LMS/RFS/S07693

Third Five-Year Review Report for the Rocky Flats Site Jefferson and Boulder Counties, Colorado

July 2012

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Third Five-Year Review Report for the Rocky Flats Site Jefferson and Boulder Counties, Colorado

July 2012

Prepared by
U.S. Department of Energy
Office of Legacy Management

Approved by: Date: 7/23/12

U.S. Department of Energy

Concurrence Letter Enclosed
U.S. Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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JUL 30 2012

Ref: 8 EPR-F

Scott Surovchak
Rocky Flats Site Manager
US Department of Energy,
Office of Legacy Management
11025 Dover Street Suite 1000
Westminster, Colorado 80021

Re: Five Year Review Report for Rocky Flats US DOE Site, Jefferson County, Colorado

Dear Mr. Surovchak:

Thank you for submitting the Five Year Review Report for the Rocky Flats US DOE Site, Jefferson County, Colorado. The US Environmental Protection Agency (EPA) in consultation with the State of Colorado concurs with your assessment that the remedy for the Central Operable Unit is protective of human health and the environment. We agree with your determination in the sitewide protectiveness statement that the remedy is protective of human health and the environment. This information will be included in the EPA's annual Superfund Five-Year Review Report to Congress.

No issues or recommendations relating to this Five Year Review will be tracked in the EPA's Superfund tracking system, CERCLIS. Although the report lists some issues and recommendations, none of these affect protectiveness, and therefore will not be tracked. The environmental indicator for this site is "current human exposure is controlled and a protective remedy is in place." Environmental indicators include site wide human exposure control and contaminated groundwater migration.

The due date for the next five year review report will be August 03, 2017.

Sincerely,

Martin Hestmark
Acting Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

cc. Carl Spreng, CDPHE

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Abbreviations

AEA	Atomic Energy Act
AEU	Aquatic Exposure Unit
AL	action level
AMP	Adaptive Management Plan
AOC	Area of Concern
AOI	analyte of interest
ARAR	applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances Disease Registry
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CCP	Comprehensive Conservation Plan
CCR	*Code of Colorado Regulations*
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CGP	construction general permit
CHWA	Colorado Hazardous Waste Act
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
CRS	Colorado Revised Statutes
CY	calendar year
DCF	dose-conversion factor
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
ECOC	ecological contaminant of concern
ECOI	ecological contaminant of interest
ECOPC	ecological contaminant of potential concern
Eco-SSL	Ecological Soil Screening Level
ECOTOX	ECOTOXicology
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESL	ecological screening level
ETPTS	East Trenches Plume Treatment System
EU	Exposure Unit
FC	Functional Channel
FR	*Federal Register*
FY	fiscal year
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HR	high resolution
IA	Industrial Area
ICP/MS	inductively coupled plasma/mass spectrometry
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action

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IRIS	Integrated Risk Information System
LANL	Los Alamos National Laboratory
LHSU	lower hydrostratigraphic unit
LM	Office of Legacy Management
LOAEL	lowest observed adverse effects level
µg/L	micrograms per liter
m^3	cubic meter
M&M	monitoring and maintenance
MCL	maximum contaminant level
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mrem	millirems
MSPTS	Mound Site Plume Treatment System
NCP	National Contingency Plan
NOAEL	no observed adverse effects level
NOIPD	Notice of Intent for Partial Deletion
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCPP	Natural Resource Compliance and Protection Program
NWP	nationwide permit
O&M	operation and maintenance
OLF	Original Landfill
OU	Operable Unit
PAC	Potential Area of Concern
PBA	Programmatic Biological Assessment
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PIC	Potential Incident of Concern
PLF	Present Landfill
PLFTS	Present Landfill Treatment System
PMJM	Preble's meadow jumping mouse
POC	Point of Compliance
POE	Point of Evaluation
PQL	practical quantitation limit
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RFLMA	Rocky Flats Legacy Management Agreement
RFSC	Rocky Flats Stewardship Council
RI	Remedial Investigation

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RI/FS	Remedial Investigation/Feasibility Study
SPPTS	Solar Ponds Plume Treatment System
STP	Sewage Treatment Plant
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TEDE	total effective dose equivalent
TEF	Toxic Equivalency Factor
TEQ	toxicity equivalence
TIMS	thermal ionization mass spectrometry
TRV	toxicity reference value
UBC	Under Building Contamination
UCL	upper confidence level
UHSU	upper hydrostratigraphic unit
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WBEU	Wind Blown Area Exposure Unit
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division
WRV	wildlife refuge visitor
WRW	wildlife refuge worker
ZVI	zero valent iron

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Executive Summary

The U.S. Department of Energy's (DOE's) Rocky Flats Site (Rocky Flats), which is located approximately 16 miles northwest of Denver, Colorado, was listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) in 1989. The final remedy was selected in the September 29, 2006, Corrective Action Decision/Record of Decision (CAD/ROD) after completion of cleanup and closure by DOE under the Rocky Flats Cleanup Agreement (RFCA). The CAD/ROD was based on the results of the July 2006 Remedial Investigation/Feasibility Study, which included a Comprehensive (Human Health and Ecological) Risk Assessment (CRA), and the July 2006 Proposed Plan.

Rocky Flats has two Operable Units (OUs) within the boundaries of the property: the 1,308-acre Central OU and the 4,883-acre Peripheral OU. The Central OU contains the areas of Rocky Flats that required additional remedial/response actions, within a boundary based on the practicalities of future land management. The Peripheral OU includes the remaining, generally unimpacted portions of Rocky Flats, and surrounds the Central OU. The Offsite Areas at Rocky Flats, known as OU 3, were addressed under a separate no action CAD/ROD dated June 3, 1997. Conditions in OU 3 and the Peripheral OU allow for unlimited use and unrestricted exposure and these OUs were deleted from the NPL in May 2007.

The response action in the final CAD/ROD is no action for the Peripheral OU, and institutional controls and physical controls with continued monitoring for the Central OU. A CAD/ROD amendment to clarify certain institutional controls and their implementation was approved on September 21, 2011. Because remaining contamination in the Central OU does not allow for unlimited use and unrestricted exposure, CERCLA requires that a periodic review be conducted at least every five years to determine whether the Central OU remedial actions remain protective of human health and the environment. This third five-year review covers May 2007 through April 2012 and evaluates the performance of the remedy implemented under the final CAD/ROD (as amended in September 2011) and RFLMA.

Most of the Rocky Flats property outside the Central OU was transferred on July 12, 2007, to the U.S. Department of the Interior for establishment of a National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. The Central OU land was retained by DOE for remedy implementation and is managed consistent with the Refuge purposes.

The *Rocky Flats Legacy Management Agreement* (RFLMA), between DOE, the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE), provides the implementing regulatory framework for the Central OU remedy.

The primary contaminants, contaminated media, and waste present in the Central OU are:

- Wastes disposed in two closed landfills: the Present Landfill (PLF), and the Original Landfill (OLF).
- Some subsurface soils with residual volatile organic compounds (VOCs), metals, and radionuclide contamination and areas where former building and infrastructure components, debris, and incinerator ash remain well below the surface with low levels of uranium, plutonium, and americium contamination.

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- Areas of groundwater that comprise contaminant plumes that contain VOCs, nitrates, and uranium at levels above Colorado's surface water standards.
- Areas of surface soil contaminated with low levels of plutonium-239/240 and americium-241.
- Some subsurface areas with VOC contamination at levels that could lead to inhalation of unacceptable VOC concentrations by building occupants if buildings were constructed in these areas.

Institutional controls prohibit soil disturbance activities that are not appropriately controlled, activities that could damage the landfill covers or other remedy components, construction of buildings for human occupancy, and the non-remedy-related use of surface water or groundwater. Physical controls include no trespassing signage at access points to the Central OU listing the institutional controls and no trespassing signs around the Central OU perimeter prohibiting unauthorized access. Monitoring includes requirements to routinely inspect and maintain the landfill covers, treatment systems, and institutional controls; and sampling and analysis of groundwater and surface water at specified locations and frequencies.

This review was conducted in accordance with EPA's *Comprehensive Five-Year Review Guidance* dated June 2001 and updates to the guidance regarding institutional controls dated September 2011. DOE, as the CERCLA federal lead agency under Executive Order 12580, conducted the review, using a team composed of knowledgeable DOE, DOE's contractor, CDPHE, and EPA staff. The team conducted a site inspection as part of the review on March 12, 2012.

While this report provides background information on the Peripheral OU and OU 3, a five-year review for these OUs is not required. But, information about studies regarding levels of residual plutonium in soil for these areas is included in Appendix E, "Public Participation Summary," because this report provides another opportunity to help inform stakeholders regarding this topic.

This report summarizes the progress made since the second five-year review, including the completion of all recommendations made for issues identified in the Second Five-Year Review Report, which was approved on September 14, 2007.

This report documents the technical evaluation of the performance of the remedy to determine the status of protectiveness of the remedy. The technical evaluation included consideration of monitoring and surveillance information reported in RFLMA quarterly and annual reports of site surveillance and maintenance activities and information on post-remedy decision-making documented in RFLMA Party contact records and amendments or modifications to remedy requirements. It also included review of the status of the remedial action objectives, any changes to the applicable or relevant and appropriate requirements the remedy must attain, any changes to toxicity factors or exposure parameters or assumptions that might affect the level of risk posed by residual contamination and any new information that may call into question the protectiveness of the remedy.

In accordance with RFLMA requirements, the review includes an evaluation of remedy implementation components to provide recommendations regarding continuing, discontinuing or modifying any components and whether any additional response actions based on new technologies could be taken. This evaluation resulted in a recommendation to discontinue

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specific landfill vegetation monitoring because the vegetation meets success criteria, and continuation of groundwater treatment system optimization activities begun within the last five years.

The following Five-Year Review Summary Form provides further information related to the review including issues, recommendations, and follow-up actions that were identified.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Flats Site		
EPA ID: CO7890010526		
Region: 8	**State:** CO	**City/County:** Golden/Jefferson and Boulder

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy
Author name (Federal or State Project Manager): Scott Surovchak, Site Manager
Author affiliation: U.S. Department of Energy, Office of Legacy Management
Review period: September 8, 2011- April 30, 2012
Date of site inspection: March 12, 2102
Type of review: Statutory
Review number: 3
Triggering action date: September 14, 2007, Second Five-Year Review Report
Due date *(five years after triggering action date)*: September 14, 2012

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
There are no issues or recommendations for the Peripheral OU and OU3, Offsite Areas. Conditions in these OU's allow for unlimited use and unrestricted exposure. EPA published a Notice of Partial Deletion from the NPL for the Peripheral OU and OU3 on May 25, 2007. A five-year review is not required for these OU's.

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): Central OU	**Issue Category:** Monitoring			
	Issue: Surface water Point of Evaluation (POE) GS10 uranium concentration has periodically exceeded the *Rocky Flats Legacy Management Agreement* (RFLMA) standard during this review period and exceeds the standard at the end of this review period. POEs are located upstream of surface water Points of Compliance (POCs) at the edge of the former Industrial Area within the Central OU to provide early indication of potential contaminant migration.			
	Recommendation: Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the Colorado Department of Public Health and Environment (CDPHE) - and EPA-approved evaluation plan.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended, and to establish the schedule to complete actions.
OU(s): Central OU	**Issue Category:** Monitoring			
	Issue: Surface water POE GS10 americium concentration began to exceed the RFLMA standard in 2011 and exceeds the standard at the end of this review period.			
	Recommendation: Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended, and to establish the schedule to complete actions.

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): Central OU	**Issue Category:** Monitoring			
	Issue: Surface water POE SW027 plutonium concentration exceeded the RFLMA standard in 2010 during a high precipitation event. Flow at SW027 is precipitation dependent. After mitigating actions to improve erosion controls in the drainage were completed in 2010, only very small volumes of infrequent, short-term, intermittent flows occurred at SW027. No samples have been able to be obtained for over a year. Because the RFLMA standard is based on 12 month rolling average of the results, and there are no sample results for averaging, the standard was no longer exceeded at the end of this review period. Samples will be obtained when there is sufficient flow to evaluate the effectiveness of the mitigating measures.			
	Recommendation: Continue to monitor in accordance with RFLMA requirements.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	When water flows at SW027 allowing sample collection and analysis again.
OU(s): Central OU	**Issue Category:** Institutional Controls			
	Issue: Institutional controls might not be easily enforceable against a utility easement holder who is not a party to the Environmental Covenant granted by DOE to CDPHE. While this is not a near-term issue (because the Office of Legacy Management (LM) maintains a good working relationship with the current easement holder), the lack of enforceability could become an issue in the future if LM and the easement holder (or any successor) do not maintain routine contact.			
	Recommendation: Replace the Environmental Covenant with a restrictive notice under Colorado law, as provided for in the 2011 Corrective Action Decision/Record of Decision amendment. While an environmental covenant might not be directly enforceable against a prior holder of an interest in land who is not a party to the covenant, a restrictive notice is enforceable by the CDPHE against any person in violation of the institutional controls.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	DOE and CDPHE will consult with a goal to replace the Environmental Covenant with a restrictive notice by end of 2012.

Protectiveness Statement		
Operable Unit:	***Protectiveness Determination:***	***Addendum Due Date (if applicable):***
Central OU	Protective	Not Applicable
Protectiveness Statement:		
The remedy for the Central OU is protective of human health and the environment because surface water concentrations are meeting standards at points of compliance, and monitoring and maintenance plans and institutional controls are working to prevent unacceptable exposure to site contaminants.		

Sitewide Protectiveness Statement	
Protectiveness Determination:	***Addendum Due Date (if applicable):***
Protective.	Not Applicable
Protectiveness Statement:	
Because the conditions at all OUs are protective, the site is protective of human health and the environment.	

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1.0 Introduction

The U.S. Department of Energy's (DOE's) Office of Legacy Management (LM) has conducted a third five-year review of remedial actions implemented at the Rocky Flats, Colorado, Site (Rocky Flats).[1] Because remaining contamination in the Central Operable Unit (Central OU) of Rocky Flats does not allow for unlimited use and unrestricted exposure, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; also known as "Superfund") requires that a review be conducted at least every five years to determine whether remedial actions remain protective of human health and the environment.

The *First Five-Year Review Report for Rocky Flats* (DOE 2002) was for the period May 1997 through April 2002 and was approved by the U.S. Environmental Protection Agency (EPA) on September 26, 2002.

The *Second Five-Year Review Report for Rocky Flats* (DOE 2007a) was for the period May 2002 through April 2007 and was approved by EPA on September 14, 2007.

The methods, findings, and conclusions of this third five-year review, including identified issues and recommendations and follow-up actions, are documented in this report.

Rocky Flats is a 6,191-acre[2] (DOE 2007b) property owned by the United States. It is located in the Denver metropolitan area, approximately 16 miles northwest of Denver and 10 miles south of Boulder (Figure 1). Nearby communities include the cities of Arvada, Broomfield, and Westminster. The majority of the federally-owned Rocky Flats property is located in Jefferson County, with a small portion located in Boulder County.

Rocky Flats was established in 1951 as part of the United States' nationwide nuclear weapons complex to manufacture nuclear weapons components under the jurisdiction and control of DOE and its predecessor agencies. The land was acquired beginning in 1951, with additional parcels acquired in 1974 and 1975. The majority of the land was used as a security buffer around an approximately 300-acre Industrial Area (IA) near the center of Rocky Flats. In 1995, control and jurisdiction of 234 acres (located in the northwestern corner of Rocky Flats) were transferred to the DOE Golden, Colorado, Field Office to be used as a scientific wind turbine testing facility for alternative energy development (DOE 1998). This area is known as the National Wind Technology Center. Pursuant to the 2002 National Defense Authorization Act, an additional 25 acres were transferred from Rocky Flats to the National Wind Technology Center.

DOE has conducted investigation and remediation at Rocky Flats since the mid-1980s, and has completed cleanup and closure of the Site in accordance with requirements of CERCLA, the Resource Conservation and Recovery Act (RCRA), and the Colorado Hazardous Waste Act (CHWA). The EPA Identification Number for Rocky Flats is CO7890010526.

Two OUs are located within the boundaries of Rocky Flats: the Central OU and the Peripheral OU (Figure 2). The 1,308-acre (DOE 2007b) Central OU consolidates all areas of Rocky Flats that require additional remedial/corrective actions, while also considering

[1] The National Priorities List (NPL) identification is the Rocky Flats Plant. Over the years of its existence, the Rocky Flats Plant was also known as the Rocky Flats Environmental Technology Site (RFETS), the Rocky Flats Site, or simply the Site.
[2] The 6,191-acre total is based on a land survey completed in 2007. All acreage is reported as "more or less." The previously reported Rocky Flats acreage of approximately 6,240 acres was estimated and not from a total survey.

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practicalities of future land management. The Peripheral OU includes the remaining, generally unimpacted portions of Rocky Flats and surrounds the Central OU. The final Corrective Action Decision/Record of Decision (CAD/ROD) for Rocky Flats was issued on September 29, 2006 (DOE, EPA, and CDPHE 2006). The selected remedy/corrective action in the final CAD/ROD for the Peripheral OU is "no action." The selected remedy/corrective action for the Central OU is "institutional and physical controls, incorporating continued monitoring and maintenance" (CAD/ROD, p.3).

The Offsite Areas at Rocky Flats, also known as OU 3, were addressed under a separate no action CAD/ROD dated April 1997 (DOE, EPA, and CDPHE 1997)[3]. No action CAD/RODs were issued for the Peripheral OU and OU 3 because they were determined to be in a protective state allowing unlimited use and unrestricted exposure. Therefore, no five-year review is required for the Peripheral OU and OU 3.

Consequently, because remaining contamination in the Central OU does not allow for unlimited use and unrestricted exposure, this third five-year review focuses on whether the final remedy for the Central OU continues to be protective of human health and the environment.

Jurisdiction and control of approximately 3,935 acres of Rocky Flats in the Peripheral OU were transferred to the U.S. Fish and Wildlife Service (USFWS) in July 2007 for the purposes of establishing the Rocky Flats National Wildlife Refuge, as prescribed by the Rocky Flats National Wildlife Refuge Act of 2001 (Refuge Act). The portion of Rocky Flats retained by DOE includes the Central OU, and approximately 948 acres in the Peripheral OU that will be transferred to USFWS at an appropriate time in the future after remaining private subsurface mineral rights are obtained by the United States.

The five-year review process does not reopen the remedy decision, but looks at conditions in the Central OU based on documents and other sources described in this report for comparison to the remedy design goals and objectives.

1.1 Period Covered by the Review and Related Information

The *Second Five-Year Review Report for the Rocky Flats Site* (DOE 2007a) covered the evaluation period for May 2002 through April 2007 and was approved by EPA on September 14, 2007. The cutoff date for environmental monitoring data evaluated in the second five-year review was for samples collected as of December 31, 2006, to allow use of validated data.

This third five-year review covers the period for May 2007 through April 2012 and the cutoff date for environmental monitoring data is for samples collected as of December 31, 2011 (unless monitoring data results for later sample dates are noted in this report), to allow use of validated data. The dates for other remedy-related information evaluated in the review are noted in this report.

[3] When established, OU 3 was simply defined as the offsite areas. Although this definition is inclusive of areas north, south, east and west of the Rocky Flats property boundary, a study area was identified for the OU 3 remedial investigation based on areas where previous studies indicated the presence of measureable contamination. The OU 3 study area encompassed an approximately 38-square mile area north, south and east of the Rocky Flats property boundary. For simplicity, Figure 2 does not show the OU 3 study area. The offsite study area is shown and described in Appendix B, *Final Historical Release Report* in the *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study* (RI/FS Report) (DOE 2006a).

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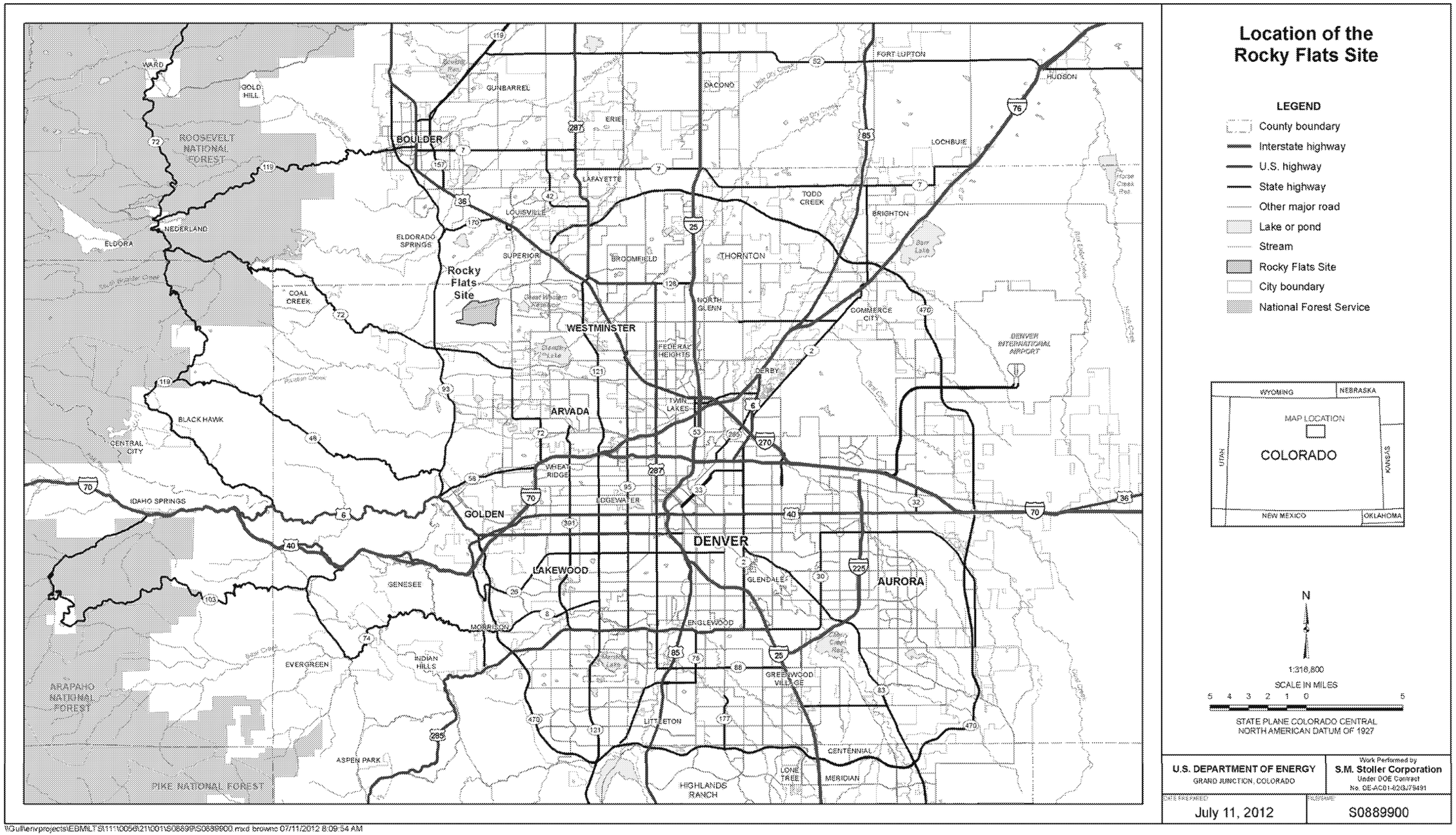

Figure 1. Location of the Rocky Flats Site Map

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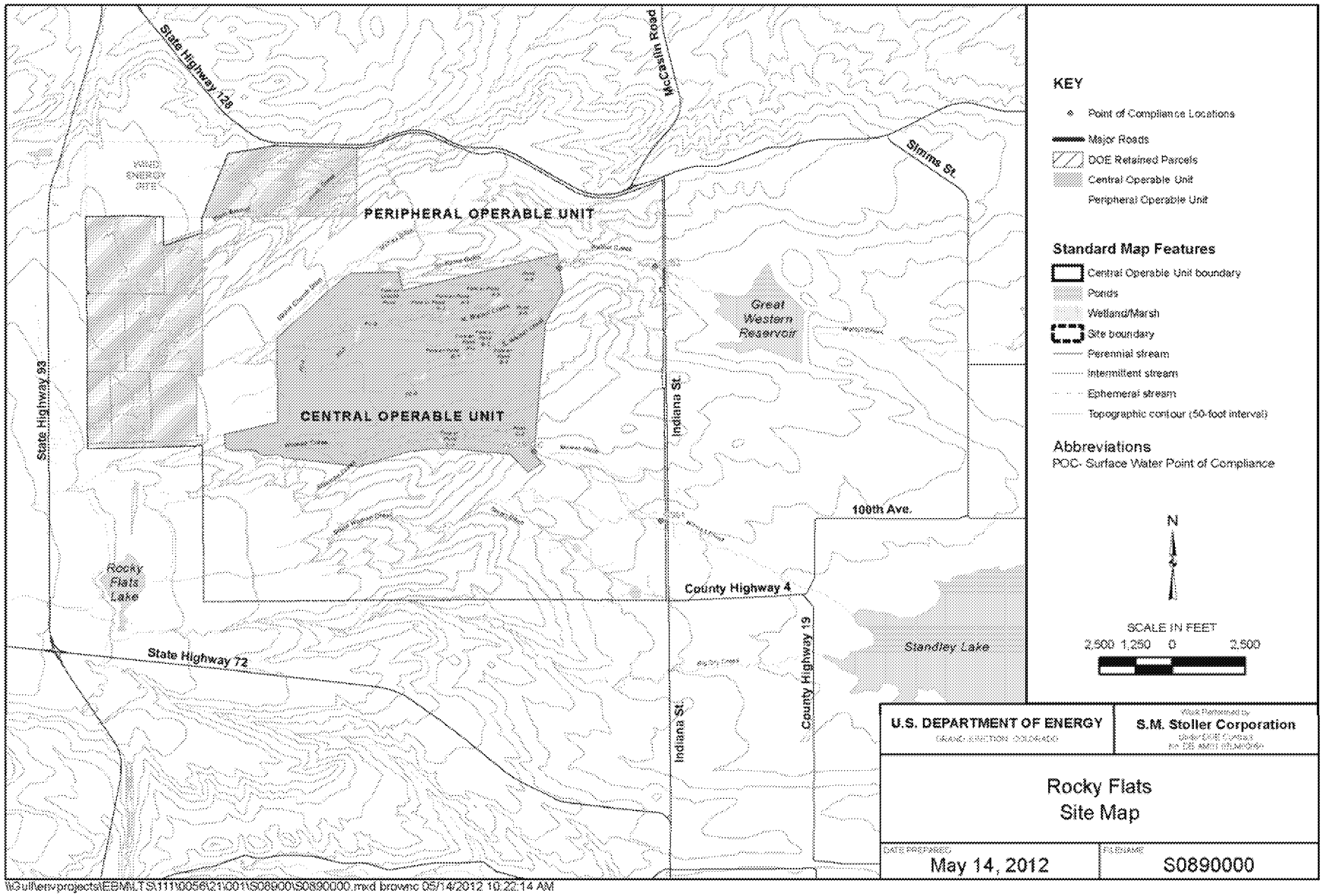

Figure 2. Site Map

1.2 Contents of the Report

In addition to this Introduction section, which includes information on the legal authority for the review, DOE's responsibility to conduct the review, and other review characteristics, the report consists of the following sections:

- Section 2.0, "Rocky Flats Chronology," provides information on the Rocky Flats Site history and the regulatory framework.
- Section 3.0, "Background," includes a description of the Rocky Flats Site's physical characteristics, land and resource use, and contamination history. Accelerated actions conducted at Rocky Flats in accordance with the Rocky Flats Cleanup Agreement (RFCA), as well as activities to complete Site closure in general, are also described. The basis for taking action, including results of the Remedial Investigation/Feasibility Study (RI/FS) including the Comprehensive Risk Assessment (CRA), is also covered in this section.
- Section 4.0, "Remedial Actions," provides details on the selected remedy for the Central OU, including the remedy selection process, implementation of the preferred remedy, and the system operations associated with the remedy.
- Section 5.0, "Progress Since the Last Five-Year Review," evaluates the status of Rocky Flats since the second five-year review was completed in 2007. This section includes the protectiveness statement from the second review, as well as the issues and recommendations identified during that review.
- Section 6.0, "Five-Year Review Process," describes the activities and information used to conduct the current five-year review.
- Section 7.0, "Technical Assessment," focuses on three questions used to evaluate whether the remedy at the Central OU is protective:
  - Question A: Is the remedy functioning as intended by the decision documents?
  - Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?
  - Question C: Has any other information come to light that could call into question the protectiveness of the remedy?
- Section 8.0, "Issues, Recommendations, and Follow-Up Actions," presents issues identified during the review. Recommendations and follow-up actions are also presented.
- Section 9.0, "Protectiveness Statement," presents the protectiveness statement for the Central OU.
- Section 10.0, "Next Review," discusses the anticipated schedule for the fourth five-year review of the Rocky Flats Site.
- Section 11.0, "References," lists the references used to prepare this report.

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This report also includes several appendixes as follows:

- Appendix A contains the *Rocky Flats Legacy Management Agreement* (RFLMA) (DOE, EPA, and CDPHE 2007) Attachment 2 figures and tables relevant to this five-year review evaluation for reference.
- Appendix B contains the inspection checklist and maps for the March 12, 2012, Central OU inspection. Several photographs taken during the inspection are also included. This appendix also includes the Operation and Maintenance Inspection Report for the Colorado Department of Public Health and Environment's (CDPHE's) February 16, 2012, inspection of the monitoring and sampling of RCRA wells at Rocky Flats.
- Appendix C contains a summary list of contact records related to the outcome of RFLMA Party consultation regarding various aspects of remedy implementation during this review period.
- Appendix D contains several aerial photographs that illustrate the changes since the second five-year review, as well as other photographs depicting conditions at Rocky Flats.
- Appendix E provides the five-year review Public Participation Summary.

1.3 Authority for Conducting the Five-Year Review

This review was conducted pursuant to CERCLA Section 121 and the National Contingency Plan (NCP). CERCLA Section 121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

EPA interpreted this requirement further in the NCP; 40 *Code of Federal Regulations* (CFR) Section 300.430(f)(4)(ii) states:

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

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1.4 Agency Conducting the Five-Year Review

DOE is the lead agency for CERCLA Section 121 reviews at DOE sites, in accordance with Executive Order 12580. EPA Region 8 and CDPHE are the designated support agencies for this CERCLA review. This DOE-led review was conducted by a team composed of personnel from LM, LM's Rocky Flats contractor S.M. Stoller Corporation (Stoller), EPA, and CDPHE.

1.5 Other Review Components

The conduct of the review and format of this report follows EPA's *Comprehensive Five-Year Review Guidance* (EPA 2001, 2011a).

DOE followed the EPA Guidance and the *Rocky Flats Site Legacy Management Public Involvement Plan* (DOE 2011a) to notify and inform the public regarding the five-year review process and to solicit input. Further details on the public participation activities are provided in Section 6.0 and Appendix E.

In addition, the review included an evaluation of RFLMA remedy implementation requirements and the following RFLMA paragraph 67 periodic review requirement:

> *...To the extent that remedies have incorporated institutional controls, the Parties shall review the continuing effectiveness of such controls, and shall evaluate whether additional response action could be taken that would reduce the need to rely on institutional controls. In making such an evaluation, the Parties shall consider all relevant factors, including advances in technology and the availability of funds. ...*

RFLMA Attachment 2, "Legacy Management Requirements," also provides in Section 7.3:

> *... the 5-year review will evaluate the components of the remedy (including, but not limited to, requirements for monitoring, maintenance and inspections, institutional controls, and reporting.) The 5-year review will determine whether such remedy components will be continued, modified, or discontinued.*

RFLMA Attachment 2, Table 3, "Present and Original Landfill Inspection and Maintenance Requirements," also specifies that the inspection frequency of the final cover and storm water management systems for the Original Landfill (OLF) and the Present Landfill (PLF) be evaluated in the CERCLA periodic review.

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2.0 Rocky Flats Chronology

This section provides a summary of key events in the approximately 60-year history of the Rocky Flats Site related to releases to the environment, site investigation, and completion of cleanup and closure. It also provides a summary of the regulatory framework for cleanup and closure and implementation of the final remedy requirements in the CAD/ROD.

2.1 Rocky Flats History

Beginning in 1951 DOE and its predecessor agencies and contractors managed and operated the Rocky Flats Plant under authorization of the Atomic Energy Act (AEA). Rocky Flats was part of the United States' nationwide nuclear weapons complex to manufacture nuclear weapons components from various radioactive, hazardous, and nonhazardous materials. Other support activities included chemical recovery and purification of recyclable transuranic radionuclides (i.e., plutonium, which is a "special nuclear material" under the AEA) and research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Manufacturing activities, accidental industrial fires and spills, and support activities including waste management resulted in the release of hazardous substances, hazardous wastes, and hazardous waste constituents to air, soil, sediment, groundwater, and surface water at Rocky Flats.

The majority of Rocky Flats structures were located within an approximately 300-acre industrial area (IA) at the center of the approximately 6,191-acre property. The IA was surrounded by the security Buffer Zone (BZ), which contained some supporting activities, such as waste disposal, but was left mostly undisturbed.

Some buildings and infrastructure systems became contaminated. Leaking storage drums, unlined disposal trenches, surface water impoundments, and leaking underground tanks contributed to the contamination of soils at Rocky Flats. Contaminants released to the environment include, but are not limited to, plutonium-239/240, americium-241, depleted uranium and enriched uranium, carbon tetrachloride, tetrachloroethene (PCE), trichloroethene (TCE), nitrates, and chromium.

Volatile organic compounds (VOCs), nitrate, and uranium contaminated shallow groundwater. Plutonium, uranium, and americium and other hazardous substances contaminated the soils. The potential for radioactive particles on soil to become airborne during strong winds or to be transported to streams was a concern.

Investigation and cleanup of released hazardous substances, including hazardous wastes, began in the 1980s. Because environmental investigations indicated that operations at Rocky Flats resulted in the release of materials defined by CERCLA as hazardous substances, contaminants, and pollutants, as well as hazardous wastes and waste constituents as defined by RCRA and CHWA, EPA proposed Rocky Flats for inclusion on the CERCLA National Priorities List (NPL) in 1984. The listing became final in 1989.

Beginning in 1992, when weapons components production halted, the Rocky Flats mission included the safe storage and shipment of special nuclear material, nuclear deactivation and decommissioning, waste management and shipment, environmental investigations, cleanup, and

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site closure. The Rocky Flats Plant name was changed to the Rocky Flats Environmental Technology Site (RFETS) during cleanup and closure. The property is now known as the Rocky Flats Site or Rocky Flats.

As discussed in Section 1.0, DOE retains jurisdiction and control over the Central OU and that portion of the Peripheral OU that has not yet been transferred to USFWS as part of the Rocky Flats National Wildlife Refuge.

2.2 Rocky Flats Regulatory Framework

Under CERCLA, the responsibility for the response action for hazardous substance releases at Rocky Flats is delegated to DOE as the lead agency in accordance with Executive Order 12580. EPA and CDPHE are the support agencies. Under RCRA and CHWA, DOE is responsible for corrective action for releases of hazardous waste and hazardous waste constituents at Rocky Flats. In Colorado, RCRA/CHWA corrective action is regulated by CDPHE.

Investigation and cleanup activities were formally covered under three successive federal facility agreements and compliance orders, beginning in 1986 and culminating with RFCA, signed by DOE, EPA, and CDPHE in July 1996. Cleanup, closure, and selection of the final remedy in the CAD/ROD were accomplished in accordance with RFCA. The remedy is in place and EPA issued the Preliminary Close Out Report for the remedy on September 29, 2006 (EPA 2006).

On March 14, 2007, DOE, EPA, and CDPHE entered into RFLMA (DOE, EPA, and CDPHE 2007), which modifies and supersedes RFCA. RFLMA establishes the regulatory framework for implementing the final remedy for Rocky Flats, and ensuring that it remains protective of human health and environment. RFLMA Attachment 2 specifies remedy performance standards, monitoring, inspection and maintenance requirements, criteria for evaluating monitoring and inspection results, and reporting. The purpose of RFLMA Attachment 2 is to ensure the remedy remains protective of human health and the environment.

A number of modifications to RFLMA Attachment 2 requirements have been approved by EPA and CDPHE since the second five-year review. The modifications include a change of the location of the surface water Points of Compliance (POCs) inside the Central OU and the phase-out of POC monitoring locations outside of the Central OU. The modifications also include incorporation of changes to Colorado's water quality standards, changes to monitoring locations reflecting replacement wells and groundwater treatment system upgrades and optimization, and non-remedy-related surface water configuration changes in the Central OU.

On June 11, 2007, EPA certified that cleanup and closure of Rocky Flats was completed, except for operations and maintenance associated with the response actions in the Central OU, and that all response actions in the Central OU are operating properly and successfully (EPA 2007).

An amendment to the CAD/ROD was approved by EPA and CDPHE in 2011. The CAD/ROD was amended to clarify certain institutional controls related to soil disturbance and excavation and to more accurately reflect the objective and rationale of the institutional controls. RFLMA Attachment 2 was also modified to incorporate the CAD/ROD amendment requirements.

The CAD/ROD amendment and RFLMA modifications since the second five-year review are described in more detail in Section 4.0.

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3.0 Background

This section presents information on the Rocky Flats Site background, including physical characteristics, land and resource use, history of contamination, and initial responses (e.g., accelerated actions). The basis for taking action, including results of the Remedial Investigation (RI), is also presented.

3.1 Physical Characteristics

The Rocky Flats Site is located at the interface between the Great Plains and the Rocky Mountains. Approximately 2 miles west of the Site's western boundary, the foothills of the Front Range of the Rocky Mountains rise sharply above the plains. The western portion of Rocky Flats is located on a broad, relatively flat pediment that slopes eastward from these foothills. On the eastern portion of Rocky Flats, the pediment surface is dissected by small stream valleys that trend generally from the west down to the east.

The average annual precipitation at Rocky Flats is approximately 12 inches. Most precipitation falls between April and October. The mean monthly temperature ranges from a low of approximately 34 °F in January to a high of approximately 71 °F during July. High winds, sometimes in excess of 90 miles per hour, frequently buffet the Front Range during the winter months.

Elevations range from approximately 5,700 feet in the east to approximately 6,100 feet along the western edge of Rocky Flats. The topography consists of gently east-sloping flat pediment (mesa) tops that have been dissected by intermittent and ephemeral streams, resulting in moderate to steep hillsides. The primary topographic features at Rocky Flats are the Rock Creek, Walnut Creek, and Woman Creek drainages. Figure 3 shows the location of some of the key features in the Central OU described in this section. Appendix A of this report also contains RFLMA Attachment 2 figures showing other features as noted in this section.

Cleanup and closure resulted in the removal of buildings, except for the former east and west vehicle inspection sheds. Surface pavement was removed. Revegetation and erosion controls were utilized to control erosion in areas of disturbed soil and sloping surfaces. Five Functional Channels (FCs) were configured to also minimize soil disturbance and were generally placed in areas of existing major surface water drainage features. Each of the five FCs was designed to convey the 100-year storm event.

Other manmade features at Rocky Flats include protective covers constructed under approved Interim Measure/Interim Remedial Action (IM/IRA) decision documents at two landfills, the OLF (DOE 2005a) and the PLF (DOE 2004a), which were used for historical Rocky Flats Site operations. The OLF has a soil cover layer with a minimum thickness of 2 feet. The PLF cover consists of a geosynthetic clay liner, a flexible membrane liner, a geocomposite drainage layer, a cushion layer, a cobble layer, and a soil cover layer.

Between the ground surface and 3 feet below grade, essentially all structures were removed, with the exception of some utility lines less than 2 inches in diameter, the aforementioned vehicle inspection sheds, three groundwater plume collection and treatment systems and the PLF seep collection and treatment system.

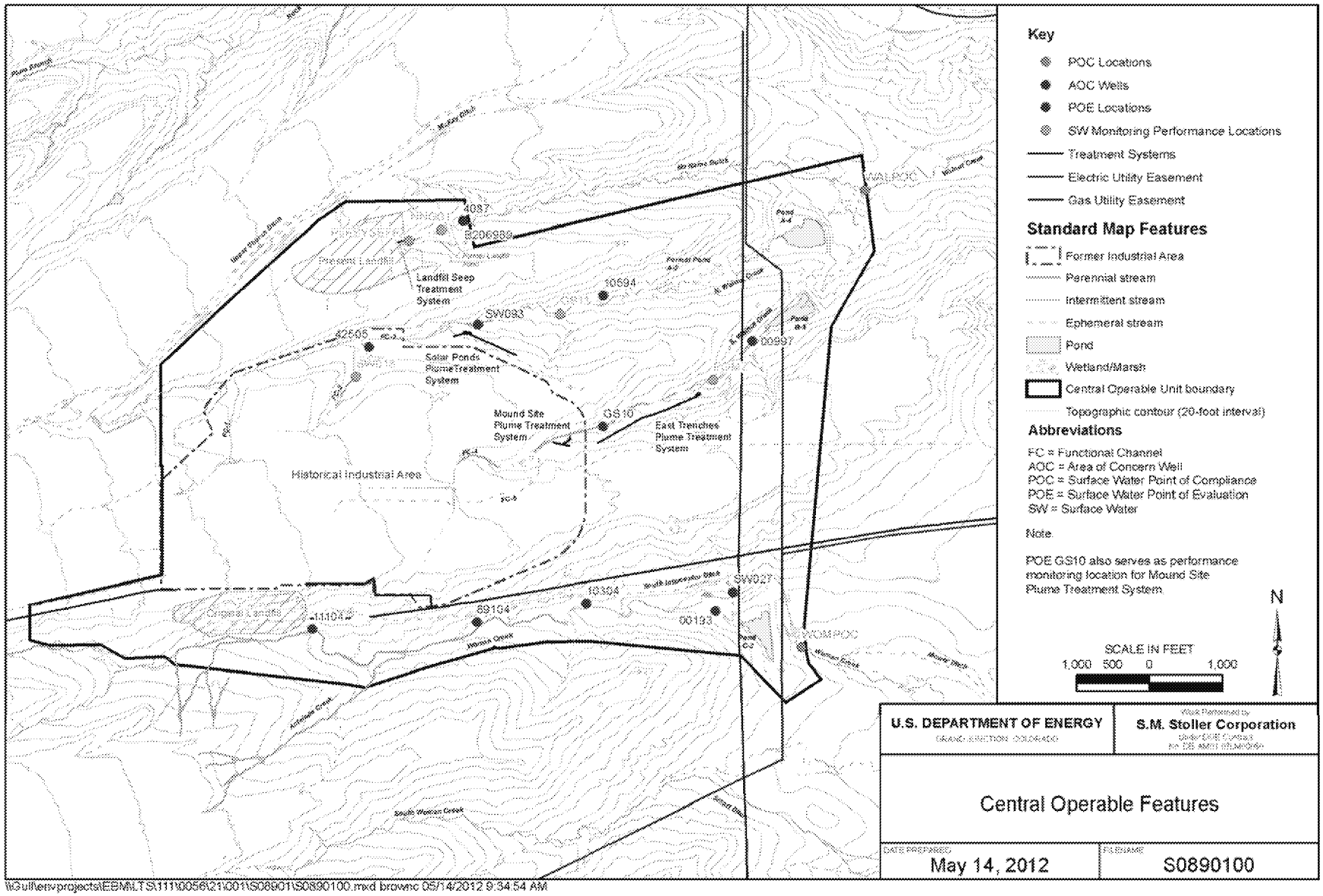

Figure 3. Central OU Features

At depths greater than 3 feet below grade, some subsurface structures remain in place. RFLMA Attachment 2, Figures 3 and 4 (Appendix A of this report), show the location of remaining historical disposal areas, building slabs, tunnels and foundations, as well as remaining valve vaults and process waste lines.

Some of these subsurface features may contain residual contamination. Portions of the former Buildings 371/374 basement and sub-basement slab/walls, the former Building 730 basement slab, the former Building 771 first and second floor slabs and walls, the former Building 771C slab, the former Building 774 first and second floor slab/walls, and the tunnel between former Buildings 771 and 776 have residual americium-241 and plutonium-239/240 contamination. The remaining contamination in these former building slabs, walls, and tunnel is fixed within the building concrete matrix after concrete surface removal by mechanical decontamination was performed to the extent practical.

Twelve dams were constructed during operation of the Rocky Flats Plant to form retention ponds for surface water management. The retention ponds are not part of the remedy.

Nine dams have been breached by constructing notches in the dam embankments, in accordance with the designs approved by the Colorado State Engineer's office. Most recently, in accordance with DOE's proposed action described in the *Surface Water Configuration Environmental Assessment and Finding of No Significant Impact* (EA) (DOE 2011b), DOE began construction to breach the PLF Dam on No Name Gulch and the A-3 Dam on Walnut Creek in January 2012. The construction work was completed on May 10, 2012. The construction work to breach seven other dams was completed as follows:

- Dams A-1 and A-2 on North Walnut Creek in 2009
- Dams B-1, B-2, B-3 and B-4 on South Walnut Creek in 2009
- Dam C-1 on Woman Creek in 2004

The remaining dams are:

- Dam A-4 on North Walnut Creek
- Dam B-5 on South Walnut Creek
- Dam C-2 in the Woman Creek drainage

DOE will breach these remaining dams to reduce or eliminate the retention of surface water to return the surface water flow configuration to the approximate conditions existing prior to construction of the dams. In accordance with the EA, DOE proposes to breach the A-4, B-5, and C-2 dams in the 2018 to 2020 time frame. Ponds A-4, B-5, and C-2, referred to as the terminal ponds, were historically operated in batch and release mode. Flow-through operation was a part of the proposed action evaluated in the EA. The A-4, B-5 and C-2 dams began to be operated in flow-through mode in the fall of 2011.

Rocky Flats is biologically diverse, reflecting its geographical setting. Five primary plant communities occur there: mesic mixed grassland, xeric tall grass prairie, wetlands, riparian woodlands, and tall upland shrubs. Grasslands are the dominant plant communities. Typical wildlife includes mammals such as mule deer, coyote, whitetail deer, black-tailed prairie dogs, foxes, elk, skunks, and a variety of rodents and other small mammals. The Preble's meadow

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jumping mouse (PMJM), a federally listed threatened species at the time of the CAD/ROD, is found along the drainages. Over 200 species of birds have been observed at Rocky Flats. A small number of reptiles and amphibians occur at Rocky Flats, including the prairie rattlesnake.

A Programmatic Biological Assessment (PBA) and accompanying Biological Opinion (DOE 2004b, 2004c; USFWS 2004a) addresses various generic site activities and include best management practices and mitigation measures. On December 15, 2010, USFWS finalized a ruling that designated critical habitat for the Preble's meadow jumping mouse (Preble's mouse; *Zapus hudsonius preblei*) at Rocky Flats (Volume 75, *Federal Register,* page 78430 [75 FR 78430]). As a result, DOE has re-initiated consultation with USFWS to amend the PBA to address the critical habitat designation, remove completed activities from the PBA, and address ongoing and future DOE activities that may take place at the site.

With regard to Rocky Flats geology, the Laramie and Arapahoe Formations are exposed at the surface or underlie the Rocky Flats Site, beneath which are the Fox Hills Sandstone and Pierre Shale. The latter formations are exposed in quarries along the western edge of Rocky Flats. Unconsolidated surficial deposits (for example, the Rocky Flats Alluvium [RFA] and the Verdos terrace alluvium) unconformably overlie bedrock. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock (Arapahoe and/or Laramie Formations) form the upper hydrostratigraphic unit (UHSU). Because of the wide extent of unconsolidated surficial materials beneath the historical IA and eastern part of the Rocky Flats Site, and their relatively high hydraulic conductivity compared to that of the underlying weathered and unweathered claystone bedrock, the unconsolidated portion of the UHSU is the primary influence on groundwater flow and contaminant transport at Rocky Flats. Groundwater flow in the UHSU generally follows Site topography.

In the western portions of Rocky Flats, where the thickness of the RFA can exceed 100 feet, the depth to UHSU groundwater is 50 to 70 feet. The depth to groundwater generally becomes shallower, and the saturated thickness becomes thinner, from west to east as the alluvial layer thins and the underlying claystones are closer to the surface. The amount of groundwater in the UHSU is limited. Although some monitoring wells in the UHSU have been estimated as capable of producing enough water for residential uses, groundwater at Rocky Flats has never been used as a drinking water source, and this use is not anticipated in the future.

The relatively small portion of infiltrating precipitation that does become shallow groundwater and that is not lost to evapotranspiration ultimately discharges to surface water. The UHSU groundwater that has been impacted by Rocky Flats activities discharges to surface water upgradient of the Central OU boundary. In addition to the UHSU, a lower hydrostratigraphic unit (LHSU) has been identified at Rocky Flats. The LHSU is composed of the unweathered Arapahoe, Laramie, and Fox Hills Formations. The upper Laramie Formation claystones of the LHSU, with low permeability, act as an effective aquitard that restricts downward vertical groundwater flow from the UHSU to the LHSU. Because the LHSU is hydraulically isolated from the UHSU, and because the LHSU does not show evidence of contamination from the UHSU, the LHSU is not a concern as a contaminant transport pathway from the Rocky Flats Site.

The removal of impervious surfaces has resulted in an increase in infiltration of precipitation and a general increase in groundwater levels in most areas since closure (though some areas had

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lower levels), consistent with the results of pre-closure modeling. There are fewer groundwater level monitoring locations for post-closure monitoring than there were for monitoring prior to closure and there are different climate periods for the pre-closure and post-closure data, so an exact comparison is not possible. However, potentiometric surface maps based on post-closure groundwater level measurements appear to indicate the groundwater flow directions are similar to pre-closure conditions (Integrated Hydro 2012). (See also Section 3.5.3).

3.2 Land and Resource Use

Rocky Flats is located at the intersection of Boulder, Broomfield, and Jefferson Counties. The communities of Arvada, Boulder, Broomfield, Golden, Leyden, Superior, and Westminster are located near Rocky Flats. The combined population of these communities, based on 2010 census data, is approximately 400,000. The population growth rate in the Denver/Boulder area in the 2010 to 2020 time frame is estimated to be about 1.5 percent (DOLA 2012).

The Central OU is surrounded by Rocky Flats National Wildlife Refuge land. Specific prohibitions on activities in the Central OU are included in the remedy as institutional controls, as discussed in Section 4.0. The Refuge boundary with the Central OU is surrounded by a barbed wire fence and five locked gates for DOE's access use. The Central OU is closed to the public, except for access under utility easements for natural gas pipelines and electric power lines that cross the Central OU (See Figure 3). No trespassing signs are posted along the Central OU boundary as physical controls, as specified in the CAD/ROD. Signs listing the institutional controls are posted at the Central OU access gates. (Photographs of the signs are included in Appendix B.)

DOE retains jurisdiction and control over the approximately 1,308-acre Central OU and approximately 948 acres in the Peripheral OU where parcels with private mineral rights exist. One active gravel mine operation is present on the south end of this area. These parcels will eventually be transferred to the Refuge. DOE retains permanent access to the Central OU through the Refuge land under the land transfer agreement with USFWS.

DOE's National Renewable Energy Laboratory wind test site is located directly northwest of Refuge and the land retained by DOE in the Peripheral OU. North of the Refuge is open space land owned and managed by the City of Boulder and Boulder County. Most of the land east of the Refuge and within the City and County of Broomfield and City of Westminster is open space property.

Management options for the Refuge were evaluated and proposed in a Comprehensive Conservation Plan (CCP). The CCP served as the Environmental Impact Statement for this action as required under the National Environmental Policy Act. The Refuge has not yet been opened for any public access. Visitor use facilities will eventually include 12.8 miles of multi-use trails, 3.8 miles of hiking-only trails, a visitor contact station, interpretive overlooks, viewing blinds, and associated access and parking facilities. Public use programs will include environmental education programs for high school and college students, a limited hunting program (two weekends per year) for youth and disabled, and interpretive programs. Visitor facilities and uses will be carefully planned to minimize impact to habitat and wildlife. The majority of the facilities will be located on previously disturbed sites. Seventy-two percent of the trails will be constructed by narrowing the width of existing gravel or dirt roads on the site. All

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of the trails in the Rock Creek drainage will be restricted to hiking only, and will be subject to seasonal closures (USFWS 2004b).

The Refuge Act imposes the following land management consequences:

- Land ownership will remain with the United States (subject to existing private subsurface mineral rights).
- The U.S. Department of the Interior (DOI), specifically USFWS, will administer the Refuge.
- The lands retained by DOE are expected to be managed in ways that are consistent with the Refuge, unless the needs of the remedy dictate otherwise.
- Property transferred to the National Wildlife Refuge will not be subject to annexation by any unit of general local government.
- Use of the land for residential, commercial, or industrial purposes will not occur, and surface water and groundwater will not be used for potable water supplies. The land is not anticipated to be used as cropland, although the CCP allows for limited livestock grazing for the purpose of vegetation management.
- The United States is prohibited from transferring any rights, title, or interest in land within the boundaries of Rocky Flats, except for the purpose of transportation improvements, which is discussed further below.

Pursuant to the Refuge Act, a strip of land up to 300 feet wide on the eastern edge of the refuge bordering the existing Indiana St. right-of way is to be made available for the sole purpose of transportation improvements. USFWS completed a final Land Protection Plan and Environmental Assessment review of the alternatives related to possible real estate transactions to implement this part of the Refuge Act. USFWS proposed to expand the administrative boundary of the Rocky Flats National Wildlife Refuge and conduct a land exchange of the transportation corridor for an interest in a parcel known as Section 16, adjacent to the southwestern side of the Refuge. According to USFWS, expanding the refuge boundary will facilitate the acquisition of this environmentally significant land. A Finding of No Significant Impact was signed by the USFWS Regional Director on December 2, 2011. The USFWS Director approved the Land Protection Plan expanding the refuge boundary and describing the specifics of the proposed land exchange on December 8, 2011 (USFWS 2011).

Historically, land around Rocky Flats consisted primarily of rangeland, preserved open space, mining areas, and low-density residential areas. However, this rural pattern is changing due to the spread of development in Superior, Broomfield, and Arvada to the north, northeast, and southeast of Rocky Flats.

State, municipality, and privately owned lands southwest and west of Rocky Flats are used for grazing, mining, and storage and conveyance of municipal water supplies. Along Highway 93, an area of land approximately 1,200 feet wide adjacent to the Rocky Flats Site's western boundary is available for eventual development, open space, or highway right-of-way.

Privately owned lands west of Rocky Flats have been permitted by the State of Colorado and Jefferson County for mineral extraction (primarily clay, sand, and gravel mining). To the south, several cattle and horse operations and small hay fields exist at present. However, mixed-use residential and commercial development is progressing to the south, as well.

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As discussed previously, shallow groundwater that has been contaminated by Rocky Flats Site-related activities becomes surface water prior to leaving Rocky Flats. Surface water in Walnut Creek is not used as a supply of drinking water in the vicinity of Rocky Flats. Water in Walnut Creek downstream of Rocky Flats may be impounded by the City of Broomfield in Great Western Reservoir for reuse as irrigation water. Surface water in Woman Creek is also not used as a drinking water supply. Water leaving Rocky Flats in Woman Creek is collected in Woman Creek Reservoir above Standley Lake. It is then held, tested, and released to Big Dry Creek below the Great Western Reservoir. Big Dry Creek flows to the South Platte River. Woman Creek Reservoir is operated by the Woman Creek Reservoir Authority, a consortium of the cities of Westminster, Thornton, and Northglenn, using funds provided by DOE.

3.3 History of Contamination

Rocky Flats was a large industrial facility, composed of over 800 structures, including several large processing facilities for plutonium and uranium. The vast majority of industrial activities (including waste disposal) took place in or near the center of the Rocky Flats Site, in the approximately 300-acre IA. Several waste disposal pits and two larger landfills are or were present at Rocky Flats.

The majority of Rocky Flats, known previously as the BZ, contained some supporting activities such as waste disposal, but was generally left undisturbed. This land provided a security and safety buffer area around the IA. Portions of the BZ were co-managed by USFWS for ecological resources beginning in 1999, prior to the incorporation of this land into the Refuge property in 2007.

Over the decades, manufacturing activities, accidental industrial fires and spills, and support activities such as waste management resulted in the release of contaminants to the air, soil, sediment, groundwater, and surface water at Rocky Flats. Some of the more noteworthy environmental incidents and practices are described below.

- Building fires occurred on a number of occasions at Rocky Flats; of these, two are most notable. On September 11, 1957, a fire occurred in a glovebox in historical Building 771 in a plutonium fabrication line. The fire and subsequent control efforts resulted in the spread of contamination within the building and breached the filter plenums. On May 11, 1969, a major fire occurred in gloveboxes in historical Building 776, started by the spontaneous ignition of plutonium, causing extensive building contamination and release of plutonium to the atmosphere. The fire led to a number of follow-on actions including use of inert atmospheres in gloveboxes, upgrades to the retention pond system, and purchase (in 1974) of additional BZ property.
- Drum storage in the area known as the historical 903 Pad, located off the southeast corner of the former IA, caused environmental contamination. The Plant stored drums containing radioactive waste on the pad beginning at least in 1958, and possibly as early as 1955. The wastes contained various hazardous constituents, including beryllium, solvents, and uranium, as well as waste oils containing plutonium-239/240. Leaking drums were discovered as early as 1959, when a rust inhibitor was added to the drum contents in an attempt to prevent further deterioration. The area was closed in April 1967 when a heavy rainstorm caused the release of more contamination from the drums. The drums were

removed in 1968, by which time numerous drums were empty, their contents having leaked entirely. Contaminated soil particles were spread by the wind and the area was covered by an asphalt pad in November 1969. The 903 Pad windblown contamination is the major source for plutonium-239/240 releases to the environment from Rocky Flats operations.

- The Plant used various disposal trenches and waste dumps during its early years. Many of these historical disposal sites, such as the Mound and Trenches T-1, T-3, and T-4, are located just northeast of the 903 Pad, in the Mound-East Trenches Area. The various disposal areas were used from approximately 1954 to 1968. Many of the wastes that ended up there originated from historical Building 444 or other buildings on the south side of the former IA. Common contaminants included depleted uranium and solvents. Uranium in drums excavated from Trench T-1 made it necessary to take precautions to prevent these drums from catching fire from spontaneous combustion. A number of these sites (the Mound Source Area and Trenches T-1, T-2/Ryan's Pit, T-3, and T-4) were remediated in the late 1990s.
- Wastewater containing nitrates and radioactive contaminants (primarily uranium) was placed in a series of solar evaporation ponds starting in 1953. The Solar Ponds were located in the northeast corner of the former IA, and they were lined with earth, clay, concrete, asphalt, and other materials at one time or another. In 1961, results from monitoring wells showed high nitrate concentrations in groundwater around the ponds, and a French drain system to capture this groundwater was installed in the 1960s. This system was replaced with an expanded version in 1980 that was subsequently upgraded in 1981 and included a pump house to route captured water for further management, treatment, or disposal. The Solar Ponds were drained and the sludge removed from them in the 1980s and 1990s, and the area was remediated in 2002.
- Two major landfills operated at the Rocky Flats Site. The first, known as the OLF, occupies approximately 20 acres on the north side of Woman Creek. The OLF operated as an unlined waste dump from the opening of Rocky Flats in 1952 until 1968. The landfill contains approximately 70,000 cubic yards of waste of various types, including construction debris, concrete, and scrap metal. The landfill also contains solvents, paints, oils, pesticides, and items contaminated with beryllium and uranium. The second landfill, known as the PLF, is located north of the former IA at the head of No Name Gulch, the drainage immediately north of North Walnut Creek. Disposal operations began there in 1968 and continued until 1998. The landfill was originally intended as a sanitary landfill to receive uncontaminated solid wastes such as office trash, construction debris, and scrap metal. However, the landfill also received hazardous wastes streams (such as paints and solvents), beryllium-contaminated materials, asbestos-containing materials, polychlorinated biphenyls (PCBs) from fluorescent light ballasts, and radioactively contaminated sludge from the Rocky Flats Sewage Treatment Plant.

During cleanup, specific locations where solid wastes, hazardous substances, pollutants, contaminants, hazardous wastes, or hazardous constituents may have been disposed or released into the environment were designated as Individual Hazardous Substances Sites (IHSSs), Potential Areas of Concern (PACs), Under Building Contamination (UBC) Sites, or Potential

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Incidents of Concern (PICs).[4] The locations of some of these areas are shown on Figure 3. Contaminants released to the environment from the activities at Rocky Flats have included, but were not limited to, radionuclides such as plutonium-239/240, americium-241, and various uranium isotopes; organic solvents such as TCE, PCE, and carbon tetrachloride; metals such as chromium; and nitrates.

3.4 Initial Response

Considerable remediation of Rocky Flats took place during the late 1990s and early 2000s under the auspices of RFCA, which adopted an accelerated action approach to the cleanup, equivalent to the removal authority found in CERCLA. Activities performed at Rocky Flats in accordance with RFCA, and to complete Site closure in general, included the following:

- All special nuclear materials were packaged and shipped to other DOE facilities, including:
  - Approximately 21 tons of weapons-grade material; and
  - Approximately 100 tons of plutonium residues and 30,000 liters of plutonium and enriched uranium solutions, which were processed to meet transportation and receiver site requirements.
- More than 800 structures were decontaminated to the degree necessary and removed, including five major plutonium facilities and two uranium facilities totaling over 1 million square feet.
- A total of 1,457 gloveboxes, many of them highly contaminated with radioactive materials, were decontaminated, removed from their buildings, and disposed of offsite.
- Six hundred ninety tanks, many of which were highly contaminated, were decontaminated, removed, and shipped offsite.
- A total of 421 IHSSs, PACs, UBC Sites, and PICs were investigated and dispositioned, either by accelerated actions or by a determination that no accelerated action was required.
- Engineered covers were installed on the PLF and the OLF.
- Three groundwater treatment systems (addressing contamination from the Solar Ponds, East Trenches disposal area, and Mound Site disposal area) and one seep treatment system (at the PLF) were installed and continue to operate; more than 11 million gallons of groundwater and 5 million gallons of seep water have been successfully treated to date.
- All waste from cleanup and closure activities was managed and packaged appropriately, and shipped for offsite disposal, including:
  - More than 15,000 cubic meters (m^3) of transuranic and transuranic mixed waste
  - More than 500,000 m^3 of low-level and low-level mixed radioactive wastes (including contaminated soils from areas such as the 903 Pad and Lip Area)
  - More than 820,000 m^3 of sanitary waste, much of it building debris
  - More than 4,300 m^3 of nonradioactive hazardous waste

[4] Over time, IHSSs, PACs, UBC Sites, and PICs totaled 421 areas requiring investigation and/or remediation. Regardless of the designation, each area was evaluated and investigated as needed. See Appendix B of the RI/FS Report for detailed information regarding each historical IHSS, PAC, UBC Site, and PIC.

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Many of these activities were achieved by or in coordination with the conduct of accelerated CERCLA and RCRA/CHWA remedial actions, using RFCA action levels (ALs). The foregoing work was completed in October 2005 (Kaiser-Hill 2005a) and accepted by DOE in December 2005 (DOE 2005b). DOE continued to prepare a final CAD/ROD and finalize regulatory requirements for the land to be retained by DOE for remedy-related purposes, and to prepare to transfer remaining portions to the USFWS for the Wildlife Refuge.

The *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study* (RI/FS Report) (DOE 2006a) analyzed Site conditions following the completion of these actions, calculated the risks posed by residual contaminants to the anticipated future land users, and evaluated alternatives for the final remedial action. The 2006 Proposed Plan for Rocky Flats (DOE 2006b) identified DOE's preferred final remedy for the Site and provided the rationale for that preference. The selected final remedial decisions for Rocky Flats are documented in the CAD/ROD (DOE, EPA, and CDPHE 2006).

3.5 Basis for Taking Action

As discussed in previous sections, DOE began more than 20 years ago to investigate and take remedial actions pursuant to CERCLA, RCRA, and CWHA to address the known or suspected release of hazardous substances at Rocky Flats.

3.5.1 Nature and Extent of Contamination

In the RI/FS Report (DOE 2006a), the nature and extent of contamination for soil, sediment, groundwater, surface water, and air were evaluated after completion of the RFCA accelerated actions. Each nature and extent of contamination evaluation identified analytes of interest (AOIs). AOIs are chemicals that have been detected at concentrations that may contribute to the risk to future receptors. The evaluation studied the extent of sitewide contaminants and evaluated which chemicals remained after the completed accelerated actions. The nature and extent of AOIs identified in the RI/FS Report are presented in Table 1.

3.5.2 Summary of Risks

The RI/FS Report (DOE 2006a) included a CRA. Details of the CRA are provided in Appendix A of the RI/FS report. The CRA was conducted in accordance with the EPA- and CDPHE-approved *Comprehensive Risk Assessment Work Plan and Methodology* (DOE 2005c). The CRA was designed to provide risk information to help select a final remedy that is adequately protective of human health and the environment.

Calculations and conclusions in the CRA were based on post-remediation data; that is, after the completion of all RFCA accelerated actions. The CRA estimated the risks posed by the site if no additional RFCA accelerated actions were taken. It provided the basis for taking additional action and identified the contaminants and exposure pathways that needed to be addressed by the selected remedial action described in the CAD/ROD.

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Table 1. Nature and Extent of Contamination

Purpose: Shows the nature and extent of the analytes of interest (AOIs) by specific medium.

Soil—Screened Against Wildlife Refuge Worker (WRW) Preliminary Remediation Goals (PRGs) (Screening methodology, standards, and results are discussed in Section 3.0 of the RI/FS Report [DOE 2006a].)				
Surface soil	**Subsurface soil (0.5–3 feet)**	**Subsurface soil (3–8 feet)**	**Subsurface soil (8–12 feet)**	**Subsurface soil (12–30 feet)**
Radionuclides				
Americium-241 Plutonium-239/240 Uranium-233/234[a] Uranium-235[a] Uranium-238[a]		Americium-241[a] Plutonium-239/240 Uranium-235[a] Uranium-238[a]	Plutonium-239/240[a] Uranium-235[a] Uranium-238[a]	
Metals				
Aluminum Arsenic Chromium (Total) Vanadium[a]	Lead[a]	Chromium (Total)[a] Lead[a]	Chromium (Total)[a]	
Volatile Organic Compounds (VOCs)				
		Tetrachloroethene[a]	Tetrachloroethene[a]	Tetrachloroethene[a] Trichloroethene[a] 1,1,2,2-Tetrachloroethane[a] Carbon tetrachloride[a] Chloroform[a] Methylene chloride[a]
Semivolatile Organic Compounds (SVOCs)				
Benzo(a)pyrene Dibenz(a,h)anthracene	Benzo(a)pyrene	Benzo(a)pyrene[a]	Benzo(a)pyrene	
Polychlorinated Biphenyls (PCBs)				
PCB-1254 PCB-1260 Dioxins 2,3,7,8-TCDD TEQ				PCB-1260

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Table 1 (continued). Nature and Extent of Contamination

Groundwater—Screened Against Surface Water Standards (Screening methodology, standards, and results are discussed in Section 4.0 of the RI/FS Report [DOE 2006a].)			
Upper Hydrostratigraphic Unit (shallow groundwater)			
Radionuclides	**VOCs**	**Metals**	**Water Quality Parameters**
Uranium (sum of isotopes)	*cis*-1,2-Dichloroethene 1,2-Dichloroethane[a] 1,1-Dichloroethene Benzene[a] Carbon tetrachloride Chloroform Chloromethane[a] Methylene chloride Tetrachloroethene Trichloroethene Vinyl chloride	Arsenic (D) Chromium (T) Nickel (D) Nickel (T)	Fluoride Nitrate/Nitrite, as N Sulfate
Lower Hydrostratigraphic Unit (deep groundwater)			
None			
Surface Water—Screened Against Surface Water Standards (Screening methodology, standards, and results are discussed in Section 5.0 of the RI/FS Report [DOE 2006a].)			
Radionuclides	**VOCs**	**Metals**	**Water Quality Parameters**
Americium-241 Plutonium-239/240 Uranium (sum of isotopes) Gross alpha Gross beta	*cis*-1,2-Dichloroethene Carbon tetrachloride Chloroform Methylene chloride Tetrachloroethene Trichloroethene Vinyl chloride	Aluminum (D) Beryllium (T) Chromium (T) Lead (T) Nickel (T)	Nitrate/Nitrite, as N
Sediment—Screened Against WRW PRGs (Screening methodology, standards, and results are discussed in Section 5.0 of the RI/FS Report [DOE 2006a].)			
Radionuclides	**Metals**	**SVOCs**	
Americium-241	Arsenic	Benzo(a)pyrene	
Plutonium-239/240	Chromium		
Air—Screened Against Air Emission Standards (Screening methodology, standards, and results are discussed in Section 6.0 of the RI/FS Report [DOE 2006a].)			
Radionuclides			
Americium-241 Plutonium-239/240 Uranium-233/234 Uranium-235 Uranium-238			

[a] Indicates those soil AOIs that have a frequency of detection less than 1 percent above the designated standard or WRW PRG and were retained based on process knowledge that indicates the analyte is associated with Rocky Flats activities (such as uranium).
D = Dissolved; T = Total; TCDD = tetrachlorodibenzo-p-dioxin; TEQ = toxicity equivalence

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The CRA Work Plan and Methodology developed screening-level human-health preliminary remediation goals (PRGs) and ecological screening levels (ESLs) for exposure to contaminants within surface and subsurface soil, sediment, surface water, and groundwater. The PRGs are in Appendix A and ESLs are in Appendix B of the CRA Work Plan and Methodology. The ecological risk assessment portion of the CRA is referred to as the "ERA." The ESLs (and associated toxicity reference values [TRVs]) used in the ERA were identified through the consultative process with members of the Risk Assessment Working Group for the RFETS (including EPA, CDPHE, and DOE representatives) and are documented in the CRA Methodology (DOE 2005c).

The PRGs and ESLs were developed based on a site-specific Site Conceptual Model, which included various exposure scenarios, exposure pathways, and receptors. As discussed in Section 3.2 above, the future land use assumptions for Rocky Flats were well documented because of the Refuge Act. The main human receptors identified in the Site Conceptual Model are a wildlife refuge worker (WRW) and a wildlife refuge visitor (WRV). Workers and visitors could theoretically contact or be exposed to contaminants in surface soil, subsurface soil, sediment, surface water, and groundwater. The WRW scenario is equivalent to the work activities of the current onsite workers in the DOE-managed Central OU.

All exposure pathways included in the Site Conceptual Model were identified as complete (meaning that exposure through the pathway was at least theoretically possible). Some pathways would result in such low exposure that there would be negligible risk even if exposure occurred and were considered insignificant pathways. Other pathways, such as ingestion of contaminated fish and ingestion of building rubble, were considered incomplete and not included in the Site Conceptual Model and were not evaluated in the CRA.

Assumptions used in the Site Conceptual Model as the basis for incomplete and insignificant pathways were subsequently incorporated as land-use prohibitions in the remedy institutional controls. The implementation of institutional controls is discussed in Section 4.4 below.

For purposes of the CRA, the Rocky Flats Site was divided into 12 Exposure Units (EUs) for assessing potential risks to human health and terrestrial ecological receptors. The EUs were designated based on known sources and potential contaminant release patterns to allow areas with similar types of potential contaminants to be evaluated collectively. Other criteria used to designate the EUs included separate watersheds, similar topography, vegetation, expected future land use, and functional areas. Functional areas refer to areas that fall within a size range where future onsite workers would likely spend their time. A sitewide analysis was also conducted for wide-ranging terrestrial receptors. Seven Aquatic Exposure Units (AEUs) were also identified for assessing potential risks to aquatic ecological receptors. AEUs were designated to represent separate drainages on the upper and lower portions of a large single drainage.

Based on the RI/FS Report, and as discussed in more detail in Section 4, the selected remedy reconfigured the Rocky Flats OU boundaries to consolidate all areas that might require controls or further remedial action into the Central OU. Areas that were not impacted by releases of hazardous substances at the Site and would not any require controls or further remedial action were merged into the Peripheral OU. The majority of the land in the Peripheral OU was subsequently transferred to the USFWS and became the Rocky Flats National Wildlife Refuge.

Figures 4 and 5 show the locations of the human health EUs and AEUs in relation to the Central OU boundary.

The surface soil and subsurface soil PRGs were used to screen the levels of residual contamination on an EU basis to identify contaminants of concern (COCs) that required further evaluation in the human health risk assessment (HHRA). The EUs, COC screening process, identified COCs, and risk evaluation are documented in the CRA. A similar screening process was used in the ERA. ESLs were used to identify ecological contaminants of potential concern (ECOPC) that were evaluated quantitatively in the ERA. The methodology and results of the ecological risk evaluation are also documented in the ERA.

Radiologically contaminated subsurface features remain in the Central OU. Under the RFCA accelerated action approach, some portions of building basements and process waste piping infrastructure were left with residual contamination 6 feet or more below the surface. The contamination is fixed within the building materials or in piping that is grouted (to the extent feasible). The decision to leave these contaminated features rather than remove them was based on an evaluation of the effectiveness, implementability, and cost for removal, pursuant to the RFCA accelerated action protocols. A comparison of these factors resulted in a RFCA regulatory determination that leaving these contaminated features in the subsurface significantly reduced potential risks to workers while maintaining adequate protection of human health and the environment. The RFCA accelerated action decisions included the requirement that these features be at least 6 feet below the ground surface.

These contaminated subsurface features were not carried through the full risk characterization as it was determined that this pathway would be incomplete for the most likely exposure scenario (a wildlife refuge worker or visitor). Consequently, the CAD/ROD includes institutional controls to prohibit excavation deeper than three feet and/or soil disturbance that would not return the surface to the preexisting grade without regulatory approval under RFLMA.

VOCs have been detected in some subsurface soil and groundwater sampling locations of Rocky Flats. While the WRW or WRV would not be directly exposed to contaminated groundwater, the VOCs contaminating the groundwater can emanate through the soil in the vicinity of the contaminated groundwater. If a building were erected over these locations in the future, the volatile chemicals may migrate through the building foundation indoors and subsequently be inhaled by people occupying the building. This exposure assumption resulted in calculation of a volatilization PRG. The indoor air inhalation pathway is potentially significant if buildings for human occupation uses were constructed in locations where groundwater contamination exceeded the volatilization PRG. For all other areas the indoor air inhalation pathway is considered insignificant.

The CAD/ROD includes an institutional control prohibiting the construction of buildings for occupation on a temporary or permanent basis to ensure the indoor air inhalation pathway remains incomplete.

The CRA identified the human health COCs and ECOPCs, and the estimated risk posed by each.

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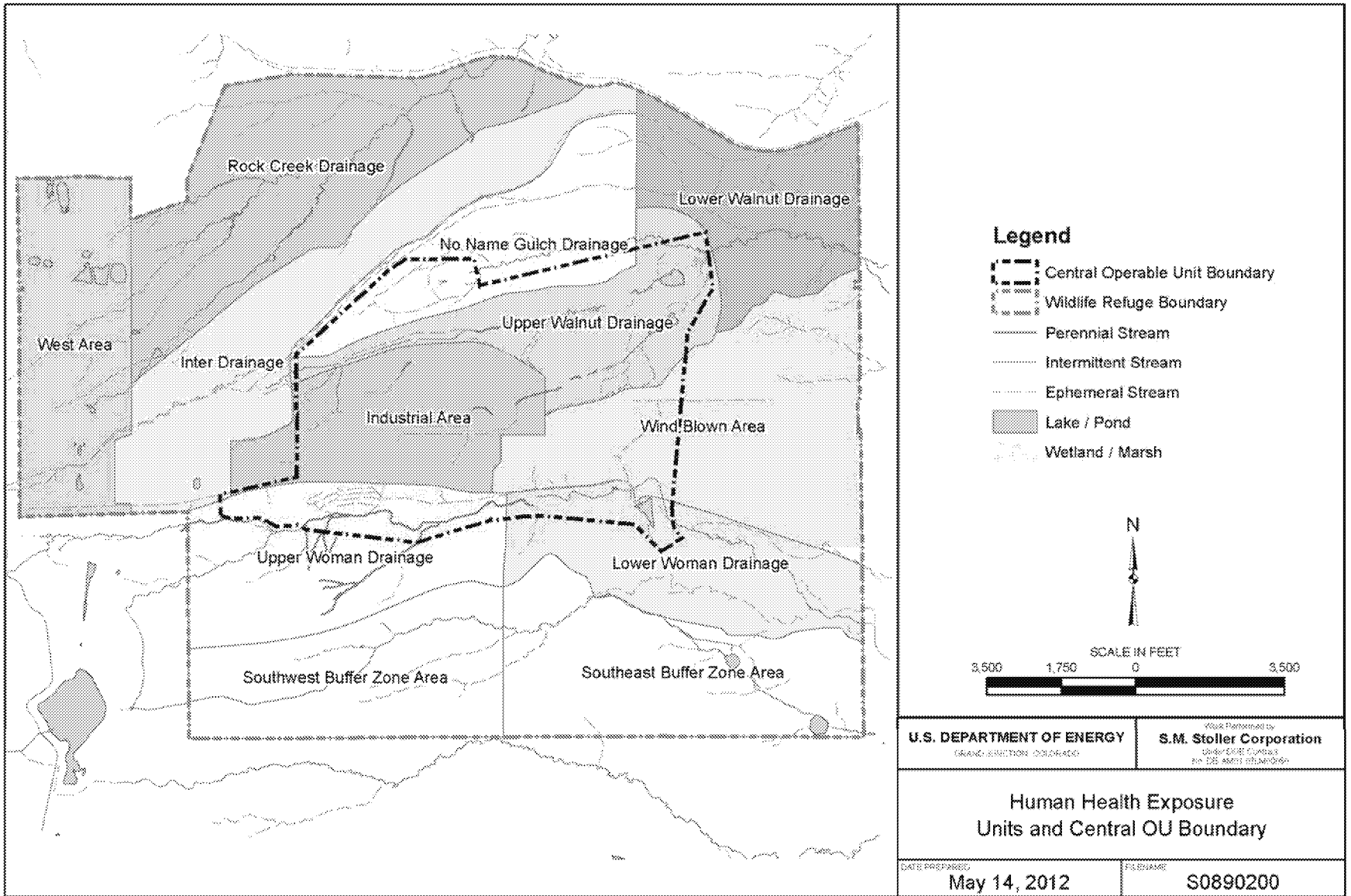

Figure 4. Human Health Exposure Units and Central OU Boundary

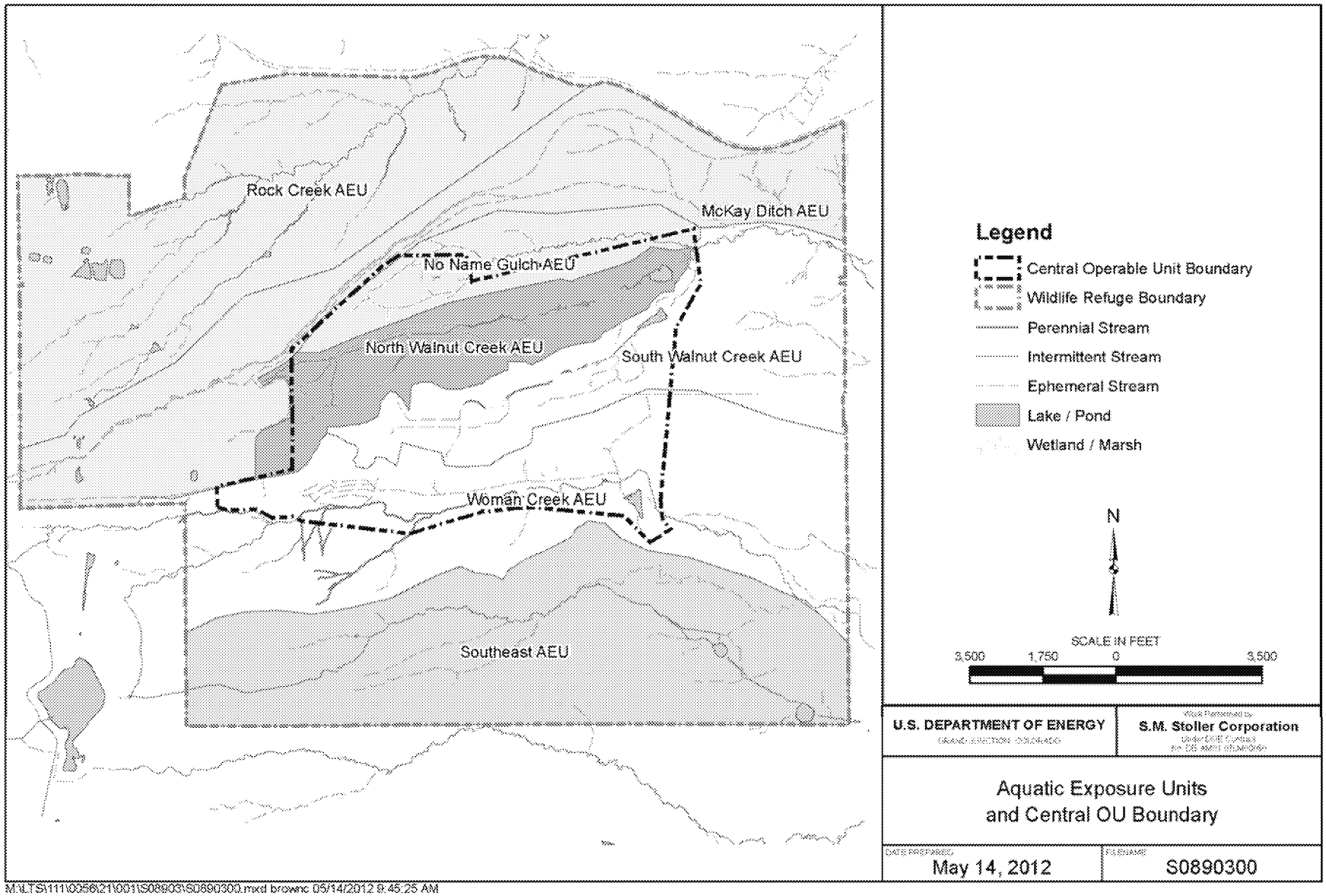

Figure 5. Aquatic Exposure Units and Central OU Boundary

In addition to human health risk calculations performed in the CRA, a radiation dose assessment for exposure to residual radionuclide contamination in surface soil and subsurface soil was also conducted. The dose assessment was conducted to demonstrate compliance with the annual dose limits in CDPHE's Radiation Control Regulations (Title 6 *Code of Colorado Regulations* 1007-1, Part 4 [6 CCR 1007-1, Part 4]), which was identified as an applicable or relevant and appropriate requirement (ARAR) in the RI/FS Report.

The results of the CRA (including the ERA) and the dose assessment are discussed in more detail below.

3.5.2.1 Human Health Risk Assessment

Under CERCLA and the NCP, EPA considers environmental concentrations corresponding to a 1×10^{-6} to a 1×10^{-4} cancer risk range and a total noncancer hazard index (HI) less than or equal to 1.0 to be adequately protective of human health. CDPHE defines acceptable human health risk as a lifetime excess cancer risk of 1×10^{-6} from exposure to carcinogenic compounds and/or a hazard quotient (HQ) less than 1.0 for noncarcinogenic compounds.

The WRW receptor scenario resulted in more conservative human health PRGs than for the WRV scenario. The PRGs are concentration levels corresponding to a lifetime excess cancer risk of 1×10^{-6} from exposure to carcinogenic compounds and/or a hazard quotient less than 0.1 for noncarcinogenic compounds for the scenario for which they are developed. Use of these conservative levels for contaminant screening ensured that all relevant constituents contributing to potential risks would be identified through this process.

Through the CRA screening process, COCs were identified for surface soil/surface sediment for 5 of the 12 EUs. A conservative approach was used to ensure that all important site-related constituents would be identified. The screening process involved the following:

- Compare the maximum detected concentration (MDC) of each potential contaminant of concern (PCOC) in soil for each EU to the soil PRGs (WRW PRGs at 1×10^{-6} of HQ of 0.1).
- If MDC > PRG, calculate exposure point concentrations (EPCs). Two types of EPCs were calculated: Tier 1 and Tier 2 (see discussion below).
- If an EPC > PRG, compare EU and background data sets.
- If a PCOC > background statistically, evaluate the weight-of-evidence to determine if the constituent needs to be included for quantitative risk evaluation and be considered as a COC.

Exposure parameters define the methods and rates at which contaminants in soil enter the body. The same exposure parameters that were used to develop the PRGs were used to determine the risk from the COC concentration levels. Exposure from radiation emitted by residual radionuclides outside the body (e.g., in surface soil) was also included in the exposure parameters.

EPCs were calculated for the identified surface soil/surface sediment COCs. The WRW exposure parameters assume the WRW will spend time in all parts of the EU. The WRW is therefore exposed to an average of the concentration over time. EPCs are an estimate of the COC average concentrations that cause an exposure.

Two types of concentration estimates were used to evaluate exposure: Tier 1 and Tier 2. Because there is some uncertainty in measuring the average concentration accurately, a value higher than the simple average is used in risk assessments. This value is the upper confidence level (UCL) of the average or mean concentration within an area. The 95 percent UCL is defined as the value that equals or exceeds the true mean of data within an EU with 95 percent confidence, and was used as the Tier 1 EPC.

The Tier 1 EPC can be an overestimate of the average if most data points in the EU are from locations with residual contamination, and few data points are from locations not impacted by contamination. A second averaging approach takes the average of the data from small subareas of the EU (in the case of Rocky Flats, 30-acre subareas) and averages all the EU subarea results. This result was used as the Tier 2 EPC.

Risk estimates for all COCs were calculated using both EPCs, and the most conservative result (i.e., highest resulting calculated risk) was used for comparison to the CERCLA risk range.

COCs were identified for surface soil/surface sediment, but not for subsurface soil/subsurface sediment at the site. COCs were identified in 5 of the 12 EUs. All groundwater pathways were incomplete and surface water pathways (ingestion, dermal) were determined to be insignificant.

Surface soil/surface sediment COCs are provided in Table 2 along with calculated risks from the CRA. These risks are based on post-remediation data and therefore are representative of current surface conditions unless otherwise indicated.

Table 2. Human Health Risk Estimates for Surface Soil/Surface Sediment COCs Following Accelerated Actions

Exposure Unit	COC	Excess Lifetime Cancer Risk		Noncancer Hazard Quotient		Comments
		Tier 1	Tier 2	Tier 1	Tier 2	
No Name Gulch Drainage	Vanadium	NC	NC	0.1	0.05	Well below HI of 1
Upper Walnut Drainage	Benzo(a)pyrene	1×10^{-6}	1×10^{-6}	NC	NC	Low end of risk range
Wind Blown Area	Arsenic	2×10^{-6}	2×10^{-6}	0.02	0.01	Comparable to background
	Plutonium 239/240	2×10^{-6}	9×10^{-7}	NC	NC	Exceeds point of departure of 1×10^{-6}
Upper Woman Drainage	2,3,7,8-TCDD TEQ	2×10^{-6}	2×10^{-6}	NC	NC	Materials no longer at surface at completion of remediation
	Benzo(a)pyrene	6×10^{-6}	2×10^{-6}	NC	NC	
Industrial Area	Arsenic	2×10^{-6}	2×10^{-6}	0.01	0.02	Comparable to background
	Benzo(a)pyrene	1×10^{-6}	2×10^{-6}	NC	NC	Not a known release area; low end of risk range

Tier 1 exposure point concentrations are based on sample means for each EU.
Tier 2 exposure point concentrations are based on area-weighted sample means for each EU.
NC = Not calculated; appropriate toxicity criteria not available
TCDD = tetrachlorodibenzo-p-dioxin
TEQ = toxicity equivalence

The Upper Woman Drainage EU risk estimate used the 2,3,7,8-TCDD TEQ and benzo-a-pyrene data for surface soils associated with the OLF existing prior to the closure of the OLF. The

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closure of the OLF included recontouring and grading the surface and covering with a 2-foot-thick soil cover. As noted in Table 2, the soil concentrations used to estimate risk are no longer on the surface.

Potential risks to human health were primarily associated with the soil ingestion pathway and, to a lesser extent, the dermal exposure pathway. Risks associated with the inhalation pathway were determined to be negligible (one to two orders of magnitude less than ingestion/dermal).

Of the five COCs, the risk management conclusion based on the HHRA identified only one COC within one EU that required further evaluation in the Feasibility Study (FS). The surface soil COC for the portion of the Wind Blown Area EU (WBEU) located within the Central OU is plutonium-239/240 with an estimated cancer risk of 2×10^{-6}. Even though the low risk level presented by this COC is protective of human health, the FS evaluated an alternative for removal of surface soil to reduce the residual plutonium-239/240 contamination to reduce the estimated risk to below 1×10^{-6}. This alternative (i.e., removing the surface soil) was not selected as part of the final remedy because it would provide only a small reduction in long-term risk (reducing the potential risk from 2×10^{-6} to below 1×10^{-6}) for a disproportionately high cost (750 percent increase in present worth cost) and would entail high short-term risks (increased worker risk and mobilization of contaminants).

For the dose assessment, the following sections in the CDPHE Radiation Control Regulations, 6 CCR 1007-1, Part 4, were identified as ARARs:

- **Section 4.61.1.2:** The maximum total effective dose equivalent (TEDE)[5] to the average member of the critical group[6] within the first 1,000 years after decommissioning must be calculated.
- **Sections 4.61.3 and 4.61.3.2:** A site may be released for restricted use so that the TEDE to the average member of the critical group will not exceed 25 millirems per year (mrem/yr). Provisions must be made for durable, legally enforceable institutional controls that provide reasonable assurance these levels will not be exceeded.
- **Section 4.61.3.3:** If institutional controls were no longer in effect, the TEDE above background is as low as reasonably achievable and would not exceed 100 mrem/yr.

The dose assessment calculations and results are presented in RI/FS Report, Section 10, Attachment 1 (DOE 2006a). The computer code RESRAD 6.3 was used for the dose calculations. Dose rate calculations were completed for the WRW as the most likely receptor (average member of the critical group). A rural resident land use scenario was also evaluated to determine the potential dose to a rural resident adult and child if the future restricted Refuge land use was no longer maintained. Calculations were completed for 5-acre parcels of land across the site (size of a "ranchette"). Conservative assumptions were used for the scenarios assessed.

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[5] "Total effective dose equivalent" (TEDE) means the sum of the deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures (6 CCR 1007-1, Part 1, sec. 1.2).

[6] "Critical group" means the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances (6 CCR 1007-1, Part 1, sec. 1.2).

The calculated dose rates show that the applicable dose limit is met for the WRW exposure scenario. The dose assessment estimated that a WRW would receive a dose of less than 1 mrem/yr through exposures to soil and sediment. Dose estimates for exposure to surface water are also less than 1 mrem/yr, which is a small fraction of CDPHE's dose limit of 25 mrem/yr. In addition, the dose limit of 100 mrem/yr if the land use was no longer restricted is met for a rural resident exposure scenario in the areas with the highest surface soil and subsurface soil residual radionuclide concentrations. The exposure scenario includes excavation of subsurface soil (contaminated with the highest residual concentrations of radionuclides) to construct a basement for a rural residence.

Deer studies (Todd and Sattelberg 2005) conducted by USFWS were used to estimate potential risks associated with exposure to radionuclides through ingestion of game animals living at the site. Results indicated no significant uptake or accumulation of radionuclides by deer from the onsite population. Only two of 454 isotopic analyses from 26 resident deer had concentrations exceeding the reporting threshold level. The reporting threshold was set roughly an order of magnitude lower than the 1×10^{-6} risk-based concentration, based on estimated risks due to human consumption. The study concluded that uptake of radionuclides was negligible and only likely to decrease in the future. Deer tissue sampling was done in 2002, prior to the completion of RFLMA accelerated actions that reduced residual radionuclide contamination. Risks based on consumption of meat from a single deer with the highest concentrations of radionuclides were estimated at approximately 7×10^{-8}. Consumption of this same amount of deer tissue yearly throughout an individual's lifetime (70 years) would result in a risk level of 4.73×10^{-6}. Though this scenario is highly unlikely, risks are within EPA's acceptable risk range.

The CRA concluded that based on the parameters and assumptions in the Site Conceptual Model, the risk from residual contamination was at the low end of the CERCLA risk range.

3.5.2.2 Ecological Risk Assessment

The overall risk management goal used in the ERA is:

> *Site conditions due to residual contamination should not represent significant risk of adverse ecological effects to receptors from exposure to site-related residual contamination.*

The ERA was designed and implemented to determine whether Rocky Flats Site conditions meet the defined goal, and evaluated both terrestrial and aquatic receptors.

The ecological Site Conceptual Model identified a variety of representative ecological receptors and pathways, both terrestrial and aquatic. Terrestrial receptors were categorized as being PMJM or non-PMJM. The ERA took a quantitative approach in evaluating soils, sediments, and surface water. Concentrations of chemicals and radionuclides in site media were compared to ESLs for representative species.

The ERA assumed that non-PMJM receptors could be exposed to any part of the terrestrial environment at the Site while the PMJM receptor would be confined to previously identified PMJM habitat "patches" within the terrestrial EUs.

Contaminants detected at the site were initially screened from ecological contaminants of interest (ECOIs) to ECOPCs using a conservative approach. Maximum detected concentrations of environmental media were first compared to ESLs to determine if there were any exceedances. Data were then screened further based on frequency of detection (>5% detects) and comparison to background (> background). Retained ECOIs were further evaluated based on an EU-wide basis using the entire dataset for a given Exposure Unit (Tier 1: equal weight to all data points; Tier 2 area-weighted: used a measure of the population mean). Constituents that passed through the screening process were considered as ECOPCs and were evaluated quantitatively in the ecological risk characterization portion of the CRA.

Potential risks were calculated for exposure of terrestrial receptors to site soils. The approach for chemical constituents relied heavily on using various benchmarks from the literature as ESLs (these "default" values were from a variety of sources, such as EPA's Eco-SSL guidance, and Sample, Opresko, and Suter II 1996). If adequate literature benchmarks were not available, EPA's Eco-SSL approach (EPA 2003) was used to calculate site-specific TRVs for representative receptors for each ECOPC. EPA guidance provides the equations for TRV calculations plus guidance on how to use and interpret toxicological data from the literature (e.g., data quality interpretation). TRV calculations included the use of both "no observed adverse effects level" (NOAEL) toxicity data as well as less conservative "lowest observed adverse effects level" (LOAEL) data. To identify ECOPCs, concentration data were screened through progressively less conservative TRVs (e.g., NOAEL-based values followed by LOAEL-based values; default benchmarks followed by more site-specific values).

TRVs for radionuclides were calculated using RESRAD-BIOTA 1.0. No ECOPCs were identified for radionuclides. Analytical data from the deer studies (Todd and Sattelberg 2005) support the conclusion that residual radionuclides are not being significantly retained by large game animals.

For aquatic receptors, surface water and sediment TRVs are based on established sediment and water quality criteria (e.g., EPA's Ambient Water Quality Criteria). These aquatic receptor TRVs are assumed to be protective of all aquatic species. The values are already expressed as concentrations that were directly compared to site surface water and sediment concentrations; receptor-specific calculations were not required (as they were with soil TRVs).

For ECOPCs that made it through the screening process, risks were quantified by calculating HQs, where HQ = exposure/TRV. HQs for terrestrial receptors are species-specific.

Soil risks for non-PMJM terrestrial receptors were determined to be none to low to moderate (some had HQs exceeding 10; all were less than 100). Risks to PMJM receptors were low to none. Further evaluations of constituents with the highest HQs were conducted using more refined or site-specific criteria. Based on this evaluation, no risks were judged to be significant enough to elevate any ECOPC to ecological contaminant of concern (ECOC) status for any terrestrial EU.

This conclusion was corroborated by a number of site-specific wildlife studies conducted at the site through the Natural Resource Compliance and Protection Program (NRCPP; Kaiser-Hill 2001). After the NRCPP was established in 1992, site ecologists conducted routine surveys to monitor the health and populations of high-visibility and sensitive wildlife groups

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such as migratory birds, game species, indicator organisms (groups that are more sensitive to contaminants and stress) and species that are afforded special protection by federal and state statutes (Kaiser-Hill 2000). These studies involved monitoring permanent transects through different habitats. These transects were surveyed monthly for more than a decade. Observations of wildlife included migratory birds, raptors, coyotes, and deer. Small mammal monitoring was also conducted in variety of habitats (Whicker et al. 1990; Whicker and Ibrahim 1991).

PMJM monitoring demonstrated that populations have not declined over recent years. Species were identified that are indicative of diverse and healthy small mammal communities (Kaiser-Hill 2001).

Overall results of the wildlife surveys indicated high species diversity and continued use of Rocky Flats by numerous vertebrate species. It was concluded that habitat quality for these species remains acceptable and that ecosystem functions are being maintained. Data collected on wildlife abundance and diversity indicate wildlife populations are stable and species richness remains high at Rocky Flats. This supports the quantitative chemical and radiological risk assessment conclusions that no significant risks are predicted for terrestrial receptor populations.

For aquatic EUs, sediment and surface water criteria for several constituents were exceeded, indicating the potential for adverse ecological effects. However, more refined analysis using additional benchmarks and considerations indicate risks are likely low. This assessment is supported by site-specific aquatic studies that included tissue analyses of aquatic organisms, aquatic population studies, bioassay analyses, waterfowl/wading bird studies, and chemical loading analyses (summarized in CRA Appendix A, Volume 15B2, Attachment 7). Studies were conducted from the early 1990s through the early 2000s. The majority of these studies support the conclusion that physical factors (e.g., flow conditions) have a more important influence on the habitat quality and prevailing ecosystem than residual site-related contamination.

The AEU assessments indicate there are no continuing, significant risks to aquatic life from residual ECOPCs due to Rocky Flats-related operations. Overall, the aquatic communities are limited by natural environmental conditions such as low flows and poor habitat characteristic of this area along the Colorado Front Range. No additional significant risks above what would be expected to be encountered in the natural environment in the vicinity of Rocky Flats are predicted for the aquatic life receptors evaluated in the ERA.

The overall conclusions of the ERA indicate Rocky Flats Site conditions do not represent a significant risk of adverse ecological effects to receptors from exposure to Rocky Flats-related residual contamination.

However, because of uncertainties due to limitations in the data (e.g., temporal and spatial limitations) for the AEUs, further monitoring was recommended to determine whether ECOPCs with somewhat uncertain risks might be of greater ecological concern than indicated by the limited data available.

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Through consultation, CDPHE, DOE, and EPA developed an ecological sampling strategy to address the uncertainties identified in the CRA for the AEUs. RFLMA Attachment 2, Table 5 (Appendix A of this report), summarizes the ecological sampling requirements that were agreed to. These sampling requirements included the following:

- Sampling of surface water and sediment for ammonia, cyanide, and radium-228 from Ponds A-4 (North Walnut Creek AEU), B-5 (South Walnut Creek AEU), and C-2 (Woman Creek AEU); and
- Surface water sampling to be conducted quarterly for a minimum of three quarters; sediment sampling to be conducted once.

Sampling was completed in 2007, and it is discussed in RFLMA Contact Record 2008-01 (contact records are discussed in Section 4.6). The results of the surface water and sediment sampling conducted in 2007 support the conclusions of the CRA. Uncertainties related to the ammonia, cyanide, and radium-228 data have been addressed and no further sampling is needed. See Section 6.5.2 for more detailed information on the 2007 sampling results.

3.5.3 Contaminant Fate and Transport

The contaminant fate and transport evaluation used information about the Rocky Flats Site physical characteristics, contaminant source characteristics, and contaminant distribution across the Site to describe how contaminants could migrate in environmental media. The primary focus, consistent with the RFCA objectives, was evaluating the potential for contaminants from any medium to impact surface water quality. Evaluation of a contaminant's fate and transport is based upon two criteria: (1) does a complete migration pathway exist based on an evaluation of contaminant transport in each environmental medium, and (2) is there a potential impact to surface water quality based on data collected at representative groundwater and surface water monitoring locations.

A complete pathway from surface soil or sediment to surface water is measured at representative surface water monitoring locations; a complete pathway from subsurface soil or groundwater to surface water is measured at representative groundwater monitoring locations (at Area of Concern [AOC] wells and Sentinel wells). AOC wells are those wells within a drainage and downgradient of a contaminant plume or group of plumes. These are locations at which migration trending may be evaluated. AOC wells are monitored to determine whether the plume(s) may be discharging to surface water in the AOC well area. Sentinel wells are typically located near downgradient edges of contaminant plumes, in drainages, and downgradient of groundwater treatment systems. Sentinel wells are monitored to determine whether concentrations of contaminants are increasing, which could indicate plume migration or treatment system problems. RFLMA Attachment 2, Figure 1 (Appendix A of this report), presents groundwater and surface water monitoring locations.

Complete pathways from surface soil/surface sediment to surface water were identified for two surface soil AOIs: americium-241 and plutonium-239/240.

Complete pathways from subsurface soil to surface water (via groundwater) were identified for five subsurface soil AOIs, all of which are VOCs. These AOIs were carbon tetrachloride, chloroform, methylene chloride, PCE, and TCE. All of these subsurface soil AOIs are associated with one or more groundwater areas, as listed below.

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Complete pathways from shallow (UHSU) groundwater to surface water were identified for 10 groundwater AOIs: uranium (sum of isotopes uranium-233/234, uranium-235, and uranium-238), *cis*-1,2-dichloroethene, carbon tetrachloride, PCE, TCE, chloroform, methylene chloride, nitrate/nitrite (as N), fluoride, and sulfate. These groundwater AOIs are primarily associated with one or more Sentinel wells (discussed in more detail in Section 4.0) in the following five groundwater areas (see Appendix A of this report, Figure 2):

- North of former Building 771
- Historical East Trenches area (downgradient portion of plume)
- Historical Solar Evaporation Ponds area and 700 Area Northeast area (downgradient portion of plume)
- Historical Mound Site/Oil Burn Pit #2 area (downgradient portion of plumes)
- Historical 903 Pad/Ryan's Pit area

The fate and transport evaluation focused on potential impacts on surface water quality. The surface water data are provided for reference because they confirm the AOIs' presence in surface water (necessary to confirm a complete pathway to surface water exists). Four surface water AOIs were observed intermittently at concentrations above the highest of the surface water standard, background, or practical quantitation limit (PQL) at representative surface water locations. These AOIs are plutonium-239/240, americium-241, uranium (sum of isotopes), and nitrate/nitrite (as N).

Inhalation of airborne contaminants was identified as a significant and complete pathway in the Site Conceptual Model. However, fate and transport was not evaluated for air AOIs because the potential contaminant exposure received by a human receptor via the airborne pathway was determined to be insignificant. Modeling of radionuclide AOIs indicates that radiation doses from post-remedy conditions will be far less than EPA's 10 mrem annual benchmark level for the airborne pathway.

3.5.4 Conclusions of the Remedial Investigation

Together, the nature and extent of contamination evaluations, results of the CRA, and contaminant fate and transport information were used to assess the extent to which residual contamination may pose a threat to human health and the environment.

Key conclusions of the RI include:

- Air emissions present no health or environmental concerns at present and anticipated future levels. The air pathway, therefore, was not evaluated in the FS.
- Because the RI concluded that the Peripheral OU poses no current or potential future threat to human health or the environment, an FS for this OU was not required and no remedial alternatives were evaluated.

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- Based on results of the RI, an FS was required for the Central OU. The specific media evaluated in the FS were:
  - Groundwater
    - Areas where contaminated groundwater may impact surface water
    - Sampling locations where groundwater contamination exceeds federal maximum contaminant levels (MCLs)
    - Sampling locations where exceedances of volatilization PRGs in groundwater indicate a potential indoor air risk
  - Surface Water
    - Surface water upstream of Ponds A-4, B-5, and C-2 (known as the terminal ponds), where some surface water monitoring results do not meet Colorado surface water quality standards for some analytes
  - Soil
    - Subsurface soil where complete pathways from subsurface soil to surface water (via groundwater) may impact surface water
    - Surface soil that may contribute to intermittent exceedances of the surface water standard for americium-241 and plutonium-239/240 upstream of the terminal ponds
    - Surface soil in the WBEU where results of the CRA indicate the potential risk to a WRW is 2×10^{-6} for plutonium-239/240
    - Subsurface soil sampling locations where exceedances of volatilization PRGs in subsurface soil indicate a potential indoor air risk

Groundwater contamination above MCLs exists in some sampling locations at Rocky Flats, generally within the groundwater plume areas (Appendix A of this report, Figure 2). Groundwater actions were implemented under RFCA to treat contaminated groundwater that may impact surface water quality, as follows:

- Installation and operation of the PLF (Seep) Treatment System (PLFTS) to treat VOCs; and
- Installation and operation of the three groundwater treatment systems: the East Trenches Plume Treatment System (ETPTS) and Mound Site Plume Treatment System (MSPTS), which are designed to treat VOCs, and the Solar Ponds Plume Treatment System (SPPTS), which is designed to treat nitrate and uranium.

Continued operation of these four systems serves to protect surface water quality over the short and intermediate term by removing contaminant loading to surface water. This protection also serves to meet long-term goals for returning groundwater to its beneficial use of surface water protection.

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4.0 Remedial Actions

This section provides details on the selected remedy for the Central OU, including the selection process used to identify the preferred remedy, implementation of the remedy, and system operations associated with the remedy.

4.1 Remedial Action Objectives

RAOs are contaminant-specific goals for the final comprehensive response action and are used in developing and evaluating remedial alternatives. The results of the RI were compared to the RAOs to determine whether additional response actions were needed to meet the RAOs. Final remediation objectives were incorporated into the CAD/ROD for the Central OU selected remedy.

RAOs provide the foundation upon which remedial cleanup alternatives are developed. Based on the results of the RI, RAOs were developed for groundwater, surface water, soil, and environmental protection as follows:

- **Groundwater RAO 1:** Meet groundwater quality standards, which are the Colorado Water Quality Control Commission (WQCC) surface water standards, at groundwater AOC wells.
- **Groundwater RAO 2:** Restore contaminated groundwater that discharges directly to surface water as base flow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable time frame. This is measured at groundwater Sentinel wells. Also, prevent significant risk of adverse ecological effects.
- **Groundwater RAO 3:** Prevent domestic and irrigation use of groundwater contaminated at levels above MCLs.
- **Surface Water RAO:** Meet surface water quality standards, which are the Colorado WQCC surface water standards (statewide basic standards or stream-segment-specific standards, including any temporary modifications).
- **Soil RAO 1:** Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.
- **Soil RAO 2:** Prevent migration of contaminants that would result in exceedances of surface water RAOs.
- **Soil RAO 3:** Prevent exposures that result in unacceptable risk to the WRW. The 10^{-6} risk level was used as the point of departure for determining remediation goals for alternatives when ARARs were not available or were not sufficiently protective because of the presence of multiple contaminants at the Rocky Flats Site or multiple pathways of exposure (40 CFR 300.430[e][2][i][A][2]). Also, prevent significant risk of adverse ecological effects.

Section 7.0 presents a discussion of the status of the RAOs at the time of the CAD/ROD and at the end of the five-year review period covered by this report.

4.2 Remedy Selection

The FS developed three alternatives for the Central OU. A detailed analysis of the Central OU remedial alternatives is provided in the RI/FS Report (DOE 2006a).[7]

4.2.1 Alternative 1, No Further Action with Monitoring

Alternative 1 consisted of the following components:

- Management of the PLF cover system and PLFTS would continue in accordance with the approved Monitoring and Maintenance (M&M) Plan (DOE 2006c). Management of the OLF cover system would continue in accordance with the approved M&M Plan (DOE 2009a).
- Management of the three existing groundwater treatment systems (MSPTS, ETPTS, and SPPTS) would continue. These systems were designed to intercept shallow contaminated groundwater and divert it to underground cells containing treatment media specific to the contaminants in the respective plumes. The MSPTS and ETPTS treat groundwater containing VOCs by passing it through a zero-valent iron media. The SPPTS treats groundwater containing nitrate and uranium by passing it through media containing sawdust (to facilitate nitrate removal) and zero-valent iron (for uranium removal).
- Surface water and groundwater monitoring as defined in the fiscal year (FY) 2005 Integrated Monitoring Plan (Kaiser-Hill 2005b).

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[7] The CRA did not specifically evaluate an unrestricted use scenario for the Peripheral OU because the Peripheral OU was unimpacted by site activities from a hazardous waste perspective (no hazardous wastes or constituents were placed in or migrated into the Peripheral OU) and only a small portion of the OU was impacted by site activities from a radiological perspective (windblown plutonium in surface soil). These conclusions are based on extensive process knowledge, a comprehensive sampling project, and studies of disturbed areas noted in historical aerial photographs. The 2006 Proposed Plan and CAD/ROD explained that, based on the levels of residual surface soil plutonium contamination in the Peripheral OU, the Peripheral OU was determined to be acceptable for all uses from a radiological perspective. The rationale for this determination was also explained in the Notice of Intent for Partial Deletion (NOIPD), section VI.A.1, Description of the Peripheral OU Remedial Investigation (RI).

As discussed in the 2006 Proposed Plan, CAD/ROD, and NOIPD, if the highest level of surface soil plutonium contamination in the Peripheral OU (20 picocuries per gram) was considered to be the average concentration in an Exposure Unit, it would correspond to a risk of approximately 1×10^{-5} for a rural resident. Though not specifically mentioned in the NOIPD, this statement is based on the Radionuclide Soil Action Level Task 3 Report, Calculations of Surface Radionuclide Soil Action Levels for Plutonium, Americium, and Uranium, completed by the regulatory agencies in 2002 (Task 3 Report). The Task 3 Report is referenced and discussed in the RI, 2006 Proposed Plan, and CAD/ROD. The rural resident was determined to be the foreseeable future land user in the unrestricted use scenario in the Task 3 Report.

The RI also evaluated compliance with the Radiation Control Regulations, 6 CCR 1007-1, Part 4, which were identified as ARARs for Rocky Flats. Based on the Task 3 Report, if the highest level of surface soil plutonium contamination in the Peripheral OU was assumed to be the average concentration, it would result in an annual dose to the rural resident that is well below the limit established by the ARAR. There are no institutional controls established for the Peripheral OU. Thus, a five-year review for the Peripheral OU is not required, because levels of residual contamination were determined to allow for unlimited use and unrestricted exposure.

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- Additional environmental sampling to further reduce uncertainties identified in the ERA portion of the CRA.
- Quarterly reporting of environmental monitoring results and timely reporting of adverse changes in Rocky Flats conditions to the regulatory agencies.

4.2.2 Alternative 2, Institutional and Physical Controls

Alternative 2, Institutional and Physical Controls, added the implementation of institutional and physical controls to Alternative 1. Institutional controls include legally enforceable and administrative land use restrictions, which are limitations or prohibitions on specific activities within designated areas of the Central OU. These restrictions ensure that the conditions remain protective for the WRW and WRV exposure scenarios and ensure the continued functioning of the remedy. Institutional controls for the Central OU are described below:

- The construction and use of buildings that would be occupied on a permanent or temporary basis (such as for residences or offices) would be prohibited. The construction and use of storage sheds or other unoccupied structures would be permitted, consistent with the restrictions below, and provided such use does not impair any aspect of the response action at Rocky Flats.
- Excavation, drilling, and other intrusive activities below a depth of 3 feet would be prohibited, except for remedy-related purposes.
- No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils would be permitted, except in accordance with an Erosion Control Plan approved by CDPHE or EPA. Any such soil disturbance would restore the soil surface to preexisting grade.
- Surface water within the Central OU above the terminal ponds would not be used for drinking water or agricultural purposes.
- The construction or operation of groundwater wells would be prohibited, except for remedy-related purposes.
- Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails, or roads), and vehicular traffic would be prohibited on the covers of the PLF and the OLF, except for authorized response actions.
- Activities that could damage or impair the proper functioning of any engineered component of the response action—including, but not limited to, any treatment system, monitoring well, landfill cap, or surveyed benchmark—would be prohibited.

Under Alternative 2, physical controls consist of signage along the perimeter of the Central OU (1) stating that the property belongs to DOE and trespassing is prohibited and (2) to notify the WRW and WRV of the institutional controls within the Central OU. Physical controls also include measures that to protect monitoring systems or other engineered portions of the remedy by controlling access. DOE would retain jurisdiction over the engineered structures and monitoring systems associated with the completed actions.

Institutional and physical controls would be inspected periodically. If evidence of activities that violate the restrictions or damage of the physical controls is found, DOE would develop a plan to correct the condition and the correction would be implemented. Inspections and corrective

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actions would be documented in an annual report to the regulatory agencies. Institutional and physical controls would be incorporated throughout the Central OU in an environmental covenant granted by DOE to CDPHE.

4.2.3 Alternative 3, Targeted Surface Soil Removal

This alternative consisted of removing the top 6 inches of soil in areas of residual surface soil contamination that have activities above the plutonium-239/240 WRW PRG concentration of 9.8 picocuries per gram (pCi/g) (based on 1×10^{-6} target risk). Surface soil over approximately 368 acres would be removed. The removed soil would be placed in shipping containers and then shipped for disposal at a permitted low-level radioactive waste disposal facility. The duration of this removal operation was estimated to be 3 years. Alternative 3 also includes implementation of the features of Alternatives 1 and 2.

4.3 Selected Remedy for the Central OU

The *Corrective Action Decision/Record of Decision for Rocky Flats Plant Peripheral Operable Unit and the Central Operable Unit* (CAD/ROD) (DOE, EPA, and CDPHE 2006) was issued September 29, 2006. The selected remedy/corrective action for the Central OU was Alternative 2, No Further Action with Monitoring, plus Institutional and Physical Controls. The selected remedy/corrective action consists of environmental monitoring and continued operation and maintenance (O&M) of engineered structures including the landfill covers and groundwater treatment systems, institutional controls, physical controls, and continued monitoring.

4.3.1 Institutional Controls

An amendment to the CAD/ROD, the *Corrective Action Decision/Record of Decision Amendment for Rocky Flats Plant (USDOE) Central Operable Unit,* was issued September 21, 2011 (DOE, EPA, and CDPHE 2011). The CAD/ROD amendment was made to clarify the description of the institutional controls pertaining to excavation, soil disturbance, and changes to engineered components because they could be misinterpreted to preclude performing work for management and maintenance of the Central OU property that was not remedy related. The CAD/ROD amendment did not change the objective and rationale of each institutional control specified in the 2006 CAD/ROD, but specified that the objective and rationale for each institutional also be incorporated into RFLMA for implementation of institutional controls.

The CAD/ROD amendment also (1) formalized certain implementation requirements for institutional controls through a Soil Disturbance Review Plan process and (2) removed the 2006 CAD/ROD requirement that any modification to institutional controls may only be made by a formal CAD/ROD amendment. Under the CAD/ROD amendment, future proposed changes to institutional controls will follow the regulations and guidance in effect at the time of the proposal, but a public review and comment period will always be provided. Table 3 lists the institutional controls described in the 2006 CAD/ROD and as clarified in the CAD/ROD amendment.

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Table 3. Institutional Controls

Original Institutional Control (IC) from *Description of the Selected Remedy/Corrective Action* (2006 CAD/ROD pp. 69–70)	**CAD/ROD Amendment IC Description**
IC 1: The construction and use of buildings that will be occupied on a permanent or temporary basis (such as for residences or offices) is prohibited. The construction and use of storage sheds or other, non-occupied structures is permitted, consistent with the restrictions contained in controls 2 and 3 below, and provided such use does not impair any aspect of the response action at Rocky Flats.	No clarification needed; description remains same as 2006 CAD/ROD.
Objective: Prevent unacceptable exposures via the indoor air pathway. **Rationale:** The analysis of the indoor air pathway in the Comprehensive Risk Assessment indicated that subsurface volatile organic compounds were at levels in certain portions of the Central OU that could pose a risk of unacceptable exposure to the WRW if occupied structures were built in these areas.	
IC 2: Excavation, drilling, and other intrusive activities below a depth of three feet are prohibited, except for remedy-related purposes and routine or emergency maintenance of existing utility easements, in accordance with pre-approved procedures.	**IC 2:** Excavation, drilling, and other intrusive activities below a depth of three feet are prohibited, without prior regulatory review and approval pursuant to the Soil Disturbance Review Plan in RFLMA Attachment 2.
Objective: Prevent unacceptable exposure to residual subsurface contamination. **Rationale:** Contaminated structures, such as building basements, exist in certain areas of the Central OU, and the CRA did not evaluate the risks posed by exposure to this residual contamination. Thus, this restriction eliminates the possibility of unacceptable exposures. Additionally, it prevents damage to subsurface engineered components of the remedy.	
IC 3: No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan (including Surface Water Protection Plans submitted to EPA under the Clean Water Act) approved by CDPHE or EPA. Any such soil disturbance will restore the soil surface to preexisting grade.	**IC 3:** No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan (including Surface Water Protection Plans submitted to EPA under the Clean Water Act) approved by CDPHE or EPA. Soil disturbances that will not restore the soil surface to preexisting grade or higher may not be performed without prior regulatory review and approval pursuant to the Soil Disturbance Review Plan in RFLMA Attachment 2.
Objective: Prevent migration of residual surface soil contamination to surface water. **Rationale:** Certain surface soil contaminants, notably plutonium-239/240, were identified in the fate and transport evaluation in the RI as having complete pathways to surface water if disturbed. This restriction minimizes the possibility of such disturbance and resultant impacts to surface water. Restoring the soil surface to preexisting grade maintains the current depth to subsurface contamination or contaminated structures.	
IC 4: Surface water may not be used for drinking water or agricultural purposes.	No clarification needed; description remains same as 2006 CAD/ROD.
Objective: Prevent unacceptable exposure to local surface water contamination above the terminal ponds. **Rationale:** While the Comprehensive Risk Assessment did not evaluate the risks posed by the use of surface water for drinking or agricultural purposes, the nature and extent of contamination evaluation in the Remedial Investigation showed that certain contaminants were found at levels exceeding standards above the terminal ponds. This restriction reduces the possibility of unacceptable exposures to future users from this source.	
IC 5: The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.	No clarification needed; description remains same as 2006 CAD/ROD.
Objective: Prevent unacceptable exposure to contaminated groundwater. **Rationale:** While the Comprehensive Risk Assessment did not evaluate the risks posed by the use of groundwater for drinking or agricultural purposes, the nature and extent of contamination evaluation in the Remedial Investigation identified areas in the Central OU where groundwater contaminants exceeded water quality standards or MCLs. This restriction reduces the possibility of unacceptable exposures to future users from this source. Additionally, it prevents the disruption of groundwater flow paths so as to avoid impacts on groundwater collection and treatment systems.	

Table 3 (continued). Institutional Controls

Original Institutional Control (IC) from *Description of the Selected Remedy/Corrective Action* (2006 CAD/ROD pp. 69–70)	**CAD/ROD Amendment IC Description**
IC6 - Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails or roads), and vehicular traffic are prohibited on the covers of the Present Landfill and the Original Landfill, except for authorized response actions.	No clarification needed; description remains same as 2006 CAD/ROD.
Objective: Ensure the continued proper functioning of the landfill covers. **Rationale:** This restriction helps ensure the integrity of the landfill covers.	
IC 7 - Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited.	**IC 7** - Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any groundwater treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited. The preceding sentence shall not be construed to prohibit the modification, removal, replacement or relocation of any engineered component of the response action in accordance with the action determinations in RFLMA Attachment 2.
Objective: Ensure the continued proper functioning of engineered portions of the remedy. **Rationale:** This restriction helps ensure the integrity of other engineered components of the remedy, including monitoring and survey points.	

Abbreviations: IC = institutional control

Note that the contaminated structures addressed by IC 2 and IC 3 were decontaminated, and piping was grouted, to the extent feasible so that the remaining contamination is well fixed on or within the structures or components.

The CAD/ROD amendment also required that the Environmental Covenant granted by DOE to CDPHE (in accordance with State law, and as specified in the 2006 CAD/ROD) be modified to reflect the institutional control clarifications. The Environmental Covenant was modified on November 14, 2011. As specified in the CAD/ROD amendment, the Environmental Covenant may also be replaced by an Environmental Use Restriction (also known as a "restrictive notice") now provided for by a July 1, 2008 amendment to State law (CRS 2008).

The Soil Disturbance Review Plan in the RFLMA Attachment 2 modification essentially formalized a process that had already been implemented by the RFLMA Parties to evaluate proposed soil-disturbing activities that are subject to institutional controls and to document regulatory approval.

4.4 Remedy Implementation

The requirements of the remedy are implemented in accordance with RFLMA and through an environmental covenant incorporating the institutional controls for the Central OU granted by DOE to CDPHE, in accordance with State law. The covenant is recorded in Jefferson County, Colorado.

RFLMA Part 5, "Regulatory Approach," provides that the RFLMA Parties will follow a consultative process in implementing the agreement.

The RFLMA Parties document decisions regarding remedy implementation in accordance with the criteria in the NCP, Title 40 CFR 300, *et seq.*, Section 300.435; and *A Guide to Preparing Superfund Proposed Plans, Record of Decision, and Other Remedy Selection Decision Documents,* OSWER 9200.1-23P, EPA 540-R98-031, July, 1999, Section 7.0, "Documenting Post-ROD Changes; Minor Changes, Explanation of Significant Differences, and ROD Amendments."

The outcome of consultation is documented in RFLMA contact records, which are posted for the public on the Rocky Flats website and made part of the post-closure Administrative Record.

When resolution of particular issues requires changes to RFLMA or RFLMA Attachments (including documents for components of the remedy incorporated by reference in a RFLMA attachment), then the RFLMA parties follow the process in RFLMA Part 10, "Amendment of Agreement and Modification to Attachments," which includes CDPHE and EPA approval, public notice, and public review and comment for significant proposed changes to RFLMA.

For the period covered by this review, no amendments to the body of RFLMA (i.e., RFLMA Parts 1–17) have been proposed or made. RFLMA Attachment 1, "Site Map," has been modified to reflect changes to surface water configuration. RFLMA Attachment 2 has been modified on four occasions to incorporate changes agreed to by the RFLMA Parties.

Appendix C provides a list of RFLMA contact records, subject matter and status as of the end of this review period. Table 4 provides a list of modifications to RFLMA Attachments made during this review period.

Table 4. Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
February 2007	Original document, effective on RFLMA effective date, March 14, 2007.	Included in original RFLMA public comment period.
March 2008	Modification to Section 5.3.2 to change reference for *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan* (PLF M&M Plan) to "as approved," to allow modification of the PLF M&M Plan, without need to update the specific date in Attachment 2 each time.	Contact record 2007-08. RFLMA Parties determined change(s) not significant.
March 2008	Modification to Table 2 regarding PLF Area sampling frequency for GWISINFNORTH and GWISINFSOUTH from "Quarterly; Monthly (if required by decision)", to "Discontinued". Table 2, Note 11, changed to add "GWISINFNORTH and GWISINFSOUTH may be used for investigative purposes."	
March 2008	Modification to Table 3 regarding frequency of PLF inspections and exit strategy to reflect reduction in frequency, based on results of inspections since closure. Based on modification of PLF M&M Plan.	

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Table 4 (continued). Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
September 2009	Modification to Section 5.3.1 to change reference for *Final Landfill Monitoring and Maintenance Plan, RFETS Original Landfill* (OLF M&M Plan) to "as approved," to allow modification of the OLF M&M Plan without having to update the specific date in Attachment 2 each time.	Contact record 2008-07. RFLMA Parties determined change(s) not significant.
September 2009	Modification to Table 1 to make standards consistent with changes promulgated by the WQCC through June 2009, as follows: • Gross alpha/beta removed from analyte list • Uranium standard changed to 16.8 micrograms per liter (µg/L) • Arsenic standard changed from 50 µg/L to 0.02–10 µg/L • Footnote [a] modified to change the reference to the December 31, 2005, effective date of the Colorado WQCC regulations to "promulgated", and added (for simplicity), "If relevant, effective date information is included in subsequent footnotes" • Deleted PRG acronym in Footnote [b] because it is not used in Table 1 • Deleted reference to segment specific ambient uranium standards in Footnote [l] and added explanation of radiological parameter units • Footnote [n] added for arsenic: "Standard is 50 µg/L until December 31, 2009. Beginning January 1, 2010, the second number in the range is applied as the applicable or corresponding Table 1 standard the flowcharts in Figures 5 through 13." This is based on footnote 13 to Table III of WQCC Regulation 31, "Water bodies will be considered in attainment of this standard, and not included on the Section 303(d) List, so long as the existing ambient water quality does not exceed the second number in the range."	Contact record 2008-09. RFLMA Parties determined change(s) not significant. Minor changes such as these (and as described in Contact record 2008-04) will be accumulated and the RFLMA Attachment 2 will be modified to incorporate the accumulated minor changes at the same time.
September 2009	Modification to Table 2 and Figure 1 to reflect changes to Table 1 for uranium and changes to monitoring locations, as follows: • U** replaced with U, and note ** referring to uranium isotopes deleted • Well 45605 removed and replaced with well 45608 • Well TH046992 removed and SPPMM01 replaced by SPOUT See RFLMA Contact Records 2007-07, 2008-04, and 2008-09.	Contact record 2008-09. RFLMA Parties determined change(s) not significant. Minor changes such as these (and as described in Contact record 2008-04) will be accumulated and the RFLMA Attachment 2 will be modified to incorporate the accumulated minor changes at the same time.
September 2009	Modification to Table 3 regarding frequency of OLF inspections and exit strategy to reflect reduction in frequency, based on results of inspections since closure and based on modification of OLF M&M Plan. See RFLMA Contact Record 2008-07. Clarified frequency for vegetation surveys and vegetation monitoring, and made PLF and OLF requirements read the same.	Contact record 2008-07. RFLMA Parties determined change(s) not significant.

Table 4 (continued). Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
September 2009	Modification of Section 5.3.7 and Table 5 to reflect completion of additional ecological sampling.	Contact record 2008-01. RFLMA Parties determined change(s) not significant.
September 2009	Modification of Section 7.2 to change reference "DOE 2006" to "as approved" for the PLF and OLF M&M Plan for consistency with modification to Sections 5.3.1 and 5.3.2.	Contact record 2008-07. RFLMA Parties determined change(s) not significant.
December 2009	Modification to Table 1, footnote [m], making 1,4-dioxane standard effective through 3/21/2012, consistent with changes promulgated by the WQCC in November 2009.	Minor changes such as these will be accumulated and the RFLMA Attachment 2 will be modified to incorporate the accumulated minor changes at the same time.
March 2011	Modification to Section 2.1 to reflect change to the surface water Recreation Classifications adopted by the Colorado WQCC, effective January 1, 2010.	Contact record 2010-04. RFLMA Parties determined the proposed modifications to water monitoring locations was a significant change. Modification based on proposed modifications released for public review and comment on July 20, 2010. The final modification reflects consideration of public comments received, and a comment responsiveness summary is included in the CDPHE and EPA approval letter.
March 2011	Modification to Section 5: • Section 5.1 revised to reflect new Points of Compliance (POCs) in Walnut Creek and Woman Creek near the Central OU boundary. The new POCs (WALPOC and WOMPOC) replace GS08, GS11, and GS31 when DOE notifies CDPHE and EPA that construction of new flumes and monitoring equipment for WALPOC and WOMPOC is complete. POCs GS01 and GS03 remain POCs for two years after WALPOC and WOMPOC become POCs. EPA or CDPHE may require DOE to submit a modification to the 2-year period in accordance with RFLMA paragraph 65. • Section 5.4.1 revised to reflect removal of Boundary wells as RFLMA monitoring points, and to move the provision for duplicate and split samples from 5.4.2 to 5.4.1. • Section 5.4.2 revised to reflect discontinuance of protocol for pond predischarge samples when Pond A-4, B-5, or C-2 are no longer operated in batch and release mode.	
March 2011	In Section 6.0, a bullet item referring to Figure 7 was changed to remove a reference to Boundary wells.	

Table 4 (continued). Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
March 2011	Modification to Figure 1, Water Monitoring Locations: • Added note that surface water POC locations GS01, GS03, GS08, GS11, GS31 will be deleted as POCs in accordance with Section 5.1. • Added note that Figure 1 reflects current surface water configuration with ponds A-3, A-4, B-5, C-2 and PLF. Former ponds A-1, A-2, B-1 through B-4, and C-1 designated as wetland/marsh. If remaining dams are breached the configuration of resulting wetland/marsh will be based on the dam breach design. • Wetland/marsh symbol added to Standard Map Features. • Deleted treatment system monitoring location PLFPONDEFF and added monitoring location NNG01. • Deleted Boundary wells 10394 and 41691. • Added new surface water POC monitoring locations WALPOC and WOMPOC. • Errata. Deleted note in Key incorrectly referencing Attachment 3.	
March 2011	Modification to Figure 2 to add "(CAD/ROD Figure 13)" to the title to show source.	
March 2011	Modification to Figures 3 and 4: • Former ponds A-1, A-2, B1 through B-4, and C-1 designated as wetland/marsh. • Wetland/marsh symbol added to Standard Map Features.	
March 2011	Modification to Figure 5 to change terminology from "compliance value" to "calculated value" in flowchart and note 1. Changed reference from "Terminal Pond POCs" and "Indiana St. POCs" to "POCs inside Central OU" and "GS01 and GS03," respectively, in note 1. Calculated value for nitrate evaluation changed to "30-day average" from "85th percentile of 30-day averages for previous calendar year".	
March 2011	Modification to Figure 6 to correct the reference in note 1. Note 2 (explanation of 30-day average calculation) and note 3 (explanation of 12-month rolling average calculation), were inadvertently reversed in the original Figure 6. Changed terminology from "compliance value" to "calculated value" in flowchart and note 1.	
March 2011	Modification to Figure 7 to remove reference to Boundary wells.	

Table 4 (continued). Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
March 2011	Modification to Figure 11 to change name of sampling location PLFPONDEFF to NNG01. Other modifications: • Deleted note 8 regarding evaluating pond operations. • Deleted reference to SPPMM01 in note 5. Replaced by SPOUT in September 2009 modification. • Deleted reference to GWISINFNORTH and GWISINFSOUTH in note 4 and in flowchart. These locations deleted in March 2008 modification of Table 2.	
March 2011	Modification to Figure 13, "Pre-discharge Pond Sampling," for discontinuance of pre-discharge sampling if ponds are not operated in batch and release mode.	
March 2011	Modification to Table 1 to delete column for Temporary Modifications [TMs] and revise footnotes [c] and [h] to reflect expiration of TMs on December 31, 2009. Also revised footnote [n] to clarify it only applies to the arsenic standard.	
March 2011	Modification to Table 2 to make it consistent with changes to Figures 1, 5, 7, 11, and 13 and Section 5. • Deleted reference to Boundary wells from note 7. • In footnote *, uranium added to list of analytes for groundwater samples that are filtered in the field using a 0.45 µm in-line filter.	
March 2011	Modification to RFLMA Attachment 1, *Site Map*, to reflect the surface water features after breaching the dams for Ponds A-1, A-2, and B-1 through B-4 in 2009.	Some of the changes suggested by commenters to the proposed RFLMA Attachment 2 modification resulted in updates to figures in RFLMA Attachment 2 containing maps of the surface water features to reflect the configuration after breaching of dams for Ponds A-1, A-2, and B-1 through B-4 in 2009. RFLMA Attachment 1, *Site Map*, was also updated to reflect the surface water features after breaching the dams for those ponds.
September 2011	Modification of Section 4.0 to allow replacing the Environmental Covenant with a restrictive notice issued by CDPHE. Specifies that institutional controls (ICs) shall be implemented to meet the objective and rationale for each IC as provided in the CAD/ROD. Adds requirements for the Soil Disturbance Review Plan documentation of RFLMA Party consultation via contact record or correspondence and posting on the Rocky Flats website for public information in accordance with the Public Involvement Plan.	Contact record 2010-02. CDPHE withdrew approval of Contact record 2010-02 to allow for further consideration of concerns raised by communities and for possible clarification of Institutional Control #2 (regarding soil excavation deeper than 3 feet) before potential reconsideration of the contact record. Modification based on proposed modifications in Attachment 1 of the *Proposed Plan for Amendment of the Corrective Action Decision/Record of Decision* released for public review and comment on June 3, 2011. The final modification reflects consideration of public comments received, and a comment responsiveness summary is included in the CAD/ROD amendment approved by EPA and CDPHE.
September 2011	Modification of Section 5.0 to provide for either a restrictive notice issued by CDPHE or an environmental covenant.	
September 2011	Modification of Table 4 to incorporate the CAD/ROD amendment description for ICs 2, 3, and 7 and to include the CAD/ROD objective and rationale for all ICs.	

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Table 4 (continued). Modifications to RFLMA Attachment 2

Date	Description of Changes	Public Participation
September 2011	The following administrative changes, not associated with the CAD/ROD amendment, were also made: • Typo in Section 5.1, ". . . DOE notification to DOE and CDPHE certifying . . ." corrected to read, ". . . DOE notification to EPA and CDPHE certifying . . ." • In Table 2 and Figure 1, deleted well number 33703 and inserted well number 33711. Well 33711 replaced well 33703 per RFLMA Contact Record 2011-02.	
September 2011	Footer date for whole document updated to September 2011 to incorporate all previous modifications, which were made by page changes. Whole document repaginated.	

Abbreviations
IC = institutional control
µg/L = micrograms per liter
POC = Point of Compliance
TM = Temporary Modifications

The *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan* (PLF M&M Plan) (DOE 2006c) and the *Original Landfill Monitoring and Maintenance Plan, Rocky Flats Site* (OLF M&M Plan) (DOE 2006d) were incorporated into the final CERCLA remedy requirements (see CAD/ROD Section 17.) The PLF M&M Plan also fulfilled the CDPHE requirements for a hazardous waste disposal facility post-closure plan in 6 CCR 1007-3 §265.118 and §265.121(a)(3).

The February 2006 OLF M&M Plan and the May 2006 PLF M&M Plan were approved prior to the CAD/ROD. The OLF M&M Plan and PLF M&M Plan are incorporated by reference as enforceable requirements of RFLMA (see RFLMA Attachment 2, Sections 5.3.1 and 5.3.2 and Table 3, "Present and Original Landfill Inspection and Maintenance Requirements").

The February 2006 OLF M&M Plan and the May 2006 PLF M&M Plan referenced RFCA in certain sections. RFLMA terminated and superseded RFCA. The M&M Plans were revised to change the original text as appropriate to recognize the implementation of the remedy under RFLMA, and as further summarized below.

The PLF M&M Plan modification (DOE 2008a) was based on the outcome of the RFLMA consultative process as documented in Contact Record 2007-08. The modification was approved on March 27, 2008. The modification incorporated changes in inspection frequencies, the completion of certain monitoring requirements, and the clarification of vegetation inspection schedules and completion criteria, as anticipated in the May 2006 PLF M&M Plan. RFLMA Attachment 2, Table 3, was also modified accordingly.

The OLF M&M Plan modification (DOE 2009a) was based on the outcome of the RFLMA consultative process as documented in Contact Record 2008-07. The modification was approved on January 25, 2010. The modification incorporated changes in inspection frequencies, the completion of certain monitoring requirements, and the clarification of vegetation inspection

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schedules and completion criteria, as anticipated in the February 2006 OLF M&M Plan. RFLMA Attachment 2, Table 3, was also modified accordingly.

The modified OLF M&M Plan also incorporated changes resulting from the implementation of the *Proposed Action Plan for Original Landfill Cover Repairs and Geotechnical Investigation* (DOE 2007c) (OLF Action Plan), approved by CDPHE on July 16, 2007. The OLF Action Plan implementation is discussed in more detail in Section 6.

As discussed previously, one CAD/ROD amendment was issued during this review period. No Explanations of Significant Differences were issued during this review period. Minor changes were documented in RFLMA contact records and modifications to RFLMA Attachments.

The Environmental Covenant between DOE and CDPHE pursuant to section 25-15-317, et seq. Colorado Revised Statutes (DOE and CDPHE 2006), granted by DOE to CDPHE on December 4, 2006, contained the CAD/ROD institutional control use restrictions, a legal description for the Central OU, and a summary description of wastes disposed of at the PLF. The covenant was modified on November 14, 2011, to include the institutional controls as described in the CAD/ROD Amendment.

Individual components of the remedy are described in more detail below. Figures and tables from RFLMA Attachments included in this report are from the Attachments that are effective at the end of this review period.

4.4.1 Institutional Controls

The CAD/ROD-required institutional controls are included in RFLMA Attachment 2, Table 4 (Appendix A of this report). Under RFLMA Attachment 2, DOE is required to employ administrative procedures to control all modifications, maintenance, or other activities involving soil disturbance and excavation within the Central OU to prevent violation of the institutional controls. DOE must also ensure that all such activities will not compromise the integrity or function of the remedy or result in uncontrolled releases of or exposures to subsurface contamination.

In addition, DOE must utilize work control procedures to help maintain the use restrictions and ensure protection of the integrity of the institutional controls. These procedures are derived from EPA and State of Colorado regulation and guidance as well as DOE Orders and guidance. The DOE Integrated Safety Management System utilizes processes such as the job hazard analysis to identify and mediate environmental, health, and safety risks to ensure all work is done in a safe and environmentally protective manner.

4.4.2 Physical Controls

Also under RFLMA Attachment 2, DOE is required to post signs legible from at least 25 feet at intervals around the perimeter of the Central OU, sufficient to notify persons that they are at the boundary of the Central OU. These signs measure at least 11 inches by 14 inches and include the following language: "U.S. Department of Energy – No Trespassing." In addition, signs listing the institutional controls use restrictions and providing contact information must be posted at access points to the Central OU. Pictures of the signs are included in Appendix B.

DOE is also required to maintain physical controls as necessary to protect engineered elements of the remedy, such as landfill covers, groundwater treatment systems, and monitoring equipment. In particular, DOE is required to implement remedy monitoring and maintenance, water monitoring, and operational monitoring, as described below.

4.5 Remedy Monitoring and Maintenance

The following specific remedy monitoring and maintenance activities are required to be conducted in accordance with RFLMA Attachment 2 requirements:

- **Landfills:** Inspection and maintenance requirements for the PLF and OLF remedies are provided in the approved Landfill M&M Plans.
- **Groundwater treatment systems:** Each system will be monitored, at a minimum, for untreated influent and treated effluent, and for impacts to surface water downstream of the effluent discharge point according to the water monitoring and sampling criteria discussed below. The systems will be maintained to ensure the effluent meets surface water standards discussed below.
- **Residual subsurface contamination:** DOE must monitor the Central OU for significant erosion annually and following major precipitation events. DOE will evaluate whether the erosion is in proximity to the subsurface features shown on RFLMA Attachment 2, Figures 3 and 4 (Appendix A of this report). Monitoring will include visual observation (and measurements, if necessary) of precursor evidence of significant erosion (cracks, rills, slumping, subsidence, and/or sediment deposition).
- **Physical controls:** DOE must inspect the condition of signs and other physical controls maintained on a quarterly basis.
- **Institutional controls:** DOE must determine the effectiveness of the institutional controls described in RFLMA Attachment 2, Table 4 (Appendix A of this report), and in the Environmental Covenant (or restrictive notice) by inspecting the Central OU at least annually for any evidence of violations of those controls. DOE will also annually verify that the Environmental Covenant (or restrictive notice) remains in the Administrative Record and on file with the Jefferson County Planning and Zoning Department.
- **Ecological monitoring:** The ERA determined that residual contamination does not represent a significant risk of adverse ecological effects. The CAD/ROD, however, required that specific additional sampling be conducted to reduce the uncertainties determined in the ERA. The required additional ecological sampling is listed in RFLMA Attachment 2, Table 5 (Appendix A of this report), and was completed during this reporting period.

4.6 Water Monitoring

Water monitoring and evaluation is required to be conducted as described below.

4.6.1 Surface Water Standards and Application to Groundwater

Protection of surface water was a basis for making soil and groundwater response action decisions during the cleanup period so that surface water on the Rocky Flats Site and leaving

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Rocky Flats would be of sufficient quality to support all uses. The applicable surface water uses are consistent with the following Colorado WQCC surface water use classifications:

- Water Supply
- Aquatic Life—Warm 2
- Agriculture
- Recreation N (North Walnut Creek, South Walnut Creek, and Pond C-2)
- Recreation E (Woman Creek)

Surface water standards are listed in RFLMA Attachment 2, Table 1 (Appendix A of this report), and are based on WQCC Regulation No. 31: Basic Standards and Methodologies for Surface Water (5 CCR 1002-31) and on the Rocky Flats-specific standards in WQCC Regulation No. 38 (5 CCR 1002-38). If the basic standard numeric values and Rocky Flats-specific standards differ, the Site-specific standard applies, except where temporary modifications are in place. At the beginning of this review period, temporary modifications applied for six organic compounds, nitrate, and nitrite, through the year 2009. The temporary modifications no longer apply. In addition to PQLs allowed by the WQCC regulations, Rocky Flats-specific PQLs may be approved by CDPHE.

The WQCC-designated groundwater use classification at Rocky Flats is surface water protection. The numeric values for measuring potential effects of contaminated groundwater on surface water quality are the surface water standards in RFLMA Attachment 2, Table 1 (Appendix A of this report).

RFLMA provides criteria and strategies for comparing surface water and groundwater analytical results to these numeric values, which are implemented through the use of a series of logic flowcharts. These flowcharts are identified in the RFLMA Attachment 2, Table 2 Notes (Appendix A of this report), and are contained in that Attachment as Figures 5 through 13 (Appendix A of this report). The same logic flowchart process was used for this third five-year review in evaluating water monitoring data, as described and discussed in more detail in Section 6.0.

4.6.2 Water Monitoring Locations and Sampling Criteria

Surface water and groundwater monitoring locations required to implement the remedy are shown on RFLMA Attachment 2, Figure 1 (Appendix A of this report). Monitoring activities are outlined in RFLMA Attachment 2, Table 2 (Appendix A of this report), and are designed to provide data that meet designated monitoring objectives to support operational and regulatory decision making. Particular aspects of the monitoring activities presented in RFLMA Attachment 2, Table 2 (Appendix A of this report), are discussed below.

4.6.2.1 Surface Water Monitoring Locations

Compliance with the surface water standards in RFLMA Attachment 2, Table 1 (Appendix A of this report), are measured at the Points of Compliance (POCs) downstream of the terminal ponds in Woman and Walnut Creeks.

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Points of Evaluation (POEs) and additional performance monitoring locations serve to monitor the quality of surface water in and flowing from the Central OU. The surface water monitoring locations for Rocky Flats are as follows:

- **POCs:** Located in Woman and Walnut Creeks at the Central OU eastern boundary and at Indiana Street.
- **POEs:** Located in the Central OU upstream of the historical retention ponds and POCs. POEs are established for the purpose of monitoring the quality of water flowing from the former Rocky Flats IA.
- **Performance monitoring locations:** Located downstream of specific remedies to determine the short- and long-term effectiveness of these remedies where known contaminants may affect surface water.

As noted in Section 4.4, a RFLMA Attachment 2 modification, dated March 2011, for changes to monitoring locations (and changes to operational monitoring discussed below in Section 4.7) was approved by CDPHE and EPA on May 2, 2011 (CDPHE and EPA 2011). The following changes to surface water monitoring locations were made:

- Designation of new POC WALPOC at the Central OU boundary, removing GS08 and GS11 as POCs in Walnut Creek, after completion of installation of the new flume for WALPOC
- Designation of new POC WOMPOC in Woman Creek at the Central OU boundary, removing GS31 as a POC at the outfall of the Pond C2 Dam upstream of WOMPOC, after completion of installation of the new flume for WOMPOC

The modification retained the Woman Creek and Walnut Creek POCs at Indiana Street (GS01 and GS03, respectively) in the Peripheral OU for a period of 2 years after the new flumes in the Central OU are operational.

In accordance with RFLMA Attachment 2, Section 5.1, "Monitoring Surface Water":

> After each new flume and associated sampling equipment is installed and tested for proper operation, DOE shall notify CDPHE and EPA that construction is complete. WALPOC will replace GS08 and GS11 on the date of the DOE notification for that location. WOMPOC will replace GS31 on the date of the DOE notification for that location. WALPOC and WOMPOC will also replace GS03 and GS01 respectively upon DOE notification to EPA and CDPHE certifying that WALPOC and WOMPOC have been functioning as POCs for at least two years.

DOE provided the notification that construction was complete to CDPHE and EPA for WALPOC on September 9, 2011 (DOE 2011c), and for WOMPOC on September 28, 2011 (DOE 2011d).

Environmental sampling, analysis, and data management must conform to the *Legacy Management CERCLA Sites Quality Assurance Project Plan* (DOE 2007d) and meet the quality assurance and quality control requirements in current EPA guidance. Standard EPA analytical methods will be used with the intent that detection limits will be less than the respective standards. If standard analytical methods cannot attain the standard, then alternative methods or PQLs will be proposed to CDPHE.

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4.6.2.2 Groundwater Monitoring Locations

Groundwater is monitored in or near areas of groundwater contamination that might adversely affect surface water quality. All groundwater emerges to surface water before leaving the Central OU. DOE must maintain a network of groundwater monitoring wells, as described below, to assess the potential effects of contaminated groundwater on surface water quality. These wells and sampling criteria are identified in RFLMA Attachment 2, Table 2 (Appendix A of this report). The groundwater monitoring classifications are as follows:

- **AOC wells:** Located within a drainage and downgradient of a contaminant plume or group of contaminant plumes. These wells are monitored to determine whether the plume(s) may be discharging to surface water.
- **Sentinel wells:** Typically located near downgradient edges of contaminant plumes, in drainages, and downgradient of groundwater treatment systems. These wells are monitored to determine whether concentrations of contaminants are increasing, which could indicate plume migration or treatment system problems.
- **Evaluation wells:** Typically located within plumes and near plume source areas, or in the interior of the Central OU. Data from these wells will help determine when monitoring of an area or plume can cease. A subset of these wells is located in areas that may experience significant changes in groundwater conditions as a result of closure activities.
- **RCRA wells:** Dedicated to monitoring the PLF and OLF.

RFLMA Attachment 2, Figure 2 (Appendix A of this report), provides the Central OU groundwater composite plume map.

4.7 Operational Monitoring

Operational monitoring is not a requirement of the CAD/ROD, but it is a requirement of RFLMA Attachment 2. Operational monitoring provides information that will supplement CAD/ROD-required monitoring. Operational monitoring consists of the following elements:

- **Pre-discharge pond sampling:** DOE will collect pre-discharge samples from Pond A-4, Pond B-5, and Pond C-2, and as needed from any other pond upstream of a POC temporarily functioning as a terminal pond when said pond is operated in batch and release mode. DOE will notify appropriate parties in accordance with RFLMA Attachment 2, Figure 13 (Appendix A of this report), in advance of pre-discharge pond sampling. Samples will be analyzed for POC constituents far enough in advance of a routine discharge to allow action to be taken if exceedances are suggested, but near enough to the time of discharge to be representative of the discharge composition. Figure 13, Pre-discharge Pond Sampling (Appendix A of this report), shows how actions are determined based on the results of pre-discharge samples. Ponds will be operated to maintain dam safety regardless of the status or results of pond sampling.
- **Duplicate or split sampling:** CDPHE and EPA will be allowed the opportunity to collect duplicate or split samples for any monitoring. This opportunity shall be coordinated in accordance with the consultative process and right-of-entry provisions in RFLMA.
- **Adverse biological conditions:** DOE will note evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) observed during other M&M activities described above.

The RFLMA Attachment 2 modification (dated March 2011 and discussed in Section 4.6.1) also modified RFLMA Attachment 2, Figure 13, to specify that pre-discharge sampling will be discontinued when batch and release operations are discontinued. Ponds A-4, B-5, and C-2 have been operated in flow-through mode since the fall of 2011.

4.8 Legacy Management Activities

The activities being conducted at Rocky Flats are now referred to as post-closure, or LM activities. As discussed in Section 3.4, the physical cleanup and closure work was completed in October 2005. Thus, post-closure or LM activities have been ongoing since that time. The CAD/ROD and RFLMA establish the regulatory requirements for the ongoing remedy-related work. For a summary of activities that are remedy related, see Section 6.8.

Not all LM activities are directly required or specifically related to the remedy, but they all are conducted pursuant to DOE's jurisdiction and control responsibilities for the Rocky Flats property. These LM activities are also related to compliance with DOE directives and use of best management practices.

During this review period LM activities included the following:

- Road maintenance repairs and upgrades are conducted to allow safe, continual access to and within the Central OU. Depending on the specific problem being addressed, the improvements involve road base, geotextile fabric, rock water crossings, and surfactant.
- Maintenance of erosion controls existing from RFCA cleanup and closure is conducted and subsequent recontouring is maintained and repaired to protect the bare soil areas until the vegetation can stabilize the soil. Areas lacking sufficient vegetative cover were reseeded and erosion controls were applied to ensure adequate establishment of the native vegetation in these areas. All areas met the revegetation success criteria during this review period. In 2009, 2010, and 2011, EPA conducted revegetation monitoring to assess the status of the revegetation efforts at the Rocky Flats Site (EPA 2009a, 2010, 2011b).
- Revegetation and weed control are being conducted to establish native vegetation species and control weeds and invasive species.
- Monitoring and reporting on PMJM habitat and wetland mitigation areas in accordance with USFWS requirements are ongoing.
- Rocky Flats property security is continually assessed.
- The three-strand barbed wire fence on the perimeter of the Central OU is maintained and repaired as required. The fence is not required by the remedy but is used to delineate the Refuge/Central OU boundary.
- Prior to completing cleanup and closure, DOE issued the October 2004 *Environmental Assessment Comment Response, and Finding of No Significant Impact, Pond and Land Reconfiguration* (DOE/EA-1492) (DOE 2004d), in which it proposed to breach Dams A-1 and A-2 and Dams B-1, B-2, B-3, and B-4). The dam breach construction work was completed in 2009.
- Breaching of the remaining dams at Rocky Flats was evaluated in the May 2011 *Surface Water Configuration Environmental Assessment and Finding of No Significant Impact*,

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DOE/EA-1747, LMS/RFS/S06335 (May 2011 EA). As discussed in Section 3.1, the PLF Dam and Dam A-3 were breached in the beginning of 2012. The A-4, B-5, and C-2 dams, known as the terminal pond dams, are scheduled to be breached in the 2018–2020 time frame. Flow-through operations began in September 2011 for Ponds A-4 and B-5, and in November 2011 for Pond C-2, after the installation of the new POCs at WALPOC and WOMPOC. The flow-through operation and breaching of the dams is intended to provide and improve wetlands and return the creeks to their approximate configuration prior to the construction of the Rocky Flats site in the 1950s.

- A water quality monitoring and data evaluation program is underway as documented in the June 2011 *Surface Water Configuration Adaptive Management Plan for the Rocky Flats, Colorado, Site* (AMP). The AMP is implemented through a cooperative approach between DOE and interested stakeholders. The AMP is to assist in deciding whether to implement the final steps of the May 2011 EA by breaching the terminal pond dams during the planned timeframe of 2018–2020, or to delay the completion of the action to gather additional information for evaluation. Ponds A-4, B-5, and C-2 are expected to be operated in flow-through condition during the period leading up to the final dam breach work. Flow-through operation will provide data that will be similar to what can be expected post-breach. The AMP involves a significant effort and includes the following:
  - Collecting samples at designated monitoring points until the AMP process is complete. These include:
    - Pre-discharge sampling before flow-through operation commenced at Terminal Ponds A-4, B-5, and C-2
    - Targeted groundwater monitoring
    - Monitoring to evaluate flow-through operations at Terminal Ponds A-4, B-5, and C-2
    - Storm-event monitoring
    - Continuous flow-paced composite sampling to evaluate uranium transport
    - Grab sampling for uranium in North and South Walnut Creeks
    - Grab sampling for nitrate + nitrite as N in Walnut Creek
  - Providing e-mail notifications to members of the public regarding sample collection and results, quarterly monitoring reports, and annual status reports, with an annual public meeting to present evaluation results.
    - In 2011, the initial year of AMP implementation, results for 238 individual samples were included in the AMP quarterly reports
  - Reviewing the AMP using a cooperative approach with stakeholders to evaluate potential AMP changes at 2-year intervals beginning in 2013 and making changes as appropriate.
  - Conducting AMP-related monitoring for up to 2 years following the final breach of the terminal dams (currently expected to occur in the 2018–2020 time frame).

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5.0 Progress Since the Last Five-Year Review

The second five-year review period ended just after the completion of cleanup and closure work and the issuance of the CAD/ROD and RFLMA. This third five-year review includes the progress made during the initial period of remedy implementation, which included maintenance, repairs, optimization and adjustments to various components of the remedy, and implementing all the recommendations resulting from the second five-year review. Appendix D contains photographs of Rocky Flats illustrating the significant changes over the period.

The protectiveness statement from the Second Five-Year Review Report follows:

> *The remedy for the Central OU is protective of human health and the environment, and exposure pathways that could result in unacceptable risks are being controlled.*

The Second Five-Year Review Report identified several issues relevant to the determination that the identified remedies and accelerated actions are protective and should be considered as the Rocky Flats Site proceeds with the cleanup pursuant to RFCA. Table 5 summarizes the issues and recommendations identified in Second Five-Year Review Report. Table 5 also shows the current status of each recommendation. Based on the results of the third five-year review, all issues from the second five-year review have been satisfactorily closed out because they have been fully addressed.

Key aspects of remedy implementation are timely evaluation of the data in accordance with decision rules specified in RFLMA, reporting conditions that require an action determination and consultation with the RFMLA regulatory agencies to decide what, if any, mitigating actions should be taken and the schedule for the actions. This means that issues are addressed and resolved as they arise and are not reserved for evaluation in the next five-year review cycle.

Appendix C provides a list of the contact records that documented the outcome of the RFLMA consultative process and Table 4 provides a list of the RFLMA Attachment 2 modifications that also were based on the outcome of the RFLMA consultative process. A CAD/ROD amendment was also approved during this review period, as discussed in Section 4.3.1.

During this review period the efficacy of these implementation practices to address a range of potential issues in a timely manner has been demonstrated to work well and to promote the continuing effectiveness of the remedy. The RFLMA consultative process also facilitates operating, maintaining, and optimizing remedy components through the use of site procedures.

All RFLMA-required periodic reporting of monitoring, maintenance, inspections, and evaluations of remedy implementation—through RFLMA quarterly and annual reports of site surveillance and maintenance activities—was completed on or ahead of schedule (see Section 6.3).

Additional ecological sampling to reduce the level of uncertainty for the ERA was completed and no further sampling is required (see Section 3.5.2.2).

The work described in the OLF Action Plan and construction to implement recommendations was completed (see Section 4.4 and Section 6.3).

Table 5. Status of the Second Five-Year Review Report Recommendations

Issue	Recommendation, Follow-Up, and Expected Completion Date	Status	Does Issue Affect Protectiveness?
GS10 Uranium Concentrations GS10, the surface water monitoring Point of Evaluation in South Walnut Creek at Pond B-1 Bypass, showed total uranium above surface water standards in 2006. Surface water discharged from the Central OU meets surface water standards. Evaluation suggests that these reportable values are due to changes in hydrologic conditions resulting in groundwater with naturally occurring uranium making up a larger proportion of stream flow at GS10.	Continue to monitor in accordance with RFLMA requirements. Employ special analytical methods to determine if natural uranium isotopic signatures have significantly changed from the levels prior to closure. This sampling and analysis are expected to be completed by the end of 2008.	Recommended sampling was completed in 2008. Showed isotopic signature consistent with pre-closure levels. Uranium concentrations returned to below the RFLMA standard in 2009. But levels again exceeded standards in April 2011, triggering further evaluation. See Table 8 for further recommendations regarding this issue.	No. While the 12-month rolling average concentration has been above the RFLMA standard of 16.8 micrograms per liter (µg/L), it has not been above the EPA's MCL of 30 µg/L. The RFLMA uranium standard was met at the downstream Point of Compliance locations throughout this review period. Los Alamos National Laboratory (LANL) analysis results from a sample taken in July 2011 had a lower percentage of natural uranium than past samples and sampling for further evaluation is ongoing.
Uranium Concentrations at OLF Wells Uranium analytical results are higher than the surface water standard in well 80205, one of three downgradient RCRA monitoring wells.	Continue to monitor the OLF in accordance with RFLMA requirements. Employ special analytical methods to determine if isotopic signatures indicate this to be predominantly natural uranium. This sampling and analysis are expected to be completed by the end of 2008.	Recommended sampling was completed in 2008. Showed isotopic signature of 100% natural uranium consistent with pre-closure levels. Natural uranium is not associated with releases of hazardous substances.	No. Well 80205 uranium concentrations remain above the uranium surface water standard of 16.8 µg/L and above the EPA's MCL of 30 µg/L, but uranium concentrations at downstream surface water performance monitoring location GS59 remain below the surface water standard.
Sentinel Well 45605 Sentinel well is located within a hillside slump south of former B991, which has moved the well casing out of vertical and the serviceability of the well is uncertain.	Continue to monitor in accordance with RFLMA. If necessary, after movement in the area stops, replace the well after regrading of the hillside has been completed. This is expected to be completed by the end of 2008.	The well was replaced by Sentinel well 45608 in 2008, after regrading of the hillside slump. However, the hillside has continued slumping and is moving the casing for Sentinel well 45608.	No. Sentinel well 45608 is still functioning and being sampled semiannually as required by RFLMA. Eventually, the well may need to be replaced or a different monitoring location selected.

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Table 5 (continued). Status of the Second Five-Year Review Report Recommendations

Issue	Recommendation, Follow-Up, and Expected Completion Date	Status	Does Issue Affect Protectiveness?
Water Quality Standards Changes Changes to RFLMA surface water standards for arsenic, copper, and uranium may be promulgated by the Colorado WQCC on the completion of the triennial review for the Big Dry Creek Basin in 2009. Also, the existing temporary modification to the standards for nitrates and certain VOCs incorporated in the RFLMA surface water standards are set to expire in 2009. The impacts of any changes to standards at the time of completion of the WQCC triennial review will depend on the results of continuing remedy implementation activities.	DOE should actively participate in the triennial review process to identify issues and collect and provide any necessary data to the WQCC for its decision-making process. The triennial review is expected to be completed by mid-2009.	DOE was a party to the triennial review process. DOE did not propose extending the temporary modifications and they expired at the end of 2009. The standard for arsenic was changed from 50 µg/L to 10 µg/L and DOE provided information regarding arsenic monitoring results during the proceeding to confirm that monitoring information showed that Rocky Flats surface water quality met the changed standard. Copper was not an issue for Rocky Flats surface water.	No. Surface water quality has not exceeded any RFLMA standards that were changed during this review period (which are based on WQCC standards) at Points of Compliance. No changed standards impacted the implementation of the remedy.
Original Landfill Cover Routine inspections have identified historical seeps and small areas of slumps and slides on the cover that need to be addressed and repaired as necessary to continue to meet cover design criteria.	Continue to monitor the OLF in accordance with RFLMA requirements. Cover repairs should be made in accordance with the OLF Monitoring and Maintenance Plan (OLF M&M Plan) so that design criteria continue to be met. Engineering evaluation to identify possible causes and approaches to address the causes should be completed. The engineering evaluation is expected to be completed by the end of 2008.	A geotechnical investigation was performed in accordance with a CDPHE- and EPA-approved investigation plan. Recommendations resulting from the investigation have been fully implemented. Construction work to regrade the west perimeter channel and improve seep drains was completed in 2008. Inspections, monitoring, maintenance, and repairs are conducted in accordance with the OLF M&M Plan. Annual review of OLF stability inspections and monitoring results has been done by a qualified geotechnical engineer for 2009–2011. These reviews confirmed the 2008 investigation findings and confirmed that the recommended maintenance activities are adequate to address the localized instability.	No. The geotechnical investigation concluded that the localized instability is result of small-scale localized slump features that appear to be originating in a weak clay layer. Large-scale failure is unlikely. Seeps, which historically intermittently expressed in this area prior to closure, are the result of precipitation water that has flowed into the OLF subsoil from upslope areas. Seeps do not impact OLF stability. Results of samples of seep water are below RFLMA standards.

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Table 5 (continued). Status of the Second Five-Year Review Report Recommendations

Issue	Recommendation, Follow-Up, and Expected Completion Date	Status	Does Issue Affect Protectiveness?
Solar Ponds Plume Treatment System Treatability Study Routine maintenance is difficult and costly.	Complete treatability study to determine whether a simpler, more efficient, and less management-intensive system could be designed and installed. Based on the results, proposed modifications should be developed in accordance with RFLMA Part 10. The study is expected to be completed by the end of 2007. Evaluation of alternatives and any proposal for recommended modifications is expected to be completed by the end of 2008.	The recommendation was actually implemented in relation to phased upgrades to the SPPTS. The phased upgrades were approved by CDPHE and EPA prior to implementation. Phase I, completed in 2007, captured more contaminated groundwater, resulting in increased flow rates to the SPPTS and higher nitrate and uranium concentrations for treatment. A pilot scale test for treatment of nitrate, known as the Phase III upgrade, was installed in 2009. The Phase II upgrade, installed at the same time as and upstream of Phase III, was intended to treat for uranium prior to the Phase III nitrate treatment. Phase II treatment did not perform as expected, with the treatment media, Zero Valent Iron (ZVI), becoming exhausted very rapidly. Phase III results demonstrated very effective nitrate treatment, but indicated that scaleup to full-scale treatment would not result in a simpler, more efficient, and less management-intensive system. The Phase II and III results have been evaluated and the Phase IV recommendation will be implemented after RFLMA Party consultation and approval by CDPHE and EPA.	No. Uranium and nitrate concentrations do not exceed RFLMA standards at the downstream Point of Compliance. The SPPTS effluent exceeds RFLMA standards, but the original design criteria for the system were to reduce loading to surface water and that objective continues to be met. The results of pilot scale testing for nitrate treatment do not indicate a simpler, less management-intensive system is feasible for nitrate. Since the nitrate standard of 10 milligrams per liter (mg/L) is applied at the intake to drinking water system (and there is none downstream of Rocky Flats), the current SPPTS effluent nitrate concentration does not result in any exceedance of the standard at the Central OU boundary. Improvements to uranium treatment resulted from the phased upgrade optimization studies. The improvements being evaluated involve downsizing the cell containing ZVI media to minimize the groundwater passivation or oxidation of the iron before its effective uranium removal capacity is reached. The RFLMA Parties will use the consultative process to determine implementation of improvements.

Abbreviations
LANL = Los Alamos National Laboratory
µg/L = micrograms per liter
mg/L = milligrams per liter

6.0 Five-Year Review Process

This section describes the third five-year review process components used to gather information to assess the continuing protectiveness of the implemented remedy. As discussed in Section 3.4, the cleanup and closure activities required under RFCA were completed in October 2005 and the post-closure activities, including water monitoring, have been ongoing since that time. The September 2006 CAD/ROD and the March 2007 RFLMA, as amended and modified during this review period, establish the regulatory requirements to implement the remedy.

To recap, the selected remedy for the Central OU is institutional and physical controls, with continued monitoring. The remedy decision is discussed and described in more detail in Section 4.0 of this report.

The five-year review process looks at conditions in the Central OU based on documents and other sources described in this report for comparison to the remedy design goals and objectives.

6.1 Administrative Components

The Rocky Flats CERCLA five-year review team consisted of personnel from DOE, CDPHE, EPA, and DOE's LM contractor, the S.M. Stoller Corporation.

The Second Five-Year Review Report was approved by EPA on September 14, 2007. The schedule to complete the third five-year review was based on second five-year review period and designed to allow timely submittal of the DOE report to EPA for EPA approval by September 14, 2012. The five-year review planning process began in September 2011 for the following tasks:

- Community Involvement
- Document Review
- Data Review
- Site Inspection
- Five-Year Review Report Preparation

6.2 Community Notification and Involvement

Notice was published in two local newspapers of general circulation, the *Boulder Daily Camera* on September 8, 2011, and the *Broomfield Enterprise* on September 10, 2011, that the Rocky Flats five-year review process had begun. On September 7, 2011, a page on the Rocky Flats public website was set up with a Fact Sheet describing the Rocky Flats Site's CERCLA review process, links to EPA's five-year review guidance, the Second Five–Year Review Report, the Rocky Flats site contacts for obtaining information and the address to submit questions or comments related to the five-year review. The Rocky Flats public website also contains links to the Rocky Flats Site CERCLA pre-remedy decision and post-remedy decision Administrative Record.

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The review team gave an initial public presentation at the September 12, 2011, Rocky Flats Stewardship Council[8] (RFSC) meeting, which was open to the public. The public was notified of this presentation in newspaper notices, as well as on the Rocky Flats and RFSC public websites. This presentation included an overview of the review process and a question and answer period.

Public presentations were also given at subsequent RFSC meetings on November 14, 2011, and February 6, 2012, to provide the status of the third five-year review, preparation of the review report, and availability of information on the Rocky Flats public website, and to provide question and answer periods. These public presentations were also posted to the Rocky Flats public website five-year review page.

Questions regarding the content of the report and whether a formal public review and comment period would be provided for the report were raised by some RFSC members during the September 12, 2011, meeting. The review team responded that a formal public review and comment period is not required for five-year reviews, no formal review was planned for, and the content of the report was planned to follow the EPA guidance. However, the public was invited to submit questions and comments to the e-mail address provided in the newspaper notices for the RFSC presentations and listed on the Rocky Flats public website five-year review page.

EPA guidance includes consideration of the need for interviews with local residents or other stakeholders to identify issues that might be included in the review. The RFLMA Parties keep the public informed by making all RFLMA required reports and contact records available on the Rocky Flats public website, making quarterly presentations at RFSC meetings, holding periodic technical meetings with interested stakeholders, and providing formal public review and comment periods as required for proposed RFLMA modifications and CAD/ROD amendments. These comment periods included extensive formal public review and comment periods from early 2010 through mid-2011 regarding non-remedy-related proposed changes to the Site surface water configuration and an associated adaptive management plan, and remedy-related modifications to RFLMA monitoring locations, as well as clarifications of CAD/ROD required institutional controls. Based on these continual public participation activities and the steps taken to inform the public about this review, the review team concluded specific interviews were not needed.

Some comments and questions related to the five-year review were directed to the RFLMA Project Coordinators in meetings with stakeholders, such as the RFSC meetings, during the review period.

Also, while specific interviews were not conducted, the RFLMA Parties were aware of several press reports at the end of 2011 and the beginning of 2012 related to residual levels of plutonium in soil in eastern edge of the Peripheral OU and OU 3. The reports were related to public controversy over the USFWS proposed action to transfer the strip of land on the eastern edge of the Refuge for a transportation corridor as provided in the Refuge Act. The USFWS proposal is discussed in more detail in Section 3.2.

[8] The RFSC was formed in March 2006 and is managed by a Board of Directors. Membership includes elected officials from counties and cities surrounding Rocky Flats, as well as three community organizations and one individual. The Board of Directors meets quarterly and partners with DOE and USFWS to provide periodic updates to the community about issues related to the management of Rocky Flats.

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Appendix E provides the five-year review Public Participation Summary. While this third five-year review is for the remedy in the Central OU, DOE believes it would be helpful to provide information and references of studies related to residual plutonium contamination in soil on land east of the Refuge, so that information is also included in Appendix E.

No significant issues regarding the review scope or process were identified through community feedback during the review period. No written comments or questions regarding the review scope or process were submitted to the DOE address for submittal of comments during the review period.

6.3 Document Review

The documents listed below are relevant to the selected remedy and served as the key references used to assess remedy performance and controls in relation to the remedy goals and objectives.

***RCRA Facility Investigation-Remedial Investigation/Corrective Measures Study-Feasibility Study Report for the Rocky Flats Environmental Technology Site* (RI/FS Report) (DOE 2006a):** The RI/FS Report, which is discussed in more detail in Section 3.0 of this report, contains information on the identification and locations of hazardous substances that remained in the Central OU upon the completion of cleanup and closure activities conducted under RFCA. Groundwater and surface water monitoring data in the RI/FS Report are for the period through July 31, 2005. Sediment monitoring data are also through July 31, 2005. Sampling for these media that was required by the CAD/ROD and RFLMA is discussed further in Section 6.6.

Soil monitoring data in the RI/FS Report reflect the conditions after completion of all RFCA investigations and accelerated actions and are for the period through August 22, 2005, when these accelerated actions were completed. Air monitoring data are for the period ending October 31, 2005. Continuing periodic soil monitoring or air monitoring is not required in the CAD/ROD (DOE, EPA, and CDPHE 2006).

RAOs to address the risks posed by remaining hazardous substances were developed in the RI/FS Report and remedy alternatives were evaluated, resulting in a proposed alternative to be selected as the remedy. The RAOs also included identified ARARs to be achieved for use in evaluation of remedy alternatives. ARARs are discussed further in this section and RAOs are discussed further in Section 7.0 of this report.

In addition to the above information, several components of the RI/FS Report are of particular interest in this five-year review as described below:

- **CRA and CRA Methodology:** An evaluation, including a quantification when required, of the risks posed by remaining hazardous substances to human health and the environment is presented in the CRA. The CRA includes an HHRA and an ERA (hereinafter, reference to the CRA includes the HHRA and the ERA, unless the terms are specifically limited in the text). The exposure scenario and exposure parameters used in the CRA were developed and documented in the CRA Methodology (DOE 2005c).

  These documents are relevant to evaluate whether any changes to cancer slope factors and toxicity factors that were used to identify human health COCs or toxicity factors used to identify ECOPCs may affect protectiveness of the remedy. In addition, differences between

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the implemented remedy exposure parameters and the exposure parameters used in the CRA Site Conceptual Model may affect protectiveness of the remedy.

- **O&M Costs**: Projected costs to implement each remedial alternative are presented in the RI/FS Report and the CAD/ROD. The projected cost of implementing the selected remedy versus the actual implementation cost may provide an indication of whether the remedy is performing as expected.

***Rocky Flats Environmental Technology Site Proposed Plan* (DOE 2006b):** The 2006 Proposed Plan was based on the results of the RI/FS Report. The 2006 Proposed Plan summarizes the remedial alternatives evaluation and presents DOE's proposed alternative to be selected as the remedy for public review and comment. The 2006 Proposed Plan includes the RAOs developed in the RI/FS Report.

***Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (DOE, EPA, and CDPHE 2006):** The 2006 CAD/ROD selected the remedy currently being implemented at Rocky Flats. The 2006 CAD/ROD finalized the RAOs, including identified ARARs to be achieved by the selected remedy. The 2006 CAD/ROD contains information regarding the objective and rationale for each of the institutional controls established for the final remedy, which also are relevant in assessing remedy performance. The ARARs review is discussed in more detail below. As discussed in Section 4.4.1, an amendment to the 2006 CAD/ROD was approved in 2011, and is referenced below.

***Rocky Flats Legacy Management Agreement* (DOE, EPA, and CDPHE 2007):** RFLMA is the regulatory framework for implementing the final response action selected and approved in the CAD/ROD, and ensuring that it remains protective of human health and the environment. In particular, RFLMA Attachment 2, "Legacy Management Requirements," specifies the requirements to ensure continuing protectiveness, which are thus relevant to this five-year review assessment of performance. RFLMA Attachment 2 specifies:

- Remedy performance standards and requirements, including surface water standards
- Physical controls, including engineered remedies and signs
- Monitoring requirements, including for surface water, groundwater, remedy monitoring and maintenance, and operational monitoring
- Action determinations
- Periodic inspections and reporting requirements, including quarterly and annual reports (described in more detail below)
- CERCLA five-year review requirements

Modifications to RFLMA Attachment 2 were approved during this reporting period, as summarized in Section 4.4.

RFLMA quarterly and annual reports of site surveillance and maintenance activities (DOE 2007e, 2007f, 2008b, 2008c, 2008d, 2008e, 2009b, 2009c, 2009d, 2009e, 2010a, 2010b, 2010c, 2010d, 2011e, 2011f, 2011g, 2011h, 2012a, 2012b): In accordance with RFLMA Attachment 2, Section 7.0, "Periodic Reporting Requirements," periodic reporting is done to

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provide CDPHE, EPA, and the public with updated information pertaining to the surveillance and maintenance of the remedy. Reports are posted on the Rocky Flats public website and are available for regulatory and public review in accordance with the following schedule:

- Quarter ending March 31 posted by July 15
- Quarter ending June 30 posted by October 15
- Quarter ending September 30 posted by January 15
- Year and Quarter ending December 31 posted by April 30

The following topics are included in quarterly reports:

- Surface water monitoring data
- Groundwater monitoring data
- Groundwater treatment system monitoring data
- Ecological sampling data (sampling requirements completed in 2007)
- Adverse biological conditions (if any observed)
- Inspection reports (for the landfills and the annual inspection)
- Summary of maintenance and repairs

The following topics are included in annual reports (along with quarterly report information for the previous quarter):

- Discussion of surface water monitoring data
- Discussion of groundwater monitoring data
- Discussion of groundwater treatment system monitoring data
- Discussion of ecological sampling data (sampling requirements completed in 2007)
- Summary of actions taken in response to any reportable conditions
- Verification of the Environmental Covenant and evaluation of the effectiveness of institutional controls
- Assessments of analytical data, including laboratory audits
- Other conditions or actions taken that are pertinent to the continued effectiveness of the remedy

In addition to posting the RFLMA required quarterly and annual reports to the Rocky Flats public website, a public briefing summarizing the contents of the reports is presented at the RFSC's next scheduled meeting. The public briefing slides are also posted to the Rocky Flats Public website. The reports and briefings are also placed in the Administrative Record.

Note that the remedy performance monitoring data for this third five-year review period is for the period from January 1, 2007, through December 31, 2011 (unless data after December 31, 2011, is included because it is available and pertinent). These data are provided and evaluated in the reports required to be submitted between July 15, 2007, through April 30, 2012. The site inspection required by EPA's guidance for this review period was

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performed on March 12, 2012, and is discussed in this Third Five-Year Review Report. It will also be included in the RFLMA quarterly report due to be posted by July 15, 2012.

High-Resolution Inductively Coupled Plasma/Mass Spectrometry (HR ICP/MS) and Thermal Ionization Mass Spectrometry (TIMS) Analyses: Prior to Site closure, groundwater and surface water samples from select locations were sent to the Los Alamos National Laboratory (LANL) for HR ICP/MS analysis, TIMS analysis, or both. These analytical methods measure mass ratios of four uranium isotopes (masses 234, 235, 236, and 238). Isotopic ratios provide a signature that indicates whether and to what extent the source of uranium is natural or anthropogenic (manmade).

The results of all the pre-closure HR ICP/MS and TIMS analyses are summarized in a report titled Quantitative Evaluation of Mixture Components in RFETS Uranium Isotopic Analyses: Development & Verification/Validation of Calculations Using an Excel Spreadsheet (LANL 2006) (included in RI/FS Report, Section 8, Attachment 3). During this review period, samples from certain RFLMA surface water and groundwater monitoring locations and other locations selected to provide evaluation information were sent to LANL to determine post-closure percentages of natural and anthropogenic uranium (LANL 2007, 2008a, 2008b, 2010, 2012).

***Proposed Plan for Amendment of the Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (DOE, EPA, and CDPHE 2011b):** The 2011 Proposed Plan provided information supporting an amendment of the CAD/ROD to clarify the wording of institutional controls to more accurately reflect the objective and rationale of the institutional controls, as stated in the CAD/ROD. The objective and rationale for each institutional control was not proposed to change. It also proposed a regulatory review and approval process to be included in RFLMA Attachment 2 to implement institutional controls.

The 2011 Proposed Plan also discussed either amending the December 4, 2006, Environmental Covenant or issuing a restrictive notice to incorporate the CAD/ROD amendment institutional control clarifications. Finally, it provided that any future proposed modification or termination of institutional controls would follow CERCLA post-remedy decision-making regulations and guidance in effect at that time.

***Corrective Action Decision/Record of Decision Amendment for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (DOE, EPA, and CDPHE 2011a):** The CAD/ROD was amended as discussed in the 2011 Proposed Plan discussed above.

***Environmental Covenant Between DOE and CDPHE pursuant to §25-15-321, Colorado Revised Statutes* (DOE and CDPHE 2011):** The November 14, 2011, covenant granted by DOE to CDPHE contains the CAD/ROD institutional control use restrictions, a legal description for the Central OU, and a summary description of wastes disposed of at the PLF. This is an amendment to the Environmental Covenant granted by DOE to CDPHE on December 4, 2006, and reflects modifications in the 2011 CAD/ROD Amendment.

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***Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan* (DOE 2008a):** The PLF M&M Plan is designed to meet the following objectives:

- Describe the procedures to maintain the integrity and effectiveness of the final cover, including making repairs as necessary;
- Describe the features to maintain and monitor the groundwater monitoring system; and
- Present the Landfill Seep and East Landfill Pond Environmental Monitoring Plan.

The PLF M&M Plan is incorporated by reference as an enforceable requirement of RFLMA (see RFLMA Attachment 2, "Legacy Management Requirements," Section 5.3.2). The PLF inspection and monitoring requirements are included in RFLMA Attachment 2, Table 3 (Appendix A of this report). The PLF M&M Plan fulfills the requirements for a post-closure plan in 6 CCR 1007-3 §265.118 and the requirements of 6 CCR 1007-3 §265.121(a)(3). 6 CCR 1007-3 §265.121 is identified as an ARAR in the CAD/ROD. Subsection (a)(3) refers to requirements for monitoring programs in 6 CCR 1007-3 §264.91–§264.100. A modification to the PLF M&M Plan was approved during this reporting period, as summarized in Section 4.4.

A RCRA Subtitle C-compliant cover was selected to address closure of the PLF (DOE 2004a). The cover is a geosynthetic composite cover with a rock layer to deter burrowing animals and a 2-foot-thick topsoil layer, and includes installation of perimeter drainage channels to control surface water run-on and runoff around the PLF cover. The closure also included modification of the PLFTS. Construction of the PLF cover included removing sediments from the East Landfill Pond, drying the sediments, and placing the dried sediments under the PLF cover. Construction was completed in May 2005, with a minor drainage modification on the PLF east face completed in August 2005.

***Original Landfill Monitoring and Maintenance Plan* (DOE 2009a):** The OLF M&M Plan is designed to meet the following objectives:

- Describe the procedures to be used to maintain the integrity and effectiveness of the final cover, including making repairs as necessary;
- Describe the features necessary to maintain and monitor the groundwater monitoring system; and
- Describe the features necessary to prevent run-on and runoff from eroding or otherwise damaging the final cover.

The OLF M&M Plan is incorporated by reference as an enforceable requirement of RFLMA (see RFLMA Attachment 2, "Legacy Management Requirements," Section 5.3.1). The OLF inspection and monitoring requirements are included in RFLMA Attachment 2, Table 3, (Appendix A of this report). A modification to the OLF M&M Plan was approved during this reporting period, as summarized in Section 4.4.

A 2-foot-thick soil cover was selected to address closure of the OLF (DOE 2005a). To enhance the landfill's slope stability, the existing slopes were regraded before the soil cover was placed, and a buttress fill was installed at the toe of the landfill. The remedial action also included the installation of perimeter drainage channels and cover diversion berms to control surface water run-on and runoff around the landfill cover. Construction was completed in September 2005, with the final regulatory walkdown occurring on September 12, 2005.

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The modified OLF M&M Plan also reflects changes resulting from the implementation of the OLF Action Plan (DOE 2007c), approved by CDPHE on July 16, 2007. The OLF Action Plan implementation is discussed further, below.

***Rocky Flats Original Landfill Geotechnical Investigation Report* (Geotech Report) (TetraTech 2008):** Conditions that warranted further repair and that triggered further investigation were found at the OLF beginning in 2007, and were noted in the *Second Five-Year Review Report*. These conditions involved the localized slumping and settling of the OLF cover and seeps observed to daylight intermittently on the cover, and the development of a continuous seep at the eastern toe of the buttress. In addition, ponding in lengths of the diversion berm channels from precipitation and snowmelt runoff were observed, and a topographic survey showed that portions of the diversion berms did not meet the minimum OLF M&M Plan–specified 2-foot height.

As discussed in Section 4.4, the RFLMA Parties consulted on appropriate actions which included Phase 1 (near-term) repair, Phase 2 geotechnical investigation, and Phase 3 design and construction for long-term repair. A summary of the results of the OLF Action Plan implementation and the path forward is included in RFLMA Contact Record 2008-07.

Phase 1 repairs to address localized differential settlement, slumping, and surface cracks were made in 2007 by filling, grading, and compacting. Investigation fieldwork for Phase 2 began in December 2007 and was completed in April 2008.

The Geotech Report describes the Phase 2 work performed and concludes that a clay layer containing organic materials at or near the bedrock contact appears to be a weak interface area. As described in the Geotech Report, modeling predicts small-scale instability due to percolating moisture that lubricates this weak interval. The OLF buttress is providing stability as intended, and there is no large-scale instability predicted; therefore, the observed conditions do not appear to indicate a need for urgent or major responses.

The construction to complete the necessary repairs and to implement design changes was completed in November 2008, and the as-built surveys for inclusion in the revised OLF M&M Plan were completed in March 2009.

During the Phase 2 work seven inclinometers were installed in boreholes at the OLF in 2008 as part of the geotechnical investigation. Movement of the inclinometers has been monitored approximately monthly since installation. Inclinometer deflection is a result of lateral movement of the ground in which the inclinometer is located, and enough movement can cause the inclinometer tube to break. Once an inclinometer tube breaks, it will no longer be monitored. Inclinometer data provide information on localized soil movement and serve to focus periodic inspections of the soil cover surface on signs of potential instability, such as cracking, vertical displacement, and slumping. A qualified geotechnical engineer has reviewed the inclinometer data annually since 2008 to determine the significance of the deflection in relation to recommendations for maintenance or repairs to address potential instability in accordance with the OLF M&M Plan. The evaluations are included in the RFLMA Annual Reports.

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The conclusion of the evaluations is that recommendations made in the Geotech Report remain valid. The instrumentation indicates that instability is caused by one or more weak layers in the shallow subsurface, and movement is exacerbated by precipitation events and elevated water levels. Slope stability modeling indicates the large scale, overall slope is stable. However, as with other hillsides of similar geology across the Colorado Front Range, localized failures have occurred on the OLF under elevated water level conditions. A reduction in the water level alone is not considered adequate to ensure the long term stability of the slope, however it is possible that the reduced movements recorded by inclinometers during 2011 are related to drainage improvements constructed at the OLF in 2008. Continued monitoring and regular maintenance of distress in accordance with the OLF M&M Plan are recommended.

***Original Landfill Data Summary and Evaluation Report* (DOE 2010e):** Subsurface soil sampling at OLF using geoprobe equipment was conducted from June 29, 2010, to July 8, 2010, in accordance with the CDPHE-approved *Original Landfill Sampling and Analysis Plan* (OLF SAP) (DOE 2010f). The OLF SAP provides information on the data quality objectives, sample location selection methodology, and analytes and quality assurance/quality control for the characterization work.

The report also provides the analytical results and presents the evaluation of the results and recommendations in relation to the CDPHE policy criteria.

The OLF soil sampling was done to provide preliminary data for residual contamination levels of OLF soils for evaluation in relation to the 2008 CDPHE policy regarding post-closure care termination criteria (CDPHE 2008). The data from this OLF sampling project supplements OLF surface and subsurface soil data from samples collected in the early 1990s and presented in the March 10, 2005, *Final Interim Measure/Interim Remedial Action for the Original Landfill* (DOE 2005a).

***Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2006e):** This plan employs an integrated framework of techniques to control excessive vegetation that can increase wildfire hazards, control present and future infestations of noxious weeds, and enhance the native plant communities and wildlife habitat.

***Rocky Flats, Colorado, Site Wetland Mitigation Monitoring and Management Plan* (DOE 2006f):** This plan outlines a strategy to determine whether wetland mitigation efforts at Rocky Flats have successfully mitigated for wetland impacts resulting from cleanup and closure activities. Approximately 7.7 acres of wetlands were affected by cleanup and closure activities at Rocky Flats. The overall performance objective is to reestablish a minimum of 7.7 acres of wetlands to mitigate and replace those that were affected by closure activities.

6.4 ARARs Review

Section 121(d) of CERCLA and the NCP, 40 CFR 300.430(f)(1)(ii)(B), require that onsite remedial actions must attain those ARARs that were identified at the time of the CERCLA remedy decision. The ARARs to be met for the Central OU final remedy are identified by specific statutory or regulatory citation in the CAD/ROD, Table 21 (DOE, EPA, and CDPHE 2006).

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Among other things, the RFLMA Attachment 2 requirements outlined previously provide the remedy implementation, operation and administrative activities, and controls to achieve ARAR requirements. All ARARs identified in Table 21 of the CAD/ROD have been implemented and are being attained.

These laws and regulations may be revised from time to time by legislative or regulatory agency action. In accordance with 40 CFR 300.430(f)(1)(ii)(B)(*1*), requirements that are promulgated after the remedy decision must be attained only when determined to be applicable or relevant and appropriate and necessary to ensure the protectiveness of the remedy.

ARARs are identified as chemical-, location-, and/or action-specific. Chemical-specific requirements are usually health- or risk-based numerical values or methodologies. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment. Location-specific requirements are restrictions placed on the concentration of hazardous substances because they occur in particular locations. Action-specific requirements are usually technology- or activity-based requirements or limitations on actions taken with respect to management of remediation waste or closure of a facility.

6.4.1 Promulgated ARAR Changes During This Review Period

A review of the CAD/ROD ARARs was conducted to determine whether there have been any promulgated changes to these statutes or regulations relevant to the chemicals, location, and/or action addressed by the CAD/ROD for the Central OU during this review period. Promulgated ARAR changes since the CAD/ROD are briefly discussed below.

6.4.1.1 Clean Water Act Requirements for Discharge of Pollutants

Onsite remedial actions do not require permits, but remedies requiring discharges into waters of the United States must meet substantive requirements of any nationwide permits (NWPs), general permits, or specific permits that may otherwise be required pursuant to the Clean Water Act. The following National Pollution Discharge Elimination System permits were issued or reissued during this review period.

Permits for Discharges of Dredged or Fill Material into Waters of the United States, 33 CFR 323: Under this ARAR, some types of activities conducted to implement the remedy may result in the discharge of dredged or fill material. Some types of activities are exempt from permit requirements, such as drainage ditch routine maintenance.

Anticipated remedy implementation activities that otherwise require a dredge or fill discharge permit are covered by NWPs issued by the permitting authority, the U.S. Army Corps of Engineers (USACE). The NWPs issued in 2007 expired in March 2012, and USACE reissued NWPs effective for five years to replace the expired NWPs.

While the reissued NWPs, conditions, or definitions added and clarified certain substantive aspects of the NWPs, the implementation of the remedy is not impacted because all activities subject to this ARAR, such as installation and maintenance of surface water monitoring stations, are conducted in accordance with the substantive conditions of the reissued NWPs.

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National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) for Stormwater Discharges: Under this ARAR, construction activities conducted to implement the remedy may result in the discharge of sediment in stormwater. Some types of activities are exempt from permit requirements, such as construction activities involving less than an acre of soil disturbance.

Anticipated remedy implementation activities that otherwise require a storm water discharge permit are covered by the CGP issued by the permitting authority, the EPA. The CGP issued in 2007 expired in February 2012, and EPA issued a new CGP effective for five years to replace the expired CGP.

While the new CGP added and clarified certain substantive aspects of the CGP, the implementation of the remedy is not impacted because all activities subject to this ARAR, such as construction work to maintain the landfill covers and groundwater treatment systems, are conducted in accordance with the CGP substantive conditions.

NPDES Pesticide General Permit (PGP): In accordance with a 2009 U.S. Court of Appeals ruling (*National Cotton Council, et al. v. EPA*), effective October 31, 2011, discharges to waters of the United States from the application of pesticides require NPDES permits. This decision means that certain discharges to implement the remedy (such as application of pesticides to control noxious weeds that could negatively impact remedy performance, or discharges associated with maintenance of runoff controls at the landfills or that interfere with surface water monitoring locations) are subject to this ARAR.

In response to the court's ruling, EPA promulgated its *Final National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit for Point Source Discharges From the Application of Pesticides*, 76 FR 68750–68756, November 7, 2011.

The PGP substantive requirements include following the pesticide manufacturer's instructions and monitoring the performance of the pesticide application. Types of pesticide applications that might be subject to the PGP include mitigation or elimination of invasive aquatic species that could hinder the proper operation and maintenance of any remedy component.

The implementation of the remedy is not impacted because all activities subject to this ARAR can be conducted in accordance with the PGP substantive requirements.

6.4.1.2 Colorado Water Quality Standards

The RFLMA water quality standards are in RFLMA Attachment 2, Table 1 (Appendix A of this report). The RFLMA standards are based on (1) Colorado WQCC regulation # 31, "Colorado Basic Standards and Methodologies for Surface Waters" (5 CCR 1002-31), which are statewide basic standards, and (2) Colorado WQCC regulation #38, "Classification and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin" (5 CCR 1002-38), which are site-specific standards. The Walnut and Woman Creek portions in the Central OU are Big Dry Creek segments 4a and 5 of the South Platte River Basin. Because the use classification of groundwater at Rocky Flats is surface water protection, the applicable RFLMA surface water standards also apply to groundwater.

Modifications to RFLMA Attachment 2, Table 1, have been made as changes to standards in regulations #31 or #38 that are the basis for RFLMA standards are promulgated. See Section 4.4 for a discussion and listing of modifications to RFLMA Attachment 2 during this review period.

Temporary Modifications: Temporary modifications to standards for some analytes, at levels above the statewide basic standards, were promulgated by the WQCC in regulation #38 before cleanup and closure was completed. The temporary modifications were for the Walnut Creek portions of segment 5 for nitrate and nitrite, benzene, carbon tetrachloride, 1,2-dichloromethane, 1,1-dichloroethene, PCE, and TCE. The temporary modifications automatically expired at the end of 2009. The temporary modification levels for these analytes were below the WRW PRG values and below the chronic ecological screening level values in the CRA. The standards for these analytes upon expiration of the temporary modifications did not impact the protectiveness of the remedy.

Site-Specific Standards for Uranium and Gross Alpha and Gross Beta: DOE filed a petition for rulemaking with the WQCC in 2007 to remove the site-specific uranium standard (10 pCi/L for Walnut Creek and 11 pCi/L for Woman Creek), which would result in the statewide basic standard for uranium becoming the RFLMA standard. The statewide basic standard at that time was EPA's MCL for uranium of 30 micrograms per liter (µg/L)—approximately twice the RFLMA standard. There was no promulgated statewide basic standard for gross alpha and gross beta. The basis for DOE's petition was the changed conditions resulting from cleanup and closure.

The WQCC revised the uranium standard to 16.8 µg/L (the WQCC health based standard) rather than the requested revision to 30 µg/L and eliminated the gross alpha and gross beta site-specific standards, effective March 30, 2009. Based upon a conversion factor of 0.67 pCi/µg uranium, 16.8 µg/L equates to 11.3 pCi/L.

Arsenic: The WQCC's triennial review of regulation #38 was completed in 2009[9] and changes adopted by the WQCC were effective January 1, 2010.

The site-specific arsenic standard was lowered from 50 µg/L to the statewide basic water supply standard of 0.02–10 µg/L (standards expressed as a range of values are discussed in the Statewide Basic Standard for Uranium section, below). Prior to the hearing, a summary of the post-closure arsenic data for the locations where arsenic is monitored as one of the metals analytes (GS05, GS59, and PLFSYSEFF) was submitted to the Colorado Water Quality Control Division (WQCD)[10] staff for consultation. The data indicated the 50th percentile of the data did

[9] The Water Quality Control Act directs WQCC to review all water quality classifications and standards at least once every 3 years. There are three steps in the triennial review process. The process begins within 3 years after the end of the previous review, and is completed approximately 2 years thereafter. There are three steps in the process:

- An issues scoping hearing, to identify early any issues that will likely need to be addressed in the next major rulemaking hearing;
- An issues formulation hearing, to formulate the specific issues that will be addressed in the next major rulemaking hearing; and
- A rulemaking hearing.

[10] The WQCD is the agency with permitting and enforcement authority to implement the WQCC standards, and WQCD staff act as technical advisors to the WQCC during rulemaking proceedings.

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not exceed the higher value in the standard range (10 µg/L), and ambient standards for total recoverable metals (such as arsenic) are typically based on the 50th percentile of the data. Under WQCC rules, water bodies are considered in attainment of the standard so long as the existing ambient water quality does not exceed the highest number of the range for the standard. Thus, arsenic is considered in attainment with the revised standard.

Use Classifications: The triennial review of regulation #38 also changed the segment 4b recreation use classification to recreation class P[11] (potential primary contact use), because the majority of the segment is on Refuge land, and the Refuge will be open to the public within the next 20 years.[12]

The small portion of segment 4b that was in the Central OU was changed to segment 5, which has a recreational use classification of class N (not primary contact use). These changes did not result in any changes to RFLMA surface water standards for the Central OU.

Statewide Basic Standard for Uranium—The triennial review of regulation #31 was completed in 2010. The WQCC revised the uranium standard to 16.8–30 µg/L, effective January 1, 2011. The following footnotes in regulation #31, Section 31.16, Tables, apply to the standard:

> Table III footnote (13) Whenever a range of standards is listed and referenced to this footnote, the first number in the range is a strictly health-based value, based on the Commission's established methodology for human health-based standards. The second number in the range is a maximum contaminant level, established under the federal Safe Drinking Water Act that has been determined to be an acceptable level of this chemical in public water supplies, taking treatability and laboratory detection limits into account. Control requirements, such as discharge permit effluent limitations, shall be established using the first number in the range as the ambient water quality target, provided that no effluent limitation shall require an "end-of-pipe" discharge level more restrictive than the second number in the range. Water bodies will be considered in attainment of this standard, and not included on the Section 303(d) List, so long as the existing ambient quality does not exceed the second number in the range. …
>
> Table III footnote (17) When applying the table value standards for uranium to individual segments, the Commission shall consider the need to maintain radioactive materials at the lowest practical level as required by Section 31.11(2) of the Basic Standards regulation.

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[11] In the 2005 triennial review of regulation #31, the WQCC revised the recreational classification designation codes from recreation class 1a to recreation class E for "existing primary contact use," from recreation class 1b to recreation class P for "potential primary contact use," and from recreation class 2 to recreation class N for "not primary contact recreation use." The Regulation 38 triennial review included revising the designation codes as specified by Regulation 31.

[12] Pursuant to Regulation 31.13 section 1.a, Class P (Potential Primary Contact Use) means surface waters have the potential to be used for primary contact recreation. This classification shall be assigned to water segments for which a reasonable level of inquiry has failed to identify any existing primary contact uses of the water segment, but primary contact uses may potentially occur in the segment within the next 20-year period. Pursuant to Regulation 31.5 (32), "PRIMARY CONTACT RECREATION" means recreational activities where the ingestion of small quantities of water is likely to occur. Such activities include but are not limited to swimming, rafting, kayaking, tubing, windsurfing, water-skiing, and frequent water play by children.

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Table III footnote (17) is consistent with Regulation #38, Section 38.5 (3)(b), "Uranium level in surface waters shall be maintained at the lowest practicable level."

RFLMA surface water standards are not currently impacted as a result of the Regulation #31 adoption of the new uranium standard. The lower value in the range is the Regulation #38 uranium standard, which is the basis for the RFLMA standard.

Nitrate and Arsenic Standards: In the triennial review of Regulation #31, the WQCC clarified how the domestic water supply standards for arsenic and nitrate would be implemented in permits by expanding on the Section 31.16 Table II footnote 4 (nitrate) and Table III footnote 14 (arsenic).

> The two standards apply at the point of water supply intake. In order to provide a consistent level of protection and simplify implementation in the permitting process, the default assumption will be that the standard is applied at the end of the applicable regulatory mixing zone. This presumption can be overcome if the permittee provides information demonstrating 1) that there is no actual domestic water supply use; or 2) that the standard will not be exceeded at the point of intake.

While DOE is not a permittee, the WQCC clarification provides good information regarding the intent of the nitrate and arsenic standards for the water supply classification in relation to protection of human health. This is relevant to evaluating the operation, maintenance, and optimization of the SPPTS to remove nitrate loading from nitrate contaminated groundwater. It is also relevant in evaluating PLFTS effluent monitoring results for arsenic, since the system is not designed to remove metals contamination from the seep water.

6.4.1.3 Environmental Covenant or Restrictive Notice

Colorado's environmental covenant law, Environmental Covenants and Use Restrictions, Colorado Revised Statutes (CRS) §§ 25-15-317 et seq., was amended by Senate Bill 08-037 effective July 1, 2008, to provide for use of an Environmental Use Restriction (restrictive notice) for protection of human health and the environment when environmental remediation projects may leave residual contamination at levels that have been determined to be safe for a specific use, but not all uses, and may incorporate engineered structures that must be maintained or protected against damage to remain effective. Prior to the amendment, an environmental covenant was the only authorized instrument to accomplish these purposes.

An environmental covenant is an agreement between the landowner and Colorado to subject the property to enforceable land use restrictions, to meet the intent of CRS § 25-15-317 et seq. An environmental covenant shall run with the land and shall bind the owner of the land, the owner's successors and assigns, and any person using the land. As previously discussed, DOE granted CDPHE an environmental covenant that includes the CAD/ROD-required institutional controls.

A restrictive notice is an action by CDPHE based on the state's police power. A restrictive notice is binding on current and subsequent owners of the affected land and any person using or possessing interest in the land. A restrictive notice provides for enforcement of land use restrictions when an environmental covenant is not granted by the landowner, or when an environmental covenant might not provide an enforceable means to bind parties with prior

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interest in the land (in some instances such parties might not even be identifiable), such as easement holders who do not enter into the covenant.

There is a preexisting utility easement in the Central OU, and the easement holder has not entered into the Environmental Covenant. The utility easement locations are shown in Figure 3. The RFLMA Parties can resolve any concerns about possible future enforceability of the institutional controls on the easement holder by a CDPHE restrictive notice in place of the Environmental Covenant. The use of an environmental covenant or a restrictive notice as an enforcement vehicle for the institutional controls was included in the CAD/ROD amendment.

6.4.2 Recent WQCC Rulemaking for Nutrients

The WQCC is expected to finalize in 2012 new rules as part of a coordinated strategy to address current and potential future nutrient pollution of Colorado surface waters. The rules have not been adopted as final by the WQCC as of the end of this review period. Nutrient pollutants include nitrates, which is a groundwater contaminant treated by the SPPTS.

Once promulgated, the new rules will be evaluated by the RFLMA Parties for applicability as a basis for RFLMA surface water standards. As with any newly promulgated WQCC rules, the RFLMA Parties will use the consultative process in a timely manner to determine what, if any, modifications to RFLMA Attachment 2 may be needed.

The new rules include changes to Regulation #31 to establish interim numerical values (but no standards) for designated nutrient pollutants. Standard setting is proposed to occur in triennial review rulemaking proceedings over the next ten year timeframe. Information on any impacts to the protectiveness of the remedy based on nutrient standard setting will be included in the next five-year review.

6.5 CRA Review

The exposure scenario and exposure parameters used in the CRA were developed and documented in the CRA Methodology (DOE 2005c). This information was reviewed in the context of current site conditions to determine whether the scenario assumptions and parameters remain valid and to evaluate the continuing remedy protectiveness.

6.5.1 Human Health

The general Site Conceptual Model and assumption that the most conservative exposure scenario for a human receptor is approximated by a WRW scenario is still valid. The basic methodology for conducting human health risk assessments, as described in Part A of the *Risk Assessment Guidance for Superfund* (EPA 1989), has not changed. The site-specific exposure assumptions for the WRW in the CRA included 230 days per year when exposure to surface soil may occur, and 20 days per year when exposure to subsurface soil may occur.

The WRW scenario also approximates the DOE onsite worker since the tasks that bring both scenarios into contact with contaminated media are similar. Based on interviews with field operations personnel and other LM staff working in the Central OU, and a review of actual time

spent in the Central OU, these assumptions are still appropriate, conservative estimates of potential exposure for workers within the Central OU.

Assumptions used in the Site Conceptual Model as the basis for incomplete and insignificant pathways are incorporated as land use prohibitions in the remedy institutional controls. The implementation of institutional controls is discussed in Section 4.4.

Section 9, "Current and Potential Future Land and Resource Uses," in the 2006 CAD/ROD includes the following provisions regarding land use:

> As of the date of this CAD/ROD, all of Rocky Flats is the property of the United States, with activities there administered by DOE. The site is closed to public access. Per the [Rocky Flats National Wildlife] Refuge Act, the majority of the site is to have jurisdiction transferred to the U.S. Fish and Wildlife Service (Service), for the purpose of becoming a national wildlife refuge. The transfer will occur upon achieving closure as defined in the Refuge Act . . .
>
> - The lands retained by DOE are expected to be managed consistent with the Refuge, unless the needs of the remedy dictate otherwise . . .
>
> - The Refuge Act prohibits the United States from transferring any rights, title, or interest in land within the boundaries of Rocky Flats, except for the purpose of transportation improvements on the eastern edge of the site that is bordered by Indiana Street . . .
>
> - Use of the land for residential, commercial, or industrial purposes will not occur, and surface water and groundwater will not be used for potable water supplies.

The groundwater pathway is still considered incomplete because the related assumptions in the Site Conceptual Model have proven to still be valid. The most likely complete exposure pathways to residual contamination at the site are still soil ingestion and dermal contact with soils. While inhalation of surface soils is also possible, inhalation risks calculated in the CRA were negligible (i.e., 2 or more orders of magnitude lower) compared to soil ingestion. The surface water pathways likewise remain insignificant.

The COC selection process used screening level PRGs for a WRW, frequency of detection, and background levels for comparison to remedial investigation sample results (see Section 3.5.2). The last step in the COC selection process included an evaluation of PCOCs based on professional judgment. PRGs were calculated based on the lower end of the CERCLA risk range for carcinogens (1×10^{-6}) and 10 percent of the maximum acceptable HQ of 1 for noncarcinogens. The recently completed Integrated Risk Information System[13] (IRIS) profile does not result in any changes to COCs.

[13] EPA's Integrated Risk Information System (IRIS) is a human health assessment program that evaluates information on health effects that may result from exposure to environmental contaminants. Through the IRIS Program, EPA provides the highest quality science-based human health assessments to support the Agency's regulatory activities. The IRIS database is web accessible at http://www.epa.gov/IRIS/ and contains information on more than 550 chemical substances.

An indoor air/vapor intrusion evaluation was also conducted in the CRA using EPA guidance that was current when the CRA Methodology was prepared. The CRA concluded that the levels of VOCs in subsurface soil and groundwater samples from some locations in the Central OU could pose a significant indoor air/vapor intrusion exposure pathway based on a comparison to screening level subsurface soil and groundwater volatilization PRGs that were developed in the CRA Methodology. To prevent unacceptable exposures via the indoor air pathway, the selected remedy includes an institutional control prohibiting the construction and use of occupied building (such as for residences and offices) (see Section 4.3.1).

EPA has revised some of the assumptions and approaches in its risk assessment guidance for evaluating the inhalation (and therefore vapor intrusion) pathway (EPA 2009b). The revised guidance recommends using concentrations of chemicals in air as the exposure metric (e.g., $\mu g/m^3$) rather than inhalation intakes of a contaminant in air based on ingestion rates and body weight (e.g., mg/kg-day). EPA's draft vapor intrusion guidance (EPA 2002) is currently undergoing revision to reflect this change and others that may have stemmed from the review of the draft guidance. EPA has committed to release the final version of the vapor intrusion guidance by November 2012. The revised risk assessment and vapor intrusion guidance does not affect the protectiveness of the remedy, because the institutional control applies to the entire Central OU and is not limited to locations where the PRGs were exceeded as identified in the CRA. Levels of VOCs that exceed the CRA Methodology PRGs remain in some locations, and no revisions to the indoor air evaluation are warranted at this time. Any future proposals to modify or terminate the institutional control may affect the protectiveness of the remedy, and so would need to consider the risk assessment guidance in place at that time.

The COCs identified in the HHRA portion of the CRA for surface soils included arsenic; vanadium; benzo(a)pyrene; 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD toxicity equivalence [TEQ])[14]; and plutonium 239/240. Those constituents and the toxicity values used in the CRA are included in Table 6[15].

Of the toxicity values in Table 6, only the Oral Reference Dose for vanadium is undergoing review. The CRA used a provisional value for vanadium that is more conservative than the reference dose found in IRIS. This means that, even if the provisional value is adopted, the increase in estimated risks would be negligible and would not change the overall assessment of risk.

The assumptions used in the evaluation of the deer meat ingestion pathway were conservative (Todd and Sattelberg 2005). Ninety samples were analyzed for plutonium isotopes and 75 samples were analyzed each for americium and uranium isotopes. More complex approaches using the RESRAD 6.5 computer program (discussed below) are available to provide more precise risk estimates. However, given that only two samples of deer tissue analyzed had radionuclide concentrations exceeding the reporting threshold, this level of analysis is not warranted. Those updated methods would evaluate longer exposures and would take into account more age dependence of biological behavior than what is called for in this review. Uptake of radionuclides by grazing animals is negligible.

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[14] There is no longer a complete pathway for exposure to surface soil dioxin contamination. See Table 2.

[15] Inhalation slope factors for arsenic, benzo(a)pyrene, and vanadium not included in this table for simplicity, as that route of exposure was not significant.

Table 6. Toxicity Values Used in CRA

Constituent	Cancer slope factor-oral/ingestion $(mg/kg/day)^{-1}$ or Risk per pCi	Oral Reference dose (mg/kg/day)	External Slope Factor[c] (risk/yr per pCi/g)	Notes/Status
Arsenic	1.50 [a]	3.00×10^{-4} [a]	N/A	No change
Benzo(a)pyrene	7.30 [a]	N/A	N/A	No change
Plutonium-239	2.76×10^{-10} [c]	N/A	2.00×10^{-10}	No change
Plutonium-240	2.77×10^{-10} [c]	N/A	6.98×10^{-11}	No change
Vanadium	N/A	1.0×10^{-3} [b]	N/A	EPA recommended new Oral Reference Dose of 9×10^{-4} currently undergoing review
2,3,7,8-TCDD TEF[d]	1.5×10^{5}	N/A	N/A	Current Cal/EPA value is 1.3×10^{5}; use of this value would result in lower risk

Notes:
[a] IRIS
[b] EPA-National Center for Environmental Assessment (NCEA) Provisional Value
[c] Health Effects Summary Tables (HEAST), maintained by EPA
[d] Published by California Office of Environmental Health Hazard Assessment (OEHHA); Cal/EPA OEHHA Toxicity Criteria Database available at: http://oehha.ca.gov/tcdb/index.asp

Abbreviations:
Cal/EPA = California Environmental Protection Agency
mg/kg = milligrams per kilogram
TEF = Toxic Equivalency Factor

EPA produced a new version of its Exposure Factors Handbook in 2011 (EPA 2011c). Some of the main revised recommendations noted include:

- An increase in the default adult body weight average from 70 kilograms to 80 kilograms
- An updated average soil+dust ingestion rate for adults of 50 milligrams per day
- An updated life expectancy of 78 years (75 years for males, 80 years for females)

Use of these revised values instead of those used in the CRA would all cause risk estimates to be lower than CRA calculations.

The radiological dose assessment used the computer code RESRAD 6.3. There have been two updates since then, and the most recent version is RESRAD 6.5. Some of those changes are irrelevant to the Rocky Flats calculations (e.g., inclusion of C-14), but there were some potentially relevant changes in dose-conversion factors (DCFs). Given that the calculations for the WRW were less than 1 mrem/yr using conservative estimates, it is unlikely that any of the DCF changes could be significant enough to raise the estimated dose to levels approaching the CDPHE standard of 25 mrem/yr. If land use were to change or if new information on the presence of radiological contamination were to be discovered at the site, this could warrant additional analysis (or if the assumptions or methodology used in the code were to be revised significantly), but none is justified at this time.

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It can be concluded that overall the site is protective of human health for the WRW scenario and is likely to remain so as long as required institutional controls are maintained and land use does not change.

6.5.2 Ecological Risk Assessment

No significant risks were identified for any eco-receptor in any EU at the time of the CRA. No chemical or radionuclide ECOCs were identified for any medium. As discussed previously, the ecological screening process was conservative to ensure that all ECOIs were identified. Literature benchmarks used for the initial screening process were those designed to identify all constituents that required more site-specific evaluation (EPA 2003). Those screened out early in the process should not require reevaluation unless site conditions have significantly changed (e.g., new contaminants identified, changes in land use).

Risks range from none to low for exposure to subsurface soils. Potential risks to terrestrial receptors from surface soils were also mostly none to low. A few surface soil constituents had calculated risks that were low to moderate, meaning that some numerical HQs were higher than 1 for the LOAEL TRV (i.e., media concentrations exceeded concentrations demonstrated to result in some adverse effects). These constituents included: antimony, lead, chromium, nickel, uranium, vanadium, Di-n-butylphthalate, Bis(2-ethylhexyl)phthalate, and dioxins (total). For those constituents with the highest HQs, a further evaluation was conducted in the CRA using refined parameters (less conservative). Where default HQs were elevated, more site-specific analysis indicated that actual risks were likely lower than those default estimates. No constituent was determined to pose enough potential risk to be elevated to an ECOC.

A review of the ERA and recent site information confirms that major assumptions and methodologies used in the ERA are still valid. The main assumptions are listed below.

For terrestrial EUs:

- The Site Conceptual Model is still valid (land use, ecological receptors and pathways); subsurface soils are still considered inaccessible. The concept of separating eco-receptors into PMJM and non-PMJM categories is still sound.
- The methodology used for estimating quantitative ecological risks is still valid. EPA's Ecological Soil Screening Level (Eco-SSL) guidance, the use of NOAELs and LOAELs to develop TRVs, and equations used to estimate contaminant exposures are all still acceptable.
- There have been some changes to the Eco-SSL guidance since the ERA was completed and since the last five-year review. However, these changes do not affect the basic ecological risk assessment methodology. The changes could affect the calculation of some individual TRV values for certain receptors (perhaps based on the use of slightly different assumptions for the use of bioaccumulation factors). However, because the Eco-SSL process is designed so that important constituents are not likely to be overlooked, these changes are not likely to affect site-specific conclusions.
- Sources of toxicity data are still accepted, though the body of knowledge has been expanded through continuing research that has been conducted since then (hundreds of new entries have been added to EPA's ECOTOXicology [ECOTOX] database since completion of the ERA).

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- It is quite possible that some additional benchmarks have been developed based on studies that have taken place since those referenced in the ERA. For example, EPA issued guidance for use of Toxic Equivalency Factors (TEFs) in ecological risk assessment (terrestrial and aquatic) for dioxins and related compounds (EPA 2008). A similar approach was used in the ERA. However, several TEFs recommended by EPA guidance (as well as recent guidance from the National Oceanic and Atmospheric Administration [Buchman 2008]) for various congeners for different receptors vary somewhat from those used in the CRA. While these changes could change some quantitative estimates of risk (i.e., HQs), differences are within the same order of magnitude and it is unlikely that the overall assessment of risk would be different.
- The major sources used for benchmarks and for development of soil TRVs are still valid (EPA 2003; Sample, Opresko, and Suter II 1996; Efroymson et al. 1997); no revisions to these "standard" references have been completed that would necessitate a review of soil TRVs.
- For major soil ECOPCs, there have been no new developments from a toxicological standpoint that would call into question the protectiveness based on the CRA. This conclusion was made based on a review of EPA's ecological risk assessment references, USFWS contaminant publications, and U.S. Geological Survey contaminant/ biological studies.

For aquatic EUs:

- The conclusion that the ecology in the aquatic EUs is not predominantly controlled by water or sediment quality is still valid; rather, they are limited by natural environmental conditions such as low flows that occur in ephemeral headwaters streams that occur at the site. There is no reason to question this conclusion, though additional sampling was conducted to address uncertainty identified as a result of the ERA.
- As with terrestrial receptors, some additional studies completed during this review period may have contributed to scientific knowledge that could affect development of benchmarks for aquatic receptors. However, based on the foregoing conclusions regarding conditions that control aquatic ecology, it is unlikely that changes in surface water or sediment quality criteria would affect the overall assessment of risk in the aquatic EUs.
- The overall approach of using water quality and sediment quality criteria as a quantitative estimate of risk is still valid.
- Water quality monitoring results during this review period demonstrate that, except for spatially limited exceedances of radionuclide standards and nitrate (as N), the quality meets RFLMA standards.

As discussed in Section 3.5.3, to reduce uncertainty in the ERA, surface water and sediment samples were collected on three separate occasions in 2007 from three different AEUs as required by RFLMA Attachment 2, Table 5. Samples were analyzed for ammonia (total and un-ionized), cyanide, and radium-228. Most constituents were below detection limits for most water samples. Radium-228 was detected in three of nine total samples. Total ammonia was detected at very low levels in two of the nine samples. Results of all surface water samples were lower than acute and chronic criteria for surface water.

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Sediment sampling results for ammonia ranged from 116 to 434 milligrams per kilogram (mg/kg); cyanide ranged from 0.159 to 1.12 mg/kg; and radium-228 ranged from 0.696 to 1.59 pCi/g. Concentrations of radium-228 are well below the ESL of 87.8 pCi/g presented in the ERA. No ESLs were available for ammonia or cyanide in the ERA. The low levels and nondetections of these constituents in surface water indicate that sediments are not serving as a continuing source of surface water contamination. As summarized in RFLMA Contact Record 2008-01, the RFLMA Parties determined that the data addressed the uncertainties in the ERA and no further sampling would be required.

RESRAD BIOTA 1.0 was released in September 2003 and was used in the CRA methodology to develop benchmarks for radionuclides for terrestrial and aquatic receptors. No ECOPCs were identified based on this evaluation. RESRAD BIOTA version 1.2 and 1.2.1 were released in 2006, and version 1.5 was released in 2009. Most of the changes were made to improve the usability of the software. Some changes were made to the uncertainty and sensitivity analysis portions of the code; a simple food diet model was added to version 1.2. However, it is unlikely that these changes affect the overall assessment of ecological risks, considering all the lines of evidence used in the ecological risk assessment.

Conservative assumptions were used in quantitative estimates of ecological risks in the ERA. Combined with actual observations regarding species diversity and health, there is no reason to question the continued validity of these conclusions. No revisions to the estimates of potential ecological risk presented in the CRA are warranted at this time. Residual contamination does not pose a threat to ecological receptors at the site.

6.6 Environmental Monitoring Data Review

The CAD/ROD requires continual, periodic monitoring of surface water and groundwater. The monitoring locations, analytes, and frequencies are contained in RFLMA Attachment 2, Table 2 (Appendix A of this report). Sampling of sediment and additional surface water to reduce uncertainties in the ERA required in RFLMA Attachment 2, Table 5 (Appendix A of this report), was completed during this review period as discussed in Section 6.5.

The results of surface water and groundwater monitoring activities to implement the CAD/ROD are relevant to determine whether RAOs, including ARARs, are achieved for these media. The RFLMA quarterly and annual reports of site surveillance and maintenance activities provide the primary water monitoring information to assess remedy performance for this review period. In addition, the decision logic flowcharts in RFLMA Attachment 2, Figures 5 through 13 (Appendix A of this report), were used for evaluation of the monitoring data when the data was received, and the evaluation discussed as appropriate in the subsequent annual and quarterly reports.

The quarterly and annual reports also include monitoring, inspection, and maintenance information for the PLF and OLF and the four groundwater treatment systems that were carried over into the RFLMA requirements.

The annual reports provide thorough, detailed evaluation information to support the conclusions regarding all aspects of remedy implementation and the performance of remedy components. The following subsections provide a summary of the evaluation of remedy implementation,

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which is primarily drawn from the recently completed evaluations documented in the 2011 annual report.

6.6.1 Water Monitoring Locations

The relevant information considered in this review is for the water monitoring locations and sampling criteria in RFLMA Attachment 2, Figure 1 and Table 2 (Appendix A of this report). In addition, the decision logic flowcharts in RFLMA Attachment 2, Figures 5 through 13 (Appendix A of this report), were used for evaluation of the data when the data was received.

Results of this review were considered in relation to remedy performance and recommendations to continue, modify, or discontinue monitoring, as discussed in the Technical Assessment section and the Issues, Recommendations, and Follow-Up Actions section of this report.

Note that certain monitoring locations were changed during this review period, as described in Section 4.6.2.

6.6.2 Surface Water Monitoring Network

The surface water monitoring stations provide data relevant to the Surface Water RAO, which is listed in Section 4.1 of this report. The RFLMA Attachment 2 decision logic flowcharts in Figure 5, "Points of Compliance," and Figure 6, "Points of Evaluation" (Appendix A of this report), specify the evaluation criteria and the decision logic for timely reporting of exceedances of RFLMA surface water standards.

The RFLMA surface water monitoring network is complete and sampling and analysis are being performed as required. Monitoring for each type of monitoring point is discussed below.

The location of surface water features and monitoring locations in the Central OU is shown on Figures 2 and 3 and RFLMA Attachment 2, Figure 1, "Water Monitoring Locations at Rocky Flats" (Appendix A of this report). The retention ponds, however, are not required by the remedy. The changes to the configuration of the retention ponds during this review period and the status of the retention ponds at the end of this review period are discussed in Section 3.1. Ponds A-4, B-5, and C-2 (historically referred to as the terminal ponds) began flow-through operation in the fall of 2011. They are currently scheduled to be breached in the 2018 to 2020 time frame.

Surface water flow volumes show expected reductions resulting from land configuration changes and removal of impervious surfaces. The surface water volume data for the period of this review compared to pre-closure data reflect the integrated post-closure hydrologic conditions, primarily related to the effects of changes in the following Central OU conditions:

- All buildings (except for a small shed) and all impervious surfaces were removed and drains were removed or disrupted, resulting in infiltration of precipitation into the ground rather than surface runoff of precipitation in these areas.
- The domestic water supply was discontinued and the supply and sewer lines were removed or disrupted, resulting in total elimination of imported water that previously contributed to groundwater via leakage from these aging lines.

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- The Sewage Treatment Plant was removed, resulting in total elimination of the discharge of the treated effluent to surface water.
- Most storm water conveyances were removed and the land surface recontoured into five functional drainage channels approximating (but not intended to duplicate) drainage patterns prior to construction of the Rocky Flats facilities.

During the review period annual precipitation averaged approximately 11.7 inches, which is close to the normal annual average precipitation at Rocky Flats. Pre-and post-closure period[16] surface water discharge summaries for the two major drainages (Walnut Creek and Woman Creek) are shown on Figure 6. Walnut Creek flows are measured at GS03 and Woman Creek flows are measured at GS01. After physical completion in CY 2005, the reduction of discharge in the Walnut Creek drainage, which is the drainage area associated with most of the former industrial area, and the corresponding change in relative volumes is clearly observable. The average annual pre-closure and post-closure discharge volume for Woman Creek is approximately 269 acre-feet and 227 acre-feet, respectively. The average annual pre-closure and post-closure discharge volume for Walnut Creek is approximately 420 acre-feet and 125 acre-feet, respectively.

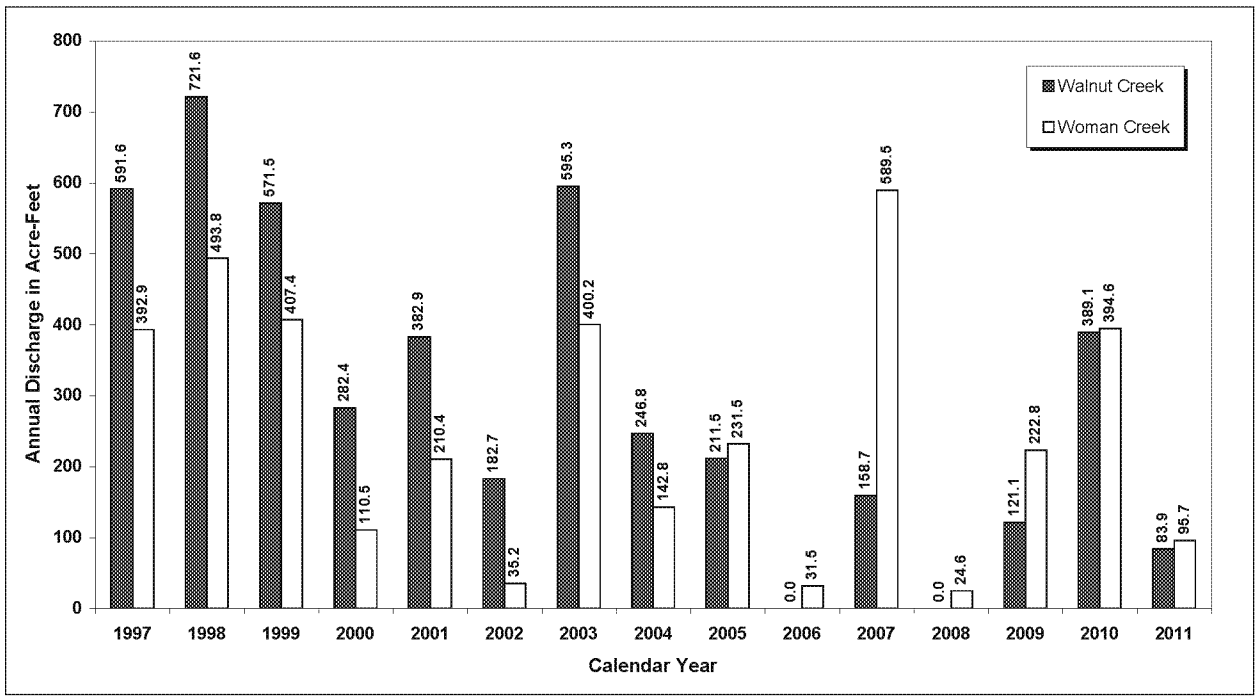

Figure 6. Annual Discharge Summary from Major Site Drainages: CY 1997–2011

As predicted prior to closure the infiltration of precipitation has also resulted in higher groundwater levels in some locations (see Section 3.1). The changes in groundwater levels can result in the mobilization of naturally occurring (such as uranium) and anthropogenic contaminants that can migrate towards surface water and impact the base flow concentrations of these constituents.

[16] The pre-closure period is for the dates 1/1/97–10/1/05; the post-closure period is for the dates 10/1/05–12/31/11.

In addition, the revegetation of the areas excavated, filled, and graded to establish the final land contours and drainage configuration are complete and all success criteria have been met. The vegetation management and revegetation work has resulted in well-established vegetation in the Central OU drainage areas, which mitigate erosion from runoff during precipitation events. This is especially important for residual surface soil plutonium and americium contamination, which may be mobilized by erosion.

The hydrologic conditions at Rocky Flats likely now approximate long-term steady-state conditions. Note that "steady-state" includes periods when possibly wide seasonal and year-to-year fluctuations in hydrologic conditions can occur due to the effects of precipitation, including large accumulation and subsequent melting of snow and ice, very large infrequent events, and drought versus wet years.

6.6.2.1 POCs

POCs are located in Walnut and Woman Creeks downstream of the terminal ponds and at Indiana Street (see Figure 3). POCs are used to demonstrate compliance with RFLMA surface water standards.

Changes to POC locations discussed in Contact Record 2010-04 and approved in the March 2011 RFLMA Attachment 2 modification occurred during this review period (see Section 4.6). The new POC locations, WALPOC and WOMPOC, which are close to the Central OU boundary, replaced the POCs close to the terminal ponds (GS08, GS11, and GS31). The new POC locations are at locations chosen to be representative of surface water leaving the Central OU. The new POCs are at downstream locations that will not be disrupted by terminal pond dam breach construction work in the future. The other POCs (GS01 and GS03) are downstream of WALPOC and WOMPOC, respectively, and near Indiana St. well east of the Central OU boundary.

The evaluation of POC monitoring results was performed in accordance with RFLMA Attachment 2, Figure 5, "Points of Compliance" (Appendix A of this report). During this review period there were no exceedances of RFLMA standards at the POCs.

6.6.2.2 POEs

POEs are located in the Central OU upstream of POCs (see Figure 3). POEs are also used to evaluate water quality in comparison to RFLMA surface water standards. POEs are located specifically to provide an indication of the quality of surface water flowing toward the POCs. This upstream monitoring serves as an advance indicator for potential downstream impacts.

The evaluation of POE monitoring results was performed in accordance with RFLMA Attachment 2, Figure 6, "Points of Evaluation" (Appendix A of this report). During this review period, there were intermittent periods when a RFLMA standard was exceeded, which resulted in the determination of RFLMA reportable conditions at POEs GS10 (for uranium and americium) and SW027 (for plutonium). There were no reportable conditions during this review period for POE SW093.

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Pursuant to RFLMA Attachment 2, Section 6.0, "Action Determinations," in response to a reportable condition:

- DOE must submit a plan and schedule for an evaluation to address the condition within 30 days of receiving the validated data for the reportable condition.
- DOE will consult with CDPHE and EPA to determine if mitigating actions are necessary.
- The objective of the consultation will be to determine a course of action (if determined necessary) to address the reportable condition and to ensure that the remedy remains protective.
- The results of the consultation will be documented in contact records, in written correspondence, or both.

The reportable conditions and evaluations are summarized below.

GS10 Uranium: GS10 is the POE in South Walnut Creek upstream of former Pond A-1 and monitors surface water from the drainage area for a major portion of the former industrialized area.

Elevated uranium concentrations at GS10 above the RFLMA 12-month rolling average standard of 16.8 µg/L resulted in a RFLMA reportable condition at the end of April 2011. The elevated uranium concentrations at GS10 appear to result from proportionally increased groundwater contribution to surface water base flow due to reduced surface runoff. The groundwater in the GS10 area has high concentrations of naturally occurring uranium as well as lower concentrations of anthropogenic uranium.

The uranium concentrations are expected to vary due to the natural variability in environmental conditions such as the amounts of precipitation over time. Elevated uranium concentrations previously occurred at GS10 for the period from April 30, 2006 (before the CAD/ROD and RFLMA), to March 31, 2009. Levels returned to below the RFLMA standard after March 31, 2009, because precipitation levels increased.

The plan and schedule to evaluate the reportable condition through additional sampling and analysis is in Contact Records 2011-04 and 2011-05. To keep the public informed, the outcome of continuing RFLMA Party consultation regarding the evaluation is reported in RFLMA quarterly and annual reports of site surveillance and maintenance activities or in subsequent contact records.

The RFLMA Parties agreed no mitigating actions were necessary while the condition was being evaluated through additional sampling and analysis. The 12-month rolling average uranium concentration at GS10 remains below the uranium MCL of 30 µg/L. Uranium concentrations at the POC downstream of GS10 and the evaluation monitoring locations downstream of GS10 have not exceed the RFLMA standard, which indicates that the remedy remains protective.

GS10 Americium and Plutonium: Elevated americium concentrations at GS10 above the RFLMA 12-month rolling average standard of 0.15 pCi/L resulted in a RFLMA reportable condition for americium at the end of August 2011. The results of RFLMA Party consultation regarding the reportable condition and the evaluation plan is documented in Contact Record 2011-08.

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The 12-month rolling average values for americium approximated 0.20 pCi/L during the evaluation period, and remains above the RFLMA standard at the end of this review period. While the 12-month rolling average for plutonium at GS10 is not reportable, the evaluation of the reportable americium values also includes consideration of the plutonium results.

The RFLMA Parties also agreed no mitigating actions were necessary while the condition was being evaluated because plutonium and americium concentrations at the downstream POC and the other evaluation surface water monitoring locations downstream of GS10 have not exceeded the RFLMA standards, which indicates that the remedy remains protective.

To keep the public informed, the outcome of continuing RFLMA Party consultation regarding the evaluation will be reported in RFLMA quarterly and annual reports of site surveillance and maintenance activities or in subsequent contact records.

SW027 Plutonium: Surface water location SW027 is the POE at the eastern (downstream) end of the South Interceptor Ditch, upstream of Pond C-2. The 12-month rolling average for plutonium-239/240 at SW027 initially exceeded the RFLMA surface water standard on April 30, 2010. The 12-month rolling average concentration was 0.16 pCi/L and the standard is 0.15 pCi/L.

RFLMA Contact Record 2010-06 provides a discussion of the monitoring results and recaps the outcome of the RFLMA Party consultation regarding steps to be taken to evaluate the SW027 drainage area.

Mitigating actions included reseeding of some areas that had poor foliar cover, and installing additional erosion controls. Since these measures were completed in December 2010, flow and volume at SW027 has been miniscule so no confirmation samples of water quality have been possible. To keep the public informed, the outcome of continuing RFLMA Party consultation regarding the evaluation will be reported in RFLMA quarterly and annual reports of site surveillance and maintenance activities or in subsequent contact records.

Plutonium concentrations at the POC downstream of SW027 have not exceeded the RFLMA standard, which indicates that the remedy remains protective.

6.6.2.3 Performance Monitoring Locations

Performance monitoring locations are downstream of groundwater treatment systems (see Figure 3). Monitoring at these locations is used to determine short- and long-term effectiveness of these remedies where known contaminants may affect surface water.

RFLMA surface water standards are met at the surface water performance monitoring locations at the end of 2011 except for GS13. During this review period there have been several samples at performance monitoring locations that had isolated exceedances of an individual analyte, but standards were met on subsequent samples.

Surface water monitoring location GS13, in North Walnut Creek downstream of the SPPTS discharge gallery and upstream of former Pond A-1, had uranium and nitrate concentrations

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exceeding the RFLMA standard. This station helps in evaluating changes in the stream water quality resulting from removal of uranium and nitrate from groundwater by the SPPTS and provides upstream water quality data for evaluation in the event downstream water quality exceeds standards. Additional discussion of work to optimize removal of uranium and nitrate by the SPPTS is included in Section 6.6.4.2.

Uranium and nitrate standards are met at the POC downstream of GS13.

6.6.3 Groundwater Monitoring Network

The groundwater monitoring wells provide data relevant to the groundwater RAOs to restore groundwater quality and prevent significant impact to surface water quality by the migration of contaminated groundwater (see Section 4.1). Groundwater monitoring locations in the Central OU are shown on Figure 2 and RFLMA Attachment 2, Figure 1, "Water Monitoring Locations at Rocky Flats" (Appendix A of this report). Groundwater, which may include contaminated groundwater, emerges to surface water before leaving the Central OU. The RFLMA Attachment 2 decision logic flowcharts in Figure 7, "Area of Concern Wells and SW018"; Figure 8, "Sentinel Wells"; Figure 9, "Evaluation Wells"; and Figure 10, "RCRA Wells" (see Appendix A) are relevant to the groundwater monitoring data. Groundwater monitoring results are compared to RFLMA surface water standards, because the use classification of Rocky Flats groundwater is surface water protection.

Because of the naturally-elevated uranium content in much of the groundwater at Rocky Flats (and in this area of Colorado), concentrations of uranium in groundwater samples are compared with a "uranium threshold" of 120 µg/L for evaluation in accordance with the decision logic flowcharts. This value was derived for RFCA monitoring purposes prior to closure based on groundwater monitoring results from across the site.

The groundwater monitoring network is complete and sampling and analyses are being performed as required. Monitoring for each type of well in the network is discussed below.

6.6.3.1 AOC Wells

AOC wells are located within a drainage and downgradient of a contaminant plume or group of contaminant plumes. AOC wells are monitored to determine whether contaminant plumes may be discharging to surface water in the AOC well monitoring area.

Results for AOC wells during this review period indicate that the upgradient contaminant plumes are not discharging to surface water in the area of these wells.

6.6.3.2 Sentinel Wells

Sentinel wells are typically located near downgradient edges of contaminant plumes, in drainages, and downgradient of groundwater treatment systems. These wells are monitored to determine whether concentrations of contaminants indicate plume migration or treatment system problems that may result in impacts to surface water quality.

Groundwater quality in Sentinel wells at the end of this review period was generally consistent with conditions at the time of closure. Groundwater does not meet surface water standards for some analytes in most Sentinel well locations. Thus, continued implementation of the remedy to achieve groundwater RAOs is necessary. There is no indication of significant plume migration or problems with the treatment systems that impact the continuing protectiveness of the remedy.

6.6.3.3 Evaluation Wells

Evaluation wells are typically located within plumes or near plume source areas, or in the interior of the Central OU. A subset of these wells is located in areas that may experience significant changes in groundwater conditions because of closure activities. These wells are monitored to help determine when monitoring of a plume or area may cease.

Groundwater does not meet surface water standards for some analytes in most Evaluation well locations. Thus, continued monitoring of Evaluation wells is necessary to determine when groundwater is of sufficient quality to remove institutional control use restrictions and monitoring may cease.

6.6.3.4 RCRA Wells

RCRA wells monitor the PLF and OLF to determine compliance with ARAR criteria. The RFLMA Attachment 2 decision logic flowcharts in Figure 10, "RCRA Wells" (Appendix A of this report), are relevant to these data. Note that the Figure 10 evaluation includes a step for an evaluation under RFLMA Attachment 2, Figure 8, "Sentinel Wells." Results of the comparison of downgradient concentrations to upgradient concentration for a few analytes triggered RFLMA Party consultation, the outcome of which was most recently summarized in Contact Record 2010-05 (see Section 4.4) and the 2011 Annual Report.

The RFLMA Parties agreed that the results do not require any specific response other than continued RFLMA monitoring and evaluation.

6.6.4 Groundwater Treatment System Monitoring and Operations and Maintenance

The locations of the groundwater treatment systems in the Central OU are shown on Figure 3 and in RFLMA Attachment 2, Figure 1, "Water Monitoring Locations at Rocky Flats" (Appendix A of this report). Sampling and analysis of treatment system influent and effluent is conducted as required. The RFLMA Attachment 2 decision logic flowchart on Figure 11, "Groundwater Treatment Systems" (Appendix A of this report), is relevant to the treatment systems monitoring data.

Operation and maintenance conducted for three groundwater plume treatment systems during this review period included installation of automated instrumentation at the ETPTS and MSPTS, routine media replacement at the ETPTS and MSPTS, installation of pilot-scale polishing component at the MSPTS, expansion of the groundwater collection component for the SPPTS, and installation of pilot-scale treatment study components at the SPPTS. The PLFTS, which is a seep collection and flow-through aeration treatment system, did not require any repairs, enhanced maintenance or system optimization during this review period.

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The plume treatment systems remove the target contaminants from groundwater and reduce contaminant load to surface water. As discussed in Section 6.6.2, surface water monitoring indicates that RFLMA standards for the groundwater plume contaminants are consistently met at the surface water performance monitoring locations, except for uranium and nitrate at GS13, the performance monitoring location for the SPPTS.

While the SPPTS is removing significant uranium and nitrate, the original system design goals recognized that the SPPTS would not result in these standards being consistently met in system effluent, nor in them being met at GS13. In addition, the temporary modification that set the nitrate standard at 100 mg/L (i.e., at the WQCC Regulation # 31 statewide standard for agricultural use classification) expired at the end of 2009, and the RFLMA standard is now 10 mg/L (i.e., the WQCC Regulation # 31 statewide standard for the water supply use classification). Water monitored at GS13 continues to meet the agricultural use based nitrate standard. As discussed in Section 6.4.1.2, the nitrate standard for the water supply use classification applies at the inlet to drinking water supplies. Water at the POC known as WALPOC meets the standard, and there is no known drinking water supply inlet downstream of WALPOC. Uranium concentrations at GS13 are influenced by natural uranium in groundwater that contributes to baseflow.

The plume treatment systems are being properly maintained and operated, but some analytes in system effluent (which discharges to underground discharge galleries) have not consistently met RFLMA standards. This triggers RFLMA Party consultation in accordance with RFLMA Attachment 2, Figure 11, to determine if any mitigating actions should be implemented. The actions resulting from the consultative process are focused on optimizing treatment capabilities of the systems and are summarized below.

6.6.4.1 PLFTS

During this review period several quarterly effluent monitoring location samples had isolated exceedances of an individual analyte, triggering monthly sampling. Standards were met on subsequent samples, and so the sampling frequency returned to quarterly.

The monitoring results indicate that the system is meeting its objective to effectively remove trace VOC contaminants in the seep water and the treated water meets RFLMA standards at the end of this review period.

6.6.4.2 SPPTS

As discussed in Section 5, a recommendation in the Second Five-Year Review Report was made to evaluate a whether an operationally simpler and more efficient system could be designed. Based on the outcome of RFLMA Party consultation, this recommendation was implemented in a phased upgrade approach, as approved in Contact Records 2008-07 and 2009-01.

The Phase I upgrade involved installation of a groundwater collection sump, solar-powered pumping system, and effluent piping and it was completed in October 2008. The objective of the upgrade was to capture additional contaminated groundwater, thereby reducing commingling of contaminated groundwater that was not effectively captured by the original SPPTS groundwater collection system with SPPTS-treated effluent at the discharge gallery. This objective was

successfully met, with significantly higher SPPTS influent flow volumes and contaminant concentrations following completion of the Phase I upgrades. Effluent concentrations were no longer impacted between the treatment cells and subsurface point of discharge. Data collected subsequent to completion of Phase I were used to inform the Phase II and Phase III upgrades. The data collection associated with these phases is intended to inform the evaluation of alternatives for final nitrate system upgrades, referred to as Phase IV. Phases II and III were installed in 2009.

The Phase II objective was to install a new uranium treatment cell upstream of the two existing treatment cells. Routing untreated water through the zero valent iron (ZVI) for uranium removal prior to the nitrate treatment media might allow future disposal of the nitrate media as non-radioactive waste. This would also allow for easier periodic replacement of the ZVI media without impacting the nitrate treatment media. The actual uranium treatment method using ZVI remained unchanged.

Based on operating experience to date, the Phase II ZVI media, which was designed with a capacity to perform for a year or longer, was found to be capable of effective uranium removal for only about one month. It appears that the nitrate concentrations or other naturally occurring compounds in the influent groundwater may be passivating the ZVI. At the end of this review period the possible utility of a much smaller treatment cell that would use up the uranium removal capacity before passivation can occur was being evaluated.

With the expiration of the temporary modification for the nitrate standard, a goal of the proposed Phases III was to optimize nitrate treatment based on the water supply standard of 10 mg/L. The Phase III study indicates use of an inert substrate with the metered addition of nutrients is capable of adequate nitrate treatment, but implementation on a full-scale level may not be practical because of biomass fouling and the need for frequent maintenance. This treatment approach would not provide a simpler, more efficient, and less management-intensive system.

Phase II and III component operation and monitoring is ongoing. The RFLMA Parties continue to use the consultative process as appropriate to consider the Phase II and Phase III results and the development of an appropriate final configuration.

6.6.4.3 MSPTS

The MSPTS was designed to treat groundwater contaminated with VOCs from the Mound source area and was installed in 1998. The treatment media in the MSPTS is ZVI. As a part of Site closure, the nearby former Oil Burn Pit #2 was remediated via source removal in 2005. Addition of a hydrogen-releasing compound (an electron donor) in the excavation backfill was also done after soil remediation to promote biological action to break down the residual VOCs in situ. Contaminated groundwater from the former Oil Burn Pit #2 area was also routed to the MSPTS groundwater intercept trench to be treated. This caused influent flow rates and contaminant loads to increase substantially. Higher flow rates result in a lower residence time within the treatment media, which can reduce the treatment effectiveness of ZVI. Because of the addition of a hydrogen-releasing compound, the contaminants in groundwater collected from this area include elevated concentrations of metabolic byproducts such as *cis*-1,2-dichloroethene and vinyl chloride, both of which are effectively treated by increasing residence times of the contaminated water in the ZVI media. Since the groundwater is gravity fed into the system and

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flow rate is dependent on the amount of groundwater intercepted (which is influenced by normal precipitation variation), residence times cannot be effectively controlled.

Roughly one year after the former Oil Burn Pit #2 source removal some residual contaminants measured in the MSPTS effluent (upstream of the MSPTS discharge gallery) exceeded RFLMA standards. Replacement of the ZVI treatment media in the MSPTS in late summer 2006 did not fully resolve these conditions.

Based on the outcome of RFLMA Party consultation, as approved in Contact Records 2010-07 and 2011-01,the ZVI media was replaced in 2011 and a small solar-powered air stripper incorporating a sump pump and spray nozzles was installed inside the MSPTS effluent metering manhole. The air stripper has proven to be a very effective method in reducing residual VOCs in the MSPTS effluent.

The initial installation of the air stripper solar-power system was scaled to operate during daylight hours so that sufficient seasonal operational and maintenance data could be obtained to optimize a final system to operate 24 hours per day. RFLMA Party consultation related to the installation of components for the final system configuration was proceeding at the end of this review period and additional work is expected to be performed in 2012.

6.6.4.4 ETPTS

The ETPTS was designed to treat groundwater contaminated with VOCs from the East Trenches source area to the south, and was installed in 1999. The treatment media in the ETPTS is ZVI. Since installation, effluent from this system has often included one or more constituents at concentrations exceeding RFLMA standards. ZVI media replacement, most recently in late 2009, has not fully resolved these conditions.

Since the conditions observed at the ETPTS were similar to the observed conditions at the MSPTS discussed above, the RFLMA Party consultation for the MSPTS included consideration of the ETPTS effluent residual VOCs. The RFLMA Parties decided that finalizing the approach to optimize the ETPTS would depend on the outcome of the MSPTS air stripper operation. Now that the MSPTS air stripper has been shown to be very effective, RFLMA Party consultation on a similar solar-powered air stripper for the ETPTS was ongoing at the end of this review period. An initial installation is expected to be completed in 2012.

6.6.5 Present Landfill Monitoring and Maintenance

The PLF was closed in place to meet CHWA/RCRA applicable requirements of ARARs, with the construction of an approximately 22-acre RCRA-compliant composite cover, monitoring wells, and the PLFTS (completed during 2005). The location of the PLF is shown in Figure 3. A diversion channel surrounds the landfill and diverts storm water runoff away from the landfill to No Name Gulch. The PLFTS treats landfill seep water and Groundwater Intercept System water for VOCs by a passive air stripper (an arrangement of concrete steps over which the seep water flows) that discharges into No Name Gulch. A gas extraction system is also built into the landfill and allows subsurface gas to vent to the atmosphere.

During this review period all required inspections and monitoring and maintenance activities were conducted in accordance with the PLF M&M Plan and RFLMA Attachment 2, Table 3, "Present and Original Landfill Inspection and Maintenance Requirements" (Appendix A of this report).

6.6.5.1 Inspections

The inspection frequency for the PLF is quarterly and settlement monuments are surveyed annually. Inspection information includes groundwater and surface water monitoring facilities, subsidence/consolidation, slope stability, soil cover, vegetation, storm-water management structures, and erosion in surrounding features so that corrective actions can be taken in a timely manner.

The inspection form in the PLF M&M Plan is used to document the conditions found during the inspection and the follow-up actions to resolve any items that require maintenance or repair. No significant problems were observed during PLF inspections during this review period.

The vegetation on the PLF cover is now well established and has met the success criteria in the PLF M&M Plan. Therefore, a recommendation is included in Section 8.0 to terminate the PLF specific vegetation inspections. The *Rocky Flats, Colorado, Site Vegetation Management Plan* applicable to LM activities provides for appropriate vegetation monitoring, including weed monitoring and weed control in the Central OU (see Section 4.8).

The quarterly inspection frequency for other items and annual settlement monument surveying is recommended to continue.

6.6.6 Original Landfill Monitoring and Maintenance

The OLF was closed in place to meet the relevant and appropriate requirements of RCRA/CHWA as ARARs. The OLF consists of approximately 20 acres of an engineered soil cover with a minimum thickness of 2 feet, over a former solid sanitary and construction debris landfill located on the hillside north of Woman Creek. The location of the OLF is shown in Figure 3. The closure included cutting, filling, and regrading the surface to an 18-percent grade and construction of a 20-foot-high, 1,000-foot-long buttress on the south side of the OLF prior to installing the cover. A series of east-west berms on the cover direct surface runoff toward perimeter drainage channels east and west of the OLF cover. The channels carry runoff from the cover and surrounding area to below the south side of the buttress. These actions were designed to achieve hillside stability and control precipitation run-on and runoff to minimize erosion of the cover and minimize infiltration of precipitation into the OLF. The cover was completed in August 2005.

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Surface water monitoring for the OLF is performed at GS59, downstream of the OLF and the results are compared to results from GS05, upstream of the OLF and just east of the Central OU boundary (Figure 1, Appendix A of this report). The RFLMA Attachment 2 decision logic flowchart in Figure 12, "Original Landfill Surface Water" (Appendix A of this report) is relevant to the surface monitoring data. During this review period there have been several samples that had isolated exceedances of an individual analyte, but standards were met on subsequent samples. RFLMA surface water standards are met at GS59 at the end of this review period.

During this review period all required inspections and monitoring and maintenance activities were conducted in accordance with the OLF M&M Plan and RFLMA Attachment 2, Table 3, "Present and Original Landfill Inspection and Maintenance Requirements" (Appendix A of this report).

6.6.6.1 Inspections

The inspection frequency for the OLF is monthly and settlement monuments are surveyed quarterly. Inspection information includes groundwater and surface water monitoring facilities, subsidence/consolidation, slope stability, soil cover, vegetation, storm water management structures, and erosion in surrounding features so that corrective actions can be taken in a timely manner.

The inspection form in the OLF M&M Plan is used to document the conditions found during the inspection and the follow-up actions to resolve any items that require maintenance or repair. The only significant items noted in OLF inspections involved the localized slumping and settling and seep conditions that were observed in 2007 and discussed in the Second Five-Year Review Report. A discussion of the response to these conditions during this review period is included in Section 6.3.

The vegetation on the OLF cover is now well established and has met the success criteria in the OLF M&M Plan. Therefore, a recommendation is included in Section 8.0 to terminate the OLF specific vegetation inspections. The *Rocky Flats, Colorado, Site Vegetation Management Plan* applicable to LM activities provides for appropriate vegetation monitoring including weed monitoring and weed control in the Central OU (see Section 4.8).

Because of the localized instability and intermittent surface expression of seeps on the OLF cover, the quarterly settlement monument surveying and monthly inspection frequency for other items is recommended to continue.

6.6.7 Ecological Sampling

RFLMA Attachment 2, Table 5 (Appendix A of this report), requires a minimum of three quarterly water samples at Ponds A-4, B-5, and C-2 for radium-228, cyanide, and ammonia in support of ecological objectives. The sampling was completed as discussed in Section 3.5.2.2.

6.7 Inspection of the Central OU

RFLMA Attachment 2, Sections 5.3 and 5.4, specifies the remedy M&M requirements, which includes the periodic inspections and monitoring of particular aspects of the remedy components,

including quarterly and annual inspection. During this review period, all required inspections were conducted and reported in accordance with RFLMA requirements.

An annual inspection was conducted in accordance with RFLMA Attachment 2 on March 12, 2012, which also served as the Central OU inspection in accordance with CERCLA five-year review guidance. Appendix B contains the inspection checklist and maps for the March 12, 2012, Central OU inspection. Several photographs taken during the inspection are also included.

The RFLMA annual inspections results are included in the RFLMA Quarterly Report of Site Surveillance and Maintenance Activities for the quarter in which the inspection occurred, as well as in each RFLMA Annual Report of Site Surveillance and Maintenance Activities.

Evidence of significant erosion and institutional control violations must be inspected for annually, in accordance with RFLMA Attachment 2, Sections 5.3.4 and 5.3.6.

The following categories were monitored during the inspection:

- Evidence of significant erosion in the COU and evaluation of the proximity of significant erosion to subsurface features in RFLMA Attachment 2, Figures 3 and 4. This monitoring included visual observation for precursor evidence of significant erosion (e.g., cracks, rills, slumping, subsidence, sediment deposition);
- The effectiveness of institutional controls, as determined by any evidence of their being violated; and
- Evidence of adverse biological conditions, such as unexpected morbidity or mortality, observed during the inspection and monitoring activities.

On March 13, 2012, a team member verified that the Environmental Covenant for the COU remains in the Administrative Record and on file with the Jefferson County land records. In addition, physical controls (signs placed along the COU fence) were also inspected.

Marker flags were placed where conditions showed evidence of the three condition categories listed above, to track their location for follow-up by Site subject matter experts. As in previous annual inspections, several areas were noted as having evidence of erosion, possible depressions, or holes.

Most inspection observations were related to metal debris on the surface or trash that was either picked up or marked for subsequent removal and pickup. Rocky Flats field operations subject matter experts subsequently visited the areas to determine if any observations appear to be significant or require repairs and to collect debris.

Note that the 2012 inspection (as well as the 2011 inspection) also included the SW027 drainage area, to look for signs of significant erosion or precursors of significant erosion, such as cracks, rills, slumping, subsidence, and sediment deposition. This area was included pursuant to the revegetation seeding and erosion controls installed as follow-up actions for elevated levels of plutonium at SW027 (see Section 6.6.2.2). There were no signs of significant erosion or precursors to erosion. The compost/wood-chip-filled wattles that were placed on the hillside in 2010 are holding up well and working effectively.

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No evidence of violations of institutional controls or physical controls was observed.

A deep hole in the vicinity of the southwest corner of former Building 881 was noted during the 2011 annual inspection. Survey coordinates indicate that the location of the hole was the south stairwell leading from the building entrance hallway to the basement level. A photograph of the hole is included in Appendix B. The area was then filled and contoured. The hole appears to be due to settling of fill material at the bottom area of the staircase, causing the fill soil to settle into the staircase structure that did not fully collapse during demolition.

The hole was filled and graded and the area reseeded. Based on the depth of the Building 881 hole and the possibility that other holes could form in the future above buried subsurface structures, the areas have been marked with fence posts and site operations personnel now inspect selected areas quarterly. In the fourth quarter of 2011 it was noted that a minor depression and surface cracking had formed on the gravel road that is just south of former Building 771. Evaluation indicated that the hump and cracking were in the vicinity of a stairwell on the southeast corner of the building. The gravel road was relocated further south and the depression and minor cracking area was filled and graded and the area was reseeded.

No other former building areas were noted as having depressions or subsidence.

No adverse biological conditions were noted during the inspection.

6.7.1 Inspection of RCRA Well Sampling

CDPHE also observed the routine scheduled sampling of RCRA wells associated with the PLF on February 16, 2012. O&M Inspections are conducted on a triennial schedule as required by RCRA inspection national core program requirements for Land Disposal Facilities, which CDPHE has agreed to implement in a CDPHE/EPA RCRA Hazardous Waste Program Memorandum of Agreement dated September 11, 2000.

CDPHE determined the sampling was in accordance with applicable procedures. The CDPHE observations are included in Appendix B of this report.

6.8 Review of O&M Costs

The O&M cost of the selected remedy was estimated in the RI/FS Report and presented in the 2006 Proposed Plan. The total annual estimated O&M costs were $2,575,000, which included groundwater treatment system media replacement estimated at $728,000 every five years for each of the three systems.

The remedy-related implementation cost for this review period was compiled using actual costs for fiscal years (FYs) 2008 through 2011, while FY 2012 costs were estimated using the average of the four previous years. The following O&M and capital costs incurred (or estimated for FY 2012) during this review period were included in the evaluation:

- Groundwater and surface water monitoring
- Operation, inspection, and maintenance of the groundwater treatment systems

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- Inspections and monitoring of the remedy-related physical and institutional controls
- RFLMA required data collection and reporting, including public participation activities
- Implementing the RFLMA consultative process
- Modifications to RFLMA Attachment 2 and CAD/ROD amendment
- MSPTS and ETPTS media replacement
- OLF and PLF inspections and cover vegetation management, including weed control
- OLF soil cover and diversion berm repairs and maintenance
- OLF geotechnical investigation and soil sampling
- OLF west perimeter channel reconfiguration based on the geotechnical investigation recommendations
- SPPTS Phase I, II, and III upgrades and optimization work
- Upgrades to ETPTS piping configuration and repair of MSPTS discharge gallery to improve operability
- Addition of a solar-powered polishing air stripper to MSPTS
- Construction of flumes for new POC locations at WALPOC and WOMPOC
- Erosion controls, subsidence repair, and revegetation monitoring
- Evaluation of reportable conditions at GS10 and SW027 including investigation monitoring, and seeding and erosion controls at the SW027 drainage
- Conduct of five-year review
- Monitoring and consultation regarding threatened and endangered species and wetlands
- Water monitoring equipment capital costs and maintenance and well abandonment
- Implementing new or changed ARARs
- Project management and overhead costs

Costs for a projected SPPTS media replacement and possible addition of an air stripping unit to ETPTS in late FY 2012 were not included. The scheduled ETPTS media replacement for FY 2012 will be deferred to FY 2013 to evaluate the effect of the addition of the air stripping unit, so this cost was also not included.

Total O&M and capital costs for this review period is estimated to be approximately $13.8 million. The RI/FS Report projected that the 5-year cost for implementing Alternative 2 would be approximately $13.6 million, in unescalated 2005 dollars. Thus, the remedy implementation costs are similar to the projected costs.

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6.9 Review of New Technologies

Pursuant to RFLMA, the five-year review process includes an evaluation of additional response actions that would reduce the need to rely on institutional controls. The basis for institutional controls is provided in the objective and rationale for each institutional control, which is included in Table 3.

Institutional controls that protect engineered components are recommended until the engineered component would no longer be needed. No feasible alternatives (that were not considered in the Proposed Plan) have been identified that would result in removal of specific engineered components.

Institutional controls that prevent risk from exposure to residual contamination are recommended until the RAOs underlying the objective and rationale of the institutional controls are met. Again, no feasible alternatives (that were not considered in the Proposed Plan) have been identified to meet this goal.

However, as discussed in Section 6.6.4, system optimization initiatives are underway for the ETPTS, MSPTS, and SPPTS. These initiatives potentially could improve performance, reduce costs, or reduce the need to rely on certain institutional controls related to contaminated groundwater plumes and protection of surface water quality.

The use of ion-exchange resin treatment media to remove uranium is a new technology has been identified for potential SPPTS optimization. The approach would be similar to the use of ZVI media in a treatment cell, but it might be immune from the passivation effects that appear to reduce the capacity and longevity of the ZVI media. Several new ion-exchange resin products have been developed that will be evaluated further for application at the SPPTS.

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7.0 Technical Assessment

This section provides the answers, as well as the basis and rationale for those answers, to the following Technical Assessment questions:

- **Question A:** Is the remedy functioning as intended by the decision documents?
- **Question B:** Are the exposure assumptions, toxicity data, cleanup levels, and RAOs still valid?
- **Question C:** Has any other information come to light that would call into question the protectiveness of the remedy?

Relevant information obtained (as described in Section 6.0, "Five-Year Review Process") was evaluated to determine the answers to these questions.

7.1 Question A: Is the Remedy Functioning as Intended?

Yes, the remedy is functioning as intended.

Remaining contamination is effectively contained and the institutional and physical controls are in place and are successfully preventing exposure. DOE procedures are in place for proper operation and maintenance of remedy components and the implementation of institutional controls in accordance with RFLMA. Required physical and institutional controls are in place and successfully preventing exposure.

All RFLMA monitoring and inspections were completed in accordance with RFLMA required schedules. Evaluation and reporting of monitoring and inspection results were completed in accordance with RFLMA-required schedules.

Performance of technical elements of the remedy is consistent with expectations. RFLMA requirements for timely reporting and evaluation of reportable conditions and mitigating actions are being met. To keep the public informed, evaluation is reported in RFLMA quarterly and annual reports of site surveillance and maintenance activities or in contact records. The timely evaluations included determinations that the particular conditions did not change the level of protectiveness of the remedy.

Surface water leaving the Central OU is continuously monitored at the POCs (see Figure 3) and surface water at the Central OU boundary meets RFLMA standards. RFLMA standards are based on the Colorado surface water quality standards and thus the water is acceptable for all uses.

Elevated levels of uranium, plutonium 239/240 and americium-241 occurred at POEs GS10 and SW027, upstream of the POCs. Reporting, RFLMA Party consultation, evaluation, and mitigating actions were carried out in accordance with RFLMA. Appropriate evaluations and follow-up actions were completed or are ongoing.

Surface water is being impacted by groundwater plumes contaminated with volatile organic constituents, nitrates, and uranium (see Figure 2 and RFLMA Attachment 2, Figure 2, "Composite Plume Map" in Appendix A of this report) Monitoring results for the AOC wells

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downgradient of the groundwater plumes (see Figure 3) do not indicate plume migration into the AOC well areas.

The landfill covers are being maintained as required and the groundwater treatment systems are being properly operated and maintained and continue to reduce loading of groundwater contaminants to surface water. DOE has taken steps to optimize and improve operability of the systems in consultation with the RFLMA regulatory agencies.

In addition to ongoing inspections of remedy components in accordance with RFLMA requirements, Central OU inspections have been conducted annually, with the most recent inspection on March 12, 2012. No conditions were found that would call into question the protectiveness of the remedy.

There are no changes to ARARs or new standards that have been promulgated that call into question the protectiveness of the remedy. ARARs are being met based on the implementation status of ARARs as discussed in Section 6.0.

The costs to conduct the remedy-related activities during this review period are consistent with the estimate developed in the RI/FS Report, also indicating the remedy is performing as expected.

The issues identified in the Second Five-Year Review Report have been satisfactorily addressed as noted in Section 5.0. Several early indicators of potential issues have been identified during this review, which are discussed in Section 8.0. At this time it does not appear that these items will present significant problems in maintaining continuing remedy protectiveness. DOE will continue to follow the RFLMA consultative process for planning and taking appropriate mitigation actions if necessary.

7.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Still Valid?

Yes, these aspects of the remedy are still valid.

No changes in exposure pathways or assumptions have been identified that could call into question the protectiveness of the remedy. The Central OU land use is consistent with the Rocky Flats Wildlife Refuge land use assumption in the CAD/ROD. The Wildlife Refuge has been established in the land surrounding the Central OU. Rocky Flats conditions appear reasonably consistent with those expected in the CAD/ROD.

The type and extent of worker activities in the Central OU are consistent with the CRA exposure scenario for workers conducting required M&M activities. The duration of time spent onsite to perform activities appears to be somewhat less than the duration used in the exposure scenario.

Changes in standardized human health risk assessment methodologies (e.g., vapor intrusion guidance [EPA 2009b]) do not affect relevant exposure pathways. There have been changes to some recommended exposure factors (EPA 2011c), which would result in lower estimates of risk. Current toxicity values for human health are unchanged or (in the case of vanadium) will not affect risk estimates in the CRA. There have been some changes and additions to the body of

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knowledge regarding ecological risks and benchmarks for exposures to soil; however, in general, the methods for assessing ecological risks from soils have not changed. RESRAD computer codes for assessment of radiological risks for ecological and human health risks have been updated, but the changes would not affect the conclusions of the CRA. Based on the conservative assumptions used in the human health and the ecological risk assessments, refinements to risk assessment methodologies, toxicity values, and exposure parameters have not been significant enough to alter the overall conclusion that the remedy is protective. No reevaluation of risks is necessary.

The RAOs and ARARs used at the time of remedy selection are still valid to address the contaminated media and pathways of potential exposure and to provide continuing remedy protectiveness. Not all RAOs are currently met; however, the remedy is designed to achieve all RAOs in the long term.

The status of each RAO is as follows:

- **Groundwater RAO 1:** Meet groundwater quality standards, which are the Colorado WQCC surface water standards, at groundwater AOC wells.

  This RAO was considered met at the time of the CAD/ROD for the wells identified in the RI/FS Report as AOC wells. While uranium concentrations in the wells identified as AOC wells in the RI/FS exceeded the surface water standard, they were below the background level. The uranium threshold of 120 µg/L used for RFLMA evaluations was derived from the background level for application to RFCA monitoring.

  Results for AOC wells during this review period indicate that the upgradient contaminant plumes are not discharging to surface water in the area of these wells. All AOC well locations will continue to be monitored.

- **Groundwater RAO 2:** Restore contaminated groundwater that discharges directly to surface water as base flow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable time frame. This is measured at groundwater Sentinel wells. Prevent significant risk of adverse ecological effects.

  The status has not changed since the CAD/ROD. The first part of Groundwater RAO 2 (restore contaminated groundwater to its beneficial use) is not met at all Sentinel wells, so RFLMA-required groundwater treatment system O&M will continue. The final remedy decision recognized that no additional removal, containment, or treatment actions were practicable. Contaminated groundwater is not significantly impacting surface water because RFLMA standards are met at POCs. All sentinel wells will continue to be monitored.

  The second part of Groundwater RAO 2 (prevent significant risk of adverse ecological effects) was met at the time of the CAD/ROD and contaminant concentrations have not changed significantly since the CAD/ROD.

- **Groundwater RAO 3:** Prevent domestic and irrigation use of groundwater contaminated at levels above MCLs.

  At the time of the CAD/ROD, this RAO technically was not met because there was no formally required control in place to prevent groundwater use. Institutional controls required by the CAD/ROD have since been implemented and, thus, this RAO is now met.

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- **Surface Water RAO:** Meet surface water quality standards, which are the Colorado WQCC surface water standards.

  The status has not changed since the CAD/ROD. This RAO was met at the time of the CAD/ROD at the POCs. However, the CAD/ROD also recognized that surface water in the Central OU does not always meet Colorado surface water quality standards at surface water monitoring points upstream of the terminal ponds, such as at POE GS10 and the performance monitoring station GS13 for uranium. Progress toward meeting this RAO will continue to be evaluated in accordance with RFLMA Attachment 2.

- **Soil RAO 1:** Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.

  This RAO was not met at the time of the CAD/ROD. The status has not changed since the CAD/ROD. This RAO is not met everywhere in the Central OU. Some remaining subsurface contamination has complete pathways to surface water (via groundwater) resulting in samples that are above surface water standards at a number of Sentinel wells for VOCs, nitrate, and uranium. However, the final remedy decision recognized that no additional removal, containment, or treatment actions were practicable. Progress toward meeting this RAO will continue to be evaluated in accordance with RFLMA Attachment 2.

- **Soil RAO 2:** Prevent migration of contaminants that would result in exceedances of surface water RAOs.

  The CAD/ROD recognized that this RAO is met if residual contamination in surface soil is not disturbed, as the fate and transport evaluation found that two soil contaminants (plutonium-239/240 and americium-241) have complete pathways to surface water if soil is allowed to migrate. Institutional controls are now in place to prohibit soil disturbance unless controls are being followed to limit contaminated soil migration. Institutional controls required by the CAD/ROD have been implemented and, thus, this RAO is now met.

- **Soil RAO 3:** Prevent exposures that result in unacceptable risk to the WRW. The 10^{-6} risk level was used as the point of departure for determining remediation goals for alternatives when ARARs were not available or were not sufficiently protective because of the presence of multiple contaminants at Rocky Flats or multiple pathways of exposure (40 CFR 300.430[e][2][i][A][2]). Prevent significant risk of adverse ecological effects.

  At the time of the CAD/ROD, Soil RAO 3 was determined not to be met for human health unless all exposure assumptions inherent in the CRA are met. In addition, for subsurface soil, the CRA concluded that the indoor air pathway is potentially significant if buildings were constructed and occupied in portions of the Central OU where there are exceedances of volatilization WRW PRGs in subsurface soil and groundwater. The ERA indicated that soil conditions do not represent significant risk of adverse ecological effects, so this RAO is met for the environment.

  Institutional and physical controls required by the CAD/ROD have been implemented and exposures are within the scenario assumptions. Thus, this RAO is now met.

7.3 Question C: Has Any Other Information Come to Light That Could Call Into Question the Protectiveness of the Remedy?

No. Although there were some changes to toxicity factors and exposure pathways in IRIS and EPA guidance, these do not change the level of risk. If ICs that are in place to prevent certain

exposure pathways, such as the occupied building restriction for the air volatilization pathway, are proposed to be changed or discontinued, the risks would need to be evaluated using factors and guidance in effect at that time.

No other information has come to light that could call into question the protectiveness of the remedy.

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8.0 Issues, Recommendations, and Follow-Up Actions

The review identified several issues that if they were not being addressed under the RFLMA consultative process, could become early indicators of potential remedy problems. Because they are being appropriately addressed under the RFLMA remedy implementation requirements, they do not affect the remedy protectiveness currently or in the future.

Table 7 presents a summary of issues and their relationship to the status of current or future protectiveness in accordance EPA's Five-Year Review Guidance, along with follow up to address the issues.

Recommendations regarding continuing, modifying, or discontinuing the remedy components as required by RFLMA Section 7.3 and Attachment 2, Table 3 (Appendix A of this report), are presented in Table 8.

Table 7. Issues, Recommendations, and Follow-Up

Issue	Currently Affects Protectiveness (Y/N)?	Potentially Affects Future Protectiveness (Y/N)?	Follow-Up and Expected Completion Date
Surface water Point of Evaluation (POE) GS10 uranium concentration has periodically exceeded the RFLMA standard during this review period and exceeds the standard at the end of this review period. POEs are located upstream of surface water POCs at the edge of the former Industrial Area to provide early indication of potential contaminant migration.	N	N	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended, and to establish the schedule to complete actions. Uranium levels at GS10 are linked to seasonal low flow conditions and the influence of predominantly natural uranium in groundwater that contributes to base flow at GS10. Monitoring downstream of GS10 shows that conditions at GS10 do not and are not likely to result in exceedance of the RFLMA standard at the POC. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.
Surface water POE GS10 americium concentration began to exceed the RFLMA standard in 2011 and exceeds the standard at the end of this review period.	N	N	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended, and to establish the schedule to complete actions. Americium levels at GS10 may be linked to colloidal transport mechanisms or surface soil and sediment erosion mechanisms. Soil erosion does not appear to be a primary factor, since erosion is usually associated with heavy precipitation events and high flow conditions. The elevated americium levels have occurred generally during low flow conditions indicating colloidal transport at GS10. Monitoring downstream of GS10 shows that conditions at GS10 do not and are not likely to result in exceedance of the RFLMA standard at the POC. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.

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Table 7 (continued). Issues, Recommendations, and Follow-Up

Issue	Currently Affects Protectiveness (Y/N)?	Potentially Affects Future Protectiveness (Y/N)?	Follow-Up and Expected Completion Date
Surface water POE SW027 plutonium concentration exceeded the RFLMA standard in 2010 during a high precipitation event. The standard was no longer exceeded at the end of this review period.	N	N	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended, and to establish the schedule to complete actions. After mitigating actions to improve erosion controls in the drainage were completed in 2010, only very small volumes of infrequent, short-term, intermittent flows occurred at SW027. No samples have been able to be obtained for over a year. Because the RFLMA standard is based on 12 month rolling average of the results, and there are no sample results for averaging, the standard was no longer exceeded at the end of this review period. Samples will be obtained when there is sufficient flow to evaluate the effectiveness of the mitigating measures. Continue to monitor in accordance with RFLMA requirements.
Institutional controls might not be easily enforceable against a utility easement holder who is not a party to the Environmental Covenant. While this is not a near-term issue (because the Office of Legacy Management (LM) maintains a good working relationship with the current easement holder), the lack of enforceability could become an issue in the future if LM and the easement holder (or any successor) do not maintain routine contact.	N	N	Replace the Environmental Covenant with a restrictive notice under Colorado law, as provided for in the 2011 CAD/ROD amendment. While an environmental covenant might not be directly enforceable against a prior holder of an interest in land who is not a party to the covenant, a restrictive notice is enforceable by CDPHE against any person in violation of the institutional controls. DOE and CDPHE will consult with goal to replace the Environmental Covenant with a restrictive notice by end of 2012.

Table 8. Results of the Evaluation of Remedy Components Under RFLMA

Physical Controls – DOE must maintain physical controls as necessary to protect engineered elements of the remedy, such as landfill covers, groundwater treatment systems, and monitoring equipment.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 3.1: Physical controls are required as necessary to protect engineered elements of the remedy, such as landfill covers, groundwater treatment systems, and monitoring equipment.	Engineered components of treatment systems and monitoring locations are protected by adequate enclosures or by construction materials, such as concrete. The landfill cover components are also subject to institutional controls to prevent activities that might damage the components.	Continue
Section 3.2: "No Trespassing" signs are required to be posted around the Central OU perimeter. Signs listing the institutional controls and providing contact information are required to be posted at Central OU vehicle access points.	The required signs are in place and are repaired or replaced as needed to maintain them in good condition.	Continue
Section 5.3.5: Condition of signs and other physical controls maintained by DOE must be inspected on a quarterly basis.	The condition of components is evaluated at least quarterly as inspections, monitoring, maintenance, or sampling is performed in accordance with RFLMA requirements. Signs are inspected quarterly.	Continue
Institutional Controls – DOE will implement a series of institutional controls so that the assumptions incorporated into the risk assessments for the likely future users are not violated so that users do not receive unacceptable levels of exposure to residual contamination. Certain controls are also needed to prevent damage to engineered components of the remedy. These controls will be embodied in an environmental covenant or a restrictive notice. DOE will inspect the Central OU on a regular basis, but no less than annually, to ensure that these institutional controls are maintained.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 4.0: Institutional controls are established in the CAD/ROD and implemented to meet the objective and rationale of the institutional control. The RFLMA consultative process is used for any regulatory determination required regarding proposed activities subject to institutional controls.	The institutional controls are in place and being adhered to. The RFLMA consultative process is being properly implemented and, as applicable, the public is kept informed of the outcome of the process by contact records posted to the Rocky Flats public website at least 10 days prior to conducting activities requiring RFLMA regulatory approval.	Continue
Section 5.3.6: The effectiveness of the institutional controls is determined by inspecting the Central OU at least annually for any evidence of violations of those controls. DOE also annually verifies that the environmental covenant or restrictive notice for the Central OU remains in the Administrative Record and is recorded in Jefferson County.	Based on the annual inspections of the Central OU the institutional controls are effective. DOE has granted CDPHE an environmental covenant for the institutional controls and it is on file in the Administrative Record and the Jefferson County land records.	Continue inspections and verification. Continue the environmental covenant until it is replaced by a restrictive notice. There is no recommendation to modify or discontinue any institutional control.
Table 4, "Institutional Controls for the Central Operable Unit"	All required institutional controls and the objective and rationale for each one are included in Table 4.	Continue

Table 8 (continued). Results of the Evaluation of Remedy Components Under RFLMA

Section 5.3.4: The Central OU will be monitored for significant erosion annually and following major precipitation events. DOE will evaluate whether the erosion is in proximity to the subsurface features shown in Figures 3 and 4. Monitoring will include visual observation (and measurements, if necessary) of precursor evidence of significant erosion (cracks, rills, slumping, subsidence, sediment deposition, etc.).	Items requiring maintenance to address erosion or precursor evidence of significant erosion is performed in a timely manner. This helps assure that the assumptions incorporated into the risk assessments are not violated so that workers do not receive unacceptable levels of exposure to residual contamination.	Continue
Environmental Monitoring: Surface Water Monitoring – Conducted at the following types of locations: • POCs are established for the purpose of monitoring compliance with surface water quality standards for water leaving the Central OU. • POEs are established for the purpose of monitoring the quality of water flowing from the former Industrial Area. • Monitoring points in addition to POEs and POCs are established as needed in surface water at points known to be affected by contamination from Rocky Flats activities, for the purpose of determining the effects of the remedy on surface water quality.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 2.0: The remedy performance standards for surface water are in Table 1 and are based on Colorado WQCC Regulation #. 31: Basic Standards and Methodologies for Surface Water (5 CCR 1002-31) and on the site-specific standards in Regulation # 38 (5 CCR 1002-38).	The RFLMA standards are being applied as required. The RFLMA Parties remain cognizant of any proposed and final changes to standards in Regulations # 31 and # 38. As appropriate, DOE may petition the WQCC to initiate a rulemaking proceeding to modify particular standards or participate as a party or as a commenter in particular rulemaking proceedings that may affect the basis for RFLMA standards. The RFLMA Parties use the consultative process to consider modifications to RFLMA Attachment 2 (Including Table 1) that may be needed based on WQCC rulemaking.	Continue
Table 1, "Surface Water Standards "	Table 1 reflects the current standards in WQCC Regulations # 31 and # 38.	Continue
Table 2, "Water Monitoring Locations and Sampling Criteria"	Table 2 includes the surface water monitoring locations, monitoring frequency, and analytes. In addition to POCs and POEs, plume treatment system performance monitoring locations, OLF and PLF monitoring locations, and a remediated carbon tetrachloride release location are monitored. Required water monitoring locations are established and, where applicable, automated sampling equipment is in place and operating properly.	Continue
Section 5.1: The data evaluation methods for sampling data collected at the RFLMA surface water monitoring locations are described in the flowcharts in Figures 5, 6, 7, 12, and 13	Required evaluations are done when laboratory data is received. The evaluation flowcharts are effective in determining when results trigger notification of a reportable condition and trigger implementation of the RFLMA consultative process to determine what, if any, mitigating actions may be required.	Continue

Table 8 (continued). Results of the Evaluation of Remedy Components Under RFLMA

Environmental Monitoring: Groundwater Monitoring – Conducted at the following types of locations: • AOC wells: Located within drainages downgradient of a contaminant plume or group of plumes. • Sentinel wells: Typically located near downgradient edges of contaminant plumes, in drainages, and at and downgradient of groundwater treatment systems. • Evaluation wells: Typically located within plumes and near plume source areas, or in the interior of the former Industrial Area. • RCRA Wells: Located upgradient and downgradient of the OLF and PLF.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 2.0: The WQCC-designated groundwater use classification is surface water protection. The numeric values for measuring potential effects of contaminated groundwater on surface water quality are the surface water standards in Table 1.	The RFLMA standards are being applied as required.	Continue
Table 2, "Water Monitoring Locations and Sampling Criteria."	Table 2 includes the groundwater monitoring locations, monitoring frequency and analytes. Required well locations are established and operating properly.	Continue
Section 5.2: Groundwater is monitored in or near areas of groundwater contamination that might adversely affect surface water quality. The data evaluation methods for sampling data collected at the RFLMA groundwater monitoring locations are described in the flowcharts in Figures 7 through 11.	Required evaluations are done when laboratory data is received. The evaluation flowcharts are effective in determining when results trigger notification of a reportable condition and trigger implementation of the RFLMA consultative process to determine what, if any, mitigating actions may be required.	Continue
Operation and Maintenance of Engineered Structures: Plume Treatment Systems – Monitoring, inspection, and maintenance requirements for the plume treatment systems are derived from the respective RFCA accelerated action decision documents for the ETPTS, MSPTS and SPPTS.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 5.3: The plume treatment systems will be monitored, at a minimum, for untreated influent and treated effluent, and for impacts to surface water downstream of the effluent discharge point according to the sampling criteria in Table 2 and the decision rules in the flowchart in Figure 11. The systems will be maintained to ensure the effluent meets Table 1 standards.	The RFCA monitoring plans were superseded by RFLMA requirements. The flowchart decision rules for each system in Figure 11 is consistent with RFCA accelerated action decision document goals to reduce surface water loading of contaminants from contaminated groundwater plumes as determined by system effluent and RFLMA performance monitoring locations.	Continue
Table 2, "Water Monitoring Locations and Sampling Criteria."	Table 2 includes the monitoring locations, monitoring frequency, and analytes associated with the treatment systems. Required sampling locations are established and operating properly.	Continue

Table 8 (continued). Results of the Evaluation of Remedy Components Under RFLMA

Monitoring and Maintenance of Engineered Structures: Landfills – Inspection and maintenance of the OLF and PLF covers and the PLF seep treatment system are derived from the OLF and PLF M&M Plans, respectively.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Table 3: "Present and Original Landfill Inspection and Maintenance Requirements."	Table 3 summarizes the inspection and maintenance requirements contained in the approved OLF M&M Plan and PLF M&M Plan. Inspection and maintenance is being performed as required. The OLF and PLF cover vegetation meets success criteria. The OLF has areas of localized slumping and settling and intermittent surface expression of seeps and routine maintenance to address these conditions is being done in a timely manner.	Discontinue specific vegetation monitoring, which is no longer needed. Continue the other inspection requirements.
Section 5.3: PLFTS monitoring requirements are same as specified for the plume treatment systems, above.	The flowchart decision rules in Figure 11 are consistent with RFCA accelerated action decision document goals to meet surface water standards determined by system effluent and RFLMA performance monitoring locations.	Continue
Periodic Reporting – DOE will perform regular reporting to CDPHE and EPA, and will maintain site data related to the remedy in a manner that is accessible to regulators and the public.		
RFLMA Attachment 2 – Remedy Performance Standards/Implementation	**Status**	**Continue, Modify, or Discontinue?**
Section 7.0: Analytical data and other information will be clearly presented along with summaries and evaluations to help interpret the data. Reports will be posted on the LM public website and available for regulatory and public review on specified dates.	As required by RFLMA paragraph 26, CDPHE has approved all quarterly reports and all annual reports, except for the 2011 report, submitted on April 30, 2011, which is under review.	Continue
Section 7.1: Quarterly Legacy Management Reports: • Quarter ending March 31 posted by July 15 • Quarter ending June 30 posted by October 15 • Quarter ending September 30 posted by January 15	All required quarterly reports were posted to the Rocky Flats public website on or ahead of the RFLMA submittal milestone.	Continue
Section 7.2: Annual Legacy Management Report: Year and Quarter ending December 31 posted by April 30.	All required annual reports were posted to the Rocky Flats public website on or ahead of the RFLMA submittal milestone.	Continue

8.1 Additional Recommendations Resulting From the Review

Other recommendations resulting from this review are described below.

Continuation of activities related to groundwater treatment system optimization is recommended. This includes evaluating ion exchange resin as a possible uranium treatment media for the SPPTS.

9.0 Protectiveness Statement

The remedy for the Central OU is protective of human health and the environment because surface water concentrations are meeting standards at points of compliance, and monitoring and maintenance plans and institutional controls are working to prevent unacceptable exposure to site contaminants.

In accordance with EPA guidance, because Rocky Flats is a construction complete site, a site-wide protectiveness statement is also required in the five-year review report. Because the conditions in all OUs associated with the Rocky Flats NPL site are protective, the site is protective of human health and the environment.

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10.0 Next Review

Contaminants at the Central OU are expected to remain at levels that do not allow unlimited use and unrestricted exposure and will require continued remedy implementation for the foreseeable future. Thus, a fourth five-year review will be required.

The next five-year review report will be submitted to EPA for concurrence in 2017.

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