.050e+006	5.786e-002	1.157e-002	2.042e-005
11	0.3	2.011e+006	2.089e-001	6.268e-002	1.189e-004
12	0.4	3.729e+006	5.021e-001	2.009e-001	3.913e-004
13	0.5	1.667e+005	2.622e-002	1.311e-002	2.573e-005
14	0.6	4.698e+006	8.268e-001	4.961e-001	9.683e-004
15	0.8	9.197e+005	1.919e-001	1.535e-001	2.920e-004
16	1.0	3.051e+006	7.249e-001	7.249e-001	1.336e-003
17	1.5	1.855e+006	5.571e-001	8.356e-001	1.406e-003
18	2.0	2.608e+006	9.161e-001	1.832e+000	2.833e-003
	TOTALS:	2.245e+007	4.012e+000	4.330e+000	7.392e-003

Results Without Buildup

Group #	Energy (MeV)	Activity photons/sec	Fluence Rate photons/cm²/sec	Energy Fluence MeV/cm²/sec	Exposure Rate mR/hr
5	0.05	1.077e+005	2.363e-020	1.181e-021	3.147e-024
7	0.08	2.246e+006	5.411e-007	4.329e-008	6.850e-011
8	0.1	1.322e+004	3.563e-007	3.563e-008	5.451e-011
10	0.2	1.050e+006	4.268e-003	8.536e-004	1.507e-006
11	0.3	2.011e+006	2.086e-002	6.258e-003	1.187e-005
12	0.4	3.729e+006	6.216e-002	2.486e-002	4.844e-005
13	0.5	1.667e+005	3.846e-003	1.923e-003	3.774e-006
14	0.6	4.698e+006	1.392e-001	8.350e-002	1.630e-004
15	0.8	9.197e+005	3.980e-002	3.184e-002	6.056e-005
16	1.0	3.051e+006	1.755e-001	1.755e-001	3.234e-004
17	1.5	1.855e+006	1.740e-001	2.610e-001	4.391e-004
18	2.0	2.608e+006	3.320e-001	6.640e-001	1.027e-003
	TOTALS:	2.245e+007	9.516e-001	1.250e+000	2.078e-003

Attenuation Coefficients for Shield Materials

Source	Shield 1	Air Gap
5.838e-01	1.457e+01	2.396e-04
3.202e-01	4.331e+00	1.969e-04
2.723e-01	2.692e+00	1.841e-04
1.998e-01	1.087e+00	1.495e-04
1.715e-01	8.363e-01	1.297e-04
1.532e-01	7.231e-01	1.162e-04
1.396e-01	6.510e-01	1.061e-04
1.291e-01	5.982e-01	9.810e-05
1.134e-01	5.222e-01	8.619e-05
1.019e-01	4.682e-01	7.746e-05
8.299e-02	3.822e-01	6.305e-05
7.155e-02	3.341e-01	5.417e-05

Conversion of calculated exposure in air to dose
Results (Summed over energies)

	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.516e-001	4.012e+000
Photon Energy Fluence Rate	MeV/cm²/sec	1.250e+000	4.330e+000
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.078e-003	7.392e-003
Absorbed Dose Rate in Air	mGy/hr	1.815e-005	6.453e-005
	mrad/hr	1.815e-003	6.453e-003

Deep Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	2.075e-005	7.448e-005
Opposed		1.797e-005	6.336e-005
Rotational		1.797e-005	6.336e-005
Isotropic		1.611e-005	5.669e-005

Shallow Dose Equivalent Rate(ICRP 51 - 1987)

Parallel Geometry	mSv/hr	2.184e-005	7.843e-005
Opposed		2.110e-005	7.548e-005
Rotational		2.110e-005	7.548e-005
Isotropic		1.691e-005	5.970e-005

Effective Dose Equivalent Rate(ICRP 51 - 1987)

Anterior/Posterior Geometry	mSv/hr	1.865e-005	6.668e-005
Posterior/Anterior		1.723e-005	6.103e-005
Lateral		1.389e-005	4.842e-005
Rotational		1.557e-005	5.501e-005
Isotropic		1.385e-005	4.854e-005

Table B-1
Radionuclide Activities in Background Native Soils and Potential Source Materials at the FMC OU

Material	Sample	Data Source	Sample Type[a]	Sample ID	Units	Assoc. with Potassium			<- parents -- Uranium-238 Decay Series -- daughters ->															Thorium-232 Decay Series					
						Potassium-40			Uranium-238			Uranium-234			Thorium-230			Radium-226			Lead-210			Polonium-210			Thorium-232			Radium-228		
						actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual
Background Soil	Native subsurface soils [h]	Bechtel 1996			pCi/g	20.5			3.88												3.03			3.58								
Phosphate Ore	FMC Ore	Bechtel 1996	PSW	FOSFPO01	pCi/g	10.9	2.46		24.2	6.92											1.7	0	U									
	Phosphate Rock (ore) [c]	EPA 1977			pCi/g				22	3.2		22	2		22	4.1		26	19		27	12		22	3		0.43	0.12		0.89	0.28	
	Phosphate Rock (ore) sample #1[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				22.3	3.35		22	3.3		21.4	0.641		24.3	0.243		27.7	0.9		21.5	3.2		0.483	0.0676		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				22	5.5		21	5.2		23	1.1		26	0.93		2.7	0.69		24	2.4		0.3	0.11		0.78	0.76	
	Phosphate Rock (ore) sample #2[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				21.0	3.05		20.6	2.99		24.1	0.723		24.0	0.24		31.8	1.9		22.8	3.3		0.516	0.0722		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				20	2.2		22	2.4		24	1.00		27	0.94		6.4	0.83		22	1.3		0.37	0.13		0.74	0.66	
	Phosphate Rock (ore) sample #3[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				22.2	3.11		21.4	2.99		22.2	0.666		21.3	0.213		29.4	1.5		25.2	3.7		0.439	0.0636		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				23	2.3		23	2.3		19	0.96		14	0.68		4.7	0.76		21	1.7		0.49	0.16		0.98	0.68	
	Phosphate Rock (ore) sample #4[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				21.8	3.15		21.7	3.15		22.8	0.648		19.4	0.194		27.7	1		19.4	1.5		0.441	0.0639		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				26	4.7		22	4.7		23	0.99		30	1		5.8	0.8		22	1.7		0.42	0.14		0.67	0.65	
	Phosphate Rock (ore) sample #5[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				21.9	3.07		21.8	3.05		22.1	0.662		21.1	0.211		15.4	1.3		21.5	1.5		0.454	0.0635		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				24	4.0		24	3.9		23	1.0		29	0.98		6.5	0.82		23	1.6		0.46	0.15		<0.65		U
	Phosphate Rock (ore) sample #6[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				20.5	2.97		20.7	3.00		22.0	0.66		20.8	0.208		31.9	1.8		22.4	0.9		0.479	0.0646		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				22	3.2		21	3.0		17	0.87		53	1.3		7.2	1		21	2.4		0.36	0.13		<0.81		U
Nodules (Calcined Briquettes)	Calcined Rock (aka nodules) [c]	EPA 1977			pCi/g				24	1.8		23	2.2		23	2		25	8.6		18	8.6		<2.65		U	0.47	0.1		0.97	0.48	
	Calcined Briquettes (aka nodules) sample #1[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				23.5	3.53		23.8	3.56		21.6	0.648		24.2	0.242		19.1	0.3		ND		U	0.479	0.0574		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				24	2.0		22	2.0		23	1.00		28	0.97		8.1	0.9		9.2	1.1		0.5	0.15		1.3	0.84	
	Calcined Briquettes (aka nodules) sample #2[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				23.0	3.22		22.3	3.12		23.0	0.689		21.8	0.218		20.5	0.3		ND		U	0.404	0.8606		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				22	1.8		22	1.7		23	0.98		20	0.82		6.5	0.85		8.5	0.88		0.52	0.15		<0.73		U
	Calcined Briquettes (aka nodules) sample #3[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				22.3	3.23		21.9	3.18		22.7	0.68		22.4	0.224		25.1	0.6		ND		U	0.575	0.0719		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				24	1.9		22	2.0		23	1.0		31	1.0		8.7	0.93		11	1.2		0.44	0.14		1.5	0.83	
	Calcined Briquettes (aka nodules) sample #4[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				23.6	3.3		23.2	3.25		23.8	0.713		20.3	0.203		17.4	0.6		ND		U	0.410	0.0636		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				23	1.6		23	1.5		23	0.95		25	0.91		5.2	0.77		9.3	0.86		0.49	0.14		<0.74		U
	Calcined Briquettes (aka nodules) sample #5[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				23.7	3.32		23.1	3.23		21.4	0.641		20.7	0.207		12.8	1.3		<2.65		U	0.465	0.0674		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				25	2.4		26	2.5		24	1.0		29	0.98		5	0.77		11	1.1		0.42	0.14		<0.78		U
	Calcined Briquettes (aka nodules) sample #6[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				23.9	3.7		23.0	3.56		20.9	0.627		21.6	0.216		15.2	1.5		ND		U	0.522	0.0705		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				25	2.5		23	2.3		24	1.0		32	1.0		9.7	0.94		9.0	0.89		0.42	0.13		<0.63		U
Silica	Silica [c]	EPA 1977			pCi/g				1.5	1.4		<0.86		U	1.6	0.53		1.7	0.24		0.67	0.55		2.6	0.9		0.69	0.37		<0.89		U
Coke	Coke [c]	EPA 1977			pCi/g				<0.51		U	<0.44		U	<0.23		U	0.78	0.17		2.4	0.62		<1.3		U	<0.69		U	<0.95		U
	Coke Supplement [c]	EPA 1977			pCi/g				<0.59		U	<0.95		U	<0.20		U	0.7	0.16		0.61	0.54		0.98	0.11		<0.22		U	<0.91		U
	Coke Settling Sediment Pond	Bechtel 1996	PSW	FWSCSP01	pCi/g	0.926	0.48	UJ	3.11	0	U										6.64	0	U									
Ferrophos	Ferrophosphorus [c]	EPA 1977			pCi/g				19	4.9		21	5.2		0.42	0.27		0.27	0.11		1.1	0.58		<0.57		U	0.26	0.2		0.99	0.94	
	Ferrophos	Bechtel 1996	PSW	FWSFSA01	pCi/g	2.3	0.77		4.68	1.85	UJ										1.26	0	U									
	Ferrophos	Bechtel 1996	PSW	FWSFSA02	pCi/g	0.794	0.33	UJ	9.69	1.9											1.34	0	U									
	Ferrophos	Bechtel 1996	PSW	FWSFSA03	pCi/g	2.04	0.71		12.3	2.68											1.39	0	U									
Slag	Slag [c]	EPA 1977			pCi/g				25	7		25	6.7		26	11		32	13		11	7.9		<16		U	0.59	0.29		0.96	0.46	
	Slag sample #1[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				29.4	4.41		28.4	4.25		25.5	0.764		22.8	0.228		11.6	1.0		8.27	2.86		0.648	0.081		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				25	4.2		27	4.4		29	1.4		37	1.1		2.3	0.67		8.3	1.3		0.52	0.19		<0.80		U
	Slag sample #2[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				22.2	3.1		21.2	2.96		25.8	0.774		23.2	0.232		11.1	1.7		ND		U	0.632	0.0789		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				26	2.4		27	2.4		11	0.40		40	1.2		0.86	0.61		2.4	0.50		0.20	0.055		<0.76		U
	Slag sample #3[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				21.6	2.92		21.6	2.91		26.3	0.789		24.8	0.248		6.6	0.6		23.7	5.85		0.533	0.0693		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				29	2.6		27	2.5		28	1.1		36	1.1		2.1	0.68		11	1.1		0.47	0.15		1.6	0.86	
	Slag sample #4[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				27.7	3.88		27.2	3.81		26.6	0.797		32.5	0.325		7.8	0.7	.	ND		U	0.672	0.084		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				25	2.3		29	2.4		23	0.95		37	1.1		0.69	0.62		3.3	0.45		0.66	0.16		<0.76		U

Table B-1
Radionuclide Activities in Background Native Soils and Potential Source Materials at the FMC OU

Material	Sample	Data Source	Sample Type[a]	Sample ID	Units	Assoc. with Potassium			<- parents -- Uranium-238 Decay Series -- daughters ->															Thorium-232 Decay Series					
						Potassium-40			Uranium-238			Uranium-234			Thorium-230			Radium-226			Lead-210			Polonium-210			Thorium-232			Radium-228		
						actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual	actual value	uncertainty	qual
Slag (continued)	Slag sample #5[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				18.6	2.32		19.7	2.46		28.1	0.843		32.3	0.323					ND		U	0.627	0.0783		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				24	3.3		24	3.3		33	1.5		37	1.1		1.4	0.66		11	0.95		0.73	0.22		<0.80		U
	Slag sample #6[g]	EPA 1977																														
	EERF Laboratory results	EPA 1977			pCi/g				20.3	2.64		20.4	2.65		27.3	0.819		33.3	0.333		16.7	2.8		ND		U	0.683	0.0854		<1.0		U
	EMSL Laboratory results	EPA 1977			pCi/g				28	2.0		27	2.0		31	1.2		23	0.87		4.2	0.82		8.0	0.72		0.70	0.18		<0.76		U
	FMC Slag	Bechtel 1996	PSW	FWSSSA01	pCi/g	8.48	2.09		24.4	7.22											4.66	0	U									
	FMC Slag	Bechtel 1996	PSW	FWSSSA02	pCi/g	7.38	2.18		28.1	7.14											4.55	0	U									
	FMC Slag	Bechtel 1996	PSW	FWSSSA03	pCi/g	8.09	1.85		26.3	7.52											4.52	0	U									
	FMC Slag	Bechtel 1996	PSW	FWSSSA04	pCi/g	9.22	1.91		22.1	6.34											3.7	0	U									
	FMC Slag	Bechtel 1996	PSW	FWSSSA05	pCi/g	10.9	2.16		30.7	8.90											4.35	0	U									
	FMC Slag	Bechtel 1996	PSW	FWSSSA06	pCi/g	9.05	2.61		26.5	8.34											4.58	0	U									
Calciner Pond Wastes	Calciner Pond 2C - Liquid	Bechtel 1996	PSL	CALPOND2	pCi/L													0.62	0.16	U									-0.5	0.40	U
	Calciner Pond 2C - Liquid (3/12/03 sample)	Hazen 2003	PSL	C351/03-1	pCi/L	44,400[f]			<1[b]						0	0.6	U	0.9	1		8.4	4.2		18	4		0	0.6		1	1.7	U
	Water Discharged to Calciner Ponds - time composite	Bechtel 1996	PSL	FSWCPW01	pCi/L													0.34	0.11	UJ									-0.4	0.70	U
	Sediment in Calciner Ponds	Bechtel 1996	PSW	FSDCPW01	pCi/g	70.4	8.34		17.5	7.96											1.7	0	U									
Precipitator Slurry/Phossy Wastes	Precipitator Slurry Discharged to Pond 8E - time composite	Bechtel 1996	PSL	FSWPS88E	pCi/L													103	4.48										-2.7	1.00	U
	Precipitator Slurry Discharged to Phase IV Ponds - time composite	Bechtel 1996	PSL	FSWPWSIV	pCi/L													1.9	0.56	J									-2.4	1.10	U
	Fluid Bed Dryer Prills (dried precipitator dust)[c]	EPA 1977			pCi/g				<71		U	<91		U	<24		U	13	0.65		52	1.8		440	27		<17		U	1.9	1	
	Sediments from Pond 11S	Bechtel 1996	PSW	FWSP1101	pCi/g	25.9	3.16		4.46	0	U										352	89.4										
	Sediments from Pond 12S	Bechtel 1996	PSW	FWSP1201	pCi/g	27.4	3.5		4.98	0	U										465	117										
	Sediments from Pond 15S	Bechtel 1996	PSW	FWSP5S01	pCi/g	22	3.32		3.93	4.14	UJ										204	53.8										
	Sediments from Pond 8S	Bechtel 1996	PSW	FWSP8S01	pCi/g	13.1	2.28		0.694	3.28	UJ										230	60.4										
	Sediments from Pond 9E	Bechtel 1996	PSW	FWSP9E01	pCi/g	50.7	5.78		8.36	5.32											0.782	0	U									
	Phossy Waste (V-3600/V-3700/V-3800 composite)	Astaris 2001	PSW	G-0620 115-1	pCi/g	163[f]			<3[e]						2.2	0.9		10	2		1,240	17		510	8		0.3	0.4		0	1.5	U
	Phossy Waste (V-3600/V-3700/V-3800 composite)	Astaris 2001	PSW	G-0620 115-2	pCi/g	176f			<3[e]						1.5	0.7		10	2		1,240	17		540	8		0	0.2	U	0.6	1.5	U
	Phossy Waste (V-3600/V-3700/V-3800 composite)	Astaris 2001	PSW	G-0620 118-1	pCi/g	157f			<1[e]						13	5		7.5	1.7		1,340	40		750	20		0	1.2	U	0.3	1.2	U
	Phossy Waste (V-3600/V-3700/V-3800 composite)	Astaris 2001	PSW	G-0620 118-2	pCi/g	157f			<19[e]						3.4	2.6		11	2		1,370	40		720	20		0.4	1.4	U	0	1.2	U
IWW System	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWA	pCi/L													0.89	0.15	U									-0.30	0.80	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWD	pCi/L													0.31	0.10	U									-2.90	0.30	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWE	pCi/L													0.46	0.10	U									-1.50	0.60	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWF	pCi/L													0.79	0.13	U									-0.30	0.40	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWG	pCi/L													0.18	0.08	U									6.50	0.80	
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWH	pCi/L													0.63	0.12	U									-1.10	0.40	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWN	pCi/L													0.00	0.1	U									0.00	0.30	U
	IWW Ditch Discharge (July 1993)	Bechtel 1996	PSL	O307IWP	pCi/L													0.18	0.08	U									-0.70	0.30	U
	IWW Ditch Discharge (Sept. 1992) - time composite	Bechtel 1996	PSL	FSWIWW01	pCi/L													0.72	0.17	UJ									-0.2	0.60	U
	IWW Ditch Sediments	Bechtel 1996	PSW	FSDIWW01	pCi/g																											
	IWW Ditch Sediments	Bechtel 1996	PSW	FSDIWW02	pCi/g																											
	IWW Ditch Sediments	Bechtel 1996	PSW	FSDIWW03	pCi/g																											
	IWW Ditch Sediments	Bechtel 1996	PSW	FSDIWW04	pCi/g																											
	IWW Ditch Sediments	Bechtel 1996	PSW	FSDIWW05	pCi/g																											
	IWW Ditch Sediments (composite)	Bechtel 1996	PSW	FSDIWW06	pCi/g																											
Railroad Swale	Water in Railroad Swale - location composite	Bechtel 1996	PSL	FWWRRS01	pCi/L													1.59	0.23										-0.3	0.50	U
	Sediment in Railroad Swale	Bechtel 1996	PSW	FSDRRS01	pCi/g																											

Notes:

Blank result cells - radionuclide not analyzed

J = Estimated value.

U = Not detected.

[a] Station location code used in EMF Site remedial investigation

[b] Uranium as U (pCi/g) calculated from total uranium; U-238 not reported, but is < U (pCi/g)

[c] As stated in EPA report Table 3, data are average results from both EMSL and EERF laboratories except for lead-210 and polonium-210 (corrected) which are average of EERF values only from Appendix C, Tables C-1, C-2 and C-3 of EPA report.

[e] Uranium as U (pCi/g) calculated from total uranium; U-238 not reported, but is < U (pCi/g)

[f] K-40 calculated from total potassium assuming natural abundance of K-40 is 0.0118%

[g] EPA collected 6 samples of phosphate ore, 6 samples of calcined briquettes, and 6 samples of slag in December 1976 from the FMC facility. These samples were split. One set was analyzed at EPA's EMSL laboratory and the other set was analyzed at EPA's EERF laboratory. Table C-1 provides analytical results for phosphate ore samples. Table C-2 provides results of calcined briquettes

[h] Data are 95th percentile representative background levels developed by EPA and reported in Table 4.2.1-1 of the RI Report (Bechtel, 1996).

Astaris 2001:Pre-Start Up LDR Radionuclides Study

Bechtel 1996: EMF Site Remedial Investigation Report

EPA 1977: Radiological Surveys of Idaho Phosphate Ore Processing -- The Thermal Process Plant

Hazen 2003: Report of Analysis for Sample Calciner 2-C 03/12/2003

Table B-2
Exposure Point Activities for Background Soils and Potential Source Materials at the FMC Plant OU

Media	Units	Associated with Potassium		<- parents -- Uranium-238 Decay Series -- daughters ->												Thorium-232 Decay Series			
		Potassium-40		Uranium-238		Uranium-234		Thorium-230		Radium-226		Lead-210		Polonium-210		Thorium-232		Radium-228	
Background (1)																			
Native Subsurface Soils	pCi/g	20.50		3.88		3.88	(2)	3.88	(2)	3.88	(2)	3.03		3.58		-		-	
Potential Source Materials																			
Phosphate Ore	pCi/g	10.90	(3)	23.28		22.32		23.13		31.28		32.22		23.00		0.47		0.68	
Calcined Nodules	pCi/g	-		24.10		23.59		23.35		27.10		21.79		10.92		0.50		0.82	
Silica (3)	pCi/g	-		1.50		0.43		1.60		1.70		0.67		2.60		0.69		0.45	
Coke	pCi/g	0.46	(3)	1.54		0.48	(4)	0.12	(4)	0.78	(4)	3.32	(4)	0.98	(4)	0.35	(4)	0.48	(4)
Ferrophos	pCi/g	2.30	(4)	17.58		21.00	(3)	0.42	(3)	0.27	(3)	0.99		0.29	(3)	0.26	(3)	0.99	(3)
Slag	pCi/g	9.82		26.81		26.86		29.30		35.19		9.12		14.03		0.67		0.74	
Calciner Pond Sediment	pCi/g	70.40		17.50		17.50	(5)	17.50	(5)	17.50	(5)	0.85		0.85	(6)	-		-	
Phossy Solids	pCi/g	135.22		13.03		45.50		11.33		12.04		1005.30		711.12		5.08		1.18	
IWW Ditch Sediments	pCi/g	-		-		-		-		-		-		-		-		-	
Sediment in Railroad Swale	pCi/g	-		-		-		-		-		-		-		-		-	

- = No data available.

1) Unless otherwise noted, background activities obtained from Table 2-8 of the EMF HHRA (E&E, 1996).

2) Background activity characterized assuming constituent in secular equilibrium with U-238.

3) Due to the availability of only one sample, exposure point concentration characterized by the maximum data point.

4) 95% UCL on the mean exceeds the maximum activity reported; exposure point concentration characterized by maximum data point.

5) In the absence of data, constituent activity characterized assuming secular equilibrium with U-238.

6) In the absence of data, constituent activity characterized assuming secular equilibrium with Pb-210.

Table B-3
Radionuclide Carcinogenicity Slope Factors (1)

Decay Series	Isotope (2)	Radioactive Carcinogenicity - Slope Factors (1)		
		Soil Ingestion (risk/pCi)	Inhalation (risk/pCi)	External Exposure (risk/yr per pCi/g)
Potassium	Potassium-40	6.18E-11	1.03E-11	7.97E-07
Uranium- 238	Uranium-238+D	2.10E-10	9.35E-09	1.14E-07
	Uranium-234	1.58E-10	1.14E-08	2.52E-10
	Thorium-230	2.02E-10	2.85E-08	8.19E-10
	Radium-226+D	7.30E-10	1.16E-08	8.49E-06
	Lead-210 + D	2.66E-09	1.39E-08	4.21E-09
	Polonium-210	7.96E-10	1.08E-08	3.95E-11
Thorium-232	Thorium-232	2.31E-10	4.33E-08	3.42E-10
	Radium-228+D	2.29E-09	5.23E-09	4.53E-06

(1) Slope factors obtained from HEAST (EPA, 2001).

(2) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-4
Radionuclide Half-Lives and Decay Constants

Decay Series	Isotope (1)	Half-Life (years) (2)	Decay Constant ($years^{-1}$) (3)
Potassium	Potassium-40	1.28E+09	5.42E-10
Uranium- 238	Uranium-238+D	4.47E+09	1.55E-10
	Uranium-234	2.45E+05	2.83E-06
	Thorium-230	7.70E+04	9.00E-06
	Radium-226+D	1.60E+03	4.33E-04
	Lead-210 + D	2.23E+01	3.11E-02
	Polonium-210	3.78E-01	1.83E+00
Thorium-232	Thorium-232	1.41E+10	4.92E-11
	Radium-228+D	5.75E+00	1.21E-01

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

(2) Half-lives obtained from HEAST (EPA, 2001).

(3) Decay constant calculated as ln(2)/half-life for each radionuclide.

Table B-5
Parameter Values Used to Estimate Radiological Risk to Future Commercial/Industrial Workers Exposed to Potential Source Materials at the FMC Plant OU

Parameter	Units	Value	Source
Equation F-1: Incidental Soil Ingestion			
t_w - Time worker	years	25	Default value (EPA, 2004)
EF_{ow} - Outdoor worker exposure frequency	days/year	225	Default value (EPA, 2004)
ED_{ow} - Outdoor worker exposure duration	years	25	Default value (EPA, 2004)
IR_{sow} - Outdoor worker soil ingestion rate	mg/day	100	Default value (EPA, 2004)
Equation F-3: Inhalation of Fugitive Dust			
t_w - Time worker	years	25	Default value (EPA, 2004)
EF_{ow} - Outdoor worker exposure frequency	days/year	225	Default value (EPA, 2004)
ED_{ow} - Outdoor worker exposure duration	years	25	Default value (EPA, 2004)
IR_{ow} - Outdoor worker inhalation rate	m^3/day	60	Default value (EPA, 2004)
ETowo - Outdoor worker exposure time outdoors	hour/hour	0.33	Default value (EPA, 2004): Equivalent to 8 hours/work day
ETowi - Outdoor worker exposure time indoors	hour/hour	0	Default value (EPA, 2004)
DF_i - Indoor dilution factor	unitless	0.4	Default value (EPA, 2004)
PEF - Particulate emission factor	m^3/kg	3.41E+08	Derived for outdoor commercial/industrial workers at the FMC Plant OU in Section 4.2.3
Equation F-5: External Exposure to Gamma Radiation			
t_w - Time worker	years	25	Default value (EPA, 2004)
EF_{ow} - Outdoor worker exposure frequency	days/year	225	Default value (EPA, 2004)
ED_{ow} - Outdoor worker exposure duration	years	25	Default value (EPA, 2004)
ACF - Area correction factor	unitless	1	Due to the spatial extent of the FMC Plant OU no area correction factor applied
GSF - Gamma shielding factor	unitless	0.4	Default value (EPA, 2004)
ET_{owo} - Outdoor worker exposure time outdoors	hour/hour	0.33	Default value (EPA, 2004): Equivalent to 8 hours/work day
ET_{owi} - Outdoor worker exposure time indoors	hour/hour	0	Default value (EPA, 2004)

Table B-6

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Phosphate Ore

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	10.90	3.79E-07	0.03%	3.71E-11	0.00%	4.46E-05	3.02%
Uranium- 238	Uranium-238 + D	23.28	2.75E-06	0.19%	7.19E-08	0.00%	1.36E-05	0.92%
	Uranium-234	22.32	1.98E-06	0.13%	8.40E-08	0.01%	2.89E-08	0.00%
	Thorium-230	23.13	2.63E-06	0.18%	2.18E-07	0.01%	9.73E-08	0.01%
	Radium-226 + D	31.28	1.28E-05	0.87%	1.19E-07	0.01%	1.36E-03	91.93%
	Lead-210 + D	32.22	3.35E-05	2.27%	1.03E-07	0.01%	4.84E-07	0.03%
	Polonium-210	23.00	2.25E-07	0.02%	1.79E-09	0.00%	1.02E-10	0.00%
Thorium-232	Thorium-232	0.47	6.10E-08	0.00%	6.72E-09	0.00%	8.25E-10	0.00%
	Radium-228 + D	0.68	2.76E-07	0.02%	3.70E-10	0.00%	4.98E-06	0.34%
		Total	**5.46E-05**	**3.70%**	**6.05E-07**	**0.04%**	**1.42E-03**	**96.26%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-7

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Calcined Nodules

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
Uranium- 238	Uranium-238 + D	24.10	2.85E-06	0.23%	7.44E-08	0.01%	1.41E-05	1.14%
	Uranium-234	23.59	2.10E-06	0.17%	8.88E-08	0.01%	3.05E-08	0.00%
	Thorium-230	23.35	2.65E-06	0.21%	2.20E-07	0.02%	9.82E-08	0.01%
	Radium-226 + D	27.10	1.11E-05	0.89%	1.03E-07	0.01%	1.18E-03	94.91%
	Lead-210 + D	21.79	2.27E-05	1.83%	6.95E-08	0.01%	3.28E-07	0.03%
	Polonium-210	10.92	1.07E-07	0.01%	8.50E-10	0.00%	4.83E-11	0.00%
Thorium-232	Thorium-232	0.50	6.51E-08	0.01%	7.16E-09	0.00%	8.80E-10	0.00%
	Radium-228 + D	0.82	3.33E-07	0.03%	4.46E-10	0.00%	6.01E-06	0.49%
		Total	**4.18E-05**	**3.38%**	**5.64E-07**	**0.05%**	**1.20E-03**	**96.58%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-8
Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Silica

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
Uranium- 238	Uranium-238 + D	1.50	1.77E-07	0.22%	4.63E-09	0.01%	8.78E-07	1.10%
	Uranium-234	0.43	3.82E-08	0.05%	1.62E-09	0.00%	5.57E-10	0.00%
	Thorium-230	1.60	1.82E-07	0.23%	1.51E-08	0.02%	6.73E-09	0.01%
	Radium-226 + D	1.70	6.94E-07	0.87%	6.48E-09	0.01%	7.37E-05	92.14%
	Lead-210 + D	0.67	6.97E-07	0.87%	2.14E-09	0.00%	1.01E-08	0.01%
	Polonium-210	2.60	2.54E-08	0.03%	2.02E-10	0.00%	1.15E-11	0.00%
Thorium-232	Thorium-232	0.69	8.97E-08	0.11%	9.87E-09	0.01%	1.21E-09	0.00%
	Radium-228 + D	0.45	1.81E-07	0.23%	2.43E-10	0.00%	3.27E-06	4.08%
		Total	**2.08E-06**	**2.60%**	**4.02E-08**	**0.05%**	**7.79E-05**	**97.35%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-9
Radionuclide and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Coke

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	0.46	1.61E-08	0.04%	1.58E-12	0.00%	1.90E-06	4.26%
Uranium- 238	Uranium-238 + D	1.54	1.82E-07	0.41%	4.75E-09	0.01%	9.01E-07	2.03%
	Uranium-234	0.48	4.22E-08	0.09%	1.79E-09	0.00%	6.15E-10	0.00%
	Thorium-230	0.12	1.31E-08	0.03%	1.08E-09	0.00%	4.84E-10	0.00%
	Radium-226 + D	0.78	3.19E-07	0.72%	2.97E-09	0.01%	3.38E-05	76.08%
	Lead-210 + D	3.32	3.45E-06	7.77%	1.06E-08	0.02%	4.99E-08	0.11%
	Polonium-210	0.98	9.57E-09	0.02%	7.63E-11	0.00%	4.34E-12	0.00%
Thorium-232	Thorium-232	0.35	4.48E-08	0.10%	4.93E-09	0.01%	6.06E-10	0.00%
	Radium-228 + D	0.48	1.93E-07	0.43%	2.59E-10	0.00%	3.49E-06	7.84%
		Total	**4.27E-06**	**9.61%**	**2.65E-08**	**0.06%**	**4.02E-05**	**90.33%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-10

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Ferrophos

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	2.30	8.00E-08	0.18%	7.82E-12	0.00%	9.42E-06	21.15%
Uranium- 238	Uranium-238 + D	17.58	2.08E-06	4.66%	5.43E-08	0.12%	1.03E-05	23.12%
	Uranium-234	21.00	1.87E-06	4.19%	7.91E-08	0.18%	2.72E-08	0.06%
	Thorium-230	0.42	4.77E-08	0.11%	3.95E-09	0.01%	1.77E-09	0.00%
	Radium-226 + D	0.27	1.10E-07	0.25%	1.03E-09	0.00%	1.17E-05	26.30%
	Lead-210 + D	0.99	1.03E-06	2.31%	3.16E-09	0.01%	1.49E-08	0.03%
	Polonium-210	0.29	2.78E-09	0.01%	2.22E-11	0.00%	1.26E-12	0.00%
Thorium-232	Thorium-232	0.26	3.38E-08	0.08%	3.72E-09	0.01%	4.57E-10	0.00%
	Radium-228 + D	0.99	4.02E-07	0.90%	5.40E-10	0.00%	7.27E-06	16.32%
		Total	**5.65E-06**	**12.68%**	**1.46E-07**	**0.33%**	**3.87E-05**	**86.99%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-11
Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Slag

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	9.82	3.41E-07	0.02%	3.34E-11	0.00%	4.02E-05	2.48%
Uranium- 238	Uranium-238 + D	26.81	3.17E-06	0.20%	8.28E-08	0.01%	1.57E-05	0.97%
	Uranium-234	26.86	2.39E-06	0.15%	1.01E-07	0.01%	3.48E-08	0.00%
	Thorium-230	29.30	3.33E-06	0.21%	2.76E-07	0.02%	1.23E-07	0.01%
	Radium-226 + D	35.19	1.44E-05	0.89%	1.34E-07	0.01%	1.53E-03	94.09%
	Lead-210 + D	9.12	9.48E-06	0.58%	2.91E-08	0.00%	1.37E-07	0.01%
	Polonium-210	14.03	1.37E-07	0.01%	1.09E-09	0.00%	6.21E-11	0.00%
Thorium-232	Thorium-232	0.67	8.73E-08	0.01%	9.61E-09	0.00%	1.18E-09	0.00%
	Radium-228 + D	0.74	2.99E-07	0.02%	4.01E-10	0.00%	5.40E-06	0.33%
		Total	**3.36E-05**	**2.07%**	**6.34E-07**	**0.04%**	**1.59E-03**	**97.89%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-12

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Calciner Pond Sediment

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	70.40	2.45E-06	0.23%	2.39E-10	0.00%	2.88E-04	26.83%
Uranium- 238	Uranium-238 + D	17.50	2.07E-06	0.19%	5.40E-08	0.01%	1.02E-05	0.95%
	Uranium-234	17.50	1.56E-06	0.14%	6.59E-08	0.01%	2.27E-08	0.00%
	Thorium-230	17.50	1.99E-06	0.19%	1.65E-07	0.02%	7.36E-08	0.01%
	Radium-226 + D	17.50	7.15E-06	0.67%	6.67E-08	0.01%	7.59E-04	70.67%
	Lead-210 + D	0.85	8.84E-07	0.08%	2.71E-09	0.00%	1.28E-08	0.00%
	Polonium-210	0.85	8.30E-09	0.00%	6.62E-11	0.00%	3.76E-12	0.00%
Thorium-232	Thorium-232	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
	Radium-228 + D	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
		Total	**1.61E-05**	**1.50%**	**3.54E-07**	**0.03%**	**1.06E-03**	**98.47%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-13

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Phossy Solids

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	135.22	4.70E-06	0.22%	4.60E-10	0.00%	5.54E-04	25.38%
Uranium- 238	Uranium-238 + D	13.03	1.54E-06	0.07%	4.02E-08	0.00%	7.63E-06	0.35%
	Uranium-234	45.50	4.04E-06	0.19%	1.71E-07	0.01%	5.89E-08	0.00%
	Thorium-230	11.33	1.29E-06	0.06%	1.07E-07	0.00%	4.77E-08	0.00%
	Radium-226 + D	12.04	4.92E-06	0.23%	4.59E-08	0.00%	5.22E-04	23.94%
	Lead-210 + D	1005.30	1.05E-03	47.94%	3.21E-06	0.15%	1.51E-05	0.69%
	Polonium-210	711.12	6.95E-06	0.32%	5.53E-08	0.00%	3.15E-09	0.00%
Thorium-232	Thorium-232	5.08	6.61E-07	0.03%	7.27E-08	0.00%	8.93E-09	0.00%
	Radium-228 + D	1.18	4.79E-07	0.02%	6.43E-10	0.00%	8.66E-06	0.40%
		Total	**1.07E-03**	**49.06%**	**3.70E-06**	**0.17%**	**1.11E-03**	**50.77%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-14

Radionuclide- and Pathway-Specific Contributions to Total Risk for Commercial/Industrial Workers Exposed to Background Soil

Decay Series	Isotope (1)	Background Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	20.50	7.13E-07	0.27%	6.97E-11	0.00%	8.39E-05	32.11%
Uranium- 238	Uranium-238 + D	3.88	4.58E-07	0.18%	1.20E-08	0.00%	2.27E-06	0.87%
	Uranium-234	3.88	3.45E-07	0.13%	1.46E-08	0.01%	5.02E-09	0.00%
	Thorium-230	3.88	4.41E-07	0.17%	3.65E-08	0.01%	1.63E-08	0.01%
	Radium-226 + D	3.88	1.58E-06	0.61%	1.48E-08	0.01%	1.68E-04	64.39%
	Lead-210 + D	3.03	3.15E-06	1.21%	9.67E-09	0.00%	4.56E-08	0.02%
	Polonium-210	3.58	3.50E-08	0.01%	2.79E-10	0.00%	1.58E-11	0.00%
Thorium-232	Thorium-232	- (2)	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
	Radium-228 + D	- (2)	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
		Total	**6.73E-06**	**2.57%**	**8.79E-08**	**0.03%**	**2.55E-04**	**97.39%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

(2) Data sufficient to characterize background activity are unavailable for this constituent.

Table B-15
Summary of Total Risk for Commercial/Industrial Workers Exposed to Background Soils and Potential Source Materials

Potential Source Material	Exposure Pathway						All Pathways	
	Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation			
	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Background								
Subsurface soil	6.73E-06	2.57E-02	8.79E-08	3.36E-04	2.55E-04	9.74E-01	2.61E-04	100.00%
Potential Source Material								
Phosphate Ore	5.46E-05	3.70%	6.05E-07	0.04%	1.42E-03	96.26%	1.48E-03	100.00%
Calcined Nodules	4.18E-05	3.38%	5.64E-07	0.05%	1.20E-03	96.58%	1.24E-03	100.00%
Silica	2.08E-06	2.60%	4.02E-08	0.05%	7.79E-05	97.35%	8.00E-05	100.00%
Coke	4.27E-06	9.61%	2.65E-08	0.06%	4.02E-05	90.33%	4.45E-05	100.00%
Ferrophos	5.65E-06	12.68%	1.46E-07	0.33%	3.87E-05	86.99%	4.45E-05	100.00%
Slag	3.36E-05	2.07%	6.34E-07	0.04%	1.59E-03	97.89%	1.62E-03	100.00%
Calciner Pond Sediment	1.61E-05	1.50%	3.54E-07	0.03%	1.06E-03	98.47%	1.07E-03	100.00%
Phossy Solids	1.07E-03	49.06%	3.70E-06	0.17%	1.11E-03	50.77%	2.18E-03	100.00%

= Total risk from commercial/industrial worker exposure to this potential source material is lower than the risk associated with exposure to background soils over the same time duration.

Table B-16

Parameter Values Used to Estimate Radiological Risk to Future Construction Workers Exposed to Potential Source Materials at the FMC Plant OU

Parameter	Units	Value	Source
Equation F-1: Incidental Soil Ingestion			
t_w - Time worker	years	1	Section 4 construction worker SSL calculations
EF_{ow} - Outdoor worker exposure frequency	days/year	130	Section 4 construction worker SSL calculations
ED_{ow} - Outdoor worker exposure duration	years	1	Section 4 construction worker SSL calculations
IR_{sow} - Outdoor worker soil ingestion rate	mg/day	330	Section 4 construction worker SSL calculations
Equation F-3: Inhalation of Fugitive Dust			
t_w - Time worker	years	1	Section 4 construction worker SSL calculations
EF_{ow} - Outdoor worker exposure frequency	days/year	130	Section 4 construction worker SSL calculations
ED_{ow} - Outdoor worker exposure duration	years	1	Section 4 construction worker SSL calculations
IR_{ow} - Outdoor worker inhalation rate	m^3/day	60	Default value (EPA, 2004)
ETowo - Outdoor worker exposure time outdoors	hour/hour	0.33	Default value (EPA, 2004): Equivalent to 8 hours/work day
ETowi - Outdoor worker exposure time indoors	hour/hour	0	Default value (EPA, 2004)
DF_i - Indoor dilution factor	unitless	0.4	Default value (EPA, 2004)
PEF - Particulate emission factor	m^3/kg	7.44E+05	Derived for construction worker at the FMC Plant OU in Section 4.4.3
Equation F-5: External Exposure to Gamma Radiation			
t_w - Time worker	years	1	Section 4 construction worker SSL calculations
EF_{ow} - Outdoor worker exposure frequency	days/year	130	Section 4 construction worker SSL calculations
ED_{ow} - Outdoor worker exposure duration	years	1	Section 4 construction worker SSL calculations
ACF - Area correction factor	unitless	1	Due to the spatial extent of the FMC Plant OU no area correction factor applied
GSF - Gamma shielding factor	unitless	0.4	Default value (EPA, 2004)
ET_{owo} - Outdoor worker exposure time outdoors	hour/hour	0.33	Default value (EPA, 2004): Equivalent to 8 hours/work day
ET_{owi} - Outdoor worker exposure time indoors	hour/hour	0	Default value (EPA, 2004)

Table B-17
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Phosphate Ore

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	10.90	2.89E-08	0.04%	3.92E-10	0.00%	1.62E-06	2.49%
Uranium- 238	Uranium-238 + D	23.28	2.10E-07	0.32%	7.60E-07	1.17%	4.95E-07	0.76%
	Uranium-234	22.32	1.51E-07	0.23%	8.89E-07	1.37%	1.05E-09	0.00%
	Thorium-230	23.13	2.00E-07	0.31%	2.30E-06	3.54%	3.53E-09	0.01%
	Radium-226 + D	31.28	9.79E-07	1.51%	1.27E-06	1.95%	4.95E-05	76.10%
	Lead-210 + D	32.22	3.62E-06	5.57%	1.54E-06	2.37%	2.49E-08	0.04%
	Polonium-210	23.00	3.60E-07	0.55%	3.98E-07	0.61%	7.76E-11	0.00%
Thorium-232	Thorium-232	0.47	4.66E-09	0.01%	7.11E-08	0.11%	2.99E-11	0.00%
	Radium-228 + D	0.68	6.28E-08	0.10%	1.17E-08	0.02%	5.40E-07	0.83%
		Total	**5.62E-06**	**8.64%**	**7.24E-06**	**11.13%**	**5.22E-05**	**80.23%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-18

Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Calciner Nodules

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
Uranium- 238	Uranium-238 + D	24.10	2.17E-07	0.40%	7.87E-07	1.44%	5.12E-07	0.94%
	Uranium-234	23.59	1.60E-07	0.29%	9.39E-07	1.72%	1.11E-09	0.00%
	Thorium-230	23.35	2.02E-07	0.37%	2.32E-06	4.25%	3.56E-09	0.01%
	Radium-226 + D	27.10	8.49E-07	1.55%	1.10E-06	2.01%	4.29E-05	78.44%
	Lead-210 + D	21.79	2.45E-06	4.48%	1.04E-06	1.91%	1.68E-08	0.03%
	Polonium-210	10.92	1.71E-07	0.31%	1.89E-07	0.35%	3.68E-11	0.00%
Thorium-232	Thorium-232	0.50	4.96E-09	0.01%	7.57E-08	0.14%	3.19E-11	0.00%
	Radium-228 + D	0.82	7.58E-08	0.14%	1.41E-08	0.03%	6.51E-07	1.19%
		Total	**4.13E-06**	**7.55%**	**6.47E-06**	**11.84%**	**4.41E-05**	**80.61%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-19
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Silica

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
Uranium- 238	Uranium-238 + D	1.50	1.35E-08	0.35%	4.90E-08	1.29%	3.19E-08	0.84%
	Uranium-234	0.43	2.91E-09	0.08%	1.71E-08	0.45%	2.02E-11	0.00%
	Thorium-230	1.60	1.39E-08	0.36%	1.59E-07	4.18%	2.44E-10	0.01%
	Radium-226 + D	1.70	5.32E-08	1.40%	6.89E-08	1.81%	2.69E-06	70.65%
	Lead-210 + D	0.67	7.53E-08	1.98%	3.20E-08	0.84%	5.18E-10	0.01%
	Polonium-210	2.60	4.07E-08	1.07%	4.49E-08	1.18%	8.77E-12	0.00%
Thorium-232	Thorium-232	0.69	6.84E-09	0.18%	1.04E-07	2.74%	4.40E-11	0.00%
	Radium-228 + D	0.45	4.12E-08	1.08%	7.66E-09	0.20%	3.54E-07	9.30%
		Total	**2.48E-07**	**6.50%**	**4.83E-07**	**12.69%**	**3.08E-06**	**80.80%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-20
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Coke

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	0.46	1.23E-09	0.05%	1.67E-11	0.00%	6.88E-08	2.70%
Uranium- 238	Uranium-238 + D	1.54	1.39E-08	0.54%	5.02E-08	1.98%	3.27E-08	1.28%
	Uranium-234	0.48	3.22E-09	0.13%	1.89E-08	0.74%	2.23E-11	0.00%
	Thorium-230	0.12	9.97E-10	0.04%	1.14E-08	0.45%	1.76E-11	0.00%
	Radium-226 + D	0.78	2.44E-08	0.96%	3.16E-08	1.24%	1.23E-06	48.51%
	Lead-210 + D	3.32	3.73E-07	14.66%	1.59E-07	6.24%	2.57E-09	0.10%
	Polonium-210	0.98	1.53E-08	0.60%	1.69E-08	0.67%	3.31E-12	0.00%
Thorium-232	Thorium-232	0.35	3.42E-09	0.13%	5.22E-08	2.05%	2.20E-11	0.00%
	Radium-228 + D	0.48	4.40E-08	1.73%	8.17E-09	0.32%	3.78E-07	14.85%
		Total	**4.79E-07**	**18.85%**	**3.48E-07**	**13.69%**	**1.72E-06**	**67.46%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-21
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Ferrophos

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	2.30	6.10E-09	0.15%	8.28E-11	0.00%	3.42E-07	8.47%
Uranium- 238	Uranium-238 + D	17.58	1.58E-07	3.93%	5.74E-07	14.24%	3.74E-07	9.26%
	Uranium-234	21.00	1.42E-07	3.53%	8.36E-07	20.74%	9.86E-10	0.02%
	Thorium-230	0.42	3.64E-09	0.09%	4.18E-08	1.04%	6.41E-11	0.00%
	Radium-226 + D	0.27	8.45E-09	0.21%	1.09E-08	0.27%	4.27E-07	10.59%
	Lead-210 + D	0.99	1.11E-07	2.75%	4.73E-08	1.17%	7.64E-10	0.02%
	Polonium-210	0.29	4.46E-09	0.11%	4.93E-09	0.12%	9.62E-13	0.00%
Thorium-232	Thorium-232	0.26	2.58E-09	0.06%	3.93E-08	0.98%	1.66E-11	0.00%
	Radium-228 + D	0.99	9.16E-08	2.27%	1.70E-08	0.42%	7.87E-07	19.53%
		Total	**5.29E-07**	**13.11%**	**1.57E-06**	**38.98%**	**1.93E-06**	**47.91%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-22
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Slag

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	9.82	2.60E-08	0.04%	3.53E-10	0.00%	1.46E-06	2.13%
Uranium- 238	Uranium-238 + D	26.81	2.42E-07	0.35%	8.76E-07	1.28%	5.70E-07	0.83%
	Uranium-234	26.86	1.82E-07	0.27%	1.07E-06	1.56%	1.26E-09	0.00%
	Thorium-230	29.30	2.54E-07	0.37%	2.92E-06	4.26%	4.47E-09	0.01%
	Radium-226 + D	35.19	1.10E-06	1.61%	1.43E-06	2.08%	5.57E-05	81.27%
	Lead-210 + D	9.12	1.02E-06	1.49%	4.36E-07	0.64%	7.04E-09	0.01%
	Polonium-210	14.03	2.20E-07	0.32%	2.43E-07	0.35%	4.73E-11	0.00%
Thorium-232	Thorium-232	0.67	6.66E-09	0.01%	1.02E-07	0.15%	4.28E-11	0.00%
	Radium-228 + D	0.74	6.81E-08	0.10%	1.27E-08	0.02%	5.85E-07	0.85%
		Total	**3.12E-06**	**4.56%**	**7.08E-06**	**10.34%**	**5.83E-05**	**85.10%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-23

Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Calciner Pond Sediment

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	70.40	1.87E-07	0.43%	2.53E-09	0.01%	1.05E-05	24.00%
Uranium- 238	Uranium-238 + D	17.50	1.58E-07	0.36%	5.72E-07	1.31%	3.72E-07	0.85%
	Uranium-234	17.50	1.19E-07	0.27%	6.97E-07	1.60%	8.22E-10	0.00%
	Thorium-230	17.50	1.52E-07	0.35%	1.74E-06	4.00%	2.67E-09	0.01%
	Radium-226 + D	17.50	5.48E-07	1.26%	7.09E-07	1.63%	2.77E-05	63.55%
	Lead-210 + D	0.85	9.55E-08	0.22%	4.06E-08	0.09%	6.57E-10	0.00%
	Polonium-210	0.85	1.33E-08	0.03%	1.47E-08	0.03%	2.87E-12	0.00%
Thorium-232	Thorium-232	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
	Radium-228 + D	NA	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
		Total	**1.27E-06**	**2.92%**	**3.78E-06**	**8.67%**	**3.85E-05**	**88.41%**

NA = No data available for this constituent.

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-24
Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Phossy Solids

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	135.22	3.59E-07	0.15%	4.87E-09	0.00%	2.01E-05	8.67%
Uranium- 238	Uranium-238 + D	13.03	1.17E-07	0.05%	4.25E-07	0.18%	2.77E-07	0.12%
	Uranium-234	45.50	3.08E-07	0.13%	1.81E-06	0.78%	2.14E-09	0.00%
	Thorium-230	11.33	9.82E-08	0.04%	1.13E-06	0.49%	1.73E-09	0.00%
	Radium-226 + D	12.04	3.77E-07	0.16%	4.88E-07	0.21%	1.91E-05	8.22%
	Lead-210 + D	1005.30	1.13E-04	48.76%	4.81E-05	20.75%	7.77E-07	0.34%
	Polonium-210	711.12	1.11E-05	4.80%	1.23E-05	5.31%	2.40E-09	0.00%
Thorium-232	Thorium-232	5.08	5.04E-08	0.02%	7.69E-07	0.33%	3.24E-10	0.00%
	Radium-228 + D	1.18	1.09E-07	0.05%	2.03E-08	0.01%	9.38E-07	0.40%
		Total	**1.26E-04**	**54.18%**	**6.50E-05**	**28.06%**	**4.11E-05**	**17.76%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

Table B-25

Radionuclide- and Pathway-Specific Contributions to Total Risk for Construction Workers Exposed to Background Soils

Decay Series	Isotope (1)	Exposure Point Activity (pCi/g)	Exposure Pathway					
			Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation	
			Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Potassium	Potassium-40	20.50	5.44E-08	0.50%	7.38E-10	0.01%	3.05E-06	27.76%
Uranium- 238	Uranium-238 + D	3.88	3.50E-08	0.32%	1.27E-07	1.16%	8.24E-08	0.75%
	Uranium-234	3.88	2.63E-08	0.24%	1.55E-07	1.41%	1.82E-10	0.00%
	Thorium-230	3.88	3.36E-08	0.31%	3.86E-07	3.52%	5.92E-10	0.01%
	Radium-226 + D	3.88	1.21E-07	1.11%	1.57E-07	1.43%	6.14E-06	55.96%
	Lead-210 + D	3.03	3.40E-07	3.10%	1.45E-07	1.32%	2.34E-09	0.02%
	Polonium-210	3.58	5.60E-08	0.51%	6.19E-08	0.56%	1.21E-11	0.00%
Thorium-232	Thorium-232	- (2)	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
	Radium-228 + D	- (2)	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
		Total	**6.67E-07**	**6.08%**	**1.03E-06**	**9.41%**	**9.27E-06**	**84.51%**

(1) For each radionuclide listed, slope factors correspond to the risks per unit intake or exposure for that radionuclide only, except when marked with a "+D" to indicate that the risks from associated short-lived radioactive decay products (i.e., those decay products with radioactive half-lives less than or equal to 6 months) are also included.

(2) Data sufficient to characterize background activity are unavailable for this constituent.

Table B-26
Summary of MICROSHIELD 5.05 Model Results

Model Scenario	Trench Floor Dose (uR/hr)	Trench Wall Dose (uR/hr)	Total Exposure Rate (uR/hr)	Fractional Increase from Trench Walls
5' deep trench with no shield	54	26	80	1.48
5' deep trench with 0.25" steel shield	54	21	75	1.39
5' deep trench with 0.5" steel shield	54	17	71	1.31
5' deep trench with 1" steel shield	54	11	65	1.20
9' deep trench with 0.25" steel shield	54	31	85	1.57
9' deep trench with 0.5" steel shield	54	24	78	1.44
9' deep trench with 1" steel shield	54	15	69	1.28

Table B-27
Summary of Total Risk for Construction Workers Exposed to Background Soils and Potential Source Materials

Potential Source Material	Exposure Pathway						All Pathways	
	Incidental Soil Ingestion		Fugitive Dust Inhalation		External Gamma Radiation			
	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk	Cancer Risk	% of Total Risk
Background								
Subsurface soil	6.67E-07	6.08E-02	1.03E-06	9.41E-02	9.27E-06	8.45E-01	1.10E-05	100.00%
Potential Source Material								
Phosphate Ore	5.62E-06	8.64%	7.24E-06	11.13%	5.22E-05	80.23%	6.50E-05	100.00%
Calcined Nodules	4.13E-06	7.55%	6.47E-06	11.84%	4.41E-05	80.61%	5.47E-05	100.00%
Silica	2.48E-07	6.50%	4.83E-07	12.69%	3.08E-06	80.80%	3.81E-06	100.00%
Coke	4.79E-07	18.85%	3.48E-07	13.69%	1.72E-06	67.46%	2.54E-06	100.00%
Ferrophos	5.29E-07	13.11%	1.57E-06	38.98%	1.93E-06	47.91%	4.03E-06	100.00%
Slag	3.12E-06	4.56%	7.08E-06	10.34%	5.83E-05	85.10%	6.85E-05	100.00%
Calciner Pond Sediment	1.27E-06	2.92%	3.78E-06	8.67%	3.85E-05	88.41%	4.36E-05	100.00%
Phossy Solids	1.26E-04	54.18%	6.50E-05	28.06%	4.11E-05	17.76%	2.32E-04	100.00%

= Total risk from commercial/industrial worker exposure to this potential source material is lower than the risk associated with exposure to background soils over the same time duration.