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AUG -2 2017

Ref: 8EPR-SR

Scott Surovchak
Rocky Flats/LM Site Manager
US Department of Energy, Office of Legacy Management
11025 Dover Street, Suite 1000
Westminster, Colorado 81503

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

Dear Mr. Surovchak:

Thank you for submitting the Five-Year Review Report for Rocky Flats Site, Jefferson County, Colorado. The U.S. Environmental Protection Agency in consultation with the State of Colorado concurs with your assessment that the remedy at this site 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 are being tracked in the EPA's Superfund Environmental Management System (SEMS). The environmental indicator for this site is "current human exposure is controlled and a protective remedy is in place."

The due date for the next five-year review report will be August 3, 2022.

Sincerely,

Betsy Smidinger

Betsy Smidinger
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

cc: Carl Spreng, CDPHE
Lindsay Masters, CDHE

LMS/RFS/S15528

Fourth Five-Year Review Report for the Rocky Flats Site Jefferson County, Colorado

June 2017

U.S. DEPARTMENT OF ENERGY | Legacy Management

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LMS/RFS/15528

Fourth Five-Year Review Report
for the Rocky Flats Site
Jefferson County, Colorado

June 2017

Approved by:

U.S. Department of Energy, Office of Legacy Management

Date:

6/12/17

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Abbreviations

Am	americium
AOC	Area of Concern
AOI	analyte of interest
ARAR	applicable or relevant and appropriate requirement
CAD/ROD	Corrective Action Decision/Record of Decision
CCR	*Code of Colorado Regulations*
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COU	Central Operable Unit
CR	contact record
CRA	comprehensive risk assessment
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
ETPTS	East Trenches Plume Treatment System
EU	exposure unit
EUR	Environmental Use Restriction
FR	*Federal Register*
FYR	five-year review
HQ	hazard quotient
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
LM	Office of Legacy Management
µg/L	micrograms per liter
m^3	cubic meters
M&M	monitoring and maintenance
MCL	maximum contaminant level
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter

mrem/year	millirems per year
MSPTS	Mound Site Plume Treatment System
NPL	National Priorities List
O&M	operation and maintenance
OLF	Original Landfill
OU	operable unit
OU3	Offsites Areas (Operable Unit 3)
pCi/g	picocuries per gram
PLF	Present Landfill
PLFTS	Present Landfill Treatment System
POC	point of compliance
POE	point of evaluation
POU	Peripheral Operable Unit
PQL	practical quantitation limit
PRG	preliminary remediation goal
Pu	plutonium
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFLMA	Rocky Flats Legacy Management Agreement
RFP	Rocky Flats Plant
RFS	Rocky Flats Site
RFSC	Rocky Flats Stewardship Council
RI/FS	Remedial Investigation/Feasibility Study
RSL	regional screening level
SPPTS	Solar Ponds Plume Treatment System
TCE	trichloroethene
U	uranium
UU/UE	unlimited use/unrestricted exposure
VOC	volatile organic compound
WALPOC	Walnut Creek point of compliance
WOMPOC	Woman Creek point of compliance
WRW	wildlife refuge worker
ZVI	zero-valent iron

Executive Summary

This report documents the fourth five-year review for the Rocky Flats Site Central Operable Unit (COU). The Rocky Flats Site is located approximately 16 miles northwest of Denver and 12 miles north of Golden in Colorado. Because remaining contamination in the COU does not allow for unlimited use and unrestricted exposure, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that a review be conducted every 5 years to determine whether remedial actions remain protective of human health and the environment. The U.S. Department of Energy (DOE), as the lead agency, conducted the review with the assistance of the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). This fourth five-year review report covers remedy implementation at the COU for the period of January 1, 2012, through December 31, 2016.

The Rocky Flats Plant was established in 1952 as part of the nuclear weapons complex to manufacture nuclear weapons components under the jurisdiction and control of DOE and its predecessor agencies. Manufacturing activities, accidental industrial fires, spills, and support activities resulted in the release of hazardous constituents to air, soil, sediment, groundwater, and surface water at the Rocky Flats Plant. Contaminants released to the environment include the radionuclides plutonium, americium, and uranium isotopes; organic solvents including trichloroethene, tetrachloroethene, and carbon tetrachloride; metals such as chromium; and nitrates.

The Rocky Flats Plant was listed on the CERCLA National Priorities List (NPL) in 1989. In 1991, the Rocky Flats Plant and surrounding lands were divided into 16 operable units (OUs) to facilitate investigation and cleanup. At this time, the Rocky Flats Plant was renamed the Rocky Flats Environmental Technology Site. The 16 OUs were ultimately consolidated into three OUs: the COU, the Peripheral OU (POU), and the Offsite Areas, Operable Unit 3 (OU3).

The COU contains the areas of the Rocky Flats Environmental Technology Site that required additional remedial/response actions. Following accelerated remedial actions, the COU was closed in 2005. The final remedy of institutional and physical controls, incorporating continued monitoring and maintenance was selected for the COU in the 2006 Corrective Action Decision/Record of Decision (CAD/ROD). In 2007, the *Rocky Flats Legacy Management Agreement* (RFLMA) between DOE, EPA, and CDPHE was signed, which provides the implementing regulatory framework for the COU remedy.

The POU includes the generally unimpacted portions of the Rocky Flats Environmental Technology Site and surrounds the COU. The 2006 CAD/ROD contains the selected remedial action for the POU, which was no action. In May 2007, the POU was deleted from the NPL and the lands comprising the POU were transferred to the U.S. Fish and Wildlife Service for establishment as the Rocky Flats National Wildlife Refuge.

Operable Unit 3 consists of lands outside the Rocky Flats Environmental Technology Site boundary that were potentially impacted by historical operations. This OU was addressed under a separate no action CAD/ROD in June 1997, and the OU was deleted from the NPL in May 2007. A review of changes to toxicity factors conducted for this FYR confirmed that conditions in OU3 and the POU remain suitable for unlimited use and unrestricted exposure.

Table ES-1 presents the remedial action objectives established in the CAD/ROD, the remedy components that support these objectives, and the current remedy status for the COU.

Protectiveness Determination

The COU remedy was reviewed according to the EPA *Comprehensive Five-Year Review Guidance*, which outlines a review process that includes community involvement, document and data review, site inspections, and a technical assessment of the protectiveness of a remedy. The three questions examined during the technical assessment are:

A. Is the remedy functioning as intended by the decision documents?

B. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

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

No issues or recommendations for the COU were identified in the technical assessment.

Protectiveness Statement

The remedy at the COU is protective of human health and the environment.

Interim removal actions completed prior to the CAD/ROD included the removal of contaminated soils and sediments, decontamination and removal of equipment and buildings, construction of cover systems at the two landfills, and construction and operation of four groundwater treatment systems. A monitoring and maintenance plan is in place to ensure the long-term integrity of the remedy. Routine inspections of remedy components ensure that maintenance and repairs are identified and implemented. Groundwater treatment systems continue to reduce contaminant load to surface water. Surface water and groundwater monitoring provide assurance that water quality at the COU boundary is protective. Institutional controls are effective in preventing unacceptable exposures to residual contamination by prohibiting building construction, controlling intrusive activities, restricting the use of groundwater and surface water, and protecting engineered remedy components. Physical controls are effective at controlling access to the COU.

Because the remedial actions at the COU are protective and the other OUs associated with the former Rocky Flats Plant (POU and OU3) are suitable for unlimited use and unrestricted exposure, the site is protective of human health and the environment.

Table ES-1. Remedial Action Objectives and Remedy Status

Remedial Action Objective	Remedy		Remedy Status
Groundwater			
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater AOC wells.	Institutional and physical controls: • Perimeter signage • Building construction prohibited • Excavation, drilling, digging restrictions • Drinking and agricultural surface water use prohibited • Unauthorized groundwater well drilling prohibited • Any activities that interfere with remedy actions prohibited except when in accordance with the RFLMA	• Groundwater monitoring at AOC wells • Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water	Complete, in place, and protective in the long-term
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.			
3. Prevent domestic and irrigation use of groundwater contaminated at levels above MCLs.			
Surface Water			
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Institutional controls listed above	• Surface water monitoring at POCs	Complete, in place, and protective in the long term
Soil			
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Institutional controls listed above	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water	Complete, in place, and protective in the long term
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.		• Repair and maintenance of landfills covers, vegetation • Ongoing protection of remedy components	
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.		• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	

Abbreviations:
AOC = area of concern; ARARs = applicable or relevant and appropriate requirements; MCLs = maximum contaminant levels; POCs = points of compliance; RAOs = remedial action objectives; RFLMA = Rocky Flats Legacy Management Agreement

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Flats Site		
EPA ID: CO7890010526		
Region: 8	**State:** CO	**City/County:** Golden/Jefferson County
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: June 10, 2016–June 20, 2017		
Date of site inspection: March 16, 2017		
Type of review: Statutory		
Review number: 4		
Triggering action date: July 30, 2012		
Due date *(five years after triggering action date)*: August 3, 2017		
OUs Not Evaluated in This Five-Year Review:		
For the POU and OU3, changes in risk assessment factors adopted since the initial unlimited use and unrestricted exposure (UU/UE) determinations were evaluated. Conditions in these OUs continue to allow for UU/UE, and as a result, these OUs were not further evaluated in this FYR report.		

1.0 Introduction

This report documents the fourth five-year review (FYR) for the Rocky Flats Site (RFS) Central Operable Unit (COU). The RFS is located approximately 16 miles northwest of Denver and 12 miles north of Golden in Colorado (Figure 1 inset). This FYR was conducted in accordance with the requirements in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121 and the National Contingency Plan. Because remaining contamination in the COU does not allow for unlimited use and unrestricted exposure, CERCLA requires that a review be conducted every 5 years to determine whether remedial actions remain protective of human health and the environment. The U.S. Department of Energy (DOE) Office of Legacy Management (LM), as the lead agency, conducted the review with the assistance of the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). This fourth five-year review report covers remedy implementation at the COU for the period January 1, 2012, through December 31, 2016. The cutoff date for inclusion of environmental monitoring data in this FYR is December 31, 2016 (unless otherwise noted).

The Rocky Flats Plant (RFP) was established in 1952 as part of the nuclear weapons complex to manufacture nuclear weapons components under the jurisdiction and control of DOE and its predecessor agencies. Manufacturing activities, accidental industrial fires and spills, and support activities resulted in the release of hazardous constituents to air, soil, sediment, groundwater, and surface water at the RFP. Contaminants released to the environment from activities at the RFP included the radionuclides plutonium (Pu), americium (Am), and uranium (U); organic solvents including trichloroethene (TCE), tetrachloroethene (PCE), and carbon tetrachloride; metals such as chromium; and nitrates.

Throughout its history, the names and boundaries of the lands associated with the RFP changed. From 1952 to 1995 or so, the federal property at Rocky Flats was referred to as the Rocky Flats Plant. In 1989, the RFP was listed on the CERCLA National Priorities List (NPL). The NPL listing comprises the land areas now referred to as the COU, the Peripheral Operable Unit (POU), and Offsites Area, Operable Unit 3 (OU3). When the plant mission changed to cleanup and closure, the name was changed to the Rocky Flats Environmental Technology Site. Throughout this FYR report, the COU may also be referred to as the RFS and represents the land area currently under DOE jurisdiction. The POU may also be referred to as the Rocky Flats National Wildlife Refuge and represents the land area that is currently managed by the U.S. Fish and Wildlife Service. The term OU3 refers to the land area adjacent to the POU that is not under federal control.

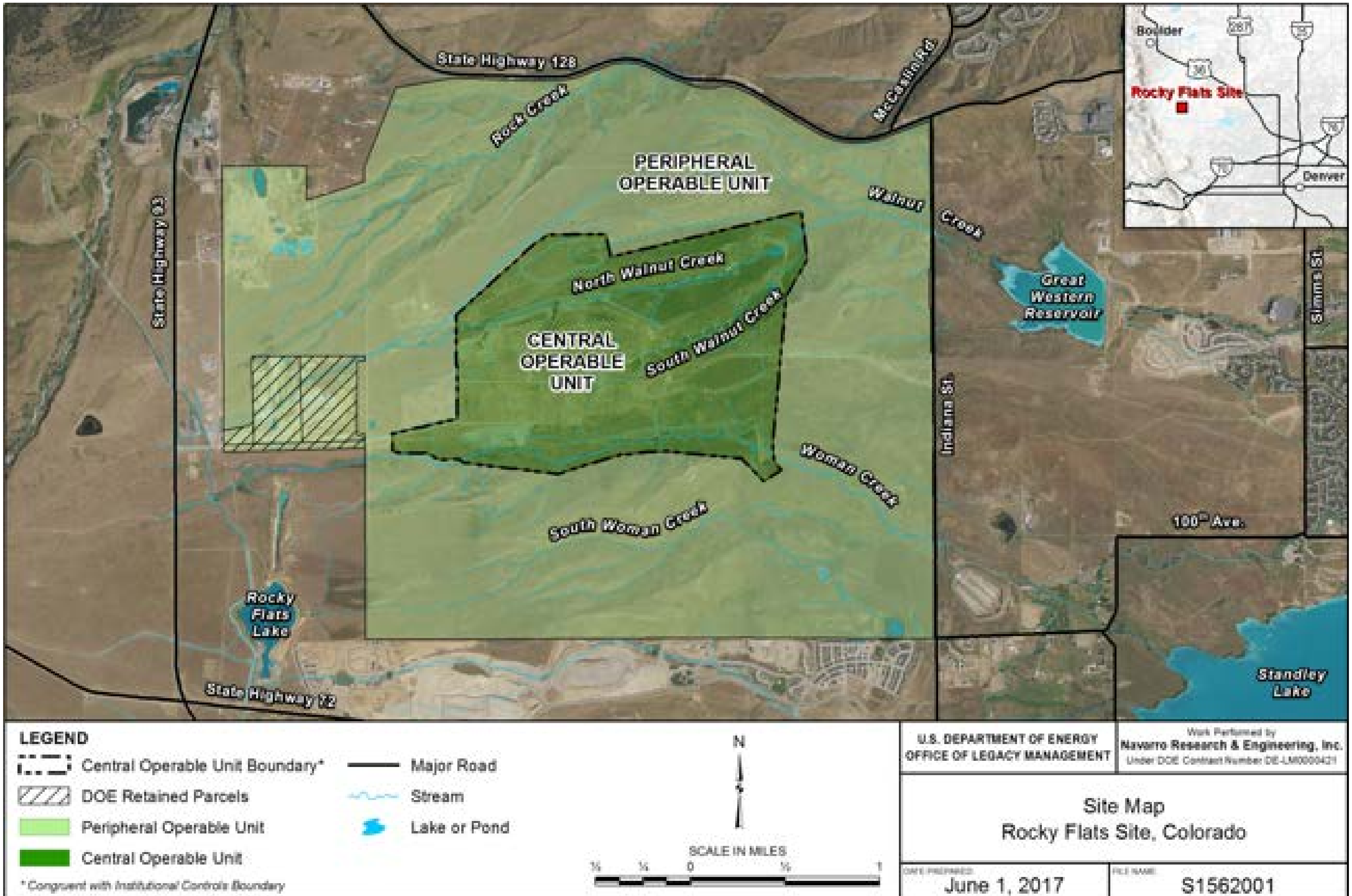

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Figure 1. Rocky Flats Site Map

2.0 Background

This section presents a summary of major actions taken at the former Rocky Flats Plant. A chronology of site activities is presented in Appendix A, and additional information on the history of the Rocky Flats Plant may be found in the *Third Five-Year Review Report for the Rocky Flats Site* (DOE, EPA, and CDPHE 2012).

Investigation and cleanup of the Rocky Flats Plant began in the 1980s, while the plant was still operating. In 1989, the RFP was placed on the CERCLA NPL. Soon thereafter, the RFP mission transitioned from nuclear weapons component production to investigation, cleanup, and closure and the plant was renamed the Rocky Flats Environmental Technology Site. Considerable remediation of the Rocky Flats Environmental Technology Site took place during the late 1990s and early 2000s as interim measures/interim removal actions under a federal facilities agreement known as the Rocky Flats Cleanup Agreement. This agreement, between DOE, EPA, and CDPHE, outlined an accelerated action approach to cleanup. The interim measures/interim removal actions completed during accelerated cleanup from 1995 to 2005 included the construction and operation of four groundwater treatment systems, installation of engineered covers at the two landfills, decontamination and removal of buildings and other structures, and removal and offsite disposal of contaminated soils and sediments. DOE completed cleanup and closure of the COU in 2005. A *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study for the Rocky Flats Environmental Technology Site* (RI/FS Report) (DOE 2006) was then completed that analyzed conditions within the COU following interim remedial actions. The primary contaminants, contaminated media, and waste remaining in the COU include:

- 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 radionuclides.
- Backfilled disposal trenches and areas where former building and infrastructure components, debris, and incinerator ash remain below the surface with low levels of U, Pu, and Am.
- Areas of groundwater contamination containing VOCs, nitrates, and U at levels above surface water quality standards.
- Areas of surface soil contaminated with low levels of Pu and Am.
- 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.

The RI/FS Report included a comprehensive risk assessment that calculated the risks posed by residual contaminants to the anticipated future land users and evaluated alternatives for the final remedial action. On the basis of the RI/FS Report, the Rocky Flats Environmental Technology Site boundaries were reconfigured into two operable units (OUs) in 2006:

- The COU, which included all areas that might require controls or further remedial action
- The Peripheral OU (POU), which comprised areas that would likely not require further action or controls

The final remedy for each OU was selected in the 2006 Corrective Action Decision/Record of Decision (CAD/ROD). The selected remedy for the COU is institutional and physical controls, incorporating continued monitoring and maintenance. In 2007, the federal facilities agreement known as the *Rocky Flats Legacy Management Agreement* (RFLMA) was signed by DOE, EPA, and CDPHE (DOE, EPA, and CDPHE 2007). This agreement superseded the Rocky Flats Cleanup Agreement and serves as the implementing regulatory framework for the COU remedy. Attachment 2 to the RFLMA (Appendix B) specifies remedy performance standards, monitoring, inspection, and maintenance requirements, criteria for evaluating monitoring and inspection results, and reporting requirements.

The selected remedy for the POU in the 2006 CAD/ROD is no action, because this OU met the criteria for unlimited use/unrestricted exposure (UU/UE). The majority of land comprising the POU was transferred to the U.S. Fish and Wildlife Service in July 2007 for the purpose of establishing the Rocky Flats National Wildlife Refuge. An additional OU associated with the former Rocky Flats Plant known as OU3 was addressed in a separate no action CAD/ROD in 1997 (DOE, EPA, and CDPHE 1997). This OU also met the conditions to allow for UU/UE. An assessment of the POU and OU3 was completed during this FYR period to determine if changes to risk assessment factors (e.g., slope factors, reference doses) would impact the UU/UE determinations for these OUs. This assessment concluded that the determinations of UU/UE at the POU and OU3 are still valid (i.e., the POU and OU3 remain suitable for any use). A summary of this assessment is provided in Appendix C. Because the UU/UE determinations remain applicable at OU3 and the POU, these OUs were not further evaluated as part of this FYR.

3.0 Remedial Actions

3.1 Remedial Action Objectives

Remedial action objectives (RAOs) are the remediation goals a remedial action is designed to achieve. The RAOs for the COU were developed for groundwater, surface water, and soil and are presented in the CAD/ROD (DOE, EPA, and CDPHE 2006). The remedy components selected in the CAD/ROD that support the RAOs include institutional and physical controls, surface and groundwater monitoring, and maintenance of remedy engineered components (e.g., landfill covers, groundwater treatment systems). The RAOs and components of the remedy that are pertinent to achieving each RAO are shown in Table 1.

3.2 Remedy Selection

The selected remedy for the COU is institutional and physical controls, incorporating continued monitoring and maintenance (DOE, EPA, and CDPHE 2006).

- Monitoring at the COU includes sampling and analysis of groundwater and surface water at specified locations and frequencies; inspection and maintenance of the OLF and PLF covers and groundwater treatment systems; and inspection of institutional and physical controls.
- Institutional controls prohibit unauthorized soil disturbance activities, 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 (Table 2).

- Physical controls consist of signs with use restriction and DOE contact information posted at access points to the COU and signs prohibiting unauthorized access posted around the COU perimeter.

3.3 Remedy Implementation

3.3.1 Regulatory Framework

During this FYR period, the requirements of the remedy have been implemented in accordance with the CAD/ROD and RFLMA and through an Environmental Covenant incorporating the institutional controls for the COU granted by DOE to CDPHE. While the CAD/ROD documents the final remedy selected, the RFLMA outlines the consultative process to be followed in implementing the remedy. The consultative process is initiated for all reportable conditions defined in the RFLMA, other conditions not considered reportable, or at the request of RFLMA parties (DOE, EPA, and CDPHE). As stated in the RFLMA, "The objective of the consultation will be to determine a course of action to address the reportable condition and to ensure the remedy remains protective" (DOE, EPA, and CDPHE 2007). The outcome of consultation is typically documented in RFLMA contact records (CRs), which are available to the public on the LM website and part of the post-closure Administrative Record. Appendix D provides a list of RFLMA contact records documented since the inception of the RFLMA and a copy of the contact records referenced in this FYR report. Contact records from previous years may be obtained at https://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

One Explanation of Significant Differences (ESD) was issued during this FYR period. This ESD is documented in CR 2016-02, which was written to satisfy both RFLMA and CERCLA reporting requirements. This ESD/CR documents the change in location of Mound plume groundwater treatment from the Mound Site Plume Treatment System (MSPTS) to the East Trenches Plume Treatment System (ETPTS). Previously, groundwater from the Mound plume and the East Trenches plume was treated by two separate treatment systems, located downgradient of each plume. The ESD/CR documented the reconfiguration of the MSPTS. This reconfiguration included the removal of the existing zero-valent iron (ZVI) treatment media and small air-stripper component from the MSPTS and the rerouting of groundwater intercepted at the MSPTS to the ETPTS for treatment. The subsurface MSPTS collection system for groundwater impacted by the Mound plume was not altered.

Table 1. Remedial Action Objectives and Remedy Summary

Remedial Action Objective	Remedy
Groundwater	
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater area of concern wells.	• Groundwater monitoring at AOC wells
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.	• Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water
3. Prevent domestic and irrigation use of groundwater contaminated at levels above maximum contaminant levels.	• Institutional and Physical Controls, which prohibit building construction, control access to and intrusive activities within the COU, restrict use of groundwater and surface water, and protect engineered remedy components
Surface Water	
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Surface water monitoring at points of compliance
Soil	
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.	• Repair and maintenance of landfills covers, vegetation • Ongoing protection of remedy components
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when applicable or relevant and appropriate requirements are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.	• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components • Institutional and Physical Controls, which prohibit building construction, control access to and intrusive activities within the COU, restrict use of groundwater and surface water, and protect engineered remedy components

Table 2. Rocky Flats Site Institutional Controls

Controls	Use Restrictions
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.
	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 COU that could pose a risk of unacceptable exposure to the WRW if occupied structures were built in these areas.
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 COU, and the Comprehensive Risk Assessment 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.
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 disturbance 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 Remedial Investigation 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.
4	Surface water may not be used for drinking water or agricultural purposes.
	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.
5	The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.
	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 COU 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.
6	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.
	Objective: Ensure the continued proper functioning of the landfill covers. **Rationale:** This restriction helps ensure the integrity of the landfill covers.
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. 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.

Note: This table incorporates changes made as a result of the 2011 CAD/ROD amendment (DOE, EPA, and CDPHE 2011).

3.3.2 Institutional and Physical Controls

The selected remedy in the CAD/ROD requires implementation of institutional and physical controls at the COU. The effectiveness of these controls is integral to the evaluation of groundwater, surface water, and soil RAOs (Table 1) and in determining protectiveness.

Institutional controls are applicable to the COU. The institutional controls consist of a set of use restrictions that restrict or prohibit activities that may adversely impact the remedy and/or result in unacceptable exposures in the COU. These use restrictions were recorded in an Environmental Covenant between DOE and CDPHE in December 2006. The Covenant was modified in 2011 to clarify the use restriction language (DOE and CDPHE 2011); the modified use restrictions are presented in Table 2. The COU boundary defined in the Environmental Covenant represents the extent of the area where institutional controls are appropriate and necessary (see Figure 1). The Environmental Covenant was in place throughout this entire FYR period (2012–2016); however, as recommended in the third FYR report, DOE has since replaced the Covenant with Environmental Use Restrictions (EURs) in accordance with *Colorado Revised Statutes* 25-15-318.5. The EURs, also known as a Restrictive Notice, supersede the Environmental Covenant and are effective as of April 5, 2017. Unlike the Environmental Covenant, the EURs will allow CDPHE to enforce institutional controls on certain third parties, including DOE, as necessary to maintain the protectiveness of the remedy in the long term. EURs are binding on all current and future owners of the affected land and any persons possessing an interest in the land.

The physical controls implemented at the COU include signs located at access points and around the perimeter. DOE inspected the condition of signs on a quarterly basis.

During this FYR period, DOE determined the effectiveness of the institutional controls described in the RFLMA and the Environmental Covenant by inspecting the COU at least annually for any evidence of violations of those controls (see Section 5.4). DOE also annually verified that the Environmental Covenant remained in the Administrative Record and on file with Jefferson County.

3.3.3 Remedy Monitoring and Maintenance

The selected remedy in the CAD/ROD also requires environmental monitoring of groundwater and surface water and continued operation and maintenance of engineered remedy components (landfill covers and groundwater treatment systems).

Groundwater monitoring is performed as required by the RFLMA. The groundwater monitoring network includes four types of monitoring wells: Area of Concern (AOC), Sentinel, Evaluation, and Resource Conservation and Recovery Act (RCRA). The AOC wells provide data directly relevant to groundwater RAO 1; the Sentinel wells provide data directly relevant to groundwater RAO 2 and soil RAO 1 (Table 1). AOC wells are located downgradient of contaminant plumes and are monitored to determine if groundwater contaminants are reaching surface water. Surface water monitoring location SW018 is monitored on the same routine schedule as the AOC wells to assess groundwater impacts to surface water from specific source areas in the COU. The locations of AOC wells and location SW018 are shown in Figure 2. Sentinel wells are located near downgradient edges of contaminant plumes and downgradient of the groundwater treatment systems. These wells are monitored to determine if concentrations of contaminants are

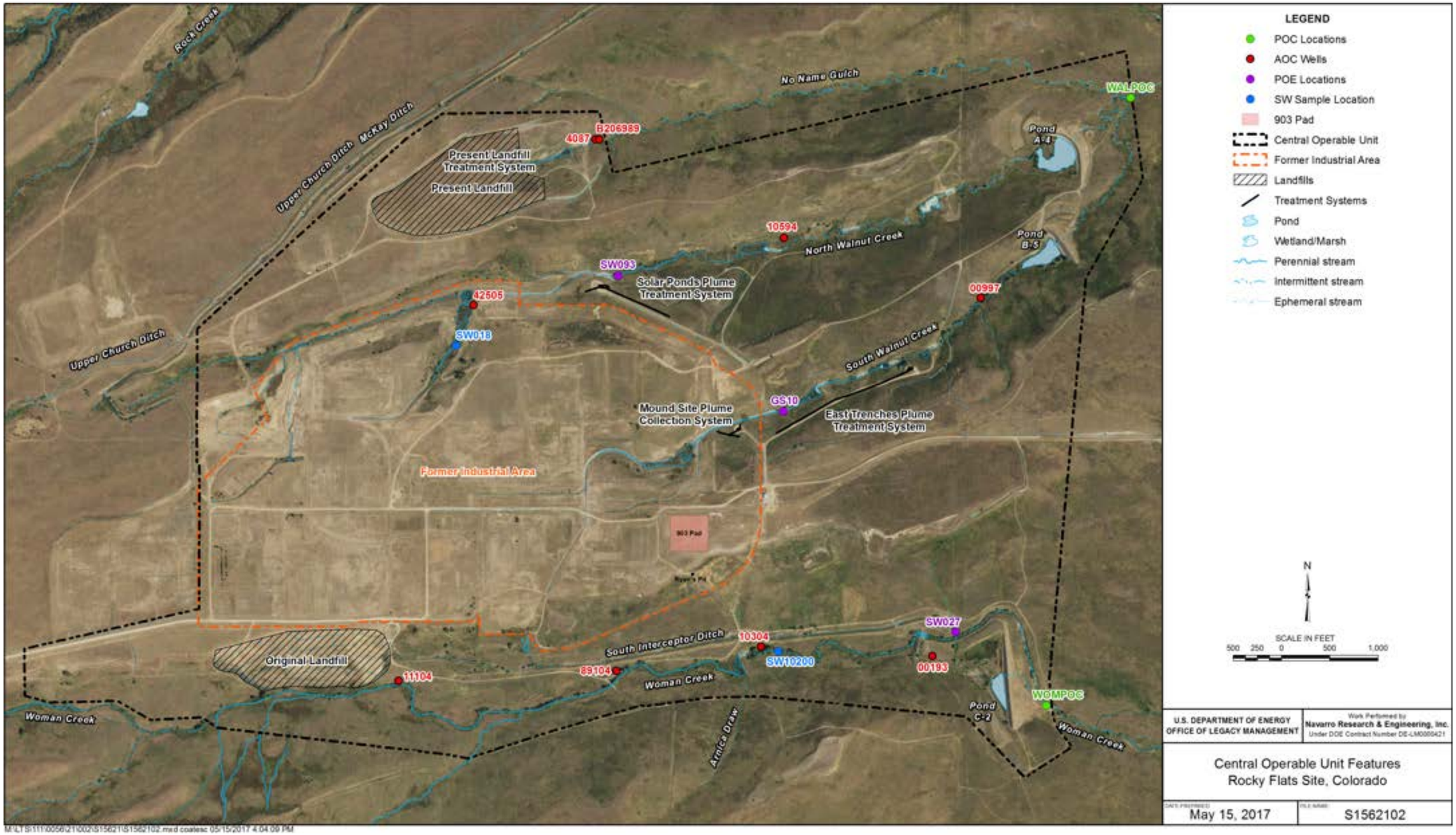

Figure 2. Central Operable Unit Features

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increasing, indicating possible plume migration or treatment system issues. A discussion of AOC and Sentinel well data as they relate to RAOs is presented in Section 6.1.2. Evaluation wells are located within groundwater contaminant plumes and near plume source areas. Data from these wells support various objectives, such as providing input to groundwater modeling efforts, modification of groundwater monitoring and treatment requirements, or evaluation of changing contaminant conditions as indicated by downgradient AOC or Sentinel wells. RCRA wells are located at the PLF and OLF and are used to monitor groundwater conditions upgradient and downgradient of each landfill.

Surface water monitoring is performed as required by the RFLMA. The surface water monitoring network includes three types of locations: points of compliance (POCs), points of evaluation (POEs), and performance monitoring locations. The two POCs are located at the eastern boundary of the COU in Woman and Walnut Creeks and are monitored to determine water quality as it leaves the COU. Data collected at the POCs are evaluated against surface water quality standards and are directly relevant to the surface water RAO 1 in Table 1. A discussion of POC data as it relates to this RAO is presented in Section 6.1.3. The three POEs are located upstream of the POCs and provide an early indication of potential downstream impacts at the POCs. The POC and POE locations are shown in Figure 2. Data collected at performance monitoring locations are used to determine the short- and long-term effectiveness of specific remedies (e.g., groundwater treatment systems). A map showing the performance monitoring locations is presented in Appendix E.

The following specific remedy monitoring and maintenance activities are required in accordance with the CAD/ROD and/or RFLMA:

- **Residual subsurface contamination:** DOE must monitor the COU 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 B of this report). Monitoring will include visual observation (and measurements, if necessary) of precursor evidence of significant erosion (cracks, rills, slumping, subsidence, and sediment deposition).
- **Physical controls:** DOE must inspect the condition of signs on a quarterly basis.
- **Institutional controls:** DOE must determine the effectiveness of the institutional controls described in RFLMA Attachment 2 and in the Environmental Covenant (or Restrictive Notice) by inspecting the COU 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 Jefferson County.

The engineered components of the remedy defined in the CAD/ROD consist of the PLF and OLF covers and the four groundwater treatment systems. Each engineered component has associated groundwater and surface water monitoring locations that support the evaluation of remedy performance. All remedy components are in place and operating in accordance with the RFLMA.

- **Landfills:** Inspection and maintenance requirements for the PLF and OLF remedies are provided in the approved monitoring and maintenance plans (DOE 2009; DOE 2014). At the OLF, the remedy involved the construction of a 2-foot-thick soil cover with a buttress at the toe of the landfill and the installation of perimeter drainage channels and cover diversion berms to control surface water run-on and runoff. The remedy at the PLF includes a RCRA-compliant cover consisting of a geosynthetic composite cover with a rock layer and

surface water run-on and runoff controls. Performance of the landfill cover systems is evaluated in relation to soil RAOs 2 and 3 (Table 1) and is discussed in Sections 6.1.4.1 and 6.1.4.2.

- **Groundwater treatment systems:** At a minimum, each system is monitored for untreated influent, treated effluent, and impacts to surface water downstream of the effluent discharge point. The remedy in the CAD/ROD incorporated the four passive groundwater treatment systems in place when the COU closed in 2005: the Present Landfill Treatment System (PLFTS), the Solar Ponds Plume Treatment System (SPPTS), the Mound Site Plume Treatment System (MSPTS), and the East Trenches Plume Treatment System (ETPTS). Optimization and reconfiguration of three of these treatment systems (SPPTS, MSPTS, and ETPTS) has taken place during this FYR period and is discussed further in Section 6.1.4.3. Performance of these systems is evaluated in relation to groundwater RAO 2 and soil RAO 1 (Table 1) and is discussed in Sections 6.1.4.1 (PLFTS) and 6.1.4.3 (SPPTS, MSPTS, and ETPTS).

4.0 Progress Since the Last Five-Year Review

The protectiveness statement from the third FYR report is as follows (DOE, EPA, and CDPHE 2012):

The remedy for the COU 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.

The third FYR report identified four issues to be addressed in the next FYR period. Table 3 presents each issue and a summary of the status at the end of this FYR period. Three of the identified issues concerned reportable conditions for radionuclides at surface water POE monitoring locations. Additional detail regarding these POE reportable conditions is presented in Appendix E.

All issues from the third FYR have been satisfactorily resolved.

Table 3. Status of the Third FYR Report Recommendations

Issue	Follow-Up and Expected Completion Date	Status	Does Issue Affect Protectiveness?
Surface water point of evaluation (POE) GS10 uranium concentration periodically exceeded the RFLMA standard during the third FYR period and exceeds the standard at the end of the third 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.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing 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. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.	Complete. The RFLMA standard for U has been exceeded at GS10 intermittently during this FYR period (see Appendix E). Figure E-7 illustrates the 12-month rolling averages for U at GS10. The exceedances and subsequent reportable conditions for U led to an extensive evaluation of the Walnut Creek drainage system (Wright Water Engineers 2015). This evaluation identified natural processes that may be contributing to U increases in surface water, including precipitation events in 2013 and 2015 (see Section 6.1.3). At the end of this fourth FYR period, the 12-month rolling average for U at GS10 does not exceed the RFLMA standard.	No. Consultation with the RFLMA parties on the reportable conditions for U at GS10 resulted in an evaluation plan for addressing the condition (CR 2011-04, CR 2011-05) to ensure the remedy remains protective.
Surface water POE GS10 americium concentration began to exceed the RFLMA standard in 2011 and exceeded the standard at the end of the third FYR period.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing 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. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.	Complete. The RFLMA standards for Pu and Am have been exceeded at GS10 intermittently during this FYR period (see Appendix E). Figure E-8 illustrates the Pu and Am 12-month rolling averages at GS10. Evaluation of these reportable conditions did not yield a definitive cause for the exceedances. Monitoring locations downstream at GS08 and WALPOC did not exceed the standards during this time period. Plutonium and americium concentrations fell below RFLMA standards in 2014, and routine monitoring at GS10 recommenced. At the end of this fourth FYR period, the 12-month rolling averages for Am and Pu at GS10 do not exceed the RFLMA standard.	No. Consultation with the RFLMA parties on the reportable conditions for Am and Pu at GS10 resulted in an evaluation plan for addressing the condition (CR 2011-08) to ensure the remedy remains protective.

Table 3. Status of the Third FYR Report Recommendations (continued)

Issue	Follow-Up and Expected Completion Date	Status	Does Issue Affect Protectiveness?
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 the third FYR period.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing 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. As a result, no samples were obtained for over a year. Because the RFLMA standard is based on 12- month rolling average of the results, and there were no sample results for averaging, the standard was no longer exceeded at the end of the third FYR review period (2012). 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.	Complete. The RFLMA standards for Pu and Am were exceeded at SW027 intermittently beginning in 2010 through the end of this FYR period (see Appendix E). Figure E-13 illustrates the Am and Pu 12-month rolling averages at SW027. The exceedances coincide with periods of increased runoff resulting from heavy precipitation. Evaluation of these reportable conditions suggests that Pu and Am move with particulates (DOE 2013) and may be a result of soil erosion. Mitigation measures to control erosion originating from the contaminant source at the 903 Pad/Lip Area were completed in 2010, 2011, and 2015 following each reportable occurrence. Evaluation of upstream and downstream data does not indicate an unknown source of contamination. There have been no exceedances of Pu or Am at WOMPOC, located downstream of SW027, during this fourth FYR period.	No. Consultation with the RFLMA parties on the reportable conditions for Am and Pu at SW027 resulted in an evaluation plan for addressing the condition (CR 2015-05) to ensure the remedy remains protective.
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 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.	Replace the Environmental Covenant with a Restrictive Notice/Environmental Use Restrictions (EURs) 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 the goal to replace the Environmental Covenant with a Restrictive Notice by the end of 2012.	Complete. The Restrictive Notice/EURs became effective on April 5, 2017. The Restrictive Notice supersedes the Environmental Covenant adopted in 2006 and modified in 2011.	No. There have been no incidences involving current easement holders that call into question the effectiveness of institutional or physical controls. However, the establishment of the Restrictive Notice/EURs provides a means of enforcing these controls.

5.0 Five-Year Review Process

5.1 Community Notification and Involvement

Notification of commencement of the fourth FYR was distributed to Rocky Flats site stakeholders via email and posted to the LM website in June 2016. This notice included an overview of the FYR process, web links to the 2012 FYR report, LM contact information, and the address to submit questions or input related to the FYR.

The FYR team gave a public presentation on the fourth FYR at the June 6, 2016, Rocky Flats Stewardship Council (RFSC) meeting, which was open to the public. The RFSC serves as a forum to promote community involvement with the Rocky Flats Site, including the FYR. Other public communication tools include the LM website and emails to stakeholders. Notification of the RFSC FYR presentation was provided directly to stakeholders via email and was posted on the LM and RFSC public websites prior to the meeting. The FYR presentation included an overview of the review process including community involvement and a question and answer period.

In response to email questions from stakeholders regarding public review of the FYR report, an update to the initial June 2016 notification was provided in November 2016. This notice was distributed to Rocky Flats stakeholders via email and posted to the LM website. The update clarified that while a formal public review and comment period for the FYR report is not part of the CERCLA FYR process, the public was invited to submit questions and input by way of the communication tools provided in the notice. The update contained several web links to EPA guidance on community participation in the FYR process and general information on FYRs. In order to meet the FYR report schedule, the update requested that public input be provided no later than December 31, 2016.

EPA guidance includes consideration of whether interviews with local residents or other stakeholders are needed to identify issues that might be included in the FYR. The RFLMA parties keep the public and local community governments informed by making all RFLMA-required reports and contact records available on the LM public website, making quarterly presentations at RFSC meetings, holding periodic technical meetings with local community governments, and providing formal public review and comment periods as required for proposed RFLMA modifications and CAD/ROD amendments. Based on these continual public participation activities and the steps taken to inform the public about this FYR process, DOE, EPA, and CDPHE concluded that interviews were not needed.

Written FYR input from stakeholders was received during the submittal period in the form of four formal letters. In addition, verbal input and questions from stakeholders were offered at RFSC and other stakeholder meetings. Stakeholder input was consolidated by topic, where possible, to remain consistent with past FYR practices. A summary of this public input and the agency responses provided are presented in Appendix I.

5.2 Document Review

Documents reviewed for this FYR are listed in Appendix F. Where appropriate, references to documents where additional information or data may be found are cited throughout this report.

5.3 Data Review

The CAD/ROD and RFLMA require routine monitoring of surface water and groundwater. The data from these monitoring activities are relevant in determining if the RAOs are being met. The COU quarterly and annual reports contain monitoring and maintenance data pertaining to surface water and groundwater, the OLF and PLF, and the groundwater treatment systems. This information was used to assess the performance of the remedy over this FYR period.

RFLMA Attachment 2 implements the remedy selected in the CAD/ROD and details remedy performance standards and requirements (Appendix B). These standards and requirements are numerical values or narrative descriptions of conditions or restrictions, designed to protect existing or potential uses, against which remedy performance can be measured. These standards and requirements are derived from state surface water standards and from requirements established in the final CAD/ROD (e.g., landfill inspections). The remedy performance standards for surface water in the COU are found in Table 1 of Attachment 2 to the RFLMA. Because groundwater flows into surface water prior to exiting the COU, the groundwater use classification at the COU is surface water protection. Thus, the numeric values for measuring potential effects of contaminated groundwater on surface water quality are also the surface water standards in Table 1 of Attachment 2 to the RFLMA. Surface water and groundwater monitoring data are evaluated annually (at a minimum) by comparing results to the Table 1 standards and conducting RFLMA-required statistical analyses. The results of these evaluations are presented in the COU quarterly and annual reports required by the RFLMA and available on the LM website.

If reportable conditions defined in RFLMA are identified as a result of data evaluation, the RFLMA parties (DOE, EPA, and CDPHE) consult and develop a plan for evaluating and addressing the condition. During this fourth FYR period, reportable conditions were documented at the OLF (CR 2013-02), AOC well 10304 (CR 2015-10), POE SW027 (CR 2015-05), and WALPOC (CRs 2014-05, 2015-01, 2016-01, 2017-02). These reportable conditions are discussed in Section 6.1 and Appendix E.

5.4 Site Inspections

EPA guidance indicates that the FYR should include a recent site inspection to visually confirm and document the conditions of the remedy, the site, and the surrounding area (EPA 2001). The CAD/ROD and RFLMA also require an annual inspection of the COU, in addition to more frequent routine and weather-related inspections of remedy components at the PLF and OLF. During this FYR period, all routine inspections, and several weather-related inspections, were conducted and reported in accordance with RFLMA requirements.

This section summarizes the results of the annual inspections of the COU conducted during this FYR period; the results of routine and weather-related inspections at the PLF and OLF are summarized in Sections 6.1.4.1 and 6.1.4.2, respectively. Inspection results, including completed inspection forms, may be found in the COU quarterly and annual reports.

Annual inspections of the COU were conducted in March or April during this FYR period. The most recent COU inspection was conducted on March 16, 2017. Representatives from DOE,

EPA, and CDPHE participate in the annual inspections. Appendix G contains the inspection checklist and maps of the most recent inspection.

The following are assessed during each annual COU inspection:

- Evidence of significant erosion in the COU and evaluation of the proximity of any significant erosion to subsurface features left in place at closure. This monitoring includes visual observation for precursors of significant erosion (e.g., cracks, rills, slumping, subsidence, sediment deposition).
- The effectiveness of institutional controls, as determined by any evidence of violation.
- Evidence of adverse biological conditions, such as unexpected morbidity or mortality, observed during the inspection and monitoring activities.

Quarterly and weather-related inspections for erosion in areas where building features remain in the subsurface were completed as required during this FYR period. Evidence of subsidence near the locations of former buildings 771, 881, and 991 was noted in the 2015 annual site inspection (DOE 2016). The openings ranged from 1 to 8 feet in width and 1 to 5 feet in depth. These areas were filled and graded shortly after discovery. In 2016, additional settling was noted in the former building 881 area where the subsidence had been filled the previous year. In response, this area was filled and graded.

No evidence of violations of institutional controls or physical controls was observed in any of the annual inspections. In conjunction with each annual inspection, the presence of the Environmental Covenant in the Administrative Record and Jefferson County records was verified. The most recent verification of the Environmental Covenant was completed on March 16, 2017. The physical controls required by the remedy (i.e., signs at the COU boundary and access points) were inspected four times a year (i.e., quarterly) throughout this FYR period. A few signs were added or replaced, and faded stickers were replaced, as needed. The signs continue to function as designed.

No adverse biological conditions were noted during any of the COU inspections during this FYR period.

6.0 Technical Assessment

This section documents the technical assessment of the performance of the remedy. This assessment includes:

- Consideration of monitoring and maintenance information reported in the COU quarterly and annual reports.
- Information on post-remedy decision making documented in RFLMA contact records and amendments or modifications to remedy requirements.
- Evaluation of remedy performance against RAOs.
- Changes to remedy applicable or relevant and appropriate requirements (ARARs).

- Changes to toxicity factors, exposure parameters, or assumptions that might affect the level of risk posed by residual contamination.
- Any new information that may call into question the protectiveness of the remedy.

6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

On the basis of this FYR evaluation, the remedy is functioning as intended by the CAD/ROD (DOE, EPA, and CDPHE 2006):

- Institutional controls are in place and effective in meeting the objectives presented in Table 2. Physical controls are in place and effective at preventing human health exposures from contaminated groundwater, surface water, and soil.
- Required groundwater and surface water monitoring is ongoing and supports achievement of RAOs in the long term.
- Operation and maintenance (O&M) of remedy components at the OLF, PLF, and groundwater treatment systems is ongoing and supports achievement of RAOs in the long term.

6.1.1 Institutional and Physical Controls

The institutional and physical controls required by the remedy are in place and effective in preventing unacceptable exposures. The effectiveness of institutional controls is determined by annually inspecting the COU for evidence of violations. Less-formal inspections and observations are performed throughout the year by site staff as they perform regular monitoring and maintenance activities. An annual verification that the Environmental Covenant is located in the Administrative Record and in Jefferson County records is also required. Annual inspections of the COU were completed in accordance with the RFLMA. No evidence of institutional control violations was discovered. The presence of the Environmental Covenant in the Administrative Record and Jefferson County records was verified on March 16, 2017.

6.1.2 Groundwater Monitoring

The groundwater monitoring network in the COU consists of four types of wells (AOC, Sentinel, Evaluation, and RCRA) and one surface water location (SW018). Data from groundwater monitoring at AOC and Sentinel wells and location SW018 are directly relevant to assessing remedy performance in relation to groundwater RAOs 1 and 2 and Soil RAO 1. Remedy performance for the AOC and Sentinel wells and SW018 is discussed in this section. Data from Evaluation wells are discussed in Appendix E; data from RCRA wells are discussed in Sections 6.1.4.1 and 6.1.4.2.

6.1.2.1 Area of Concern Wells

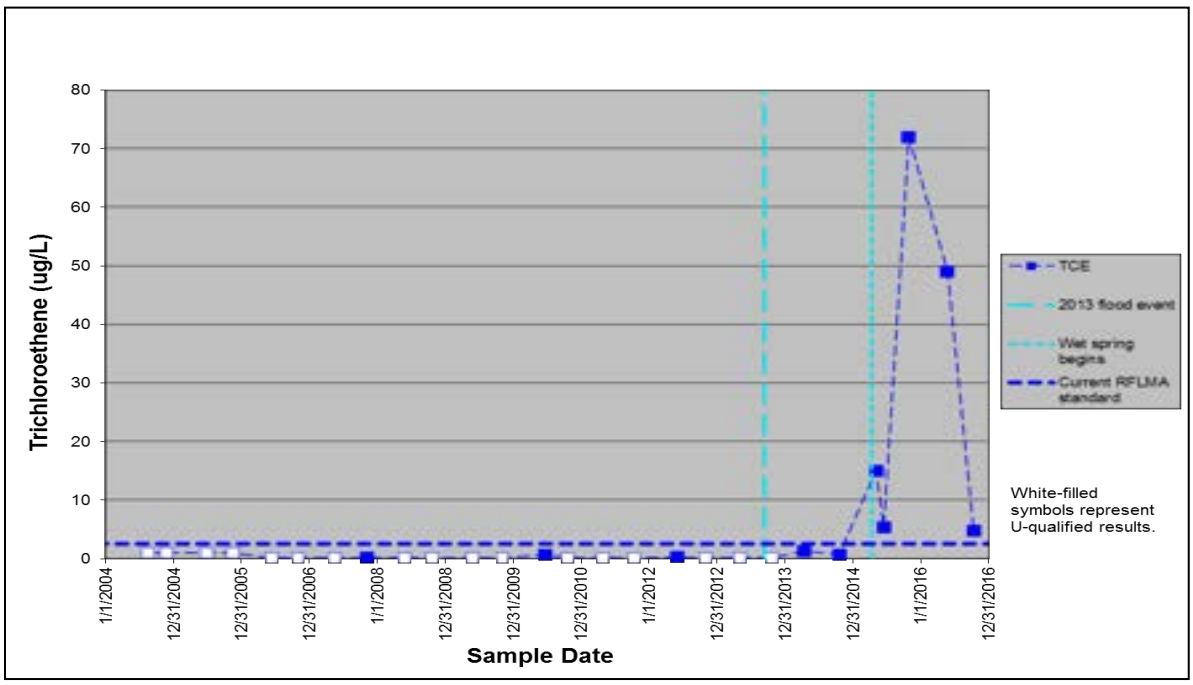
The existing AOC well network consists of nine wells from which routine RFLMA monitoring samples are collected twice a year (i.e., semiannually); surface water samples from location SW018 are also collected semiannually. Remedy performance is measured at AOC wells and SW018 by an evaluation of the two most recent routine monitoring results as compared to

RFLMA standards. The RFLMA Attachment 2 decision logic flowchart Figure 7, "Area of Concern Wells and SW018" (Appendix B), is relevant to these evaluations. If the results for an individual constituent in the two most recent routine samples are greater than its respective RFLMA standard, a reportable condition exists and consultation with EPA and CDPHE is required. There was one reportable condition at an AOC well during this FYR period. Trichloroethene (TCE) exceeded the RFLMA standard in the two sample results from AOC well 10304 in 2015 (CR 2015-10). The RFLMA standard for TCE is 2.5 micrograms per liter (µg/L), and the results were 15 and 72 µg/L in the 2015 groundwater samples. AOC well 10304 was installed in 2004 to evaluate groundwater quality adjacent to Woman Creek, downgradient of the contaminant plume caused by the 903 Pad and Ryan's Pit (Figure 2). As evidenced in Figure 3, TCE was previously detected in this well; however, this is the first reportable condition at this well.

As required by the RFLMA, DOE consulted with EPA and CDPHE and developed a plan for addressing the reportable condition. The plan included the collection of surface water samples from Woman Creek downgradient of well 10304, to assess any potential impacts to surface water quality. A surface water sample from downgradient Woman Creek location SW10200 (Figure 2) was collected in December 2015; TCE was not detected in this sample. Additional samples from this surface water location were collected concurrent with well 10304 semiannual sampling in 2016; TCE was not detected in these samples. TCE was detected in the two 2016 groundwater samples at 49 and 4.7 µg/L (Figure 3), levels which are both above the RFLMA TCE standard.

Increased concentrations of TCE in groundwater discharging to Woman Creek in this area under conditions of higher-than-normal precipitation were predicted when the COU was closed (Kaiser-Hill 2005). The potential for increased VOC concentrations during wet conditions is described in the *Final Interim Measure/Interim Remedial Action for Groundwater at the Rocky Flats Environmental Technology Site* (Kaiser-Hill 2005) and the *Fate and Transport Modeling of Volatile Organic Compounds at the Rocky Flats Environmental Technology Site* (Kaiser-Hill 2004). Given that the fall of 2013 and spring of 2015 were exceptionally wet, the TCE results reported for AOC well 10304 are not unexpected. As conditions become drier, VOC concentrations in groundwater should decrease, as is the observed trend at well 10304 (Figure 3).

TCE concentrations in AOC well 10304 are currently in decline; however, as of the end of this FYR period, the most recent semiannual data show a TCE concentration above the RFLMA standard. The reportable condition still exists, and therefore, groundwater RAO 1 is not currently met at all AOC wells (Table 4). As stated in the CAD/ROD, the RAOs for each medium are interdependent and were developed based on this premise (DOE, EPA, and CDPHE 2006). Because of the hydrologic connection of groundwater with surface water within the COU, it is therefore appropriate to assess surface water quality in combination with groundwater results in evaluating overall remedy protectiveness. The remedy remains protective in the long-term because (1) the 2016 data suggest a decreasing trend in TCE concentration in this well, suggesting a short-term event that is consistent with predictions made prior to closure, and (2) the reportable condition has not impacted downstream surface water quality, as TCE was not detected in surface water samples from Woman Creek collected downgradient of the well.



Note:
A temporary modification to the TCE standard was in effect until the end of 2009. For simplicity, this standard is not shown on the figure above; the current TCE water quality standard of 2.5 µg/L is presented.

Figure 3. TCE Concentrations at AOC Well 10304 (2004–2016)

6.1.2.2 Sentinel Wells

Sentinel wells are typically located near downgradient edges of contaminant plumes, in drainages, at groundwater treatment systems, and along contaminant pathways to surface water (Figure 4). 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. The existing Sentinel well network consists of 27 wells from which routine monitoring samples are collected semiannually. The RFLMA Attachment 2 decision logic flowchart Figure 8, "Sentinel Wells" (Appendix B), is relevant to evaluation of these data. Groundwater quality in Sentinel wells at the end of this FYR period was generally consistent with conditions at the time of closure. Groundwater does not meet RFLMA standards for some VOCs, uranium, or nitrate at many Sentinel well locations. While there are no indications of significant plume migration that impact the continued protectiveness of the remedy, groundwater RAO 2 and soil RAO 1 are not currently met at all Sentinel wells (Table 4). The CAD/ROD stated that no additional removal, containment, or treatment actions could be reasonably taken to address these RAOs at the time and recognized that the remedial actions undertaken as a part of closure of the COU were "not expected to eliminate groundwater contamination in the short term, but are expected to have a positive long-term impact on groundwater and surface water quality" (DOE, EPA, CDPHE 2006). These statements remain valid for this FYR period, and therefore, continued monitoring of the Sentinel wells is necessary.

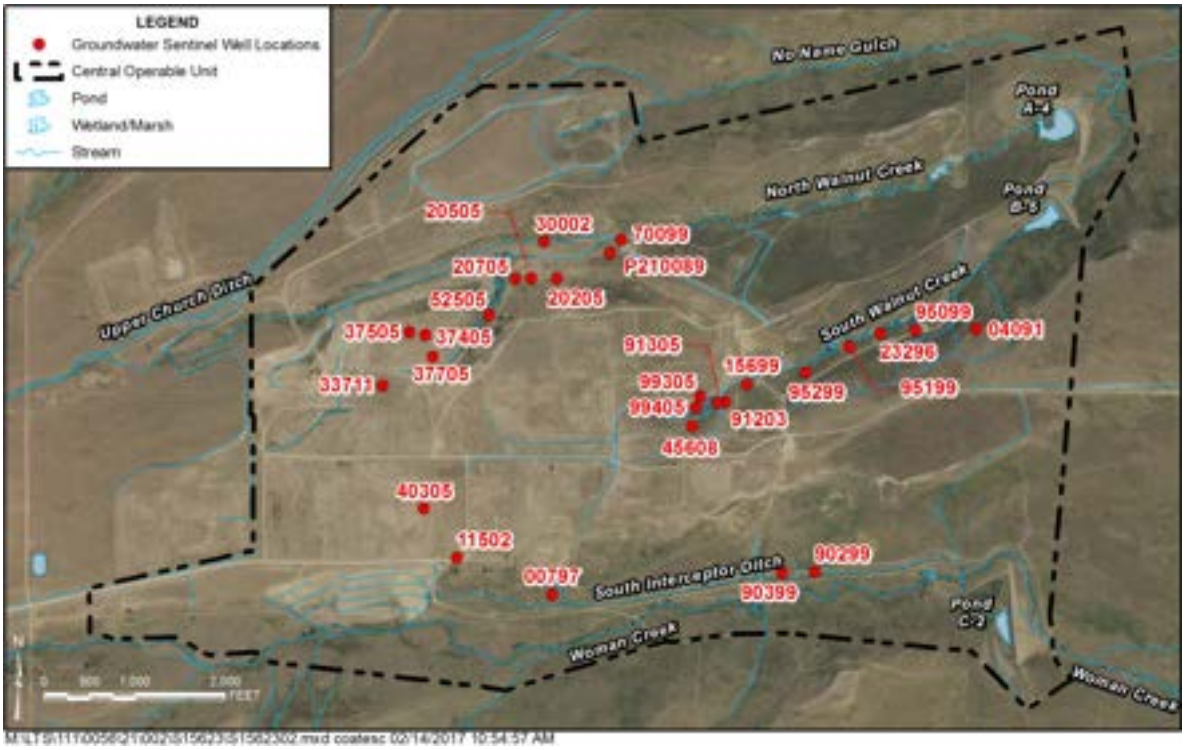


Figure 4. Rocky Flats Site Sentinel Well Locations

6.1.3 Surface Water Monitoring

The surface water monitoring network in the COU consists of three types of locations: POCs, POEs, and performance monitoring locations. Data from surface water monitoring at POCs are directly relevant to assessing remedy performance in relation to surface water RAO 1 and are discussed in this section. Data from surface water monitoring at POEs and performance monitoring locations are discussed in Appendix E.

6.1.3.1 Points of Compliance

At the beginning of this FYR period, there were two POC locations outside the COU boundary adjacent to Indiana Street (locations GS01 and GS03). In January 2014, following RFLMA modification and in consultation with EPA and CDPHE, the POCs were moved upstream to the WOMPOC and WALPOC locations just inside the eastern boundary of the COU (see CR 2014-02 and Figure 2). The WOMPOC (within Woman Creek) and WALPOC (within Walnut Creek) surface water POCs are used to measure remedy performance against applicable RFLMA surface water standards at the COU boundary prior to surface water leaving the COU. Remedy performance at the POCs is measured through a comparison of the volume-weighted 12-month rolling average of the composite sample results collected at each POC to the applicable RFLMA surface water quality standards. The volume-weighted 30-day average of these results is also evaluated. The RFLMA Attachment 2 decision logic flowchart Figure 5, "Points of Compliance" (Appendix B), is relevant to these evaluations. An exceedance of either calculated average is a reportable condition under RFLMA that requires consultation with EPA and CDPHE.

Table 4. Rocky Flats Site Fourth FYR RAO Status

RAO	Remedy	FYR Status
Groundwater		
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater AOC wells.	• Groundwater monitoring at AOC wells	A reportable condition for TCE in AOC well 10304 occurred in 2015 (Section 6.1.2). Consultation with the RFLMA parties (CR 2015-10) resulted in a plan to evaluate the condition to ensure the remedy remains protective. At the end of this FYR period, the most recent semiannual data show a TCE concentration above the RFLMA standard at AOC well 10304. The remedy remains protective because (1) the 2016 data indicate a decreasing trend in TCE concentration in this well, suggesting a short-term event and (2) the reportable condition did not impact downstream surface water quality, as TCE was not detected downgradient of the well in Woman Creek.
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.	• Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water	Sentinel well data exceeded applicable RFLMA standards for some VOCs, nitrate, or uranium. Optimization and technical improvement opportunities at the SPPTS, MSPTS, and ETPTS were identified and implemented during this FYR period through the RFLMA consultative process (CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02). Optimization of the systems has resulted in reductions of nitrate and VOC concentrations in treated groundwater (see Section 6.1.4.3). Evaluation of groundwater treatment system monitoring and operation is summarized in Appendix E. The ecological risk assessment conclusions remain valid and indicate that residual contamination in the COU does not present a significant risk of adverse ecological effects. No evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) was observed during this FYR period (2012–2016).
3. Prevent domestic and irrigation use of groundwater contaminated at levels above maximum contaminant levels.	Institutional controls: • Drinking and agricultural surface water use prohibited • Unauthorized groundwater well drilling prohibited • Any activities that interfere with remedy actions prohibited except when in accordance with the RFLMA	This RAO was met for this FYR period. Institutional controls recorded in the environmental covenant have been effective in preventing domestic and irrigation use of groundwater from the COU. The results of RFLMA routine inspections confirm that no unauthorized intrusive activities have occurred at the COU during this FYR period (Section 6.1.1).

Table 4. Rocky Flats Site Fourth FYR RAO Status (continued)

RAO	Remedy	FYR Status
Surface Water		
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Surface water monitoring at POCs	The WALPOC 12-month rolling average for U exceeded the RFLMA standard for a 4-month period in 2014/2015 (Section 6.1.3). Consultation with the RFLMA parties (CR 2015-01) resulted in a plan to evaluate the condition to ensure the remedy remained protective. Evaluation of the Walnut Creek drainage system suggests that the increase in U concentrations may be attributable to heavy precipitation events that increase the mobility of U and increase the volume of groundwater discharged to surface water (Wright Water Engineers 2015). The remedy remains protective because (1) the reportable condition was a short-term occurrence associated with an extreme weather event, (2) exceedance of the 12-month rolling average for U is not anticipated to occur with any regularity in the future, and (3) the RFLMA standard for U is based on human health risk from long-term (chronic) exposure. As such, no unacceptable exposures occurred, or are expected to occur, as a result of the reportable condition.
Soil		
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water	Sentinel well data exceeded RFLMA standards for some VOCs, nitrate, or uranium. Optimization and technical improvement opportunities at the SPPTS, MSPTS, and ETPTS were identified and implemented during this FYR period through the RFLMA consultative process (CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02). Optimization of the systems has resulted in reductions of nitrate and VOC concentrations in treated groundwater (see Section 6.1.4.3). Evaluation of groundwater treatment system monitoring and operation is summarized in Appendix E.

Table 4. Rocky Flats Site Fourth FYR RAO Status (continued)

RAO	Remedy	FYR Status
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.	• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	This RAO was met for this FYR period. Institutional controls are in place to prohibit soil disturbance without appropriate controls. Inspection and monitoring at the PLF indicate that the landfill cover and storm-water management system remain intact and effective in preventing unacceptable exposure to buried wastes. The PLFTS is operating as designed and is generally effective in removing trace VOCs from groundwater and seeps at the landfill. Although some constituents in PLFTS effluent were detected above the applicable RFLMA standards during this FYR period, these occurrences were short-lived and did not impact downstream surface water quality. A reportable condition relating to the effectiveness of the OLF cover was identified in 2013. The RFLMA parties consulted on this condition multiple times throughout this FYR period, several repairs to the OLF storm-water management system were completed (Section 6.1.4.2), and additional actions are planned. The remedy at the OLF remains protective because (1) the cover is effective in preventing unacceptable exposure to buried wastes and (2) groundwater and surface water monitoring data collected during this FYR period do not suggest the hillside instability at the OLF has negatively affected groundwater or surface water quality.
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.	(Part 1) • Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components Institutional controls: • Perimeter signage • Activity restrictions • Groundwater use restrictions • Digging restrictions • Construction restrictions (Part 2) • Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	(Part 1) This RAO was met for this FYR period. The land use and exposure assumptions for a wildlife refuge worker used in the comprehensive risk assessment remain valid, and human health risk remains below the 1×10^{-6} risk level (Section 6.2.2). Institutional controls and physical controls to prevent unacceptable exposures, including via the indoor air pathway, are in place and effective (Section 6.1.1). See PLF, PLFTS, and OLF status in Soil RAO 2 above. (Part 2) This RAO was met for this FYR period. The ecological risk assessment conclusions remain valid and indicate that soil conditions do not represent a significant risk of adverse ecological effects at the COU. No evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) was observed during this FYR period (2012–2016). See PLF, PLFTS, and OLF status in Soil RAO 2 above.

During this FYR period (2012–2016), there were no exceedances of RFLMA standards for constituents sampled at WOMPOC and no reportable conditions.

There were four reportable conditions for uranium at WALPOC during this FYR period: three involving the 30-day average and one involving the 12-month rolling average.

- The first reportable condition occurred in December 2013, when the 30-day average U concentration (16.9 µg/L) exceeded the RFLMA standard of 16.8 µg/L (CR 2014-05). Subsequent 30-day averages (17.0–21.9 µg/L) collected at WALPOC exceeded the standard until May 2014, when the 30-day average fell below the standard.
- Because the 12-month rolling average is calculated for a longer period, these 30-day averages caused the 12-month rolling average to subsequently become reportable for U in October 2014 (17.2 µg/L). The 12-month rolling average for U at WALPOC remained above the RFLMA standard (17.0–17.2 µg/L) until January 2015, when it fell below the standard.
- In January 2016, a reportable condition occurred at WALPOC when the 30-day average uranium concentration (16.9 µg/L) exceeded the RFLMA standard (CR 2016-01). Subsequent 30-day averages from routine samples collected at WALPOC remained above the standard (16.9–19.0 µg/L) until March 2016. From late March until early December 2016, the 30-day uranium averages were below the RFLMA standard. The 12-month rolling averages for this period (January through early December 2016) did not exceed the standard.
- In early December 2016, the 30-day average for U at WALPOC (16.9 µg/L) exceeded the RFLMA standard (CR 2017-02).

Figure 5 presents the uranium data for WALPOC from 2011 through the end of 2016. For each reportable condition, DOE consulted with EPA and CDPHE and developed a plan for responding to the condition (CRs 2014-05, 2015-01, 2016-01, and 2017-02). The plans included the collection of additional surface water samples from WALPOC and locations upstream and the addition of high-resolution isotopic uranium analyses for selected samples. Data collected prior to mid-2015 to evaluate these reportable conditions were included in a comprehensive evaluation of the distribution, transport mechanisms, sources, and isotopic composition of U in North and South Walnut Creeks (Wright Water Engineers 2015). Among other things, the study suggests a predictable relationship between precipitation and U concentrations in surface water. Specifically, heavy precipitation events (1) increase the mobility of U in soil which allows increased migration of U to groundwater, (2) increase groundwater discharge to surface water, and (3) increase U concentrations in surface water once direct runoff has diminished. Assessment of the Walnut Creek data shows that significant precipitation events such as those experienced in 2013 and 2015 result in an initial lowering of U concentrations in surface water due to increased runoff, followed by an increase in U concentrations over a prolonged period due to increased mobilization of U via geochemical mechanisms and increased volumes of groundwater reaching surface water. This effect was seen after the September 2013 event in which 30-day average U concentrations were first detected at reportable levels in December 2013 and did not return to concentrations below the RFLMA standard until approximately 5 months later in May 2014 (Figure 5). As of the end of this FYR period (December 2016), the 30-day average for U is above the RFLMA standard and the 12-month rolling average for U is below the standard.

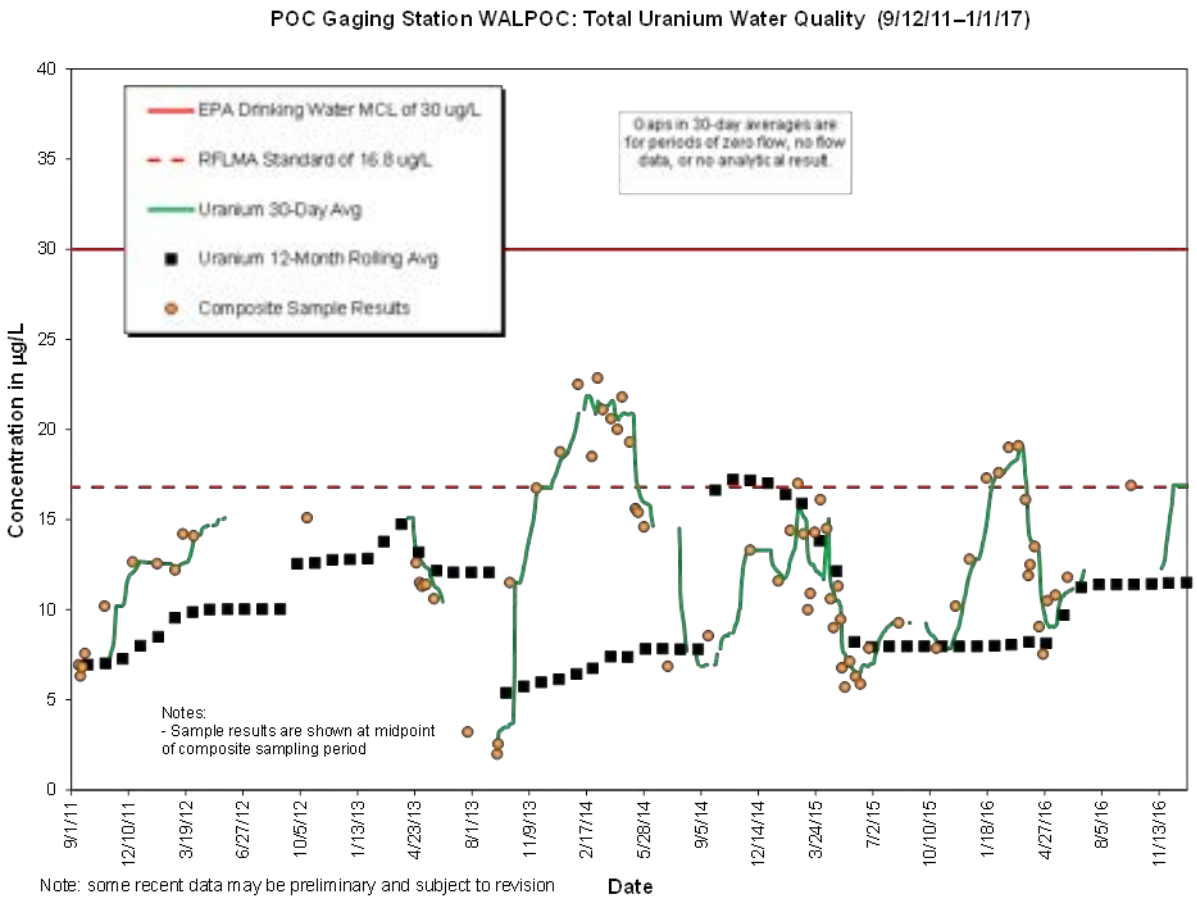


Figure 5. Uranium Concentrations at WALPOC

Other information considered during the RFLMA evaluation of the U reportable conditions at WALPOC includes the following:

(1) Data do not suggest a new source of U contamination.

(2) Uranium concentrations at WALPOC ultimately decreased to below the RFLMA standard.

(3) Not all uranium detected at WALPOC is contamination from former Rocky Flats Plant operations. Based on the isotopic analysis of 29 composite surface water samples collected at WALPOC from 2011 to 2016, 69–87% of the total uranium concentration is naturally occurring uranium (Wright Water Engineers 2015; DOE 2016; DOE 2017a).

(4) All exceedances were well below the EPA maximum contaminant level (MCL) for U in drinking water of 30 µg/L.

Although the MCLs are not directly applicable to the COU, comparison with the drinking water standard offers perspective on the quality of surface water before it leaves the COU.

While both the 30-day average and 12-month rolling average are calculated for the POCs, the RFLMA states that the 12-month rolling average is used in the evaluation of remedy performance. The evaluation of remedy performance in light of the 12-month rolling average

exceedance for U at WALPOC concluded that the remedy remains protective. This conclusion was based on the following considerations:

(1) The reportable condition was a short-term occurrence associated with an extreme weather event.

(2) Exceedance of the 12-month rolling average for uranium is not anticipated to occur with any regularity in the future.

(3) The RFLMA standard for uranium is based on human health risk from long-term (chronic) exposure.

As such, no unacceptable exposures occurred, or are expected to occur, as a result of the reportable condition.

6.1.4 Operation and Maintenance of Remedy Components

The engineered components of the remedy include the two landfill covers and the groundwater treatment systems. The operation and maintenance of the PLF and OLF covers are directly relevant to soil RAOs 2 and 3; groundwater treatment system operation and maintenance are directly relevant to groundwater RAO 2 and soil RAO 1.

6.1.4.1 Present Landfill

The Present Landfill was closed in 2005 and includes a RCRA-compliant composite cover, monitoring wells, and the PLF groundwater treatment system (PLFTS). The locations of the PLF and PLFTS are shown in Figure 6. The PLFTS consists of a passive air stripper (an arrangement of concrete steps over which the seep water flows) designed to treat VOCs. The PLFTS treats landfill seep water, surface water runoff, and groundwater intercepted by the Groundwater Intercept System, which was constructed to minimize upgradient flow into the PLF.

The evaluation of remedy performance at the PLF considers monitoring data from upgradient and downgradient RCRA wells, the PLFTS, downstream surface water location NNG01, and information obtained in routine inspections.

The inspection frequency for the PLF is quarterly, and settlement monuments are surveyed annually. The PLF inspection includes groundwater and surface water monitoring facilities, subsidence and consolidation, slope stability, soil cover, seeps on and around the soil cover, storm-water management structures, and erosion in surrounding features. During this FYR period, no notable conditions were observed during PLF inspections. Because vegetation success criteria were met at the PLF prior to the third FYR report, PLF-specific vegetation inspection requirements were discontinued at the PLF as recommended in the third FYR report (see CR 2014-03). Vegetation at the PLF is still inspected as part of the COU vegetation inspection efforts, in accordance with the *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2012).

Figure 6. Rocky Flats Site PLF Monitoring Locations

There are three upgradient and three downgradient RCRA groundwater monitoring wells at the PLF (Figure 6). These wells are sampled for VOCs and metals on a quarterly basis. The RFLMA Attachment 2 decision logic flowchart Figure 10, "RCRA Wells" (Appendix B), is relevant to evaluation of these data. The RFLMA requires that statistical analyses be conducted on RCRA well data from the PLF (and OLF) to compare constituent concentrations in groundwater at upgradient and downgradient RCRA wells and to determine concentration trends in downgradient wells. These statistical evaluations are conducted annually and are presented in the corresponding COU annual reports. The results of these analyses for each year in this FYR period are very similar, with several metals at higher concentrations downgradient than upgradient of the landfill, and in some cases, increasing metals concentration trends in downgradient wells. The full report of each analysis may be found in the COU annual reports. The RFLMA parties consulted annually during this FYR period regarding these results, and no actions were required other than continued monitoring and evaluation (see CR 2011-03).

RFLMA requires monitoring of the influent and effluent from the PLFTS to assess the operation of this passive treatment system. The influent and effluent locations are sampled on a quarterly basis for VOCs, metals, and uranium; the effluent location is also sampled for semivolatile organic compounds. The RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B), is relevant to evaluation of these data. Arsenic and selenium were detected above RFLMA standards intermittently in PLFTS effluent throughout this FYR period, triggering additional sampling in each instance. Subsequent effluent sample results were below RFLMA standards, so consultation with the RFLMA parties was not required. Vinyl chloride was detected above the RFLMA standard in PLFTS effluent for three consecutive months in both 2014 and 2015 (CRs 2014-06 and 2015-07). Consultation with the

RFLMA parties was initiated, and surface water samples were collected downstream of the PLFTS at location NNG01 (Figure 6). Vinyl chloride was not detected in either of the surface water samples from location NNG01. The RFLMA parties determined that no further action was required to address the vinyl chloride observations. PLFTS effluent meets the applicable RFLMA standards at the end of this review period.

The remedy at the PLF remains protective of human health and the environment. The landfill cover and storm-water management system at the PLF remain intact and effective in preventing unacceptable exposure to buried wastes. Monitoring data at the PLFTS indicate that the system is operating as designed and is generally effective in removing trace VOCs from groundwater and seeps at the landfill. While some constituents in PLFTS effluent were detected above the applicable RFLMA standards during this FYR period, these occurrences were short-lived and did not impact downstream surface water quality.

6.1.4.2 Original Landfill

The Original Landfill was closed in 2005 with a soil cover and storm-water management features designed to achieve hillside stability and control precipitation run-on and runoff. The location of the OLF with respect to the COU is shown in Figure 2. The evaluation of remedy performance at the OLF considers monitoring data from upgradient and downgradient RCRA wells, upstream and downstream surface water locations GS05 and GS59, and information obtained in routine inspections.

The current inspection frequency for the OLF is monthly, and settlement monuments are surveyed quarterly. Additional inspections are required following specific weather events defined in the RFLMA. Inspection information includes groundwater and surface water monitoring facilities, subsidence and consolidation, slope stability, soil cover, storm-water management structures, and erosion in surrounding features. Because vegetation success criteria were met at the OLF prior to the third FYR report, OLF-specific vegetation inspection requirements were discontinued as recommended in the third FYR report. Vegetation at the OLF is still inspected as part of the COU vegetation inspection efforts, in accordance with the *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2012).

The natural geologic and hydrologic conditions at the OLF make it prone to slumping and settling that can be exacerbated by heavy precipitation events. These conditions existed before waste was first placed on the hillside in the early 1950s. After closure of the OLF in 2005, the hillside remained stable until 2007, when landfill inspections identified localized slumping and settling in the westernmost portion of the cover following the extremely heavy snowfall accumulation of winter 2006/2007 and the resultant early 2007 runoff. These conditions triggered the RFLMA consultative process and are discussed in CR 2008-07 and the third FYR report (DOE, EPA, and CDPHE 2012). The plan for addressing these conditions included repairs to the landfill and further investigation to determine if the conditions were likely to influence the integrity of the OLF cover. The resulting geotechnical investigation concluded that, according to slope stability modeling, the large-scale overall slope at the OLF was stable and the risk of large-scale failure of the OLF was low (TtT 2008).

Following a week-long rain event in the fall of 2013, a weather-related inspection of the OLF identified localized surface cracking and settlement on the northeastern edge of the OLF hillside.

These conditions resulted in a RFLMA reportable condition for the OLF (CR 2013-02), triggering the RFLMA consultative process. Maintenance actions were taken to repair the settlement, and the East Perimeter Channel (EPC) was reconfigured (CRs 2013-03 and 2014-09). An extended period of relatively heavy precipitation occurred in the spring of 2015, resulting in extensive movement on the eastern edge of the OLF hillside. As with previous slumping, most of this movement occurred outside the waste footprint. Maintenance was completed in accordance with the OLF Monitoring and Maintenance Plan in the fall of 2015 (CRs 2015-03 and 2015-06). In the spring of 2016, the OLF hillside showed signs of movement in the southeast corner. Although this movement was not as significant as the movement noted in 2015, it was determined that further maintenance at the OLF was warranted, and the EPC and landfill berms were regraded and repaired in October 2016. Additional maintenance was completed at the East Subsurface Drain (ESSD), located in the northeast corner of the EPC, in early January 2017 (CR 2016-04). In response to the slumping, cracking, and displacements that have occurred at the edges of the landfill, LM initiated a multifaceted effort to further evaluate the stability of the slopes surrounding the OLF. Two geotechnical firms were contracted to independently assess and provide recommendations for stabilizing the hillside. The resulting geotechnical reports are attachments to the *Original Landfill Path Forward Rocky Flats Site, Colorado* report that was published in January 2017. This report provides recommendations for a phased approach to the evaluation and implementation of options for minimizing slope movement at the OLF (DOE 2017b).

There are three downgradient and one upgradient RCRA groundwater monitoring wells at the OLF (Figure 7). These wells are sampled for VOCs, semivolatile organic compounds, and metals on a quarterly basis. The RFLMA Attachment 2 decision logic flowchart Figure 10, "RCRA Wells" (Appendix B), is relevant to evaluation of these data. As with the PLF RCRA wells, statistical analyses for OLF RCRA well data were very similar for each year within this FYR period, with several metals detected at higher concentrations downgradient than upgradient of the landfill, and in some cases, increasing metals concentration trends in downgradient wells. The full report of each statistical analysis may be found in the COU annual reports. DOE has consulted with EPA and CDPHE annually on these results, and no action has been required other than continued monitoring and evaluation (see CR 2011-03).

Monitoring at the OLF also includes the collection of surface water samples at locations upstream (GS05) and downstream (GS59) of the landfill (Figure 7). These locations are sampled at least quarterly for VOCs, uranium, and metals. The RFLMA Attachment 2 decision logic flowchart Figure 12, "Original Landfill Surface Water" (Appendix B), is relevant to evaluation of these data. During this FYR period, there were three instances when downstream sample results for metals at location GS59 triggered monthly sampling. In the fourth quarter of 2013, selenium was detected at 5.5 µg/L, above the RFLMA standard of 4.6 µg/L. All subsequent samples from GS59 were below the standard until the third quarter of 2015, when both selenium (6.7 µg/L) and arsenic (10.6 µg/L) were detected above the RFLMA standards of 4.6 and 10 µg/L, respectively. Subsequent samples did not exceed the selenium or arsenic standards, and no further action was required. In the fourth quarter of 2016, selenium was detected at location GS59 at 8.03 µg/L. Monthly sampling at GS59 began in January 2017. The results of surface water monitoring at the OLF for each year in this FYR period may be found in COU annual reports.

Figure 7. Rocky Flats Site OLF Monitoring Locations

In summary, routine and weather-related inspections at the OLF identified substantial, localized slumping and cracking along the eastern and western edges of the landfill during this FYR period. While hillside movement was more extensive than in the previous FYR period (2007–2012), the central portion of the OLF has remained stable. Repair and maintenance activities have occurred throughout this FYR period in response to OLF conditions and will continue as necessary. While the majority of the cracking and slumping has occurred on the periphery of the OLF, seeps and cracks have been identified within the waste footprint. The remedy at the OLF remains protective. No unacceptable exposures to personnel working at the COU have occurred as a result of these conditions. Occupational exposure to personnel working at the OLF to implement the various repairs and maintenance operations is closely monitored and documented in the site records. Physical controls required by the remedy effectively control access to the COU, minimizing the potential for inadvertent access to the OLF by unauthorized parties. Institutional controls specific to the two landfills in the COU, including the OLF, prohibit unauthorized activities on the landfill covers to ensure that unacceptable exposures do not occur. Furthermore, groundwater and surface water monitoring data collected during this FYR period suggest the hillside instability at the OLF has not negatively affected groundwater or surface water quality.

6.1.4.3 Groundwater Treatment Systems

The remedy in the CAD/ROD included the four groundwater treatment systems operating at the time the COU was closed in 2005: the Present Landfill Treatment System (PLFTS), the Solar Ponds Plume Treatment System (SPPTS), the Mound Site Plume Treatment System (MSPTS), and the East Trenches Plume Treatment System (ETPTS). The treatment systems remove target

contaminants from groundwater (VOCs, nitrate, or uranium) and reduce contaminant load to surface water. Each groundwater treatment system is monitored, at a minimum, for untreated influent and treated effluent and for impacts to surface water downstream of the effluent discharge points. Monitoring data associated with the groundwater treatment systems is evaluated in accordance with RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B). The discussion of influent, effluent, and surface water monitoring results for this FYR period for the SPPTS, MSPTS, and ETPTS is found in Appendix E; PLFTS monitoring data are discussed in Section 6.1.4.1.

A detailed description of each system configuration at the beginning of this FYR period may be found in the third FYR report (DOE, EPA, and CDPHE 2012). Several opportunities for groundwater treatment system optimization were identified and implemented during this FYR period through the RFLMA consultative process. Treatment system modifications are discussed in CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02 (Appendix D). No changes to the PLFTS were made during this FYR period. A summary of treatment system changes implemented during this FYR period is presented below; the progression of system changes following closure of the COU may be found in the annual reports.

- **Solar Ponds Plume Treatment System.** Since the COU closed in 2005, this treatment system has been the focus of extensive study and modification. Evaluation of the system was necessary due to the poor performance of the original sawdust and zero-valent iron (ZVI) treatment media in meeting post-closure surface water standards and the cost and difficulty in maintaining the system. Changes to the system during this FYR period included the removal of existing treatment media, conversion of the system to a full-scale, interim design bioremediation lagoon to treat nitrate, and small-scale treatability studies using various reactive media to remove uranium. At the end of this FYR period, the lagoon conversion has shown promising results in the removal of nitrate. In fact, in the last 12 consecutive weekly samples of SPPTS effluent collected through the end of 2016, nitrate was not detected. Uranium treatability studies are ongoing. Optimization of the uranium treatment component at the SPPTS will be developed and evaluated through the RFLMA consultative process.
- **Mound Site Plume Treatment System and East Trenches Plume Treatment System.** Each of these two systems originally utilized ZVI treatment media. While this media was effective in reducing contaminant load in groundwater, it proved less effective in consistently reducing VOCs to meet the RFLMA water quality standards. As with the SPPTS, media removal and disposal was costly and labor-intensive. Opportunities for VOC treatment optimization were identified and implemented for the MSPTS and ETPTS through the RFLMA consultative process. To test VOC removal potential, small air strippers were added to the MSPTS in 2011(CR 2011-01) and ETPTS in 2013 (CR 2012-02). Based on the success of these air strippers, the MSPTS and ETPTS were reconfigured at different times to replace ZVI treatment with a single commercial air stripper located at the ETPTS (CRs 2014-01, 2015-04, 2016-02). Following completion of this project in late 2016, VOC concentrations in combined MSTPS and ETPTS effluent have met all applicable RFLMA standards. Because this most recent reconfiguration changed the location of groundwater treatment of the Mound Site plume from the MSPTS to the ETPTS, this modification was considered a significant difference to the selected remedy for the MSPTS. The significant difference was documented in an Explanation of Significant Differences (see CR 2016-02).

  The reconfiguration of the MSPTS and ETPTS has increased the systems' resilience to weather variability and extremes. Because the COU has no line power available, treatment

components are powered entirely by solar energy via solar panels and batteries, which are designed to limit power interruptions and allow for operation in all weather conditions. Unlike the previous gravity-fed, passive design that resulted in treatment effectiveness varying with groundwater flow rates, the reconfigured ETPTS operates in a batch treatment mode, and the air stripper treats at a constant flow rate. The result is that treatment is no longer dependent on residence time within the media and can accommodate a wide range of groundwater flows while achieving the same level of treatment. Treating the groundwater in batches ensures that groundwater processed through the system receives a consistent level of treatment. The reconfigured system provides more control over the treatment of the Mound Site and East Trenches groundwater plumes, thus providing additional flexibility in accomplishing treatment. The MSPTS, ETPTS, and SPPTS collection systems and the ETPTS and SPPTS treatment systems feature remote-access monitoring capabilities that allow for the automatic shutoff of individual system components in response to changing conditions.

6.1.5 Operations and Maintenance Costs

The O&M cost of the selected remedy was estimated in the Remedial Investigation/Feasibility Study Report and presented in the 2006 Proposed Plan. The total annual estimated O&M costs in 2005 dollars were $2,757,000, which included groundwater treatment systems media replacement estimated at $728,000 every 5 years for each of the three systems.

The remedy-related implementation cost for this review period was compiled using actual cost for fiscal years 2012–2016. While this does not correspond exactly to the period for which environmental data was evaluated, it is representative of the cost to maintain the remedy over a 5-year period. The following O&M and capital costs incurred during this review period were included in the evaluation:

- Groundwater and surface water monitoring
- Operation, inspection, and maintenance of the groundwater treatment systems
- Inspection 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
- Conversion of the ETPTS from ZVI-based treatment to a solar-powered commercial air stripper
- Installation of infrastructure to route water from the MSPTS collection trench to the ETPTS air stripper, thus eliminating the need for the ZVI-based treatment system for the Mound Site plume
- Removal of the original treatment media at the SPPTS and conversion to a full-scale test system for nitrate treatment using biological processes
- Continuation of technology investigations for uranium treatment at SPPTS
- OLF and PLF inspections and cover vegetation management, including weed control
- OLF soil cover and diversion berm repairs and maintenance
- OLF maintenance following heavy precipitation events in 2013, 2015, and 2016

- Geotechnical evaluation and path forward recommendation for additional actions to improve hillside stability at OLF
- Erosion controls, subsidence repair, and revegetation monitoring
- Conduct of the FYR
- Geochemistry evaluation for water quality in Walnut Creek
- Evaluation of reportable conditions at WALPOC, SW027, GS10, and AOC well 10304 including investigation monitoring and seeding and erosion controls at the SW027 drainage
- Monitoring and consultation regarding threatened and endangered species and wetlands
- Water monitoring equipment capital costs and maintenance
- Project management and overhead costs

Total O&M and capital cost for this period is approximately $17.9 million. The RI/FS Report projected that the 5-year cost for implementing the selected remedy would be approximately $13.6 million, in unescalated 2005 dollars. The remedy implementation costs are higher than the projected costs for this five-year review period due to the following factors:

- The original groundwater treatment systems were passive systems designed to require limited human interaction; the current systems, which provide significantly more effective treatment, also require more labor for O&M.
- Two groundwater treatment systems that were not always effective in meeting treatment targets were converted from ZVI-based treatment systems to air-stripper-based technology that is very effective in meeting treatment targets and does not generate a large volume of spent ZVI for disposition.
- The full-scale nitrate test system at SPPTS had significant up-front reconfiguration cost but is now effectively treating nitrate and does not require the disposition of a large volume of spent treatment media.
- OLF maintenance requirements during this review period were significantly higher than projected due to the slumping and cracking on the east and west edges experienced after the high precipitation events in 2013, 2015, and 2016. Additional evaluation and activities are underway to determine methods to minimize future movement.
- Geochemistry evaluation led to a better understanding of mechanisms affecting uranium and nitrate concentrations in Walnut Creek.
- Additional staff was added to support the activities performed during this 5-year period.
- Escalation since 2005.

The additional costs incurred over this FYR period do not suggest problems with the remedy because:

(1) The costs for converting the MSPTS, ETPTS, and the SPPTS nitrate treatment component are one-time costs to reconfigure the systems to provide more effective treatment with significantly less waste generation. This initiative was implemented as an opportunity for optimization of the remedy.

(2) OLF maintenance costs include evaluation of options to minimize slope movement in the future to maintain protectiveness.

(3) Some of the cost increase is due to 12 years of price escalation since the RI/FS costs were developed.

6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Still Valid?

Based on the evaluation presented in this section, the exposure assumptions, toxicity levels, cleanup levels, and RAOs used at the time of the remedy are still valid, and revision of the RAOs is not necessary. There were no changes in exposure pathways or assumptions during this FYR period; land use in the COU remains consistent with the Rocky Flats Wildlife Refuge land use assumption in the CAD/ROD. There were some revisions to surface water quality standards and toxicity levels, which are discussed in the sections below.

6.2.1 Evaluation of Changes in Standards

A review of the CAD/ROD ARARs was conducted to determine whether there were any promulgated changes to statutes or regulations relevant to the chemicals, locations, or actions addressed by the CAD/ROD during this FYR period. Appendix H is a table of changes to CAD/ROD ARARs and other potentially applicable regulations that were considered in this FYR evaluation.

The remedy performance standards for surface water and groundwater at the COU are the Colorado surface water quality standards identified as ARARs in the CAD/ROD. These standards are directly relevant to groundwater RAOs 1 and 2, surface water RAO 1, and soil RAOs 1 and 2 (Table 4). Newly promulgated or modified ARARs contribute to the evaluation of protectiveness and must be considered in the FYR.

6.2.1.1 Surface Water Standards

The surface water standards applicable to the COU are based on (1) Colorado Water Quality Control Commission (WQCC) regulation No. 31, "Colorado Basic Standards and Methodologies for Surface Waters" (Volume 5 *Code of Colorado Regulations* Regulation 1002-31 [5 CCR 1002-31]), which are statewide basic standards, and (2) Colorado WQCC regulation No. 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 COU are Big Dry Creek segments 4a and 5 of the South Platte River Basin. Because the use classification of groundwater in the COU is surface water protection, the applicable surface water standards also apply to groundwater.

The surface water standards for eight chemical constituents were revised in this FYR period (see CR 2012-03). The standards for five of these constituents (acrylamide, carbon tetrachloride, hexachloroethane, nitrobenzene, and tetrachloroethene) increased (i.e., are now less stringent). Therefore, the remedy remains protective. The standard for *cis*-1,2-dichloroethene was changed to a range of concentrations (0.014–0.070 milligram per liter [mg/L]). After consultation with the RFLMA parties, the higher number in the range (0.070 mg/L) was retained as the RFLMA surface water standard. The higher standard was the same as the previous RFLMA standard for

cis-1,2-dichloroethene; therefore, the remedy remains protective. The standards for two constituents (1,4-dioxane and pentachlorophenol) decreased from the previous standards (i.e., are now more stringent). These two constituents were not identified as analytes of interest in any media at the COU or POU in the RI/FS Report (DOE 2006), nor were they identified as contaminants of concern (COCs) in the 2006 comprehensive risk assessment (CRA) (DOE 2006); routine monitoring for these constituents is not required by RFLMA. Limited data from groundwater and treatment system monitoring during this FYR period show pentachlorophenol as a nondetect in all samples; no data for 1,4-dioxane is available. Therefore, a change in the standards for these two constituents does not affect protectiveness of the remedy.

6.2.2 Evaluation of Changes in Exposure Assumptions and Toxicity Data

There were no changes to exposure assumptions during this FYR period. The assumptions used for the wildlife refuge worker (WRW) remain valid. Exposure assumptions are conservative (i.e., likely overestimate actual risk) and appropriate based on actual land use.

The remedy performance standards for soil in the COU are site-specific, risk-based values calculated using the exposure assumptions for a WRW. These standards, referred to as preliminary remediation goals (PRGs), were used to identify COCs within the COU and are directly relevant to the evaluation of soil RAO 3 (Table 4). The risks posed by the COCs left at the COU following accelerated actions were evaluated in the 2006 CRA (DOE 2006).

The comprehensive risk assessment evaluated the land area that encompasses the POU and the COU, divided into 12 exposure units (EUs) (Appendix C, Figure C-1). The comprehensive risk assessment was completed by exposure unit and not by operable unit (POU and COU). As shown in Table 5, half the EUs overlap both the COU and POU while the rest are confined only to the POU. Table 5 summarizes all COCs (chemical and radiological) for each exposure unit for which risks were evaluated in the CRA. These are constituents for which residual soil concentrations exceeded PRGs. It should be noted that no chemical COCs were identified for the POU.

The PRGs developed for the COU represent the maximum concentrations for individual chemical constituents and radionuclides that would equate to a carcinogenic risk value of 1×10^{-6} or a noncarcinogenic hazard quotient of 0.1 based on the exposure assumptions for the WRW. The risk value represents the added probability that an individual or population will develop cancer during their lifetime as a result of exposure to site contaminants. The acceptable risk range for CERCLA sites is an added risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}). If cumulative risks (i.e., risks posed by all pathways and contaminants summed together) for a site are within or below the acceptable risk range, further action is generally not needed. The PRGs are conservative screening values for identifying individual contaminants that require further evaluation. Generally, if the concentration of a single contaminant is less than (or below) its PRG value, no further evaluation is required. If the concentration of a contaminant is greater than (or above) its PRG value, then further evaluation of the potential risks posed by the contaminant is appropriate. The PRGs for the COU were developed using toxicity levels that were current at the time of the comprehensive risk assessment and were developed for exposures to both surface and subsurface soils. Changes to the risk parameters (e.g., slope factors, reference doses) used to calculate these PRGs may impact the identification of COCs and must be considered in the FYR.

Table 5. Surface Soil COCs Identified for Each Exposure Unit in the CRA

Constituent	Exposure Unit											
	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Part of COU	●	●	●	●	●	●						
Part of POU	●	●	●	●	●	●	●	●	●	●	●	●
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	-	X	-	-	-	-	-	-	-
Plutonium-239/240	-	-	X	-	-	-	-	-	-	-	-	-

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
X = constituent designated a COC in the 2006 CRA
- = constituent not designated a COC in the 2006 CRA

6.2.2.1 Chemical Constituents

The COC identification process used in the comprehensive risk assessment was reviewed using updated EPA soil screening values comparable to the wildlife refuge worker PRGs (see Table C-5 for a listing of the constituents reviewed). Generally, the evaluation confirmed that the surface soil COCs identified in the comprehensive risk assessment remain the primary risk drivers in the COU. It also confirmed that there are no subsurface soil COCs. The toxicity levels for the COCs were reviewed by comparing current toxicity levels with those used during the CRA. A comparison of the CRA and current toxicity levels is provided in Table 6.

There have been some changes in toxicity levels for some constituents since the comprehensive risk assessment; however, these do not affect the protectiveness of the remedy for the COU. EPA has revised its methodology for determining risks associated with the inhalation pathway for both carcinogens and noncarcinogens. However, for chemical constituents, the inhalation pathway has much less effect for the wildlife refuge worker than the oral ingestion pathway and does not impact the estimation of overall risks within the COU. The toxicity level for the oral ingestion pathway has not changed for arsenic. The oral ingestion slope factor for benzo[*a*]pyrene is lower than that used in the CRA, indicating lower risks than originally estimated. The EPA oral reference dose for vanadium is higher than that used in the CRA, meaning that current estimated risks would be lower. A new reference dose has been added for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) since the CRA. However, the elevated concentrations of dioxin were associated with the OLF prior to construction of the cover and are not present on the surface. Thus, the pathway to residual dioxin contamination has been severed, and changes in toxicity levels do not affect remedy protectiveness. This evaluation confirms that conclusions reached in CAD/ROD are still valid and the COU remains protective for the WRW.

Table 6. Comparison of COC Toxicity Values

COC	Carcinogenic Toxicity Values				Noncarcinogenic Toxicity Values			
	Oral/Ingestion[a]		Inhalation		Oral/Ingestion[d]		Inhalation	
	CRA	Current	CRA[b]	Current[c]	CRA	Current	CRA	Current[e]
Arsenic	1.50	1.50	1.51×10^{1}	4.3×10^{-3}	3.00×10^{-4}	3.00×10^{-4}	n/a	1.5×10^{-5}
Vanadium	n/a	n/a	n/a	n/a	1.00×10^{-3}	9.00×10^{-3}	n/a	n/a
Benzo[*a*]pyrene	7.3	1.0	3.1	6.0×10^{-4}	n/a	3.0×10^{-4}	n/a	2.0×10^{-6}
2,3,7,8-TCDD	1.5×10^{5}	1.3×10^{5}	1.5×10^{5}	3.8×10^{1}	n/a	7.0×10^{-10}	n/a	4.8×10^{-8}

Notes:
[a] Oral slope factor $(mg/kg\text{-}day)^{-1}$.
[b] Inhalation slope factor $(mg/kg\text{-}day)^{-1}$.
[c] Inhalation unit risk $(\mu g/m^3)^{-1}$.
[d] Oral reference dose (mg/kg-day).
[e] Reference concentration (mg/m^3).

6.2.2.2 Radionuclide Constituents

Radiological Risk

The 2017 EPA online PRG calculator was used in this FYR evaluation to determine if the risk from radionuclides to the wildlife refuge worker in the COU remains within the acceptable CERCLA risk range. The acceptable risk range for CERCLA sites is an added cancer risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}). The EPA PRG calculator includes the numerous changes to toxicity factors that have occurred since 2006, including revisions specific to plutonium and uranium. A summary of the methodology used and these changes, including changes to slope factors for the different exposure pathways, is provided in Appendix C. For completeness, this FYR radiological risk review considered $^{239/240}$Pu (the only radionuclide COC identified in the 2006 CRA), ^{241}Am, ^{234}U, ^{235}U, and ^{238}U. The Am and U isotopes represent the other primary radionuclides associated with Rocky Flats Plant historical operations.

To perform this FYR radiological risk evaluation, the 2017 EPA online calculator was used to generate site-specific PRGs using the input parameters from the 2006 comprehensive risk assessment for the WRW at a 1×10^{-6} risk level. These values were then compared to the PRG WRW values in the 2006 CRA, which were also calculated at the 1×10^{-6} risk level. The PRGs calculated by the online calculator are conservative screening values that are used in this FYR to identify individual contaminants that may require further evaluation. This FYR review methodology does not require input of site-specific analytical data because PRGs represent concentrations based on a target risk level rather than a calculated risk from measured concentrations. As such, no new analytical data were collected for this FYR risk evaluation. Details of the methodology used to complete this FYR evaluation are presented in Appendix C.

As evidenced in Table 7, the 2017 PRGs calculated for ^{241}Am and ^{235}U at the 1×10^{-6} risk level are less conservative (i.e., larger) than the PRGs calculated in 2006 at the same risk level. The 2017 PRGs calculated for ^{239}Pu, ^{240}Pu, ^{234}U, and ^{238}U are slightly more conservative (i.e., smaller) than the PRGs calculated in 2006 at the 1×10^{-6} risk level. The decrease in

calculated PRGs from 2006 for ^{239}Pu, ^{240}Pu, ^{234}U, and ^{238}U can most likely be attributed to the revision of the Pu and U slope factors adopted by EPA since 2006 (see Table C-8). Although the calculated risk associated with these four radionuclides increased slightly, the risk remains on the lower end (i.e., more protective) of the risk range, between 1×10^{-5} and 1×10^{-6}. In summary, the calculated risk to a WRW in the COU remains within the acceptable risk range considered by EPA to be protective of human health, and therefore, the remedy in the COU remains protective.

Table 7. PRG Comparison for Wildlife Refuge Worker[a]

Isotope	2006 PRG[b] (pCi/g)	2017 PRG (pCi/g)		
Risk Level	**1×10^{-6}**	**1×10^{-4}**	**1×10^{-5}**	**1×10^{-6}**
^{241}Am	7.7	1150.0	115.0	11.5
^{239}Pu	9.8	929.0	92.9	9.3
^{240}Pu	9.8	931.0	93.1	9.3
^{234}U	25.3	2000.0	200.0	20.0
^{235}U	1.1	454.0	45.4	4.5
^{238}U	29.3	2290.0	229.0	22.9

Notes:
[a] The calculated risk to a WRV in the COU is less than the calculated risk to a WRW, primarily due to the difference in exposure frequency. The WRW scenario exposure frequency is 230 days/year; the WRV scenario exposure frequency for an adult is 250 hours/year.
[b] From the *Final Comprehensive Risk Assessment Work Plan and Methodology* (DOE 2005). Values have been rounded to the first decimal place.

Abbreviation:
pCi/g = picocuries per gram

Radiological Dose

The CAD/ROD identified select Colorado radiation protection standards as ARARs for the COU. For radiological sites that do not allow unrestricted use, as is the case for the COU, Colorado regulations require that institutional controls be in place that reasonably assure that the total effective dose equivalent from residual radioactivity within the COU does not exceed 25 millirems per year (mrem/year) (6 CCR 1007-4.61.2). In 2006, a dose assessment was completed for the COU using the RESRAD computer model, to determine if the COU met the 25 mrem/year dose criteria upon closure (DOE 2006). For this FYR, changes to input parameters (e.g., slope factors, dose conversion factors) used in the dose assessment were evaluated to determine if this ARAR continues to be met. The methodology used to complete this FYR review of radiological dose is described in Appendix C.

To understand the relative impact to dose resulting from the numerous changes to input parameters and the computer model that have occurred since 2006, a range of exposure scenarios and associated analytical data evaluated in the 2006 RESRAD (version 6.3) dose assessment was entered into the current RESRAD model (version 7.2). No new sample data to support this fourth FYR dose evaluation were collected.

A comparison of the RESRAD version 6.3 dose results to the RESRAD version 7.2 dose results indicates little change in total dose. All of the 2006 scenarios evaluated in Appendix C yielded

similar results, suggesting that the changes in total dose for all scenarios and locations evaluated in 2006 would be negligible using the current RESRAD model version. This simply means that the changes to RESRAD since 2006 have not resulted in major impacts to dose calculated by the model. That is, the dose calculated using RESRAD version 6.3 is nearly the same as the dose calculated using RESRAD version 7.2, using the same 2006 site-specific input parameters (see Table C-12, Appendix C). Therefore, because the dose assessment from 2006 indicated that the COU is in compliance with the dose criteria ARAR from the CAD/ROD with a total dose much less than 25 mrem/year, a recalculation of dose using the most updated version of RESRAD would yield similar results and the ARAR would still be met. The FYR dose assessment review concluded that the dose criteria ARAR is met and the remedy in the COU remains protective.

6.2.3 FYR Risk Evaluation Summary

The chemical and radiological risks to the WRW in the COU were reviewed in light of changes to toxicity factors that have occurred since the comprehensive risk assessment was published in 2006. Following are the key conclusions from this FYR risk evaluation:

- The risks posed to the WRW in the COU for chemical and radiological constituents remain within the CERCLA acceptable risk range (1×10^{-4} to 1×10^{-6}) and, in fact, are at the lower (i.e., more protective) end of the risk range
- The changes in toxicity values and other input parameters did not affect the protectiveness of the remedy
- Exposure assumptions used are conservative (i.e., likely overestimate actual risks) and remain valid
- The general Site Conceptual Model and assumption that the most likely exposure scenario for a human receptor is approximated by a WRW scenario is still valid for the COU
- Institutional controls are in place at the COU that eliminate the vapor intrusion pathway through building restrictions (see Table 2, Institutional Control 1)
- RAOs and cleanup goals remain valid

Independent of the FYR risk evaluation of the COU described above, a review of risks in the POU and OU3 was also completed. This review confirmed that UU/UE determinations for the POU and OU3 are still valid. A summary of the review methodology and results is presented in Appendix C.

6.2.4 RAO Status

The status of each RAO during this FYR period is presented in Table 4. The RAOs and ARARs in the CAD/ROD remain relevant in addressing residual contamination and potential exposure pathways at the COU and assessing remedy protectiveness. Not all RAOs were met during this FYR period; however, the remedy is designed to achieve all RAOs in the long-term. No revisions to the RAOs established in the CAD/ROD are recommended.

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

No other information collected during this FYR period has called into question the protectiveness of the remedy.

The robustness of the remedy, however, was tested during this FYR period by the high variability in precipitation from year to year. In 2012, the COU experienced one of the driest years on record, followed in 2013 by a significant precipitation event and subsequent flooding, and a very wet spring in 2015. During 2013, the precipitation measured in the second and third quarters (13.86 inches) was 68.9% higher than historical (1997–2012) values for this period. Much of this increase is due to a significant rain event and associated flooding that occurred September 11–15, 2013 (DOE 2014b). Most of the precipitation in 2015 was from multiple rain storms that occurred between April and July, when almost three-quarters of the total precipitation measured in 2015 was received; slightly over half of the annual moisture fell in the months of May and June (DOE 2016). It should be noted that this precipitation information is based on data from unheated rain gauges located in the COU and likely underestimates precipitation because snowmelt is not fully represented. The 2013 and 2015 precipitation events greatly increased the volume of surface water flow, as measured at the POCs (Figure 8) and the volume of groundwater treated in the groundwater treatment systems (Table 8).

6.3.1 Surface Water Flow and Runoff

The extreme variability in precipitation can be seen in the annual discharge volumes measured at the WOMPOC and WALPOC locations (Figure 8). Despite a very dry year (2012), a significant flooding event (2013), and a very wet spring (2015), the 12-month rolling averages for monitored constituents at WOMPOC and WALPOC were below applicable RFLMA surface water standards for the majority of this FYR period. In fact, there was only one short period in 2014/2015 that the 12-month rolling average for uranium exceeded the RFLMA standard at a POC. This occurred at WALPOC and may be largely attributed to groundwater recharge from the precipitation event in 2013. It should be noted that the maximum 12-month rolling average for uranium at WALPOC (17.2 µg/L) was only slightly above the RFLMA standard of 16.8 µg/L.

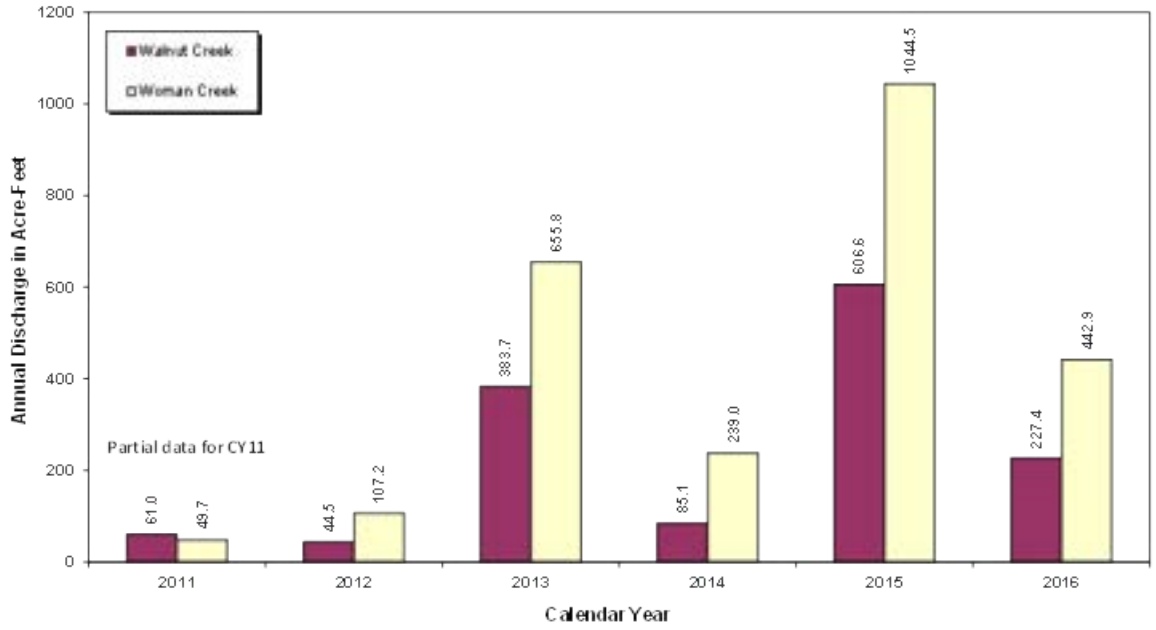


Figure 8. Annual Surface Water Discharge from WOMPOC and WALPOC

6.3.2 Groundwater Treatment Systems

The precipitation events in late 2013 and in 2015 led to increased groundwater flow to the groundwater treatment systems. While the 2013 event did not contribute as much recharge to groundwater because so much of it ran off as surface flow, a substantial amount infiltrated and contributed to the groundwater recharge. The effects of this precipitation on treatment system volumes were most notable in 2014, as shown in Table 8. The more prolonged precipitation in 2015 was much more effective in contributing to groundwater recharge, as also shown in this table.

These sharp increases in groundwater flow resulted in decreases in residence time within the reactive media in the treatment systems and, therefore, reduced contact time of contaminants with the media. Even so, the treatment systems continued to remove the bulk of the contaminants. Note that by mid-January 2015, the ETPTS had been converted from a reactive media-based treatment approach to a commercial air stripper that is better able to accommodate changes in flow conditions without affecting treatment (see Appendix E Section E1.1.2.3). The SPPTS did not perform as desired, but upgrades completed in mid-2016 were successful in achieving essentially complete treatment of the nitrate in SPPTS influent by the end of the year (see Appendix E Section E1.1.2.2).

Table 8. Volume of Groundwater Treated at MSPTS, ETPTS, and SPPTS[a]

Year	MSPTS	ETPTS	SPPTS
	Estimated Annual Volume Treated (gallons)		
2000	258,000	1,633,000	64,000
2001	119,000	1,900,000	424,000
2002	53,000	1,000,000	5,600
2003	82,000	2,100,000	340,000
2004	86,000	1,500,000	230,000
2005	506,000	1,800,000	140,000
2006	430,000	675,000	251,000
2007	326,000	951,000	244,000
2008	358,000	629,000	280,000
2009	287,000	406,000	524,000
2010	420,000	1,606,000	738,000
2011	546,000	890,000	507,000
2012	461,000	622,000	498,000
2013	422,000	604,000	498,000
2014	689,000	1,298,000	591,000
2015	981,000	2,030,000	1,094,000
2016	571,000	1,799,000	459,000

Note:
[a] The estimated volume of water treated in the PLFTS is not shown because the flow data at this treatment system is not collected continuously and is not directly comparable to the other treatment system data.

6.3.3 OLF

The 2013 precipitation and subsequent flooding resulted in unusually high groundwater levels that ultimately caused portions of the periphery of the OLF to slump. The storm-water management system at the landfill was further stressed by the very wet spring in 2015. Although there has been cracking and slumping in the eastern edge of the OLF hillside over the last several years, these occurrences have been primarily outside the waste footprint, and the central portion of the OLF has remained stable. The conditions at the OLF will continue to be evaluated to identify long-term measures that will address the slope instability.

7.0 Issues, Recommendations, and Follow-Up Actions

This fourth FYR did not identify any early indicators of potential remedy problems or other issues. Key aspects of remedy implementation are timely evaluation of the data in accordance with decision rules specified in the RFLMA and 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. As a result of the successful implementation of the RFLMA consultative process during this FYR period, potential issues and opportunities for optimization were identified and addressed as they were encountered. This process ensures that issues are addressed and resolved as they arise and not reserved for evaluation in the next FYR cycle.

8.0 Protectiveness Statement

The remedy at the COU is protective of human health and the environment.

Interim removal actions completed prior to the CAD/ROD included the removal of contaminated soils and sediments, decontamination and removal of equipment and buildings, construction of cover systems at the two landfills, and construction and operation of four groundwater treatment systems. A monitoring and maintenance plan is in place to assure the long-term integrity of the remedy. Routine inspections of remedy components ensure that maintenance and repairs are identified and implemented. Groundwater treatment systems continue to reduce contaminant load to surface water. Surface and groundwater monitoring provide assurance that water quality at the COU boundary is protective. Institutional controls are effective in preventing unacceptable exposures to residual contamination by prohibiting building construction, controlling intrusive activities, restricting use of groundwater and surface water, and protecting engineered remedy components. Physical controls are effective at controlling access to the COU.

Because the remedial actions at the COU are protective and the other OUs associated with the former Rocky Flats Plant (POU and OU3) are suitable for unlimited use and unrestricted exposure, the site is protective of human health and the environment.

9.0 Next Review

Contaminants at the COU are expected to remain at levels that do not allow UU/UE and will require continued remedy implementation for the foreseeable future. Thus, a fifth FYR will be required. The next FYR report completion date is August 3, 2022.

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Appendix A

Site Chronology

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This appendix contains a chronology of major events that have occurred at the Rocky Flats Plant (RFP) since nuclear production operations began in 1952. The history of the RFP spans more than 65 years, of which approximately 40 years were dedicated to production in support of the U.S. nuclear weapons program, approximately 10 years to cleanup and remedy implementation, and to date, over 10 years to post-closure monitoring. This chronology provides a high-level overview of key dates in this long history and provides detail for events that occurred over the five-year period covered by this report. It is by no means all-inclusive.

Rocky Flats Plant Chronology

Date	Event
Apr 1952	Operations to produce a plutonium component for use in atomic weapons begin at the RFP.
Sep 1957	A fire in Building 771 causes extensive contamination to the building and release of some plutonium to the environment.
1967	Large-scale leaking of waste oil drums being stored on the 903 Pad occurs, contaminating the soils with plutonium, machining lubricants, and chlorinated solvents.
May 1969	A plutonium glovebox fire that started in Building 776 spread to several hundred connected gloveboxes in Building 776 and Building 777. This caused extensive damage and contamination to the buildings and release of some plutonium to the environment.
1968–1970	Some of the radiologically contaminated material is removed from the 903 Pad and Lip Area, some of the surrounding Lip Area is regraded, and much of the area is covered by an imported base coarse material. Contaminated soil becomes windborne and contaminates the area east of the 903 Pad. An asphalt cap is placed over the most contaminated area of the Pad.
Sep 1973	A tritium release is discovered in a water sample collected from Woman Creek by the Colorado Department of Health (now known as the Colorado Department of Public Health and Environment [CDPHE]). A U.S. Environmental Protection Agency (EPA) report indicates that 50–100 curies of tritium reached Great Western Reservoir, just east of the RFP.
Sep 1984	Cleanup of a 0.25-mile strip of soil on the 903 Lip Area is conducted.
Jul 1986	A Compliance Agreement is entered into between the U.S. Department of Energy (DOE), EPA, and CDPHE that defined roles and established milestones for major environmental operations and response actions at the RFP. These efforts identified over 2000 waste generation points and 178 Solid Waste Management Units (SWMUs) and Resource Conservation and Recovery Act/Colorado Hazardous Waste Act (RCRA/CHWA)-regulated closure sites.
Jun 1989	Federal Bureau of Investigation and EPA agents carry out a search warrant to search for evidence of alleged criminal violations of RCRA and the Federal Water Pollution Control Act.
Sep 1989	The RFP is added to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL).
Dec 1989	Nuclear production work at the RFP is halted to address environmental and safety concerns.
Jan 1990	Construction of a system to remove chemical contaminants from groundwater at the Operable Unit (OU) 1 – 881 Hillside Area begins, a designated high-priority cleanup site at the RFP. The action followed EPA and CDPHE approval of an Interim Measure/Interim Remedial Action Plan for OU1.
Jan 1991	An Interagency Agreement (IAG) between DOE, EPA, and CDPHE is signed; the IAG replaces the 1986 Compliance Agreement. The agreement outlines multiyear schedules for environmental restoration investigations and remediation.
1993	Secretary of Energy formally announces the end of nuclear production at the RFP; facility mission changes to cleanup and closure.
Nov 1994	A no action Corrective Action Decision/Record of Decision (CAD/ROD) is issued for OU16 (Low Priority Sites). This is the first OU to be officially closed out under the IAG.
Oct 1995	No action CAD/RODs are issued for OU11 (West Spray Field) and OU15 (Inside Building Closures).

Date	Event
Jul 1996	The Rocky Flats Closure Project begins, and the Rocky Flats Cleanup Agreement is signed, which supersedes the 1991 IAG. This agreement establishes the accelerated action framework, describes the goals for cleanup and closure, and defines the regulatory approach for review and approval of work to ultimately delete the RFP from the NPL. All buildings and Individual Hazardous Substance Sites are to be dispositioned through accelerated actions. OUs are reconfigured into the Industrial Area and Buffer Zone OUs. Several IAG OUs are retained because progress toward CAD/RODs for those OUs was expected.
Mar 1997	A CAD/ROD for OU1 and 881 Hillside is issued, requiring soil excavation, treatment of contaminated groundwater, and institutional controls.
June 1997	The CAD/ROD for OU3, Offsite Areas is approved; the remedy selected for OU3 is no action.
Aug 1998	Groundwater treatment operations at the Mound Site Plume Treatment System (MSPTS) commence.
Oct 1998	The existing seep treatment system at the PLF is modified to include passive aeration.
Sep 1999	Groundwater treatment operations at the East Trenches Plume Treatment System (ETPTS) and Solar Ponds Plume Treatment System (SPPTS) commence.
Sep 2000	A major modification of the OU1 CAD/ROD is issued, deleting the soil excavation requirement and providing criteria for ceasing groundwater treatment and continued monitoring based on further investigation results.
Dec 2001	Rocky Flats National Wildlife Refuge Act signed into law.
Oct 2002	The first use of solar energy to provide power at the former RFP. A system of solar panels and storage batteries is constructed to provide power to a pump used in the groundwater collection system at the SPPTS.
Sep 2002	First FYR report is issued. Completion of this report was triggered by the completion date for the CAD/ROD for OU3. This review evaluated OU1, OU3, and several key accelerated actions at Individual Hazardous Substance Sites, as well as the installed groundwater treatment systems for the Mound Site, East Trenches, and Solar Pond Plumes and the seep at the Present Landfill (PLF).
Oct 2005	Decontamination and decommissioning of approximately 815 structures in the Industrial Area concludes with the demolition of Building 371. Physical completion of accelerated Closure Project at the former RFP. Construction of the RCRA-compliant cover on the PLF is completed; the seep treatment cascade system is installed at the Present Landfill Treatment System (PLFTS). Installation of a 2-foot cover and grading of the Original Landfill (OLF) is completed.
Jun/Jul 2006	The Remedial Investigation/Feasibility Study (RI/FS) Report and Comprehensive Risk Assessment for the Central Operable Unit (COU) and the Peripheral OU (POU) are published. The RI/FS Report documented conditions after completion of all Rocky Flats Cleanup Agreement accelerated actions, evaluated three remedial alternatives for the COU, and proposed no action for the POU. The Sitewide Proposed Plan is issued for public review and comment.
Dec 2006	The Environmental Covenant, a legal instrument restricting use and access to the COU as stated in the CAD/ROD, is signed by DOE and CDPHE.
Sep 2006	The CAD/ROD for the COU and the POU is approved. The remedy selected for the COU is institutional and physical controls and monitoring; the remedy selected for the POU is no action.
Mar 2007	The CERCLA Federal Facility Agreement and Consent Order (also known as the Rocky Flats Legacy Management Agreement [RFLMA]) is signed by DOE, EPA, and CDPHE. This agreement establishes the regulatory framework for implementing the remedy at the COU and ensuring it remains protective of human health and the environment.
May 2007	The POU and OU3 are deleted from the NPL. This is considered a partial deletion of the former RFP because the COU is retained on the NPL.
Jun 2007	Elevated nitrate and uranium detected in SPPTS discharge gallery prompt RFLMA consultation (see CR 2007-02).

Date	Event
Jun/Jul 2007	EPA certifies completion of cleanup and closure of the former RFP in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. DOE transfers jurisdiction and control of the majority of POU lands to the U.S. Department of Interior, U.S. Fish and Wildlife Service.
Jul 2007	CDPHE approves a three-phase work plan for the OLF to address slumping and erosion issues identified during routine inspections (see CR 2008-07).
Sep 2007	Second FYR report is issued. The remedy remains protective.
Jan 2008	The PLF Monitoring and Maintenance Plan, which is adopted by reference in RFLMA, is updated to incorporate changes in inspection frequencies, completion of certain monitoring requirements, and clarification of vegetation inspection schedules and completion criteria (see CR 2007-08).
Sep 2009	The OLF Monitoring and Maintenance Plan, which is adopted by reference in RFLMA, is updated (see CR 2008-07).
Jan 2010	Effective date of changes to the Colorado Water Quality Control Commission Regulation No. 38 redefining Segment 5 of Walnut Creek to be that portion of Walnut Creek between the western and eastern boundaries of the COU. Segment 4b was redefined as that portion of Walnut Creek between the eastern boundary of the COU and Indiana St. The Recreational Use Classification of N (no primary contact use) for Segment 5 was retained.
Jul 2010	Following a 30-day public review and comment period, RFLMA Attachment 2 is modified to revise several monitoring locations (see CR 2010-04).
Mar 2011	A small-scale air stripper is installed at MSPTS. This spray-type air stripper is located in the effluent manhole and is designed to treat groundwater for VOCs following passive zero-valent iron (ZVI) treatment in underground tanks. The air stripper is powered entirely by batteries, which are recharged using solar energy.
Sep 2011	Operation of new surface water points of compliance (POCs) at Woman Creek (WOMPOC) and Walnut Creek (WALPOC) commences at the boundary of the COU. These POCs replaced former POCs at locations GS08, GS11, and GS31. A CAD/ROD amendment for the COU is signed. The primary purpose of the amendment is to clarify the description of the institutional controls pertaining to excavation, soil disturbance, and changes to engineered components.
Nov 2011	DOE and CDPHE revise the 2006 Environmental Covenant restricting use and access to the COU. The Covenant may be viewed on the Office of Legacy Management website.
Sep 2012	Third FYR report is issued. The remedy remains protective.
Feb 2013	A small-scale air stripper is installed at ETPTS. This spray-type air stripper is located in the influent manhole and is designed to treat groundwater for VOCs prior to passive ZVI treatment in underground tanks. The air stripper is powered entirely by batteries, which are recharged using solar energy. Minor modifications are made to RFLMA Attachment 2 (see CR 2012-03).
Sep 2013	The two surface water POCs at Indiana Street, GS01 and GS03, cease operation under RFLMA. This change reflects the deletion of the POU from the NPL and establishment as a National Wildlife Refuge and realignment of POCs to the COU boundary. Monitoring at GS01 and GS03 continued until 2015 under the Adaptive Management Plan. Record-setting precipitation and flooding (a 1% probability per year flood) on the Front Range of Colorado.
Oct 2013	As a result of the September 2013 flooding, slumping at the OLF results in a reportable condition (see CR 2013-02). Minor slumping had also occurred in 2007 and 2010.
Dec 2013	As a result of the September 2013 flooding, a reportable condition for the 30-day average for uranium at WALPOC is documented and persists through May 2014 (see Section 6.1.3.1).
Oct 2014	As a result of the September 2013 flooding, a reportable condition for the 12-month rolling average for uranium at WALPOC is documented (see Section 6.1.3.1 and CR 2015-01).
Dec 2014	Minor modifications are made to the PLF Monitoring & Maintenance Plan (see CR 2014-03).
Jan 2015	A commercial air-stripper is installed and begins operation at the ETPTS. This technology improvement achieves a greater reduction of VOCs in groundwater than the previous ZVI-based technology (see Section 6.1.4.3).

Date	Event
May–Sep 2015	Extended heavy precipitation over several months in the spring causes significant cracking, slumping, and movement on northwestern and eastern sides of the OLF. Immediate response actions include installing overland drain pipes and developing small drainage channels to conduct water off the cover (see CR 2015-03). Subsequent interim actions include regrading the affected areas and closing cracks (see CR 2015-06). The heavy precipitation also caused significant slumping in the North Walnut Creek basin east of the SPPTS.
Sep 2015	An extensive evaluation of water quality is finalized. *Evaluation of Water Quality Variability for Uranium and Other Selected Parameters in Walnut Creek at the Rocky Flats Site* discusses geochemical conditions resulting in mobilization of uranium in the Walnut Creek drainage.
Jun 2016	An Explanation of Significant Differences (ESD) is issued to document a significant change to the CAD/ROD approved in 2006. The change consists of removing groundwater treatment components from the MSPTS and pumping the Mound Site Plume groundwater to the ETPTS air-stripper for treatment. This improved the removal of VOCs in groundwater, eliminated the use of ZVI treatment media, and reduced the number of groundwater treatment systems in the COU from four to three.
Jul 2016	SPPTS conversion from organic media/ZVI to full-scale, interim design lagoon treatment for nitrate is completed and testing is ongoing. Evaluation of treatment technologies for uranium continues.
Sep 2016	The reconfiguration of the MSPTS is complete; combined groundwater from MSPTS and ETPTS is now treated for VOCs at the commercial air stripper at the ETPTS. Wells/piezometers are installed upgradient of the OLF to allow for long-term monitoring of groundwater levels.
Dec 2016	The ESSD reconstruction project begins. This project involved the reconstruction of an existing drainage feature designed to divert groundwater before it enters the area of the most significant slumping (see CR 2016-04). The project is completed in January 2017.
Jan 2017	The *Original Landfill Path Forward* document is published. This document evaluates long-term solutions for reducing the instability of the slopes surrounding the OLF. Two key OLF technical evaluations are included as attachments to this document: *OLF Options Report* and *OLF Geotechnical Engineering Review*.

Appendix B

Rocky Flats Legacy Management Agreement Attachment 2

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Attachment 2

Legacy Management Requirements

Document History

Rocky Flats Legacy Management Agreement
Attachment 2, Legacy Management Requirements

<table>
<tr><th>Date</th><th>Description of Changes</th></tr>
<tr><td>December 2012</td><td>Modification per RFLMA Contact Record 2012-03. For simplicity, Document History table was revised to remove the detailed list of changes made in modifications through the last modification in September 2011. All prior modifications are documented in the Rocky Flats post-closure administrative record.</td></tr>
<tr><td>December 2012</td><td>Section 5.1 updated to note the date WALPOC and WOMPOC became Points of Compliance (POCs), replacing former POCs GS08, GS11, and GS31.</td></tr>
<tr><td>December 2012</td><td>Section 5.3.7 and Table 5 related to additional ecological sampling deleted for simplicity. The additional ecological sampling was completed and approved in 2008.</td></tr>
<tr><td>December 2012</td><td>Section 7.3 was based on the schedule for the second 5-year review report in 2007. The third 5-year review was completed in 2012. Section was modified to address the scheduling for completion of future reports.</td></tr>
<tr><td>December 2012</td><td>Table 1 modified to make standards consistent with changes promulgated by the Colorado Water Quality Control Commission (WQCC) with an effective date of January 31, 2013, as follows:
<table>
<tr><th>Analyte</th><th>Previous Standard (mg/L)</th><th>New Standard (mg/L)</th></tr>
<tr><td>Acrylamide</td><td>7.80E-6</td><td>2.20E-5</td></tr>
<tr><td>Carbon tetrachloride</td><td>2.30E-4</td><td>4.30E-4</td></tr>
<tr><td>1,2-Dichloroethene (cis)</td><td>7.00E-2</td><td>1.40E-2 to 7.00E-2</td></tr>
<tr><td>1,4-Dioxane</td><td>3.20E-3</td><td>3.50E-4</td></tr>
<tr><td>Hexachloroethane</td><td>4.00E-4</td><td>5.00E-4</td></tr>
<tr><td>Nitrobenzene</td><td>3.50E-3</td><td>1.40E-2</td></tr>
<tr><td>Pentachlorophenol</td><td>2.70E-4</td><td>8.00E-5</td></tr>
<tr><td>Tetrachloroethene</td><td>6.90E-4</td><td>5.00E-3</td></tr>
</table>
Table 1 footnotes modified as follows:

[c] and [h]: Deleted because footnotes referenced Temporary Modifications that expired at the end of 2009. Both footnotes marked as “Reserved.”

[e]: Revised to clarify that the WQCC promulgated standard for un-ionized ammonia applies to Segment 4a only.

[i]: Clarified that nitrate and nitrite standards are “as nitrogen.”

[m]: Deleted because footnote referred to the March 22, 2012, effective date for the 1,4-Dioxane standard (3.20E-3 mg/L). Footnote marked as “Reserved.”

[n]: Added 1,2-Dichloroethene (cis) to this footnote, to note that the higher number in the range is to be used as the applicable or corresponding Table 1 standard in the flowcharts in Figures 7 through 11. Prior to this change, arsenic was the only Table 1 analyte noted in footnote [n] based on the WQCC promulgated standard that is a range of values.</td></tr>
<tr><td>December 2012</td><td>Table 2 modified to remove former POCs GS08, GS11 and GS31, which have been replaced as POCs by WALPOC and WOMPOC as described in Section 5.1.</td></tr>
<tr><td>December 2012</td><td>Table 3 modified to remove landfill-specific vegetation and inspection requirements as recommended in the third 5-year review report.
Table 3 was also modified to change Present Landfill reference from “pond” to “downstream” monitoring because the Present Landfill Pond dam was breached in 2012.</td></tr>
</table>

Date	Description of Changes
December 2012	Figure 1 modified to remove former POCs GS08, GS11, and GS31 and to change note regarding GS01 and GS03 consistent with change to Section 5.1. The footprint of the Present Landfill Pond and Pond A-3 changed to reflect dam breach and the map feature for these ponds changed to “wetland/marsh.” The note regarding dam breach changed to delete reference to Present Landfill Pond and Pond A-3. Surface water sampling locations “Pond A4”, Pond B5” and “Pond C2” changed to “A4 Pond”, “B5 Pond” and “C2 Pond” consistent with Table 2 location codes.
December 2012	Figure 3 modified to correct typo for former sewage treatment plant Building 988, previously labeled 998.
December 2012	Figure 4 modified to show the location of the Original Landfill and the Present Landfill and to change the figure title accordingly. Figure 4 also modified to reflect Present Landfill Pond and Pond A-3 dam breach.

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1.0 PURPOSE AND BACKGROUND

The purpose of this attachment to the Rocky Flats Legacy Management Agreement (RFLMA) is to specify the legacy management requirements that will ensure the response action selected and approved in the final Corrective Action Decision and Record of Decision (CAD/ROD) for the Central Operable Unit (OU) remains protective of human health and the environment. The remedy specified in the final CAD/ROD is supported by a Comprehensive Risk Assessment, which is based on a specific land use. The remedy, therefore, relies on certain physical and institutional controls, which must be maintained to ensure long-term protectiveness. The remedy also includes engineered features—landfills and water treatment systems—which must be maintained to remain protective. Reduced levels of residual soil contamination remain at the site and may continue to affect surface water. Contaminated groundwater also exists at the site and may impact surface water quality. Continued routine monitoring for groundwater and surface water is therefore required. Air, soil, and ecological receptors have been extensively monitored for many years and routine monitoring is no longer required.

Legacy management requirements described in this attachment are intended to address the requirements of the following statutes:

- Resource Conservation and Recovery Act (RCRA);
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) including applicable or relevant and appropriate requirements (ARARs); and
- Colorado Hazardous Waste Act (CHWA).

Modifications to this attachment will occur in accordance with the provisions of Part 10 of RFLMA.

2.0 REMEDY PERFORMANCE STANDARDS AND REQUIREMENTS

Remedy performance standards and requirements are enforceable numerical values or narrative descriptions of conditions or restrictions, designed to protect existing or potential uses, against which remedy performance can be measured. These standards and requirements are derived from state surface water standards and from requirements established in the final CAD/ROD.

2.1 Surface Water Standards

Protection of surface water was a basis for making soil and groundwater response action decisions during the cleanup period so that surface water on site and leaving the site would be of sufficient quality to support all uses. The applicable surface water uses are consistent with the following Colorado Water Quality Control Commission (WQCC) surface water use classifications:

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

The remedy performance standards for surface water at the Rocky Flats Site are found in Table 1 and are based on the tables found in the WQCC Regulation No. 31: Basic Standards and Methodologies for Surface Water (5 CCR 1002-31) and on the site-specific standards in the WQCC Regulations No. 38 (5 CCR 1002-38). If the numeric values from the basic standards and the site-specific standards differ, the site-specific standard applies. In addition to practical quantitation levels (PQLs) allowed by the WQCC regulations, site-specific PQLs may be proposed to Colorado Department of Public Health and Environment (CDPHE) for approval. Any changes to the standards will be discussed in the annual legacy management report.

The WQCC-designated groundwater use classification at the site 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. Exceedances of water quality standards at a surface water POC may be subject to civil penalties under Sections 109 and 310(c) of CERCLA.

Criteria and strategies for comparing analytical results to these numeric values are established in Section 5 and in attached flowcharts.

2.2 Requirements of the Final CAD/ROD

Some response actions taken under Rocky Flats Cleanup Agreement decision documents specified conditions or restrictions that extend into the legacy management period. These requirements are captured in the final CAD/ROD and are specified in this attachment.

3.0 PHYSICAL CONTROLS

3.1 Engineered Remedies

DOE will maintain physical controls as necessary to protect engineered elements of the remedy, such as landfill covers, groundwater treatment systems, and monitoring equipment.

3.2 Signs

DOE will 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 will measure at least 11 inches by 14 inches and will include the following language: "U.S. Department of Energy – No Trespassing". In addition, signs listing use restrictions and providing contact information will be posted at access points to the Central OU.

4.0 INSTITUTIONAL CONTROLS

Institutional controls in the form of use restrictions are established in the CAD/ROD. These controls are embodied in an environmental covenant granted by DOE to the CDPHE or by a restrictive notice issued by CDPHE instead of an environmental covenant, and are listed in Table 4. The environmental covenant or restrictive notice is recorded in the land records in Jefferson County, Colorado. DOE will annually verify the environmental covenant or the restrictive notice is on file in accordance with Section 5.3.6.

The use restrictions shall be implemented to meet the objective and rationale of the institutional control as provided in the CAD/ROD. DOE shall follow the RFLMA consultative process pursuant to Part 5 of RFLMA for any regulatory determination required regarding activities subject to the institutional control.

Results of consultation will be documented in contact records or written correspondence. Except for situations where immediate action is warranted, DOE will not implement the activity for which the regulatory determination is required until 10 calendar days after the contact record or written correspondence approving the activity is posted on the Rocky Flats website and notification of the posting is made to stakeholders in accordance with the RFLMA Public Involvement Plan.

DOE will employ administrative procedures to control all site modification, maintenance, or other activities requiring excavation within the Central OU in accordance with the institutional controls to prevent violation of the restrictions listed in Table 4. DOE shall ensure that all such site activities will not compromise the integrity or function of the remedy or result in uncontrolled releases of or exposures to subsurface contamination, in accordance with the land use restrictions in Table 4.

DOE will utilize work control procedures to help maintain the use restrictions and ensure protection of the integrity of the institutional controls. These procedures derive from U.S. Environmental Protection Agency (EPA) and State of Colorado regulation and guidance and DOE Orders and guidance. The DOE Integrated Safety Management System (ISMS) utilizes processes such as the job hazard analysis (JHA) to identify and mediate environmental, health and safety risks to ensure all work is done in a safe and environmentally protective manner.

4.1 Soil Disturbance Review Plan

Activities in the Central OU subject to Institutional Control 2 or 3, listed in Table 4, that are subject to regulatory review and approval will be reviewed and approved in accordance with this Soil Disturbance Review Plan:

4.1.1 Information in Soil Disturbance Review Plan

Prior to conducting any activity that is subject to this plan, DOE will submit the following information to CDPHE and EPA:

- A description of the proposed project, including the purpose, the location, and the lateral and vertical extent of excavation.
- Information about any remaining subsurface structures in the vicinity of the proposed project (or state that there are none if that is the case).
- Information about any former Individual Hazardous Substance Sites, Potential Areas of Concern, or other known or potential soil or groundwater contamination in the vicinity of the proposed project (or state that there is no known contamination).

In consultation with EPA, CDPHE will review the information described above. CDPHE will approve the proposed activity only if it determines that the proposed activity will not result in an unacceptable release or exposure to residual subsurface contamination, and will not damage any component of the remedy. In making such determinations, CDPHE will ensure that the proposed project meets the rationale and objectives of the institutional controls.

Subsurface soils disturbed by activities implemented in areas that, based on the results of the Remedial Investigation/Feasibility Study, are or may be contaminated must be characterized. Characterization may rely on existing data, and be sufficient to implement the DOE work control procedures to establish controls for worker health and safety, potential migration of contamination and other project specific items identified through the evaluation of information in the Soil Disturbance Review Plan. Contaminated soils may be returned to the excavation, provided the rationale and objectives of the institutional controls are still met. Contaminated soils not returned to the excavation must be managed in accordance with regulatory requirements.

If an onsite or offsite borrow source is needed to fill an excavation, the source must be identified. This Soil Disturbance Review Plan also applies to any onsite borrow source.

DOE will document the elevation created by any soil-disturbing activity that does not return the soil surface to preexisting grade or higher, in order to ensure that the minimum 3-foot cover thickness above any contaminated subsurface feature in Figures 3 or 4 is maintained.

5.0 MONITORING REQUIREMENTS

Monitoring will provide measurements for remedy performance, safety, compliance with standards, and effectiveness of physical and institutional controls. Monitoring requirements are designed to provide data that meet designated monitoring objectives (as outlined in Table 2 and in attached flowcharts) and that support operational and regulatory decision making. Legacy Management operational documents relating to the monitoring and maintenance performed by DOE will be provided to CDPHE and EPA and will be available to the public.

Environmental sampling, analysis, and data management required by this attachment will conform to the Legacy Management CERCLA Sites Quality Assurance Project Plan (QAPP) and meet the quality assurance and quality control requirements in current EPA guidance. DOE will submit the QAPP to CDPHE and EPA within two months of execution of the RFLMA. DOE will ensure that laboratories generating data have procedures for assuring that the precision, accuracy, representativeness, completeness, and comparability (and sensitivity in the case of radiological analyses) of data are known and documented. DOE will also perform periodic assessments of analytical data, including laboratory audits. Upon request, all analytical data including QA/QC procedures, audits, and reports will be provided to CDPHE and/or EPA.

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. The currently accepted PQLs are listed in Table 1.

5.1 Monitoring Surface Water

Compliance with the surface-water standards in Table 1 will be measured at the Points of Compliance (POCs) downstream of the terminal ponds and consider groundwater in alluvium. Points of Evaluation (POEs) and additional performance monitoring locations serve to monitor the quality of surface water in the Central OU. The data evaluation methods described in the attached flowcharts will be used to evaluate sampling data collected at these locations. POCs, POEs and performance monitoring locations are shown in Figure 1; the monitoring location identification, description and sampling criteria are identified in Table 2.

- Points of Compliance (POCs): Located in Woman and Walnut Creeks. These locations are used to demonstrate compliance with the surface-water standards in Table 1. WALPOC, which replaced former POCs GS08 and GS11 on September 28, 2011, and WOMPOC, which replaced former POC GS31 on September 9, 2011, 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 2 years. EPA or CDPHE may extend the 2-year period by requiring DOE to submit a modification to this attachment in accordance with RFLMA paragraph 65 if either determines that such modification is necessary to ensure protection of human health and the environment.
- Points of Evaluation (POEs): Located in the Central OU upstream of the ponds and POCs. These locations are used to evaluate water-quality in comparison to the surface-water standards in Table 1.
- 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.

5.2 Monitoring Groundwater

Groundwater is monitored in or near areas of groundwater contamination that might adversely affect surface water quality (Figure 2). Contaminated groundwater emerges to surface water before leaving the Central OU. DOE will maintain a network of groundwater monitoring wells to assess the potential effects of contaminated groundwater on surface water quality. These wells and sampling criteria are identified in Table 2 and shown in Figure 1 with the following well classifications:

- Area of Concern (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 Present Landfill and Original Landfill.

5.3 Remedy Monitoring and Maintenance

5.3.1 Original Landfill

Groundwater and surface water monitoring details, including criteria and analytes, are listed in Table 2. Table 3 summarizes the inspection and maintenance requirements contained in the approved *Original Landfill Monitoring and Maintenance Plan,* which is incorporated by reference as an enforceable requirement of the RFLMA.

5.3.2 Present Landfill

Groundwater and surface water monitoring details, including criteria and analytes, are listed in Table 2. Table 3 summarizes the inspection and maintenance requirements contained in the approved *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan,* which is incorporated by reference as an enforceable requirement of the RFLMA.

5.3.3 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 sampling criteria in Table 2 and the decision rules in the attached flowcharts. The systems will be maintained to ensure the effluent meets Table 1 standards.

5.3.4 Residual Subsurface Contamination

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.).

5.3.5 Monitoring Physical Controls

The condition of signs and other physical controls maintained by DOE will be inspected on a quarterly basis.

5.3.6 Monitoring Institutional Controls

The effectiveness of the institutional controls described in Table 4 of this attachment and in the environmental covenant or restrictive notice required by Section 4.0 will be determined 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 for the Central OU remains in the Administrative Record and is recorded in Jefferson County.

5.4 Operational Monitoring

Operational monitoring is not a requirement of the CAD/ROD, but is a requirement of this Attachment. Operational monitoring provides information that will supplement CAD/ROD required monitoring.

5.4.1 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.

5.4.2 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 Figure 13 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 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.

5.4.3 Adverse Biological Conditions

DOE will note evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) observed during other monitoring and maintenance activities described above.

6.0 ACTION DETERMINATIONS

Whenever any of the following reportable conditions are observed, DOE shall follow the appropriate procedures in this section. Reportable conditions include:

- Exceedances of surface water standards at surface water and groundwater monitoring locations consistent with the attached flowcharts;
- Evidence of significant erosion in areas of residual subsurface contamination;
- Evidence of adverse biological conditions;
- Conditions affecting the effectiveness of the landfill covers;
- Evidence of violation of the institutional controls;
- Physical control failure that adversely affects the remedy; or
- Other abnormal conditions that adversely affect the remedy.

When reportable conditions occur (except in the case of evidence of violation of institutional controls as described below), DOE will inform CDPHE and EPA within 15 days of receiving the

inspection reports or validated data. Within 30 days of receiving inspection reports or validated analytical data documenting a reportable condition, DOE will submit a plan and a schedule for an evaluation to address the condition. DOE will consult as described in RFLMA Paragraph 11 to determine if mitigating actions are necessary. Final plans and schedules for mitigating actions, if any, will be approved by CDPHE in consultation with EPA. DOE is not, however, precluded from undertaking timely mitigation once a reportable condition has been identified.

In the case of evidence of violation of institutional controls, DOE will notify EPA and CDPHE within 2 days of discovering any evidence of such a violation, and at that time will initiate the consultative process to address the situation. In no case will DOE notify EPA and CDPHE more than 10 days after the discovery of a situation that may interfere with the effectiveness of the institutional controls. DOE will notify EPA and CDPHE of the actions it is taking within 10 days after beginning the process to address the situation.

The RFLMA Parties will consult whenever reportable conditions are observed or at the request of one of the Parties when routine communication processes are not sufficient or appropriate. The objective of the consultation will be to determine a course of action to address the reportable condition and to ensure the remedy remains protective. Results of consultation will be documented in contact records and/or written correspondence.

Surface water and groundwater monitoring results will be evaluated as described in the following flowcharts:

- Figure 5 Flowchart—Points of Compliance
- Figure 6 Flowchart—Points of Evaluation
- Figure 7 Flowchart—Area of Concern Wells and SW018
- Figure 8 Flowchart—Sentinel Wells
- Figure 9 Flowchart—Evaluation Wells
- Figure 10 Flowchart—RCRA Wells
- Figure 11 Flowchart—Groundwater Treatment Systems
- Figure 12 Flowchart—Original Landfill Surface Water
- Figure 13 Flowchart—Pre-discharge Pond Sampling

Exceedances of water quality standards at a POC may be subject to civil penalties under Sections 109 and 310(c) of CERCLA. In addition, failure of DOE to notify the State and EPA of such exceedances or other reportable occurrences, or failure to undertake source evaluations or mitigating actions as described above, will be enforceable consistent with the terms of Part 8 of the RFLMA.

7.0 PERIODIC REPORTING REQUIREMENTS

In addition to notifications of reportable conditions described in Section 6, periodic reporting will provide CDPHE, EPA, and the public with updated information pertaining to the surveillance and maintenance of the remedy prescribed in the final CAD/ROD. 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 website and available for regulatory and public review in accordance with the following schedule:

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

7.1 Quarterly Legacy Management Reports

The various reporting requirements may be combined into a summary report of surveillance and maintenance activities that occurred during the applicable quarter. The following topics will be included in quarterly reports:

- Surface water monitoring data;
- Groundwater monitoring data;
- Groundwater treatment system monitoring data;
- Ecological sampling data;
- Adverse biological conditions;
- Inspection reports; and
- Summary of maintenance and repairs.

7.2 Annual Legacy Management Reports

The various reporting requirements may be combined into a comprehensive report of all surveillance and maintenance activities that occurred during the applicable calendar year. Annual reports may include a summary for the previous quarter. The following will be included in annual reports:

- Discussion of surface water monitoring data;
- Discussion of groundwater monitoring data;
- Discussion of groundwater treatment system monitoring data;
- Discussion of ecological sampling data;
- Adverse biological conditions;
- Summary of actions taken in response to reportable conditions;
- Summary of maintenance and repairs;
- Inspection reports;
- Verification of the Environmental Covenant and evaluation of the effectiveness of institutional controls;

- Original Landfill Monitoring Report (see Table 3 and Section 6.1 of the *Original Landfill Monitoring and Maintenance Plan*, as approved);
- Present Landfill Monitoring Report (see Table 3 and Section 6.1 of the *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan,* as approved);
- Assessments of analytical data, including laboratory audits; and
- Other conditions or actions taken that are pertinent to the continued effectiveness of the remedy.

7.3 CERCLA 5-Year Review

A statutory 5-year review is required under CERCLA for the Central OU because the selected remedy will result in hazardous substances, pollutants or contaminants remaining above levels that allow for unrestricted use and unlimited exposure. DOE will prepare the 5-year review report consistent with EPA-OSWER Directive 9355.7-03B-P (or subsequent EPA directives), as applicable to Rocky Flats. DOE will submit the 5-year review report to EPA upon a mutually agreeable schedule determined by the RFLMA Project Coordinators in accordance with the consultative process in RFLMA paragraph 11, so as to allow for EPA concurrence within 5 years of the preceding 5-year review report. DOE will conduct 5-year reviews in accordance with RFLMA Part 11, Periodic Reviews, until such time as EPA determines that CERCLA periodic reviews are no longer required. The 5-year review will evaluate site conditions and determine whether the selected remedy remains protective of human health and the environment. In doing so, 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. The public will be notified when the review will be conducted. Results of 5-year reviews will be made available to the public.

Table 1. Surface Water Standards

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [b]	PQLs [d] (mg/L)
Acenaphthene	83-32-9	4.20E-01	W+F, WS	
Acrolein	107-02-8	3.50E-03	W+F, WS	2.50E-02
Acrylamide	79-06-1	2.20E-5	WS	3.20E-04
Acrylonitrile	107-13-1	5.10E-05	W+F	2.50E-02
Alachlor	15972-60-8	2.00E-03	W+F, WS	
Aldicarb	116-06-3	7.00E-03	WS	
Aldicarb sulfone	1646-88-4	7.00E-03	WS	
Aldicarb sulfoxide	1646-87-3	7.00E-03	WS	
Aldrin	309-00-2	4.90E-08	W+F	5.00E-05
Ammonia, un-ionized [e]	7664-41-7	1.00E-1	AL	
Aniline	62-53-3	6.10E-03	WS	1.00E-02
Anthracene	120-12-7	2.10E+00	W+F, WS	
Aramite	140-57-8	1.40E-03	WS	2.00E-02
Arsenic, total recoverable	7440-38-2	2.00E-5 to 1.00E-02 [n]	SS	
Atrazine	1912-24-9	3.00E-03	WS	

Table 1 (continued). Surface Water Standards

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [b]	PQLs [d] (mg/L)
Azobenzene	103-33-3	3.20E-04	WS	3.00E-02
Benzene [c]	71-43-2	2.20E-03	W+F	
Benzidine	92-87-5	8.60E-08	W+F	4.00E-02
alpha-BHC	319-84-6	2.60E-06	W+F	3.00E-05
beta-BHC	319-85-7	9.10E-06	W+F	6.00E-05
gamma-BHC [Lindane]	58-89-9	8.00E-05	AL	
Benzo(a)anthracene	56-55-3	3.80E-06	W+F	2.00E-02
Benzo(a)pyrene	50-32-8	3.80E-06	W+F	1.00E-02
Benzo(b)fluoranthene	205-99-2	3.80E-06	W+F	1.00E-02
Benzo(g,h,i)perylene	191-24-2	3.80E-06	W+F	1.00E-02
Benzo(k)fluoranthene	207-08-9	3.80E-06	W+F	1.00E-02
Benzotrichloride	98-07-7	2.70E-06	WS	1.00E-02
Benzyl chloride	100-44-7	2.10E-04	WS	1.00E-03
Beryllium	7440-41-7	4.00E-03	SS	
Boron, total	7440-42-8	7.50E-01	AG, SS	
Bromate	15541-45-4	5.00E-05	WS	1.00E-03
Bromodichloromethane	75-27-4	5.50E-04	W+F [f]	1.00E-03
Bromoform [Tribromomethane]	75-25-2	4.30E-03	W+F [f]	
Bromomethane [Methyl Bromide]	74-83-9	9.80E-04	W+F	1.00E-03
Butylbenzylphthalate	85-68-7	1.40E+00	W+F, WS	
Cadmium, dissolved	7440-43-9	1.50E-03	TVS [g]	
Carbofuran	1563-66-2	4.00E-02	WS	
Carbon tetrachloride	56-23-5	4.30E-4	W+F	1.00E-03
Chlordane	57-74-9	8.00E-07	W+F	2.00E-04
Chlorobenzene	108-90-7	1.00E-01	W+F, WS	
Chlorodibromomethane (HM)	124-48-1	5.40E-02	W+F	
bis(2-Chloroethyl)ether	111-44-4	3.00E-05	W+F	1.00E-02
Chloroform [Trichloromethane]	67-66-3	3.40E-03	W+F [f]	
bis(2-Chloroisopropyl)ether	108-60-1	2.80E-01	W+F, WS	
Chloromethane [Methyl chloride]	74-87-3	5.60E-03	W+F	
Bis(chloromethyl)ether (BCME)	542-88-1	1.00E-07	W+F	1.00E-02
4-Chloro-3-methylphenol	59-50-7	3.00E-02	AL	
Chloronaphthalene	91-58-7	5.60E-01	W+F, WS	
2-Chlorophenol	95-57-8	3.50E-02	W+F, WS	
Chloropyrifos	2921-88-2	4.10E-05	AL	5.00E-03
Chromium III, Total Recoverable	16065-83-1	5.00E-02	SS	
Chromium VI, dissolved	18540-29-9	1.10E-02	TVS [g]	2.00E-02
Chrysene	218-01-9	3.80E-06	W+F	1.00E-02
Copper, dissolved	7440-50-8	1.60E-02	TVS [g]	2.50E-02
Cyanide	57-12-5	5.00E-03	SS	
4,4-DDD	72-54-8	3.10E-07	W+F	1.10E-04
4,4-DDE	72-55-9	2.20E-07	W+F	5.00E-05
4,4-DDT	50-29-3	2.20E-07	W+F	1.20E-04
Dalapon	75-99-0	2.00E-01	WS	
Demeton	8065-48-3	1.00E-04	AL	1.00E-02
Dibenzo(a,h)anthracene	53-70-3	3.80E-06	W+F	1.00E-02
Dibromochloromethane	124-48-1	8.00E-02	W+F, WS [f]	

Table 1 (continued). Surface Water Standards

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [b]	PQLs [d] (mg/L)
1,2-Dibromo-3-chloropropane	96-12-8	2.00E-04	WS	1.00E-03
Di-n-butylphthalate	84-74-2	7.00E-01	W+F, WS	
Dichloroacetic acid	79-43-6	7.00E-04	WS	5.00E-04
1,2-Dichlorobenzene	95-50-1	4.20E-01	W+F	
1,3-Dichlorobenzene	541-73-1	9.40E-02	W+F, WS	
1,4-Dichlorobenzene	106-46-7	6.30E-02	W+F	
3,3-Dichlorobenzidine	91-94-1	2.10E-05	W+F	2.00E-02
1,2-Dichloroethane	107-06-2	3.80E-04	W+F	1.00E-03
1,1-Dichloroethene	75-35-4	7.00E-03	W+F, WS	
1,2-Dichloroethene (cis)	156-59-2	1.40E-2 to 7.00E-02 [n]	WS	
1,2-Dichloroethene (trans)	156-60-5	1.00E-01	W+F, WS	
2,4-Dichlorophenol	120-83-2	2.10E-02	W+F, WS	
Dichlorophenoxyacetic acid [2,4-D]	94-75-7	7.00E-02	WS	
1,2-Dichloropropane	78-87-5	5.00E-04	W+F	1.00E-02
1,3-Dichloropropylene	542-75-6	3.40E-04	W+F	1.00E-02
Dichlorvos	62-73-7	1.20E-04	WS	1.00E-02
Dieldrin	60-57-1	5.20E-08	W+F	2.00E-05
Di(2-ethylhexyl)adipate	103-23-1	4.00E-01	WS	
Diethylphthalate	84-66-2	5.60E+00	W+F, WS	
Diisopropyl methyl phosphonate	1445-75-6	8.00E-03	WS	1.00E-02
2,4-Dimethylphenol	105-67-9	1.40E-01	W+F, WS	
Dimethylphthalate	131-11-3	7.00E+01	W+F, WS	
4,6-Dinitro-2-methylphenol	534-52-1	2.70E-04	WS	5.00E-02
2,4-Dinitrophenol	51-28-5	1.40E-02	W+F, WS	5.00E-02
2,4-Dinitrotoluene	121-14-2	1.10E-04	W+F, WS	1.00E-02
2,6-Dinitrotoluene	606-20-2	2.30E-01	AL	
Dinoseb	88-85-7	7.00E-03	WS	
1,4-Dioxane	123-91-1	3.50E-4	WS	1.00E-02
Dioxin (2,3,7,8 TCDD)	1746-01-6	5.00E-12	W+F	1.00E-05
1,2-Diphenylhydrazine	122-66-7	3.60E-05	W+F	1.00E-02
Diquat	85-00-7	2.00E-02	WS	
Endosulfan	115-29-7	5.60E-05	AL	
Endosulfan, alpha	959-98-8	5.60E-05	AL	2.00E-04
Endosulfan, beta	33213-65-9	5.60E-05	AL	
Endosulfan sulfate	1031-07-8	5.60E-05	AL	6.60E-04
Endothall	145-73-3	1.00E-01	WS	
Endrin (technical)	72-20-8	3.60E-05	AL	6.00E-05
Endrin aldehyde	7421-93-4	2.90E-04	W+F	
Epichlorohydrin	106-89-8	3.50E-03	WS	1.00E-02
Ethylbenzene	100-41-4	5.30E-01	W+F	
Ethylene dibromide [1,2-Dibromomethane]	106-93-4	5.00E-05	WS	1.00E-03
bis(2-Ethylhexyl)phthalate	117-81-7	1.20E-03	W+F	1.00E-02
Fluoranthene	206-44-0	1.30E-01	W+F	
Fluorene	86-73-7	2.80E-01	WS	

Table 1 (continued). Surface Water Standards

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [b]	PQLs [d] (mg/L)
Folpet	133-07-3	1.00E-02	WS	
Furmecyclox	60568-05-0	1.20E-03	WS	1.00E-02
Glyphosate	1071-83-6	7.00E-01	WS	
Guthion	86-50-0	1.00E-05	AL	1.00E-01
Heptachlor	76-44-8	7.80E-08	W+F	5.00E-05
Heptachlor epoxide	1024-57-3	3.90E-08	W+F	1.00E-03
Hexachlorobenzene	118-74-1	2.80E-07	W+F	1.00E-02
Hexachlorobutadiene	87-68-3	4.40E-04	W+F	5.00E-03
Hexachlorocyclohexane, Technical	608-73-1	1.20E-05	W+F	1.00E-02
Hexachlorocyclopentadiene	77-47-4	5.00E-03	AL	1.00E-02
Hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-hcdd)	19408-74-3	5.60E-09	WS	2.50E-05
Hexachloroethane	67-72-1	5.00E-4	W+F	1.00E-03
Hydrazine/Hydrazine sulfate	302-01-2	1.20E-05	WS	1.00E-02
Indeno(1,2,3-cd)pyrene	193-39-5	3.80E-06	W+F	1.00E-02
Isophorone	78-59-1	1.30E-01	W+F	
Lead, dissolved	7439-92-1	6.50E-03	TVS [g]	
Malathion	121-75-5	1.00E-04	AL	1.00E-02
Mercury, total	7439-97-6	1.00E-05	SS	1.00E-03
Methoxychlor	72-43-5	3.00E-05	AL	1.80E-03
4,4-Methylene bis (N,N'-dimethyl)aniline	101-61-1	7.60E-04	WS	1.00E-02
Methylene chloride [Dichloromethane]	75-09-2	4.60E-03	W+F	
Mirex	2385-85-5	1.00E-06	AL	1.00E-02
Naphthalene	91-20-3	1.40E-01	W+F, WS	
Nickel, dissolved	7440-02-0	1.23E-01	TVS [g]	
Nitrate [i]	14797-55-8	1.00E+01	AG, SS	
Nitrite [i]	14797-65-0	5.00E-01	AL, SS	
Nitrobenzene	98-95-3	1.40E-2	W+F, WS	
Nitrophenol 4	100-02-7	5.60E-02	WS, W+F	
Nitrosodibutylamine N	924-16-3	4.30E-06	W+F	1.00E-02
N-Nitrosodiethanolamine	1116-54-7	1.30E-05	WS	1.00E-02
Nitrosodiethylamine N	55-18-5	2.30E-07	W+F, WS	1.00E-02
Nitrosodimethylamine N	62-75-9	6.90E-07	W+F, WS	2.00E-02
n-Nitrosodiphenylamine	86-30-6	3.30E-03	W+F	1.00E-02
n-Nitrosodipropylamine	621-64-7	5.00E-06	W+F, WS	1.00E-02
N-Nitroso-N-methylethylamine	10595-95-6	1.60E-06	WS	1.00E-02
Nitrosopyrrolidine N	930-55-2	1.60E-05	W+F	4.00E-02
Oxamyl(vydate)	23135-22-0	2.00E-01	WS	
PCBs	1336-36-3	6.40E-08	W+F [j]	5.00E-04
Parathion	56-38-2	1.30E-05	AL	1.00E-02
Pentachlorobenzene	608-93-5	1.40E-03	W+F	1.00E-02
Pentachlorophenol	87-86-5	8.00E-5	W+F	5.00E-02
Phenol	108-95-2	2.10E+00	W+F, WS	
Picloram	1918-02-1	4.90E-01	WS	
Propylene oxide	75-56-9	1.50E-04	WS	1.00E-02
Pyrene	129-00-0	2.10E-01	W+F, WS	

Table 1 (continued). Surface Water Standards

Analyte	CAS Reference Number	Standards [a] (mg/L)	Basis [b]	PQLs [d] (mg/L)
Quinoline	91-22-5	1.20E-05	WS	
Selenium	7782-49-2	4.60E-03	AL	
Silver, dissolved	7440-22-4	6.00E-04	TVS [g]	1.00E-03
Simazine	122-34-9	4.00E-03	WS	
Sulfide	18496-25-8	2.00E-03	SS	
Styrene	100-42-5	1.00E-01	WS	
1,2,4,5-Tetrachlorobenzene	95-94-3	9.70E-04	W+F	1.00E-03
1,1,2,2-Tetrachloroethane	79-34-5	1.70E-04	W+F	1.00E-03
Tetrachloroethene	127-18-4	5.00E-3	W+F, WS	
Toluene	108-88-3	1.00E+00	W+F, WS	
Toxaphene	8001-35-2	2.00E-07	AL	2.50E-03
Tributyltin (TBT)	56573-85-4	7.20E-05	AL	1.00E-02
1,2,4-Trichlorobenzene	120-82-1	3.50E-02	W+F	
1,1,1-Trichloroethane	71-55-6	2.00E-01	WS	
1,1,2-Trichloroethane	79-00-5	2.70E-03	W+F	
Trichloroethene	79-01-6	2.50E-03	W+F	
2,4,6-Trichlorophenol	88-06-2	1.40E-03	W+F	1.00E-02
Trichlorophenol 2,4,5	95-95-4	7.00E-01	WS, W+F	
Trichlorophenoxyproprionic acid	93-72-1	5.00E-02	WS	
Vinyl chloride	75-01-4	2.30E-05	W+F	2.00E-04
Xylene (total)	1330-20-7	1.00E+01	WS	
Zinc, dissolved	7440-66-6	1.41E-01	TVS [g]	
PHYSICAL PARAMETERS:				
Dissolved oxygen (minimum)		5.0 mg/L	SS	
pH		6.5-9.0	SS	
RADIONUCLIDES [l]				
Americium 241	14596-10-2	0.15 (pCi/L)	BS	
Plutonium 239/240	10-12-8	0.15 (pCi/L)	BS	
Radium 226/228		5 (pCi/L) [k]	BS	
Strontium 89/90	11-10-9	8 (pCi/L)	BS	
Tritium	10028-17-8	500 (pCi/L)	SS	
Uranium, total	7440-61-1	16.8 (µg/L)	SS	

NOTES:

[a] The values in this table reflect the promulgated Colorado WQCC classifications and standards. If relevant, effective date information is included in subsequent footnotes. Standards for chloride, dissolved iron, dissolved manganese, and sulfate are Secondary Drinking Water Standards, which are based on aesthetic considerations. They have been removed as site-specific standards since Segments 4a, 4b, and 5 waters will not be used for drinking water supply.

[b] Acronyms: AG = Agriculture; AL = Aquatic Life; BS = Basic Standard; SS = Site Specific Standard; TVS = Table Value Standard; WS = Water Supply; W+F = Water plus Fish

[c] Reserved.

[d] Whenever the practical quantitation level (PQL) for a pollutant is higher (less stringent) than a standard or temporary modification, "less than" the PQL will be used as the compliance threshold.

[e] Applies to Segment 4a.

[f] Per the Basic Standards, the Total Trihalomethane (TTHM) standard applies to the sum of the four TTHM compounds. For dibromochloromethane the TTHM value for water supply, 80 parts per billion, was applied.

[g] Table value standards for metals are based on a toxicity equation which uses a hardness value of 143 mg/L.

Table 1 (continued). Surface Water Standards

[h] Reserved.

[i] The listed nitrite value is the chronic aquatic life standard based on chloride levels in excess of 22 mg/L in Segment 4. Nitrate and nitrite standards are as nitrogen.

[j] The total PCB standard in the Basic Standards is based on the sum of the Aroclor analytes.

[k] Per the basic standard, this value applies to the sum of the two radium isotopes.

[l] Radionuclides are measured in activity per volume units except for uranium, which is measured as a metal parameter in mass per volume units.

[m] Reserved.

[n] The second number in the range for arsenic and 1,2-Dichloroethene (cis) is applied as the corresponding or applicable Table 1 standard in the flowcharts in Figures 7 through11.

The scientific notation used in this table indicates the power of ten by which the two-decimal-place number is multiplied (e.g., 2.52E-02 = 2.52 X 10-2 = 0.0252).

Table 2. Water Monitoring Locations and Sampling Criteria

General Objective	Classification	Media	Location ID (1)	Location Description	Frequency	Analytes (4)
Points of Compliance (POCs)						
	POC (5)	SW	WALPOC	Walnut Creek near COU Boundary	Flow-paced (varies)	Pu, Am, U, nitrate, flow rate
	POC (5)	SW	WOMPOC	Woman Creek near COU Boundary	Flow-paced (varies)	Pu, Am, U, flow rate
	POC (5)	SW	GS01	Woman Creek at Indiana Street	Flow-paced (varies)	Pu, Am, U, flow rate
	POC (5)	SW	GS03	Walnut Creek at Indiana Street	Flow-paced (varies)	Pu, Am, U, nitrate (only when water flowing from upstream terminal pond), flow rate
Points of Evaluation (POEs)						
	POE (6)	SW	GS10	S. Walnut Creek at B-Series Bypass	Flow-paced (varies)	Pu, Am, U, dissolved Ag and Cd, total Be and Cr, flow rate
	POE (6)	SW	SW027	SID at Pond C-2	Flow-paced (varies)	Pu, Am,U, dissolved Ag and Cd, total Be and Cr, flow rate
	POE (6)	SW	SW093	N. Walnut Creek at end of FC-3	Flow-paced (varies)	Pu, Am, U, dissolved Ag and Cd, total Be and Cr, flow rate
Present Landfill (PLF) Area (2)						
	RCRA (10)	GW	70193	Upgradient	Quarterly	VOCs, metals
	RCRA (10)	GW	70393	Upgradient	Quarterly	VOCs, metals
	RCRA (10)	GW	70693	Upgradient	Quarterly	VOCs, metals
	RCRA (10)	GW	73005	Downgradient	Quarterly	VOCs, metals
	RCRA (10)	GW	73105	Downgradient	Quarterly	VOCs, metals
	RCRA (10)	GW	73205	Downgradient	Quarterly	VOCs, metals
	AOC (7)	GW	4087	Below East Landfill Pond	Semiannual	VOCs, U*, nitrate
	AOC (7)	GW	B206989	Below East Landfill Pond	Semiannual	VOCs, U*, nitrate
	Treatment System (11)	GW	PLFSEEPINF	Seep influent to treatment system	Quarterly	VOCs,U*, metals, instantaneous flow rate
	Treatment System (11)	GW	GWISINFNORTH	North GWIS influent to treatment system	Discontinued	VOCs, U*, metals, nitrate
	Treatment System (11)	GW	GWISINFSOUTH	South GWIS influent to treatment system	Discontinued	VOCs, U*, metals, nitrate
	Treatment System (11)	SW	PLFSYSEFF	Treatment system effluent	Quarterly; Monthly (if required by decision)	VOCs, SVOCs, U, metals
	Treatment System (11)	SW	NNG01	East of PLFSYSEFF	As required by decision rule	As required by decision rule
Original Landfill (OLF) Area (3)						
	RCRA (10)	GW	P416589	Upgradient	Quarterly	VOCs, metals, SVOCs
	RCRA (10)	GW	80005	Downgradient	Quarterly	VOCs, metals, SVOCs
	RCRA (10)	GW	80105	Downgradient	Quarterly	VOCs, metals, SVOCs
	RCRA (10)	GW	80205	Downgradient	Quarterly	VOCs, metals, SVOCs
	AOC (7)	GW	11104	Downgradient, downstream	Semiannual	VOCs, U*
	OLF SW (12)	SW	GS05	Woman Creek at west property line (upstream)	Quarterly; Monthly (if required by decision)	VOCs, U, metals
	OLF SW (12)	SW	GS59	Woman Creek 700 feet east of OLF (downstream)	Quarterly; Monthly (if required by decision)	VOCs, U, metals

Table 2 (continued). Water Monitoring Locations and Sampling Criteria

General Objective	Classification	Media	Location ID (1)	Location Description	Frequency	Analytes (4)
Mound Site Plume and Treatment System (MSPTS)						
	Evaluation (9)	GW	00897	Source area	Biennial	VOCs
	Sentinel (8)	GW	15699	Downgradient of intercept trench	Semiannual	VOCs
	Treatment System (11)	GW	MOUND R1-0	Treatment system influent	Semiannual	VOCs
	Treatment System (11)	GW	MOUND R2-E	Treatment system effluent	Semiannual	VOCs
	Treatment System (11)	SW	GS10	S. Walnut Creek at B-Series Bypass	Semiannual	VOCs
East Trenches Plume and Treatment System (ETPTS)						
	Evaluation (9)	GW	3687	Source area	Biennial	VOCs
	Evaluation (9)	GW	05691	Source area	Biennial	VOCs
	Evaluation (9)	GW	03991	East of source area	Biennial	VOCs
	Sentinel (8)	GW	04091	East of source area	Semiannual	VOCs
	Sentinel (8)	GW	95299	Downgradient of intercept trench	Semiannual	VOCs
	Sentinel (8)	GW	95199	Downgradient of intercept trench	Semiannual	VOCs
	Sentinel (8)	GW	95099	Downgradient of intercept trench	Semiannual	VOCs
	Sentinel (8)	GW	23296	Downgradient of intercept trench	Semiannual	VOCs, U*
	Treatment System (11)	GW	ET INFLUENT	Treatment system influent	Semiannual	VOCs
	Treatment System (11)	GW	ET EFFLUENT	Treatment system effluent	Semiannual	VOCs
	Treatment System (11)	SW	POM2	S. Walnut Creek downstream of treatment system	Semiannual	VOCs
Solar Ponds Plume and Treatment System (SPPTS)						
	Evaluation (9)	GW	P210189	VOC plume source area	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	79102	SPP source area - north	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	79202	SPP source area - north	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	P208989	SPP source area - north	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	79302	SPP source area - northeast	Biennial	U*, nitrate
	Evaluation (9)	GW	79402	SPP source area - northeast	Biennial	U*, nitrate
	Evaluation (9)	GW	79502	SPP source area - east	Biennial	U*, nitrate
	Evaluation (9)	GW	79605	SPP source area - east	Biennial	U*, nitrate
	Evaluation (9)	GW	00203	SPP source area - south	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	22205	SPP downgradient plume - north	Biennial	VOCs, U*, nitrate
	Sentinel (8)	GW	P210089	SPP downgradient plume - north	Semiannual	VOCs, U*, nitrate
	Sentinel (8)	GW	70099	Northwest of system	Semiannual	U*, nitrate
	Treatment System (11)	GW	SPIN	Treatment system influent	Semiannual	U*, nitrate
	Treatment System (11)	GW	SPOUT	Treatment system effluent	Semiannual	U*, nitrate
	Treatment System (11)	SW	GS13	N. Walnut Creek at A-Series Bypass	Semiannual	U*, nitrate
	Evaluation (9)	GW	B210489	Downgradient of treatment system	Biennial	U*, nitrate
	Evaluation (9)	GW	51605	Downgradient, adjacent to GS13	Biennial	U*, nitrate

Table 2 (continued). Water Monitoring Locations and Sampling Criteria

Other Areas of Interest						
Drainages Below Impacted Areas	AOC (7)	GW	10594	N. Walnut Creek downstream of GS13	Semiannual	VOCs, U*, nitrate
	AOC (7)	GW	00997	S. Walnut Creek upstream of Pond B-5	Semiannual	VOCs, U*, nitrate
	AOC (7)	GW	00193	Woman Creek upstream of Pond C-2	Semiannual	VOCs, U*
Former Building 371/374	Sentinel (8)	GW	37505	North part of former B371 area	Semiannual	VOCs, U*, nitrate
	Sentinel (8)	GW	37405	North/northeast part of former B371/374 area	Semiannual	VOCs, U*, nitrate, Pu*, Am*
	Sentinel (8)	GW	37705	East/southeast of former B371/374 area at foundation drain confluence	Semiannual	VOCs, U*, nitrate, Pu*, Am*
Former Building 771/774	Sentinel (8)	GW	20705	North/northwest of former B771 area	Semiannual	VOCs, U*, nitrate, Pu*, Am*
	Sentinel (8)	GW	20505	North of former B771/774 area	Semiannual	VOCs, U*, Pu*, Am*
	Sentinel (8)	GW	20205	North/northeast of former B771/774 area	Semiannual	VOCs, U*, Pu*, Am*
Former North-Central IA	Evaluation (9)	GW	P114689	Southwest of former B559 area	Biennial	VOCs
	Evaluation (9)	GW	P115589	West part of former B551 Warehouse area	Biennial	VOCs
	Evaluation (9)	GW	70705	East part of former B707 area	Biennial	VOCs, U*
	Evaluation (9)	GW	33905	North of former 231 Tanks area	Biennial	VOCs
	Evaluation (9)	GW	21505	West of former B776/777 area	Biennial	VOCs
	Sentinel (8)	GW	52505	West of former IHSS 118.1 area	Semiannual	VOCs
	Evaluation (9)	GW	20902	Northwest of former IHSS 118.1	Biennial	VOCs
	AOC (7)	GW	42505	Terminus of FC-2	Semiannual	VOCs
Former Building 559	Evaluation (9)	GW	55905	North part of former B559 area	Biennial	VOCs, U*, nitrate
	Evaluation (9)	GW	56305	West part of former B559 area	Biennial	VOCs, U*, nitrate
Former IHSS 118.1	Evaluation (9)	GW	18199	North of former IHSS 118.1 area	Biennial	VOCs
	SW Performance [SW018	SW	SW018	Upstream of FC-2 wetland	Semiannual	VOCs
Former Building 444 Complex	Evaluation (9)	GW	40005	West part of former B444 area	Biennial	VOCs, U*
	Evaluation (9)	GW	40205	South part of former B444 end	Biennial	VOCs, U*
	Evaluation (9)	GW	P419689	Southeast of former B444 area	Biennial	VOCs, U*
	Sentinel (8)	GW	40305	East part of former B444 area	Semiannual	VOCs, U*
	Evaluation (9)	GW	P416889	Southeast of former B444 area	Biennial	VOCs, U*
	Sentinel (8)	GW	11502	Southeast of former B444 area	Semiannual	VOCs, U*
Former Building 881	Evaluation (9)	GW	88205	South part of former B881 area	Biennial	VOCs, U*
	Sentinel (8)	GW	88104	South part of former B881 area	Semiannual	VOCs, U*
	Sentinel (8)	GW	00797	South of former B881 area	Semiannual	VOCs, U*
Former Building 886	Evaluation (9)	GW	22996	East/northeast part of former B886 area	Biennial	VOCs, U*
Former Building 991	Sentinel (8)	GW	99305	East part of former B991 area	Semiannual	VOCs, U*, nitrate
	Sentinel (8)	GW	99405	Southeast part of former B991 area	Semiannual	VOCs, U*, nitrate
	Sentinel (8)	GW	91305	South of confluence of FC-4 and FC-5	Semiannual	VOCs, U*, nitrate
Former Oil Burn Pit No. 1	Evaluation (9)	GW	33502	Source area	Biennial	VOCs
	Evaluation (9)	GW	33604	Source area	Biennial	VOCs
	Sentinel (8)	GW	33711	Downgradient of source area	Semiannual	VOCs
Former Oil Burn Pit No. 2	Evaluation (9)	GW	91105	Source area	Biennial	VOCs
	Sentinel (8)	GW	91203	Downgradient of source area	Semiannual	VOCs
Former SW056	Sentinel (8)	GW	45608	Adjacent to French drain remnants and drain interruption	Semiannual	VOCs
OU1 Plume	Evaluation (9)	GW	891WEL	Source area	Biennial	VOCs
	AOC (7)	GW	89104	Downgradient at Woman Creek	Semiannual	VOCs
903 Pad/Ryan's Pit Plume	Evaluation (9)	GW	00191	East of former 903 Pad area	Biennial	VOCs
	Evaluation (9)	GW	50299	East of former 903 Pad area	Biennial	VOCs
	Evaluation (9)	GW	90402	Southeast of former 903 Pad area	Biennial	VOCs
	Evaluation (9)	GW	00491	Southeast of former 903 Pad area	Biennial	VOCs
	Evaluation (9)	GW	07391	Ryan's Pit source area	Biennial	VOCs, U*
	Evaluation (9)	GW	90804	Southeast part of 903 Pad/Ryan's Pit Plume	Biennial	VOCs
	Sentinel (8)	GW	90399	Southeast part of 903 Pad/Ryan's Pit Plume at SID	Semiannual	VOCs
	Sentinel (8)	GW	90299	Southeast part of 903 Pad/Ryan's Pit Plume at SID	Semiannual	VOCs
	AOC (7)	GW	10304	Southeast of 903 Pad/Ryan's Pit Plume at Woman Creek	Semiannual	VOCs, U*, nitrate
PU&D Yard Plume	Evaluation (9)	GW	30900	Source area	Biennial	VOCs
	Sentinel (8)	GW	30002	Downgradient at N. Walnut Creek	Semiannual	VOCs

Table 2 (continued). Water Monitoring Locations and Sampling Criteria

General Objective	Classification	Media	Location ID (1)	Location Description	Frequency	Analytes (4)
Pre-discharge						
	Pre-discharge (13)	SW	Pond A-4	A-Series terminal pond on N. Walnut Creek	Prior to routine discharge	Pu, Am, U, nitrate
	Pre-discharge (13)	SW	Pond B-5	B-Series terminal pond on S. Walnut Creek	Prior to routine discharge	Pu, Am, U, nitrate
	Pre-discharge (13)	SW	Pond C-2	C-Series terminal pond in Woman Creek	Prior to routine discharge	Pu, Am, U
Notes					**Acronyms and Abbreviations**	
(1) See Figure 1 for monitoring locations					Ag: silver	
(2) Laboratory analytes are limited to those listed in Appendix C of the Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan					Am: americium-241	
(3) Laboratory analytes are limited to those listed in Appendix C of the Landfill Monitoring and Maintenance Plan, RFETS Original Landfill					AOC: Area of Concern	
(4) Analysis and evaluation for metals and VOCs will be performed for some or all of the analytes listed in Table 1					B (followed by numerals): Building (e.g., B371)	
(5) Results for POCs are evaluated using Figure 5. POCs GS01 and GS03 will be replaced by WALPOC and WOMPOC per Section 5.1					Be: beryllium	
(6) Results from POEs are evaluated using Figure 6.					Cd: cadmium	
(7) Results from AOC and SW018 are evaluated using Figure 7.					Cr: chromium	
(8) Results from Sentinel wells are evaluated using Figure 8.					FC: Functional Channel (e.g., FC-2)	
(9) Results from Evaluation wells are evaluated using Figure 9.					GW: groundwater	
(10) Results from RCRA wells are evaluated using Figure 10.					IA: Industrial Area	
(11) Results from Treatment System locations are evaluated using Figure 11. GWISINFNORTH and GWISINFSOUTH may be used for investigative purposes.					N/A: not applicable	
(12) Results from OLF SW locations are evaluated using Figure 12.					OLF: Original Landfill	
(13) Results from Predischarge locations are evaluated using Figure 13.					OU1: Operable Unit 1	
					PLF: Present Landfill	
					POC: Point of Compliance	
* Samples of groundwater collected for U, Pu and Am analysis will be filtered in the field using a 0.45 um in-line filter.					POE: Point of Evaluation	
					PU&D: Property Utilization and Disposal	
					Pu: plutonium-239,240	
					RCRA: Resource Conservation and Recovery Act	
					SID: South Interceptor Ditch	
					SPP: Solar Ponds Plume	
					SVOCs: semi-volatile organic compounds	
					SW: surface water	
					U: uranium	
					VOCs: volatile organic compounds	

Table 3. Present and Original Landfill Inspection and Maintenance Requirements

Present Landfill

Requirement	Description of activity	Frequency	Documentation/Reporting	Exit strategy
Final cover inspection and monitoring	- inspect/monitor slope stability, soil cover - visually inspect surface of landfill cover for cracks, depressions, heaving, and sinkholes - monitor settlement monuments and side slope stability monuments	- quarterly (settlement and stability monuments annually); evaluate frequency during CERCLA periodic review - additional weather-related inspections within 2 days after storm event of one inch or more of rain in a 24-hour period or significant melt of 10-inch or more snowstorm	- conditions affecting effectiveness of landfill cover to be reported per note 1 below - document on inspection checklist; submit to parties within one month of inspection; include in quarterly and annual reports	Consultative process or periodic CERCLA review
Inspection and monitoring of stormwater management system and erosion control features	- Visually inspect stormwater management structures (channels/lining, culverts, and outfalls); erosion control features (perimeter channels and natural drainages); and seep treatment system	- monthly for first year; evaluate frequency during CERCLA periodic review - additional weather-related inspections within 2 days after a storm event of one inch or more of rain in a 24-hour period or significant melt of a 10-inch or more snowstorm	- conditions affecting effectiveness of landfill cover to be reported per note 1 below - document on inspection checklist; submit to parties within one month of inspection; include in quarterly and annual reports	Consultative process or periodic CERCLA review
GW monitoring	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10
Landfill seep and downstream monitoring	Included in Table 2, Figure 1, and Figure 11	Included in Table 2, Figure 1, and Figure 11	Included in Table 2, Figure 1, and Figure 11	Included in Table 2, Figure 1, and Figure 11
Maintenance and repairs	Perform minor or major repairs as needed; for major damage or repairs, consult with parties and develop appropriate actions for approval by CDPHE	- as needed	- minor/routine repairs and maintenance report on inspection form - conditions affecting effectiveness of landfill cover to be reported per note 1 below	Consultative process or periodic CERCLA review
Institutional and physical controls	Fence around perimeter of Central OU, signs at entry points to Central OU, warning signs in accordance with 6 CCR 1007-3 Part 265.14		- failure of physical controls to be reported per note 1 below - failure of institutional controls to be per note 2 below	Consultative process or periodic CERCLA review

Table 3 (continued). Present and Original Landfill Inspection and Maintenance Requirements

Original Landfill

Requirement	Description of activity	Frequency	Documentation/Reporting	Exit strategy
Final cover inspection and monitoring	- inspect/monitor slope stability and soil cover - visually inspect surface of landfill cover for cracks, depressions, heaving, sinkholes; visually inspect diversion berms; measure height and gradient if indicated (employ inclinometer monitoring results and topographic surveys as described in OLF M&M Plan.) - monitor settlement monuments	- Monthly, until CDPHE approves Quarterly frequency; topographic survey every other year; evaluate frequency during CERCLA periodic review. - Additional weather-related monitoring within 2 days after a storm event of one inch or more or rain in a 24-hour period or significant melt of a 10-inch or more snowstorm - Quarterly until CDPHE approves annual frequency.	- conditions affecting effectiveness of landfill cover to be reported per note 1 below - document on inspection checklist; submit to parties within one month of inspection; include in quarterly and annual reports	Consultative process or periodic CERCLA review
Inspection and monitoring of stormwater management system, seeps, and erosion controls	- Visually inspect/monitor stormwater management structures, seeps, and erosion controls	- Monthly, until CDPHE approves Quarterly, Semi-annual or Annual frequency; evaluate frequency during CERCLA periodic review - Additional weather-related inspections within 2 days after a storm event of one inch or more of rain in a 24-hour period or significant melt of a 10-inch or more snowstorm	- conditions affecting effectiveness of landfill cover to be reported per note 1 below - document on inspection checklist; submit to parties within one month of inspection; include in quarterly and annual reports	Consultative process or periodic CERCLA review
GW monitoring	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10	Included in Table 2, Figure 1, and Figure 10
SW monitoring	Included in Table 2, Figure 1, and Figure 12	Included in Table 2, Figure 1, and Figure 12	Included in Table 2, Figure 1, and Figure 12	Included in Table 2, Figure 1, and Figure 12
Maintenance and repairs	- Perform minor or major repairs and maintenance - For major damage or repairs, consult with parties and develop appropriate actions for approval by CDPHE	- as needed	- minor/routine repairs and maintenance, report on inspection form - conditions affecting effectiveness of landfill cover to be reported per note 1 below	Consultative process or periodic CERCLA review
Institutional and physical controls	- inspection for evidence that institutional controls were violated or physical controls damaged	- document on inspection forms	- failure of physical controls to be reported per note 1 below - failure of institutional controls to be reported per note 2 below	Consultative process or periodic CERCLA review

Table 3 (continued). Present and Original Landfill Inspection and Maintenance Requirements

Note 1: For reportable conditions as defined in RFLMA Attachment 2, Section 6.0 (except in the case of failure of institutional controls), DOE will inform CDPHE and EPA within 15 days of receiving the inspection reports or validated data. Evaluation and planning for mitigating actions, if any, will be prepared and submitted as defined in RFLMA, Attachment 2, Section 6.0.

Note 2: In case of failure of institutional controls, DOE will notify EPA and CDPHE within 2 days of discovering evidence and will perform evaluation, consultation, and actions as defined in RFLMA, Attachment 2, Section 6.0.

Table 4. Institutional Controls for the Central Operable Unit

Controls	Use Restrictions
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.
	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.
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 Comprehensive Risk Assessment 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.
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 disturbance 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 Remedial Investigation 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.
4	Surface water may not be used for drinking water or agricultural purposes.
	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.
5	The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.
	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.
6	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.
	Objective: Ensure the continued proper functioning of the landfill covers. **Rationale:** This restriction helps ensure the integrity of the landfill covers.
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. 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.

WRW = Wildlife Refuge Worker.
MCL = maximum contaminant level.