LMS/RFS/S07121

Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats, Colorado, Site

Calendar Year 2010

April 2011

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Available on DVD:

Ecology DVD: 2010 Annual RFS Ecology Reports

Abbreviations

Ag	silver
Am	americium
ANOVA	Analysis of Variance
AOC	Area of Concern
B	boron
Be	beryllium
BMP	best management practice
CAD/ROD	Corrective Action Decision/Record of Decision
Cd	cadmium
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (also known as "Superfund")
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CNHP	Colorado Natural Heritage Program
COU	Central Operable Unit
Cr	chromium
CY	calendar year
D&D	decontamination and decommissioning
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DER	duplicate error ratio
DG	Discharge Gallery
DOE	U.S. Department of Energy
DQA	data quality assessment
EPA	U.S. Environmental Protection Agency
ERP	*Emergency Response Plan for Rocky Flats Site Dams*
ESL	Environmental Sciences Laboratory
ETPTS	East Trenches Plume Treatment System
FC	Functional Channel
FR	*Federal Register*
ft/yr	feet per year
g	gram
GIS	Geographic Information System
gpm	gallons per minute
GWIS	Groundwater Intercept System
HR ICP/MS	high-resolution inductively coupled plasma/mass spectrometry
HRC	Hydrogen Release Compound
HRT	hydraulic residence time
IA	Industrial Area
IC	institutional control
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
ITPH	Interceptor Trench Pump House
ITS	Interceptor Trench System
K-H	Kaiser-Hill Company, LLC

L	liter
LCS	laboratory control sample
LM	Office of Legacy Management
M&M	monitoring and maintenance
m^3	cubic meter
MCL	maximum contaminant level
MDA	minimum detectable activity
M-K	Mann-Kendall
µg	microgram
µg/L	micrograms per liter
mg/L	milligrams per liter
mL	milliliter
MS	matrix spike
MSD	matrix spike duplicate
MSPTS	Mound Site Plume Treatment System
NA	not applicable
NOID	Notice of Intent to Delete
NPL	National Priorities List
NWTC	National Wind Technology Center
OBP	Oil Burn Pit
OLF	Original Landfill
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCE	tetrachloroethene
pCi	picocurie
pCi/L	picocuries per liter
pCi/µg	picocuries per microgram
PIP	Public Involvement Plan
PLF	Present Landfill
PLFTS	Present Landfill Treatment System
POC	Point of Compliance
POE	Point of Evaluation
POU	Peripheral Operable Unit
PQL	practical quantitation limit
Pu	plutonium
PU&D	Property Utilization and Disposal
PVC	polyvinyl chloride
PZ	piezometer
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFCA	*Rocky Flats Cleanup Agreement*
RFETS	Rocky Flats Environmental Technology Site
RFLMA	*Rocky Flats Legacy Management Agreement*
RFSOG	*Rocky Flats Site Operations Guide*
RI/FS	Remedial Investigation/Feasibility Study
RMRS	Rocky Mountain Remediation Services
RPD	relative percent difference

RPS	Responsive Pre-Hearing Statement
Se	selenium
SED	Sitewide Ecological Database
SEEPro	Site Environmental Evaluation for Projects
SEP	Solar Evaporation Pond
SID	South Interceptor Ditch
S-K	Seasonal-Kendall
SPP	Solar Ponds Plume
SPPTS	Solar Ponds Plume Treatment System
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TCA	trichloroethane
TCB	trichlorobenzene
TCE	trichloroethene
TIMS	thermal ionization mass spectrometry
TM	temporary modification
TSS	total suspended solids
U	uranium
UHSU	upper hydrostratigraphic unit
USFWS	U.S. Fish and Wildlife Service
V&V	validation and verification
VC	vinyl chloride
VOC	volatile organic compound
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division
WQP	water quality parameter
WWTP	Wastewater Treatment Plant
yr	year
ZVI	zero-valent iron

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Executive Summary

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for implementing the final response action selected in the *Final Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (CAD/ROD) issued September 29, 2006, for the Rocky Flats Site (Site).

Under the CAD/ROD, two Operable Units (OUs) were established within the boundaries of the Rocky Flats property: the Peripheral OU (POU) and the Central OU (COU). The COU consolidates all areas of the Site that require additional remedial or corrective actions while also considering practicalities of future land management. The POU includes the remaining, generally unimpacted portions of the Site and surrounds the COU. The response action in the Final CAD/ROD is no action for the POU and institutional and physical controls with continued monitoring for the COU. The CAD/ROD determined that conditions in the POU were suitable for unrestricted use. The U.S. Environmental Protection Agency (EPA) subsequently published a Notice of Partial Deletion from the National Priorities List for the POU on May 25, 2007.

DOE, EPA, and the Colorado Department of Public Health and Environment (CDPHE) have chosen to implement the monitoring and maintenance requirements of the CAD/ROD under, and as described in, the *Rocky Flats Legacy Management Agreement* (RFLMA), executed March 14, 2007. RFLMA Attachment 2 defines the COU remedy surveillance and maintenance requirements. The requirements include environmental monitoring; maintenance of the erosion controls, access controls (signs), landfill covers, and groundwater treatment systems; and operation of the groundwater treatment systems.

LM prepared the *Rocky Flats Site Operations Guide* to serve as the primary internal document to guide work performed to satisfy the requirements of RFLMA and implement best management practices at the Site.

This report addresses all surveillance and maintenance activities conducted at the Site during Calendar Year (CY) 2010 (January 1 through December 31, 2010). Highlights of the surveillance and maintenance activities are as follows:

- RFLMA references the use of contact records to document CDPHE approvals of field modifications to implement approved response actions. RFLMA Attachment 2 references the use of contact records to document the outcome of consultation related to addressing any reportable conditions. This report discusses RFLMA contact records issued in 2010 and the contact record status as of December 31, 2010.
- Monitoring of the Original Landfill (OLF) inclinometers installed in 2008 showed deflection, indicating localized movement, and minor localized surface cracking was also observed. The inclinometers were installed as part of the geotechnical investigation to address localized slumping and settling of the OLF cover observed in 2007. The annual report includes a review of the data by a qualified geotechnical engineer. The data review concluded that the observed conditions are consistent with the geotechnical investigation findings. Continued monitoring and routine maintenance are presently considered adequate to address any observed surface cracking resulting from minor slumping due to observed localized movement.

- A geotechnical evaluation of the impact on berm stability from runoff from OLF Seep 7 due to heavy spring precipitation was completed in the fourth quarter of 2010. The evaluation concluded the saturation from runoff did not adversely impact the berm stability.
- The evaluation of data from soil sampling at the OLF during 2010 to provide information in relation to CDPHE's *Termination of Post Closure Care Policy* criteria was completed in the fourth quarter of 2010. The soil sampling provided data for comparison to data from the early 1990's and provided additional data for subsurface soil characterization and risk evaluation under the CDPHE policy criteria. The evaluation concluded the levels and location of contamination do not appear to pose a significant risk and will help inform the next CERCLA 5-year review, scheduled for completion in 2012.
- Proposed modifications to surface water and groundwater monitoring locations specified RFLMA Attachment 2, "Legacy Management Requirements," were released for public review and comment in 2010. The proposed modifications were still under consideration for approval by CDPHE and EPA at the end of 2010.
- Surface-water flow volumes continue to show expected reductions resulting from land configuration changes and removal of impervious surfaces.
- All surface-water Points of Compliance showed acceptable water quality for the entire year.
- Point of Evaluation (POE) location SW027 showed reportable values for Pu-239,240 starting on April 30, 2010. RFLMA Contact Record 2010-06, "Monitoring Results at Surface Water Point of Evaluation (POE) SW027," provides a discussion of the monitoring results and recaps the outcome of the RFLMA Parties' consultation regarding steps to be taken to evaluate the SW027 drainage area. Evaluation has suggested that the reportable values are due to transport of low-level residual contamination in the SW027 drainage. Mitigating actions taken in accordance with Contact Record 2010-06 included installing additional erosion control wattles in locations along the hillside north of the South Interceptor Ditch (SID) and permanent erosion blankets and reseeding three areas in the SID. This work was successfully completed on December 20, 2010. Approximately 2,560 linear feet of Filtrexx wattles and 8,452 square feet of permanent erosion matting were installed.
- All other POEs and all other analytes at SW027 showed acceptable water quality for the entire year.
- The results of statistical evaluations of groundwater quality at the OLF and Present Landfill (PLF) were essentially identical to the results of these evaluations performed in 2009.
- Water monitoring at the Present Landfill Treatment System (PLFTS) during CY 2010 showed no analytes detected above the applicable standards. Consistent with 2009, boron in groundwater samples from one of the downgradient PLF Resource Conservation and Recovery Act (RCRA) wells was both statistically higher in concentration than in upgradient groundwater and on an increasing trend. Regulatory consultation is underway in response to these conditions. Similar regulatory consultation was conducted in 2009.
- Surface-water monitoring for the OLF during CY 2010 showed no analytes detected above the applicable standards. Consistent with 2009, boron in all three downgradient OLF RCRA wells and uranium in one of these wells was determined to be present at statistically higher concentrations than in upgradient groundwater. None of these is on an increasing trend.

Regulatory consultation is underway in response to these conditions. Similar regulatory consultation was conducted in 2009.

- Analytical results for effluent from the Mound Site Plume Treatment System (MSPTS) and East Trenches Plume Treatment System (ETPTS) continued to demonstrate the vast majority of contaminants is removed. However, concentrations of some volatile organic compounds (VOCs) in system effluent exceeded target concentrations. Consultation with the regulators followed and, per the subsequent agreement, additional sampling was conducted. VOCs continued to be present in system effluent at elevated levels, but concentrations decreased downgradient from these treatment systems. Contributing factors included the much higher flow rates and correspondingly lower residence times within the treatment media in 2010. Average flows corresponding to the sample dates in 2010 were approximately 50 percent to 100 percent greater than in 2008 and 2009 at the MSPTS, and 100 percent to 300 percent greater than in 2008 and 2009 at the ETPTS. Planning was underway to replace the media at the MSPTS and design an effluent polishing component.
- Phase II and Phase III upgrades to the Solar Ponds Plume Treatment System (SPPTS) were completed and implemented in May 2009. Optimization of these components and the system as a whole continued through 2010. The Phase I components installed in late 2008 continued to effectively capture and allow treatment of more of the contaminated groundwater that would otherwise discharge untreated to the creek. Concentrations of nitrate and uranium measured at the effluent discharge gallery have sharply decreased since Site closure, while at the surface water performance location, concentrations of nitrate are lower but uranium has increased. Increased sampling of SPPTS and North Walnut Creek locations continued to support various evaluations, including increasing uranium concentrations at this location.
- Groundwater quality and flow at the Site were generally consistent with previous years. Statistical trending calculations indicated numerous significant concentration trends.
- Elevated nitrate concentrations in groundwater that led to the reportable condition at Area of Concern well B206989 (located east of the Landfill Pond dam) in 2007 persisted through 2010. Concentrations were generally consistent with previous data, and statistical trending continues to indicate a decreasing trend in nitrate concentrations that is statistically significant at the 95 percent confidence level. A sample collected in 2010 reported the lowest concentration of nitrate since 2000.
- All RFLMA-required ecological data collection, analysis, and reporting were completed as scheduled.
- Revegetation monitoring data continue to document the establishment of the desirable grassland species at the Site. Several locations met success criteria this year.
- The annual data quality assessment showed that the Site continues to collect high-quality data sufficient for decision making.

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1.0 Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for implementing the final response action selected in the *Final Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (CAD/ROD) (DOE 2006a) issued September 29, 2006, for the Rocky Flats Site (Site). Prior to the CAD/ROD, cleanup and closure activities were completed in accordance with the requirements of the *Rocky Flats Cleanup Agreement* (RFCA) (CDPHE et al. 1996). Under the CAD/ROD, two Operable Units (OUs) were established within the boundaries of the Rocky Flats property: the Peripheral OU (POU) and the Central OU (COU). The COU consolidates all areas of the Site that require additional remedial or corrective actions while also considering practicalities of future land management. The POU includes the remaining, generally unimpacted portions of the Site and surrounds the COU. The response action in the Final CAD/ROD is no action for the POU and institutional and physical controls with continued monitoring for the COU. The Off-Site Areas at Rocky Flats, known as OU 3, were addressed under a separate no-action CAD/ROD dated June 3, 1997.

The CAD/RODs for OU 3 and the POU determined that conditions in those OUs were suitable for unrestricted use. As a result, the U.S. Environmental Protection Agency (EPA) published a Notice of Intent for Partial Deletion (NOID) of the Rocky Flats Site (Plant) from the National Priorities List (NPL) on March 13, 2007 (72 *Federal Register* [FR] 11313, March 13, 2007) to delete the POU and OU 3 from the NPL. The NOID was based on the results of the remedial investigations leading to the CAD/ROD no-action remedies being selected for these OUs. The NOID states that because no hazardous substances occur in the OUs above levels that allow for unlimited use and unrestricted exposure, no 5-year review was required for these OUs. EPA subsequently published a Notice of Partial Deletion from the NPL for the POU and OU 3 on May 25, 2007 (72 FR 29276, May 25, 2007).

On July 12, 2007, most of the property outside the COU was transferred to the U.S. Department of the Interior for establishment of a national wildlife refuge managed by the U.S. Fish and Wildlife Service (USFWS). EPA certified that cleanup and closure of Rocky Flats was complete and that the COU remedy was operating properly and successfully, in accordance with requirements for DOE to transfer land to USFWS for establishing the refuge. DOE retained the COU and is responsible for implementing the CAD/ROD final response action and for ensuring that it remains protective of human health and the environment. The monitoring, surveillance, and maintenance activities for which quarterly, annual, and 5-year review reports are issued are included in the *Rocky Flats Legacy Management Agreement* (RFLMA) (DOE 2007a).

RFLMA, signed March 14, 2007, superseded RFCA. RFLMA is a Federal Facility Agreement and Consent Order under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and the Colorado Hazardous Waste Act, between DOE, EPA Region 8, and the Colorado Department of Public Health and Environment (CDPHE). The purpose of RFLMA is to establish the regulatory framework for Attachment 2, "Legacy Management Requirements."

RFLMA Attachment 2, Section 7.0, requires DOE to provide reports pertaining to the surveillance and maintenance of the remedy prescribed in the CAD/ROD on a calendar quarter and annual basis. The fourth quarterly report information is to be included in the annual report.

RFLMA Attachment 2, Section 7.2, specifies that the annual reports may include a summary for the previous quarter and that the following will be included in annual reports:

- A discussion of surface-water monitoring data;
- A discussion of groundwater monitoring data;
- A discussion of groundwater treatment system monitoring data;
- A discussion of ecological sampling data;
- Adverse biological conditions;
- A summary of actions taken in response to reportable conditions;
- A summary of maintenance and repairs;
- Inspection reports;
- Verification of the Environmental Covenant and evaluation of the effectiveness of institutional controls (ICs);
- The Original Landfill (OLF) Monitoring Report (see Table 3 and Section 6.1 of the *Final Landfill Monitoring and Maintenance Plan, Rocky Flats Environmental Technology Site, Original Landfill* [OLF M&M Plan] [DOE 2009a]);
- The Present Landfill (PLF) Monitoring Report (see Table 3 and Section 6.1 of the *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan, U.S. Department of Energy Rocky Flats Site* (PLF M&M Plan) [DOE 2008a]);
- Assessments of analytical data, including laboratory audits; and
- Other conditions or actions taken that are pertinent to the continued effectiveness of the remedy.

This calendar year (CY) 2010 annual report contains the summary for the fourth quarter of CY 2010.

LM prepared the *Rocky Flats Site Operations Guide* (RFSOG) (DOE 2011a) as a document to guide work at the Site. The RFSOG provides details on the surveillance and maintenance needed to satisfy the requirements of the CAD/ROD as well as best management practices (BMPs) at the Site. As a "desktop procedure," the RFSOG explains how DOE will fulfill its long-term surveillance and maintenance obligations at the Site.

While the specific BMPs are not subject to regulation under RFLMA, this annual report includes a discussion of activities related to implementing BMPs to document the information for future reference and for a perspective of the work conducted over the year.

1.1 Purpose and Scope

The purpose of this report is to inform the regulatory agencies and stakeholders of the surveillance, monitoring, and maintenance activities being conducted at the Site. LM provides periodic communications such as this report and communicates through other means such as Web-based tools and public meetings.

This annual report focuses on routine surveillance, maintenance, and monitoring activities that were conducted during CY 2010 and, as stated previously, also includes information for the fourth quarter of CY 2010. Topics covered include Site operations and maintenance (Section 2.0) and environmental monitoring, including water, air, and ecological monitoring (Section 3.0). Data management, data validation, and an assessment of data quality are also included in Section 3.0. References cited in this report are included in Section 4.0.

Supporting information is provided in a series of appendixes. Appendix A provides the hydrologic data; Appendix B provides the water quality data. The fourth quarter of CY 2010 landfill inspection forms for the PLF and OLF are included in Appendix C. RFLMA and RFSOG data evaluation flowcharts that were used are provided in Appendix D. Appendix E contains the *Technical Memorandum Regarding Instrumentation and Monitoring at the Rocky Flats OLF*. Appendix F presents the *Original Landfill Data Summary and Evaluation Report* regarding the evaluation of data from soil sampling at the OLF during 2010. Appendix G contains the RFLMA contact records issued during CY 2010.

1.2 Background

Surveillance, maintenance, and monitoring activities are conducted according to RFLMA. RFLMA incorporates the following plans:

- The OLF O&M Plan (DOE 2009a); and
- The PLF M&M (DOE 2008a).

RFLMA Attachment 2 stipulates that DOE employ administrative procedures to control activities in accordance with the ICs and to meet quality assurance and quality control program requirements. Other Site procedures are established to guide work and implement BMPs. These procedures are referenced in the RFSOG and include:

- The *Operations and Maintenance Plan for Rocky Flats Surface Water Control Project* (DOE 2010a);
- The *Operations and Maintenance Manual for the Rocky Flats Groundwater Treatment Systems* (DOE 2010b);
- The *Rocky Flats, Colorado, Site Revegetation Plan* (DOE 2009b);
- The *Erosion Control Plan for the Rocky Flats Property Central Operable Unit* (DOE 2007b);
- The *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2009c);
- The *Ecological Monitoring Methods Handbook for the Rocky Flats, Colorado, Site* (DOE 2008b); and
- The *Legacy Management CERCLA Sites Quality Assurance Project Plan* (LMS/PLN/S04353).

1.3 RFLMA Contact Records

This section provides a summary of the status of activities addressed by RFLMA contact records issued during 2010. RFLMA references the use of contact records to document CDPHE oral

approvals of field modifications to implement approved response actions (see RFLMA paragraph 34). RFLMA Attachment 2 also references the use of contact records to document the outcome of consultation related to addressing any reportable conditions (see RFLMA Attachment 2, Section 6.0). Finally, the *Rocky Flats Site Legacy Management Public Involvement Plan* (PIP), in RFLMA Appendix 2, also provides that a contact record of consultative process discussions between the RFLMA parties will be made available to the Rocky Flats Stewardship Council and other interested stakeholders as early in the process as is practicable following signature approval by the parties. The PIP process to make contact records available is implemented by posting contact records on the Rocky Flats public website and by promptly notifying stakeholders (by e-mail) that the contact record is posted.

The RFLMA parties agreed, as documented in RFLMA Contact Record 2007-08, that DOE will document the status of actions or activities in RFLMA contact records from time to time and will include the documentation in RFLMA quarterly and/or annual surveillance and maintenance reports for tracking purposes. The RFLMA parties also agreed that to facilitate the status reporting, contact records should include a short discussion of the anticipated actions or activities to close out the RFLMA contact record. Thus, RFLMA Contact Record 2007-08 and subsequent contact records will include the closeout discussion.

Under certain situations, activities previously approved in a Contact Record that has been closed out will need to be performed. A simple notification and approval process has been developed for these situations, which is documented in RFLMA Contact Record 2009-05. CDPHE may receive notification of and approve the activities over the phone or in person, with e-mail follow-ups. The notification and approval of such work shall be reported in the next RFLMA annual report, in relation to the Contact Record that originally covered the work. This protocol is consistent with RFLMA paragraph 34.

Table 1 lists the RFLMA contact records issued in 2010 and their status at the end of 2010. The table also lists contact records that were issued from 2007 to 2009, which were discussed in the 2009 Annual Report that were not closed by the end of 2009, and indicates their status at the end of 2010. The table also lists e-mail approval of activities previously covered by closed out contact records. Appendix G contains copies of the 2010 contact records.

1.4 RFLMA Modification Requests

A proposed modification to RFLMA Attachment 2 was released by the RFLMA Parties for public review and comment on July 20, 2010. The proposed modification establishes new surface water Point of Compliance (POC) monitoring locations in Walnut Creek and Woman Creek that will replace the existing POCs within the Central Operable Unit (COU) when DOE completes installation of flumes and monitoring equipment at the new POC locations. The proposed modification is discussed in Contact Record 2010-04 in Appendix G.

The public comment period ended on October 19, 2010. Several public meetings with stakeholders to discuss the proposed modification were also held by the RFLMA Parties during the public comment period. At the end of 2010, the RFLMA Parties were continuing to consider the written comments received. Any resulting modification is subject to approval by CDPHE and EPA.

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Table 1. Status of RFLMA Contact Records

Contact Record No.	Purpose	Approval Date	Status as of December 31, 2009
2010-01	Targeted soil sampling at the Original Landfill (OLF) to evaluate residual contamination levels in relation to the Colorado Department of Public Health and Environment's (CDPHE's) August 2008 Policy, *End of Post-Closure Care*	1/20/10	Actions completed—closed
2010-02	Approval of Excavation Greater Than 3 Feet Below Grade to Breach Dams A-3, A-4, B-5, C-2 and the Present Landfill Dam.	4/15/10 Withdrawn 10/15/10	CDPHE withdrew approval to allow for further consideration of concerns raised by communities and for possible clarification of institutional control #2 (regarding soil excavation deeper than 3 feet) before potential reconsideration of the contact record.
2010-03	Non–Rocky Flats Legacy Management Agreement (RFLMA) Surface Water Monitoring Project for North and South Walnut Creeks	3/15/10	Contact record will be closed after completion of the non-RFLMA sampling project described herein. After this Contact Record is closed out, additional non-RFLMA sampling activities may be performed, and CDPHE will be kept apprised of the additional sampling through the consultative process.
2010-04	Rocky Flats Legacy Management Agreement Attachment 2: Modification to Revise Monitoring Points	7/15/10	Contact record will be closed when the RFLMA modification is completed and the as-built drawings are completed for the flume construction work
2010-05	Statistically Higher Concentrations of Analytes in Groundwater Downgradient of the Original Landfill (OLF) and Present Landfill (PLF)	5/10/10	Actions completed—closed
2010-06	Monitoring Results at Surface Water Point of Evaluation (POE) SW027	7/27/10	Actions completed—closed
2010-07	Monitoring Results and Water Treatment at the MSPTS and ETPTS	11/2/10	Actions completed—closed
2009-01	Phase II and III Upgrades to Solar Ponds Plume Treatment System	2/17/09	Construction and post-construction revegetation and erosion controls are in place. Optimization of the upgrades and monitoring is ongoing. Contact record will be closed when testing complete and as-built drawings completed.
	E-mail approval—application of chlorine bleach to address biofouling in Cell 1	3/31/10	Actions completed—closed
2009-02	Excavation by Xcel Energy for Valve Replacement on 12-inch Golden Pipeline	6/29/09	Actions completed—closed in 2009
	E-mail approval—excavation by Xcel to investigate anomaly in pipeline	3/10/10	Actions completed—closed
2008-05	Boron and uranium in groundwater downgradient of the Original Landfill	7/9/08	Actions completed—closed
2008-06	Management of intercepted groundwater during SPPTS repair or maintenance activities	7/9/08	Actions continuing
2007-06	Evaluation of elevated nitrate in groundwater samples from Area of Concern well B206989	10/16/07	Continuing monitoring and evaluation

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2.0 Site Operations and Maintenance

2.1 Annual Site Inspection

Evidence of significant erosion and IC violations must be inspected for annually, in accordance with RFLMA Attachment 2, Sections 5.3.4 and 5.3.6. The 2010 inspection was conducted on March 17, 2010, and reported in the *Rocky Flats Site Quarterly Report of Site Surveillance and Maintenance Activities First Quarter Calendar Year 2010* (DOE 2010c).

The following categories were monitored during the inspection:

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

As part of the IC inspection, the Environmental Covenant's presence in the Administrative Record and in Jefferson County records was verified. This verification is required annually. In addition, physical controls (signs placed along the COU fence) were also inspected.

Marker flags were placed where conditions showed evidence of the three condition categories listed above, to track their location for follow-up by Site subject matter experts. Areas that required evaluation were documented in the Site Observation Log for evaluation and follow up. Several areas with evidence of erosion, possible depressions, or holes were noted, but these imperfections appeared to be minor and of very limited areal extent. Rocky Flats field operations subject matter experts subsequently visited the areas, made minor repairs, collected debris, and determined that there was no significant indication of erosion or exposure of the subsurface.

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

On March 19, 2010, a team member verified that the Environmental Covenant for the COU remains in the administrative record (AR #PD-A-000054) and on file with the Jefferson County land records, which are used by the Planning and Zoning Department.

No adverse biological conditions were noted during the inspection.

2.2 Colorado WQCC Proceedings Related to Rocky Flats

Based on the Colorado Water Quality Control Commission (WQCC) triennial review proceedings for the "Basic Standards and Methodologies for Surface Water," Regulation 31 (Title 5 *Code of Colorado Regulations* 1002-31) (Regulation 31) in 2010, the WQCC revised the Regulation 31 table value for uranium to the hyphenated value of 16.8–30 micrograms per liter (µg/L), effective January 1, 2011. The following footnote in Regulation 31, Section 31.16, Tables, applies to the hyphenated standard:

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

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

RFLMA surface water standards are not currently impacted as a result of the Regulation 31 adoption of the hyphenated standard for uranium.

2.3 Pond Operations

Five constructed ponds collect and manage surface-water runoff at the Site.[1] The ponds are grouped together in series based on the drainage in which they are located, with the A-Series Ponds in North Walnut Creek, the B-Series Ponds in South Walnut Creek, the C-Series Ponds in Woman Creek, and the Landfill Pond in No Name Gulch. Ponds A-4, B-5, and C-2 are referred to as "terminal ponds" because they are the farthest downstream ponds in their respective drainages, and because they are the ponds from which water is discharged off Site. Off-Site discharges of water from the terminal ponds are currently performed using a batch-release method.

During CY 2010, the Site performed three terminal pond discharges (one each at A-4, B-5, and C-2). Pond A-3 was discharged to Pond A-4 periodically during CY 2010 (Table 2). As of December 31, 2010, the Landfill Pond and Ponds A-3, A-4, B-5, and C-2 were holding a total of approximately 15.2 million gallons (15.3 percent of total capacity).

[1] Former Dams A-1, A-2, B-1, B-2, B-3, and B-4 were breached during 2008−2009.

Table 2. CY 2010 Pond Water Discharges and Transfers

Discharge/Transfer	Dates	Volume (million gallons)
Pond A-3 to A-4	1/25–2/4/10	2.36
Pond A-3 to A-4	2/9–2/11/10	0.40
Pond A-3 to A-4	2/23–2/24/10	0.16
Pond A-3 to A-4	3/8–4/6/10	13.8
Pond A-3 to A-4	4/23–4/27/10	6.60
Pond B-5 to South Walnut Creek	4/23–5/16/10	20.8
Pond A-4 to North Walnut Creek	5/1–5/19/10	32.4
Pond A-3 to A-4	5/7–8/11/10	21.6
Pond C-2 to Woman Creek	7/31–8/12/10	6.97
Pond A-3 to A-4	11/30–12/31/10	0.01

As described in Section 3.1.2.11, pre-discharge samples were collected during CY 2010 at Ponds A-4, B-5, and C-2 prior to discharge. All predischarge sample results suggested that released water would meet water quality standards at downstream POCs. Subsequent POC sampling during discharge also indicated acceptable water quality for the discharged water (see Section 3.1.2.1). The valves at Ponds A-4, B-5, and C-2 were all successfully exercised through their full travel at the end of each discharge. The Landfill Pond valve was also periodically exercised during CY 2010; the Landfill Pond is normally operated in a flow-through configuration.

Routine dam inspections, pond-level measurements, and piezometer measurements were performed as scheduled during the year. Annual dam mowing and vegetation removal was completed in September. Semiannual or quarterly (as applicable to specific dams) movement monument surveys and inclinometer readings were also performed as scheduled.

In compliance with the State of Colorado Rules and Regulations for Dam Safety and Dam Construction, a registered professional engineer conducted a formal dam safety inspection for Dams A-3, A-4, B-5, and C-2 and the Present Landfill Dam in September 2010. All inspected dams received a “satisfactory” condition rating and a recommended safe storage level of “full.” Several recommendations to improve dam safety were made:

- Monument and inclinometer data for Dam B-5 continue to indicate that apparent small movement and settling of the dam is occurring; monument and inclinometer monitoring should continue at the increased quarterly frequency;
- Shallow cracks were observed in the crests of A-4 and B-5 that are believed to be shrinkage cracks; these should be monitored for increase in size and vertical displacement;
- Visual inspection of the downstream slopes at A-4, B-5, and C-2 should be made regularly for slumping or bulging;
- One very shallow crack on the north end of the crest of C-2 should be monitored for further changes;
- Rodent activity has increased at A-4, B-5, and C-2; this activity should be monitored closely and controlled if necessary;

- Sediments should be regularly removed from the toe drains at A-3; and
- Spaces between the piezometer/inclinometer pads and the ground surface were noted at some locations; these spaces should be backfilled.

2.4 Landfills

The annual report of the results of inspections, monitoring data, and maintenance activities for the PLF and OLF is provided below.

2.4.1 Present Landfill

The PLF consists of an approximately 22-acre engineered RCRA Subtitle C–compliant cover over a former sanitary and construction debris landfill. A diversion channel surrounds the landfill and diverts storm water runoff away from the landfill to No Name Gulch. The landfill has a passive seep interception and treatment system (the Present Landfill Treatment System [PLFTS]), installed to treat landfill seep water and Groundwater Intercept System (GWIS) water that discharges into the Landfill Pond. A gas extraction system is also built into the landfill and allows subsurface gas to vent to the atmosphere.

Subsidence and consolidation at the PLF is monitored by visually inspecting the surface of the landfill cover for cracks, depressions, heaving, and sinkholes. The landfill final construction site conditions are used as a baseline for comparisons made during Site inspections. In addition to the visual inspection, settlement monuments are used to evaluate the actual settlement at these specific locations compared to the expected settlement calculated in the final design. Nine settlement monuments were installed across the top of the landfill cap, and an additional six monuments are located on the east face of the landfill. The monuments were monitored quarterly for the first year and annually thereafter.

Inspections and monitoring tasks follow the format and protocol established in the PLF M&M Plan and include groundwater and surface-water monitoring, and monitoring subsidence and consolidation, slope stability, soil cover, vegetation, storm water management structures, and erosion in surrounding features so that corrective actions can be taken in a timely manner. Monthly inspections were initiated in October 2005. Quarterly inspections were initiated in the fourth quarter of CY 2007 as described in RFLMA Contact Record 2007-08.

2.4.1.1 Inspection Results

Four inspections were performed at the PLF in CY 2010. The inspection process followed the format and protocol established in the PLF M&M Plan. No significant problems were observed during these inspections. Appendix C contains the landfill inspection forms for the fourth quarter of CY 2010; earlier 2010 inspection forms are included in the applicable quarterly reports.

PLF area surface-water and groundwater monitoring, and operation of the PLFTS, is covered in those respective sections of this report.

2.4.1.2 Slumps

On February 13, 2007, a slump was discovered on the south-facing hillside just east of the PLF. The slump is not on the PLF, and engineering review determined that it does not impact the PLF cover. The slump was likely caused by heavy snow conditions and influenced by the post-closure lower water levels in the Landfill Pond. Therefore, regrading the slump is not necessary; however, deep-rooted plants were planted in the slump area to promote stabilization. There were no significant changes to the slumping area in CY 2010.

2.4.1.3 Settlement Monuments

The annual survey was completed in December 2010. Results of the settlement monument survey indicate that settling at each monument does not exceed expected settlement calculated in the final design and does not trigger any maintenance activity under the PLF M&M Plan.

2.4.2 Original Landfill

The OLF consists of an approximately 20-acre soil cover over a former solid sanitary and construction debris landfill. The final cover consists of a 2-foot-thick Rocky Flats Alluvium soil cover that was constructed over both a regraded surface and a buttress fill, and revegetated. The original surface was regraded to provide a consistent slope. A 20-foot-high, 1,000-foot-long soil mass buttress fill was placed at the toe of the landfill. Erosion is controlled by a series of diversion berms that carry storm water runoff away from the cover to channels on the east and west perimeter of the cover.

The OLF is inspected monthly in accordance with the OLF M&M Plan (DOE 2009a).

2.4.2.1 Inspection Results

Twelve inspections were performed at the OLF in CY 2010. The inspection process followed the format and protocol established in the OLF M&M Plan. Appendix C contains the landfill inspection forms for the fourth quarter of CY 2010; earlier 2010 inspections forms are included in the applicable quarterly reports.

OLF area surface-water and groundwater monitoring is covered in those respective sections of this report.

2.4.2.2 Settlement Monuments

The settlement monuments were surveyed in March, June, September, and December 2010. Survey data indicate that settling at each monument does not exceed expected settling calculated in the final design and does not trigger any maintenance activity under the OLF M&M Plan.

2.4.2.3 Geotechnical Investigation and Repairs

Conditions that warranted further repair and that triggered further investigation were found at the OLF beginning in 2007. This resulted in a geotechnical investigation of the conditions and

repairs and maintenance actions to address conditions. This work is summarized in the RFLMA annual report for 2009 and quarterly reports for 2010 (DOE 2010d, 2010c, 2010e, 2011b)
In 2010 additional maintenance to address cracking in the vicinity of Berm 1 and to recontour the eastern end of Berm 7 where the berm was slumping into the eastern perimeter channel were completed. This work is fully described in the quarterly reports for the second and third quarters of CY 2010. (DOE 2010e, 2011b) Locations are shown on Figure 1.

In addition, a geotechnical evaluation of the impact on berm stability from runoff from Seep 7 due to heavy spring precipitation was completed in the fourth quarter of 2010. The evaluation concluded that the saturation from runoff did not adversely impact berm stability. The geotechnical evaluation in included in the November 2010 OLF Inspection Report, in Appendix C.

Inclinometers

Seven inclinometers were installed in boreholes at the OLF in 2008 as part of the geotechnical investigation (Figure 1).

Movement of the inclinometers has been monitored approximately monthly since installation. During the fourth quarter CY 2010, the inclinometers were monitored on October 28, November 18, and December 13. No noticeable deflection was indicated during the quarter.

Inclinometers deflect based on lateral movement of the ground in which the inclinometer is located and can deflect enough to cause the inclinometer tube to break. Once an inclinometer tube breaks, it will no longer be monitored. Inclinometer monitoring data provide information on localized soil movement and serve to focus periodic inspections of the soil cover surface for signs of potential instability, such as cracking, vertical displacement, and slumping. A deflection of more than 1 inch is used as a trigger for evaluation of the data by a qualified geotechnical engineer. The engineer determines the significance of the deflection in relation to recommendations for maintenance or repairs to address potential instability in accordance with the OLF M&M Plan (DOE 2009a).

During 2010, deflection of inclinometers 83208, 82308, and 82408, which are in the area of localized instability on the western portion of the OLF, triggered a geotechnical evaluation. A qualified geotechnical engineer has evaluated the inclinometer data, and the *Technical Memorandum Regarding Instrumentation and Monitoring at the Rocky Flats OLF* that discusses the evaluation is included as Appendix E.

The conclusion of the evaluation is that recommendations made in the 2008 geotechnical investigation remain valid. The instrumentation indicates that instability is caused by one or more weak layers in the shallow subsurface, and movement is exacerbated by precipitation events and elevated water levels. Slope stability modeling indicates the large-scale, overall slope is stable. However, localized failures have occurred on the OLF under elevated water level conditions, but continued monitoring and maintenance provide an effective course of action.

Figure 1. Original Landfill Observed Surface Cracking Location and Inclinometer Locations

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2.5 Groundwater Plume Treatment Systems Maintenance

The system-specific summaries below focus on the maintenance and operation of the Mound Site Plume Treatment System (MSPTS), the East Trenches Plume Treatment System (ETPTS), and the Solar Ponds Plume Treatment System (SPPTS) during CY 2010. Refer also to previous quarterly reports from 2010 (DOE 2010c, 2010e, 2011b).

Details of the monitoring of the systems, including the PLFTS, are presented in Section 3.1.2.10, and interpretations related to system operation and the corresponding contaminant plumes are provided in Section 3.1.5.3.

2.5.1 Mound Site Plume Treatment System

Routine maintenance activities continued at the MSPTS through CY 2010. The system was initially operating in a series, downflow configuration: all influent water entered Cell 1 at the top and flowed downward through the media to the bottom, where it exited and was routed to the top of Cell 2, where it flowed downward through the media and exited at the bottom. Routine activities under this configuration included weekly raking of the media to break up the surface crust that develops as a result of oxygenated groundwater contacting the native iron of the media. However, the uppermost media in Cell 1 grew increasingly solidified and raking efforts had no effect; in addition, water levels in Cell 1 began to rise, as flow through the increasingly clogged zero-valent iron (ZVI) media was impeded, particularly in Cell 1. This is to be expected: because the system had been run in series (almost exclusively in a downflow direction) for several years, with all water routed through Cell 1 before being routed through Cell 2; the media in Cell 1 had removed the bulk of the dissolved constituents that contribute to media fouling (such as dissolved oxygen, calcium, and carbonate). Water entering Cell 2 had been scrubbed of these constituents, so the ZVI media in that cell was not as clogged.

These clogged conditions led to a change in flow configuration: although still operated in series, Cell 1 was operated in upflow (water entered at the bottom and flowed upward through the media, exiting at the top), and Cell 2 still operated in downflow. Raking the top surface of the media ceased. Later in the year, again in response to rising water levels caused by clogged media, the system was reconfigured from series flow (upflow through Cell 1 and downflow in Cell 2) to parallel upflow for both treatment cells.

Additional routine, weekly activities included water level measurements and inspection of the influent and effluent flow conditions.

The discharge gallery that returns treated effluent to the subsurface clogged several times during CY 2010, requiring manual snaking of the pipes. Re-plumbing of this component is scheduled during the media replacement activity planned for early CY 2011.

To support the planned media replacement, several activities were undertaken. Flow through the system was halted, and the cells were partially dewatered beginning November 8, 2010, to allow for sample collection of the ZVI media for waste characterization purposes. Samples were collected from both cells on November 10. System flows were restored immediately following sample collection. Plumbing in the main instrumentation vault was modified to include an influent line air release and new flow meters.

2.5.2 East Trenches Plume Treatment System

Routine maintenance activities continued at the ETPTS through CY 2010. The flow configuration at this system continued to be parallel upflow (i.e., water is split between each cell, with a portion rising through the media in Cell 1 as the rest rises through the media in Cell 2, and these flows are commingled as they exit the system). This configuration has been in effect since the media replacement in late 2009 was completed and the system was put back online.

Routine weekly maintenance activities include inspection of influent and effluent flow conditions. Rising water levels and uneven flow rates between the cells indicated clogging, which was unexpected given that this media was installed in late CY 2009 (see DOE 2010d for details on the media design and system upgrades). Inspection within the cells indicated the observed conditions were not related to clogging within the media, but rather to biological growth accumulating on the surface of the standing water above the media in each cell. To address this, additional weekly maintenance items were undertaken: the surface of the water in each cell is skimmed to remove accumulations of biomass, the plumbing drain that routes the standing water out of each treatment cell is brushed, and the lines from the tops of each cell are purged. These activities address the biological growth build-up and allow effluent to flow from the cells. These biological growths are probably opportunistically colonizing the interface between the oxygenated air within the top of each treatment cell and the underlying water with its high concentrations of dissolved, reduced iron.

2.5.3 Solar Ponds Plume Treatment System

This section addresses the operation and optimization of the SPPTS. Routine inspections included monitoring water levels, line pressures, power consumption, and flow rates, and cleaning flow meters and lines. For a discussion of treatment system monitoring and performance, refer to Sections 3.1.2.10 and 3.1.5.3.

Due to the wet spring, water levels in the groundwater intercept trench rose, and the influent flow rate, maintained at a relatively even rate for months to support objectives associated with optimization of Phase II and the SPPTS as a whole, were increased. (Refer to Section 3.1.5.3 for a discussion of the results.) Conversely, dry conditions in late 2010 allowed water levels in the trench to be reduced, and in late December, the influent pump automatically shut off due to the low water level. This subsequently caused an automatic shutoff of the pump for Phase III Cells A and B. Incorporation of automated triggers such as these could potentially be vital, as they can prevent unacceptable overflow, equipment failure, or other undesirable effects.

During CY 2010, several maintenance issues were addressed within the original concrete structure (which contains Cell 1 and Cell 2, as well as the overburden covering the media in these treatment cells). These were almost exclusively related to hydraulics within the original treatment cells, Cell 1 and Cell 2.

Cell 1 is filled with a sawdust-based media (90 percent sawdust and 10 percent ZVI) and is designed to treat nitrate. The top of this media is approximately 12 feet below ground surface, and therefore both the media and the associated plumbing are inaccessible. (This is a primary reason for the SPPTS upgrades; refer to previous reports, such as DOE 2007c, 2008c, 2009d, and 2010d, for further information.) Flow through Cell 1 was increasingly impeded, causing water to

back up in the piping and spill out of a weep hole in one of the Cell 1 vents, creating a puddle of water on top of the Cell 1 overburden. This was attributed to excess carbon from Phase III Cell A flowing into the sawdust media and supporting an explosion in the population of the denitrifying bacteria within. To address this situation, a biocide application was tested in April 2010: a dilute bleach solution was applied to Cell 1 through an access point to the associated influent piping located between Phase III and the inlet to Cell 1. While it appeared that the biocide application had indeed killed biomass within the influent distribution piping in Cell 1, it was not successful because the plumbing/media was still clogged. A repeated application with a stronger biocide was considered but was not conducted due to operational, logistical, and safety reasons.

The puddle on the overburden within the original structure persisted throughout the year. Because access to the clogged Cell 1 distribution gallery was not available, an auxiliary distribution gallery was installed. This feature consisted of four steel pipes driven vertically through the overburden and into the Cell 1 media, and which incorporated several feet of slotted pipe in their deepest portions. These were plumbed together and tied into the influent piping. Initially, the water level in the puddle dropped, but within days the puddle was again deepening and it was evident that the auxiliary gallery had clogged. Through the use of standard groundwater techniques, the vertical pipes were redeveloped. This initially led to improved flow through Cell 1 and a reduced puddle size, but within a day or so the pipes clogged again. They were redeveloped again, but quickly became clogged. Additional efforts to optimize flow through Cell 1 were abandoned. The plumbing supporting the auxiliary gallery was later covered by mulch for freeze protection; in addition, this organic material would provide for some additional nitrate treatment.

Finally, in response to finding a dead bird in the puddle over the overburden in the original structure, the opening of the structure was covered with netting intended to prevent wildlife entry.

2.5.3.1 Phase I Operation

Phase I components were operated throughout CY 2010. Routine inspections of these components include monitoring water levels, power usage, effluent flow totals, and details of pump operation. During the fourth quarter, battery power storage issues (related to a combination of extreme cold and cloudy conditions) arose at the Interceptor Trench System Sump (ITSS). Adjustments were made in the ITSS Battery Vault that restored the system to full power. Thenceforth, similar conditions did not cause power issues.

2.5.3.2 Phase II/III Operation and Optimization

This section describes operation and optimization activities of the Phase II and Phase III treatment system components. Routine inspection activities include monitoring water levels, power usage, flow totals, and pumping operations.

Flow rates were a main focal point of optimization efforts conducted throughout the year. Flow rates were adjusted by varying both the control voltage delivered to the pumps installed within the system influent line (denoted as SPIN) and the Metering Vault (which delivers water to Cells A and B), essentially “turning them up” or “turning them down,” and adjusting the valves downstream of those pumps to open or constrict flows.

Phase II: Optimization efforts continued within the Phase II cell during CY 2010 largely in response to the reduced treatment effectiveness (as discussed in Section 3.1.5.3). A tracer test was performed in late 2009 to assess whether the influent water was short-circuiting the ZVI/gravel media, thereby reducing residence time within the treatment media and correspondingly reducing the level of treatment. Due to operational issues (DOE 2010d), the results from that test were inconclusive. In February 2010, a second tracer test was performed; the results of this test indicated there was not significant preferential flow through the media. Samples of the media were then collected using a Geoprobe and analyzed microscopically using a microprobe. Results of this analysis did not indicate the media was overly weathered or clogged.

Alternative approaches to the Phase II question—why had treatment effectiveness been reduced prematurely?—were then developed. A technical team of in-house and external scientists evaluated the problem and recommended the installation of several smaller-sized (e.g., 5-foot-diameter) treatment cells that would be operated in parallel. Each cell would incorporate a slightly different media design, and effluent from each would be carefully monitored so that the exact cause for reduced effectiveness could be determined. However, this would require significant cost, additional construction, and a lengthy period of study.

These combined results led to the Phase II ZVI media replacement in August 2010 to improve uranium treatment. The Phase II treatment cell was dewatered in early August to prepare for media replacement, and in order to bypass the cell, the plumbing was revised to route a portion of SPIN water to Phase III Cells A and B and the balance directly to the original treatment cells (Cell 1 and 2 in the large concrete structure). The media replacement activity entailed excavating the existing ZVI pea gravel mixture and replacing it with new ZVI and pea gravel, but a different ratio of ZVI to gravel was used, and the gravel was quartzitic rather than granitic. After the media was replaced, the plumbing was restored to the former flow configuration (i.e., the configuration in effect prior to the excavation).

Phase III: Throughout CY 2010, Phase III Cell A operation and optimization continued. As discussed at greater length in Section 3.1.5.3, operational parameters that were adjusted included liquid carbon dose rates, phosphorus solution dose rates, influent flow rates, and use of the recirculation pump. These adjustments were timed, and the duration of the changes were planned to allow the weekly to biweekly sample collection to provide analytical feedback on resulting changes in treatment effectiveness.

Cell A optimization of phosphorus dosing was successfully concluded. During the second quarter of 2010, separate phosphorus dosing was discontinued. Instead, from then on the liquid carbon with which the influent to Cell A was dosed was custom-blended to contain the empirically determined ratio of phosphorus.

The recirculation pump in Cell A was turned off during a 4-week period in the third quarter to evaluate its effectiveness. It was determined that this pump was helpful in the treatment of nitrate in this cell.

In November 2010, the inert plastic media clogged with biomass. This caused water within the cell to short-circuit the media, reducing the overall level of nitrate treatment. The recirculation

pump basket and associated Cell A piping had also clogged. The main plumbing components in and supporting Cell A were cleaned and cell operation resumed. Following this event, breaking up the biomass within Cell A became an additional routine maintenance activity.

Throughout the first half of CY 2010, Cell B was operated under a batch flow approach, rather than continuous flow (see Section 3.1.5.3), because the extremely low flow rate necessary to allow effective nitrate treatment by this cell could not be reliably achieved using the existing influent pumps and valves. Batch flow operation in 2010 entailed adding approximately 26 gallons of influent twice weekly. This was discontinued in the beginning of July, as discussed in Section 3.1.5.3, and the cell was subsequently operated under continuous flow conditions.

2.6 Erosion Control and Revegetation

The existing erosion controls are maintained and repaired to protect the bare soil areas until the vegetation can stabilize the soil. Areas lacking sufficient vegetation cover are assessed, and typically reseeded; however, in some cases, soil amendments are added to help establish the native vegetation. Additional information on the revegetation activities conducted at the Site during 2010 is provided in Section 3.2.2.3.

2.6.1 Erosion Control

Maintenance, repair, replacement, and monitoring of the Site erosion control features continued as needed through 2010. Assessing the erosion control is especially important following the high-wind events that are common at the Site and after significant precipitation events. Typical repairs included re-staking (or weighting with rocks) wattles or erosion blankets that had loosened. The *Erosion Control Plan for the Rocky Flats Property Central Operable Unit* (DOE 2007b) was followed for various projects conducted in 2010. The plan addresses the regulatory approach, monitoring inspections, and the applicability and scope of erosion control activities at the Site. It outlines the responsibilities, BMPs, and implementation aspects for erosion control activities before, during, and after projects.

2.7 General Site Maintenance and Operations

The Site is managed and maintained, and activities are conducted, pursuant to DOE's jurisdiction and control responsibilities. These activities help maintain the general condition of the Site through BMPs. The Site is assessed both according to a schedule and continuously. Highlights of the routine and nonroutine maintenance and operations are described below.

2.7.1 Site Road Upgrades

2.7.1.1 Emergency Repairs

On April 26, 2010, an emergency inspection of the Site was conducted following a 3-inch precipitation event that occurred over the weekend. Site roads showed minor erosion damage in a few locations. It was determined that repairs to these areas could not wait until the Site Road Upgrades 2010 Project scheduled to be completed in September. A Spring Road Repairs Project was immediately planned to prevent further erosion problems. The spring road repairs were completed on April 28. Several Site road locations that were eroded during the recent

precipitation event were regraded and compacted. Additional 3/4 inch rock was added to the more heavily eroded areas to help strengthen the road surface.

2.7.1.2 Annual Road Upgrades

The Site Road Upgrades 2010 Project was initiated on September 16. Various Site roads were regraded, had roadbase applied, and were compacted according to the engineering specifications and drawings. The ditches that run along Central Avenue and the OLF road were removed, and the ditches were reconstructed and had had new erosion matting installed. Some 3/4-inch recycled concrete was used to cover the surface of all regraded roads and act as a surfactant. The project was completed on September 27. Installation of all the required erosion controls was completed and approved by the Site ecologist.

2.7.2 Site Security

A USFWS officer has been assigned to the Rocky Flats Site to perform nonroutine security evaluations as well as respond to any security issues encountered by Site personnel.

No security infractions were noted during CY 2010.

3.0 Environmental Monitoring

3.1 Water Monitoring

3.1.1 Introduction

This section presents data collected to satisfy water monitoring objectives implemented at the Site in accordance with RFLMA. The RFSOG provides a guidance framework in support of conducting LM activities, including monitoring, at the Site. Figure 2 shows a map with the water monitoring locations that were operational during the fourth quarter of CY 2010. Sampling maps for the first through third quarters of CY 2010 are available in the quarterly reports.

This annual report focuses on data collected during CY 2010 (January through December 2010). This section includes:

- An evaluation of analytical results from routine monitoring as required by RFLMA and detailed in the RFSOG, organized by monitoring objective;
- A summary of hydrologic data for the calendar year; and
- Supplemental data interpretation and evaluation for CY 2010.

Analytical water quality data are available in Appendix B.

3.1.1.1 Water Monitoring Highlights: CY 2010

During CY 2010, the water monitoring network successfully fulfilled the targeted monitoring objectives as required by RFLMA and using the RFSOG implementation guidance. During CY 2010, the RFLMA network consisted of 99 wells, 11 gaging stations, 10 surface-water grab sampling locations (three of which are pre-discharge pond locations), 8 treatment system grab sampling locations, and 8 precipitation gages. During CY 2010, 167 samples composed of 8,228 individual aliquots ("grabs") were collected at the surface-water locations,[2] 74 samples were collected from treatment system locations, and 157 samples were collected from monitoring wells. Additional samples were collected beyond the RFLMA requirements, as discussed in this report.

Precipitation in CY 2010 was below average, with 11.64 inches of precipitation, which is approximately 94.5 percent of the average (the CY 1993−2009 average is 12.32 inches). The fall was significantly drier than average (44.9 percent of the CY 1993−2009 average of 2.58 inches). The spring was measurably wetter than average (121.4 percent of the CY 1993−2009 average of 4.84 inches). April was significantly wetter than average (162 percent of the average), while September and December were significantly drier than average (14 percent and 10 percent of the average, respectively). The largest daily events occurred on April 22 (0.92 inch) and April 23 (1.16 inches).[3] The largest 2-day total (2.09 inches) also occurred on April 22−23. The highest peak flow rates for the year from the former Industrial Area were 19.9 cubic feet per second (cfs)

[2] Composite samples consist of multiple grabs of identical volume. Each grab is delivered by the automatic sampler to the composite container at each predetermined flow volume or time interval.
[3] The precipitation gages used in the automated surface-water monitoring network are not heated due to the lack of AC power at the locations. Thus, the gages do not accurately measure snowfall (as water equivalent).

in North Walnut Creek, 37.5 cfs in South Walnut Creek, and 8.99 cfs in the South Interceptor Ditch (SID); all of these peak flows occurred on April 23, 2010.

All water quality data at the RFLMA POCs remained below the applicable standards throughout CY 2010.

Reportable 12-month rolling average Pu activities were observed starting on April 30, 2010, in surface water at RFLMA POE monitoring station SW027, which is located on the South Interceptor Ditch upstream of Pond C-2. SW027 has been dry since June 18, 2010, and no new data have been collected. The 12-month rolling average for Pu continues to be reportable at this location. SW027 data are evaluated in Section 3.1.2.2 of this report.

DOE initiated consultation with CDPHE on June 2, 2010, soon after data were available indicating the Pu exceedance. RFLMA Contact Record 2010-06, "Monitoring Results at Surface Water Point of Evaluation (POE) SW027" provides a discussion of the monitoring results and recaps the outcome of the RFLMA Parties' consultation regarding steps to be taken to evaluate the SW027 drainage area. Contact Record 2010-06 is available on the Rocky Flats website, http://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

Subsequent to Contact Record 2010-06, the *Report of Steps Taken Regarding Monitoring Results at Surface Water Point of Evaluation (POE) SW027* was completed on August 31, 2010. This report provides data evaluation and an update on the steps taken in accordance with Contact Record 2010-06. Recommendations beyond the actions already taken and discussed in the Contact Record are also provided. This report is available on the Rocky Flats website, http://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

All other POE analyte concentrations remained below reporting levels throughout CY 2010. Erosion and runoff controls, as well as extensive revegetation efforts, have been effective in measurably reducing both sediment transport and constituent concentrations. During CY 2010, all of the other POEs had Pu and Am concentrations well below the RFLMA standards. With the removal of impervious areas resulting in decreased runoff, the stabilization of soils within the drainages, and the progression of revegetation, acceptable water quality is expected to continue.

Groundwater monitoring results at the PLF and OLF are evaluated in Section 3.1.2.8 and Section 3.1.2.9, respectively, of this report. Groundwater was monitored in accordance with RFLMA (DOE 2007a).

3.1.1.2 Use of Analytical Data

Analytical data are evaluated statistically to meet many objectives in accordance with RFLMA. Rejected data are not included in statistical evaluations. Statistical and other evaluations of analytical data focus solely on those results reported for RFLMA analytes (as listed in RFLMA Attachment 2, Table 1 [DOE 2007a]).

Surface-water data from POCs and POEs are evaluated semimonthly, and results of these evaluations are included in the quarterly reports. Details regarding data handling for all surface water can be found in Appendix B.

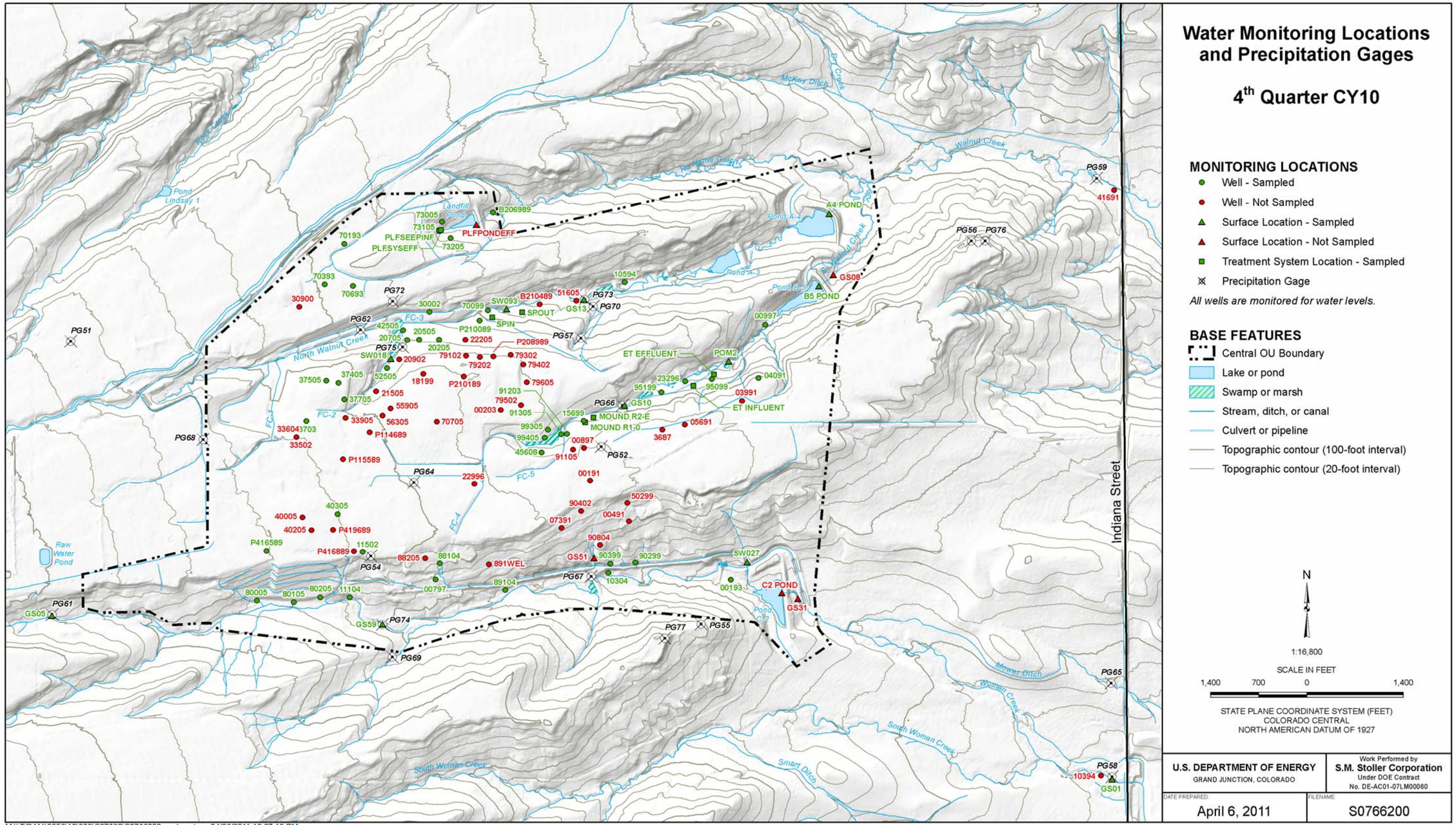

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Figure 2. Rocky Flats Site Water Monitoring Locations and Precipitation Gages: Fourth Quarter CY 2010

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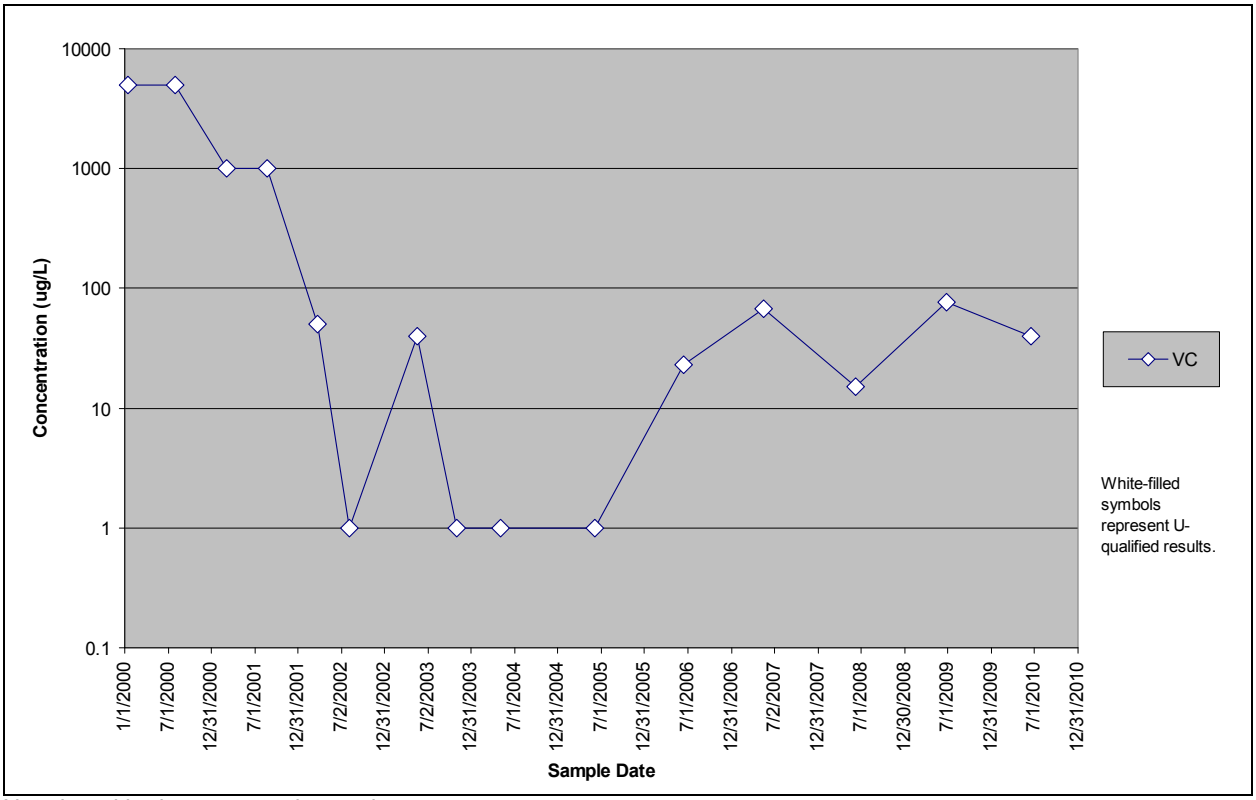
Groundwater data evaluations are reported annually because the groundwater regime is less dynamic than the surface-water regime and because groundwater conditions change much more gradually than surface-water conditions. However, groundwater data from Area of Concern (AOC) wells are evaluated for reportable conditions as they are received; when such conditions exist, they are described in the corresponding quarterly report as well as the annual report.

Groundwater statistics require a minimum of eight results representing routinely collected samples. A commercially available geostatistical software program (e.g., Sanitas, Visual Sample Plan) is used for these calculations. (**Note:** This report does not recommend any particular software; this information is merely included for the sake of completeness.) Furthermore, if trend calculations employ the Seasonal-Kendall (S-K) statistical method, the data representing these routinely collected samples must comprise four sets of results per season. For example, wells required to be monitored semiannually are sampled in the second and fourth quarters of a calendar year. Trending will require a minimum of eight sets of results from routinely collected samples, distributed as four per season—four in the second quarter and four in the fourth quarter. In this example, therefore, a well would need to be sampled for 4 years (4 samples × 2 samples/year = 8 samples total; 4 each of second quarter samples and fourth quarter samples requires 4 full years of semiannual samples) to provide the necessary and appropriate data for statistical analysis. For wells sampled quarterly, although the minimum eight sets of results could be collected in 2 years of routine sampling, the minimum four sets of results per season (four seasons) would not be collected until 4 years of successful, routine sampling had been completed.

Groundwater field duplicates are omitted from statistical evaluations. Groundwater samples assigned the laboratory qualifier "J" (estimated) are taken at face value, rather than being assigned a value of less than the method detection limit plus the practical quantitation limit (PQL). Samples assigned a "B" qualifier (which, for organics, indicates that the constituent was also detected in the blank) were also used at face value. This qualifier is commonly associated with results for methylene chloride. Because methylene chloride is a commonly used laboratory solvent, "B"-qualified results should be carefully reviewed alongside corresponding detection limits, concentrations in the blanks, and other relevant data before any decisions are based on them. (**Note:** In some cases, these considerations have led to the results being assigned a validation "U" qualifier, signifying that the result is so suspect as to be considered a nondetect. In such cases, the result is considered nondetect rather than the "B"-qualified value.)

For consistency, the RFSOG (DOE 2011a) instructs that nondetects reported for groundwater data be replaced by zeroes when performing statistical assessments. (This is because use of some common techniques, such as replacing the reported nondetect value with one-half the detection limit, could lead to false conclusions, as illustrated in Figure 3.) However, to calculate trends, the data cannot contain zeroes. Therefore, instead of zeroes, nondetects are replaced with a value of 0.001. (**Note:** This includes data with lab qualifiers as well as validation qualifiers that include "U.") Likewise, the statistical program cannot perform the necessary calculations if negative numbers are included in the results, as is occasionally the case for U isotopes and other radionuclides. Therefore, any negative results are replaced with 0.001. Calculated trends may be affected by this data replacement; therefore, the data from calculated trends of interest should be carefully inspected before any conclusions are reached or decisions made based on these trends.



Note logarithmic concentration scale.

Figure 3. Vinyl Chloride Results from Evaluation Well 07391, Illustrating Variations in Detection Limits

Evaluations of U in groundwater are based on total U concentrations. In some cases, surface-water data are also evaluated (e.g., at GS13, the performance monitoring location supporting the SPPTS). The latter data through mid-2009, as well as some earlier groundwater data, are typically reported as isotopic activities. Any negative values for individual isotopic analyses are first replaced with 0.001 as described above, and then the individual results for a given location and date are converted to mass units and summed to provide a conservative approximation of total U by mass. Any total U results that were equal to or less than zero were also replaced with 0.001 to allow for the requirements of the statistical calculations. Conversion factors used to support these groundwater evaluations are listed in Table 3.

Table 3. U Isotope Conversion Factors Used in Groundwater Evaluations

Isotope	Conversion Factor	Typical Activity Units	Typical Mass Units
U-233[a]	9,636.6 pCi/µg	pCi/L	µg/L
U-234	6,235.1 pCi/µg	pCi/L	µg/L
U-235	2.1612 pCi/µg	pCi/L	µg/L
U-236[a]	64.672 pCi/µg	pCi/L	µg/L
U-238	0.33614 pCi/µg	pCi/L	µg/L

[a] U-233 and U-236 are absent in natural U and, therefore, can be used as definitive markers for anthropogenic U. Los Alamos National Laboratory analyzes U-236 and also evaluates isotopic ratios for this purpose.

Source of conversion factors: Friedlander et. al 1981.

pCi/µg = picocuries per microgram; pCi/L = picocuries per liter

There are many instances in the database of multiple results for U on the same date at the same well. These results may represent any of the following: isotopic analysis providing results in activity units, isotopic analysis providing results in mass units, total U analysis via a metals analytical method, total U via a total U analytical method, filtered sample, unfiltered sample, unvalidated result, partially validated result, validated result, and result of reanalysis. (Note that these last four result types are most common in pre-closure data.) Before trends were calculated, for each well where this applied, these multiple results were winnowed to a single result representing each unique date. Factors evaluated in selecting the result for statistical use included:

- Filtration status;
- Validation qualifiers;
- Lab qualifiers; and
- Other U results from the well.

Because most samples for U analysis were field-filtered, where both sample results are provided, the filtered result is typically preferred for reasons of consistency. Similarly, where two very different results are presented, the result closer to others from the well is retained; if the two results are similar, the higher-concentration result is retained, to be conservative.

Data from original wells are grouped with those from replacement wells to form a data set on which the statistics are based. As additional data are collected from replacement wells, most of which were installed in 2005, this may prove to be inappropriate, given that the data populations from original and replacement wells may be discontinuous, which suggests that data from the original wells should be removed from statistical assessments of the groundwater data. This determination will be made as the post-closure data set becomes large enough to allow such an evaluation. Therefore, it should be stressed that trends for some locations may be misleading in that they may be strongly affected by well replacement and do not reflect only groundwater geochemistry and hydrology.

3.1.2 Routine Monitoring

3.1.2.1 POC Monitoring

This objective deals with monitoring discharges from the terminal ponds into Woman and Walnut creeks and streamflow at the additional POCs downstream at Indiana Street to demonstrate compliance with RFLMA surface-water-quality standards (see RFLMA Attachment 2, Table 1). Water-quality data at POCs are reportable under RFLMA when the applicable compliance parameters are greater than the corresponding Table 1 values (see Appendix D). Terminal pond discharges are monitored by POCs GS11, GS08, and GS31. Walnut Creek is monitored at Indiana Street by POC GS03. Woman Creek is monitored at Indiana Street by POC GS01. These locations are shown on Figure 4. Sampling and data evaluation protocols are summarized in Table 4.

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- Validation qualifiers;
- Lab qualifiers; and
- Other U results from the well.

Because most samples for U analysis were field-filtered, where both sample results are provided, the filtered result is typically preferred for reasons of consistency. Similarly, where two very different results are presented, the result closer to others from the well is retained; if the two results are similar, the higher-concentration result is retained, to be conservative.

Data from original wells are grouped with those from replacement wells to form a data set on which the statistics are based. As additional data are collected from replacement wells, most of which were installed in 2005, this may prove to be inappropriate, given that the data populations from original and replacement wells may be discontinuous, which suggests that data from the original wells should be removed from statistical assessments of the groundwater data. This determination will be made as the post-closure data set becomes large enough to allow such an evaluation. Therefore, it should be stressed that trends for some locations may be misleading in that they may be strongly affected by well replacement and do not reflect only groundwater geochemistry and hydrology.

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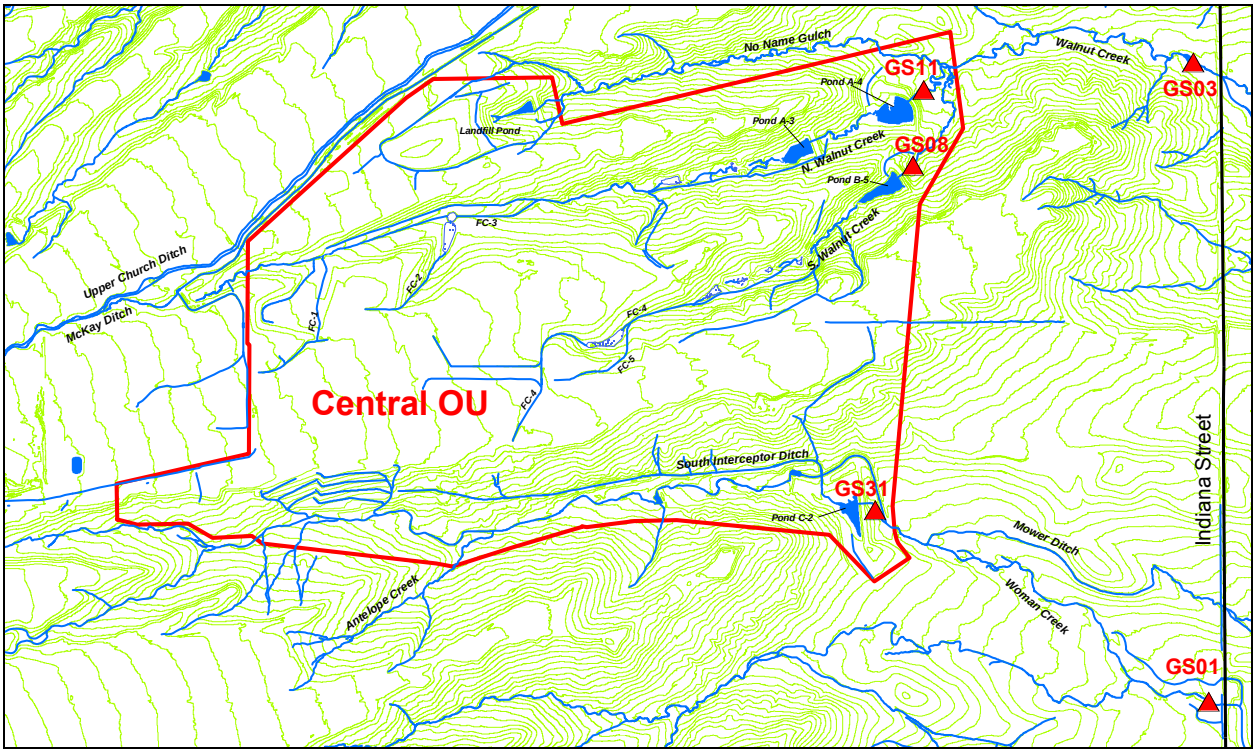


Figure 4. POC Monitoring Locations

Table 4. Sampling and Data Evaluation Protocols at POCs

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
GS01	Woman Creek at Indiana Street	Continuous flow-paced composites; frequency varies (target is 25−35 per year)[a]	total Pu, Am, and U [TSS[c]]	See Figure 5 in Appendix D
GS03	Walnut Creek at Indiana Street	Continuous flow-paced composites; frequency varies (target is 20−35 per year)[a]	total Pu, Am, and U [TSS[c]]	See Figure 5 in Appendix D
GS08	Pond B-5 Outlet	Continuous flow-paced composites; frequency varies (target is 0−14 per year)	total Pu, Am, U, and nitrate[b]	See Figure 5 in Appendix D
GS11	Pond A-4 Outlet	Continuous flow-paced composites; frequency varies (target is 0−14 per year)	total Pu, Am, U, and nitrate[b]	See Figure 5 in Appendix D
GS31	Pond C-2 Outlet	Continuous flow-paced composites; frequency varies (target is 0−7 per year)	total Pu, Am, and U	See Figure 5 in Appendix D

Notes [a] Frequency depends on available flow; samples are segregated by water origin (baseflow or pond discharge).
[b] Collected during pond discharges only as daily grabs samples that are composited over 2–4 day periods (grab samples are collected instead of flow-paced composites to meet holding time and preservation requirements; nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only.
[c] Total suspended solids (TSS) is analyzed when the composite sampling period is within TSS holding-time limits.

The following sections include summary tables and plots showing the applicable 30-day and 12-month rolling averages for the POC analytes. The evaluations include all results that were not rejected through the data verification and validation process. Data are generally presented to decimal places as reported by the laboratories. Accuracy should not be inferred; minimum detectable concentrations, activities, and analytical errors are often greater than the precision presented. When a sample has a corresponding field duplicate, the value used in calculations is the arithmetic average of the "real" and "duplicate" values. When a sample has multiple "real" analyses (Site-requested "reruns"), the value used in calculations is the arithmetic average of the multiple "real" analyses.[4]

Refer to Appendix B, which contains the water-quality data, for further information.

Location GS01

Monitoring location GS01 is located on Woman Creek at Indiana Street (Figure 4). The Woman Creek headwaters, the southern portion of the COU, and Pond C-2 contribute flow to GS01.

Table 5 shows that all of the annual average Pu and Am activities were well below the RFLMA standard of 0.15 picocurie per liter (pCi/L). Additionally, the long-term Pu and Am averages (1997−2010) are well below 0.15 pCi/L. The average total U concentrations are all well below the RFLMA standard of 16.8 µg/L.

Table 5. Annual Volume-Weighted Average Radionuclide Activities at GS01 for 1997−2010

Calendar Year	Volume-Weighted Average		
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)
1997	0.003	0.007	NA
1998	0.006	0.006	NA
1999	0.005	0.008	NA
2000	0.004	0.003	NA
2001	0.004	0.006	NA
2002	0.002	0.001	NA
2003	0.002	0.004	1.60
2004	0.003	0.002	4.58
2005	0.004	0.003	3.22
2006	0.012	0.003	6.06
2007	0.002	0.007	1.40
2008	0.002	0.003	5.74
2009	0.003	0.007	2.75
2010	0.005	0.010	2.39
Total (1997−2010)	0.004	0.006	2.33

Notes: Collection of total U data began on February 3, 2003. NA = not applicable.

[4] Significant differences in values for a data pair are an indication of potential problems with sample preparation or analysis. Under these circumstances, an applicable value to be used for comparison cannot be determined with sufficient confidence to make compliance decisions. Thus, an evaluation of the duplicate error ratio (DER) or relative percent difference (RPD), depending on the analyte, is required to assess the representativeness of the sample and its usability for compliance decisions (see Section 8.2.3 of the RFSOG for discussion).

Figure 5 and Figure 6 show no occurrences of reportable 30-day averages for the year.

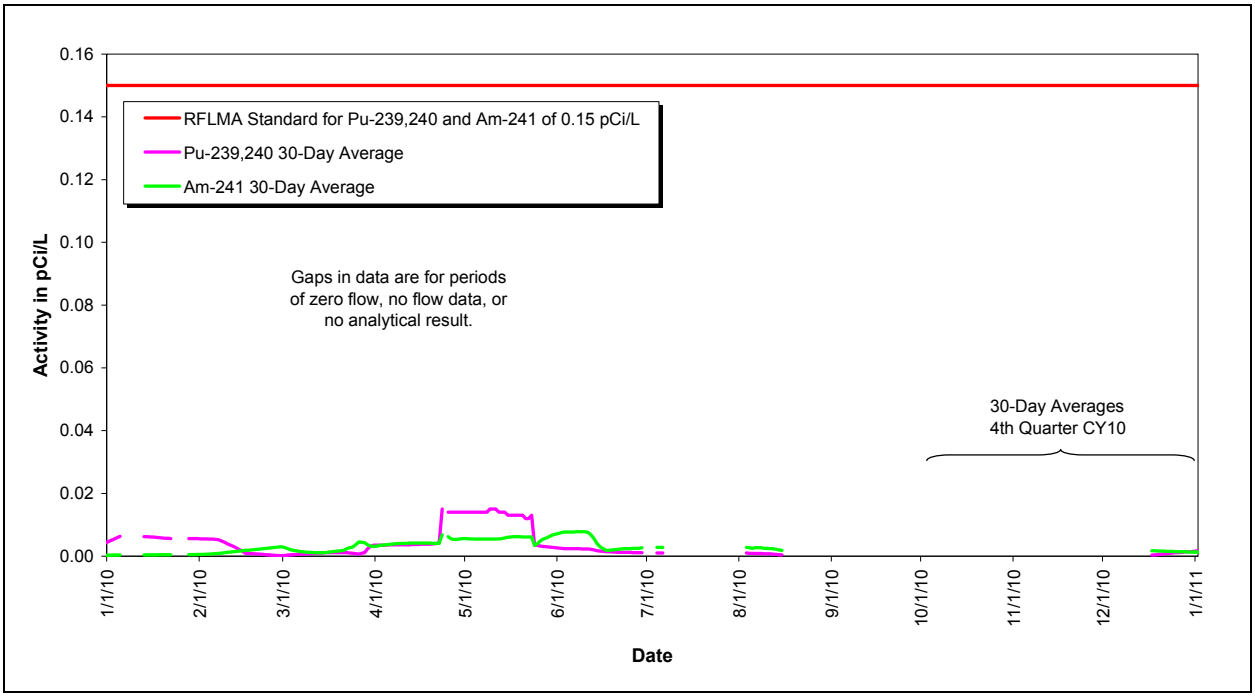


Figure 5. Volume-Weighted 30-Day Average Pu and Am Activities at GS01: Calendar Year Ending Fourth Quarter CY 2010

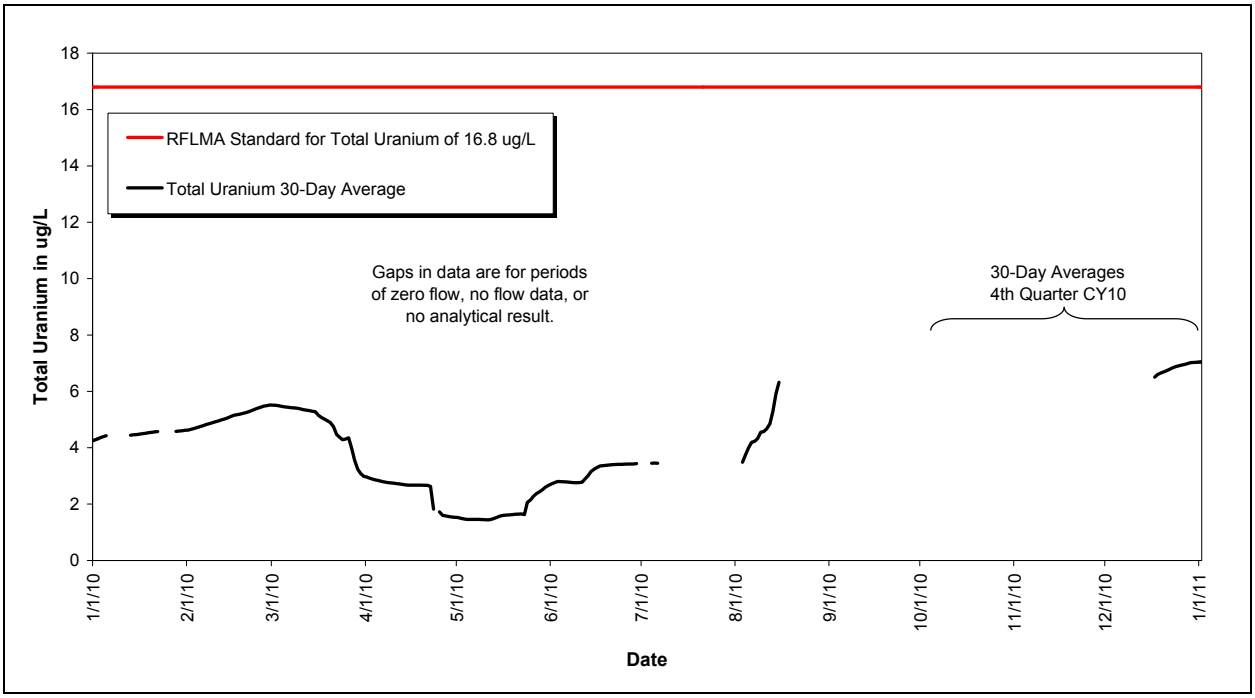


Figure 6. Volume-Weighted 30-Day Average Total U Concentrations at GS01: Calendar Year Ending Fourth Quarter CY 2010

Figure 7 and Figure 8 show similar data for the entire post-closure period.

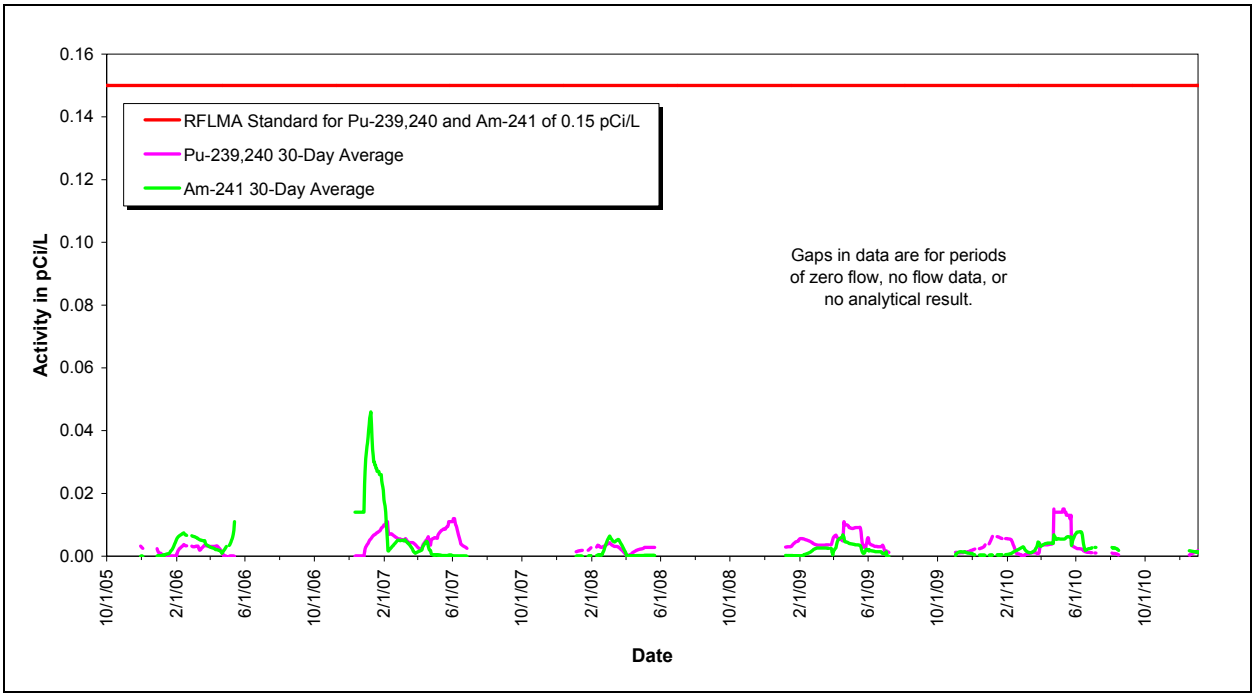


Figure 7. Volume-Weighted 30-Day Average Pu and Am Activities at GS01: Post-Closure Period

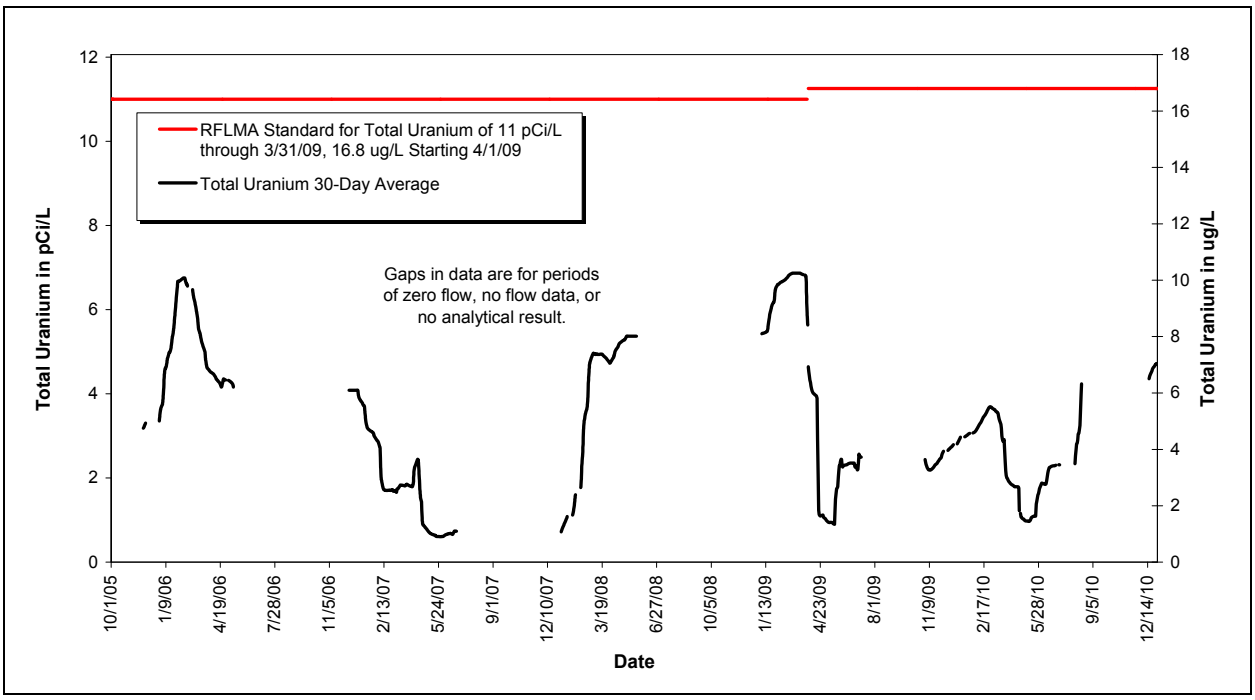


Figure 8. Volume-Weighted 30-Day Average Total U Concentrations at GS01: Post-Closure Period

Location GS03

Monitoring location GS03 is located on Walnut Creek at Indiana Street (Figure 4). The Walnut Creek headwaters, the majority of the COU, Pond A-4, and Pond B-5 contribute flow to GS03.

Table 6 shows that all of the annual average Pu and Am activities were well below 0.15 pCi/L. Additionally, the long-term Pu and Am averages (1997−2010) are well below 0.15 pCi/L. The average total U and nitrate+nitrite as N concentrations are all well below the RFLMA standard of 16.8 µg/L and 10 milligrams per liter (mg/L), respectively.

Table 6. Annual Volume-Weighted Average Radionuclide Activities and Nitrate+Nitrite as Nitrogen Concentrations at GS03 for 1997−2010

Calendar Year	Volume-Weighted Average			
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)	Nitrate+Nitrite as N (mg/L)[a]
1997	0.014	0.026	NA	NA
1998	0.010	0.014	NA	NA
1999	0.009	0.015	NA	NA
2000	0.007	0.005	NA	NA
2001	0.005	0.009	NA	NA
2002	0.006	0.012	NA	NA
2003	0.005	0.006	2.38	NA
2004	0.008	0.008	2.44	NA
2005	0.022	0.008	5.68	NA (no pond discharge after 10/13/05)
2006	NA (no flow)	NA (no flow)	NA (no flow)	NA (no pond discharge)
2007	0.002	0.006	5.13	2.34
2008	NA (no flow)	NA (no flow)	NA (no flow)	NA (no pond discharge)
2009	0.003	0.004	4.29	0.34
2010	0.005	0.007	4.81	1.88
Total (1997−2010)	0.008	0.012	3.74	1.65

Notes: Collection of total U data began on November 5, 2002. NA = not applicable.
[a] For pond discharge periods only; nitrate+nitrite as nitrogen sampling began on October 13, 2005.

Figure 9, Figure 10, and Figure 11 show no occurrences of reportable 30-day averages for the year.

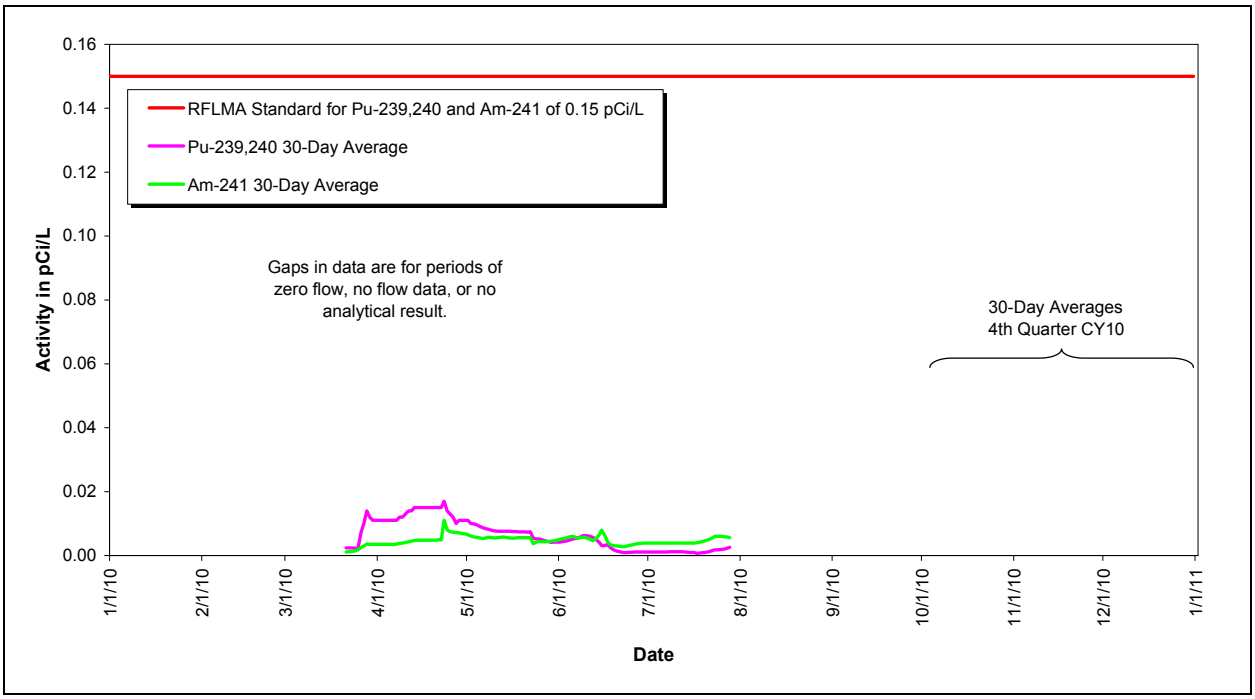


Figure 9. Volume-Weighted 30-Day Average Pu and Am Activities at GS03: Calendar Year Ending Fourth Quarter CY 2010

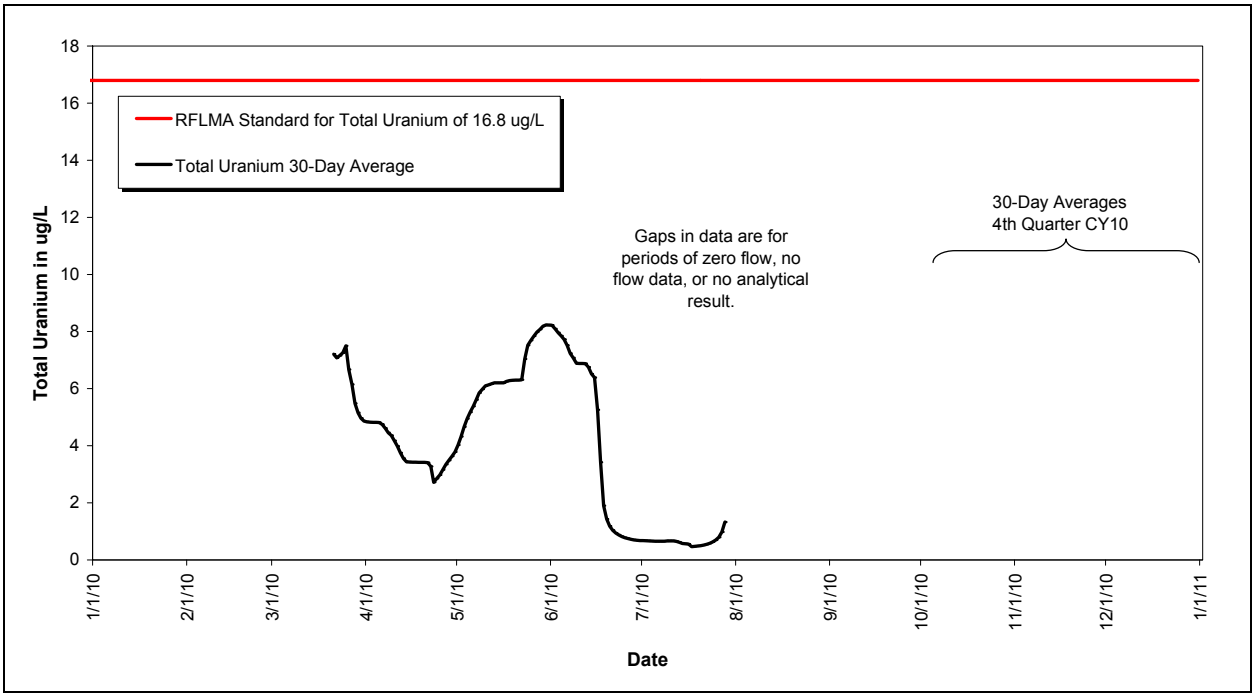


Figure 10. Volume-Weighted 30-Day Average Total U Concentrations at GS03: Calendar Year Ending Fourth Quarter CY 2010

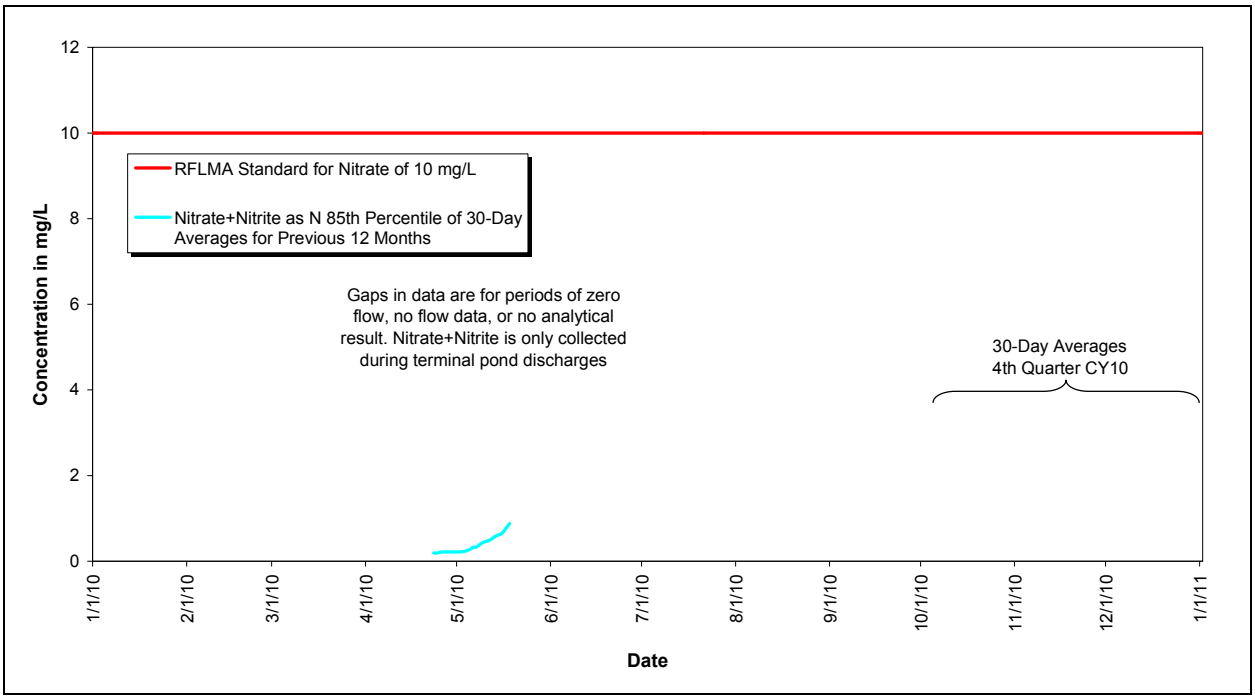


Figure 11. Volume-Weighted 30-Day Average Nitrate+Nitrite as N Concentrations at GS03: Calendar Year Ending Fourth Quarter CY 2010

Figure 12, Figure 13, and Figure 14 show similar data for the entire post-closure period.

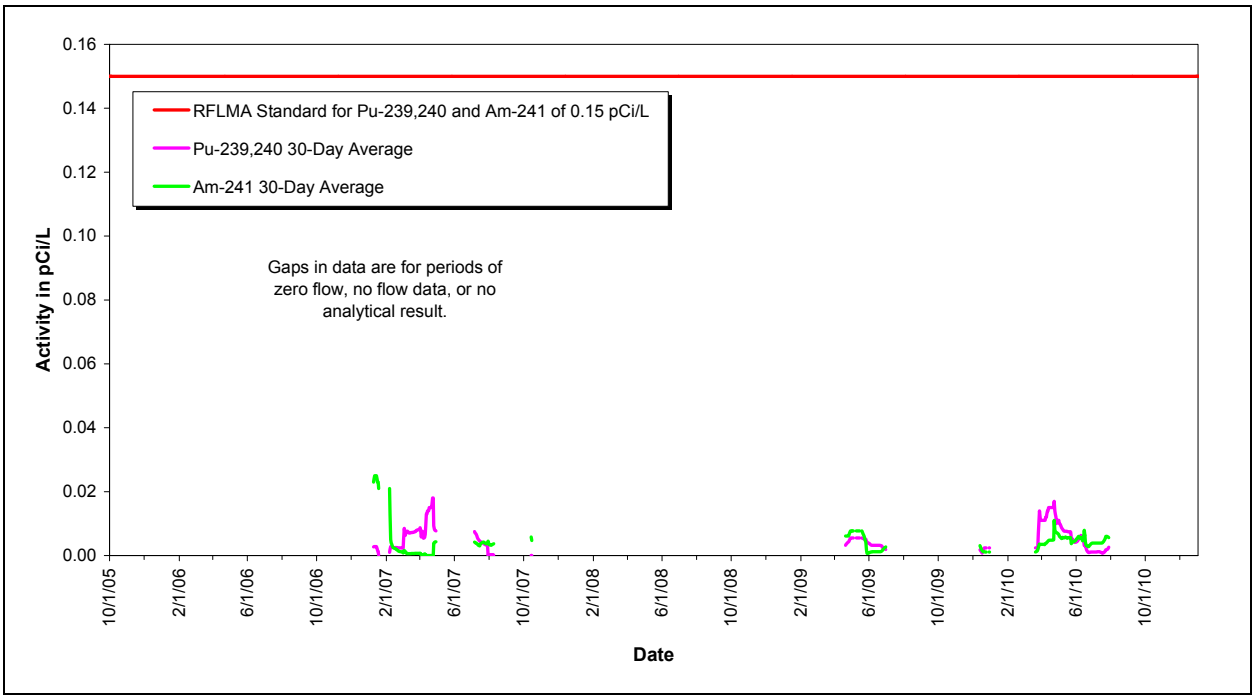


Figure 12. Volume-Weighted 30-Day Average Pu and Am Activities at GS03: Post-Closure Period

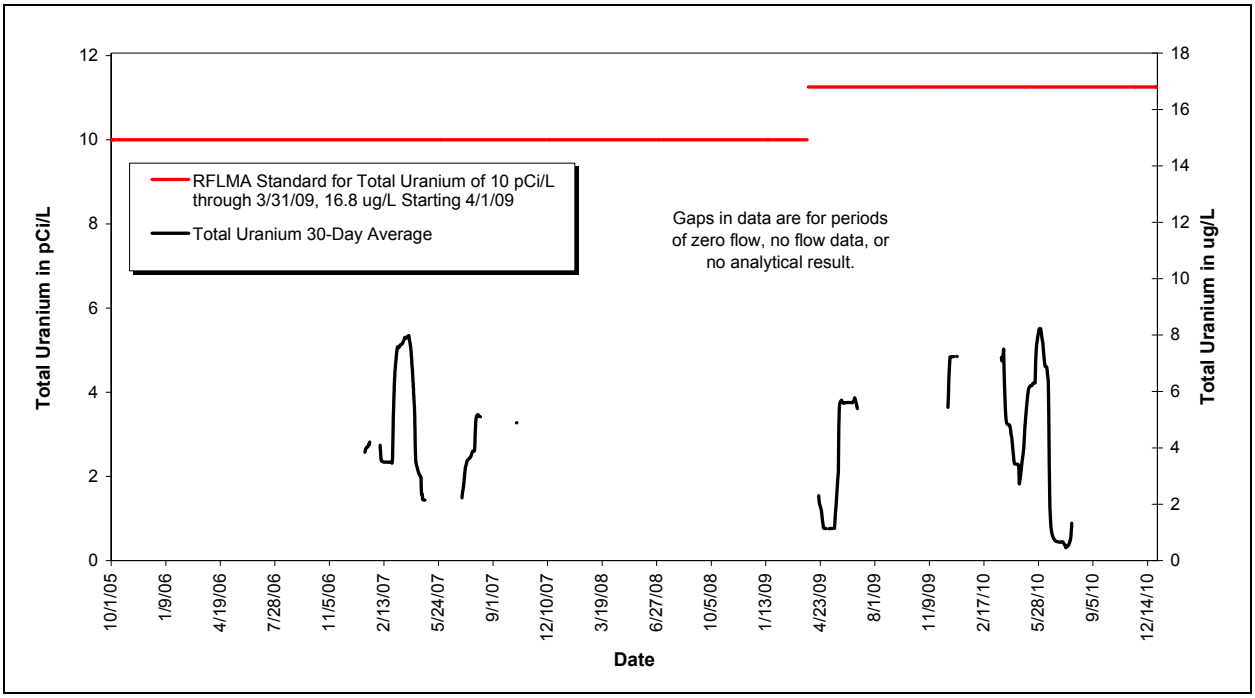


Figure 13. Volume-Weighted 30-Day Average Total U Concentrations at GS03: Post Closure-Period

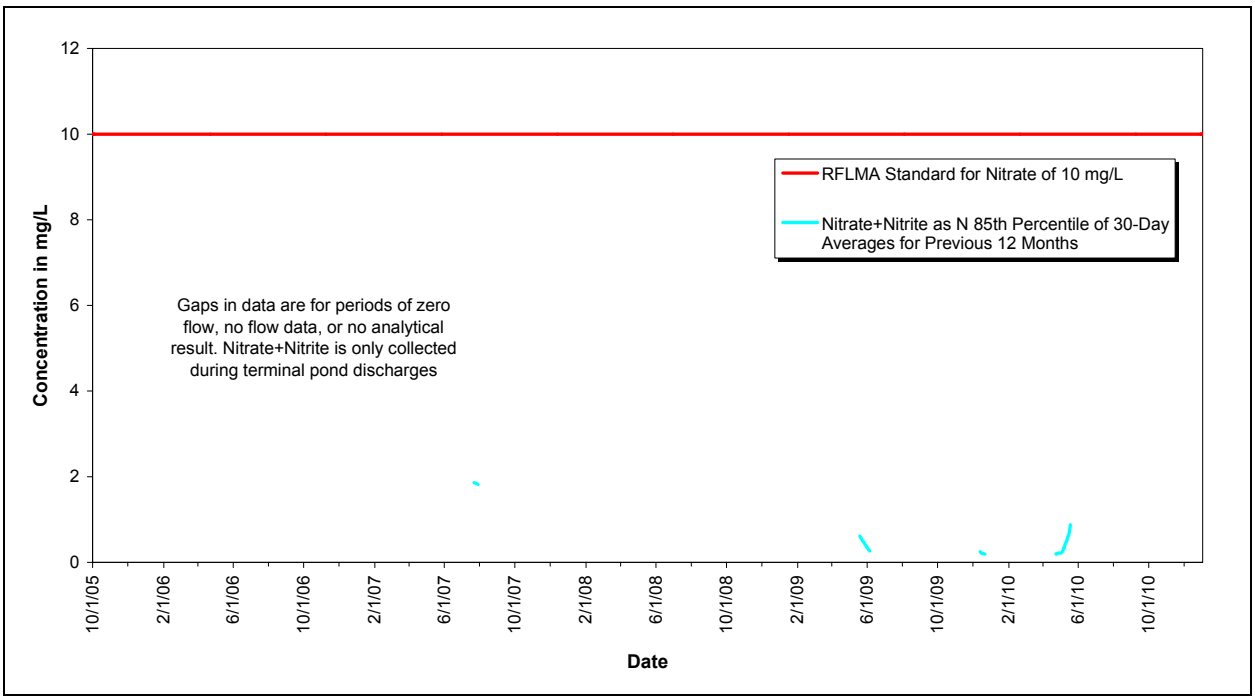


Figure 14. Volume-Weighted 30-Day Average Nitrate+Nitrite as N Concentrations at GS03: Post-Closure Period

Location GS08

Monitoring location GS08 is located on South Walnut Creek at the outlet of Pond B-5 (Figure 4). The central portion of the COU contributes flow to Pond B-5.

Table 7 shows that all of the annual average Pu and Am activities were well below 0.15 pCi/L. Additionally, the long-term Pu and Am averages (1997−2010) are well below 0.15 pCi/L. The average total U concentrations have shown recent increases due to contributions from GS10 (see Section 3.1.2.2) but are all still below the RFLMA standard of 16.8 µg/L. Nitrate+nitrite as N concentrations are well below 10 mg/L.

Table 7. Annual Volume-Weighted Average Radionuclide Activities and Nitrate+Nitrite as Nitrogen Concentrations at GS08 for 1997−2010

Calendar Year	Volume-Weighted Average			
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)	Nitrate+Nitrite as N (mg/L)[a]
1997	0.008	0.006	2.42	NA
1998	0.006	0.008	3.30	NA
1999	0.015	0.046	2.00	NA
2000	0.029	0.047	1.26	NA
2001	0.004	0.006	1.73	NA
2002	0.003	0.002	0.96	NA
2003	0.006	0.026	1.97	NA
2004	0.009	0.009	1.80	NA
2005	0.021	0.008	8.76	NA (no pond discharge after 10/13/05)
2006	NA (no discharge)	NA (no discharge)	NA (no discharge)	NA (no discharge)
2007	0.002	0.003	12.0	0.38
2008	NA (no discharge)	NA (no discharge)	NA (no discharge)	NA (no discharge)
2009	0.001	0.004	6.74	0.01
2010	0.005	0.005	9.46	0.16
Total (1997−2010)	0.011	0.021	2.73	0.17

Notes: NA = not applicable.
[a] Nitrate+nitrite as nitrogen sampling began on October 13, 2005.

Figure 15, Figure 16, and Figure 17 show no occurrences of reportable 12-month rolling averages for the year.

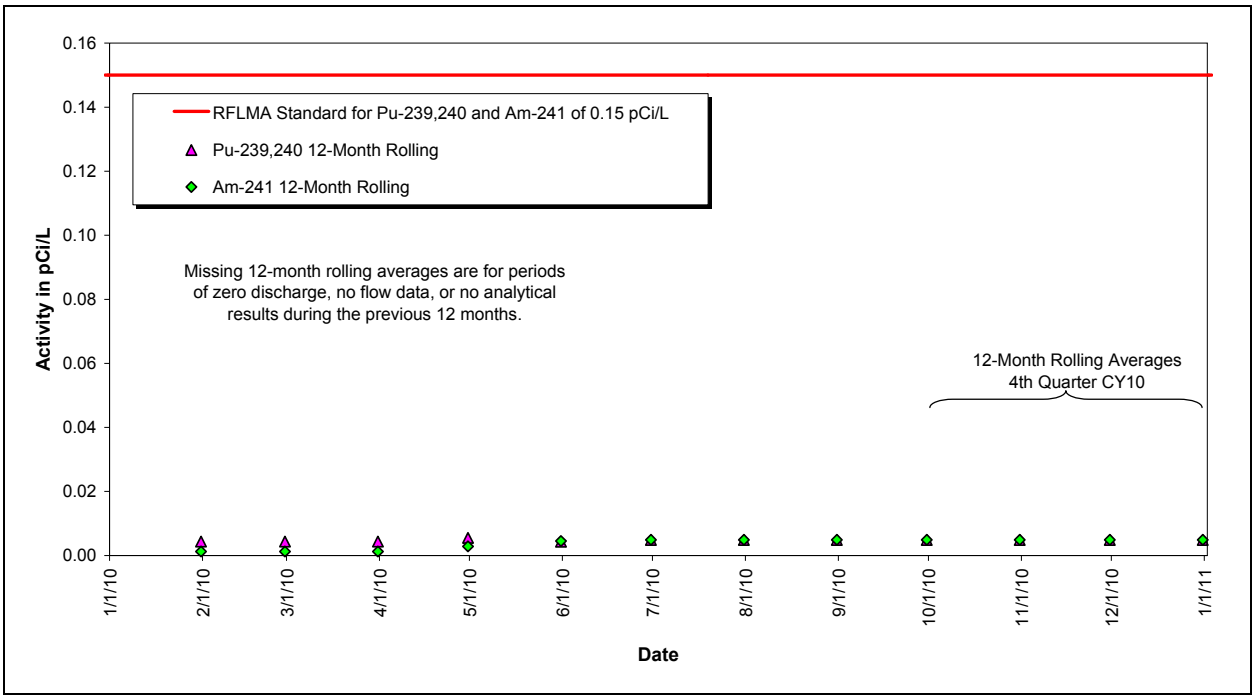


Figure 15. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS08: Calendar Year Ending Fourth Quarter CY 2010

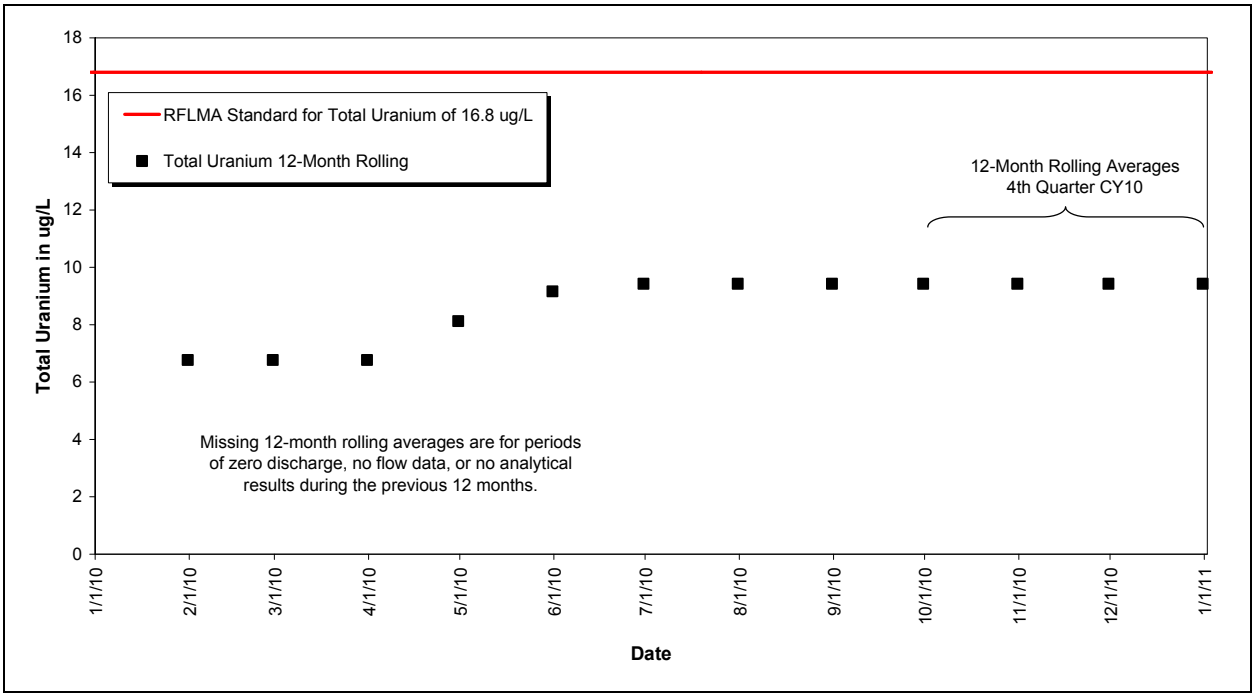


Figure 16. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS08: Calendar Year Ending Fourth Quarter CY 2010

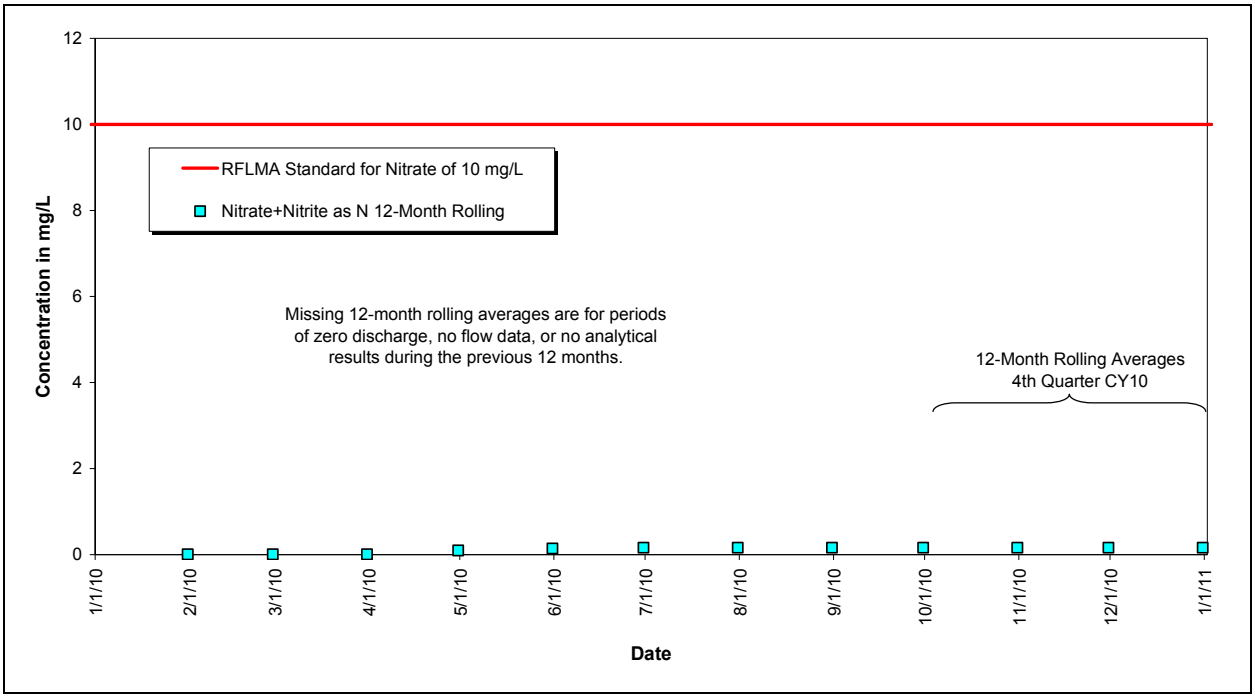


Figure 17. Volume-Weighted 12-Month Rolling Average Nitrate+Nitrite as N Concentrations at GS08: Calendar Year Ending Fourth Quarter CY 2010

Figure 18, Figure 19, and Figure 20 show similar data for the entire post-closure period.

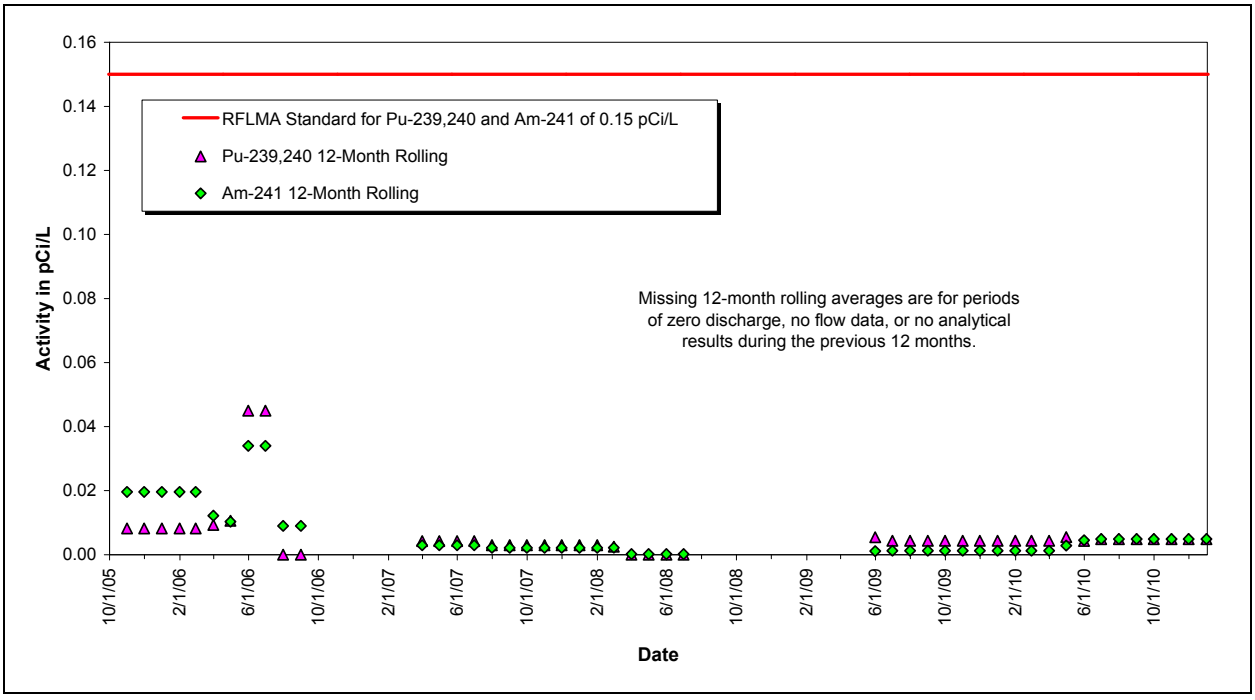


Figure 18. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS08: Post-Closure Period

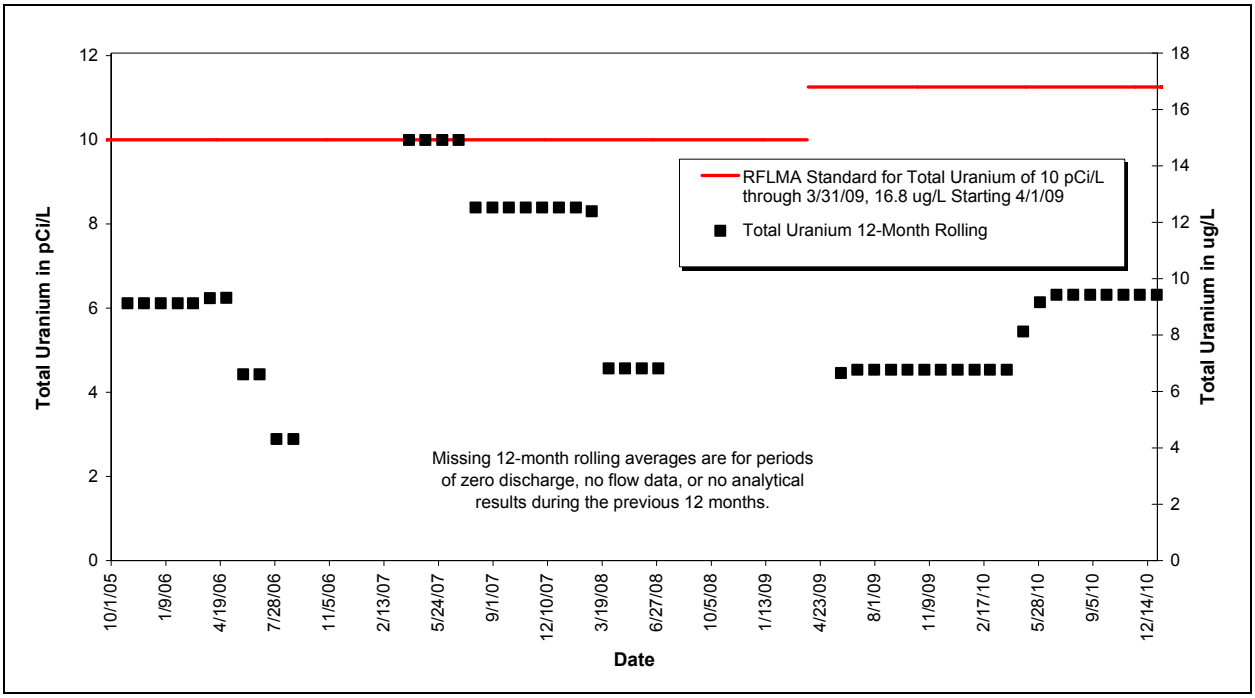


Figure 19. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS08: Post-Closure Period

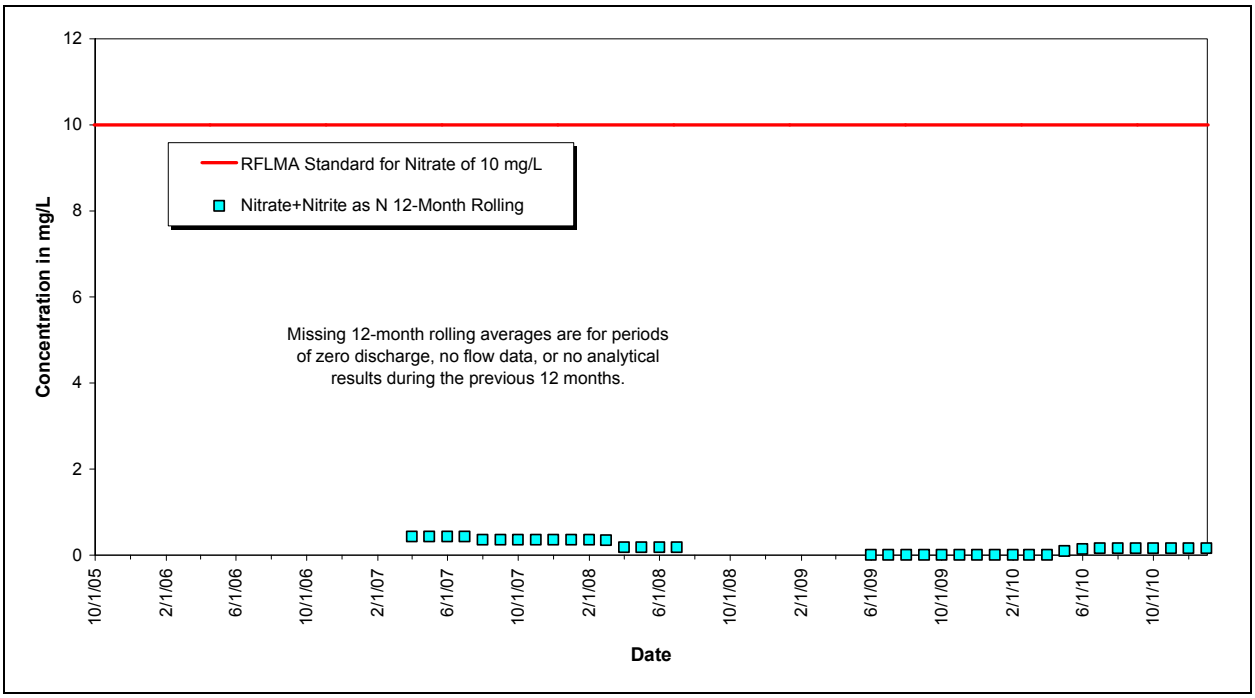


Figure 20. Volume-Weighted 12-Month Rolling Average Nitrate+Nitrite as N Concentrations at GS08: Post-Closure Period

Location GS11

Monitoring location GS11 is located on North Walnut Creek at the outlet of Pond A-4 (Figure 4). The northern portion of the COU contributes flow to Pond A-4.

Table 8 shows that all of the annual average Pu and Am activities were well below 0.15 pCi/L. Additionally, the long-term Pu and Am averages (1997−2010) are well below 0.15 pCi/L. The average total U and nitrate+nitrite as N concentrations are all below the RFLMA standard of 16.8 µg/L and 10 mg/L, respectively.

Table 8. Annual Volume-Weighted Average Radionuclide Activities and Nitrate+Nitrite as Nitrogen Concentrations at GS11 for 1997−2010

Calendar Year	Volume-Weighted Average Activity (pCi/L)			
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)	Nitrate+Nitrite as N (mg/L)[a]
1997	0.005	0.008	2.70	NA
1998	0.011	0.004	3.23	NA
1999	0.003	0.007	2.60	NA
2000	0.001	0.018	3.51	NA
2001	0.003	0.002	4.14	NA
2002	0.003	0.000	3.29	NA
2003	0.003	0.002	3.98	NA
2004	0.006	0.002	3.63	NA
2005	0.022	0.002	2.43	NA (no pond discharge after 10/13/05)
2006	NA (no discharge)	NA (no discharge)	NA (no discharge)	NA (no discharge)
2007	0.001	0.007	5.25	3.02
2008	NA (no discharge)	NA (no discharge)	NA (no discharge)	NA (no discharge)
2009	0.005	0.003	6.58	0.68
2010	0.004	0.004	9.76	4.70
Total (1997−2010)	0.006	0.006	3.73	3.26

Notes: NA = not applicable.
[a] Nitrate+nitrite as nitrogen sampling began on October 13, 2005.

Figure 21, Figure 22, and Figure 23 show no occurrences of reportable 12-month rolling averages for the year.

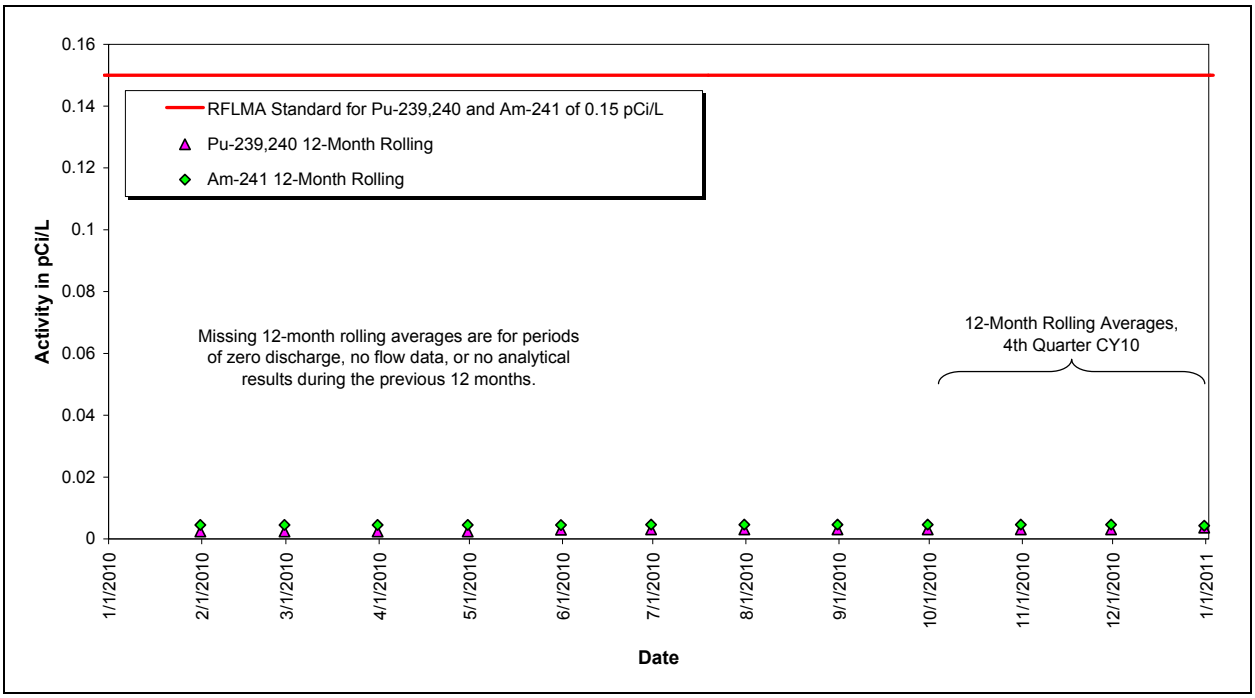


Figure 21. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS11: Calendar Year Ending Fourth Quarter CY 2010

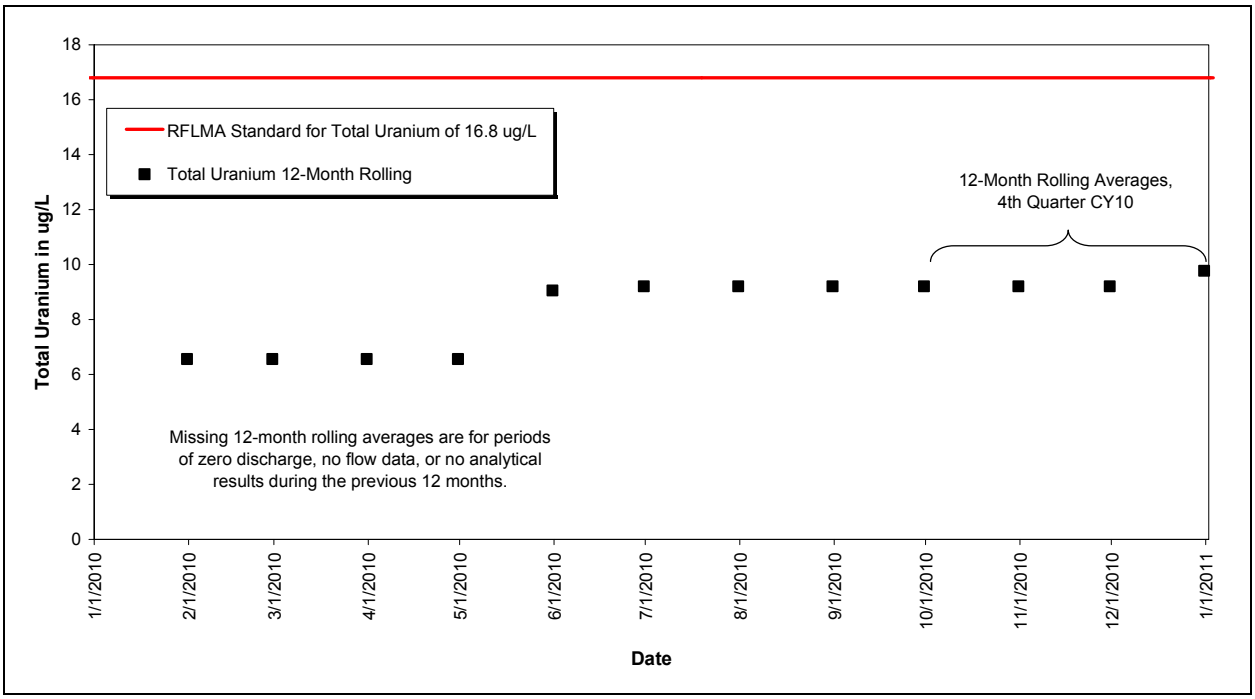


Figure 22. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS11: Calendar Year Ending Fourth Quarter CY 2010

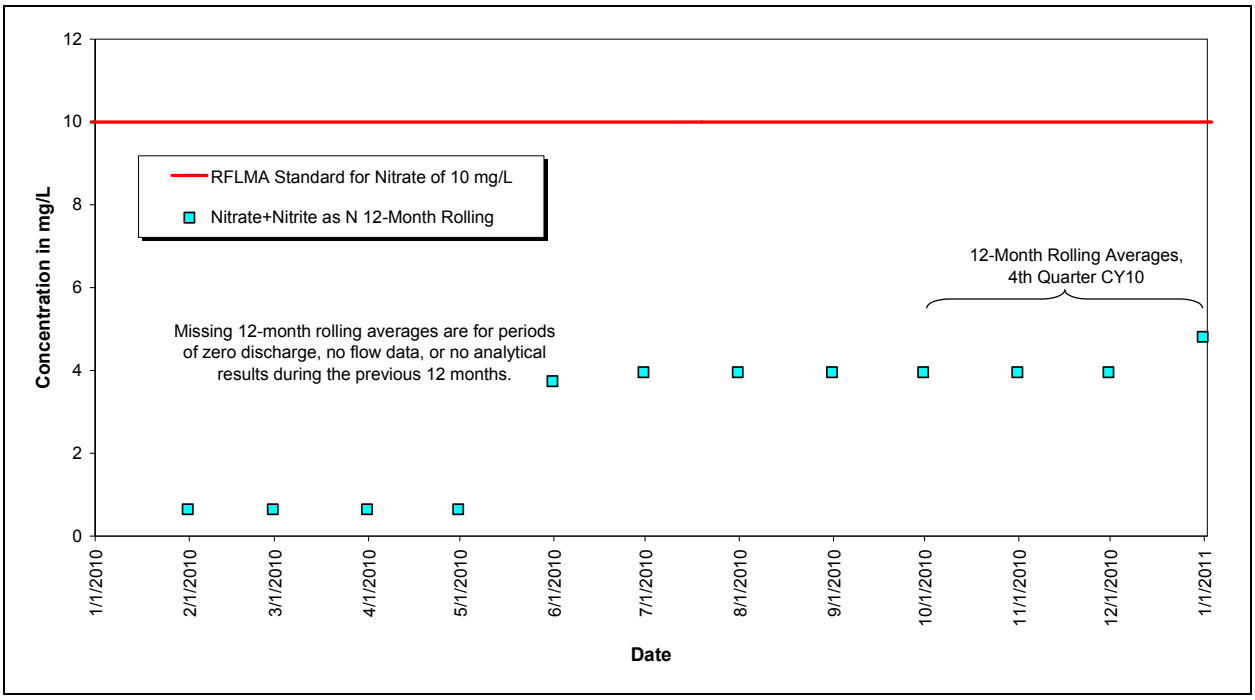


Figure 23. Volume-Weighted 12-Month Rolling Average Nitrate+Nitrite as N Concentrations at GS11: Calendar Year Ending Fourth Quarter CY 2010

Figure 24, Figure 25, and Figure 26 show similar data for the entire post-closure period.

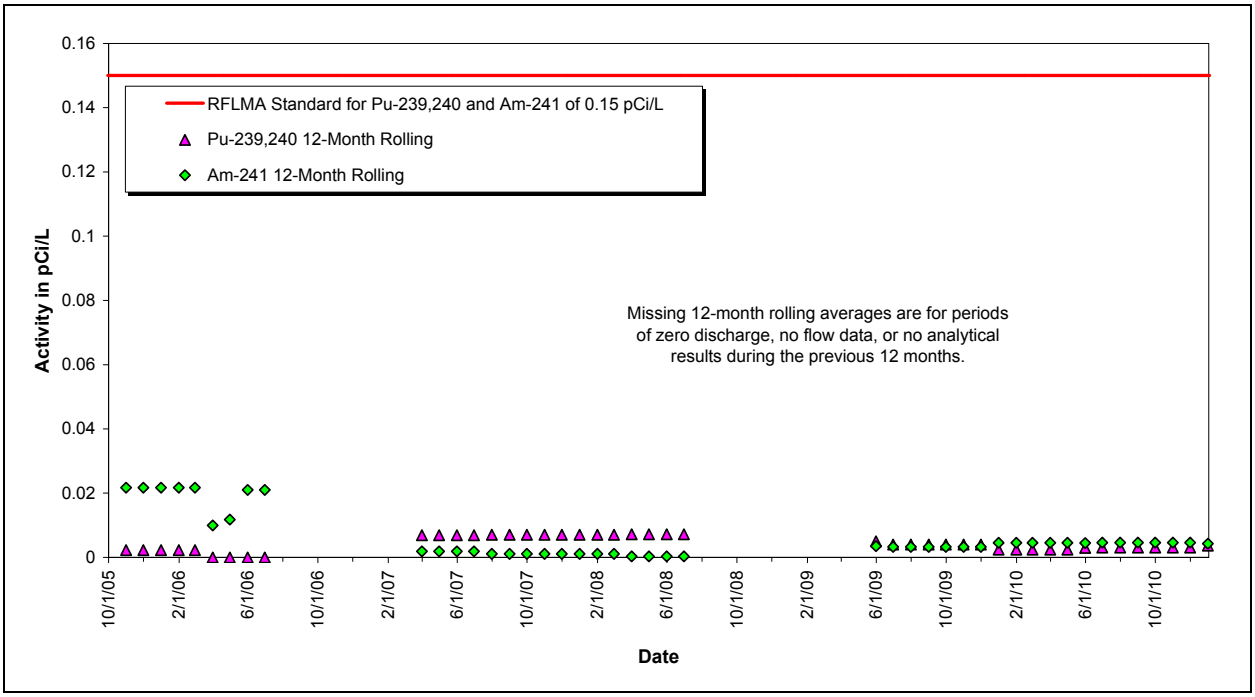


Figure 24. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS11: Post-Closure Period

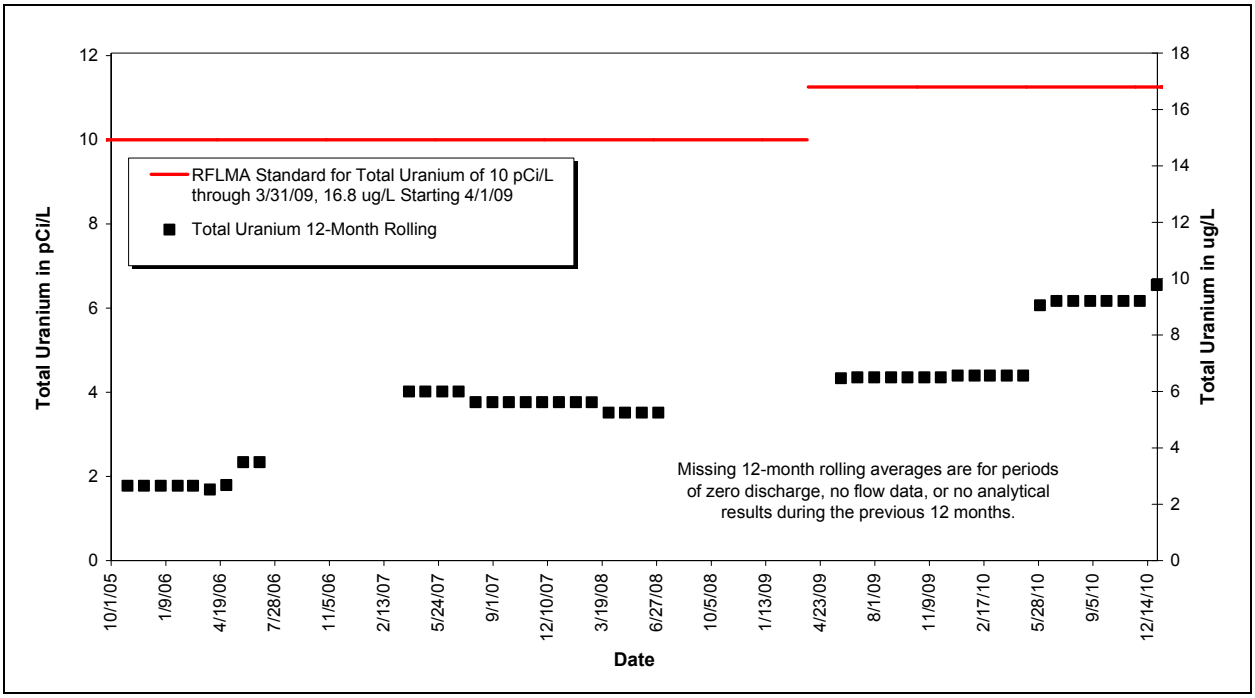


Figure 25. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS11: Post-Closure Period

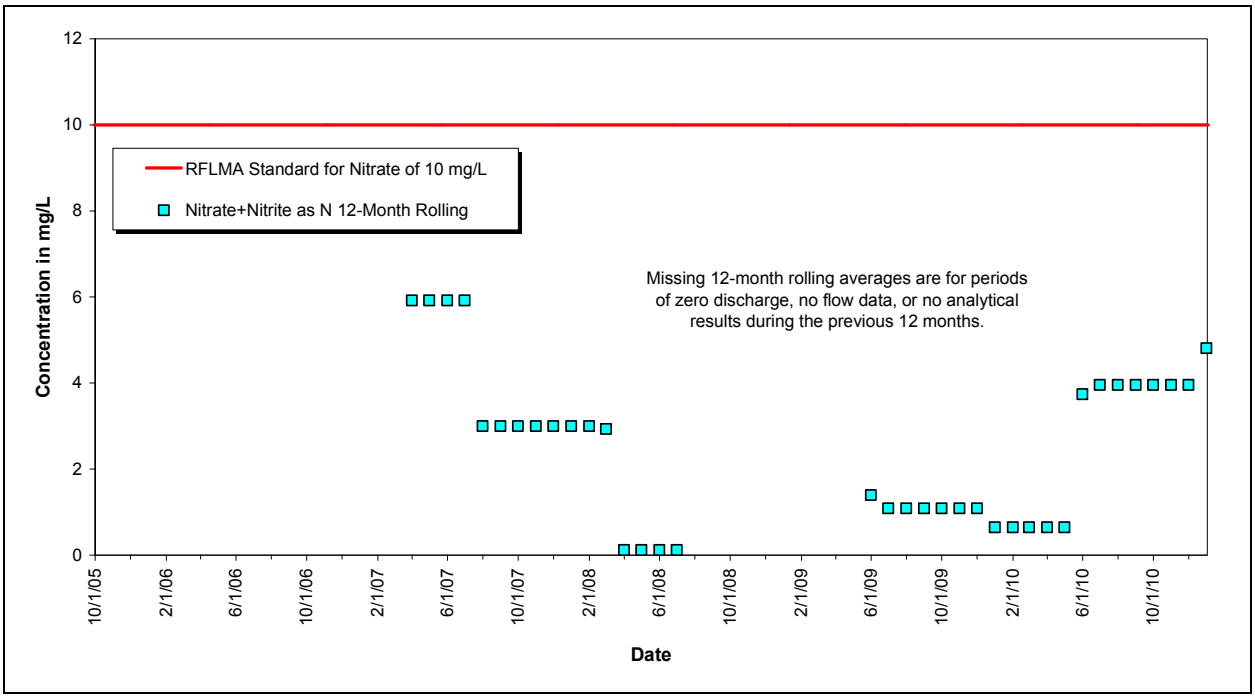


Figure 26. Volume-Weighted 12-Month Rolling Average Nitrate+Nitrite as N Concentrations at GS11: Post-Closure Period

Location GS31

Monitoring location GS31 is located on Woman Creek at the outlet of Pond C-2 (Figure 4). The southern portion of the COU contributes flow to Pond C-2.

Table 9 shows that the annual and long-term (1997–2010) average Pu and Am activities were all below 0.15 pCi/L. Additionally, the annual and long-term total U concentrations were all below the RFLMA standard of 16.8 µg/L.

Table 9. Annual Volume-Weighted Average Radionuclide Activities at GS31 for 1997−2010

Calendar Year	Volume-Weighted Average Activity		
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)
1997	0.008	0.017	3.32
1998	0.018	0.003	4.31
1999	0.010	0.043	4.22
2000	No C-2 discharge	No C-2 discharge	No C-2 discharge
2001	0.013	0.021	1.84
2002	0.015	0.089	3.54
2003	0.006	0.015	2.43
2004	0.010	0.021	2.36
2005	0.008	0.020	6.27
2006	No C-2 discharge	No C-2 discharge	No C-2 discharge
2007	No C-2 discharge	No C-2 discharge	No C-2 discharge
2008	No C-2 discharge	No C-2 discharge	No C-2 discharge
2009	0.006	0.016	5.17
2010	0.002	0.001	2.33
Total (1997−2010)	0.010	0.018	3.36

Figure 27 and Figure 28 show no occurrences of reportable 12-month rolling averages for the year.

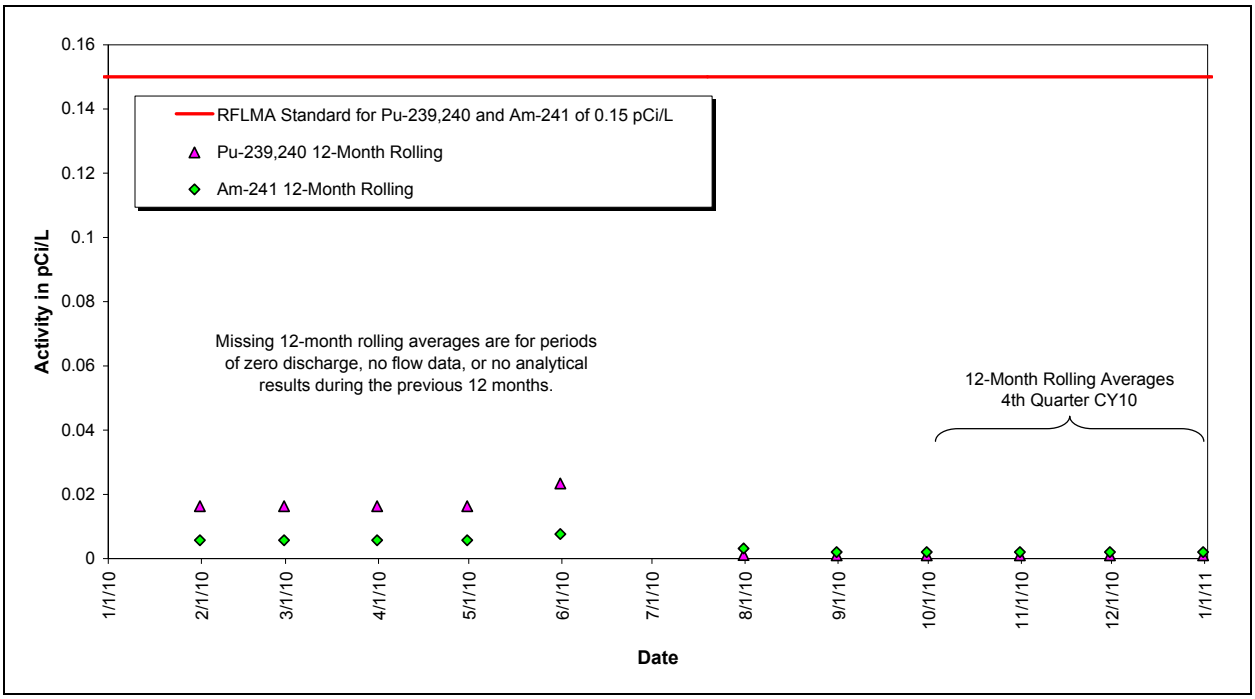


Figure 27. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS31: Calendar Year Ending Fourth Quarter CY 2010

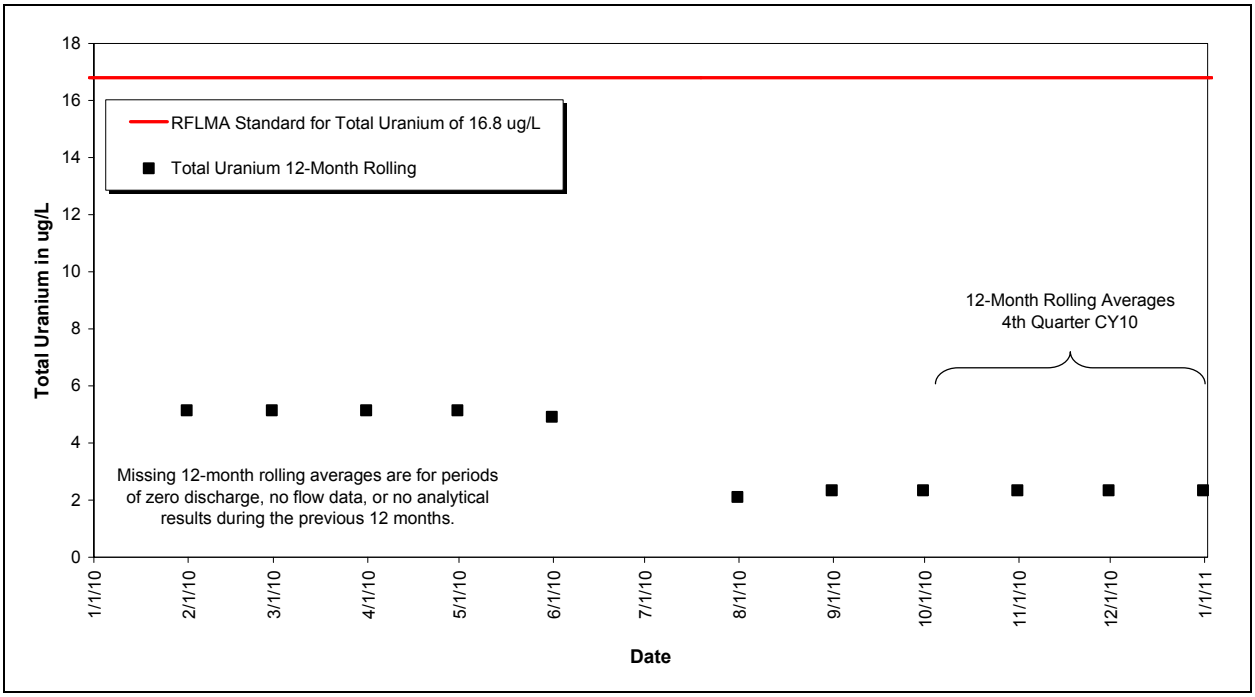


Figure 28. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS31: Calendar Year Ending Fourth Quarter CY 2010

Figure 29 and Figure 30 show similar data for the entire post-closure period.

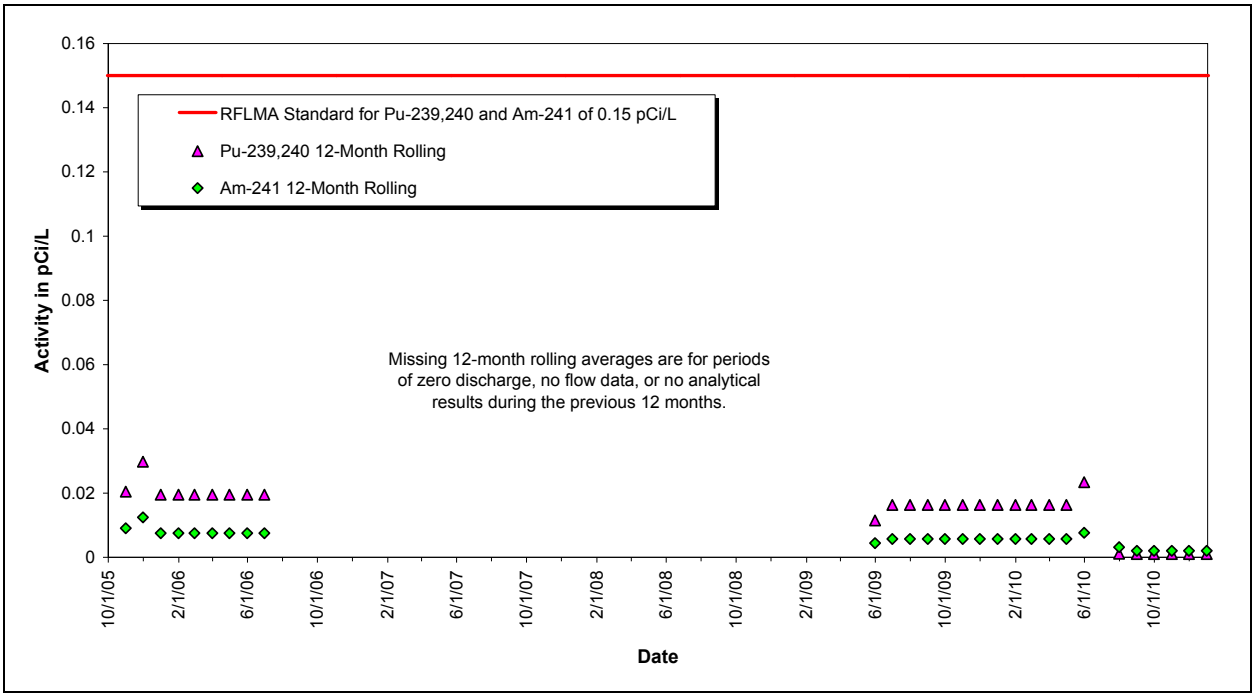


Figure 29. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS31: Post-Closure Period

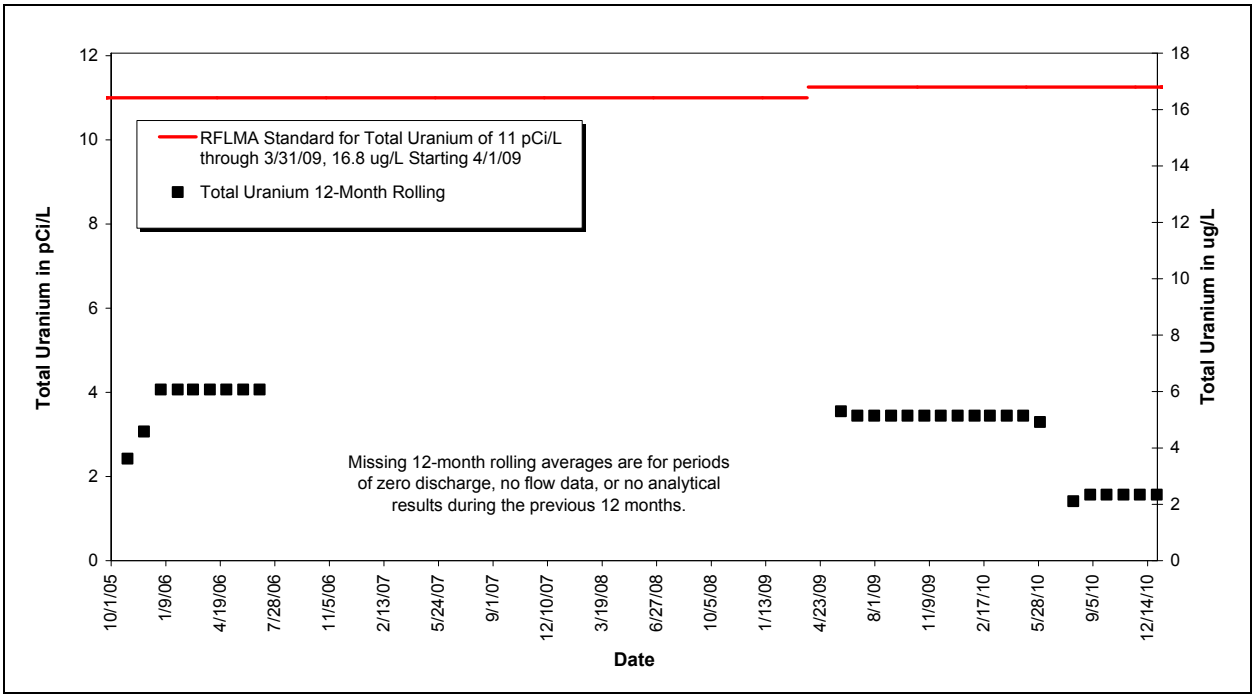


Figure 30. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS31: Post-Closure Period

3.1.2.2 POE Monitoring

This objective deals with monitoring runoff and baseflow from the interior of the COU to the A-, B-, and C-series ponds to demonstrate compliance with surface-water-quality standards (see Table 1 of RFLMA Attachment 2). Water quality data are reportable under RFLMA when the applicable compliance parameters are greater than the corresponding Table 1 values (see Appendix D). Surface water is monitored by POEs SW093, GS10, and SW027 on North Walnut Creek, South Walnut Creek, and the SID, respectively. These locations are shown on Figure 31. Sampling and data evaluation protocols are summarized in Table 10.

Table 10. Sampling and Data Evaluation Protocols at POEs

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
GS10	South Walnut Creek at Outfall of FC-4	Continuous flow-paced composites; frequency varies (target is 14 per year)[a]	Total hardness, Be, Cr, Pu, Am, and U; dissolved Ag and Cd; [TSS[b]]	See Figure 6 in Appendix D
SW027	SID at Pond C-2	Continuous flow-paced composites; frequency varies (target is 20 per year)[a]	Total hardness, Be, Cr, Pu, Am, and U; dissolved Ag and Cd; [TSS[b]]	See Figure 6 in Appendix D
SW093	North Walnut Creek at Outfall of FC-3	Continuous flow-paced composites; frequency varies (target is 20 per year)[a]	Total hardness, Be, Cr, Pu, Am, and U; dissolved Ag and Cd; [TSS[b]]	See Figure 6 in Appendix D

Notes: [a] Frequency depends on available flow.
[b] Total suspended solids (TSS) is analyzed when the composite sampling period is within TSS holding-time limits.
Ag = silver
Be = beryllium
Cd = cadmium
Cr = chromium
FC = Functional Channel

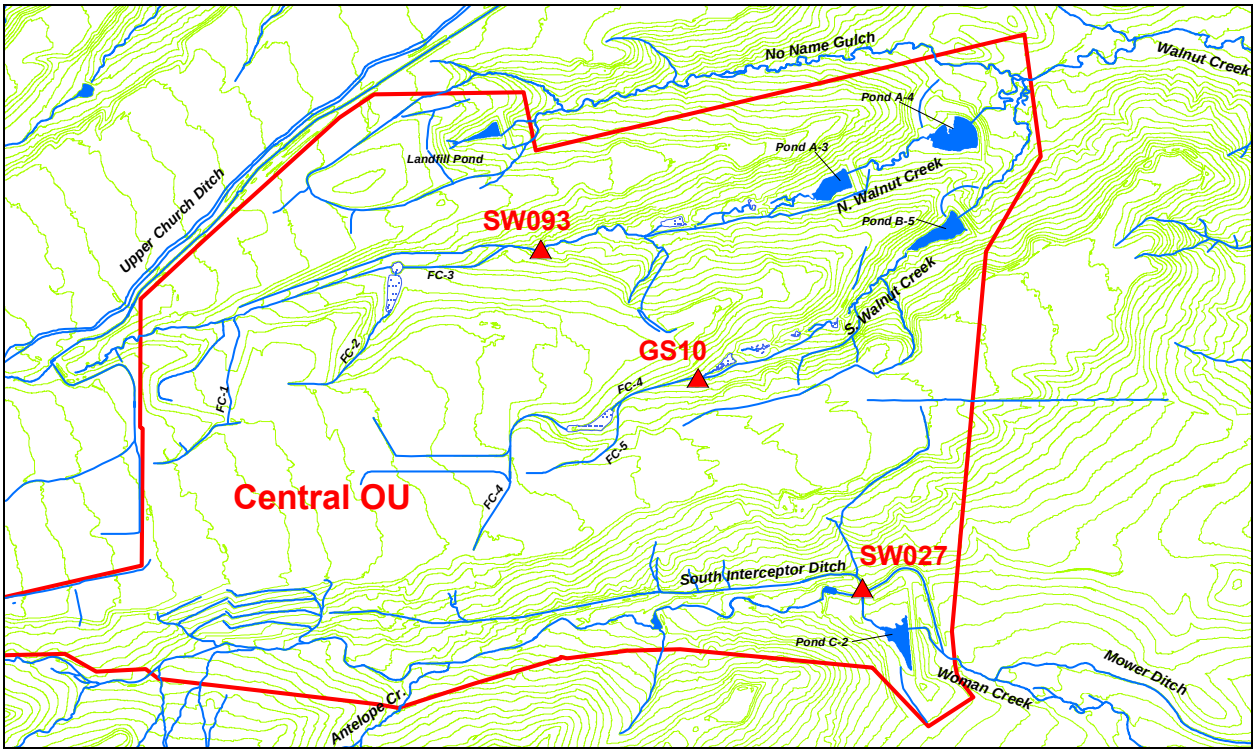


Figure 31. POE Monitoring Locations

The following sections include summary tables and plots showing the applicable 30-day and 12-month rolling averages for the POE analytes. The evaluations include all results that were not rejected through the data verification and validation process. Data are generally presented to decimal places as reported by the laboratories. Accuracy should not be inferred; minimum detectable concentrations, activities, and analytical errors are often greater than the precision presented. When a sample has a corresponding field duplicate, the value used in calculations is the arithmetic average of the "real" and "duplicate" values. When a sample has multiple "real" analyses (Site-requested "reruns"), the value used in calculations is the arithmetic average of the multiple "real" analyses.[5]

Refer to Appendix B, which contains the water-quality data, for further information.

Location GS10

Monitoring location GS10 is located on South Walnut Creek just upstream of the B-series ponds (Figure 31). The central portion of the COU contributes flow to GS10 through Functional Channel 4 (FC-4) and FC-5.

[5] Significant differences in values for a data pair are an indication of potential problems with sample preparation or analysis. Under these circumstances, an applicable value to be used for comparison cannot be determined with sufficient confidence to make compliance decisions. Therefore, an evaluation of the DER or RPD, depending on the analyte, is required to assess the representativeness of the sample and its usability for compliance decisions (see Section 8.2.3 of the RFSOG for discussion).

Table 11 shows that many of the annual average Pu and Am activities at GS10 were greater than 0.15 pCi/L during active Site closure. However, a significant reduction in both Pu and Am activities continues to be observed following Site closure. With the completion of the FCs, implementation of enhanced erosion controls, revegetation, soil stabilization, and lack of substantial runoff, transport of Pu and Am has been virtually eliminated.

Table 11. Annual Volume-Weighted Average Radionuclide Activities at GS10 for 1997−2010

Calendar Year	Volume-Weighted Average		
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)
1997	0.266	0.260	4.05
1998	0.109	0.158	4.28
1999	0.274	0.139	3.76
2000	0.421	0.195	3.20
2001	0.075	0.080	4.14
2002	0.087	0.061	4.03
2003	0.117	0.113	3.86
2004	0.136	0.314	3.64
2005	0.185	0.238	11.95
2006	0.010	0.014	19.31
2007	0.010	0.020	16.54
2008	0.025	0.020	22.87
2009	0.009	0.019	13.36
2010	0.007	0.012	14.38
Total (1997−2010)	0.163	0.150	6.19

Surface-water data from GS10 show higher post-closure U concentrations. The higher concentrations are generally associated with lower flow rates during periods of extended baseflow sustained by groundwater contributions. Groundwater data within South Walnut Creek show naturally occurring U concentrations considerably higher than the surface-water standard. Baseflow at GS10 is sustained by groundwater expressions in the form of both localized seeps and distributed flow to the streambed. As the amount of impervious surface at the Site was reduced, direct runoff to GS10 was also reduced. Similarly, removal of Site infrastructure likely resulted in reduced baseflow contributions from domestic and sanitary water leakage. Therefore, groundwater contributions to South Walnut Creek now make up a larger portion of the flows monitored at GS10. Without the attenuation of U groundwater sources by direct runoff and infrastructure leakage, increases in surface-water U concentrations would be expected.

Figure 32 and Figure 33 show no reportable Pu, Am, or U values during the year.

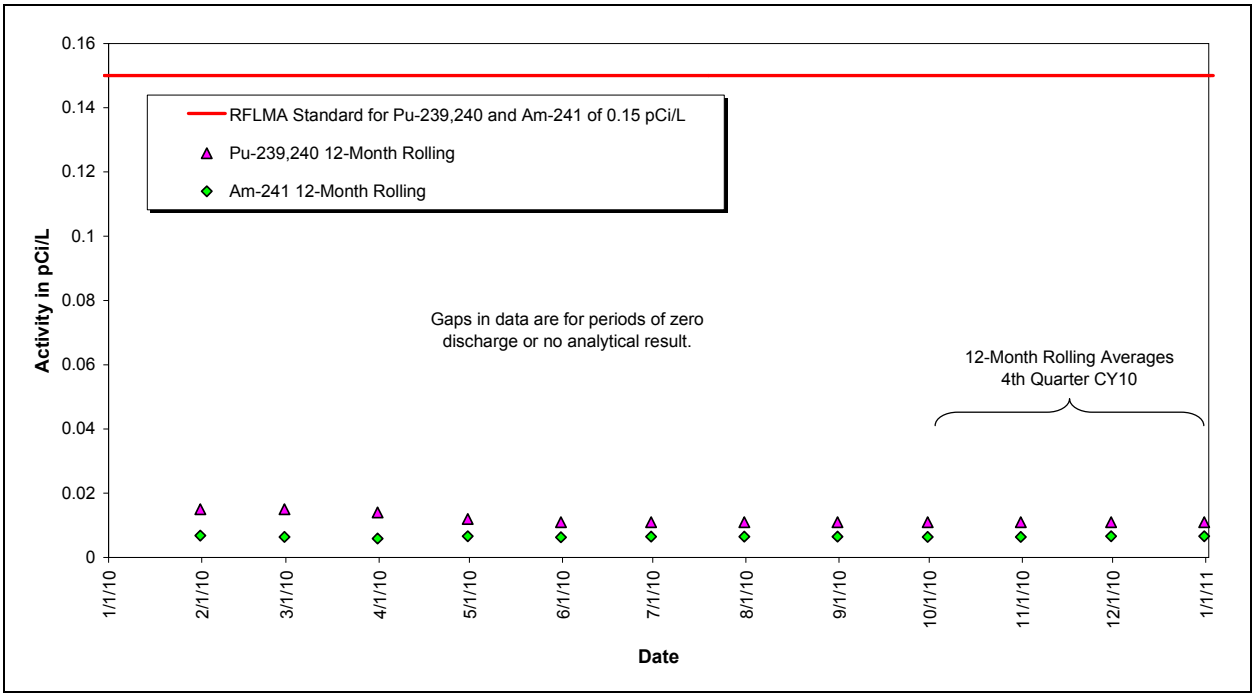


Figure 32. Volume-Weighted Average Pu and Am Compliance Values at GS10: Calendar Year Ending Fourth Quarter CY 2010

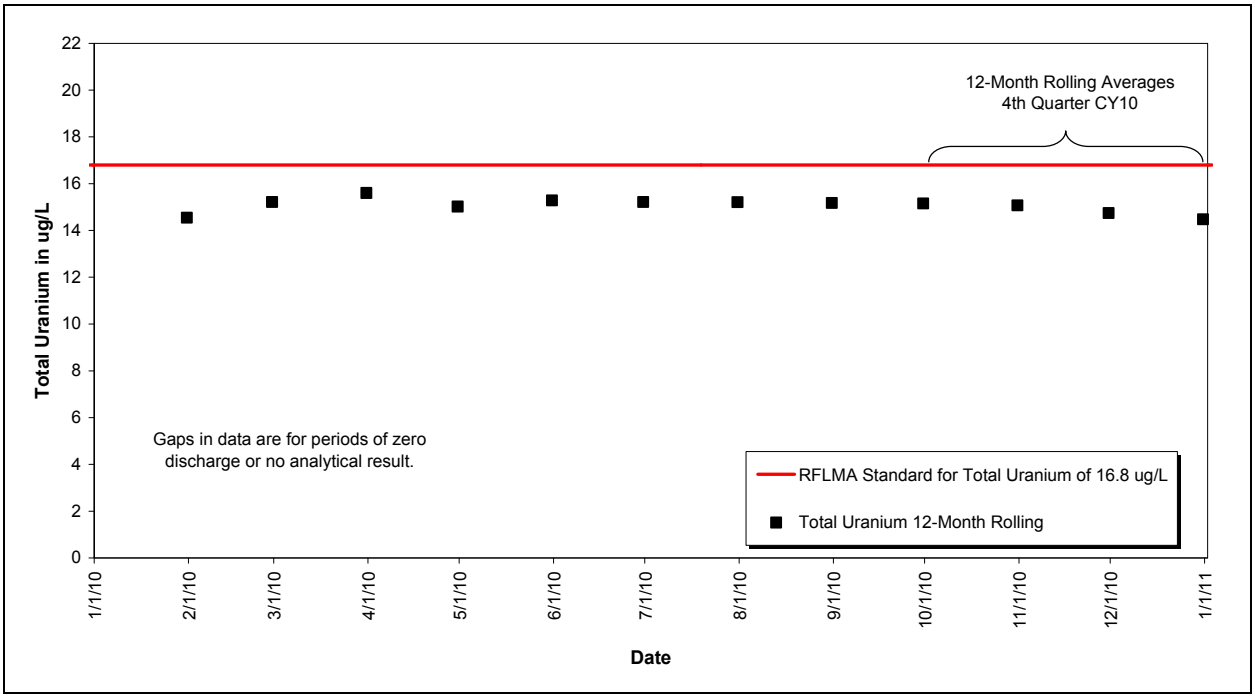


Figure 33. Volume-Weighted Average Total U Compliance Values at GS10: Calendar Year Ending Fourth Quarter CY 2010

Figure 34 and Figure 35 show similar data for the entire post-closure period.

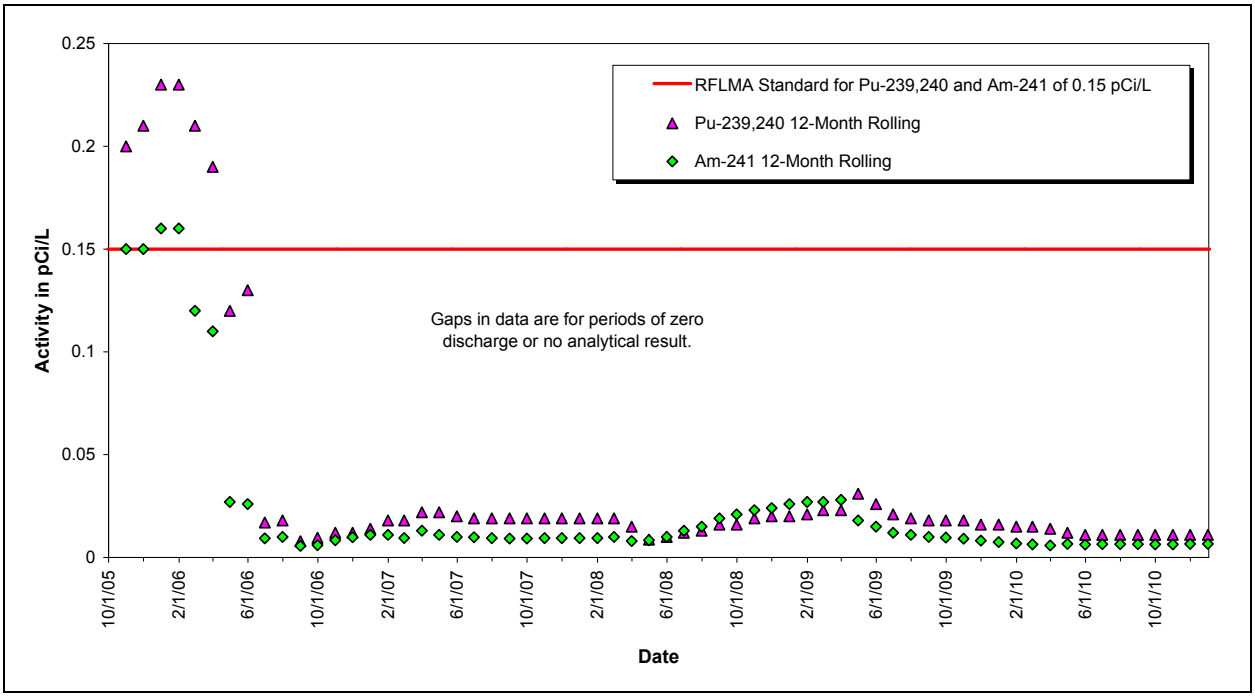


Figure 34. Volume-Weighted Average Pu and Am Compliance Values at GS10: Post-Closure Period

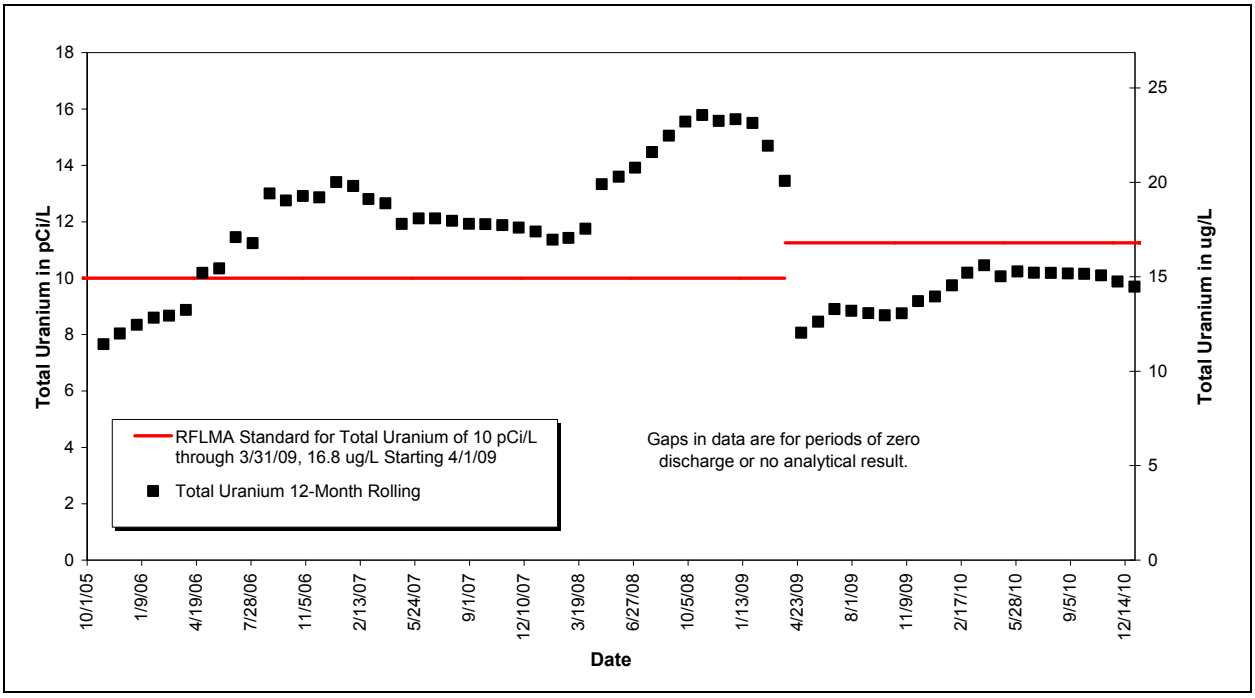


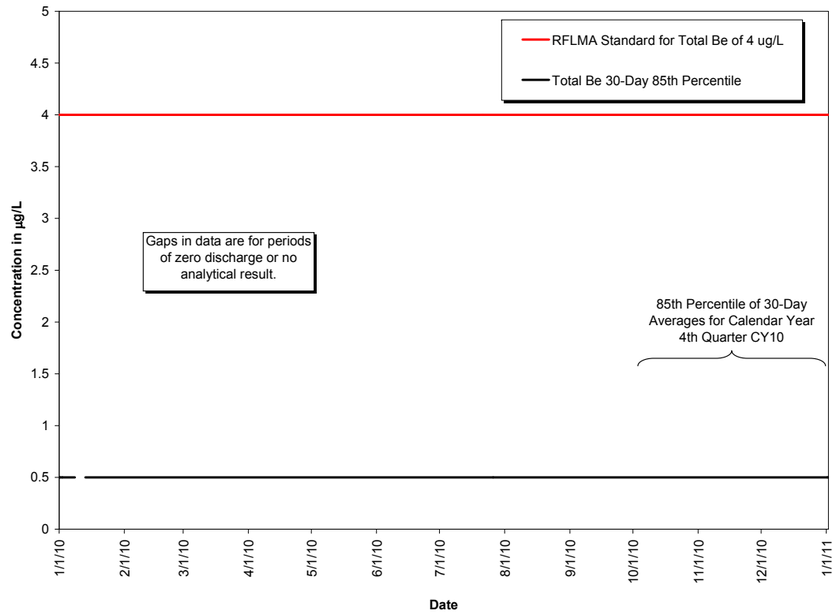
Figure 35. Volume-Weighted Average Total U Compliance Values at GS10: Post-Closure Period

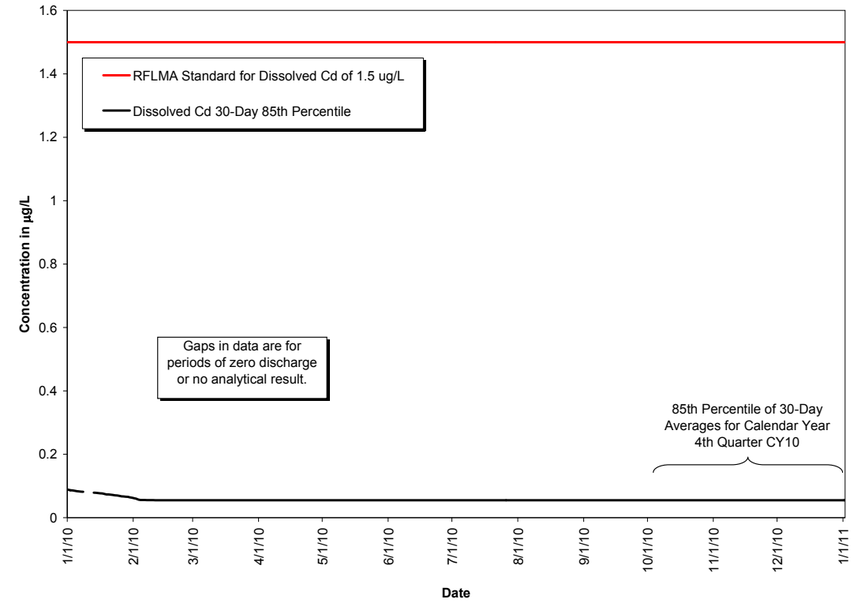
Table 12 shows that all of the annual average metals concentrations were less than the standards/PQLs. Additionally, the long-term metals averages (1997−2010) were all less than the RFLMA standards/PQLs. Figure 36 shows that none of the 85th percentile 30-day average metals concentrations were reportable for the year.

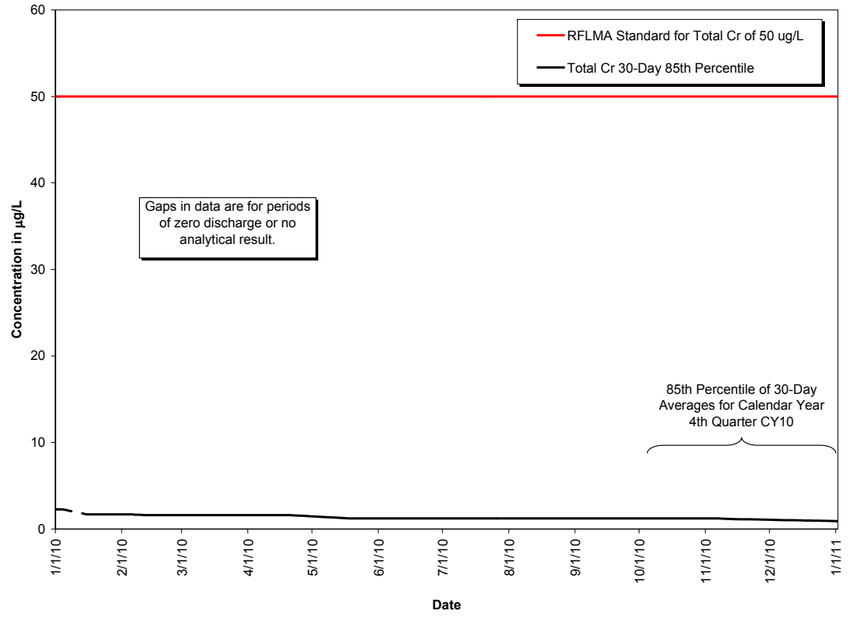
Table 12. Annual Volume-Weighted Average Hardness and Metals Concentrations at GS10 for 1997−2010

Calendar Year	Volume-Weighted Average Concentration (µg/L)				
	Hardness (mg/L)	Total Be	Dissolved Cd	Total Cr	Dissolved Ag
1997	138	0.50	0.09	4.05	0.11
1998	162	0.15	0.13	3.32	0.20
1999	139	0.16	0.07	4.08	0.15
2000	181	0.21	0.11	3.65	0.11
2001	222	0.32	0.11	5.95	0.11
2002	277	0.24	0.09	5.38	0.10
2003	228	0.22	0.10	6.91	0.12
2004	227	0.60	0.10	13.1	0.13
2005	401	0.88	0.06	17.5	0.15
2006	604	0.50	0.05	0.74	0.10
2007	383	0.50	0.10	0.89	0.10
2008	517	0.45	0.07	1.20	0.09
2009	351	0.50	0.06	1.69	0.10
2010	314	0.50	0.06	1.00	0.10
Total (1997−2010)	229	0.36	0.09	5.58	0.13

Ag = silver
Be = beryllium
Cd = cadmium
Cr = chromium







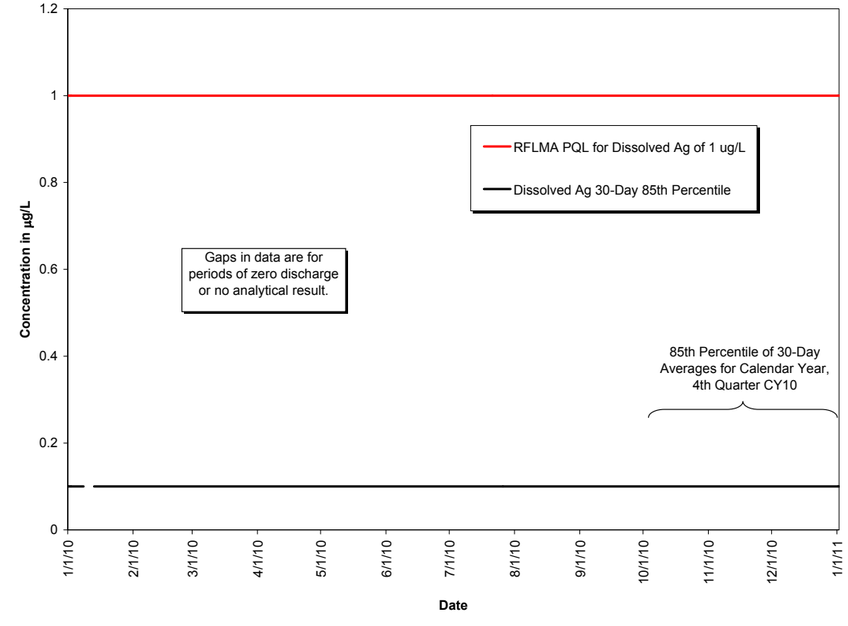


Figure 36. Volume-Weighted Average Metals Compliance Values at GS10: Calendar Year Ending Fourth Quarter CY 2010

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Location SW027

Monitoring location SW027 is located at the end of the SID at the inlet to Pond C-2 (Figure 31). The southern portion of the COU contributes flow to SW027 through the SID.

Table 13 shows that the majority of the annual average Pu and Am activities are less than 0.15 pCi/L. The significant increase in 2004 was the result of increased solids transport from disturbed areas associated with the 903 Pad/Lip accelerated actions. However, a measurable reduction in both Pu and Am activities has been observed following completion of accelerated actions in the drainage. With the completion of the 903 Pad/Lip actions, implementation of enhanced erosion controls, revegetation, soil stabilization, and lack of substantial runoff, transport of Pu and Am has been significantly reduced. The total U annual average concentrations are well below 16.8 µg/L.

Table 13. Annual Volume-Weighted Average Radionuclide Activities at SW027 for 1997−2010

Calendar Year	Volume-Weighted Average		
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)
1997	0.008	0.036	2.46
1998	0.021	0.156	5.99
1999	0.019	0.066	3.15
2000	0.060	0.348	1.62
2001	0.006	0.025	2.17
2002	0.001	0.003	0.87
2003	0.011	0.080	2.80
2004	0.413	2.273	1.55
2005	0.022	0.156	3.91
2006	NA (no flow)	NA (no flow)	NA (no flow)
2007	0.040	0.092	2.78
2008	NA (no flow)	NA (no flow)	NA (no flow)
2009	0.015	0.092	3.07
2010	0.027	0.155	4.73
Total (1997−2010)	0.056	0.305	3.11

Note: NA = not applicable.

Figure 37 shows that the 12-month rolling average for plutonium exceeds the RFLMA standard of 0.15 pCi/L. The composite sampling results for plutonium at SW027 collected during CY 2010 are given in Table 14. All other analytes were not reportable during the quarter.

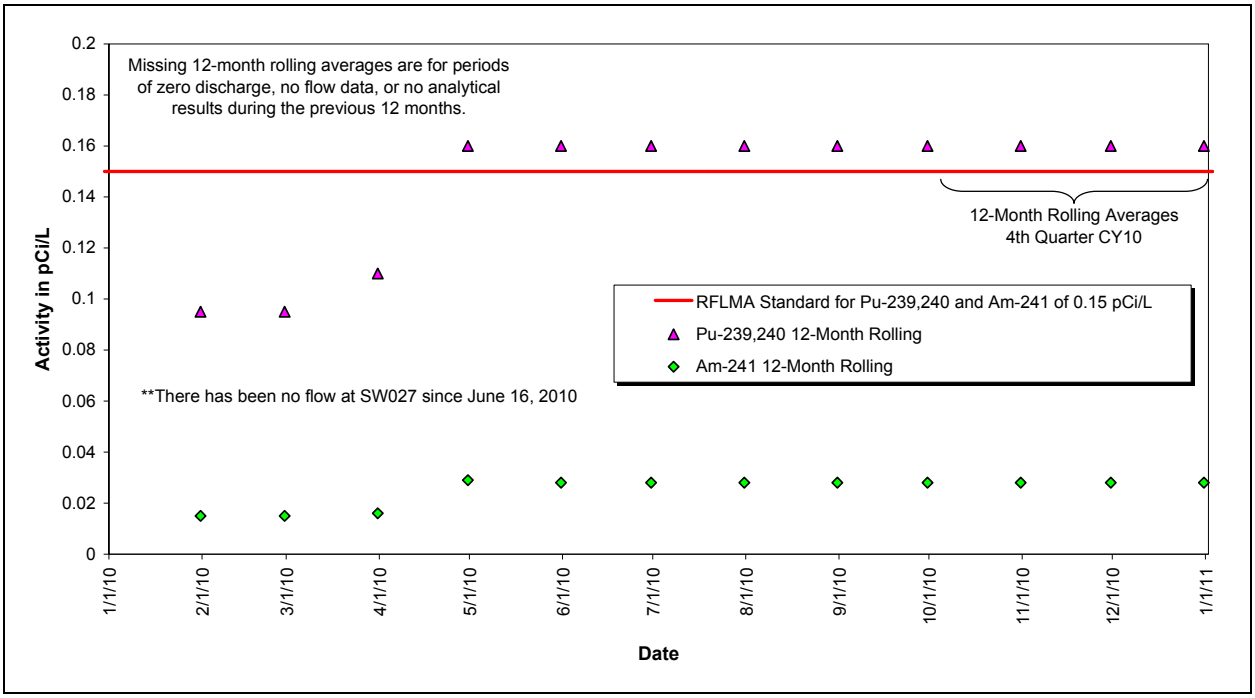

Figure 37. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at SW027: Calendar Year Ending Fourth Quarter CY 2010

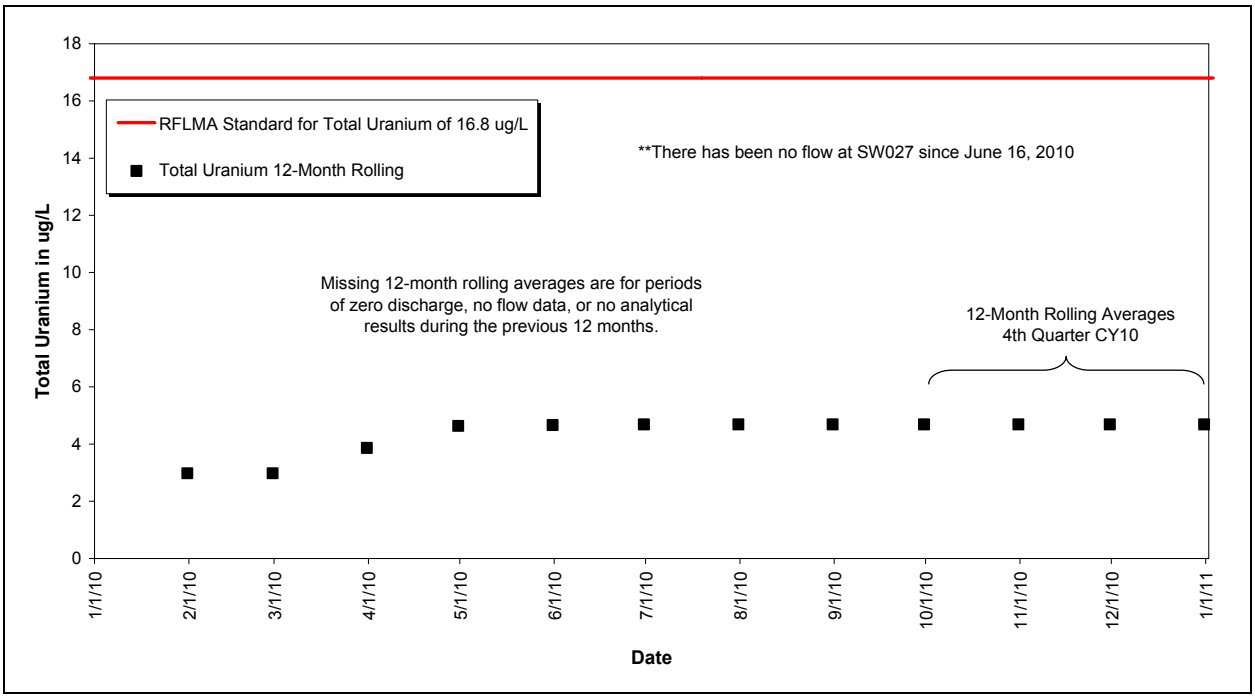

Figure 38. Volume-Weighted 12-Month Rolling Average Total U Activities at SW027: Calendar Year Ending Fourth Quarter CY 2010

Table 14. CY 2010 Composite Sampling Results for Plutonium for SW027

Date—Time Start	Date—Time End	Plutonium Result (µg/L)
1/13/10—11:11	3/29/10—11:55	0.122
3/29/10—11:55	4/23/10—11:11	0.300
4/23/10—11:11	4/23/10—19:12	0.294
4/23/10—19:12	4/27/10—12:07	0.029
4/27/10—12:07	10/4/10—12:39	0.040
10/4/10—12:39	2/17/11—9:23	NSQ

Notes: There was no flow at SW027 during the 10/4/10–2/17/11 composite sampling period; therefore there are no analytical results.

While the 12-month rolling average values could not be formally calculated until complete analytical results were available for the April 27–October 4, 2010, sample, DOE initiated preemptive consultation with CDPHE on June 2, 2010. RFLMA Contact Record 2010-06, "Monitoring Results at Surface Water Point of Evaluation (POE) SW027," provides a discussion of the monitoring results and recaps the outcome of the RFLMA Parties' consultation regarding steps to be taken to evaluate the SW027 drainage area. Contact Record 2010-06 is available on the Rocky Flats website, http://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

Subsequent to Contact Record 2010-06, the *Report of Steps Taken Regarding Monitoring Results at Surface Water Point of Evaluation (POE) SW027* was completed on August 31, 2010. This report provides data evaluation and an update on the steps taken in accordance with Contact Record 2010-06. Recommendations beyond the actions already taken and discussed in the Contact Record are also provided. The August 31, 2010, report on the status of actions related to evaluation of the conditions is included in Appendix G with Contact Record 2010-02. This report is also available on the Rocky Flats website, http://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

The recommendations in the evaluation included installing additional erosion control wattles in locations along the hillside north of the SID, installing permanent erosion blankets, and reseeding three areas in the SID. This work was successfully completed on December 20, 2010. Approximately 2,560 linear feet of Filtrexx wattles and 8,452 square feet of permanent erosion matting were installed.

Figure 39 and Figure 40 show similar data for the entire post-closure period.

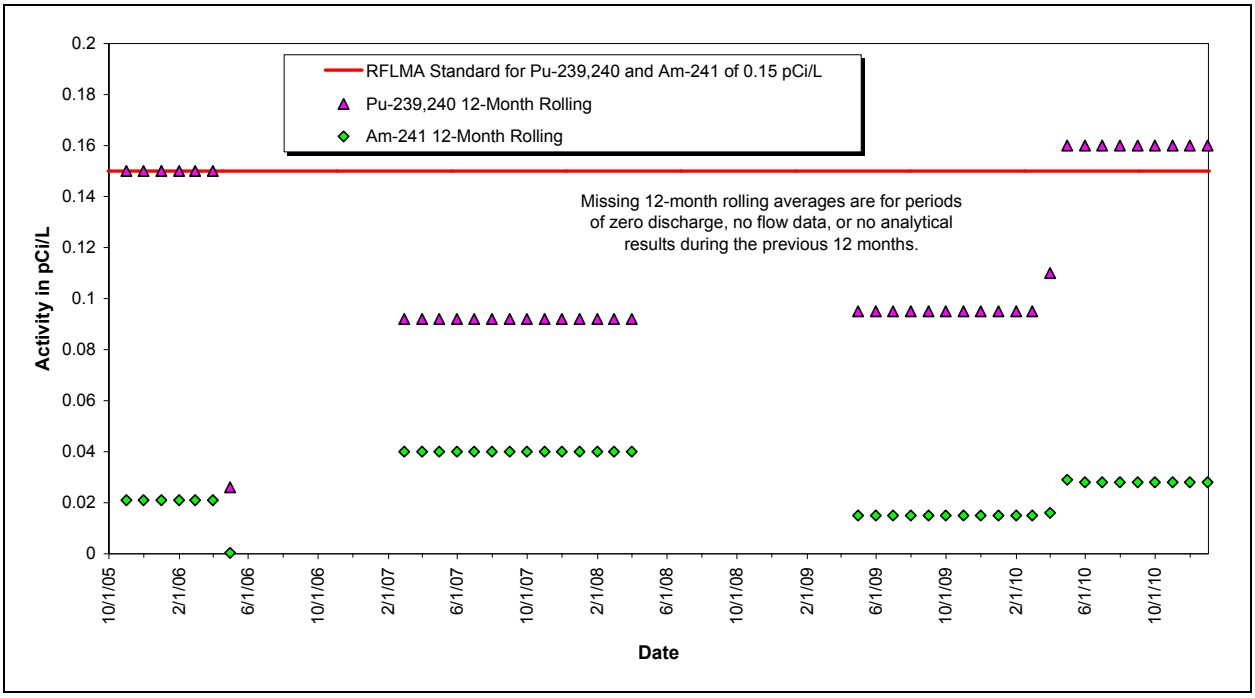

Figure 39. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at SW027: Post-Closure Period

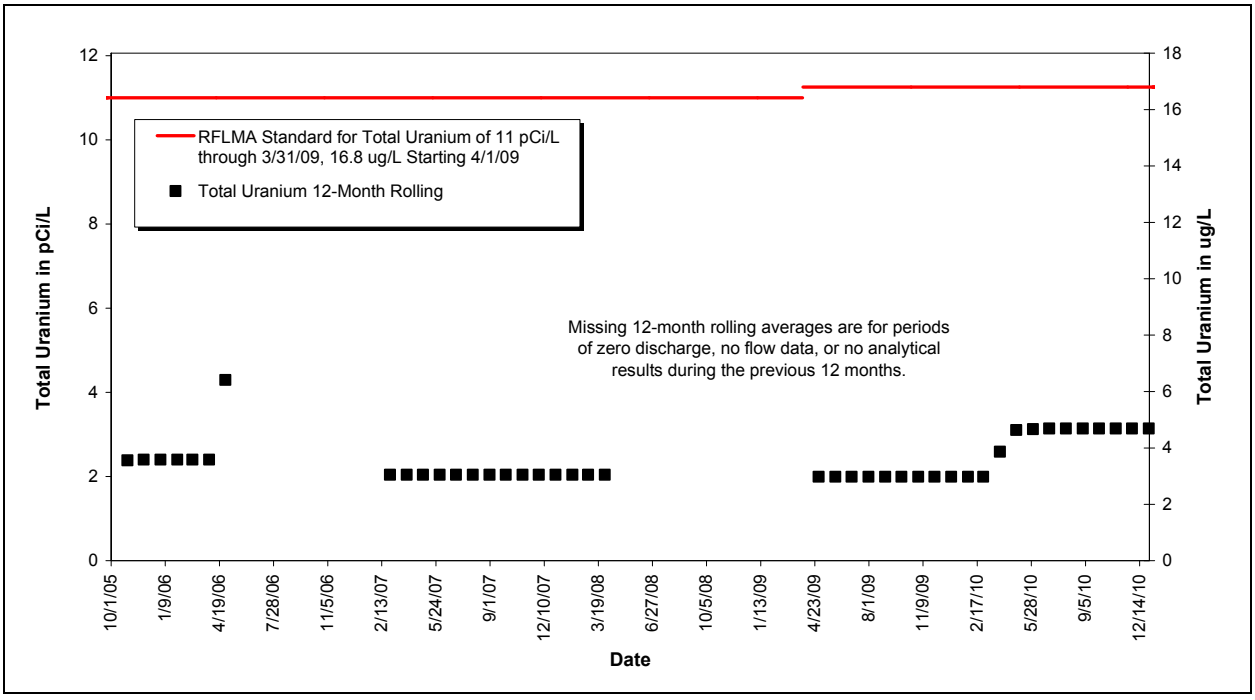

Figure 40. Volume-Weighted 12-Month Rolling Average Total U Activities at SW027: Post-Closure Period

Table 15 shows that all of the annual average metals concentrations are less than the standards/PQLs. Additionally, the long-term metals averages (1997−2010) are less than the standards/PQLs. Figure 41 shows that none of the 85th percentile 30-day average metals concentrations were reportable for the year.

Table 15. Annual Volume-Weighted Average Hardness and Metals Concentrations at SW027 for 1997−2010

Calendar Year	Volume-Weighted Average Concentration (µg/L)				
	Hardness (mg/L)	Total Be	Dissolved Cd	Total Cr	Dissolved Ag
1997	112	0.44	0.09	1.71	0.10
1998	152	0.14	0.15	0.91	0.21
1999	111	0.03	0.10	1.55	0.24
2000	150	0.27	0.05	4.14	0.09
2001	145	0.23	0.07	1.82	0.12
2002	114	0.12	0.05	2.88	0.11
2003	148	0.06	0.06	1.75	0.15
2004	133	0.32	0.06	7.36	0.19
2005	236	0.08	0.07	2.03	0.19
2006	NA (no flow)	NA (no flow)	NA (no flow)	NA (no flow)	NA (no flow)
2007	133	0.50	0.05	0.50	0.10
2008	NA (no flow)	NA (no flow)	NA (no flow)	NA (no flow)	NA (no flow)
2009	139	0.50	0.06	1.15	0.10
2010	154	0.50	0.06	1.16	0.10
Total (1997−2010)	138	0.23	0.08	2.19	0.16

NA = not applicable.
Ag = silver Be = beryllium Cd = cadmium Cr = chromium

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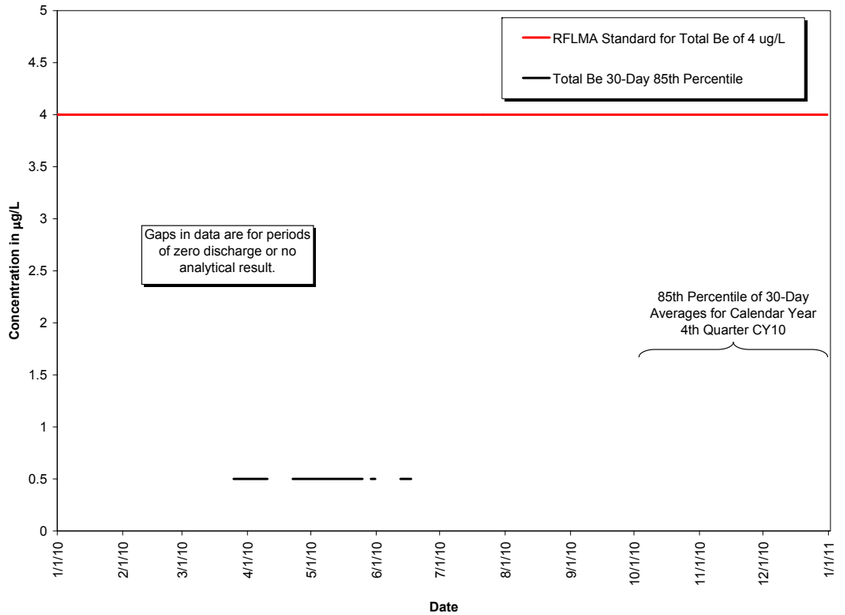

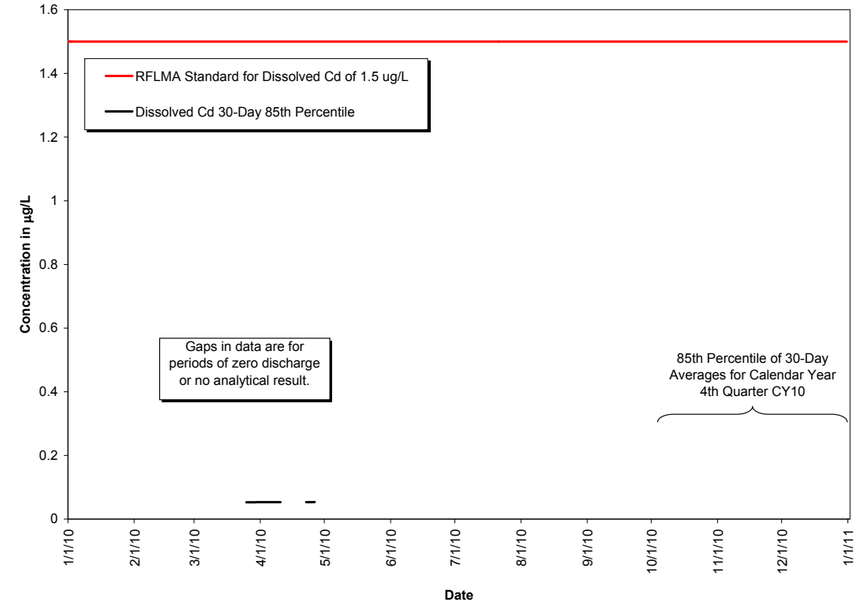

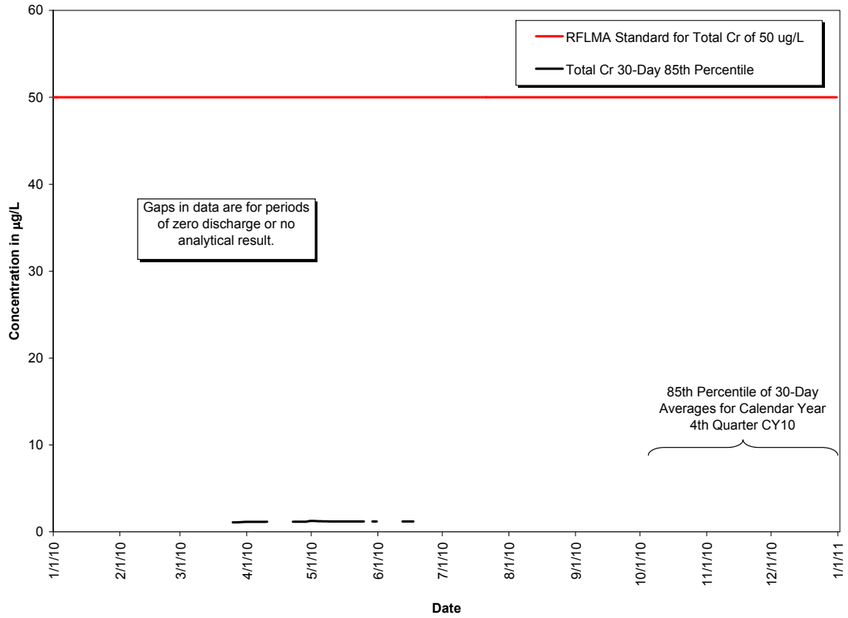

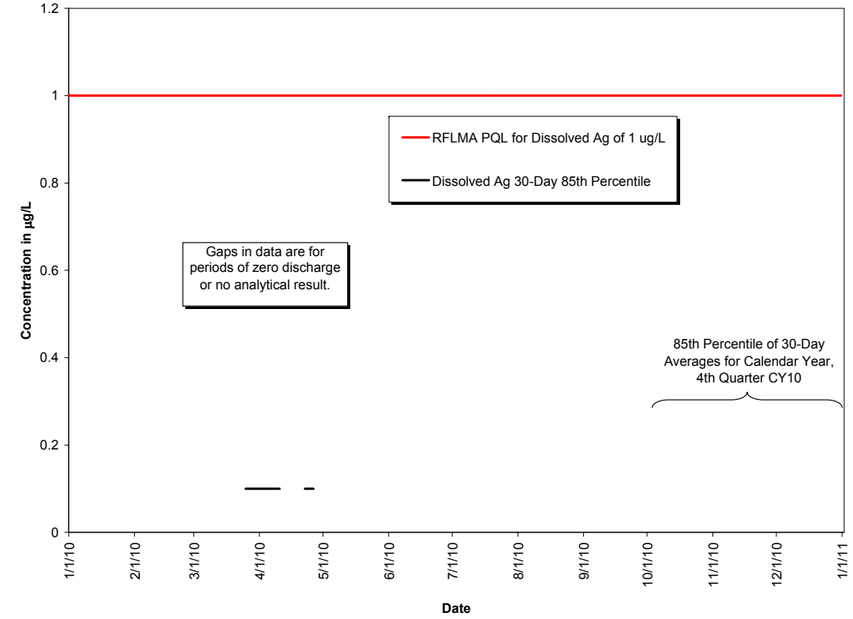

Figure 41. Volume-Weighted Average Metals Compliance Values at SW027: Calendar Year Ending Fourth Quarter CY 2010

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Location SW093

Monitoring location SW093 is located on North Walnut Creek 1,300 feet upstream of the A-Series Ponds (Figure 31). The northern portion of the COU contributes flow to SW093 through FC-2 and FC-3.

Table 16 shows that the majority of the annual average Pu and Am activities are below 0.15 pCi/L. Additionally, the long-term Pu and Am averages (1997−2010) are below 0.15 pCi/L. The total U annual average concentrations are well below 16.8 µg/L.

Table 16 indicates an increase in Pu and Am activities during 2004. However, a significant reduction in both Pu and Am activities has been observed following Site closure. With the completion of the FCs, implementation of enhanced erosion controls, revegetation, soil stabilization, and lack of substantial runoff, transport of Pu and Am has been virtually eliminated. Figure 42 and Figure 43 show no reportable Pu, Am, or total U values during the year.

Table 16. Annual Volume-Weighted Average Radionuclide Activities at SW093 for 1997−2010

Calendar Year	Volume-Weighted Average		
	Am-241 (pCi/L)	Pu-239,240 (pCi/L)	Total U (µg/L)
1997	0.035	0.052	3.84
1998	0.020	0.022	3.51
1999	0.025	0.038	3.02
2000	0.022	0.040	3.12
2001	0.011	0.015	3.12
2002	0.017	0.006	4.24
2003	0.039	0.056	3.19
2004	0.622	0.603	3.67
2005	0.029	0.022	5.55
2006	0.004	0.008	8.00
2007	0.009	0.011	4.85
2008	0.034	0.061	10.06
2009	0.007	0.016	5.67
2010	0.008	0.008	7.28
Total (1997−2010)	0.069	0.074	4.10

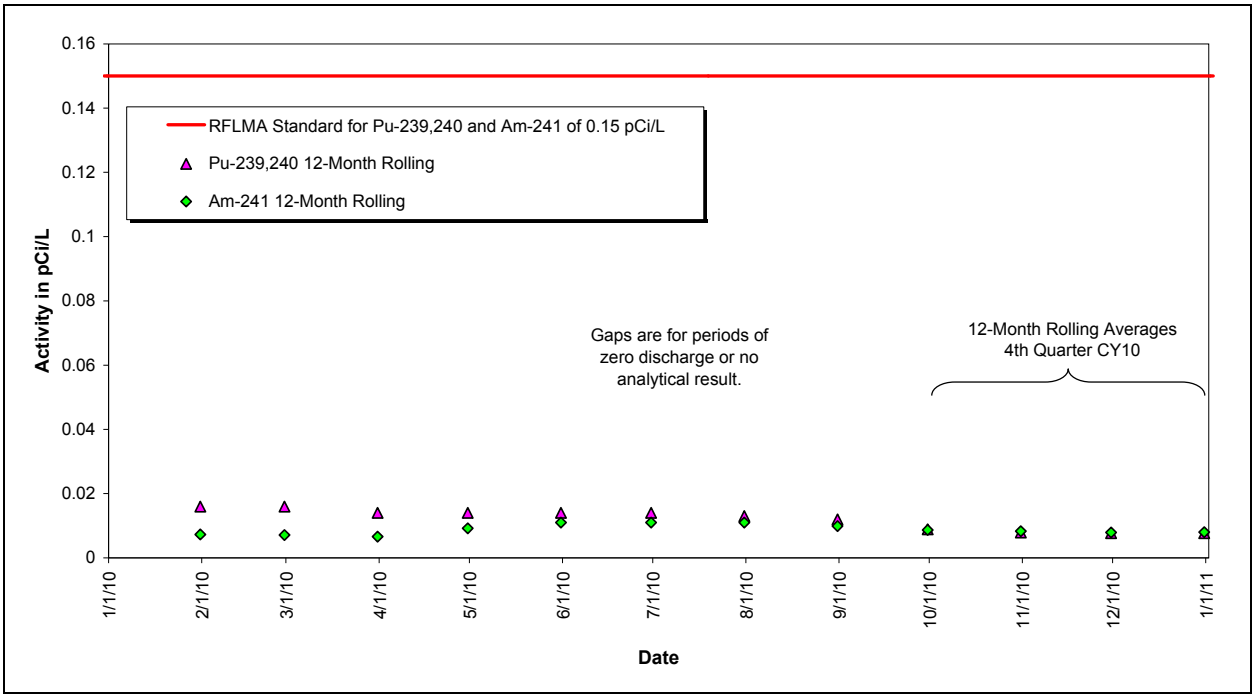

Figure 42. Volume-Weighted Average Pu and Am Compliance Values at SW093: Calendar Year Ending Fourth Quarter CY 2010

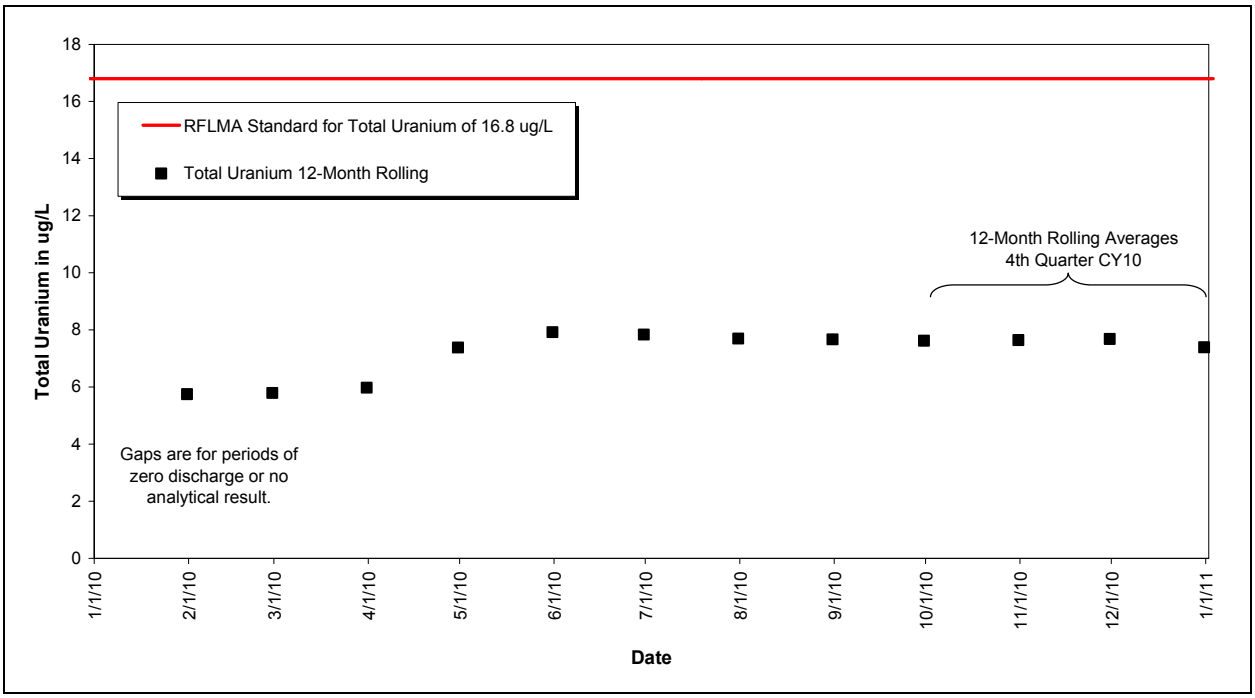

Figure 43. Volume-Weighted Average Total U Compliance Values at SW093: Calendar Year Ending Fourth Quarter CY 2010

Figure 44 and Figure 45 show similar data for the entire post-closure period.

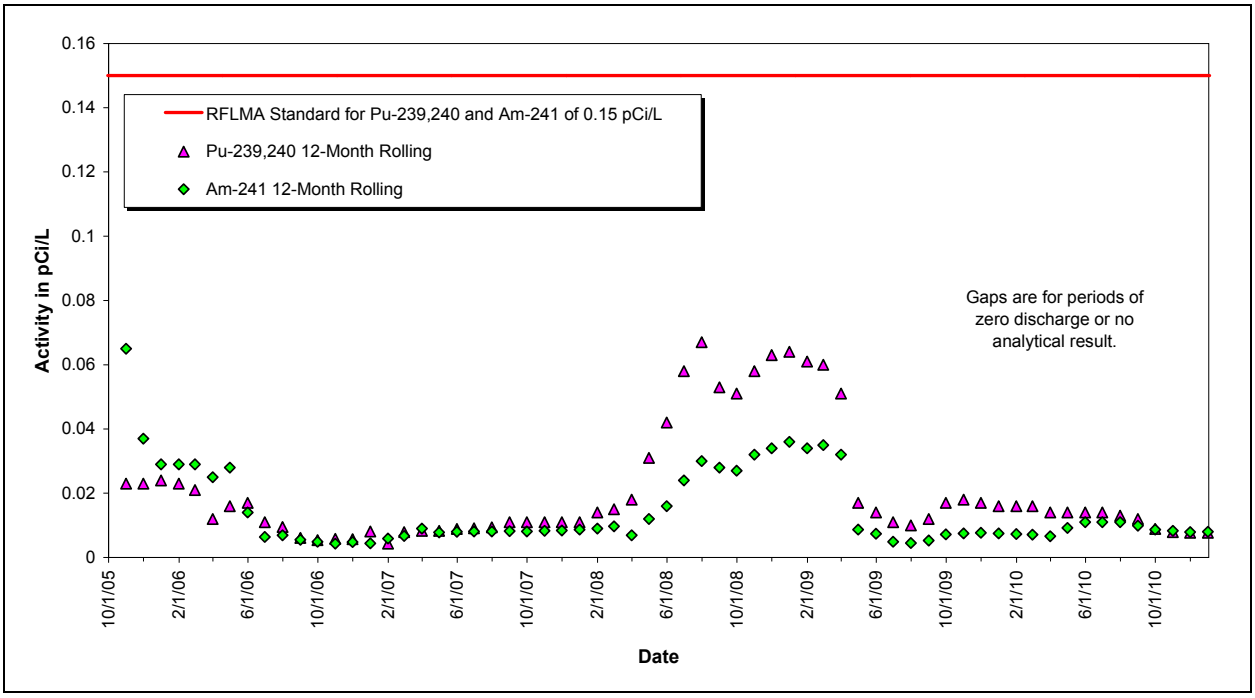

Figure 44. Volume-Weighted Average Pu and Am Compliance Values at SW093: Post-Closure Period

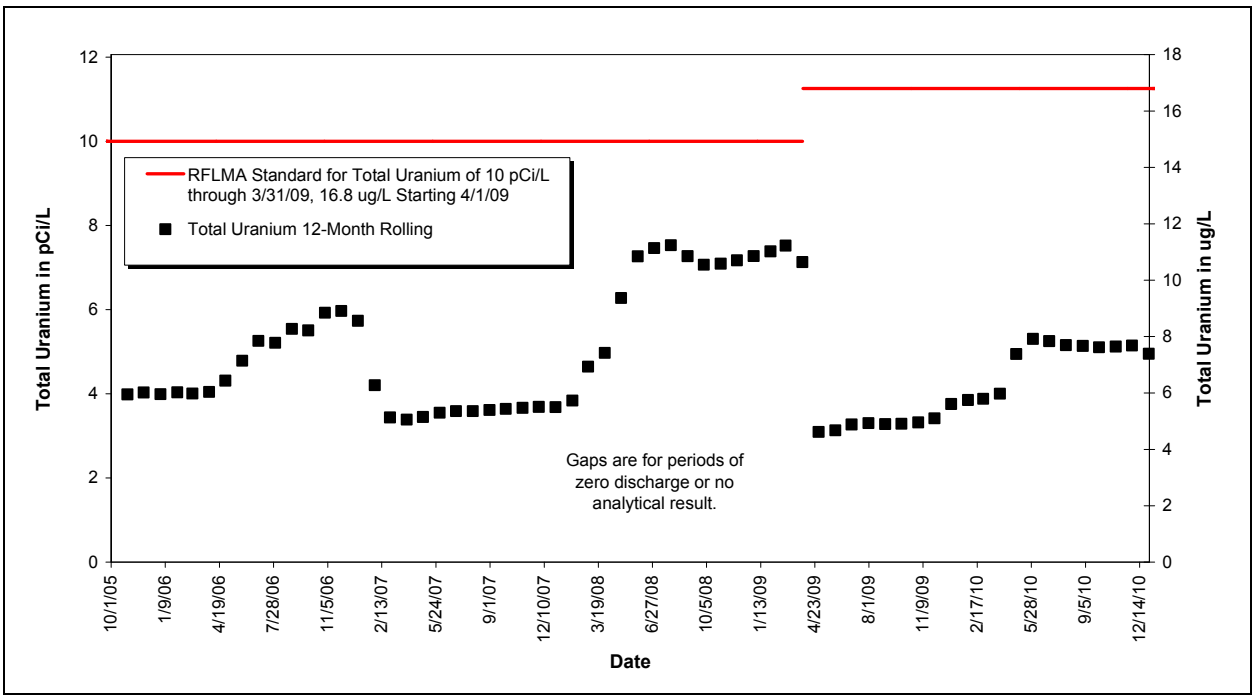

Figure 45. Volume-Weighted Average Total U Compliance Values at SW093: Post-Closure Period

Table 17 shows that all of the annual average metals concentrations are less than the standards/PQLs. Additionally, the long-term metals averages (1997−2010) are less than the standards/PQLs. Figure 46 shows that none of the 85th percentile 30-day average metals concentrations were reportable for the year.

Table 17. Annual Volume-Weighted Average Hardness and Metals Concentrations at SW093 for 1997–2010

Calendar Year	Volume-Weighted Average Concentration (µg/L)				
	Hardness (mg/L)	Total Be	Dissolved Cd	Total Cr	Dissolved Ag
1997	168	0.43	0.07	2.36	0.12
1998	184	0.14	0.23	2.22	0.22
1999	152	0.20	0.13	5.08	0.16
2000	231	0.21	0.08	3.94	0.11
2001	247	0.36	0.07	6.49	0.11
2002	365	0.30	0.08	5.95	0.11
2003	257	0.29	0.09	6.88	0.16
2004	315	0.57	0.09	12.05	0.12
2005	337	0.11	0.05	1.92	0.11
2006	564	0.50	0.05	0.82	0.10
2007	287	0.50	0.06	0.82	0.10
2008	552	0.50	0.07	1.84	0.10
2009	295	0.50	0.06	2.23	0.10
2010	231	0.50	0.06	1.15	0.10
Total (1997−2010)	245	0.33	0.10	4.37	0.13

Ag = silver Cd = cadmium Be = beryllium Cr = chromium

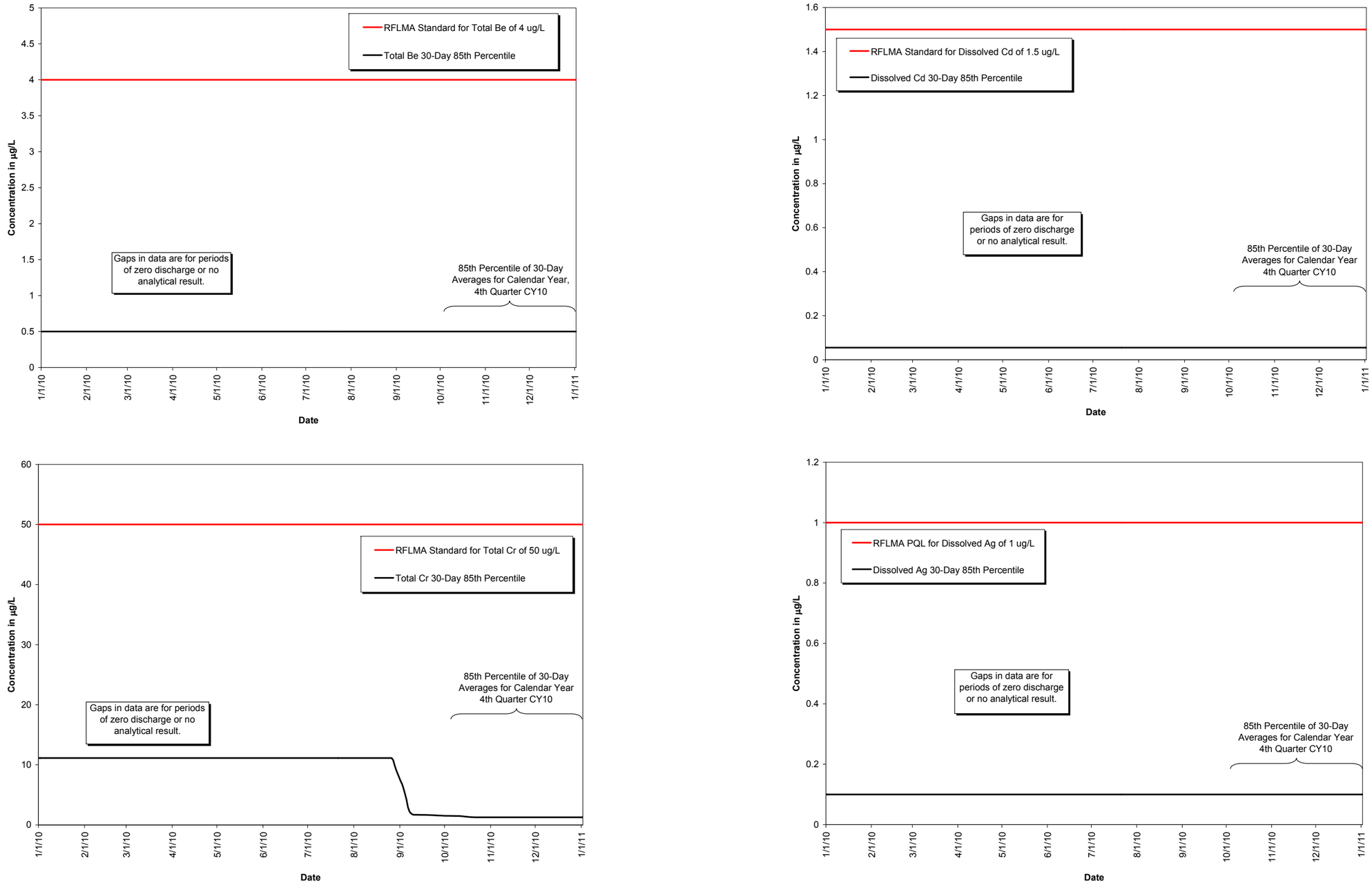

Figure 46. Volume-Weighted Average Metals Compliance Values at SW093: Calendar Year Ending Fourth Quarter CY 2010

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3.1.2.3 AOC Wells and SW018

AOC wells (Table 18 and Figure 47) are located to evaluate potential groundwater impacts to surface water. Surface Water Support location SW018 is located to assess groundwater impacts from specific source areas on surface water. Impacts are based on a minimum of two routinely scheduled sampling events in a row, not on a single data point. Analytical results from AOC wells are compared directly against the appropriate surface-water standards in Table 1 of RFLMA Attachment 2 or the RFLMA U groundwater threshold value of 120 µg/L. Analytical data from surface-water performance location SW018, where grab samples for volatile organic compounds (VOCs) are collected to support groundwater objectives, are assessed in a manner similar to data from AOC wells.

Table 18. Sampling and Data Evaluation Protocols at AOC Wells and SW018

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
00193	Woman Creek upstream of Pond C-2	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 7 in Appendix D
00997	South Walnut Creek upstream of Pond B-5	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
10304	Southeast of 903 Pad/Ryan's Pit Plume at Woman Creek	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
10594	North Walnut Creek downstream of Pond A-1	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
11104	Downgradient, downstream	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 7 in Appendix D
4087	Below Landfill Pond	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
42505	Terminus of FC-2	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 7 in Appendix D
89104	Downgradient at Woman Creek	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 7 in Appendix D
B206989	Below Landfill Pond	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
SW018	FC-2 west of former Building 771 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 7 in Appendix D

Notes: [a] Samples for the analysis of U are field-filtered using a 0.45-micrometer in-line filter.
Nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only (standard is also nitrate+nitrite as N).

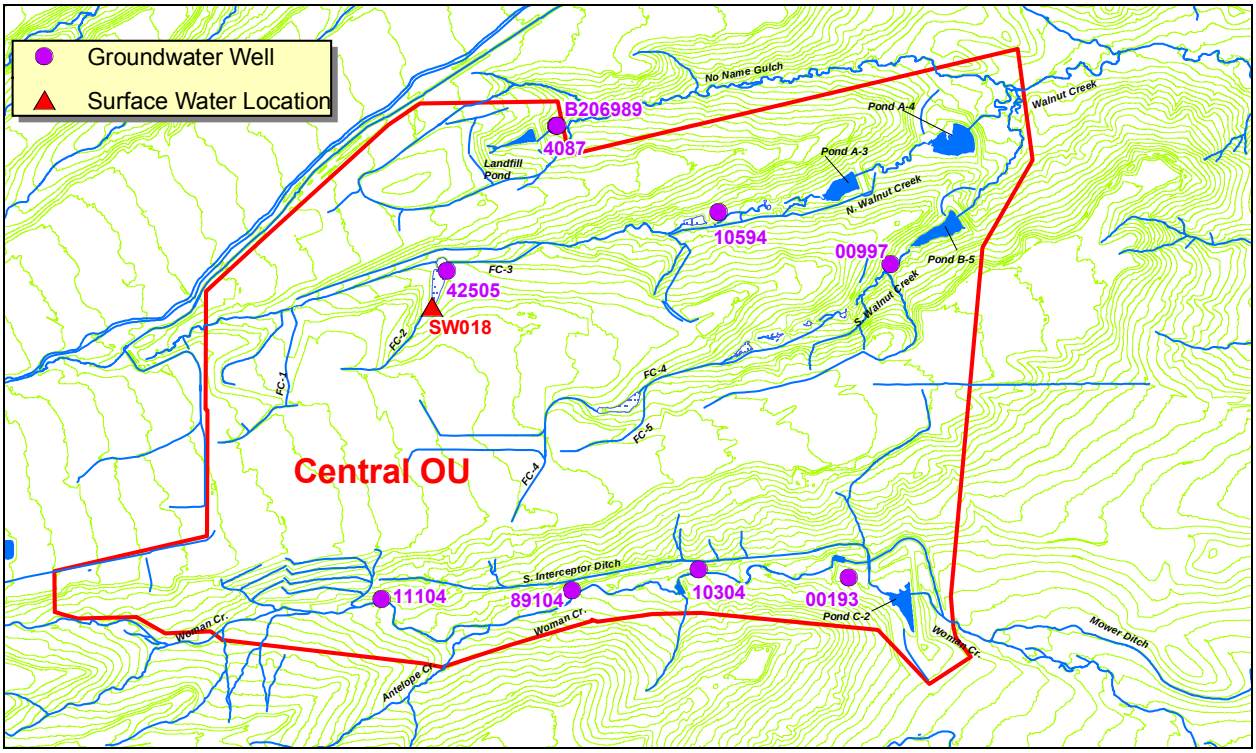


Figure 47. AOC Well and SW018 Locations

Data Evaluation

All AOC wells and SW018 were scheduled for routine monitoring in the fourth quarter of CY 2010. No decision criteria were triggered by the associated analytical results (Appendix B), which were generally consistent with previous data save for the exception discussed below for well B206989. Monitoring will continue as prescribed in RFLMA (DOE 2007a).

A reportable condition was encountered for AOC well B206989 in August 2007 (see corresponding RFLMA Contact Record 2007-06) due to elevated concentrations of nitrate in groundwater samples from this well. The fourth-quarter 2010 result was 5.7 mg/L. Updated S-K trend calculations for this well are provided in Appendix B and summarized in Section 3.1.5.3. Consistent with the results obtained in 2009, the 2010 analytical data continue to support a decreasing trend in nitrate concentrations at well B206989 that has a 95 percent level of significance. Refer to Section 3.1.5.3 for additional discussion.

3.1.2.4 Boundary Wells

Boundary wells (Table 19and Figure 48) are located at the Walnut Creek/Indiana Street and Woman Creek/Indiana Street intersections. These locations are far from contaminant source areas and well outside the actual Site (as defined by the COU). They meet no technical monitoring objectives.

Monitoring the Boundary wells is not required by the CAD/ROD. However, they have been retained in the monitoring network to provide additional assurance to local stakeholders that groundwater quality at the downgradient edge of federal government property does not pose a

significant threat to human health and the environment. These wells are included in the network as part of the operational monitoring in RFLMA.

Table 19. Sampling and Data Evaluation Protocols at Boundary Wells

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
10394	Woman Creek at Indiana Street	Annual grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D
41691	Walnut Creek at Indiana Street	Annual grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 7 in Appendix D

Notes: [a] Samples for the analysis of U are field-filtered using a 0.45-micrometer in-line filter.
Nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only.

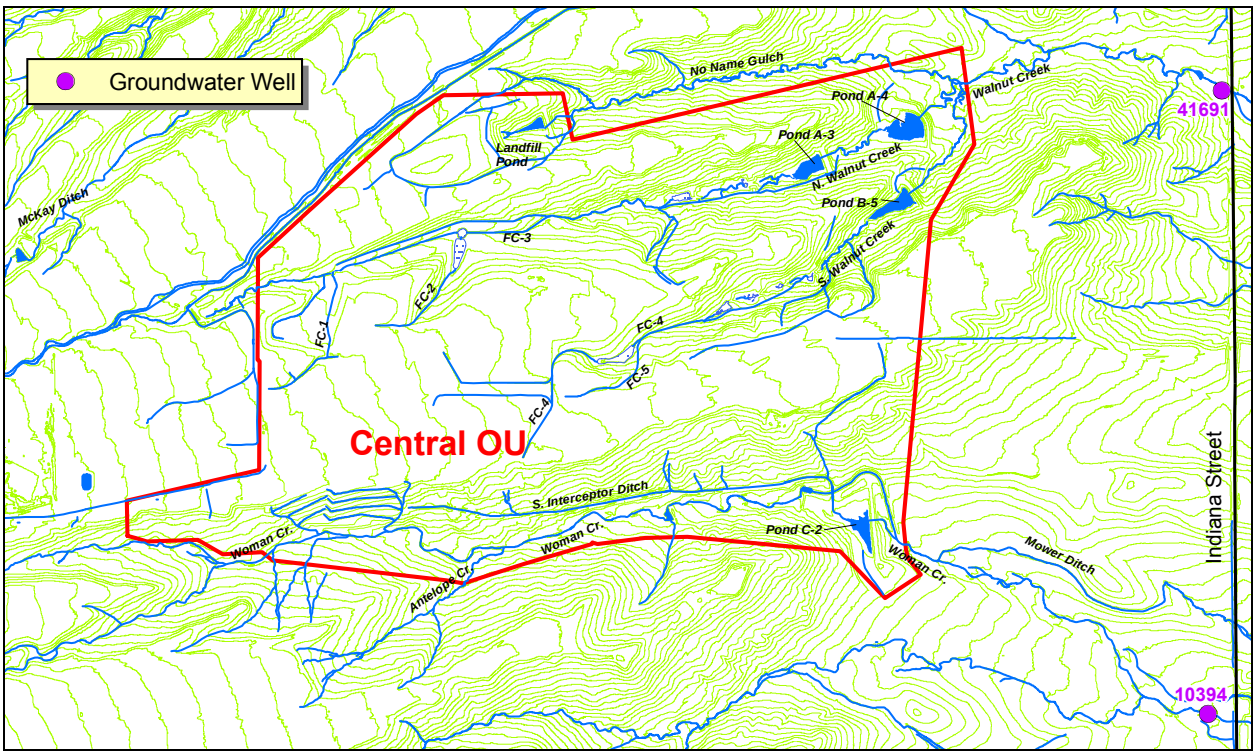


Figure 48. Boundary Well Locations

Data Evaluation

Boundary wells were not scheduled for sampling in the fourth quarter of CY 2010.

3.1.2.5 Sentinel Wells

Sentinel wells (Table 20 and Figure 49) are located near downgradient edges of contaminant plumes, in drainages, at groundwater treatment systems, and along contaminant pathways to surface water. These wells are monitored to determine whether concentrations of contaminants are increasing, thereby providing advance warning of potential groundwater-quality impacts to the downgradient AOC wells. Confirmation of a potential impact to downgradient wells will

require an analytical record that consistently indicates an impact, not a single data point that indicates that a contaminant has been detected.

Sentinel wells are used to monitor the performance of an accelerated action (including soil and source removals, in situ contaminant plume treatment, groundwater intercept components of treatment systems, and facility demolitions) and assess contaminant trends at important locations. Data from Sentinel wells are supplemented by those from Evaluation wells and are used to determine when monitoring may cease or additional remedial work should be considered.

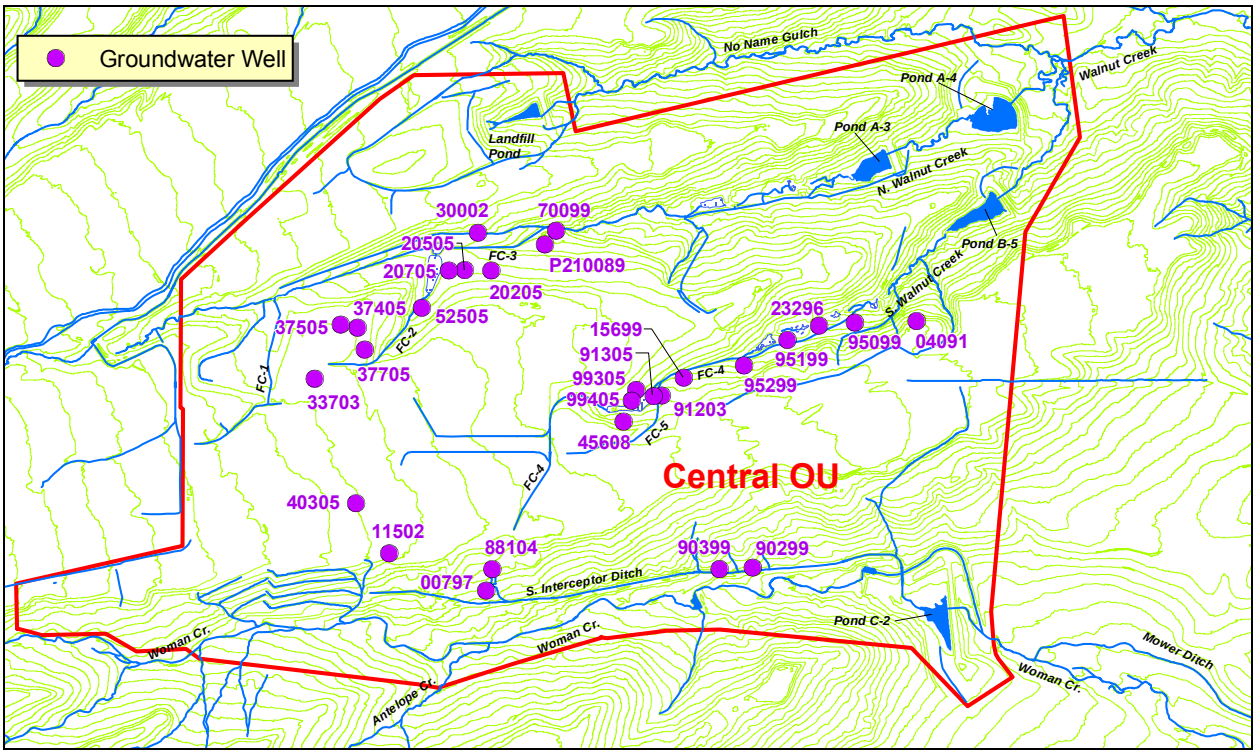
Table 20. Sampling and Data Evaluation Protocols at Sentinel Wells

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
00797	South of former Building 881 (B881) area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 8 in Appendix D
04091	East of source area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
11502	Southeast of former B444 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 8 in Appendix D
15699	Downgradient of MSPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
20205	North/northeast of former B771/774 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, Pu, Am	See Figure 8 in Appendix D
20505	North of former B771/774 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, Pu, Am	See Figure 8 in Appendix D
20705	North/northwest of former B771 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate, Pu, Am	See Figure 8 in Appendix D
23296	Downgradient of ETPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 8 in Appendix D
30002	Downgradient at North Walnut Creek	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
33703	Downgradient of source area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
37405	North/northeast part of former B371/374 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate, Pu, Am	See Figure 8 in Appendix D
37505	North part of former B371 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 8 in Appendix D
37705	East/southeast of former B371/374 area at foundation drain confluence	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate, Pu, Am	See Figure 8 in Appendix D
40305	East part of former B444 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 8 in Appendix D

Table 20 (continued). Sampling and Data Evaluation Protocols at Sentinel Wells

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
45608	Adjacent to remnants of SW056 French drain and drain interruption	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
52505	West of former IHSS 118.1 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
70099	Northwest (side-gradient) of SPPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	U, nitrate	See Figure 8 in Appendix D
88104	South part of former B881 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U	See Figure 8 in Appendix D
90299	Southeast part of 903 Pad/Ryan's Pit Plume at SID	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
90399	Southeast part of 903 Pad/Ryan's Pit Plume at SID	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
91203	Downgradient of Oil Burn Pit (OBP) #2 source area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
91305	South of confluence of FC-4 and FC-5	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 8 in Appendix D
95099	Downgradient of ETPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
95199	Downgradient of ETPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
95299	Downgradient of ETPTS intercept trench	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 8 in Appendix D
99305	East part of former B991 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 8 in Appendix D
99405	Southeast part of former B991 area	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 8 in Appendix D
P210089	Downgradient (north) portion of SPP	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs, U, nitrate	See Figure 8 in Appendix D

Notes: [a] Samples for the analysis of U, Pu, and Am are field-filtered using a 0.45-micrometer in-line filter.
Nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only.
IHSS = Individual Hazardous Substance Site



Note: Well 45608 replaces the slump-damaged 45605, which was abandoned in the fourth quarter of CY 2007; refer to the 2007 Annual Report (DOE 2008c) for more information.

Figure 49. Sentinel Well Locations

Data Evaluation

All Sentinel wells were monitored in the fourth quarter of CY 2010 (refer to Appendix B for analytical results). Analytical data are generally consistent with previous results except for well 91203, which reported significantly higher concentrations of several VOCs in the fourth quarter of 2010. Although not required, for proactive reasons a confirmatory sample was collected in the same quarter and analyzed for VOCs. Results from this second sample were consistent with those from the first.

A result for trichloroethene (TCE) from well 23296 was called out in the 2007 Annual Report (DOE 2008c) because it was unusually low (8.5 µg/L) with respect to other data from this well. This condition has been repeated each year since, with the concentration of TCE in the fourth-quarter sample lower than that in the preceding, second-quarter sample. A similar pattern applies for other VOCs, such as tetrachloroethene (PCE), though the differences are generally not as marked.

Refer to Section 3.1.5.3 for additional discussion of these and other Sentinel well data, including statistical results, and Appendix B for trend plots.

3.1.2.6 Evaluation Wells

Evaluation wells (Table 21 and Figure 50) are located within groundwater contaminant plumes and near plume source areas, and within the interior of the COU at the Site. As such, they may

monitor the effects of accelerated actions that have been performed (e.g., source removal and in situ treatment). Data from these Evaluation wells are therefore appropriate to determine whether the monitoring of a particular plume and source area may cease, and provide data to support the determination of whether corresponding groundwater plume treatment systems may be decommissioned. In addition, Evaluation wells are used to support any groundwater evaluations that may be needed as a result of changing contaminant characteristics in downgradient Sentinel or AOC wells. Data from these wells also assist evaluations of predictions made through groundwater modeling efforts.

Table 21. Sampling and Data Evaluation Protocols at Evaluation Wells

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
00191	East of former 903 Pad area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
00203	Downgradient (south) portion of SPP	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
00491	Southeast of former 903 Pad area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
00897	Mound Site source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
3687	East Trenches source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
03991	East of East Trenches source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
05691	East Trenches source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
07391	Ryan's Pit source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
18199	North of former IHSS 118.1 source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
20902	Northwest of former IHSS 118.1 source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
21505	West of former B776/777 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
22205	Downgradient (north) portion of SPP	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
22996	East/northeast part of former B886 area	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
30900	PU&D Yard Plume source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
33502	OBP#1 source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
33604	OBP#1 source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
33905	North of former 231 Tanks area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
40005	West part of former B444 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
40205	South part of former B444 end	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
50299	East of former 903 Pad area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
51605	Downgradient, adjacent to GS13	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
55905	North part of former B559 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D

Table 21 (continued). Sampling and Data Evaluation Protocols at Evaluation Wells

Location Code	Location Description	Sample Types/Frequencies	Analytes[a]	Data Evaluation
56305	West part of former B559 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
70705	East part of former B707 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
79102	SPP source area—north	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
79202	SPP source area—north	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
79302	SPP source area—northeast	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
79402	SPP source area—northeast	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
79502	SPP source area—east	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
79605	SPP source area—east	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
88205	South part of former B881 area	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
891WEL	OU 1 Plume source area	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
90402	Southeast of former 903 Pad area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
90804	Southeast part of 903 Pad/Ryan's Pit Plume	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
91105	OBP#2 source area	Biennial grabs; second calendar quarter (high-water conditions)	U, nitrate	See Figure 9 in Appendix D
B210489	Downgradient of SPPTS	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
P210189	SEP-area VOC plume source area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
P208989	SPP source area—north	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U, nitrate	See Figure 9 in Appendix D
P114689	Southwest of former B559 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
P115589	West part of former B551 Warehouse area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs, U	See Figure 9 in Appendix D
P419689	Southeast of former B444 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D
P416889	Southeast of former B444 area	Biennial grabs; second calendar quarter (high-water conditions)	VOCs	See Figure 9 in Appendix D

Notes: [a] Samples for the analysis of U are field-filtered using a 0.45-micrometer in-line filter.
Nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only.
IHSS = Individual Hazardous Substance Site
OBP = Oil Burn Pit
PU&D = Property Utilization and Disposal
SEP = Solar Evaporation Pond

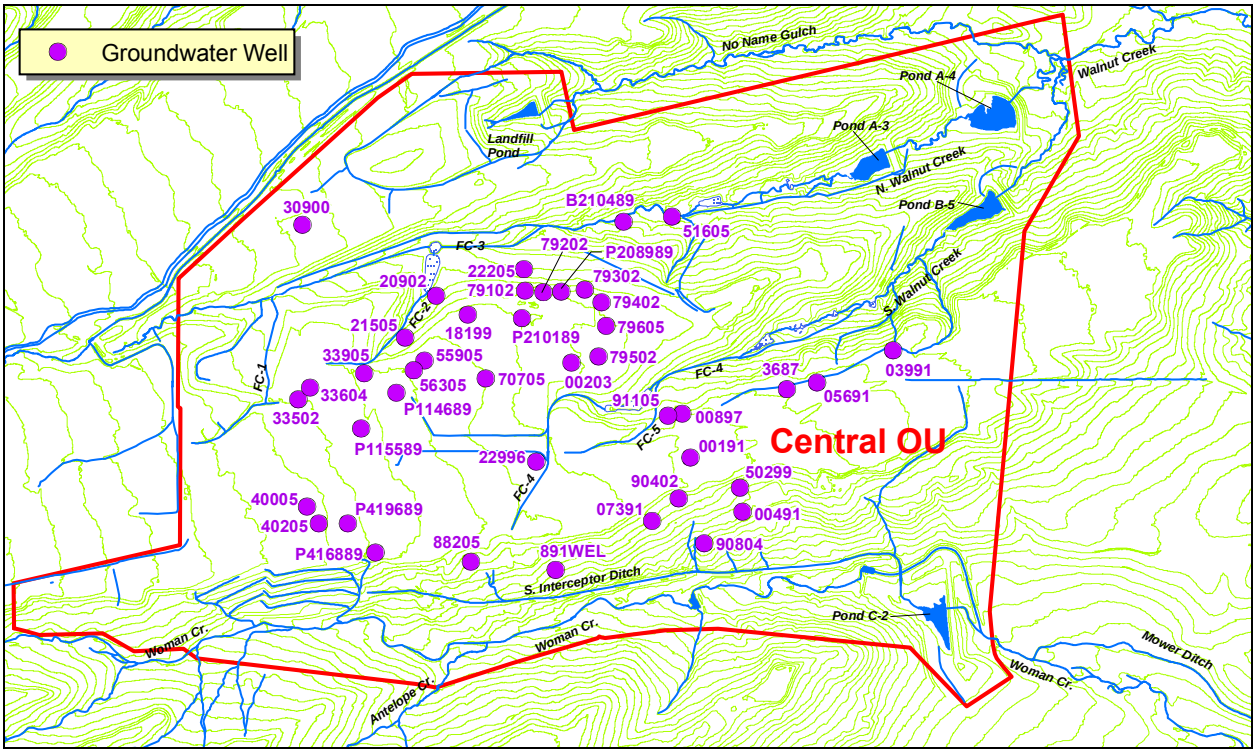


Figure 50. Evaluation Well Locations

Data Evaluation

Evaluation wells were not scheduled for in the fourth quarter of 2010.

3.1.2.7 Investigative Monitoring

When reportable water quality measurements are detected by surface-water monitoring at POEs or POCs, additional monitoring may be required to identify[6] the source and evaluate for mitigating action. Although not required by RFLMA, this investigative monitoring objective is intended to provide upstream water quality information if reportable water quality values are detected at POEs or POCs. Data collection is generally limited to POE and POC analytes and is intended to be discontinued once acceptable water quality has been demonstrated at POEs and POCs for an extended period.

Data collection is currently implemented at the locations listed in Table 22 and shown on Figure 51. The majority of these locations are sampled primarily to satisfy other monitoring objectives, though the data are used for this investigative objective. The current locations were not chosen in response to a specific source evaluation; they were chosen preemptively as a BMP immediately following cleanup and closure work and are intended to be discontinued under this monitoring objective based on data evaluation. Any future data collection upstream of POEs and POCs, subject to the consultative process, is not limited to the locations in Table 22. The parties may also elect to collect data using other methods, subject to the characteristics of the reportable water quality values and through the consultative process.

[6] Note that the term "identify" is used here to mean "locate." Characterization is also implied.

Table 22. Sampling and Data Evaluation Protocols at Investigative Monitoring Locations

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
GS05	Woman Creek at western Refuge boundary	Continuous flow-paced composites; frequency varies (target is 8 per year)[a]	total U	See Figure 6−15 in Appendix D
GS13	North Walnut Creek just upstream of A-Series Bypass	Continuous flow-paced composites; frequency varies (target is 8 per year)[a]	total U	See Figure 6−15 in Appendix D
GS51	Drainage area tributary to the SID and south of former 903 Pad/Lip	Continuous flow-paced composites; frequency varies (target is 8 per year)[a]	total Pu and Am; [TSS[b]]	See Figure 6−15 in Appendix D
GS59	Woman Creek 800 feet east of OLF	Continuous flow-paced composites; frequency varies (target is 8 per year)[a]	total U	See Figure 6−15 in Appendix D
SW018	FC-2 west of former Building 771 area	Continuous flow-paced composites; frequency varies (target is 8 per year)[a]	total Pu and Am; [TSS[b]]	See Figure 6−15 in Appendix D

Notes: [a] Frequency depends on available flow.
[b] Total suspended solids (TSS) is analyzed when the composite sampling period is within TSS holding-time limits.

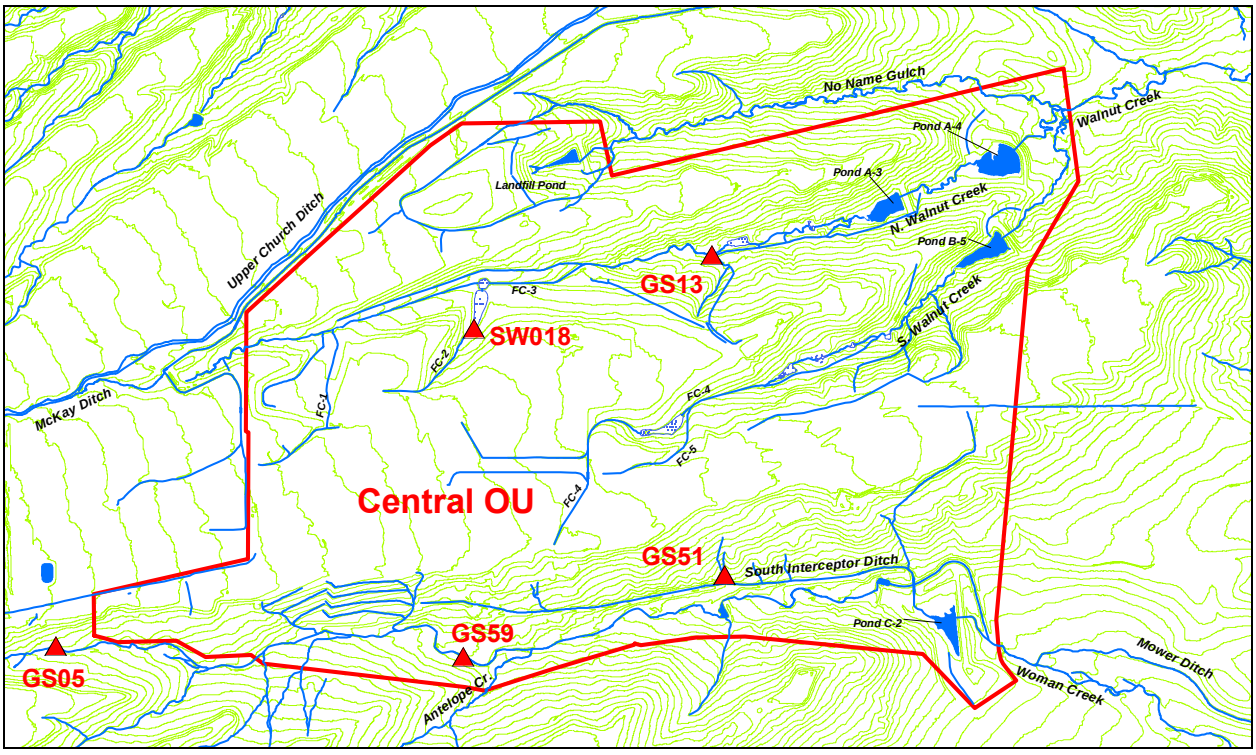


Figure 51. Investigative Monitoring Locations

Data Evaluation

During CY 2010, five investigative locations were operational (Table 22). As of November 26, 2007, analysis of composite samples collected at SW018 for Pu and Am has been discontinued. This action has been taken in accordance with the "Investigative Monitoring"

flowchart (see Appendix D) for upstream locations where no reportable compliance values have been observed at a downstream POE or POC. Composite samples for Pu and Am will continue to be collected at SW018, but analysis will not be routinely conducted. These samples will be archived for 6 months and will only be analyzed if required by a source evaluation triggered by reportable compliance values observed at a downstream POE or POC.

No routine data evaluation for the investigative objective is presented in this report. Refer to Appendix B, which contains the water-quality data, for additional information.

3.1.2.8 PLF Monitoring

The PLF is located in the COU just north of the former Industrial Area (IA). This objective deals with monitoring surface water and groundwater at the PLF to determine the short- and long-term effectiveness of the remedy. These requirements were initially identified in the *Final Interim Measures/Interim Remedial Action for IHSS 114 and RCRA Closure of the RFETS Present Landfill*, Appendix B: "Post-Accelerated Action Monitoring and Long-Term Surveillance and Monitoring Considerations" (DOE 2004), and finalized in the PLF M&M Plan (DOE 2008a).

Water monitoring locations for the PLF are shown on Figure 52. The surface-water and treatment system monitoring requirements deal specifically with the PLFTS and are discussed in detail in Section 3.1.2.10. Details regarding general groundwater monitoring are provided below.

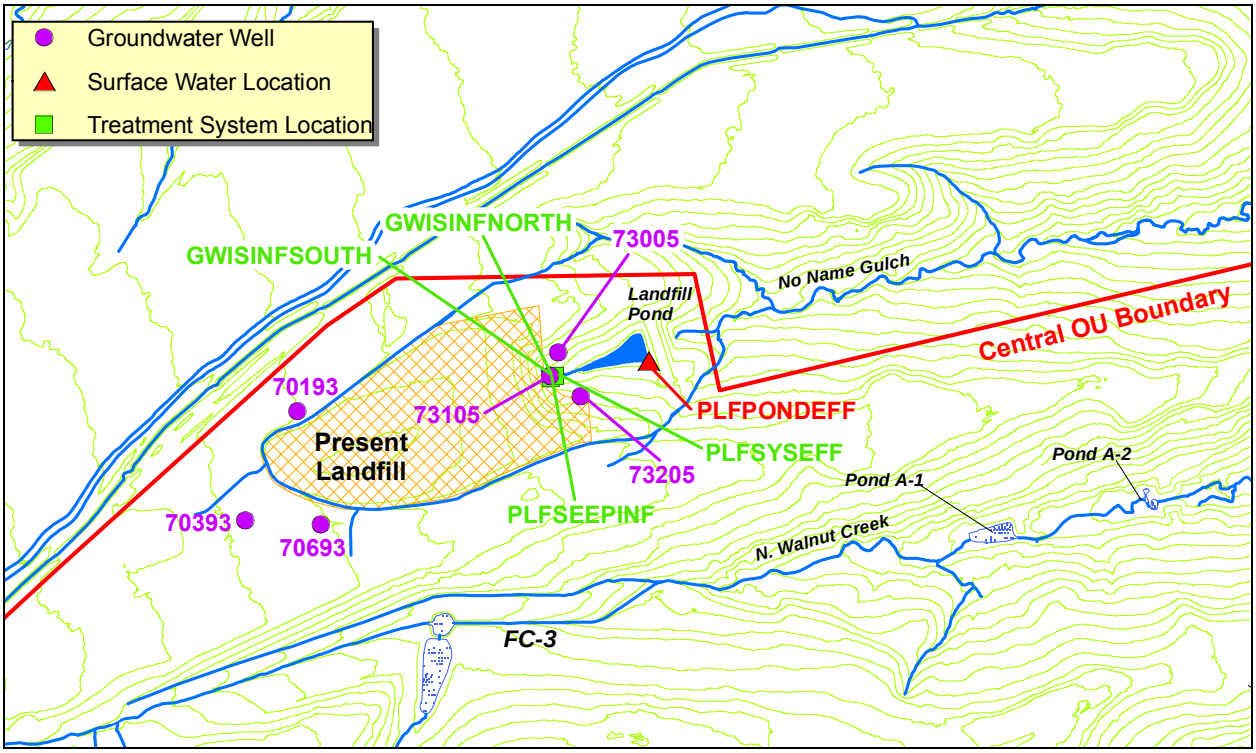
The RCRA monitoring network at the PLF comprises six wells: three are located upgradient of the landfill, and three are downgradient of the landfill but upgradient of the Landfill Pond. The RCRA wells are monitored in accordance with RFLMA. Decision rules are also set forth in that document; see Appendix D for the RFLMA decision flowcharts. Additional monitoring wells are present in the general vicinity of the PLF; however, they do not contribute to the RCRA monitoring of the landfill and are discussed in other sections of this report.

Sampling and data evaluation protocols for the RCRA wells at the PLF are provided in Table 23.

Table 23. Sampling and Data Evaluation Protocols at PLF RCRA Monitoring Wells

Location Code	Location Description	Sample Types/ Frequencies	Analytes[a]	Data Evaluation
70193	Upgradient (northwest) of the upgradient end of the PLF	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D
70393	Upgradient (west/southwest) of the upgradient end of the PLF	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D
70693	Upgradient (southwest) of the upgradient end of the PLF	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D
73005	Downgradient (northeast) of the downgradient end of the PLF	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D
73105	Downgradient (east) of the downgradient end of the PLF at the PLFTS	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D
73205	Downgradient (southeast) of the downgradient end of the PLF	Quarterly each calendar quarter	VOCs, metals	See Figure 10 in Appendix D

Notes: [a] Samples for the analysis of metals are field-filtered using a 0.45-micrometer in-line filter.
Laboratory analytes are limited to those based on the analytical methods listed in the PLF M&M Plan.



Note: PLFSYSEFF serves as both the treatment system effluent monitoring location and a performance surface-water location.

Figure 52. PLF Monitoring Locations

Data Evaluation

All RCRA wells at the PLF were sampled in the fourth quarter of CY 2010. Results are included in Appendix B.

This section presents the evaluation of the PLF groundwater quality data for all of CY 2010. Monitoring performed in 2010 at the PLF RCRA wells is summarized in Table 24.

Table 24. RCRA Groundwater Sampling Performed in 2010 at the PLF

Well	Location	Q1	Q2	Q3	Q4
70193	Upgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals
70393	Upgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals
70693	Upgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals
73005	Downgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals
73105	Downgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals
73205	Downgradient	VOCs, metals	VOCs, metals	VOCs, metals	VOCs, metals

Notes: Q = quarter. Metals include U. Only RFLMA-defined (DOE 2007a) RCRA wells supporting the PLF are listed; other wells in the area (such as Sentinel and Evaluation wells) are omitted because they are not part of the RCRA monitoring network.

Downgradient water quality (as represented by analytical data from wells 73005, 73105, and 73205) was statistically compared against upgradient water quality (as represented by analytical data from wells 70193, 70393, and 70693). Generally, water quality in the upgradient wells

continues to be more impacted than that in the downgradient wells, because upgradient wells 70393 and 70693 are within the margins of the Property Utilization and Disposal (PU&D) Yard Plume, an area of groundwater contaminated with VOCs.

Statistical evaluation of the analytical data from the PLF was performed using all nonrejected data for upgradient and downgradient RCRA wells. An interwell comparison was made (i.e., comparing upgradient wells against downgradient wells) in accordance with RFLMA and the PLF M&M Plan, using the Analysis of Variance (ANOVA) procedure as performed using the Sanitas software package (Sanitas Technologies 2009). The data were also assessed for trends, again using Sanitas and the S-K trending method in keeping with the findings of previous studies indicating this method to be most appropriate for Rocky Flats groundwater data (K-H 2004a).

RFLMA-required consultation with the regulators is required if both of two conditions are true of PLF groundwater: (1) concentration of a constituent is statistically higher in downgradient than upgradient groundwater (per ANOVA results), and (2) the constituent is also calculated to be on an increasing trend. In 2010, both of these conditions were true for B in groundwater from well 73105. Consultation was conducted in early 2011 as reported in a Contact Record issued in early 2011. (Note that this same outcome was the result of the statistical evaluations performed for the 2009 Annual Report, as reported in Contact Record 2010-05 and DOE 2010d). These groundwater conditions and statistical evaluations are described in greater detail below.

The ANOVA evaluation of the groundwater analytical data from PLF RCRA wells indicates that groundwater sample results from some of the downgradient wells are statistically higher in the concentration of certain constituents, all metals. As summarized in Table 25, one or more downgradient wells produce groundwater samples with statistically significant higher concentrations of boron (B), cadmium (Cd), selenium (Se), uranium (U), or zinc (Zn) than upgradient wells. With the exception of Cd in well 73205 and Zn in well 73005 (data sets for both of which contain numerous nondetects), these results are unchanged from those reported in the annual report for 2009 (DOE 2010d).

Table 25. Results of Groundwater ANOVA Evaluation for 2010 at the PLF

Analyte	73005	73105	73205
B	x	x	x
Cd			x
Se	x		x
U	x	x	x
Zn	x	x	

Note: x = analyte is present in groundwater at a statistically significant higher concentration in the indicated downgradient well compared to upgradient wells.

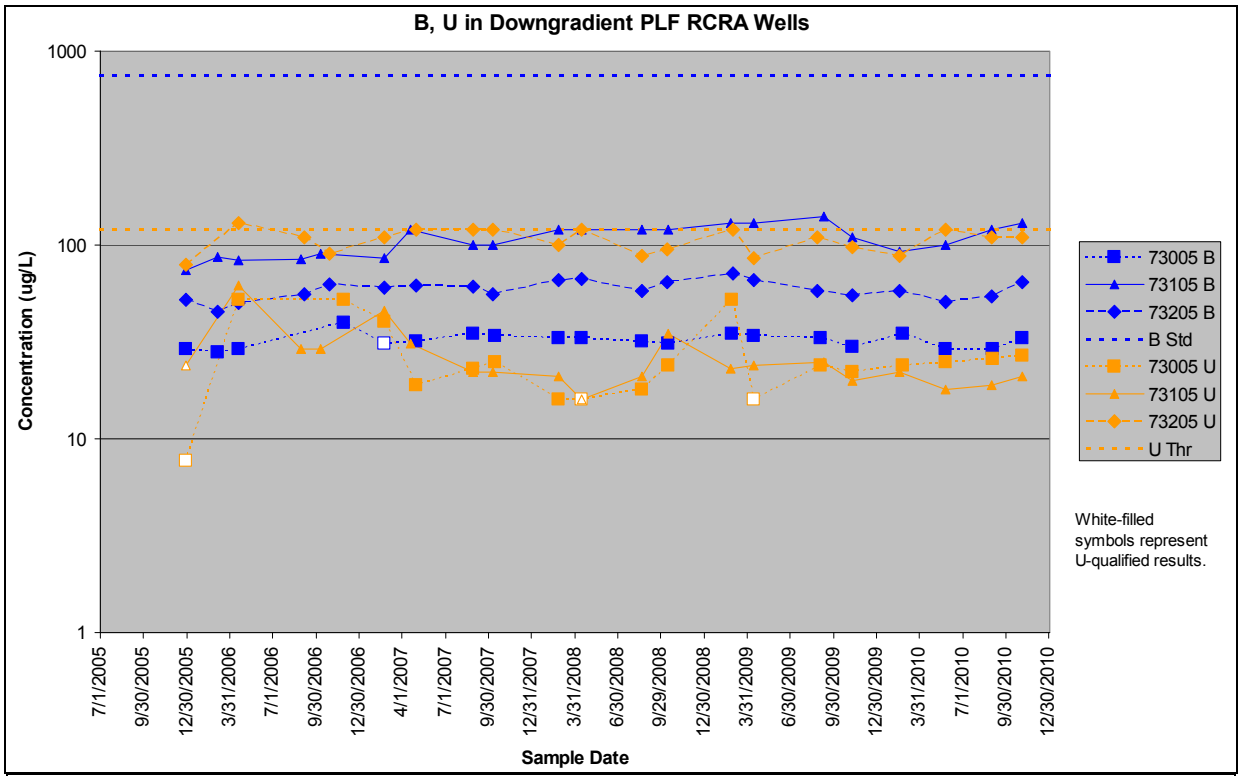
Concentrations of B in downgradient groundwater remain well under the RFLMA Table 1 standard of 750 µg/L; the highest concentration observed in 2010 from a downgradient PLF well was 130 µg/L (well 73105, November 2010). The same applies to concentrations of Zn (RFLMA standard = 141 µg/L), which in 2010 was consistently reported either as a nondetect or J-qualified concentration. The highest concentration of Zn reported in 2010 was in a sample from well 73205 (13 µg/L in February).

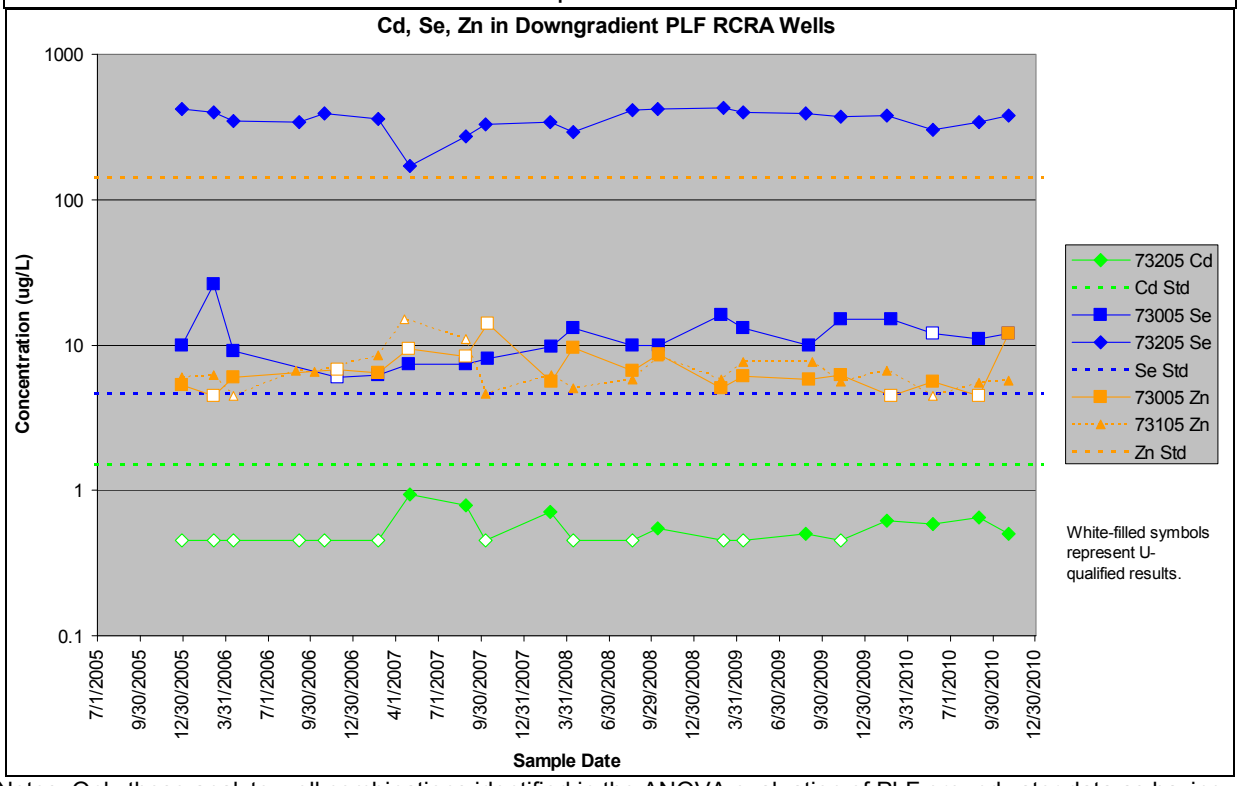
Concentrations of Se in groundwater samples from downgradient well 73005 were most often above the 4.6 µg/L RFLMA standard in 2010, ranging from nondetect to three J-qualified detections reported at 11 µg/L to 15 µg/L. These concentrations are consistent with previous data collected since this well was first installed. Similarly, as in previous years, concentrations of Se in samples from well 73205 are consistently well above the corresponding standard, ranging in 2010 from 300 µg/L to 380 µg/L.

Reported concentrations of Cd in samples collected in 2010 from well 73205 ranged from 0.5 µg/L to 0.65 µg/L. Each result was "J"-qualified.

Although all three downgradient wells produce samples with concentrations of U that are statistically higher than in upgradient wells, only well 73205 produces samples with concentrations that are close to the U threshold of 120 µg/L. To date, U data from this well include one result (from a sample collected in 2006) exceeding that concentration; in 2010, concentrations ranged from 88 µg/L to, on one occasion, 120 µg/L. (This is consistent with conditions in previous years: in 2008, concentrations of uranium in this well varied from 88 µg/L to 120 µg/L; and in 2009, the range was 85 µg/L to 120 µg/L.) The other downgradient wells produce groundwater samples with U concentrations that are much lower than the threshold.

Figure 53 provides time-series plots of the ANOVA-identified constituents summarized in Table 25. Note the frequent nondetects reported for some constituents, particularly Cd in samples from well 73205, but also Zn from 73005, as indicated above. The relatively consistent concentrations of these constituents from 2005 through 2010 are evident on this figure.





Notes: Only those analyte-well combinations identified in the ANOVA evaluation of PLF groundwater data as having statistically significant higher concentrations in downgradient RCRA wells (as listed in Table 25) are shown. RFLMA action levels are published in DOE 2007a. Note that the uranium data are compared to the uranium threshold. In addition to the nondetects ("U"-qualified results), numerous other results were qualified ("B," "J" [estimated]), but are not shown differently for the sake of simplicity. Note logarithmic concentration scales.

Figure 53. Constituents Determined Through ANOVA to be Statistically Elevated in Samples from Downgradient Wells Relative to Upgradient Wells at the PLF

One VOC was detected in downgradient wells. 1,3-dichlorobenzene (DCB) was reported at estimated (i.e., J-qualified) concentrations ranging from 0.21 µg/L to 0.87 µg/L in groundwater samples collected in the first and second quarters from wells 73105 and 73205. J-qualified detections of 1,3-DCB were also reported in one or both of these downgradient PLF wells in 2006 and 2008. Similar concentrations were reported in samples collected in 2010 from the upgradient wells (70193, 70393, and 70693) and are typically reported in one or more of these wells at least once annually, although concentrations in 2009 at the upgradient wells were as high as 3.4 µg/L. The RFLMA Table 1 standard for 1,3-DCB is 94 µg/L. This compound is used as an insecticide and fungicide, as well as a space deodorizer.

The constituents identified via the ANOVA statistical evaluation are all found in natural settings, and the statistical results summarized above may not reflect the presence of contaminants related to the PLF. For example, B is incorporated in evaporite minerals (such as ulexite, or "TV rock," and the more common borax), metamorphic minerals (such as tourmaline), and perhaps most notably in coals and similar deposits of carbonaceous fossilized organic matter. Two of the upgradient wells are screened in alluvial materials, and one is screened in weathered bedrock. The three downgradient wells are all screened in the weathered bedrock, and lithologic logs from these wells note the presence of fossilized organics (i.e., substances akin to lignite or coal) at the depth corresponding to the screened interval. Thus, these wells may produce waters with higher concentrations of B as an artifact of the geology and variations in screened materials.

Similarly, the presence of Se at elevated concentrations may be related to regional mineralization and the prevalence of coals and organic-rich sediments, clays, and iron oxides in the geologic intervals screened by PLF wells (and most monitoring wells at Rocky Flats). The sulfide mineralization that drew prospectors to Colorado and is evident in the mountains west of the Site would be a source of Se, as might shales that are closer to the Site. Se would be liberated as those rocks and minerals weather. Clays, coals, and iron oxides could then act to sorb the mobile Se and may be present in the screened interval of these wells.

According to RFLMA, if downgradient concentrations are significantly greater than upgradient concentrations (as indicated by the ANOVA statistics summarized in Table 25) *and* if downgradient concentrations show a statistically significant increasing trend (as discussed and summarized in Section 3.1.5.3), the consultative process is initiated to determine the appropriate response. Increasing concentration trends meeting the required level of significance are determined for B in PLF downgradient well 73105. This trend is visually apparent on Figure 53 and was also reported in the 2009 Annual Report (DOE 2010d). The consultative process was initiated in response to that determination and is summarized in Contact Record 2010-05. Increasing trends for B are also indicated for two of the three upgradient PLF RCRA wells, and a decreasing trend is calculated for the third well; however, these trends do not meet the 95 percent level of statistical significance. An increasing trend is also reported for chromium (Cr) in downgradient well 73005, but this analyte is not identified as being present at higher concentrations in groundwater from downgradient wells than from upgradient wells. Therefore, the trend in Cr concentrations at well 73005 does not represent a condition requiring consultation. (In addition, the Cr data for this well include numerous nondetects, suggesting this calculated trend may not be real.)

According to RFLMA, calculated 85th percentile concentrations from downgradient PLF wells are also to be compared to the corresponding standards to support the exit strategy. However, the data to be used in this comparison are from the previous two periodic (i.e., CERCLA) reviews; these wells and their corresponding monitoring requirements have not existed long enough to support two reviews. (The first review was in 2002, before any of the downgradient wells were installed and before the current RCRA monitoring schedule was in place.) Therefore, such a comparison cannot be completed at this time.

Groundwater quality at the PLF is impacted on the upgradient side by VOCs from the PU&D Yard Plume. (Refer to the separate discussion of this plume in Section 3.1.5.3.) As noted above, data from the downgradient RCRA wells in 2010 only showed J-qualified (estimated) detections of the single VOC, 1,3-DCB.

Groundwater flow at the PLF is strongly affected by the GWIS, which diverts groundwater flow around the perimeter of the PLF rather than through the wastes. The GWIS includes a slurry wall and perforated drain around the upgradient and side-gradient perimeter of the PLF and acts to isolate groundwater within the PLF from that outside the PLF. (Refer to the previously published reports referenced earlier in this section for more detail on the GWIS and related discussions.) Previous RCRA and groundwater annual reports have confirmed the effectiveness of this isolation. Because the GWIS is located between the upgradient PLF RCRA wells and the downgradient PLF RCRA wells, estimating seepage velocities as discussed in Section 3.1.3.5 between those sets of wells is not appropriate.

3.1.2.9 OLF Monitoring

The OLF is located in the COU just south of the former IA. This objective addresses monitoring surface water and groundwater at the OLF to determine the short- and long-term effectiveness of the remedy. These requirements were initially identified in the *Final Interim Measure/Interim Remedial Action for the Original Landfill (Including IHSS Group SW-2; IHSS 115, Original Landfill and IHSS 196, Filter Backwash Pond)*, Appendix B, "Post-Accelerated Action Monitoring and Long-Term Surveillance and Maintenance Considerations" (DOE 2005a), and finalized in the OLF M&M Plan (DOE 2009a).

Four groundwater monitoring wells were identified to monitor the OLF and are classified as RCRA wells in RFLMA; three of these wells were installed in 2005. One of the OLF RCRA wells is located upgradient of the landfill, and three are downgradient of the landfill but upgradient of Woman Creek. The RCRA wells are monitored in accordance with RFLMA. Decision rules are also set forth in that document; see Appendix D for the RFLMA decision flowcharts. Additional monitoring wells are present in the general vicinity of the OLF; however, they do not contribute to the RCRA monitoring of the facility and are therefore discussed in other sections of this report.

Surface-water and RCRA groundwater monitoring locations for the OLF are shown on Figure 54. Sampling and data evaluation protocols are summarized in Table 26 and Table 27.

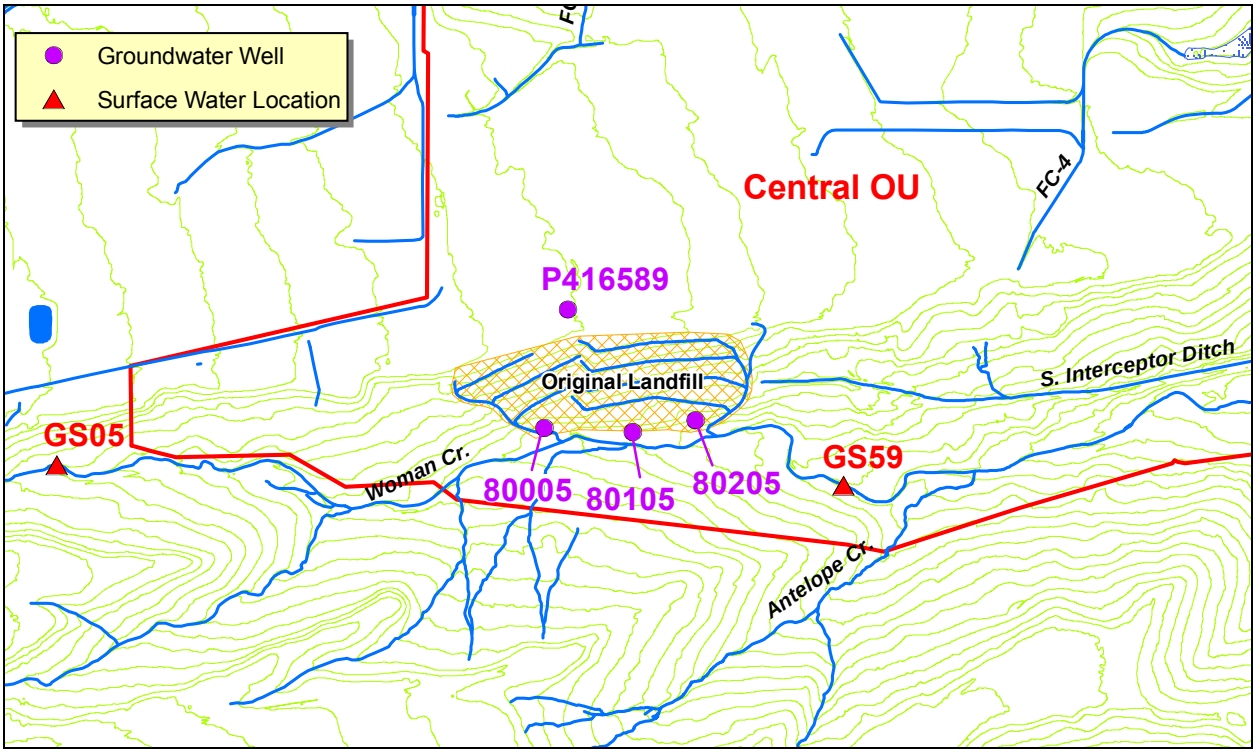


Figure 54. OLF Monitoring Locations

Table 26. Sampling and Data Evaluation Protocols at OLF Surface-Water Monitoring Locations

Location Code	Location Description	Sample Types/ Frequencies	Analytes[b]	Data Evaluation
GS05; upgradient	Woman Creek at west POU fenceline	Quarterly grab samples[a]	Total U; dissolved and total metals; VOCs; mercury	See Figure 12 in Appendix D
GS59; downgradient	Woman Creek 800 feet downstream of OLF	Quarterly grab samples[a]	Total U; dissolved and total metals; VOCs; mercury	See Figure 12 in Appendix D

Notes: [a] Samples for total U and metals are currently collected as continuous flow-paced composites in conjunction with the Investigative monitoring objective; decisions specifically for the OLF monitoring objective only require quarterly grabs.
[b] Laboratory analytes are limited to those based on the analytical methods listed in the OLF M&M Plan.

Table 27. Sampling and Data Evaluation Protocols at OLF RCRA Monitoring Wells

Location Code	Location Description	Sample Types/ Frequencies	Analytes[a]	Data Evaluation
P416589	Upgradient (north) of the OLF	Quarterly each calendar quarter	VOCs, SVOCs, metals	See Figure 10 in Appendix D
80005	Downgradient (south) of the western portion of the OLF	Quarterly each calendar quarter	VOCs, SVOCs, metals	See Figure 10 in Appendix D
80105	Downgradient (south) of the central portion of the OLF	Quarterly each calendar quarter	VOCs, SVOCs, metals	See Figure 10 in Appendix D
80205	Downgradient (south) of the eastern portion of the OLF	Quarterly each calendar quarter	VOCs, SVOCs, metals	See Figure 10 in Appendix D

Notes: [a] Samples for the analysis of metals are field-filtered using a 0.45-micrometer in-line filter.
Laboratory analytes are limited to those based on the analytical methods listed in the OLF M&M Plan.
SVOCs = semivolatile organic compounds

Data Evaluation

Analytical results for GS59 and GS05 are compared, according to Figure 12 in Appendix D, to the appropriate surface-water standard in Table 1 of RFLMA Attachment 2. During CY 2010, no analytes were detected above the applicable standards.

All RCRA wells at the OLF were sampled in the fourth quarter of CY 2010. Results are included in Appendix B.

This section presents the evaluation of the CY 2010 groundwater quality data for the OLF, previously known as OU 5. All RCRA wells are monitored quarterly. Monitoring performed in 2010 is summarized in Table 28.

Table 28. RCRA Groundwater Sampling Performed in 2010 at the OLF

Well	Location	Q1	Q2	Q3	Q4
P416589	Upgradient	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs
80005	Downgradient	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs
80105	Downgradient	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs
80205	Downgradient	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs	VOCs, metals, SVOCs

Notes: Q = quarter. SVOCs = semivolatile organic compounds. Metals include U. Only RCRA wells supporting the OLF are listed; other wells in the area (such as AOC, Sentinel, and Evaluation wells) are omitted because they are not part of the RCRA monitoring network.

In addition to being monitored and evaluated similarly to RCRA wells (i.e., sampled quarterly, and resulting analytical data evaluated by upgradient-downgradient comparisons), the three downgradient wells are also monitored and evaluated in the manner of Sentinel wells. Specifically, data from these wells are statistically evaluated using 85th percentile concentrations to compare against surface-water standards, and data trends are constructed as warranted to determine a need for action.

As with the PLF, statistical evaluation of the analytical data from the OLF was performed using all nonrejected data for upgradient and downgradient RCRA wells. An interwell comparison was made (i.e., comparing the upgradient well against downgradient wells) in accordance with RFLMA and the OLF M&M Plan (DOE 2009a), using the ANOVA procedure as performed with the Sanitas software package (Sanitas Technologies 2009). The data were also evaluated for statistical trends, again using Sanitas and the S-K trending method in keeping with the findings of previous studies indicating this method to be most appropriate for Rocky Flats groundwater data (K-H 2004a).

RFLMA-required consultation with the regulators is required if either of two conditions is true of OLF groundwater: (1) concentrations of certain constituents are statistically higher in downgradient than upgradient groundwater (per ANOVA results); or (2) concentrations of constituents in a downgradient well are on an increasing trend meeting the 95 percent level of significance. In 2010, condition (1) was true for B in all three downgradient wells and uranium in downgradient well 80205, but condition (2) did not apply because no such increasing trends were calculated. Consultation was conducted in early 2011 as reported in a Contact Record issued in early 2011. (Note that this same outcome was the result of the statistical evaluations performed for the 2009 Annual Report, as reported in Contact Record 2010-05 and DOE 2010d) These groundwater conditions and statistical evaluations are described in greater detail below.

ANOVA evaluation of the groundwater analytical data from OLF RCRA wells indicates that groundwater samples from the downgradient wells are statistically higher in the concentration of certain constituents. No VOCs were found in downgradient wells at statistically higher concentrations than in upgradient wells, but the concentrations of two metals are statistically higher in one or more downgradient wells. These results are summarized in Table 29.

Table 29. Results of Groundwater ANOVA Evaluation at the OLF

Analyte	80005	80105	80205
B	x	x	x
U			x

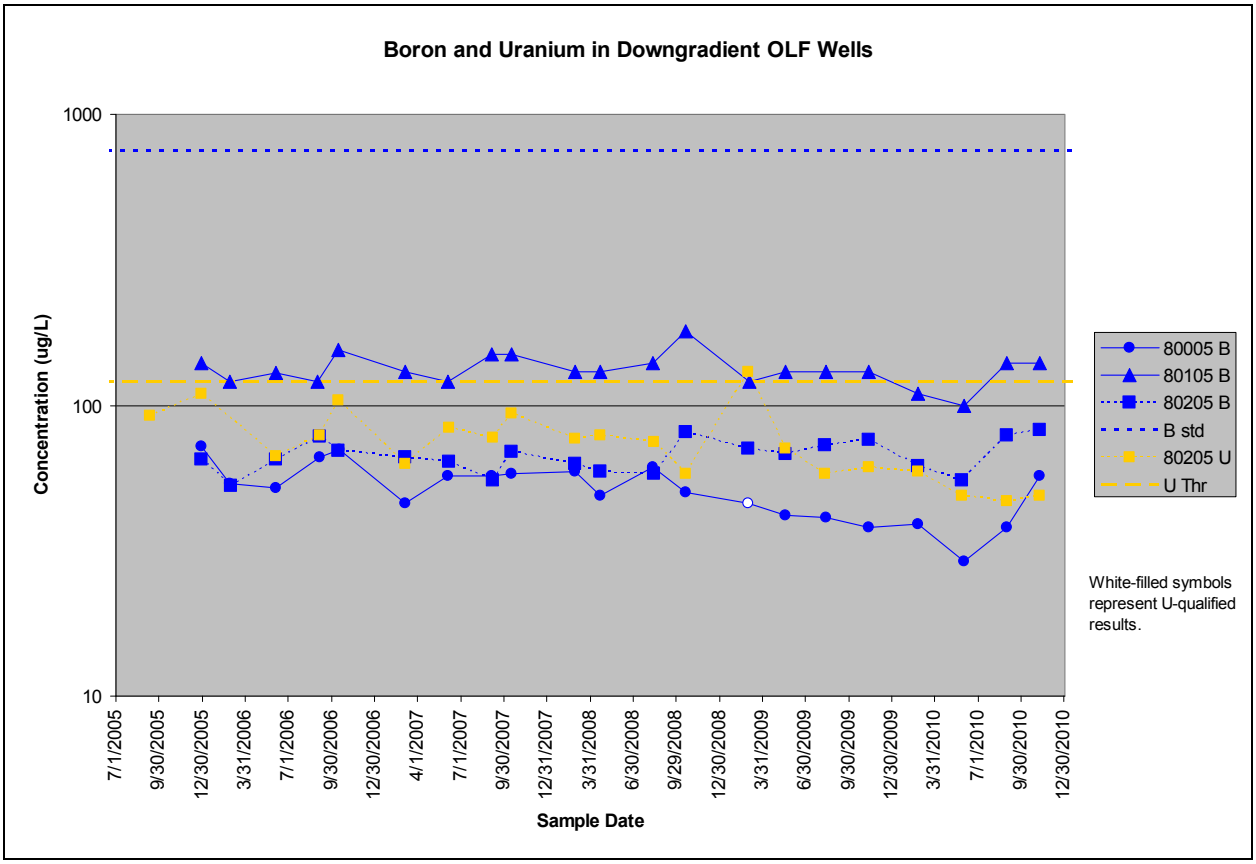
Note: x = analyte is present in groundwater at a statistically significant higher concentration in the indicated downgradient well compared to upgradient wells, based on ANOVA statistical analyses performed using the Sanitas software package.

RFLMA instructs that if concentrations in downgradient wells are found to be significantly higher than in upgradient, the consultative process is initiated to determine the appropriate response. All three downgradient wells produce groundwater samples with statistically higher concentrations of B than the upgradient well, and the same applies to concentrations of U in well 80205. This is identical to ANOVA results reported in the 2007, 2008, and 2009 Annual Reports (DOE 2008c, 2009d, and 2010d). Consistent with conditions reported above for the PLF, consultation regarding OLF conditions was conducted as documented in Contact Record 2010-05. Also as noted above in the discussion of the PLF groundwater results, these findings may be due to natural geological and geochemical conditions.

Figure 55 provides time-series plots of reported B and U concentrations in groundwater from the wells listed in Table 29. As this figure indicates, concentrations of B in downgradient groundwater are uniformly well under the RFLMA Table 1 standard of 750 µg/L; the highest

concentrations reported in 2010 were two results of 140 µg/L from well 80105. The surface-water quality reported at downstream OLF location GS59 does not indicate that B concentrations in downgradient OLF groundwater represent a threat.

Concentrations of U in samples from downgradient well 80205 (Figure 55) were consistently below the U threshold in 2010. Given that only one result has been reported above that value (in March 2009), it follows that the 85th percentile concentration of U in samples from well 80205 also does not exceed this threshold (as described in the Sentinel well decision rules that also apply to downgradient OLF RCRA wells). Including the 2010 results, the 85th percentile concentration of U in samples from well 80205 is 94 µg/L, slightly lower than the 100 µg/L value reported in the 2009 Annual Report (DOE 2010d). Groundwater from this well was analyzed for anthropogenic content in late 2007 and found to be 100 percent natural (DOE 2008c). As with B, the surface water monitored at location GS59 has not indicated that U concentrations in downgradient OLF groundwater represent a threat to surface-water quality.



Notes: Only those analyte-well combinations identified in the ANOVA evaluation of OLF groundwater data as having statistically significant higher concentrations in downgradient RCRA wells are shown. RFLMA action levels are published in DOE 2007a. Note that the U data are compared to the U threshold. Several results were qualified ("B," "J"), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 55. B and U in Downgradient Groundwater from OLF RCRA Wells Identified in 2010 ANOVA Data Evaluations

Data reported in 2010 from downgradient RCRA wells at the OLF include two VOC detections and three detections of semivolatile organic compounds (SVOCs); all but one qualified as

estimates (Table 30). Four of the reported concentrations were beneath the applicable RFLMA standard/PQL, and one detection, representing the SVOC hexachloroethane, exceeded the corresponding PQL. This constituent was reported in the fourth quarter 2010 at a concentration of 16 µg/L in a sample from well 80005; the PQL is 1 µg/L. This represents the first detection of this constituent in a groundwater sample from the RCRA wells at the OLF: every other result, for each of the wells, is a nondetect.

Table 30. VOCs and SVOCs Detected in 2010 in Downgradient Wells at the OLF

Well	Sample Date	Analyte	Result	Units	Lab Qualifier
80005	2/23/2010	Methylene chloride	0.39	µg/L	J
80005	11/8/2010	Bis(2-ethylhexyl)phthalate	1.9	µg/L	J
80005	11/8/2010	Hexachloroethane	16	µg/L	
80105	2/23/2010	Methylene chloride	0.33	µg/L	J
80105	6/1/2010	Diethyl phthalate	0.71	µg/L	J

Note: J = analyte detected, result is estimated. No validation qualifiers were attached to these results. Applicable RFLMA standards: methylene chloride, 4.6 µg/L; bis(2-ethylhexyl)phthalate, 10 µg/L (PQL); hexachloroethane, 1 µg/L (PQL); diethyl phthalate, 5,600 µg/L.

Similar to the reported detection of hexachloroethane, the results for bis(2-ethylhexyl)phthalate and diethyl phthalate represent the first validated detections of these constituents from any of the downgradient RCRA wells at the OLF. Upgradient well P416589 likewise has reported no validated detections of hexachloroethane or diethyl phthalate, but bis(2-ethylhexyl)phthalate has been detected at low, J-qualified (estimated) concentrations on several occasions. Also, the common laboratory solvent methylene chloride has been reported in several samples from downgradient OLF RCRA wells, typically B-qualified (signifying the blank was contaminated with this constituent) and always J-qualified (estimated concentration). Three detections are not B-qualified: one in August 2008 from well 80105 (estimated at 0.43 µg/L) and two in February 2010 from wells 80005 (estimated at 0.39 µg/L) and 80105 (estimated at 0.33 µg/L). Detections of this constituent have not been confirmed in samples from upgradient OLF RCRA well P416589.

According to RFLMA, downgradient OLF wells are also assessed in a manner consistent with that used for Sentinel wells (DOE 2007a); concentrations are evaluated for statistically-significant (95 percent) trends, and 85th percentile concentrations are assessed in comparison with the applicable RFLMA standards or threshold. There were no increasing trends meeting the 95 percent level of significance for the downgradient wells. However, a statistically-significant (95 percent) decreasing trend was calculated for B concentrations in samples from well 80005 and U concentrations from well 80205. In addition, an increasing trend in B meeting the 95 percent level of significance was calculated for upgradient well P416589, as was an increasing trend in U that does not meet this level of significance (see trending results in Appendix B).

RFLMA instructs that calculated 85th percentile concentrations from downgradient OLF wells are to be compared against the corresponding standards to support the exit strategy. However, as with downgradient RCRA wells at the PLF, the data to be used in this comparison are from the previous two CERCLA reviews; these OLF wells have not existed long enough to support two reviews. (The first review was in 2002, before any of the downgradient wells were installed and

before the current RCRA monitoring schedule was in place.) Therefore, such a comparison cannot be completed at this time.

Groundwater flow at the OLF is not affected by controls such as the GWIS at the PLF. Groundwater flows beneath the pediment surface on the north side of the OLF in a general west-to-east direction. As it nears the southern edge of the pediment, closest to the OLF, groundwater is diverted to a more south-southeasterly direction. This latter general flow direction applies to groundwater moving through the OLF.

Groundwater flow velocities were calculated (see Section 3.1.3.5) for OLF well pair P416589 (the upgradient well) and 80105 (the middle downgradient well). The resulting estimates for the travel time from the upgradient to downgradient well based on water level data collected in 2010 are slightly under 3 years. Note that this calculated velocity is simplistic and applies only to pure water; the migration of contaminants would be retarded to varying degrees.

Seeps are also present at the OLF and have been observed in this area for decades (as well as being suggested on aerial photographs taken before the Rocky Flats Plant came into existence in the 1950s). Additional discussion of seeps at the OLF is provided in Section 2.4.2.

3.1.2.10 Groundwater Treatment System Monitoring

Contaminated groundwater is intercepted and treated in four areas of the Site. Three of these systems (MSPTS, ETPTS, and SPPTS) include a groundwater intercept trench (collection trench), which is similar to a French drain with an impermeable membrane on the downgradient side. Groundwater entering the trench is routed through a drain pipe into one or more treatment cells, where it is treated and then discharged to the subsurface, and eventually reaches surface water. The fourth system (PLFTS) treats water from the north and south components of the GWIS and flow from the PLF seep.

Water monitoring at the MSPTS, ETPTS, and SPPTS includes a minimum of three sample-collection points: untreated influent entering the treatment system, treated effluent exiting the system, and a surface-water performance location. At the PLFTS, the treated effluent and surface-water sampling locations are typically the same; this is discussed in further detail below.

The fundamental questions at each system are whether (1) influent-water quality indicates that treatment is still necessary, (2) effluent-water quality indicates that system maintenance is required, and (3) surface-water quality suggests impacts from inadequate treatment of influent.

Note that groundwater monitoring wells also support the MSPTS, ETPTS, and SPPTS. (Wells are also present in the vicinity of the PLFTS, but their objectives differ as they directly support the PLF as RCRA wells.) These locations are discussed in the sections that correspond to their respective objectives (i.e., text describing Sentinel and Evaluation wells) and that discuss groundwater plume characteristics.

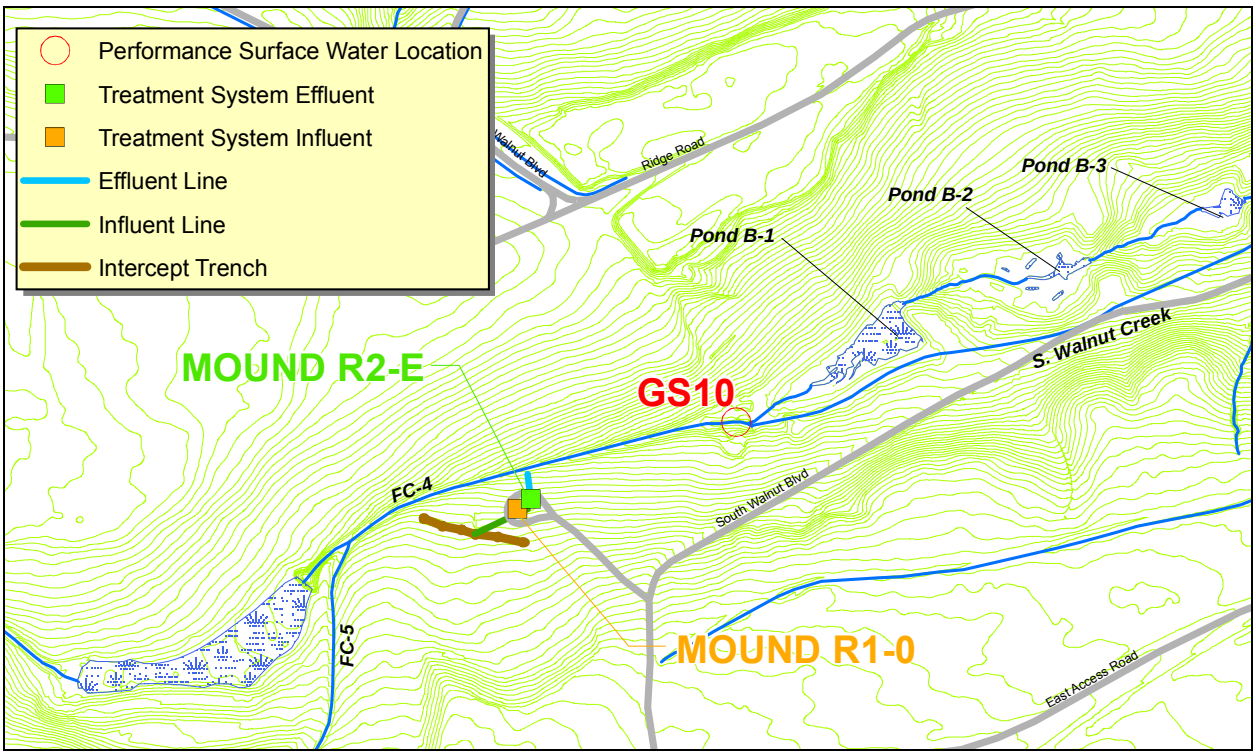
Mound Site Plume Treatment System

RFMLA monitoring locations specific to the MSPTS are shown on Figure 56. Sampling and data evaluation protocols are summarized in Table 31. In addition to the monitoring locations shown,

one well is monitored as a Sentinel well (see related text above), and several piezometers are present within the collection trench. The piezometers are retained for troubleshooting purposes.

Table 31. RFLMA Sampling and Data Evaluation Protocols at MSPTS Monitoring Locations

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
MOUND R1-0	Influent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D
MOUND R2-E	Effluent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D
GS10	Downgradient surface-water performance location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D



Note: The intercept trench also captures water from a former 72-inch storm drain utility corridor (not shown) that previously emptied to South Walnut Creek (shown here as FC-4). This corridor runs from south to north, approximately parallel to the dominant trend of FC-5 shown here. It was backfilled and tied into the western portion of the intercept trench during Site closure activities. See the 2006 Annual Report (DOE 2007c) for additional discussion, and subsequent sections of this 2010 report for water quality updates.

Figure 56. RFLMA MSPTS Monitoring Locations

Data Evaluation

All MSPTS locations listed above were scheduled for routine monitoring in the fourth quarter of CY 2010. Results are provided in Appendix B and are discussed in Section 3.1.5.3.

In addition to the RFLMA locations, the two locations in the nearby FC-4 were sampled in the fourth quarter to support the evaluation outlined in Contact Record 2010-07. This is also discussed in Section 3.1.5.3.

East Trenches Plume Treatment System

RFMLA monitoring locations specific to the ETPTS are shown on Figure 57. Sampling and data evaluation protocols are summarized in Table 32. In addition to the monitoring locations shown, several monitoring wells are present, and several piezometers are present within the collection trench. Each of the wells is monitored as a Sentinel well (see related text above). The piezometers are retained for troubleshooting purposes.

Table 32. RFLMA Sampling and Data Evaluation Protocols at ETPTS Monitoring Locations

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
ET INFLUENT	Influent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D
ET EFFLUENT	Effluent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D
POM2	Downgradient surface-water performance location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	VOCs	See Figure 11 in Appendix D

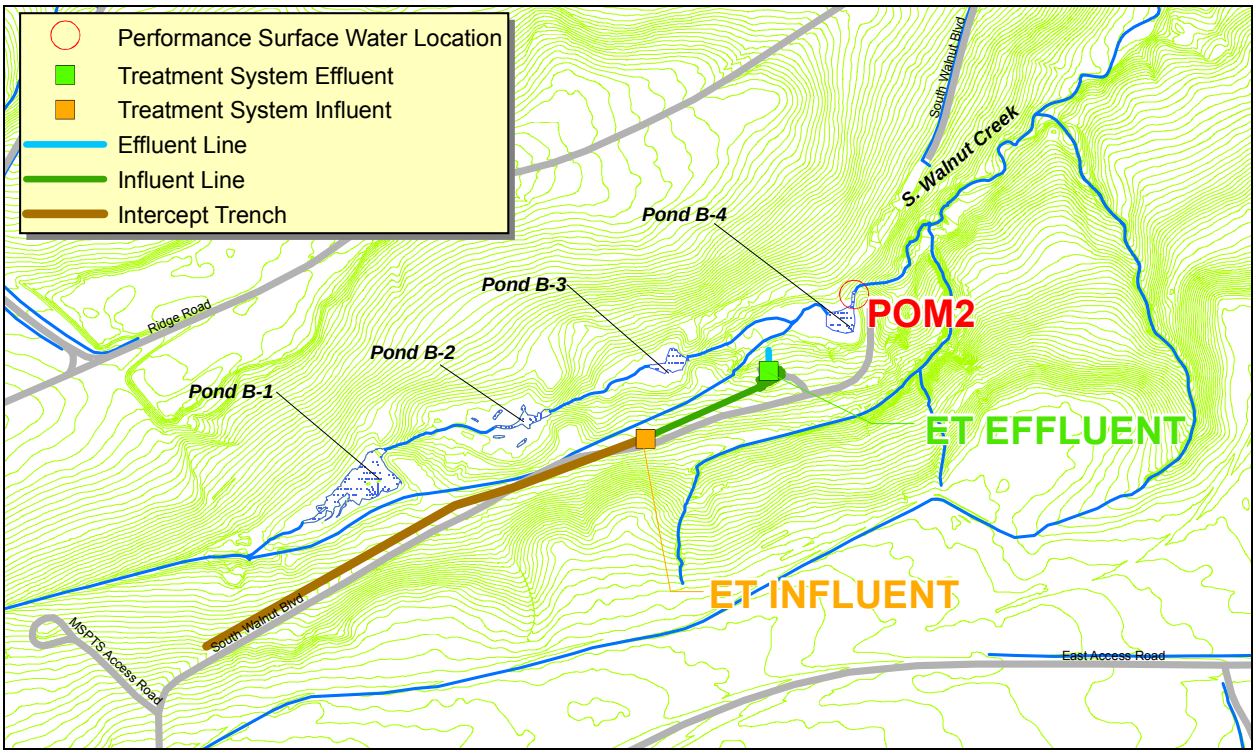


Figure 57. RFLMA ETPTS Monitoring Locations

Data Evaluation

All ETPTS locations listed above were scheduled for routine monitoring in the fourth quarter of CY 2010. Results are provided in Appendix B and are discussed in Section 3.1.5.3.

In addition to the RFLMA locations, the two locations in between the ETPTS effluent discharge gallery and performance location POM2 were sampled in the fourth quarter to support the evaluation outlined in Contact Record 2010-07. This is also discussed in Section 3.1.5.3.

Solar Ponds Plume Treatment System

RFLMA monitoring locations specific to the SPPTS are presented on Figure 58. Sampling and data evaluation protocols are summarized in Table 33. In addition to the monitoring locations shown, several monitoring wells are present, and several piezometers are present within the collection trench. The wells are monitored as either Sentinel wells or Evaluation wells (see related text above). The piezometers are retained for troubleshooting purposes.

Table 33. RFLMA Sampling and Data Evaluation Protocols at SPPTS Monitoring Locations

Location Code	Location Description	Sample Types/Frequencies	Analytes	Data Evaluation
SPIN	Influent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	U, nitrate	See Figure 11 in Appendix D
SPOUT[a]	Effluent sampling location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	U, nitrate	See Figure 11 in Appendix D
GS13[b]	Downgradient surface-water performance location	Semiannual grabs; second and fourth calendar quarters (high- and low-water conditions)	U, nitrate	See Figure 11 in Appendix D

Notes: [a] The effluent monitoring location was changed from SPPMM01 to SPOUT in 2008, as described in Contact Record 2008-09, following several rounds of sampling that showed water quality at the two locations to be equivalent.

[b] Samples collected for U at GS13 are typically flow-paced, unfiltered, and analyzed for U isotopes; however, if desired they may be collected as grab samples and field-filtered. U data at GS13 support other monitoring objectives that are not addressed here.

Nitrate is analyzed as nitrate+nitrite as nitrogen; this result is conservatively compared to the nitrate standard only.

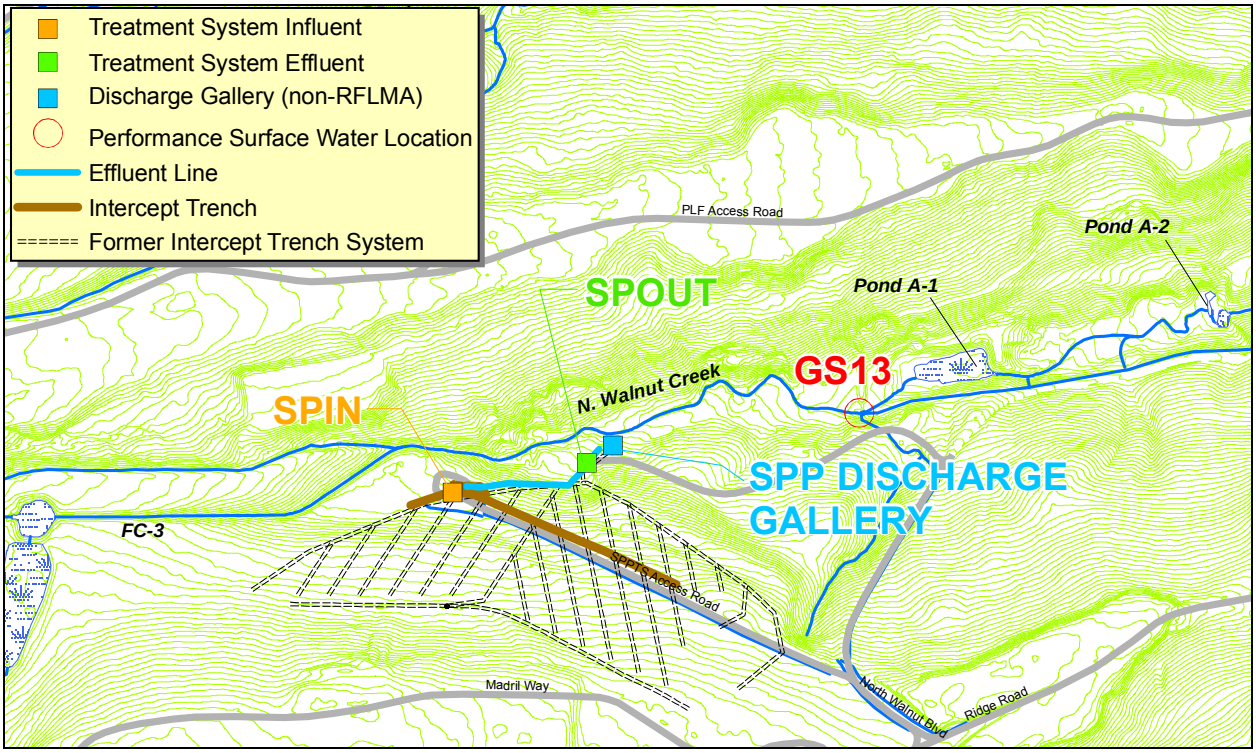


Figure 58. RFLMA SPPTS Monitoring Locations

Data Evaluation

All SPPTS locations listed above were scheduled for routine monitoring in the fourth quarter of CY 2010. Results are included in Appendix B; see Section 3.1.5.3 for discussion.

In addition to the RFLMA locations, in the fourth quarter the SPP Discharge Gallery (DG) was sampled according to the RFSOG, and all SPPTS locations plus additional locations related to system operation, optimization, and performance were also monitored to support an evaluation of the effects of Phases II and III improvements to the SPPTS (see Section 3.1.5.3).

PLF Treatment System

Water monitoring locations for the PLF are shown on Figure 59. The general groundwater monitoring requirements deal specifically with the RCRA wells and are discussed in detail in Section 3.1.2.8. Details regarding surface-water and treatment system monitoring are provided below.

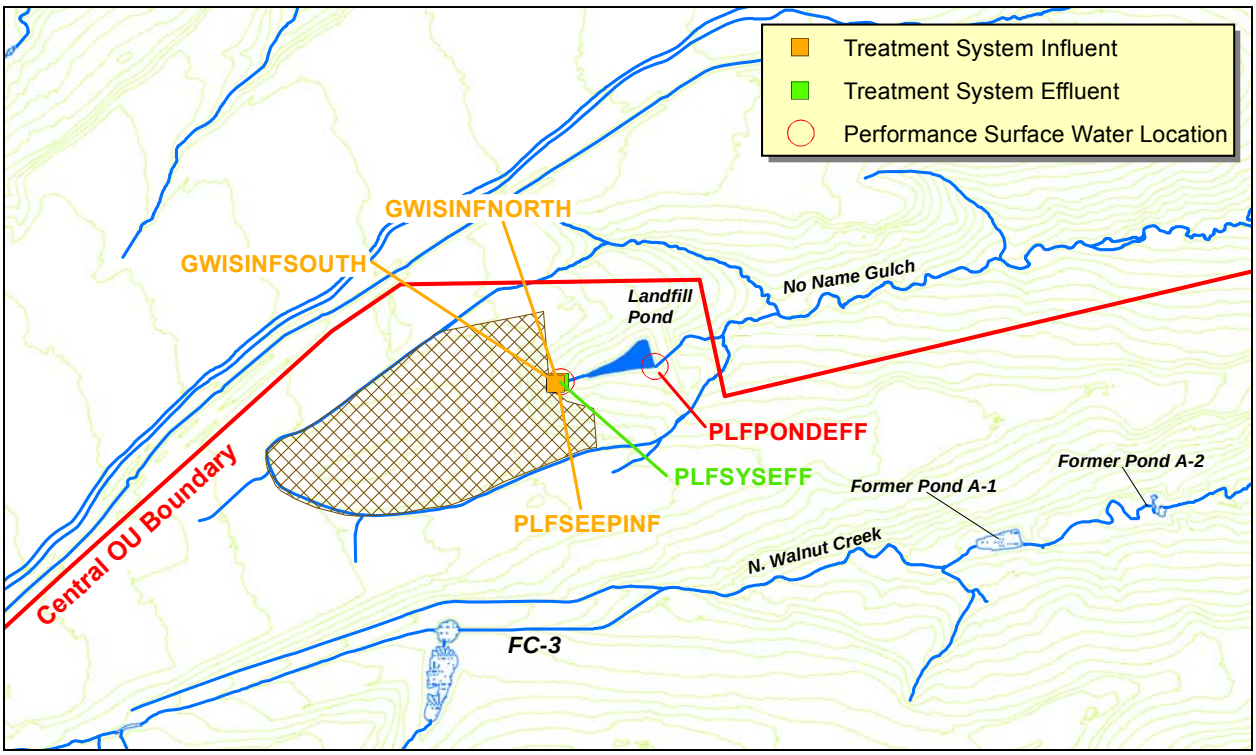
As part of PLF closure, a passive seep interception and treatment system was installed to treat landfill seep water and GWIS water. There are three sources of influent to the treatment system: two GWIS pipes and the PLF seep. Effluent for the treatment system eventually flows to the Landfill Pond. This section presents the monitoring data for the treatment system effluent as well as the Landfill Pond if the treatment system effluent exceeds surface-water standards. Details regarding PLFTS monitoring can be found in the PLF M&M Plan.

Monitoring locations for the PLFTS are shown on Figure 59. Sampling and data evaluation protocols are summarized in Table 34. As of December 21, 2007, collection of samples at the GWIS locations (GWISINFNORTH and GWISINFSOUTH) has been discontinued. This action has been taken subsequent to the consultative process in accordance with the Groundwater Treatment Systems flowchart (Appendix D) and documented in Contact Record 2007-08.

Table 34. Sampling and Data Evaluation Protocols at PLFTS Monitoring Locations

Location Code	Location Description	Sample Types/ Frequencies	Analytes	Data Evaluation
GWISINFNORTH	Northern GWIS influent to the treatment system	Discontinued	VOCs, total U, total and dissolved metals, nitrate[a]	See Figure 11 in Appendix D
GWISINFSOUTH	Southern GWIS influent to the treatment system	Discontinued	VOCs, total U, total and dissolved metals, nitrate[a]	See Figure 11 in Appendix D
PLFSEEPINF	Landfill seep influent to the treatment system	Quarterly grabs	VOCs, total U, total and dissolved metals	See Figure 11 in Appendix D
PLFSYSEFF	Effluent from the treatment system	Quarterly grabs	VOCs, total U, total and dissolved metals, SVOCs	See Figure 11 in Appendix D
PLFPONDEFF	Landfill Pond at the downstream (east) end	As needed; triggered by data evaluation	As needed; determined by decision rule	See Figure 11 in Appendix D

Notes: [a] Nitrate is analyzed as nitrate+nitrite as nitrogen.
GWISINFNORTH and GWISINFSOUTH may still be periodically sampled for investigative purposes only.



Note: PLFSYSEFF serves as both the treatment system effluent monitoring location and a performance surface-water monitoring location.

Figure 59. PLFTS Monitoring Locations

Data Evaluation

Analytical results for the treatment system effluent (PLFSYSEFF) are compared to the appropriate surface-water standards listed in Table 1 of RFLMA Attachment 2. During CY 2010, no analytes were detected above the applicable standards.

3.1.2.11 Pre-Discharge Monitoring

This monitoring objective deals with pre-discharge sampling of Ponds A-4, B-5, and C-2, or any other upstream pond functioning as a terminal pond, as a BMP to suggest compliance with surface water-quality standards (see Table 1 of RFLMA Attachment 2) at the downstream POCs. Pre-discharge samples are collected at Ponds A-4, B-5, and C-2 on North Walnut Creek, South Walnut Creek, and Woman Creek, respectively. These locations are shown on Figure 60. Sampling and data evaluation protocols are summarized in Table 35.

Table 35. Sampling and Data Evaluation Protocols at Pre-Discharge Monitoring Locations

Location Code	Location Description	Sample Types/ Frequencies	Analytes	Data Evaluation
A4 POND	Pond A-4 at east end of pond near outlet works	Prior to discharge	Pu, Am, total U, nitrate[a]	Review with regulators prior to discharge
B5 POND	Pond B-5 at east end of pond near outlet works	Prior to discharge	Pu, Am, total U, nitrate[a]	Review with regulators prior to discharge
C2 POND	Pond C-2 at east end of pond near outlet works	Prior to discharge	Pu, Am, total U	Review with regulators prior to discharge

Notes: [a] Nitrate is analyzed as nitrate+nitrite as nitrogen; the nitrate+nitrite result is conservatively compared to the nitrate standard only.

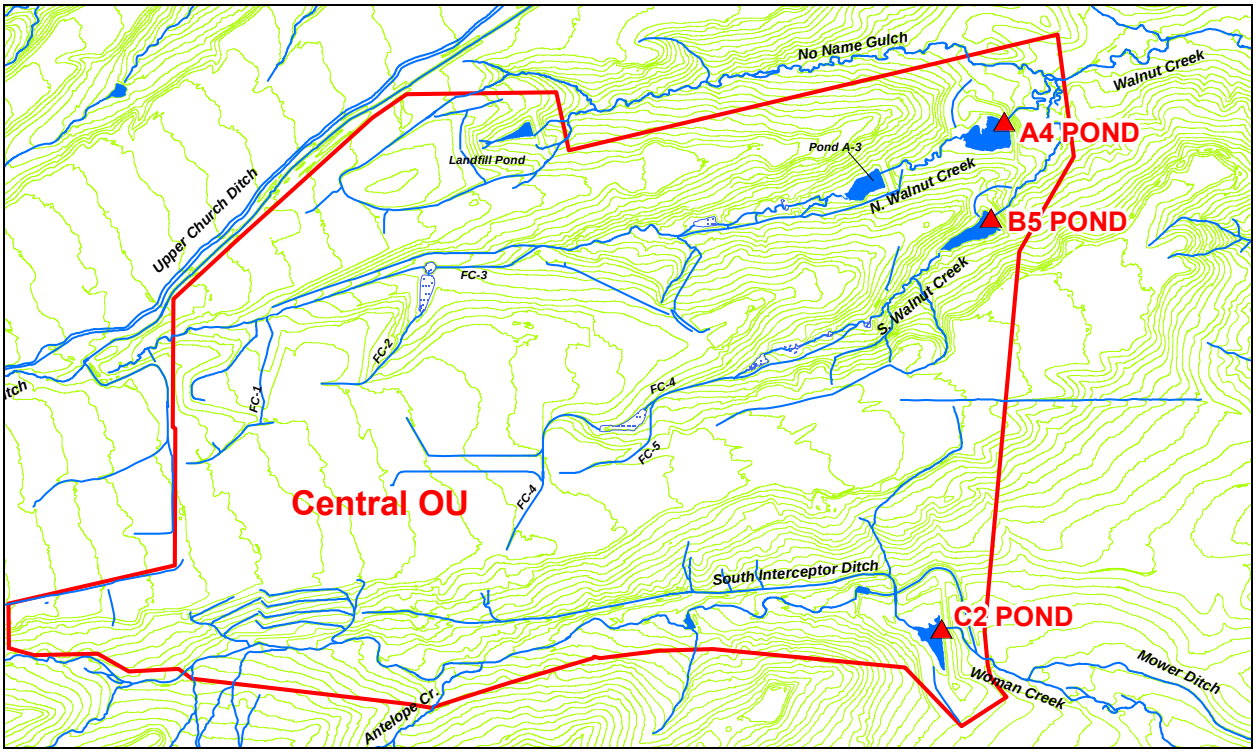


Figure 60. Pre-Discharge Sampling Locations

Data Evaluation

During CY 2010, pre-discharge samples were collected during at Ponds A-4, B-5, and C-2 prior to discharge. All predischarge sample results indicated that water quality was acceptable for discharge. Subsequent POC sampling during discharge also indicated acceptable water quality for the discharged water.

3.1.3 Rocky Flats Hydrology

The following section provides information for all automated surface-water monitoring and precipitation gage locations at the Site that operated during CY 2010. For locations with continuous flow measurement, graphical discharge summaries are provided. Graphical summaries are also provided for all precipitation gage locations. Numerical discharge and precipitation values are included in the tables in Appendix A.

Groundwater hydrology is also addressed. This includes a discussion of groundwater levels in various areas of interest via the preparation of hydrographs and potentiometric surface maps. Flow velocities are also calculated. Hydrographs for monitoring wells are included in Appendix A.

3.1.3.1 General Hydrologic Setting

Streams and seeps at the Site are largely ephemeral, with stream reaches gaining or losing flow, depending on the season and precipitation amounts. Section 3.1.3.6 discusses the 2010 efforts to document observed seeps at the site. Surface-water flow across the Site is primarily from west to east, with three major drainages traversing the Site. Five ponds within the COU collect and manage surface-water runoff.[7] The Site drainages and ponds, including their respective pertinence to this report, are described below and shown on Figure 61.

The major stream drainages leading out of the Refuge, from north to south, are Rock Creek, Walnut Creek, and Woman Creek. North Walnut Creek flows through the A-Series Ponds, and South Walnut Creek flows through the B-Series Ponds; both are tributaries to Walnut Creek. The hydrologic routing diagram (as of December 31, 2010) for the locations included in this report is shown on Figure 62.

The groundwater hydrology is generally characterized by relatively thin, shallow, saturated materials (in the COU, typically on the order of a few dozen feet thick or less, and less than 50 feet deep). This shallow saturated interval occurs within the unconsolidated Rocky Flats Alluvium, hillslope colluvium, valley-fill alluvium, artificial fill, and the weathered portion of the underlying bedrock. Collectively, these materials are referred to as the upper hydrostratigraphic unit (UHSU). Regionally, groundwater flows from west to east within the UHSU of the pediment surfaces, except where locally diverted toward the generally east-west trending drainages that bisect these pediments. Groundwater typically discharges at seeps and

[7] Former Dams A-1, A-2, B-1, B-2, B-3, and B-4 were breached during 2008−2009.

Data Evaluation

During CY 2010, pre-discharge samples were collected during at Ponds A-4, B-5, and C-2 prior to discharge. All predischarge sample results indicated that water quality was acceptable for discharge. Subsequent POC sampling during discharge also indicated acceptable water quality for the discharged water.

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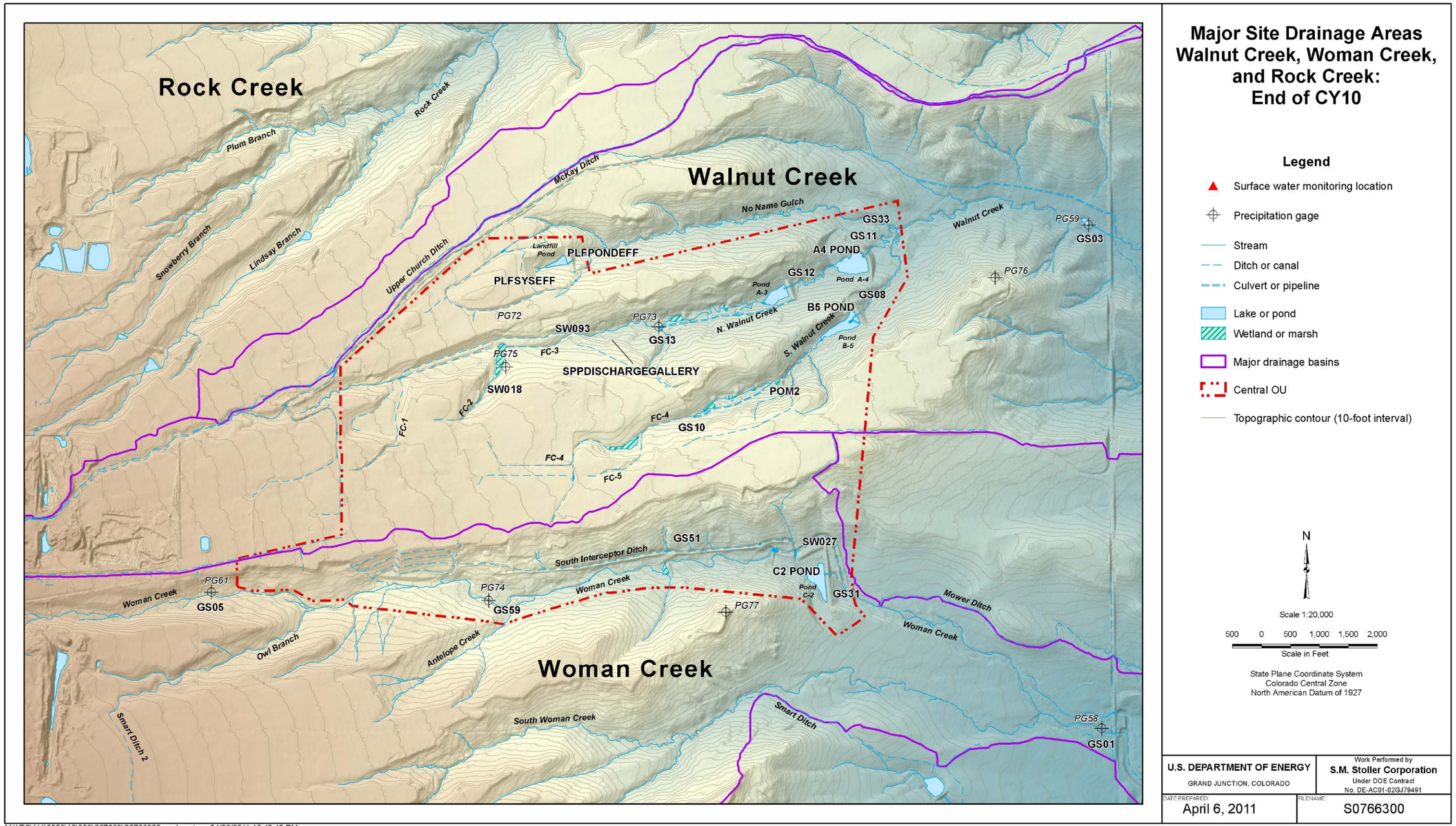


Figure 61. Major Site Drainage Areas—Walnut Creek, Woman Creek, and Rock Creek: End of CY 2010

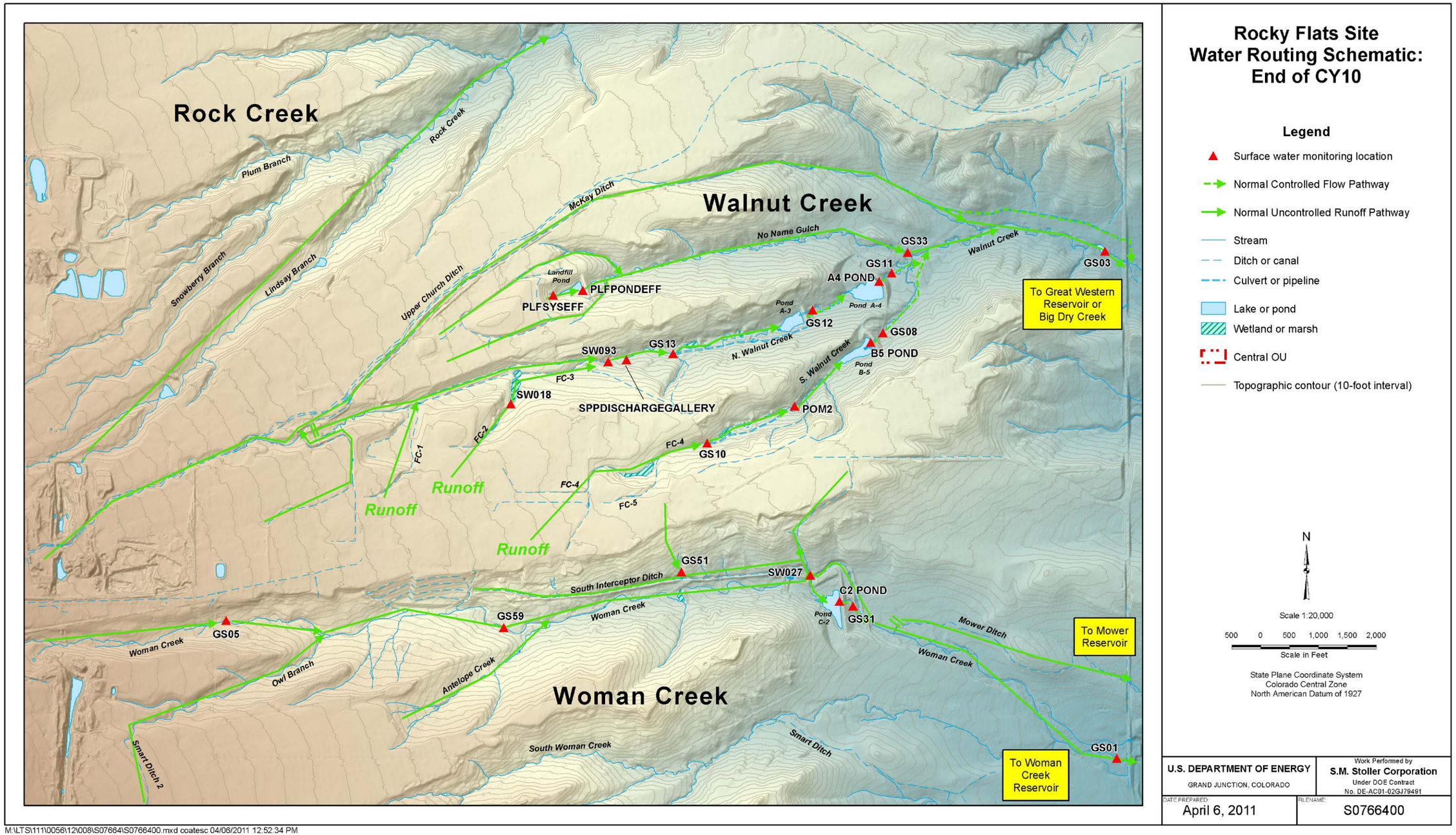


Figure 62. Rocky Flats Site Water Routing Schematic: End of CY 2010

springs along pediment edges, or as baseflow to surface water. Vertical flow is sharply limited by the low-permeability claystones underlying the unconsolidated surficial materials. This underlying low-permeability bedrock surface comprises the Arapahoe and Laramie Formations, which are typically undifferentiated; the gentle eastward dip of the unconformity marking the contact between this bedrock and the overlying unconsolidated surficial materials acts to direct the groundwater flow. Locally, this bedrock may include sandstone lenses that subcrop or are sufficiently shallow to be included in the UHSU. For a more thorough description of the hydrogeology at Rocky Flats, refer to EG&G (1995a).

Surface Water

Walnut Creek

Walnut Creek receives surface-water flow from the central third of the Refuge, including the majority of the COU. It consists of several tributaries: McKay Ditch, No Name Gulch, North Walnut Creek, and South Walnut Creek. These tributaries join Walnut Creek upstream of the Refuge's eastern boundary (Indiana Street). East of Indiana Street, Walnut Creek flows through a diversion structure normally configured to divert flow to the Broomfield Diversion Ditch around Great Western Reservoir and into Big Dry Creek. The Walnut Creek tributaries, from north to south, are described below.

McKay Ditch

The McKay Ditch was formerly a tributary to Walnut Creek within the Refuge boundary but was diverted in July 1999 into a new pipeline to keep McKay Ditch water from commingling with water in Walnut Creek upstream of Indiana Street. Although no longer a contributor to Walnut Creek, the McKay Ditch drainage is described here to clarify water routing. The new configuration allows the City and County of Broomfield to direct water from the South Boulder Diversion Canal, across the northern portion of the Refuge and directly into Great Western Reservoir, without entering Walnut Creek. This configuration prevents the commingling of McKay Ditch water with water originating in the COU. McKay Ditch (as well as both the McKay Bypass Canal and McKay Bypass Pipeline) are outside the COU; these features are not maintained by LM.

No Name Gulch

This drainage is located downstream of the Present Landfill Pond. A surface-water diversion ditch is constructed around the perimeter of the PLF to divert surface-water runoff around the landfill area to No Name Gulch. Effluent from the PLFTS and runoff from the area immediately surrounding the Landfill Pond are the sole surface-water sources to the Landfill Pond. The Landfill Pond is normally operated in a flow-through configuration, although the pool level periodically drops below the outlet works.

North Walnut Creek

Runoff from the northern portion of the COU flows into this drainage, which has four ponds (Ponds A-1, A-2, A-3, and A-4). Dams A-1 and A-2 were breached in 2008−2009. The combined capacity of the A-series ponds is approximately 174,000 cubic meters (m^3)

(46 million gallons, or 141 acre-feet). In the normal operational configuration, Ponds A-1 and A-2 receive flow for storm water attenuation and wetland habitat; the stoplog structures control water levels in these ponds, with water subsequently flowing to Pond A-3. Pond A-3 is normally operated in flow-through to the A-series "terminal pond" Pond A-4. If routine discharge of retained water is warranted, Pond A-4 is pre-discharge sampled, and water is released if surface water-quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the *Emergency Response Plan for Rocky Flats Site Dams* (ERP) (DOE 2010f).

South Walnut Creek

Runoff from the central portion of the COU flows into this drainage, which has five ponds (Ponds B-1, B-2, B-3, B-4, and B-5). Dams B-1, B-2, B-3, and B-4 were breached in 2008−2009. The combined capacity of the South Walnut Creek B-series ponds is approximately 93,000 m^3 (25 million gallons or 76 acre-feet). In the normal operational configuration, Ponds B-1, B-2, B-3, and B-4 receive flow for storm water attenuation and wetland habitat; the stoplog structures control water levels in these ponds, with water subsequently flowing to "terminal pond" Pond B-5. If routine discharge of retained water is warranted, Pond B-5 is pre-discharge sampled and water is released if surface water quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the ERP.

Woman Creek

South of the COU is Woman Creek, which flows through Pond C-1 (breached in 2004) and off site onto Refuge lands toward Indiana Street. The Woman Creek drainage basin extends eastward from the base of the foothills, near Coal Creek Canyon, to Standley Lake. In the current configuration, Woman Creek flows into the Standley Lake Protection Project, also known as the Woman Creek Reservoir, located east of Indiana Street and upstream of Standley Lake, where the water is held until it is pump-transferred to Big Dry Creek by the Woman Creek Reservoir Authority.

South Interceptor Ditch

In the southern portion of the COU, and a tributary to Woman Creek, is the SID drainage. Surface-water runoff from the southern portion of the COU is captured by the SID, which flows from west to east into Pond C-2. Woman Creek water does not enter Pond C-2, but is diverted around Pond C-2 through the Woman Creek Diversion Canal. If routine discharge of retained water is warranted, Pond C-2 is pre-discharge sampled, and water is released to Woman Creek if surface water quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the ERP.

Other Drainages

The third major drainage, other than Walnut and Woman Creeks, is Rock Creek. The Rock Creek drainage covers the northwestern portion of the Refuge. East-sloping alluvial plains to the west, several small stock ponds within the creek bed, and multiple steep gullies and stream channels to the east characterize the drainage channel. This entire basin is outside the COU.

Smart Ditch/South Woman Creek, located south of Woman Creek, is also completely outside the COU. The D-series ponds (D-1 and D-2) are located on Smart Ditch. This drainage and these ponds are not maintained by LM.

3.1.3.2 Surface-Water Hydrologic Data Presentation

Flow Data Collection and Computation

Data obtained at a continuous surface-water gaging station on a stream or conveyance, such as an irrigation ditch, consist of a continuous record of stage,[8] individual measurements of flow throughout a range of stages, and notations regarding factors that might affect the relation of stage to flow rate. These data, together with supplemental information such as climatological records, are used to compute daily mean discharges.

Continuous records of stage are obtained with electronic recorders that store stage values at selected time intervals or secondarily with radio-telemetry data-collection platforms that transmit near real-time data at selected time intervals to a central database for subsequent processing. Direct field measurements of flow are made with current meters, using methods adapted by the U.S. Geological Survey, or with flumes or weirs that are calibrated to provide a relation of observed stage to flow rate. These methods are described by Carter and Davidian (1968) and by Rantz (1982a, 1982b).

In computing flow records for nonstandard flow-control devices, results of individual measurements are plotted against the corresponding stage, and stage-flow rate relation curves are constructed. From these curves, rating tables indicating the computed flow rate for any stage within the range of the measurements are prepared. For standard devices (e.g., flumes and weirs), rating tables indicating the flow rate for any stage within the range of the device are prepared based on the geometry of the device. If it is necessary to define extremes of flow outside the range of the device, the curves can be extended using (1) logarithmic plotting, (2) velocity-area studies, (3) results of indirect measurements of peak flow rate, such as slope-area or contracted-opening measurements, and computation of flow over dams or weirs, or (4) step-back-water techniques.

Daily mean discharges are computed by averaging the individual flow measurements using the stage-flow rate curves or tables. If the stage-flow rate relation is subject to change because of frequent or continual change in the physical features that form the control, the daily mean discharge is determined by the shifting-control method, in which correction factors based on the individual flow rate measurements and notes by the personnel making the measurements are applied to the gage heights before the flow rates are determined from the curves or tables. This shifting-control method also is used if the stage-flow rate relation is changed temporarily because of aquatic vegetation growth or debris on the control. For some gaging stations, formation of ice in the winter can obscure the stage-flow rate relations so that daily mean discharges need to be estimated from other information, such as temperature and precipitation records, notes of observations, and records for other gaging stations in the same or nearby basins for comparable periods.

[8] Stage is the water level (in units such as feet or meters) in a conveyance structure.

For most gaging stations, there may be periods when no gage-height record is obtained or the recorded gage height is faulty so that it cannot be used to compute daily mean discharge. This record loss occurs when recording instruments malfunction or otherwise fail to operate properly, intakes are plugged, the stilling well is frozen, or for various other reasons. For such periods, the daily discharges are estimated from the recorded range in stage, previous or following record, field discharge measurements, climatological records, and comparison with other gaging-station records from the same or nearby basins. Information explaining how estimated daily discharge values are identified in gaging-station records is provided in the "Identifying Estimated Daily Discharge" section.

Data Presentation

The information published for each continuous-record surface-water gaging station consists of six parts: the station description, a map showing the drainage area for the station, a plot of the daily mean discharge for the CY(s), a table of daily mean discharge values for the CY with summary data, a tabular statistical summary of monthly mean discharge data for the CY, and a summary statistics table that includes statistical data of annual discharge and runoff. The tables are included in Appendix A, and the other information is presented below.

Station Description

The station description provides, under various headings, descriptive information including gaging-station location, drainage area, period of record, and gage information. The following information is provided:

- Location—This entry provides the gaging station state plane coordinates and geographic location. Gaging station state plane coordinates were obtained by geographic positioning system or digitized from Site geographic information system (GIS) coverages.
- Drainage Area—This entry provides the drainage area (in acres) of the gaged basin. If, because of unusual natural conditions or artificial controls, some part of the basin does not contribute flow to the total flow measured at the gage, the noncontributing drainage area also is identified. Drainage area is usually measured using digital techniques and the most accurate maps available. Because the type of map available might vary from one drainage basin to another, the accuracy of digitized drainage areas also can vary. Drainage areas are updated as better maps become available. Some of the gaging stations included in this report measure stage and flow rate in channels that convey water to or from reservoirs or other features; these channels might have little or no contributing drainage area. Drainage areas in this report were provided by Site GIS coverages.[9]
- Period of Record—This entry provides the period for which the Site has been collecting records at the gage. This entry includes the month and year of the start of collection of hydrologic records by the Site and the words "to current year" if the records are to be continued into the following year.
- Gage—This entry provides the type of gage currently in use and a condensed history of the types and locations of previous gages.

[9] Drainage area maps show Site configuration at the end of CY 2010.

Daily Mean Discharge Values

The daily mean discharge values computed for each gaging station during a CY are listed in the body of the data tables in Appendix A. In the monthly "Flow Rate" summary part of the table, the line headed "Average" lists the average flow rate in cubic feet per second during the month, and the lines headed "Maximum" and "Minimum" list the maximum and minimum daily mean discharges for each month. Total discharge for the month also is expressed in cubic feet, gallons, and acre-feet. The term "Partial Data" denotes a month with incomplete data.

Summary Statistics

A section of the table titled "Annual Summaries for CY10" follows the monthly mean data section. This section provides a statistical summary of annual flow rates and discharge for the labeled CY. The applicable units are to the left of the table value. The term "Partial Data" denotes a year with incomplete data.

Identifying Estimated Daily Discharge

Estimated daily discharges published in water-discharge tables and figures of this annual report are identified by *italicizing* individual daily values or through color coding in hydrographs. For periods of no data, a gap is shown on the hydrographs.

Other Records Available

Information used in the preparation of the records in this report, such as discharge-measurement notes, gage-height records, and rating tables, are on file. Information on the availability of the unpublished information or on the published statistical analyses is available from personnel involved with data collection at the Site.

3.1.3.3 Surface-Water Discharge Data Summaries

Sitewide Discharge Summary

Discharge summaries for the two major Site drainages receiving flow from the COU (Walnut and Woman Creeks) are given on Figure 63 and Figure 64.[10] Walnut Creek flows are measured at GS03 and Woman Creek flows are measured at GS01. Figure 65 shows the relative total CY 1997−2010 discharge volumes from the major Site drainages as measured at Site POEs and POCs. Through CY 2004, Walnut Creek discharged larger volumes than Woman Creek due to the contribution of imported water and runoff from impervious surfaces. After physical completion in CY 2005, the reduction of discharge in Walnut Creek and the corresponding change in relative volumes is clearly observed.

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

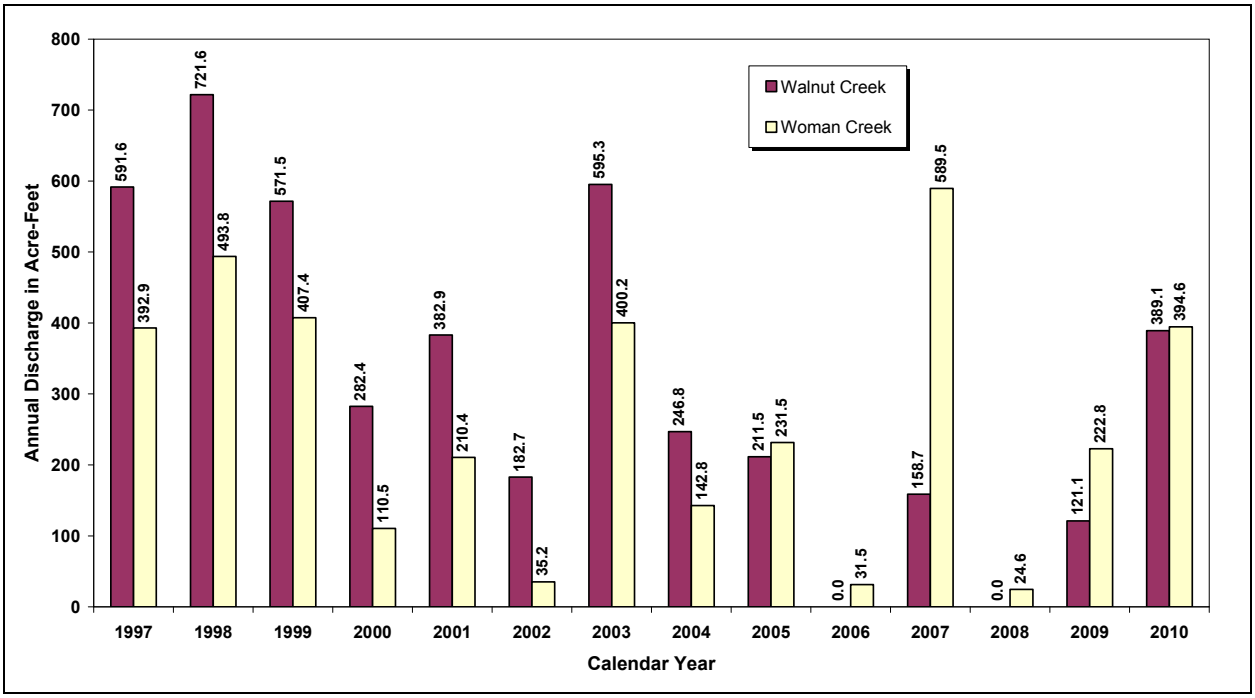


Figure 63. Annual Discharge Summary from Major Site Drainages: CY 1997−2010

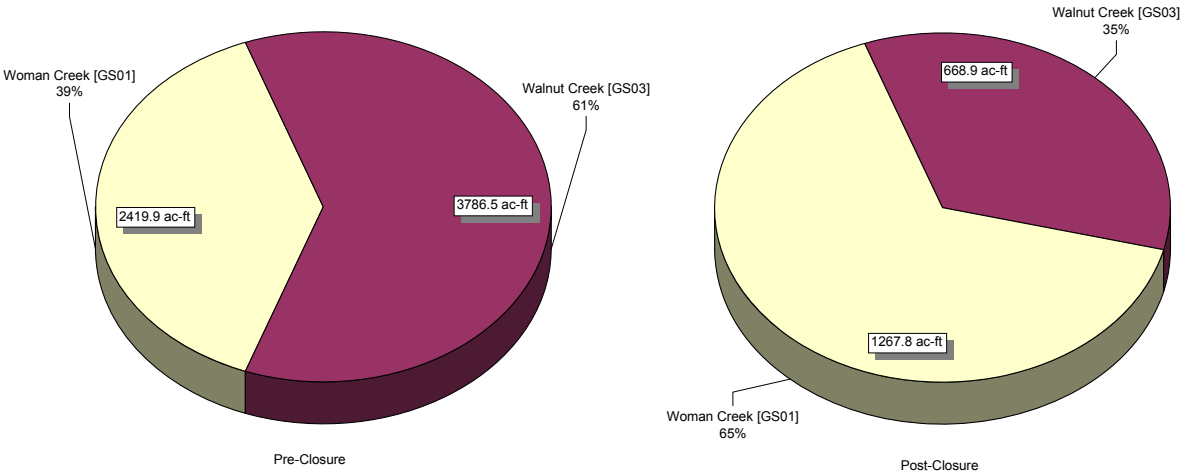


Figure 64. Relative Total Discharge Summary from Major Site Drainages: Pre- and Post-Closure Periods

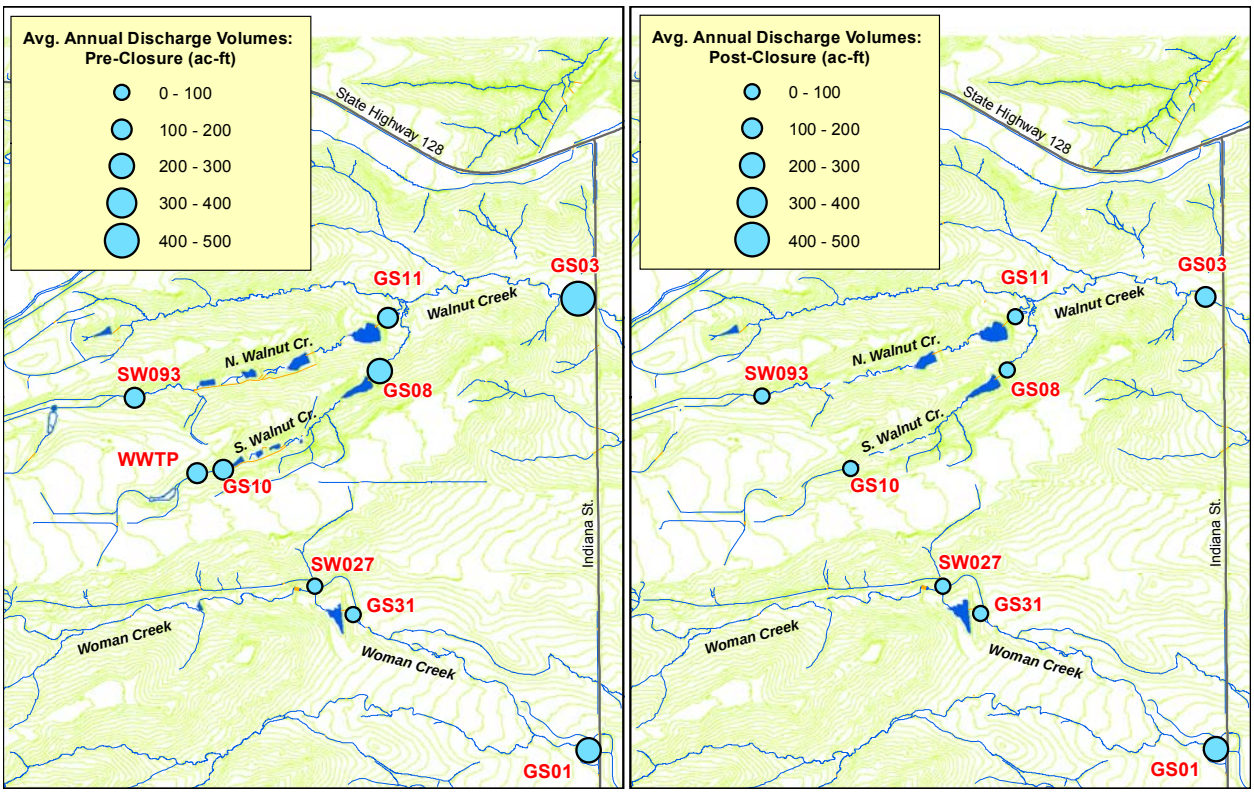
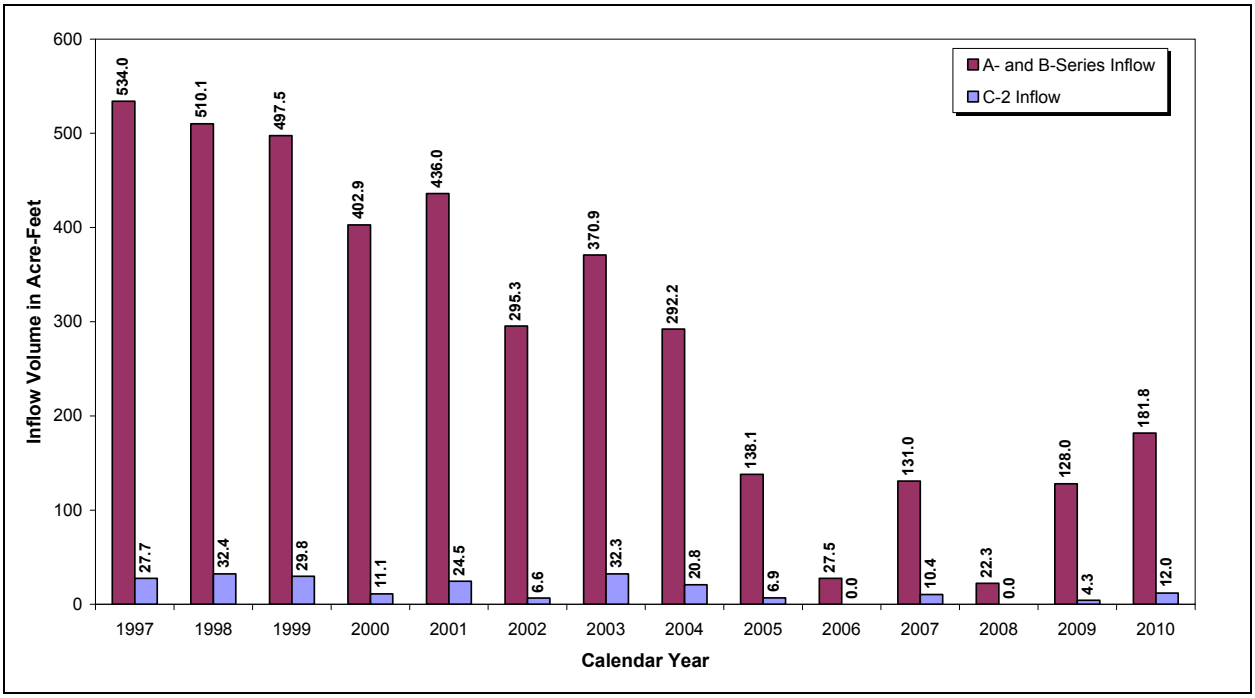


Figure 65. Map Showing Relative CY 1997−2010 Average Annual Discharge Volumes for POEs and POCs: Pre- and Post-Closure Periods

Pond Discharge Summary

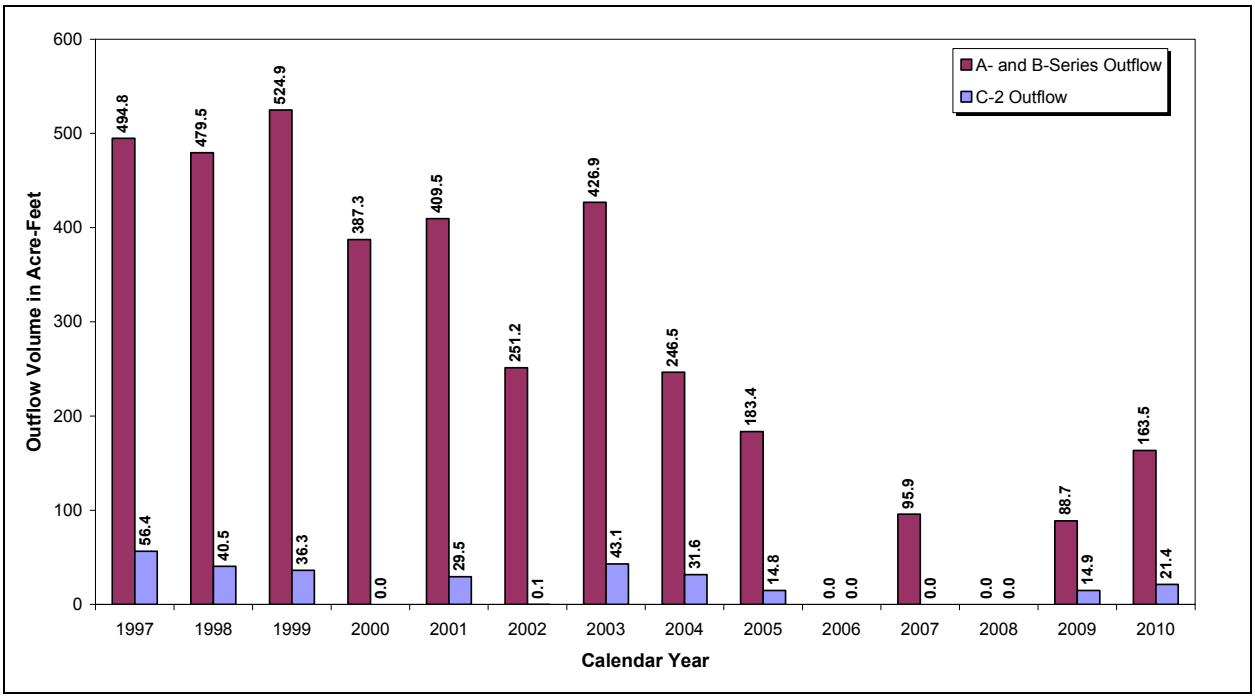
Figure 66 and Figure 67 show the annual ponds inflows and outflows, respectively. Due to the intermittent pump transfers of Pond B-5 water to Pond A-4, the volumes for the A- and B-Series Ponds are combined. The reduction in pond water volumes as the Site progressed toward closure is clearly observed. Figure 68 and Figure 69 show the relative total CY 1997−2010 discharge volumes from the ponds (as measured at GS08, GS11, and GS31) and from the major drainages tributary to the ponds (as measured at GS10, SW027, SW091, SW093, and the former Waste Water Treatment Plant [WWTP] [995POE]).[11, 12] Pond inflows do not necessarily equal outflows for any given year due to the storage of water in the ponds across water years, evaporative/seepage losses/gains, and local runoff to the ponds.

[11] The WWTP was removed from service on November 4, 2004.
[12] The pre-closure period is for the dates 1/1/97−10/1/05; the post-closure period is for the dates 10/1/05−12/31/10.



Notes: A- and B-Series Inflow is the sum of GS10, the former WWTP, and SW093. The C-2 Inflow is the volume measured at SW027.

Figure 66. Pond Inflows: CY 1997−2010



Notes: A- and B-Series Outflow is the sum of GS11 and GS08. The C-2 Outflow is the volume measured at GS31.

Figure 67. Pond Outflows: CY 1997−2010

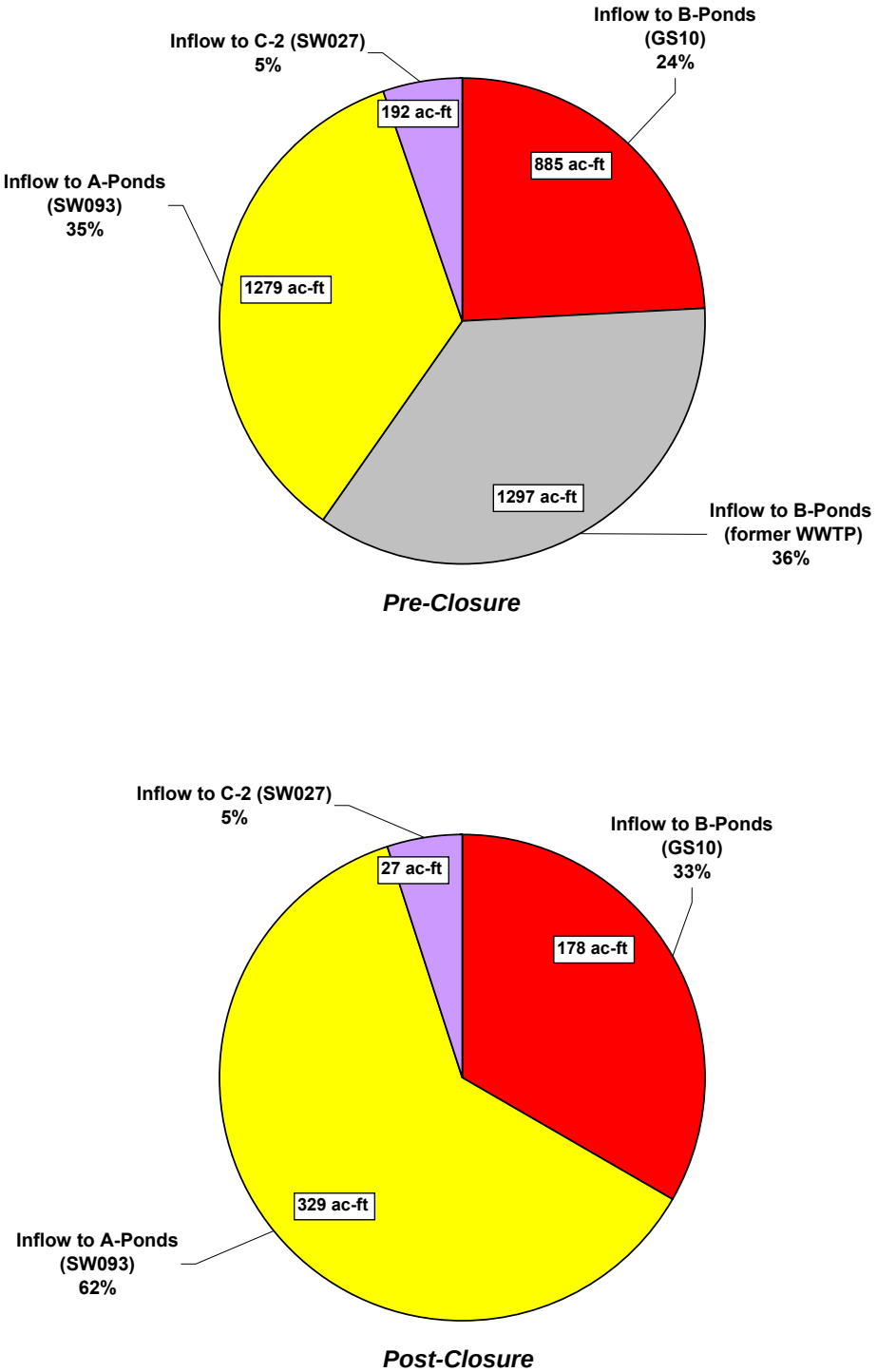


Figure 68. Relative Total Inflow Volumes for Site Ponds: Pre- and Post-Closure Periods

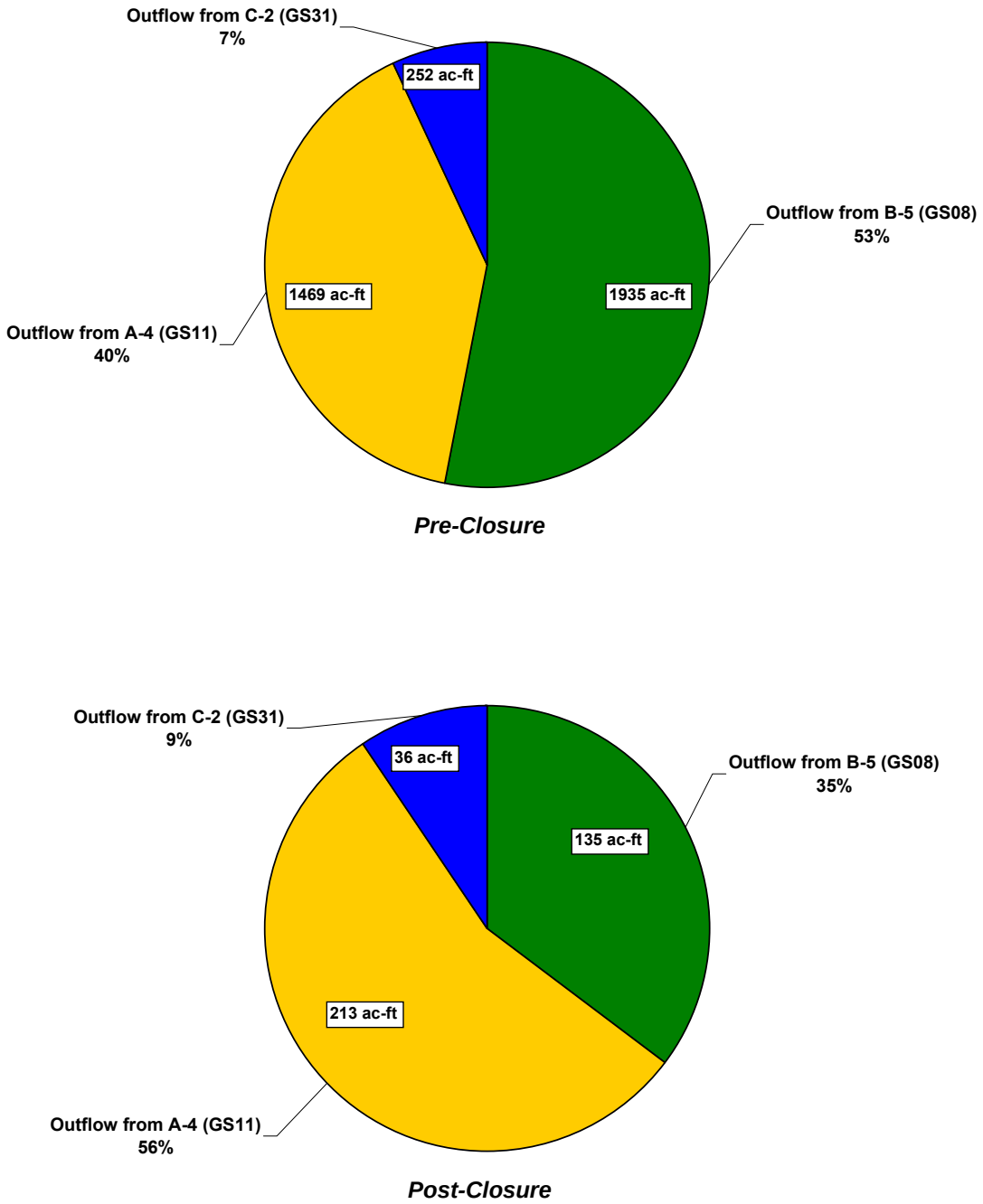


Figure 69. Relative Total Outflow Volumes for Site Ponds: Pre- and Post-Closure Periods

GS01: Woman Creek at Indiana Street

Location—Woman Creek 200 feet upstream of Indiana Street; State Plane: E2093824, N744889.

Drainage Area—The basin includes the Woman Creek drainage and southern portions of the COU; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 16, 1991, to current year.

Gage—Water-stage recorder and 18-inch Parshall flume (flume is located just east of Indiana Street, sampling conducted on Refuge property); prior to March 24, 1998, flow measurement was at the on-site sampling location using a 9-inch Parshall flume.

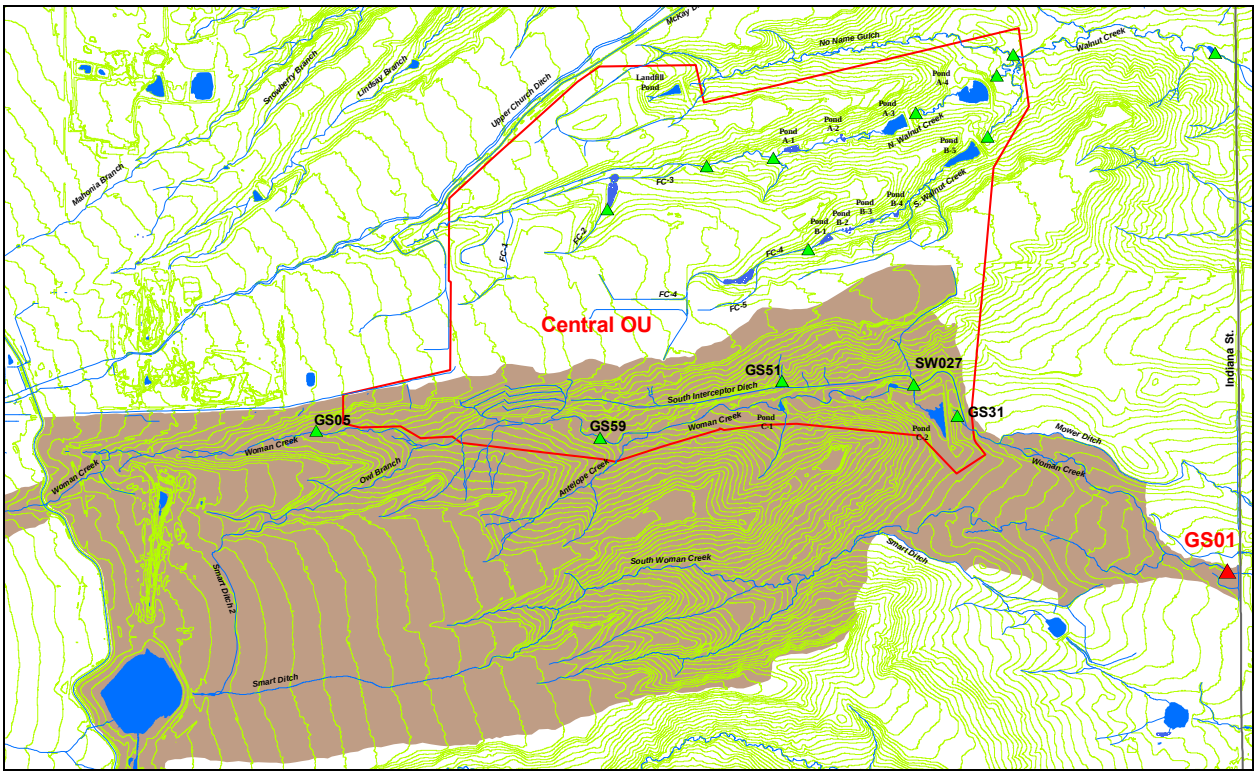


Figure 70. GS01 Drainage Area

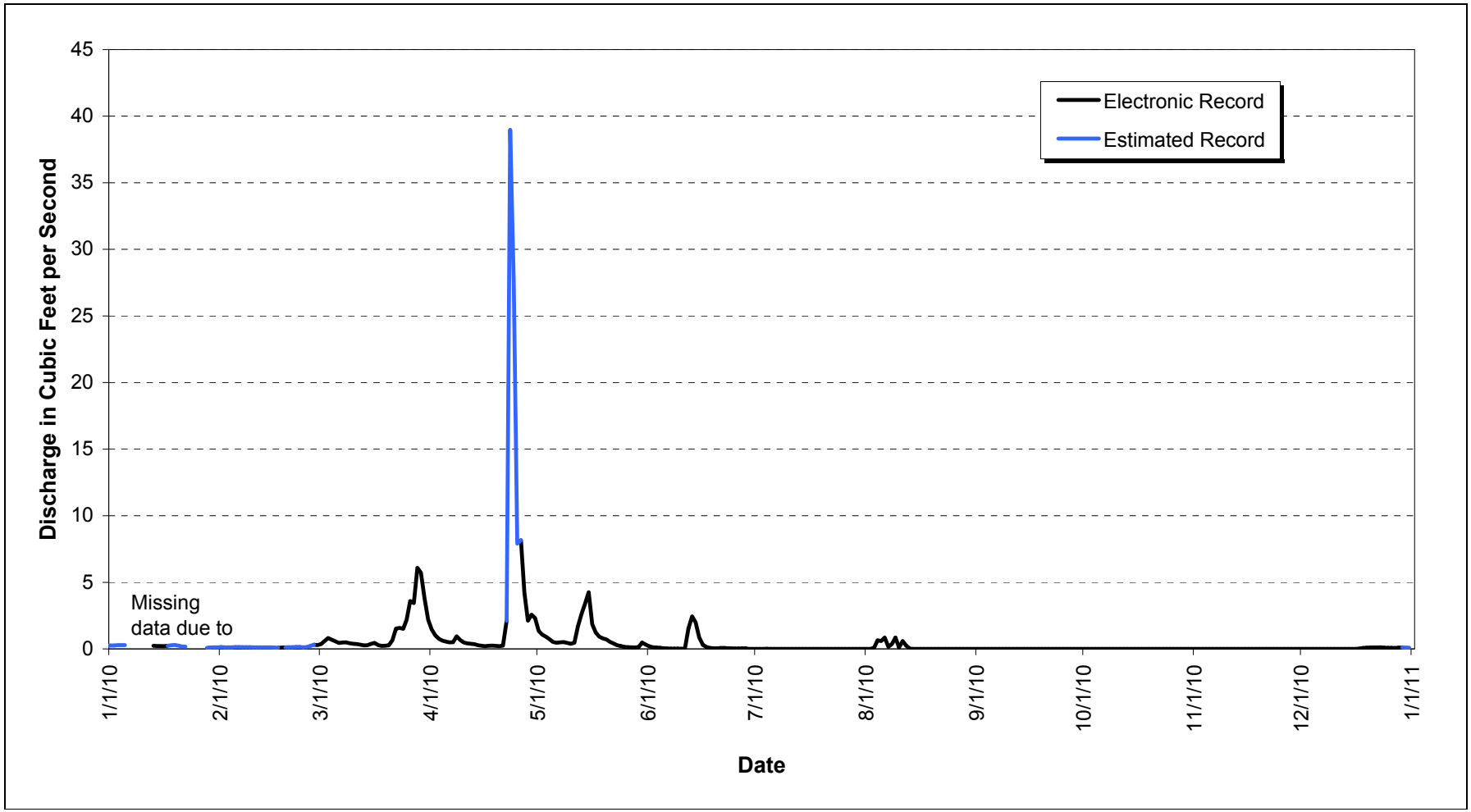


Figure 71. CY 2010 Mean Daily Hydrograph at GS01: Woman Creek at Indiana Street

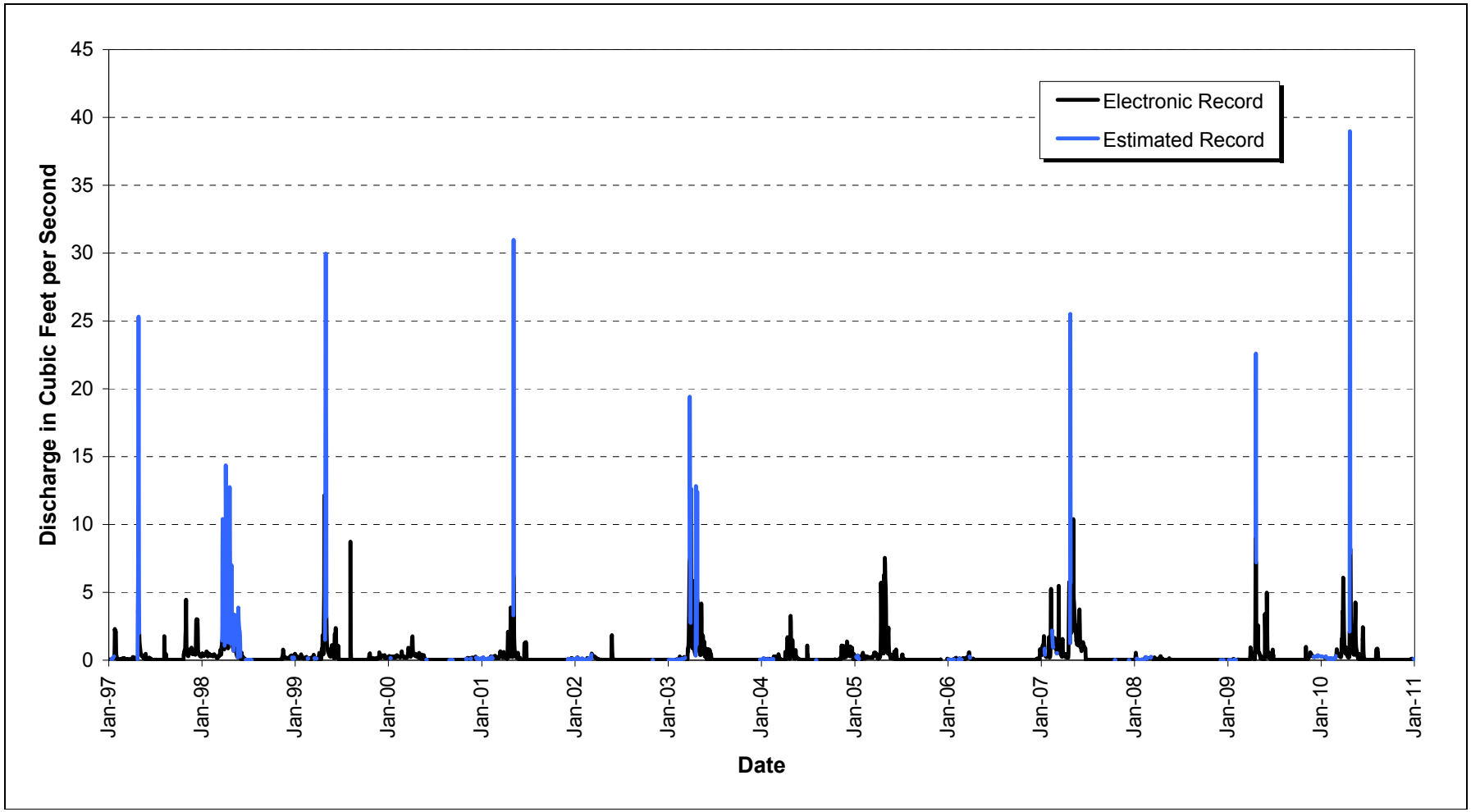


Figure 72. CY 1997−2010 Mean Daily Hydrograph at GS01: Woman Creek at Indiana Street

GS03: Walnut Creek at Indiana Street

Location—Walnut Creek at Flume Pond outlet upstream of Indiana Street; State Plane: E2093618, N753646.

Drainage Area—The basin includes the Walnut Creek drainage and the majority of the COU; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 2, 1991, to current year.

Gage—Water-stage recorder and parallel 6-inch and 36-inch Parshall flumes prior to November 5, 2002. Rated stream section during flume construction (GS03T; November 5, 2002−February 12, 2003). Three-foot HL flume starting February 12, 2003.

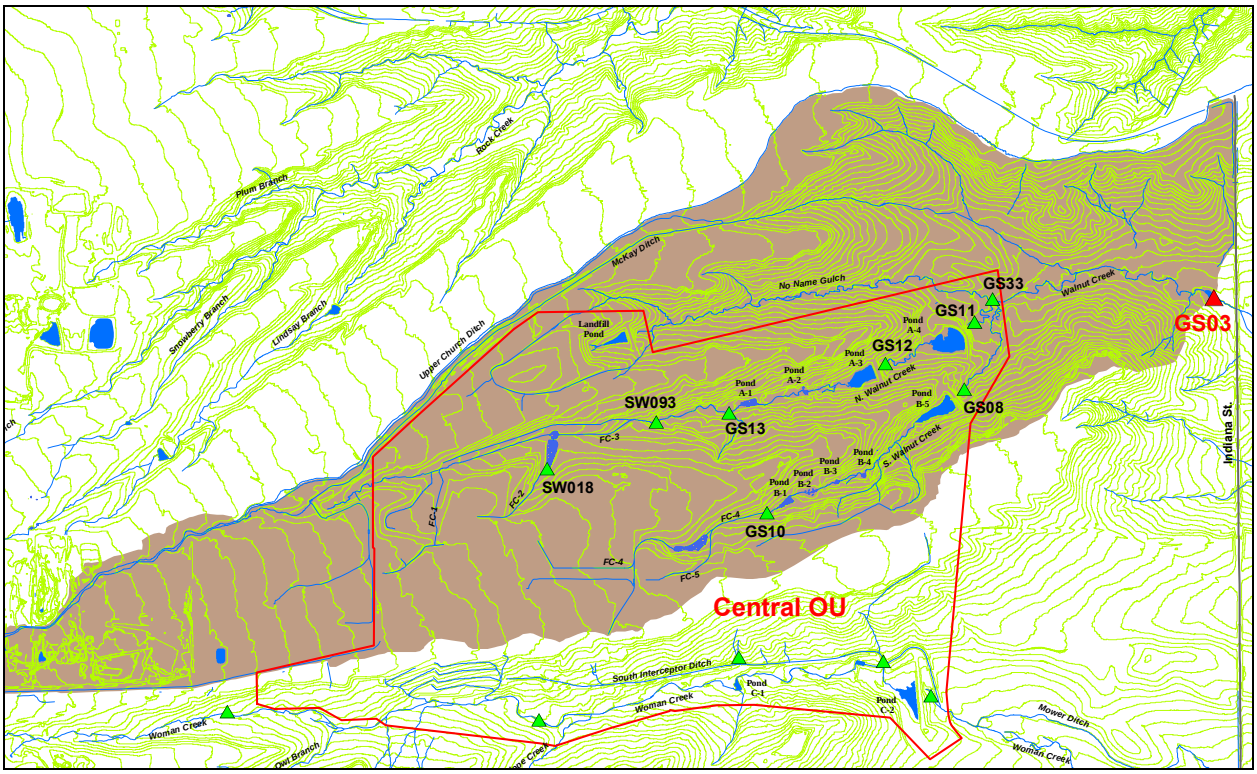


Figure 73. GS03 Drainage Area

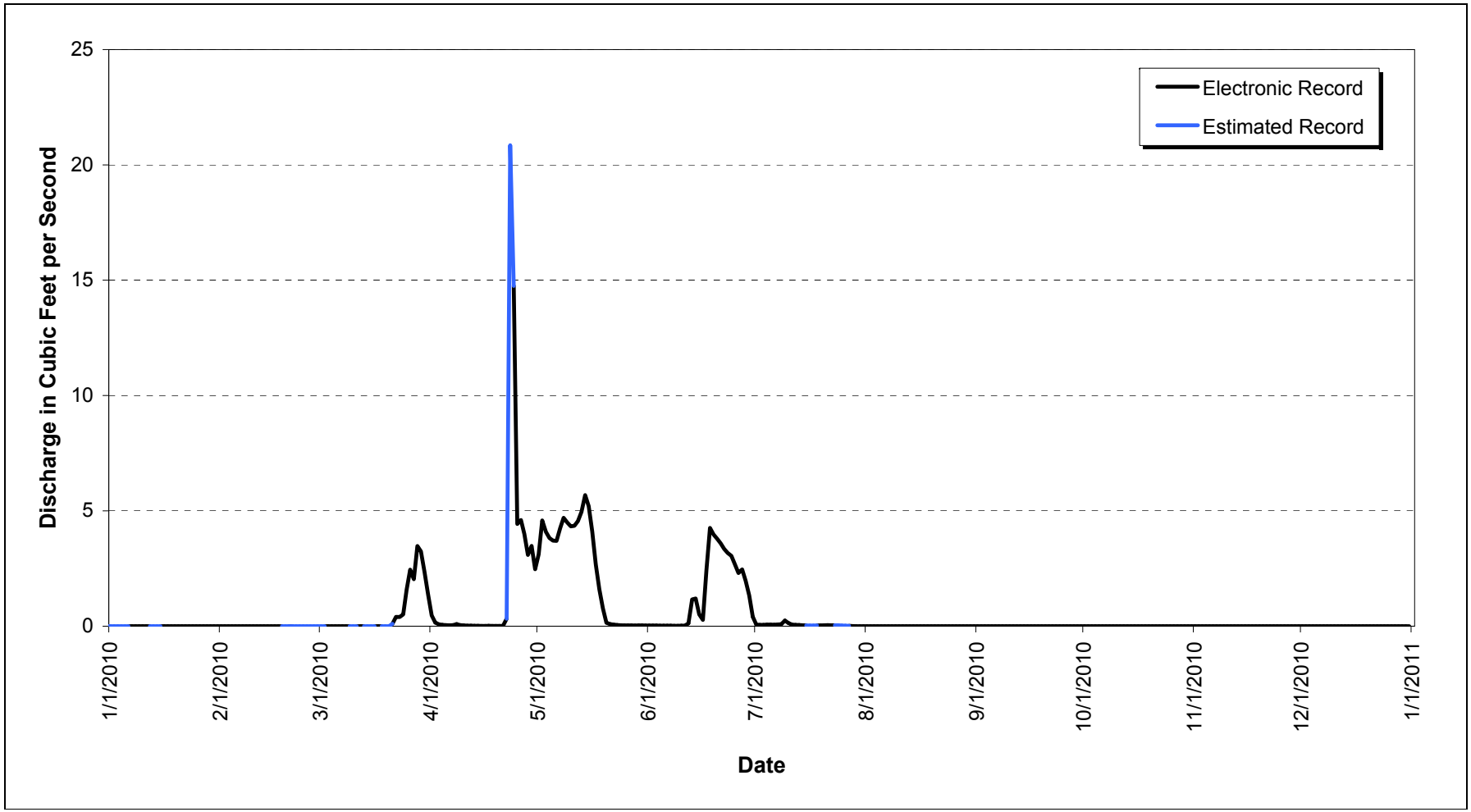


Figure 74. CY 2010 Mean Daily Hydrograph at GS03: Walnut Creek at Indiana Street

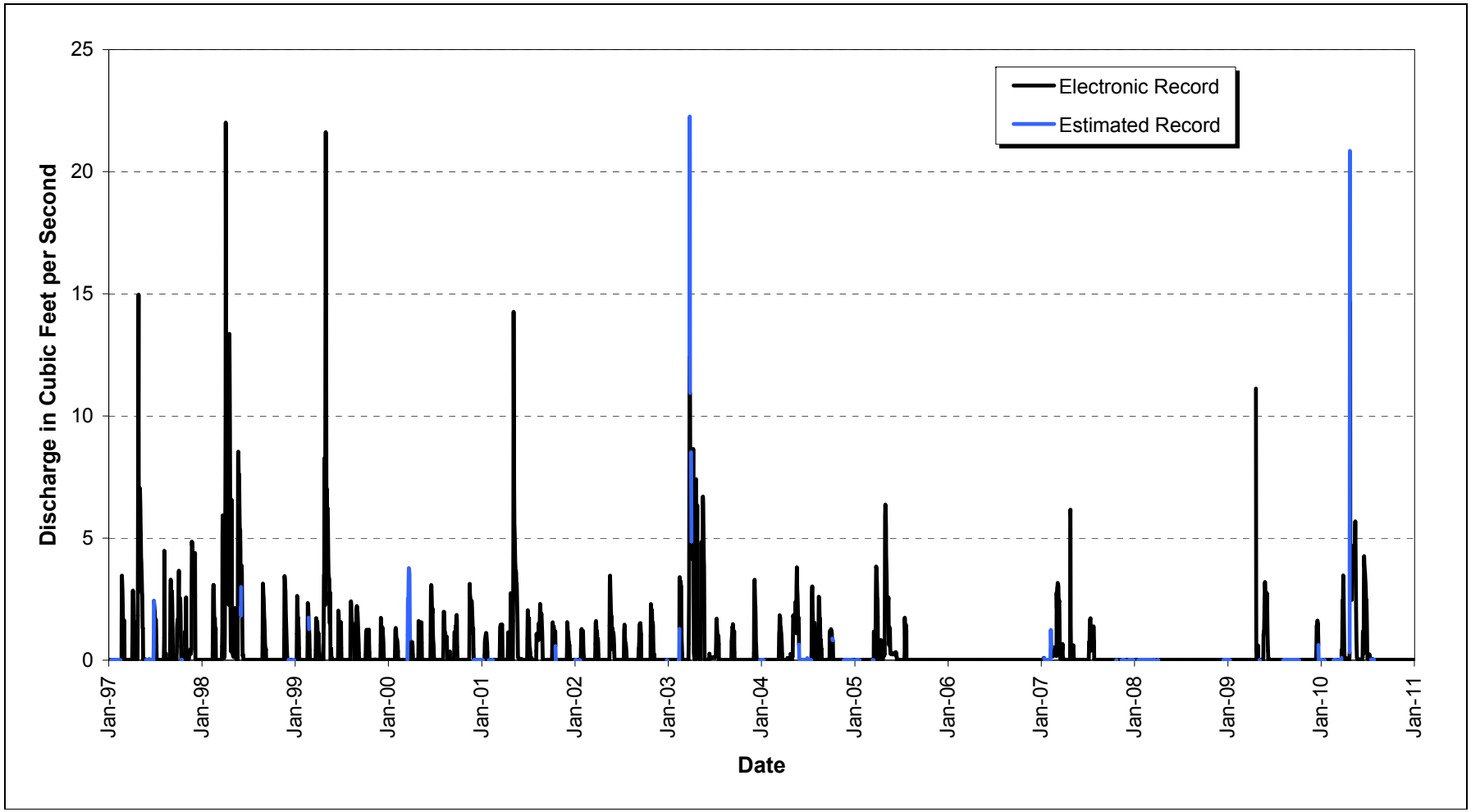


Figure 75. CY 1997−2010 Mean Daily Hydrograph at GS03: Walnut Creek at Indiana Street

GS05: North Woman Creek at West Fenceline

Location—Woman Creek east of western Site boundary; State Plane: E2078429, N747264.

Drainage Area—The basin includes a portion of the Woman Creek drainage; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 23, 1991, to current year.

Gage—Water-stage recorder and 9-inch Parshall flume with weir insert.

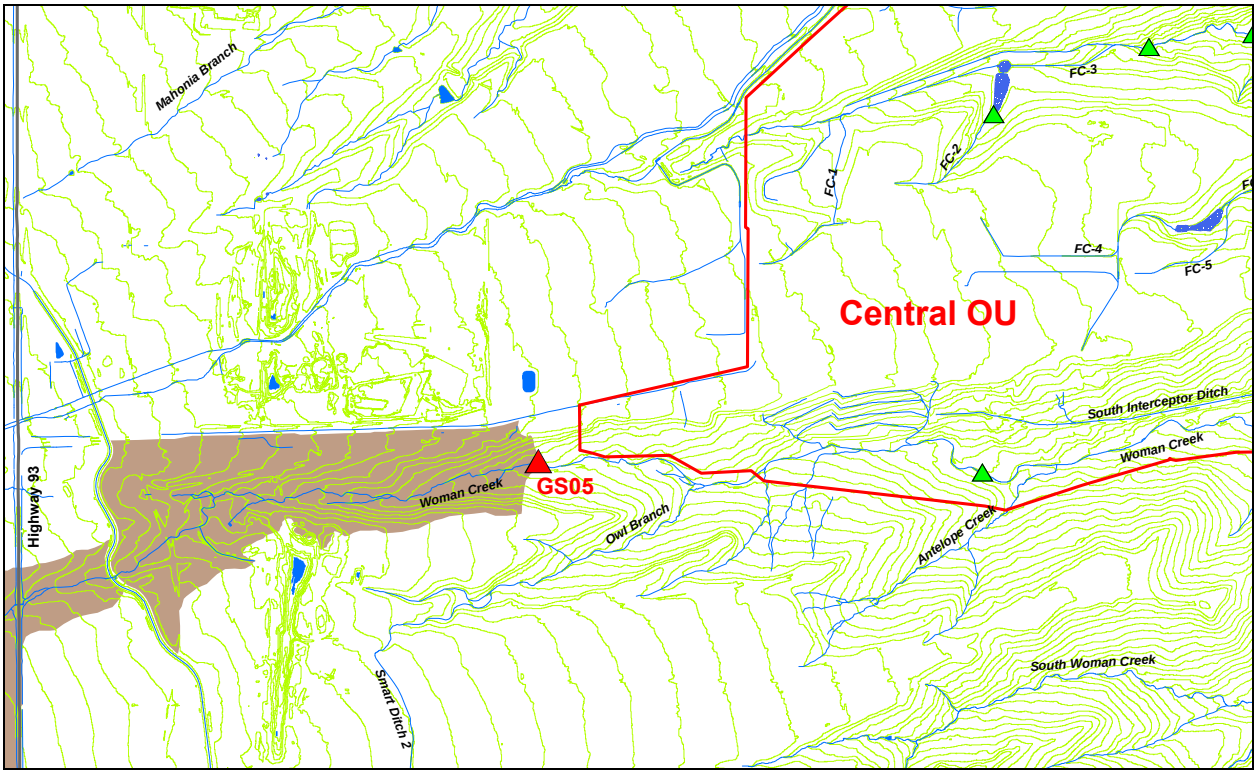


Figure 76. GS05 Drainage Area

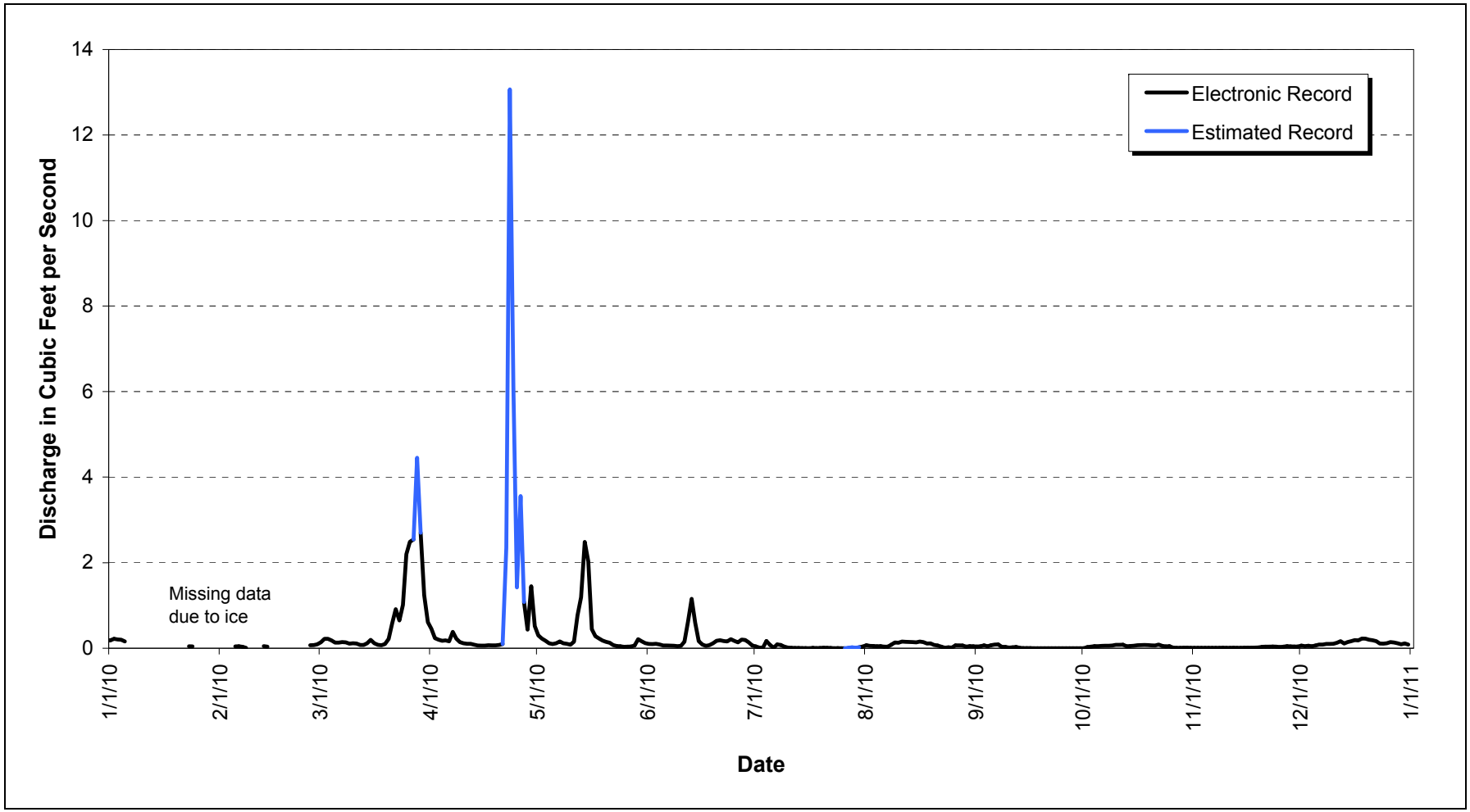


Figure 77. CY 2010 Mean Daily Hydrograph at GS05: North Woman Creek at West Fence Line

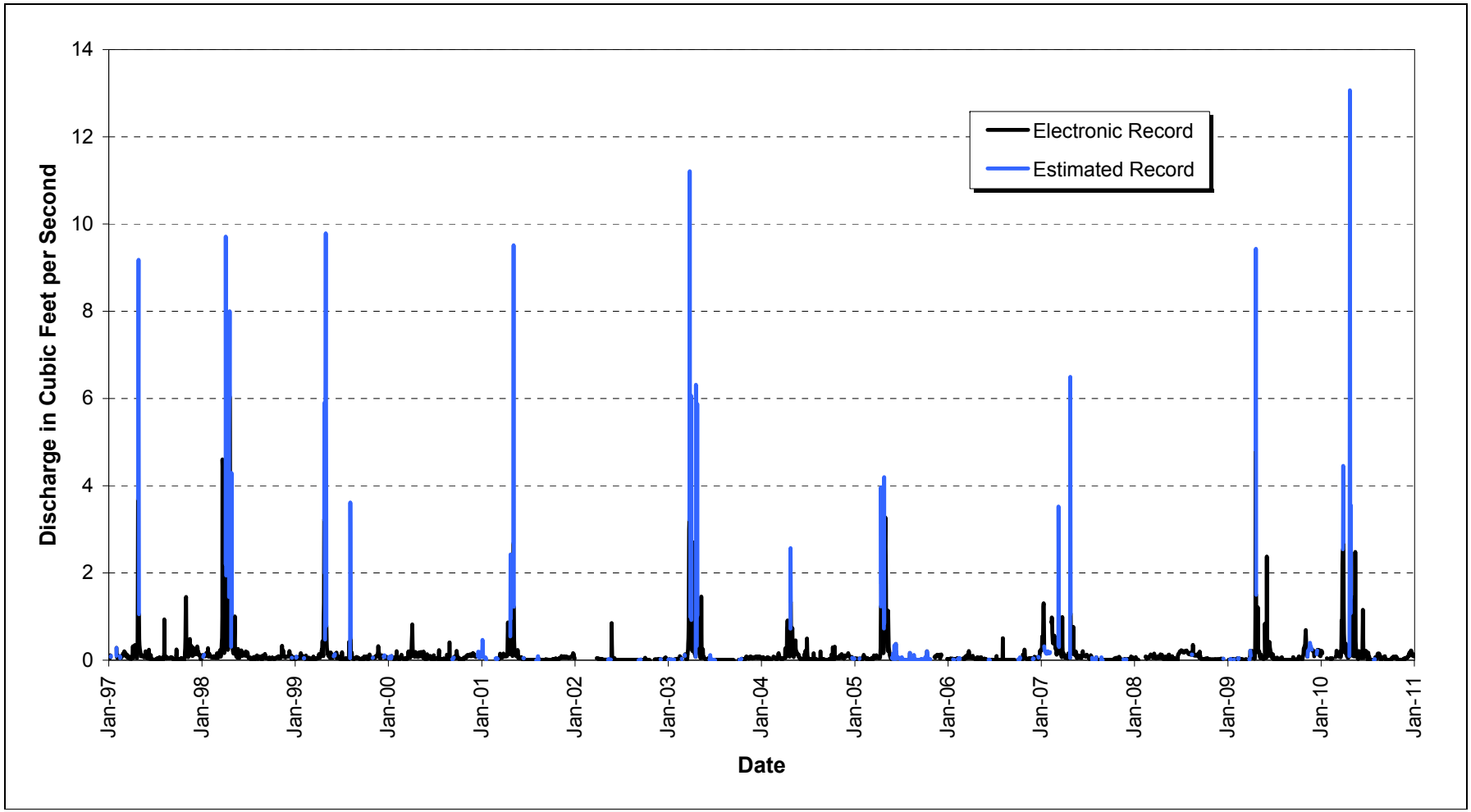


Figure 78. CY 1997−2010 Mean Daily Hydrograph at GS05: North Woman Creek at West Fence Line

GS08: South Walnut Creek at Pond B-5 Outlet

Location—South Walnut Creek at Pond B-5 outlet; State Plane: E2089778, N752231.

Drainage Area—The basin includes the South Walnut Creek drainage and central portions of the COU (total of 311.0 acres).

Period of Record—March 23, 1994, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

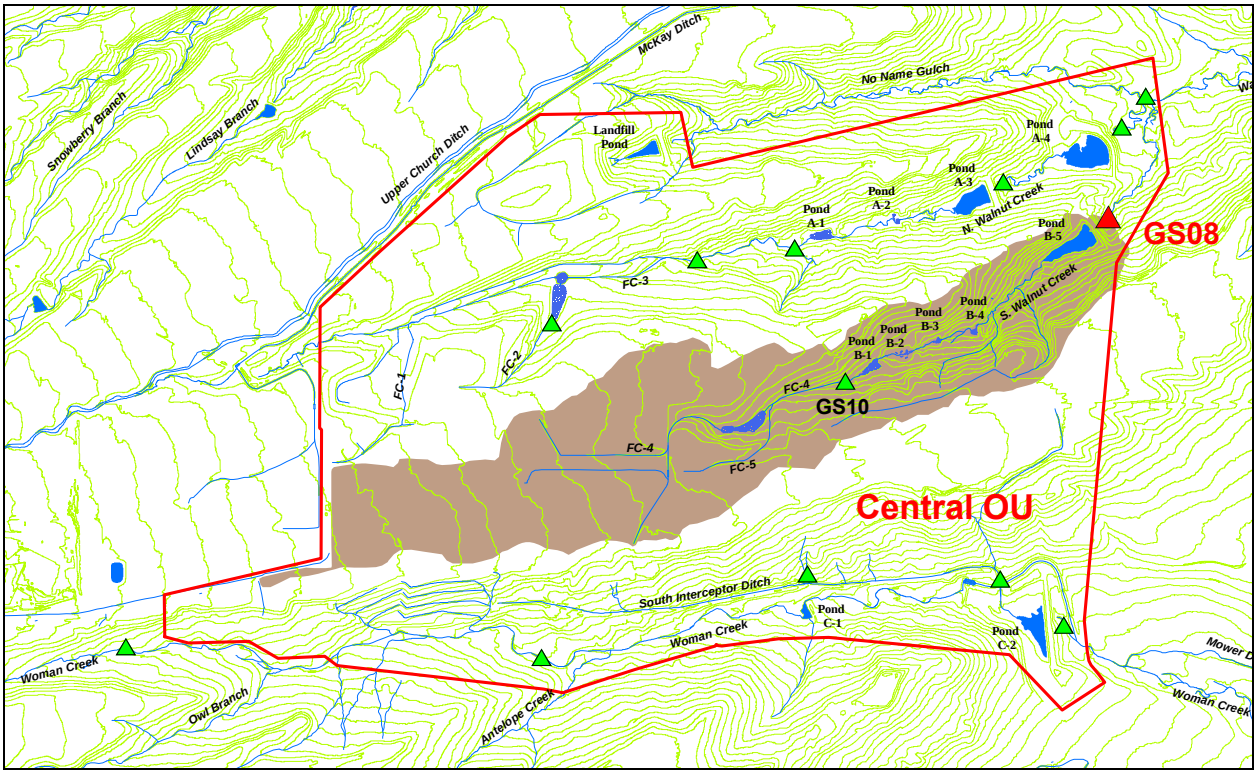


Figure 79. GS08 Drainage Area

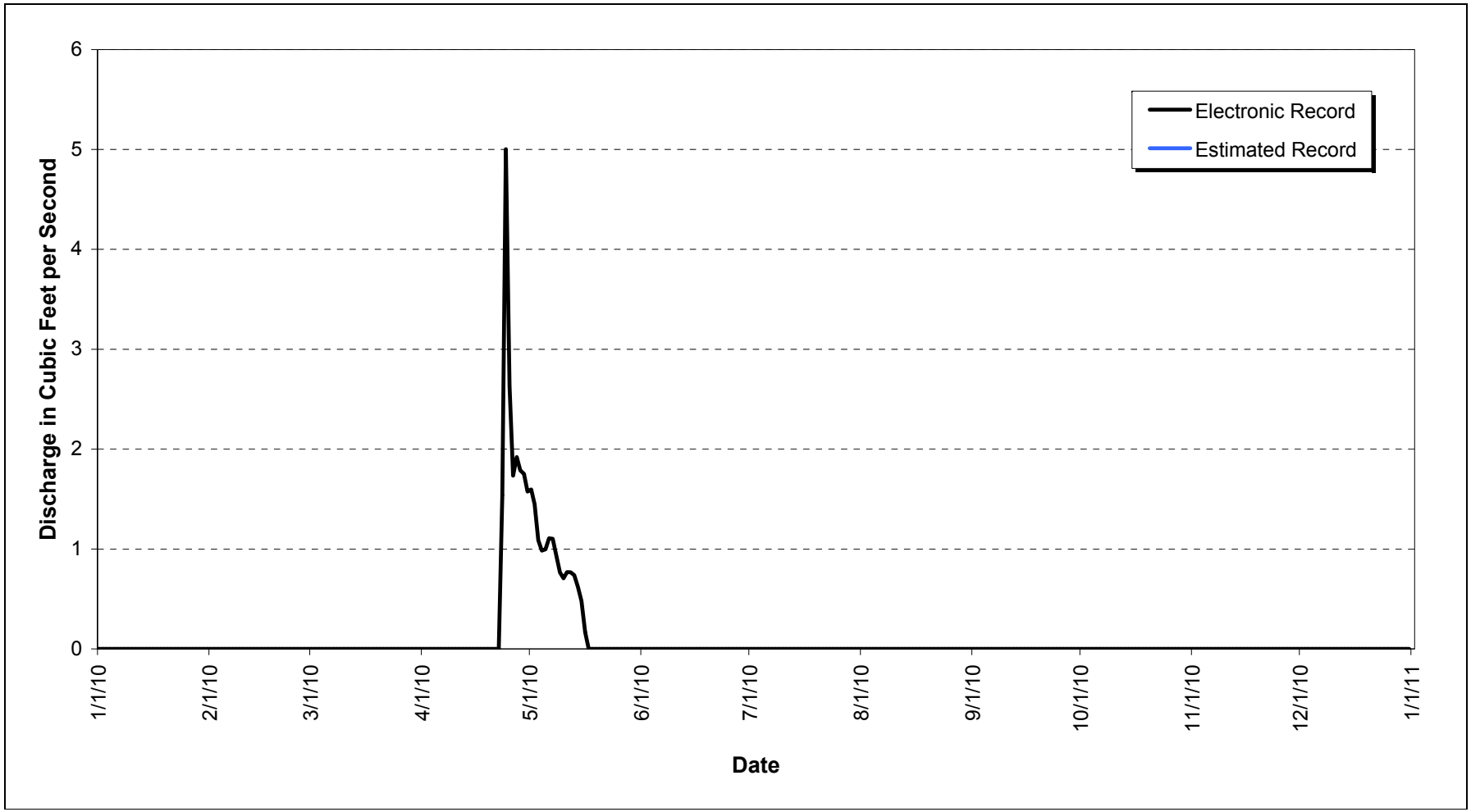


Figure 80. CY 2010 Mean Daily Hydrograph at GS08: South Walnut Creek at Pond B-5 Outlet

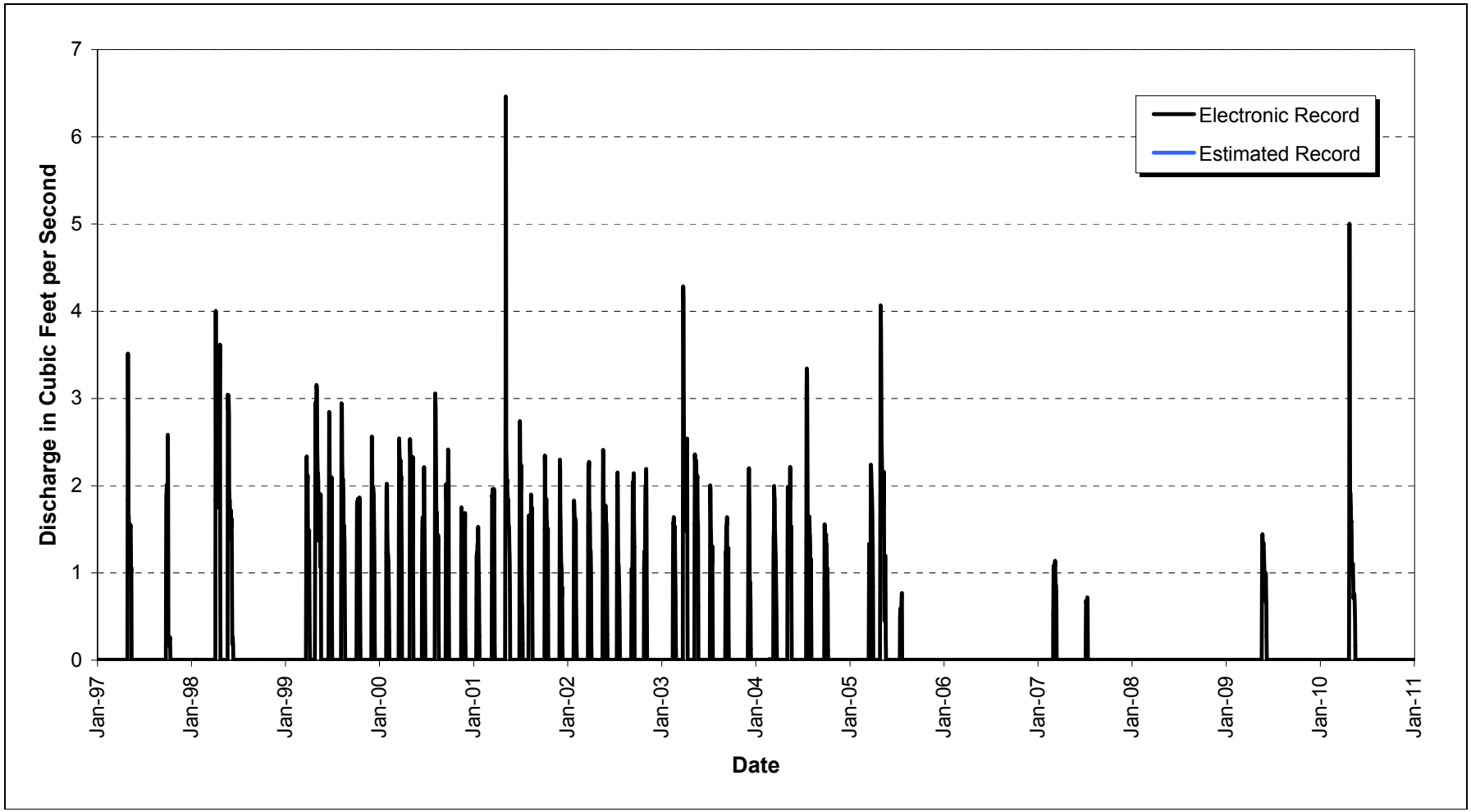


Figure 81. CY 1997−2010 Mean Daily Hydrograph at GS08: South Walnut Creek at Pond B-5 Outlet

GS10: South Walnut Creek at Pond B-1

Location—South Walnut Creek above Pond B-1; State Plane: E2086741, N750329.

Drainage Area—The basin includes the central portion of the COU (total of 206.0 acres).

Period of Record—April 1, 1993, to current year.

Gage—Water-stage recorder and 9-inch Parshall flume with weir insert.

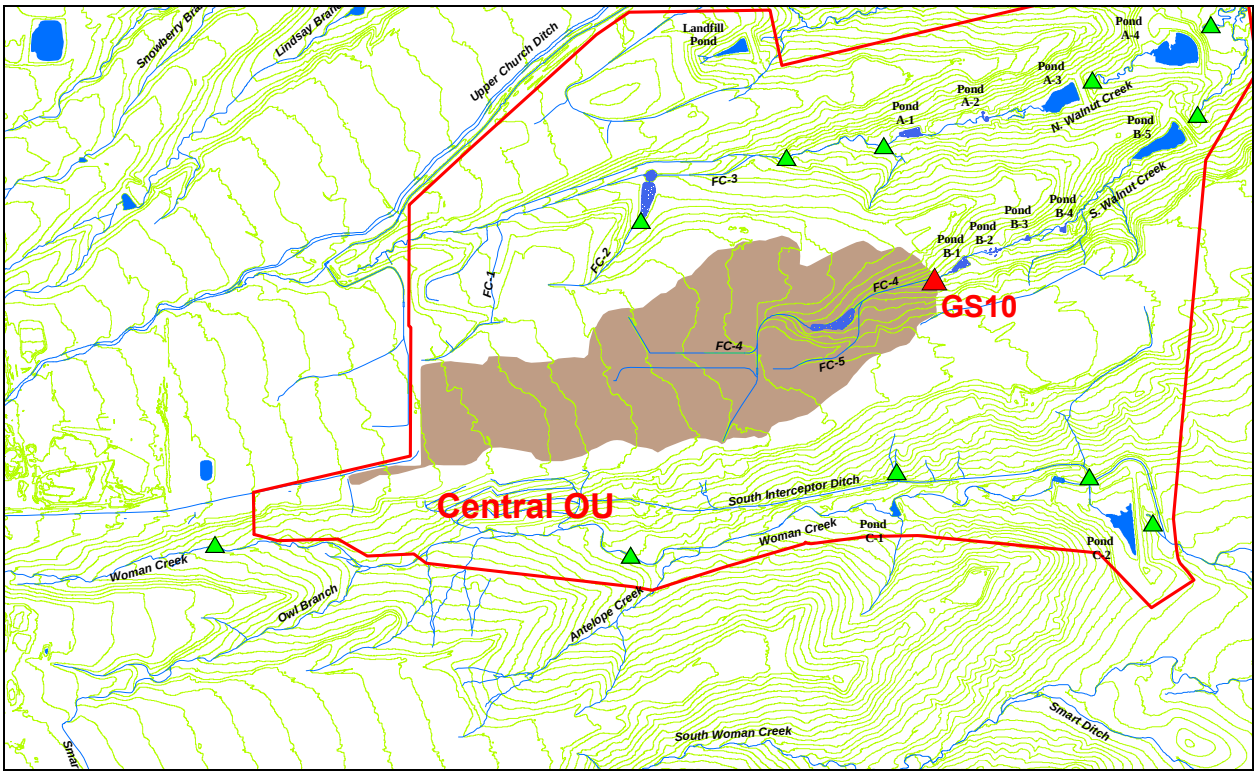


Figure 82. GS10 Drainage Area

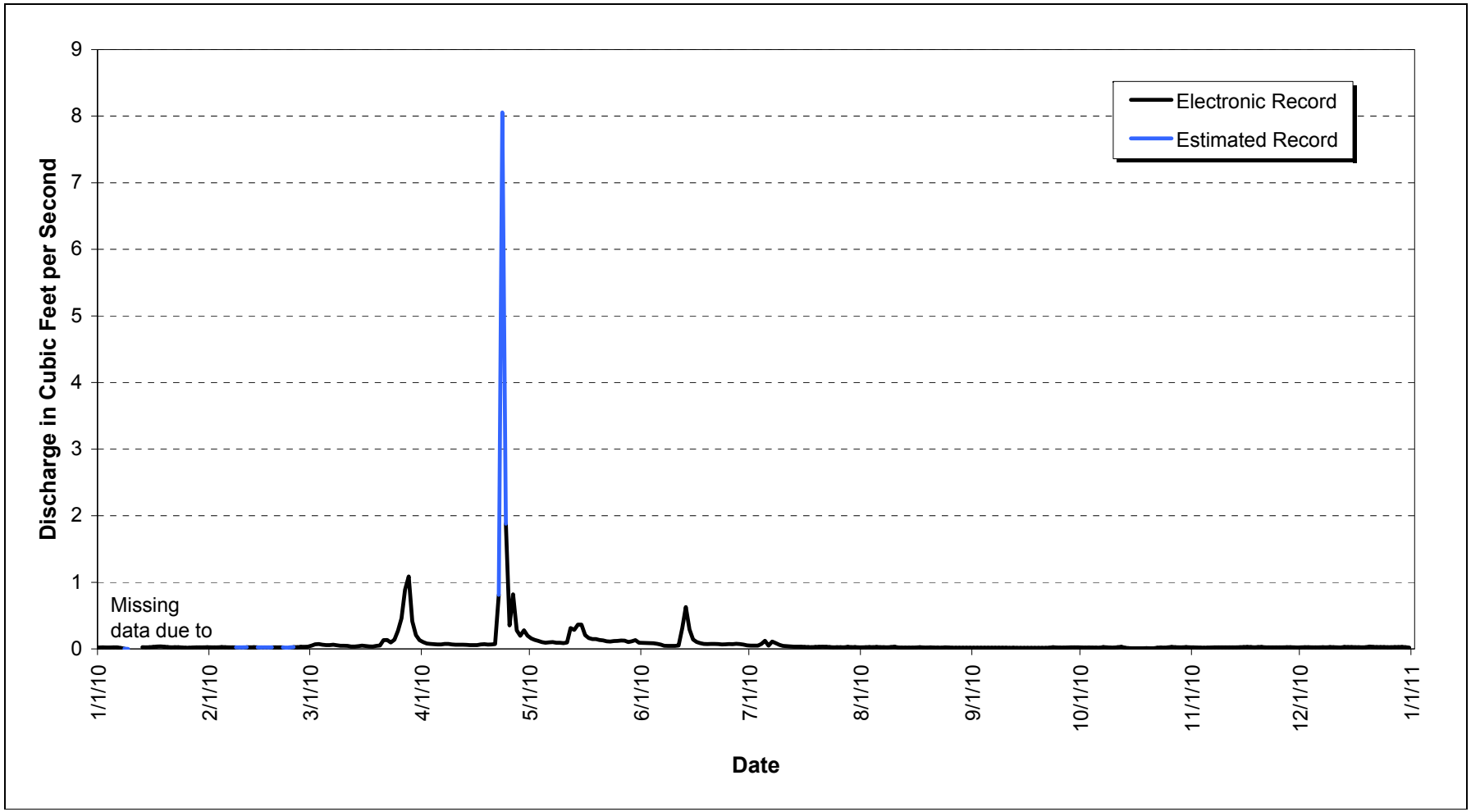


Figure 83. CY 2010 Mean Daily Hydrograph at GS10: South Walnut Creek at Pond B-1

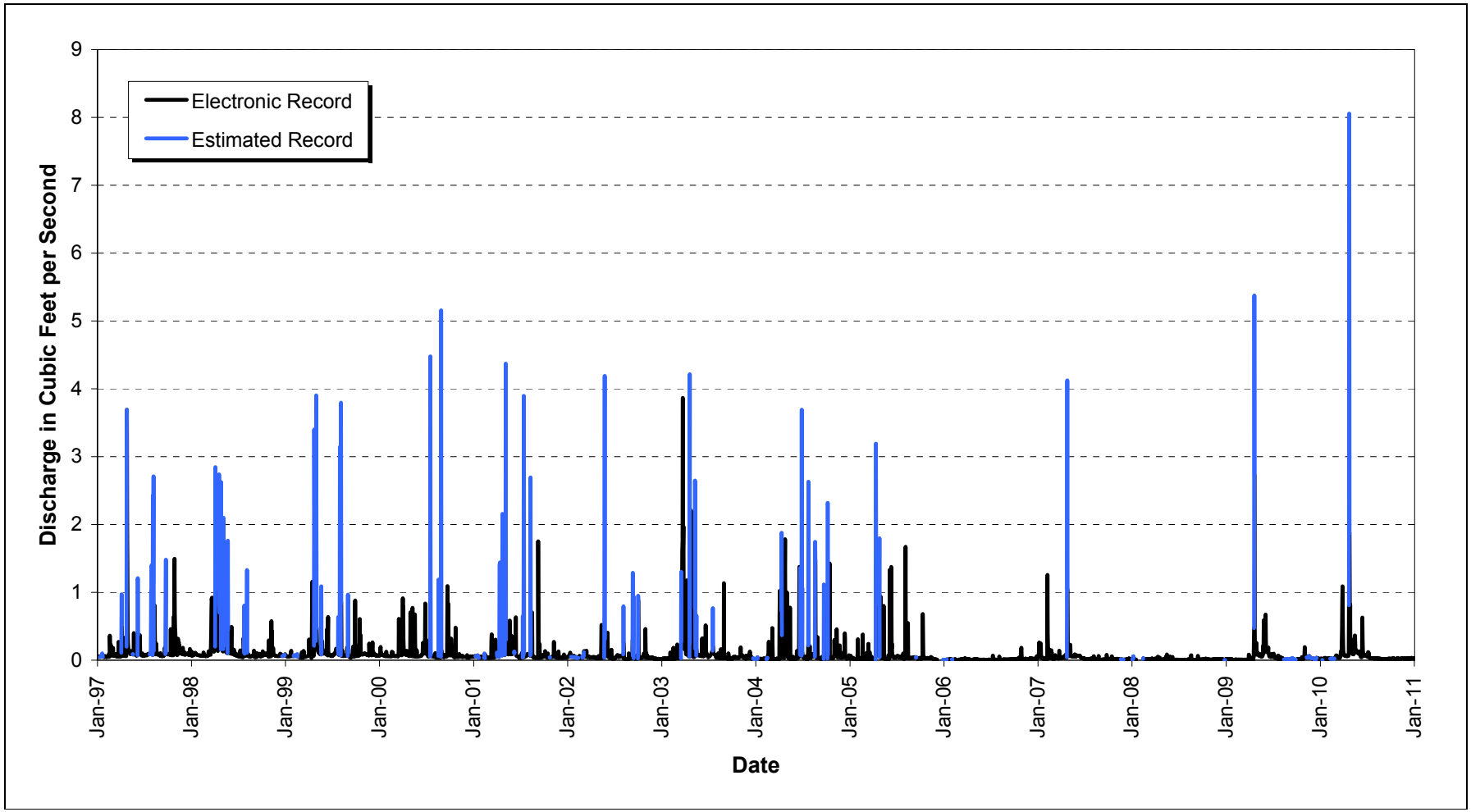


Figure 84. CY 1997–2010 Mean Daily Hydrograph at GS10: South Walnut Creek at Pond B-1

GS11: North Walnut Creek at Pond A-4 Outlet

Location—North Walnut Creek at Pond A-4 outlet; State Plane: E2089930, N753265.

Drainage Area—The basin includes the North Walnut Creek drainage and northern portions of the COU (total of 395.0 acres).

Period of Record—May 12, 1992, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

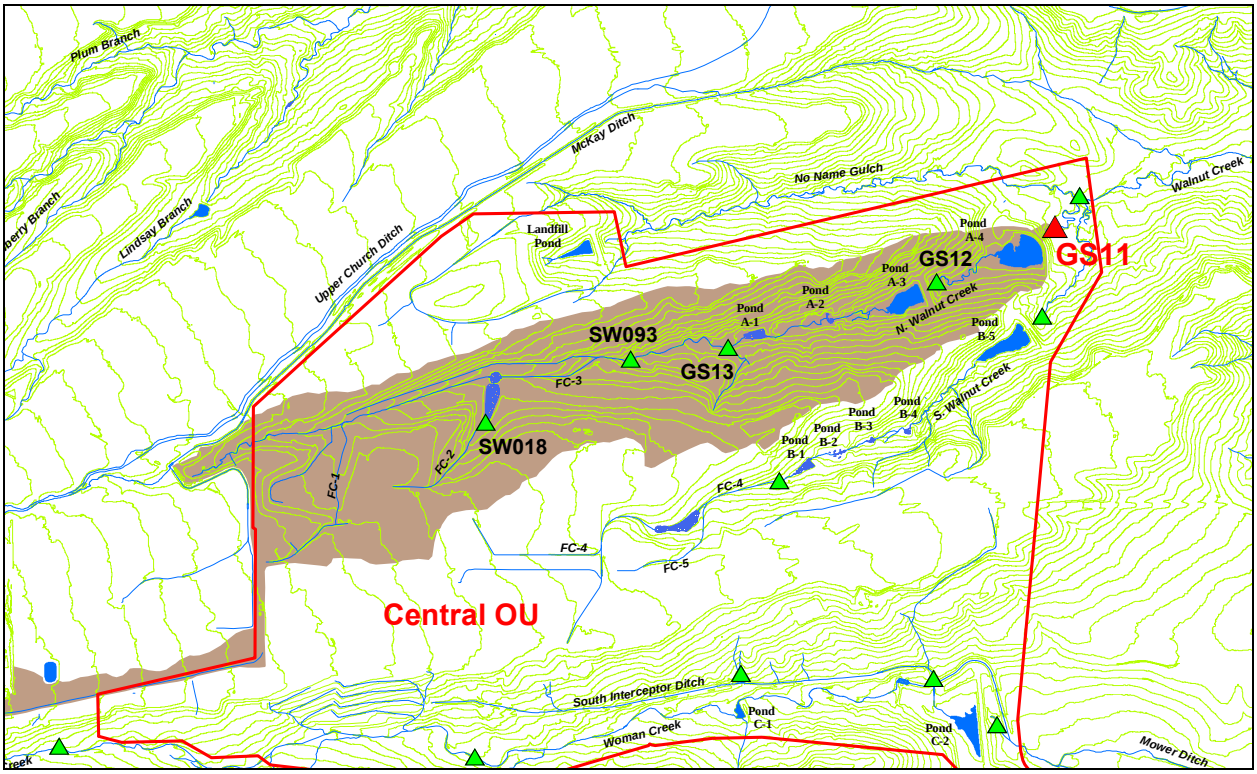


Figure 85. GS11 Drainage Area

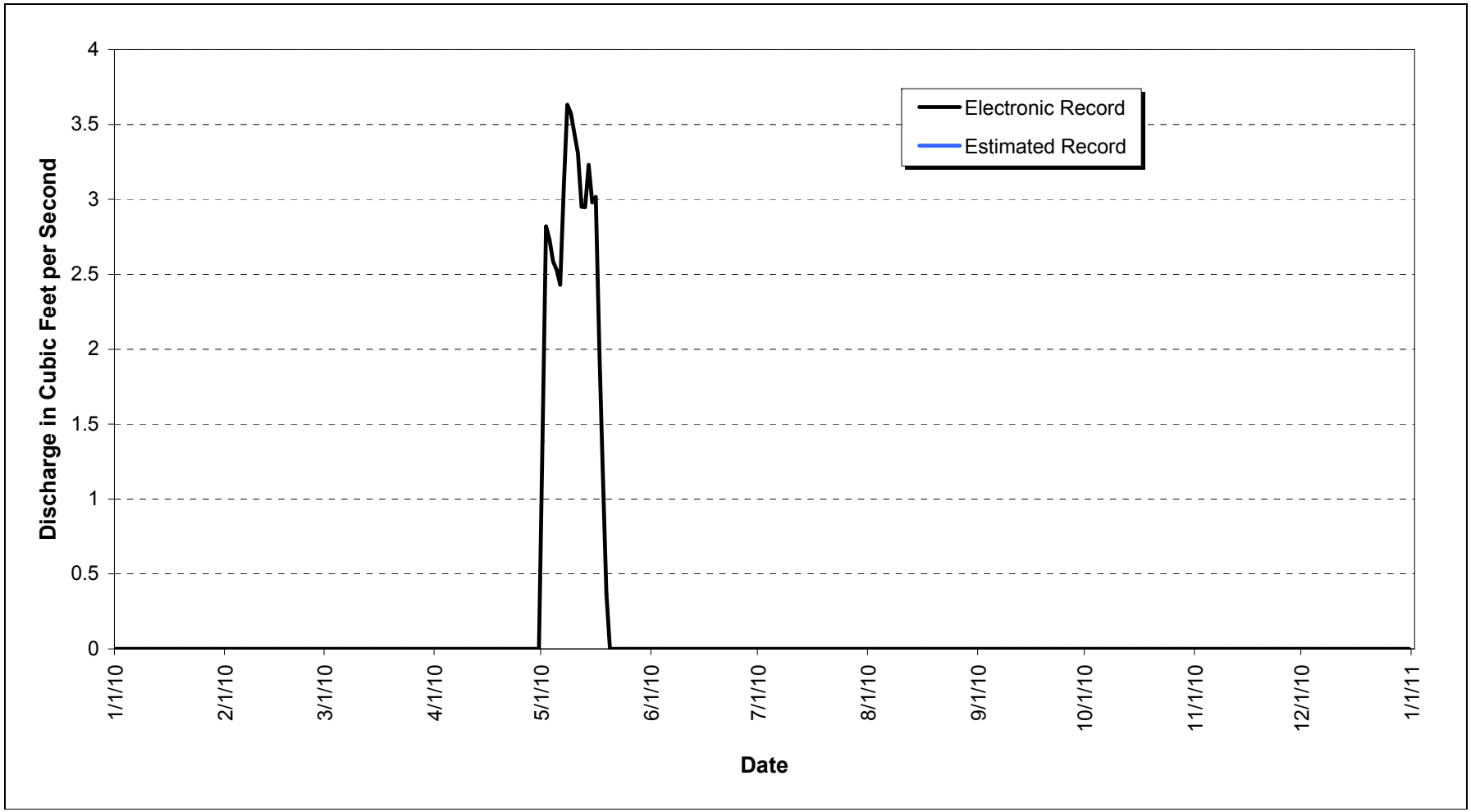


Figure 86. CY 2010 Mean Daily Hydrograph at GS11: North Walnut Creek at Pond A-4 Outlet

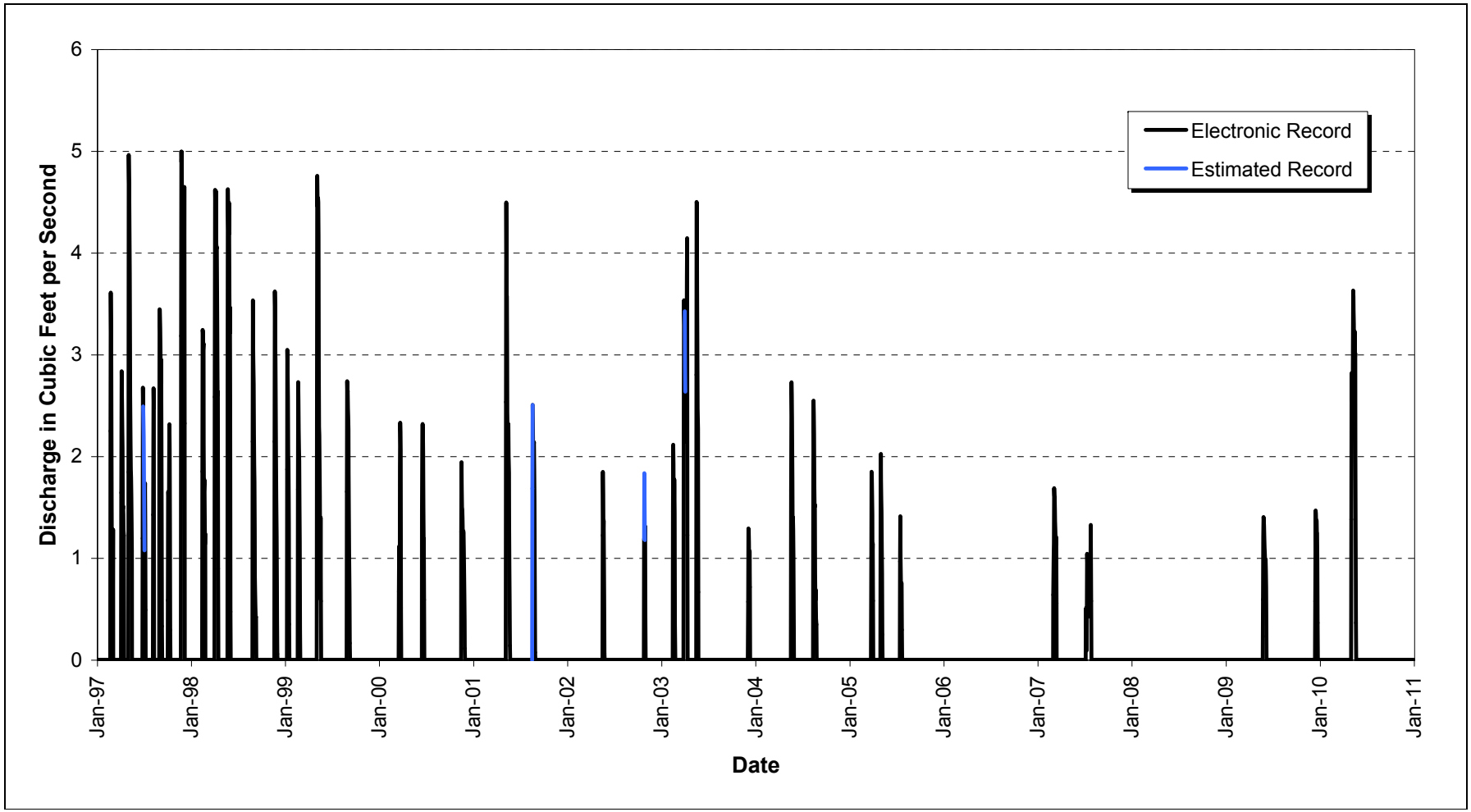


Figure 87. CY 1997−2010 Mean Daily Hydrograph at GS11: North Walnut Creek at Pond A-4 Outlet

GS12: North Walnut Creek at Pond A-3 Outlet

Location—North Walnut Creek at Pond A-3 outlet; State Plane: E2088564, N752629.

Drainage Area—The basin includes the North Walnut Creek drainage and northern portions of the COU (total of 361.7 acres).

Period of Record—May 13, 1992, to current year.

Gage—Water-stage recorder and 30-inch Parshall flume.

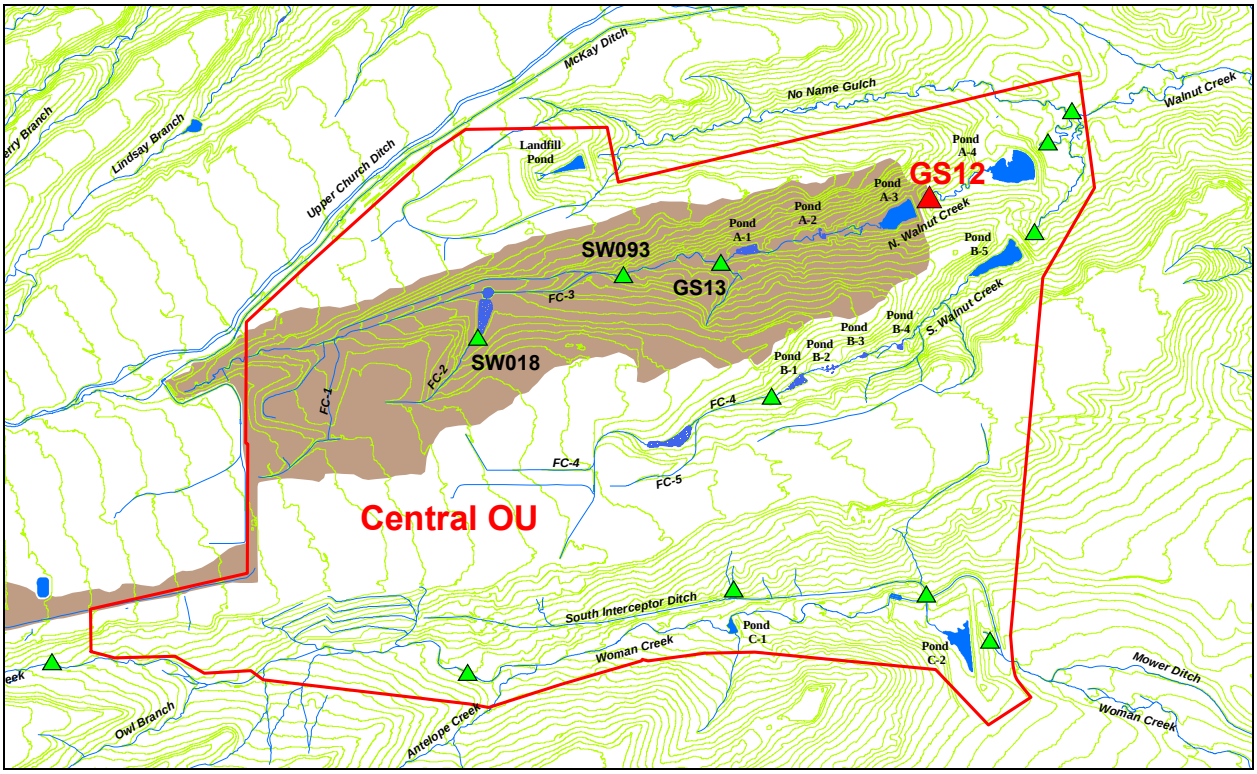


Figure 88. GS12 Drainage Area

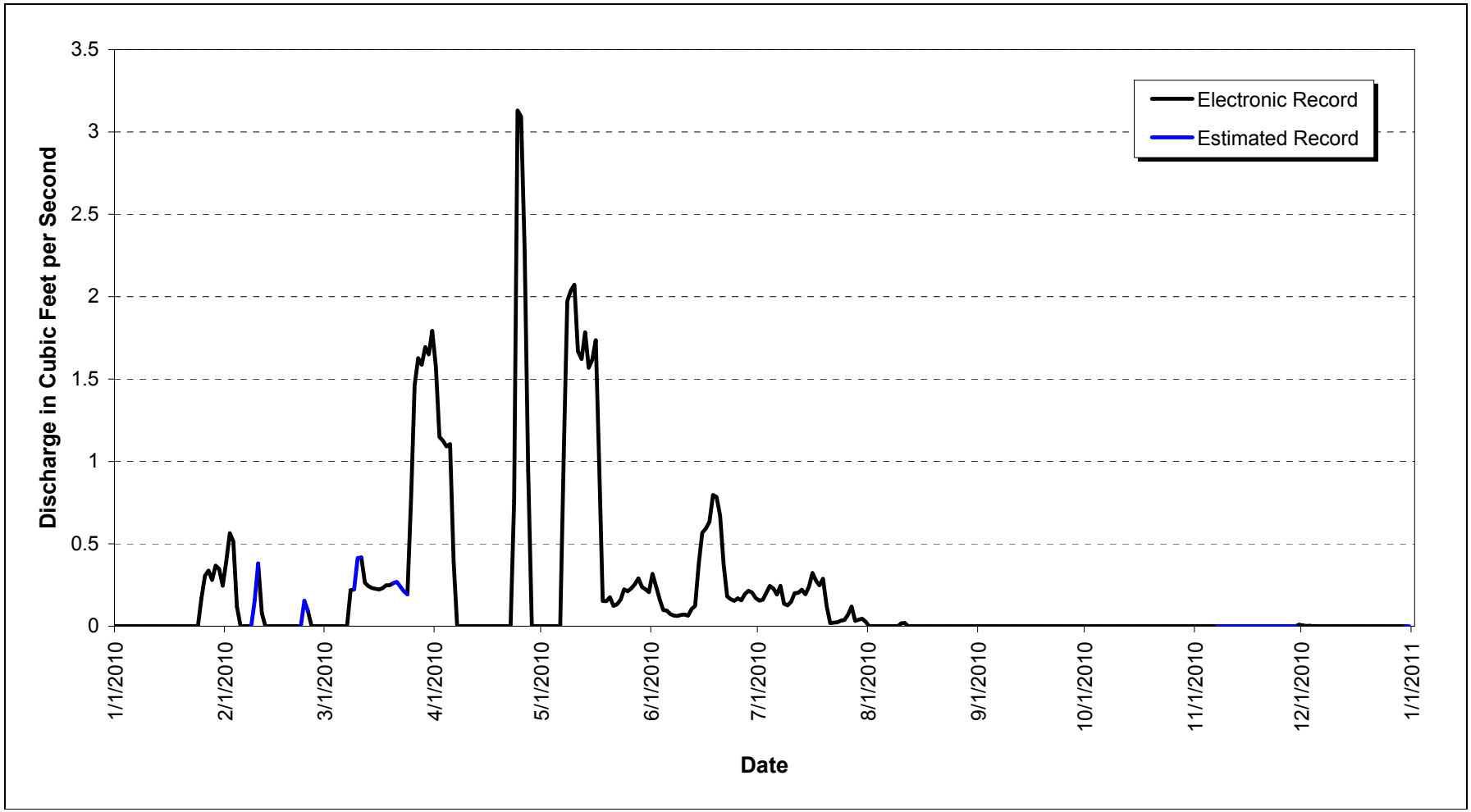


Figure 89. CY 2010 Mean Daily Hydrograph at GS12: North Walnut Creek at Pond A-3 Outlet

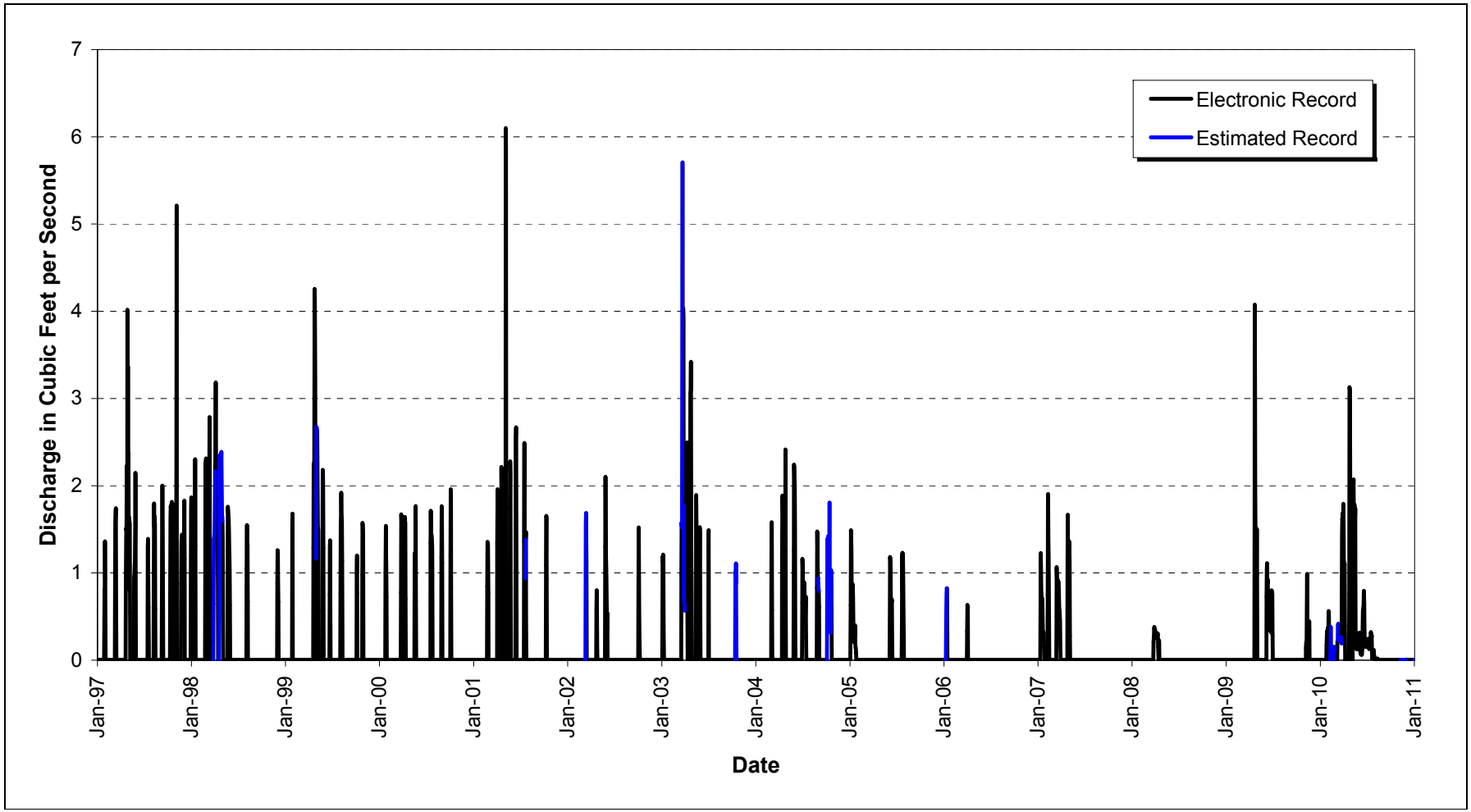


Figure 90. CY 1997−2010 Mean Daily Hydrograph at GS12: North Walnut Creek at Pond A-3 Outlet

GS13: North Walnut Creek at Pond A-1

Location—North Walnut Creek at Pond A-1; State Plane: E2086153, N751870.

Drainage Area—The basin includes the North Walnut Creek drainage and northwestern portions of the COU (total of 260.8 acres).

Period of Record—October 1, 2005, to current year.

Gage—Water-stage recorder and 6-inch Parshall flume.

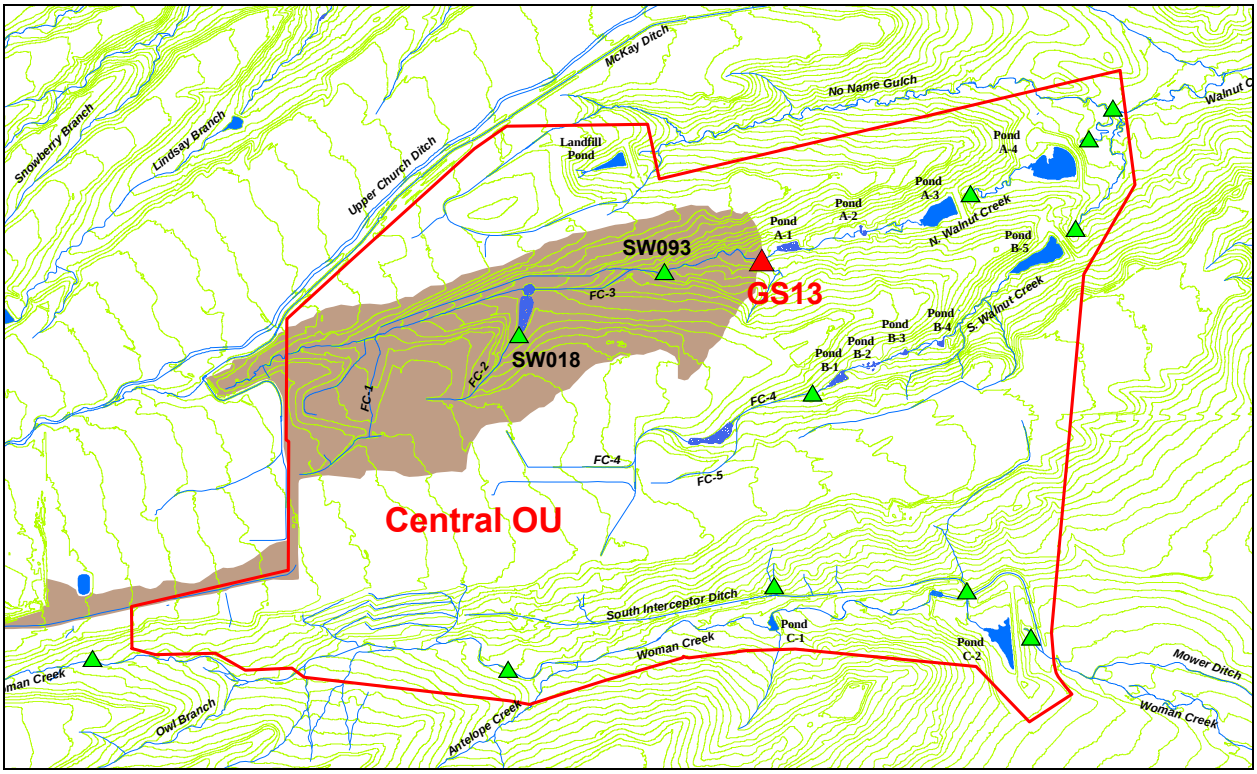


Figure 91. GS13 Drainage Area

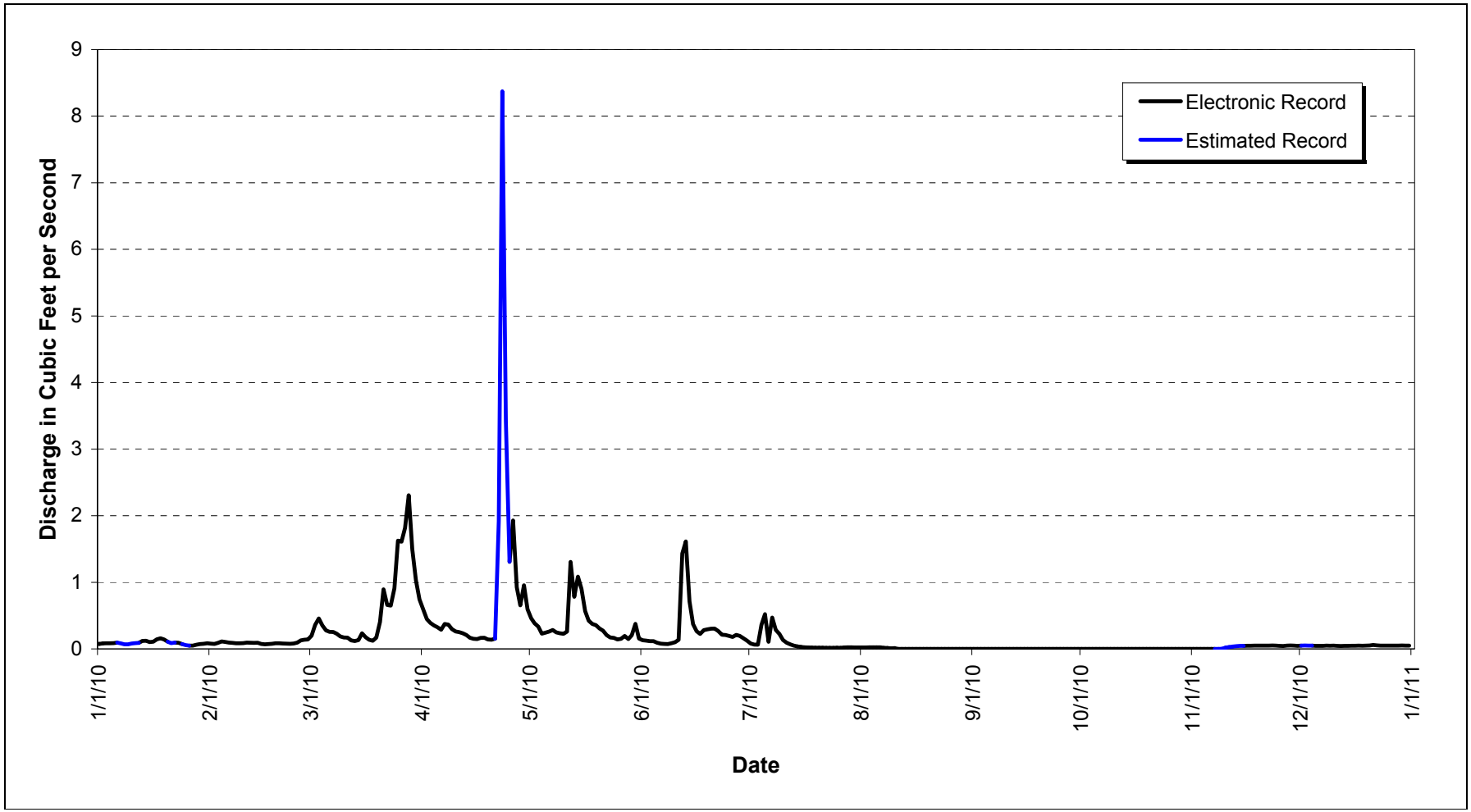


Figure 92. CY 2010 Mean Daily Hydrograph at GS13: North Walnut Creek at Pond A-1 Bypass

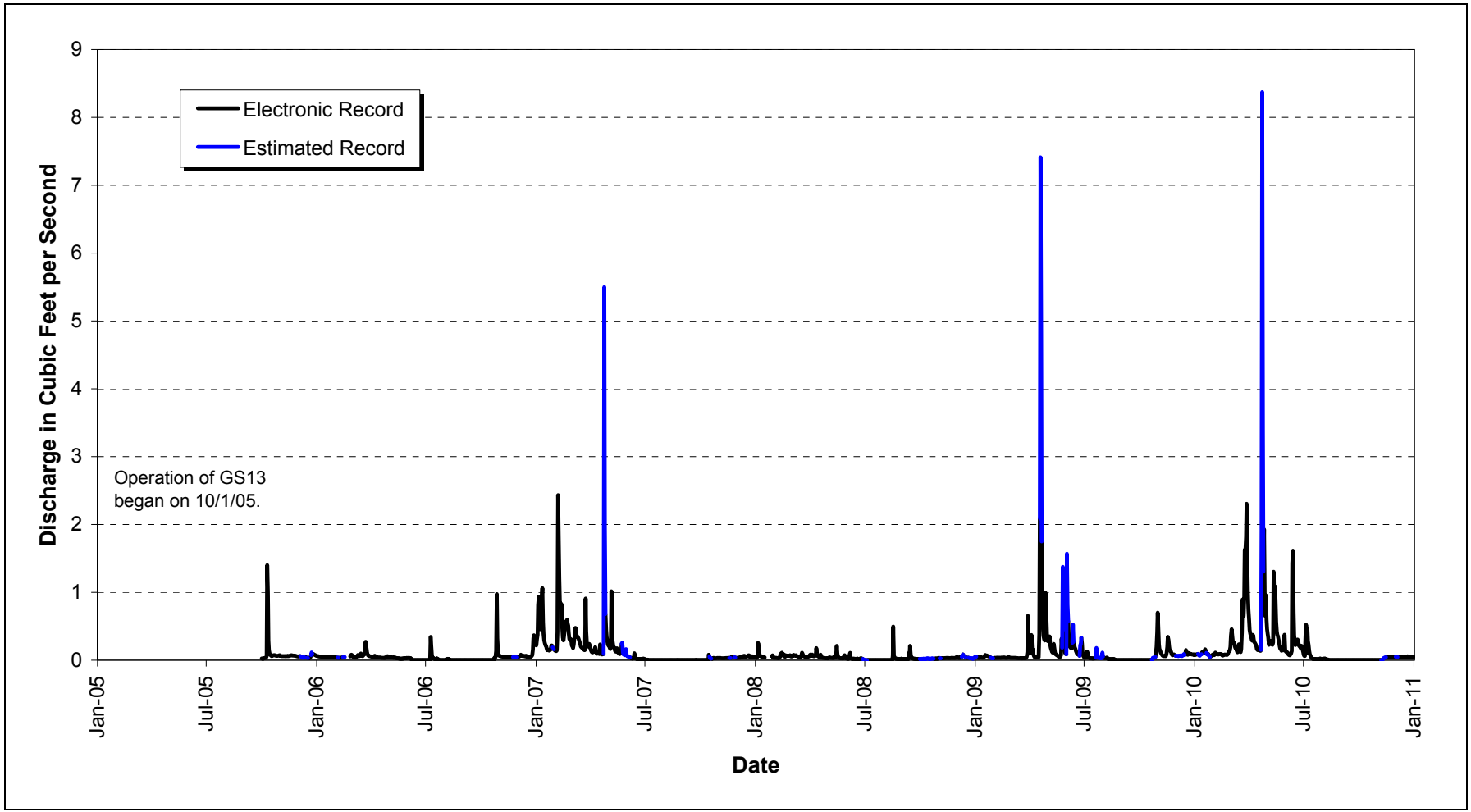


Figure 93. CY 2005−2010 Mean Daily Hydrograph at GS13: North Walnut Creek at Pond A-1 Bypass

GS31: Woman Creek at Pond C-2 Outlet

Location—Pond C-2 outlet; State Plane: E2089261, N747512.

Drainage Area—The basin includes a portion of the southern COU draining to the SID and the area surrounding Pond C-2 (total of 204.1 acres).

Period of Record—October 1, 1996, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

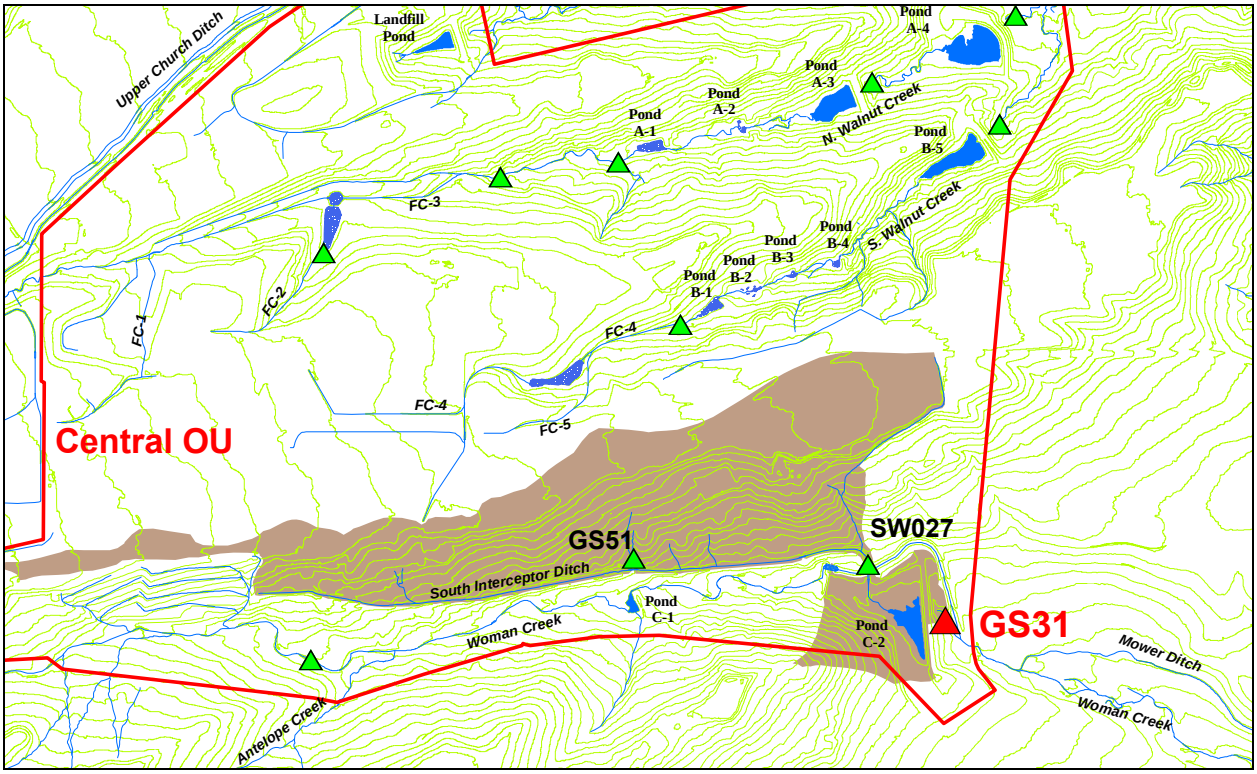


Figure 94. GS31 Drainage Area

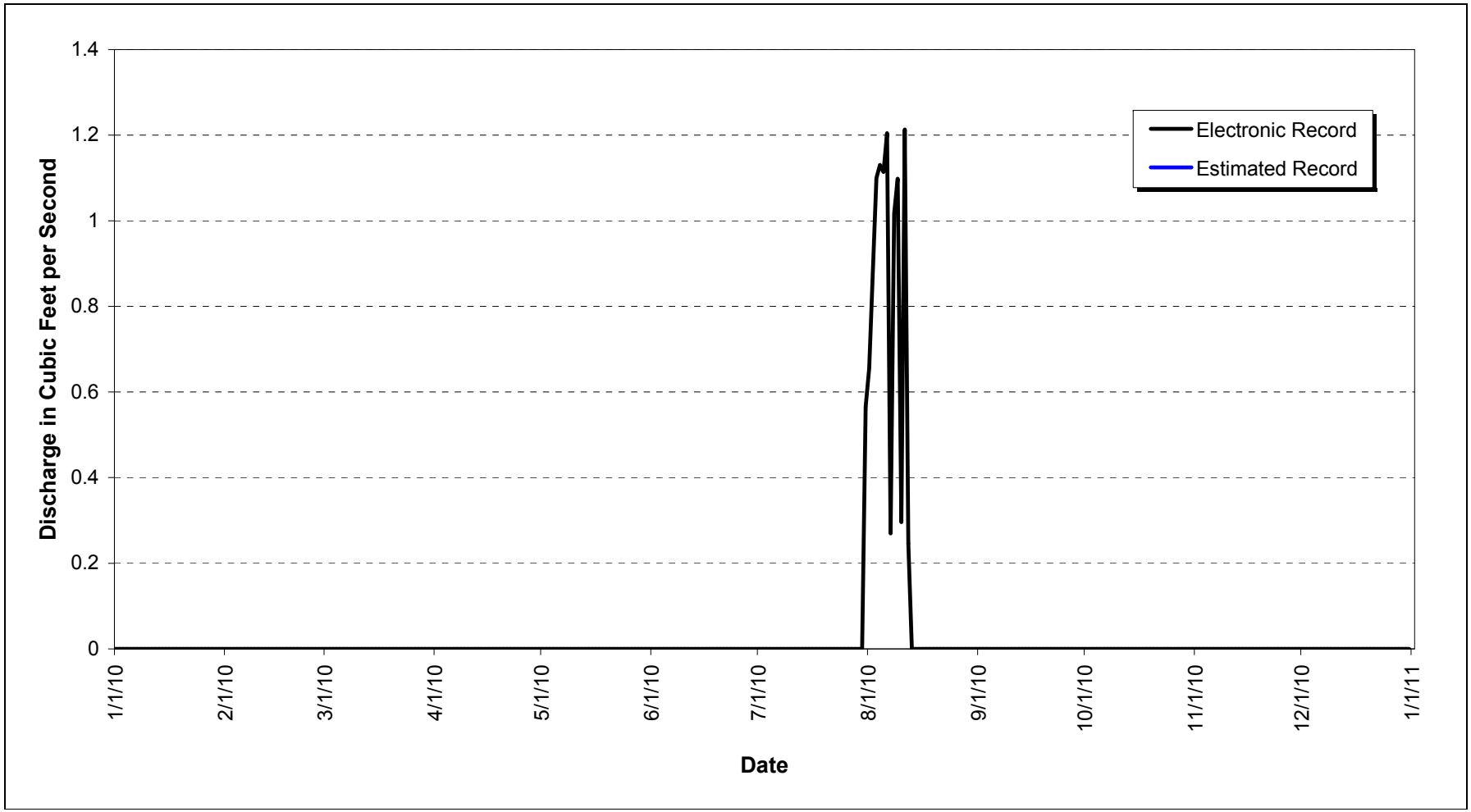


Figure 95. CY 2010 Mean Daily Hydrograph at GS31: Woman Creek at Pond C-2 Outlet

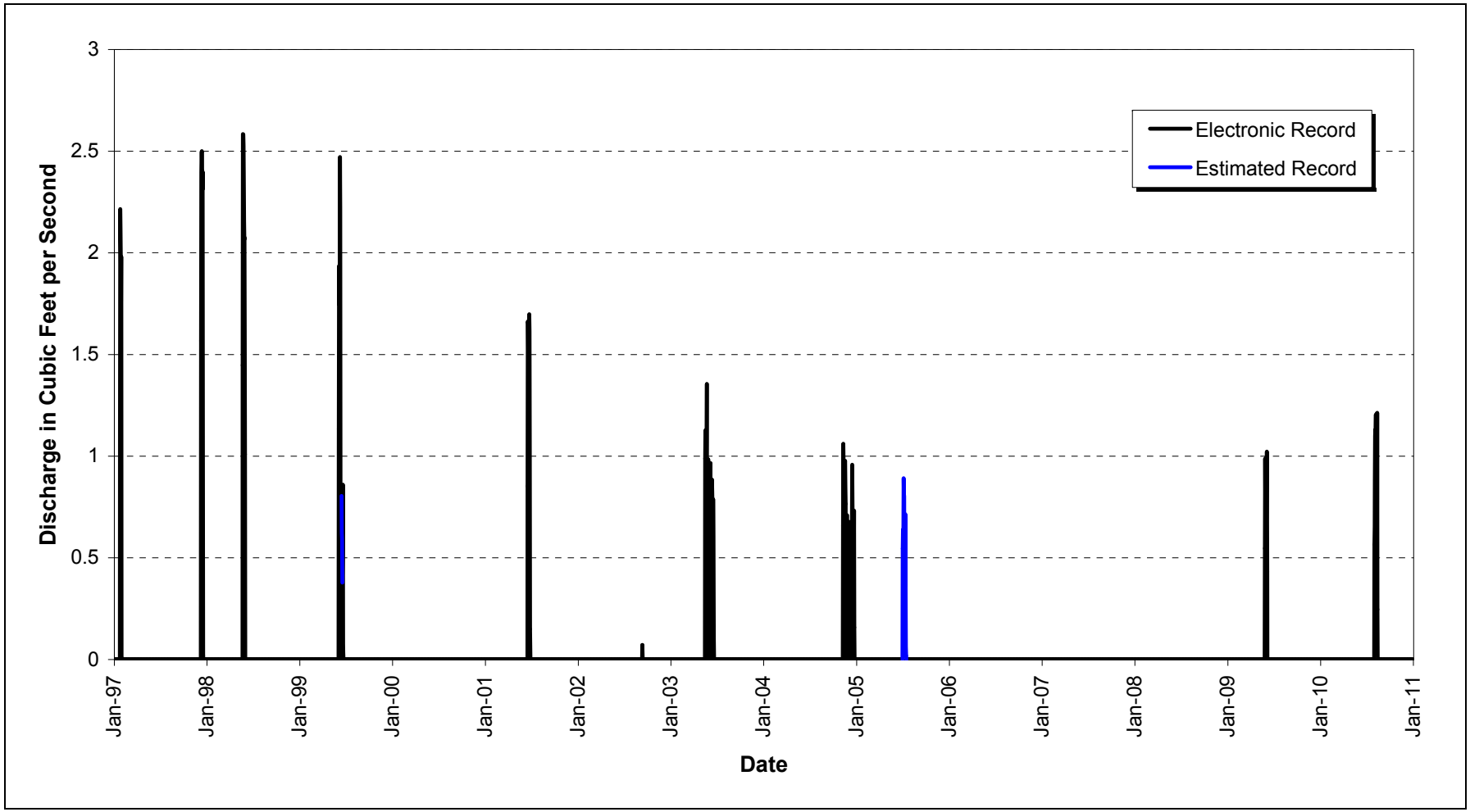


Figure 96. CY 1997−2010 Mean Daily Hydrograph at GS31: Woman Creek at Pond C-2 Outlet

GS33: No Name Gulch at Walnut Creek

Location—No Name Gulch at Walnut Creek; State Plane: E2090210, N753623.

Drainage Area—The basin is the No Name Gulch drainage (total of 295.3 acres).

Period of Record—September 16, 1997, to current year.

Gage—Water-stage recorder and 9.5-inch Parshall flume.

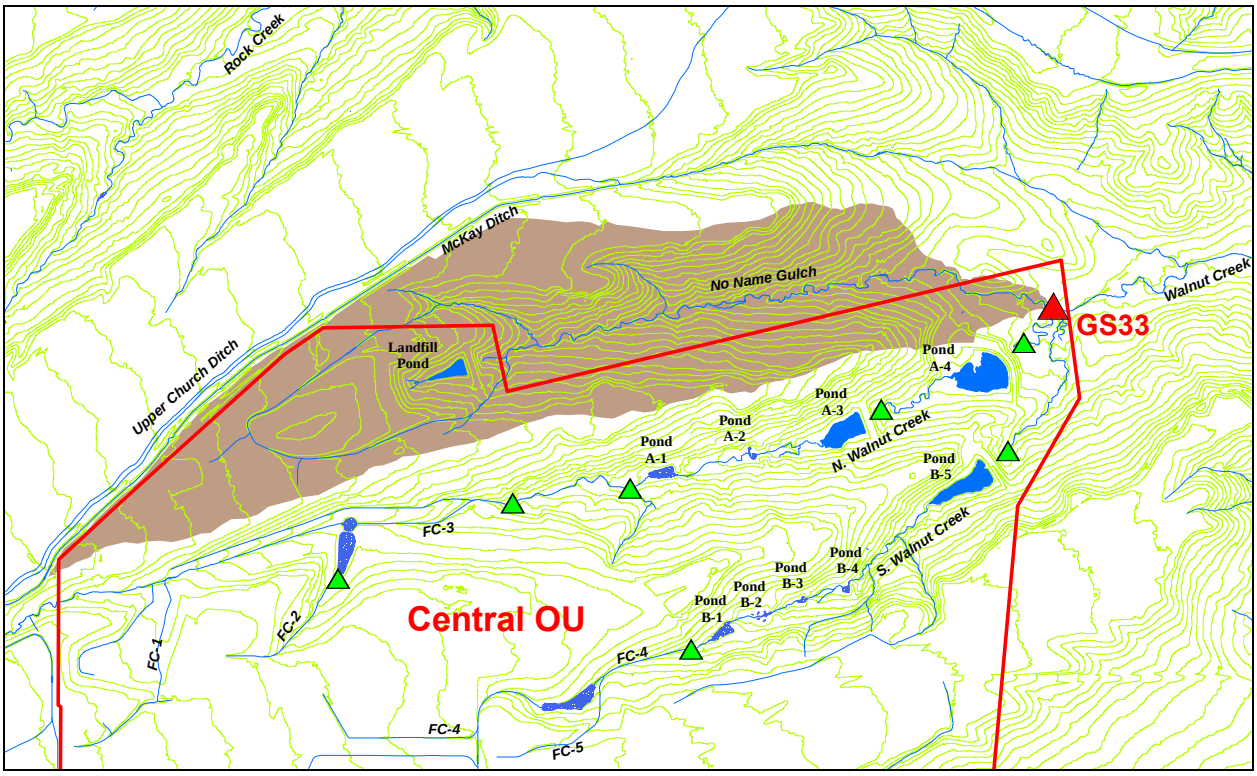


Figure 97. GS33 Drainage Area

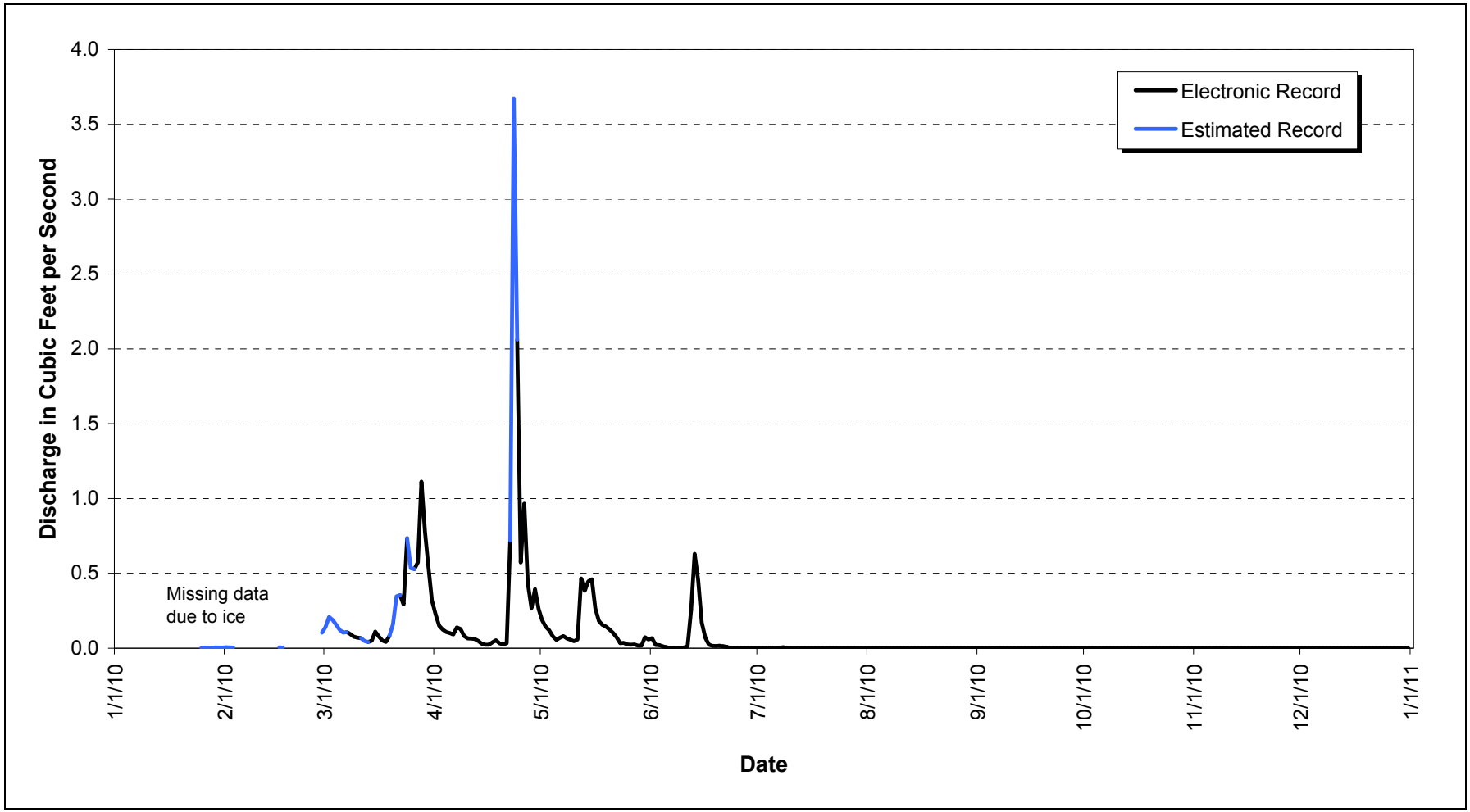


Figure 98. CY 2010 Mean Daily Hydrograph at GS33: No Name Gulch at Walnut Creek

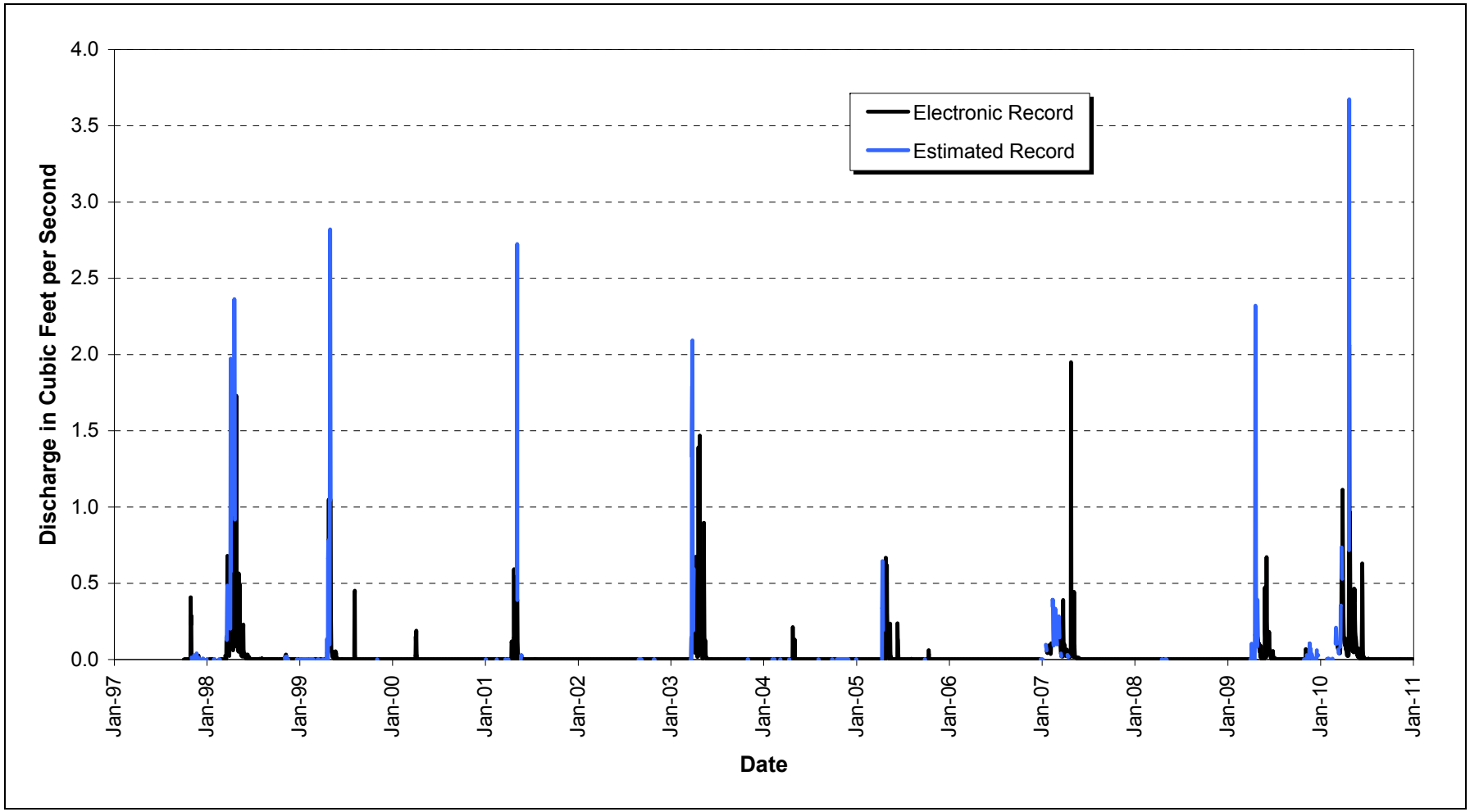


Figure 99. CY 1997−2010 Mean Daily Hydrograph at GS33: No Name Gulch at Walnut Creek

GS51: Ditch South of Former 903 Pad

Location—Ditch south of former 903 Pad; State Plane: E2086300, N748102.

Drainage Area—The basin includes an area south and west of the former 903 Pad (total of 16.0 acres).

Period of Record—August 13, 2001, to current year.

Gage—Water-stage recorder and 0.75-foot H-flume.

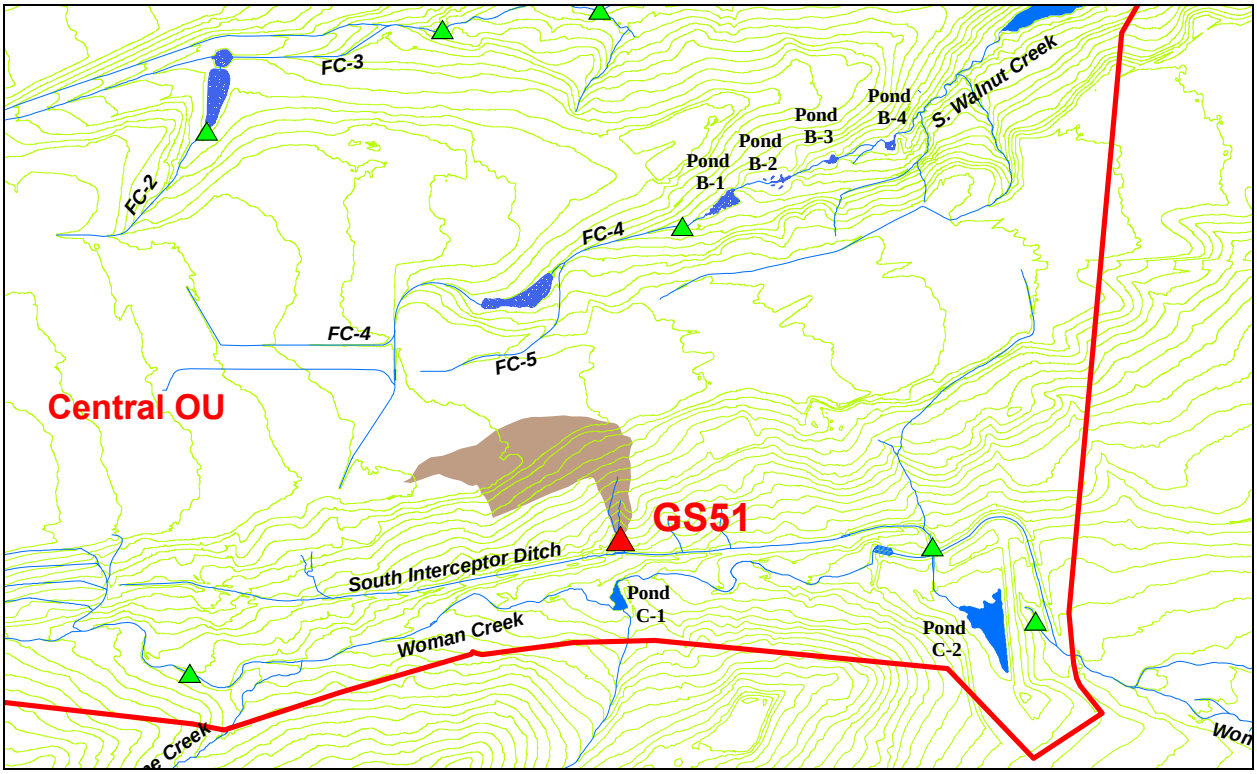


Figure 100. GS51 Drainage Area

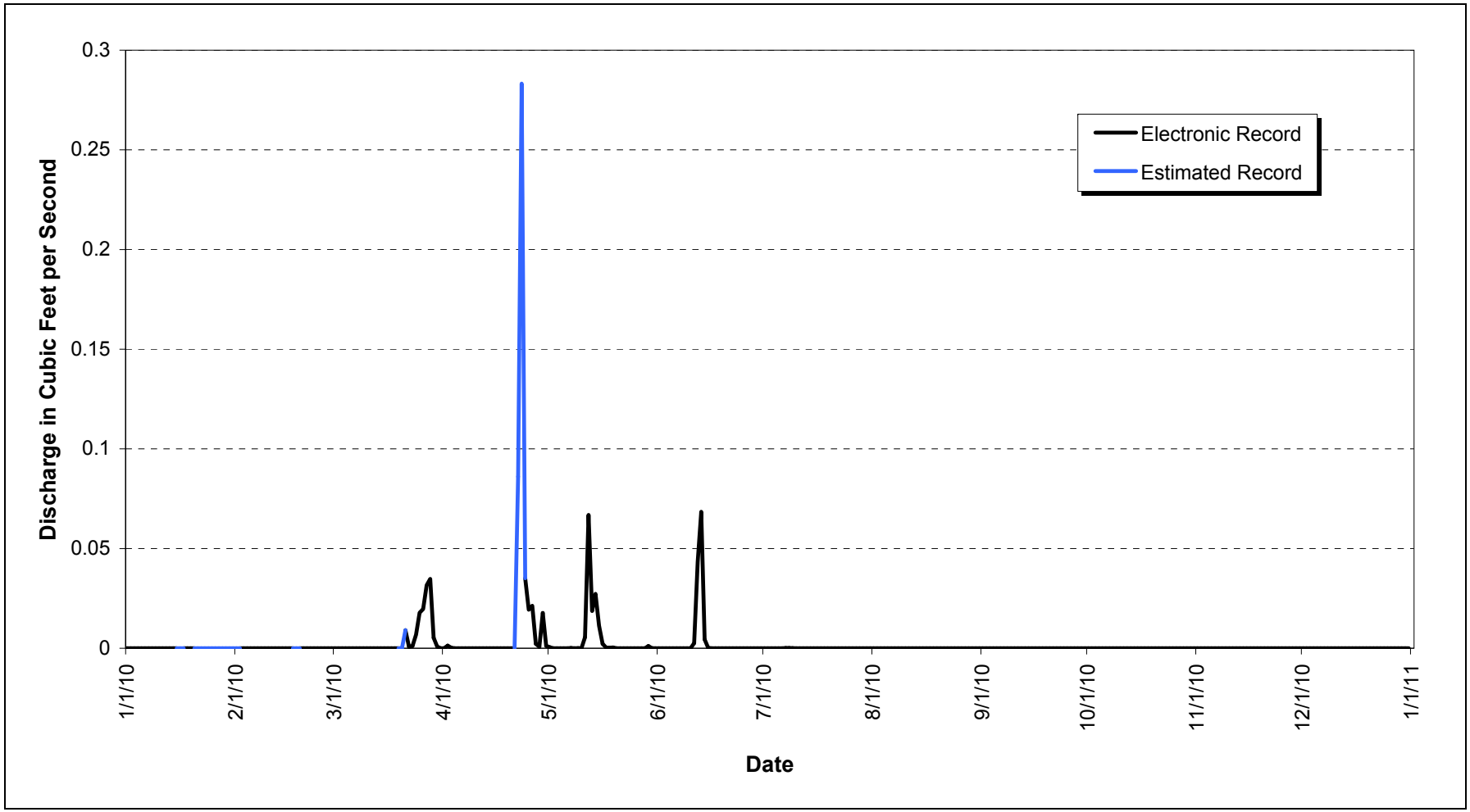


Figure 101. CY 2010 Mean Daily Hydrograph at GS51: Ditch South of 903 Pad

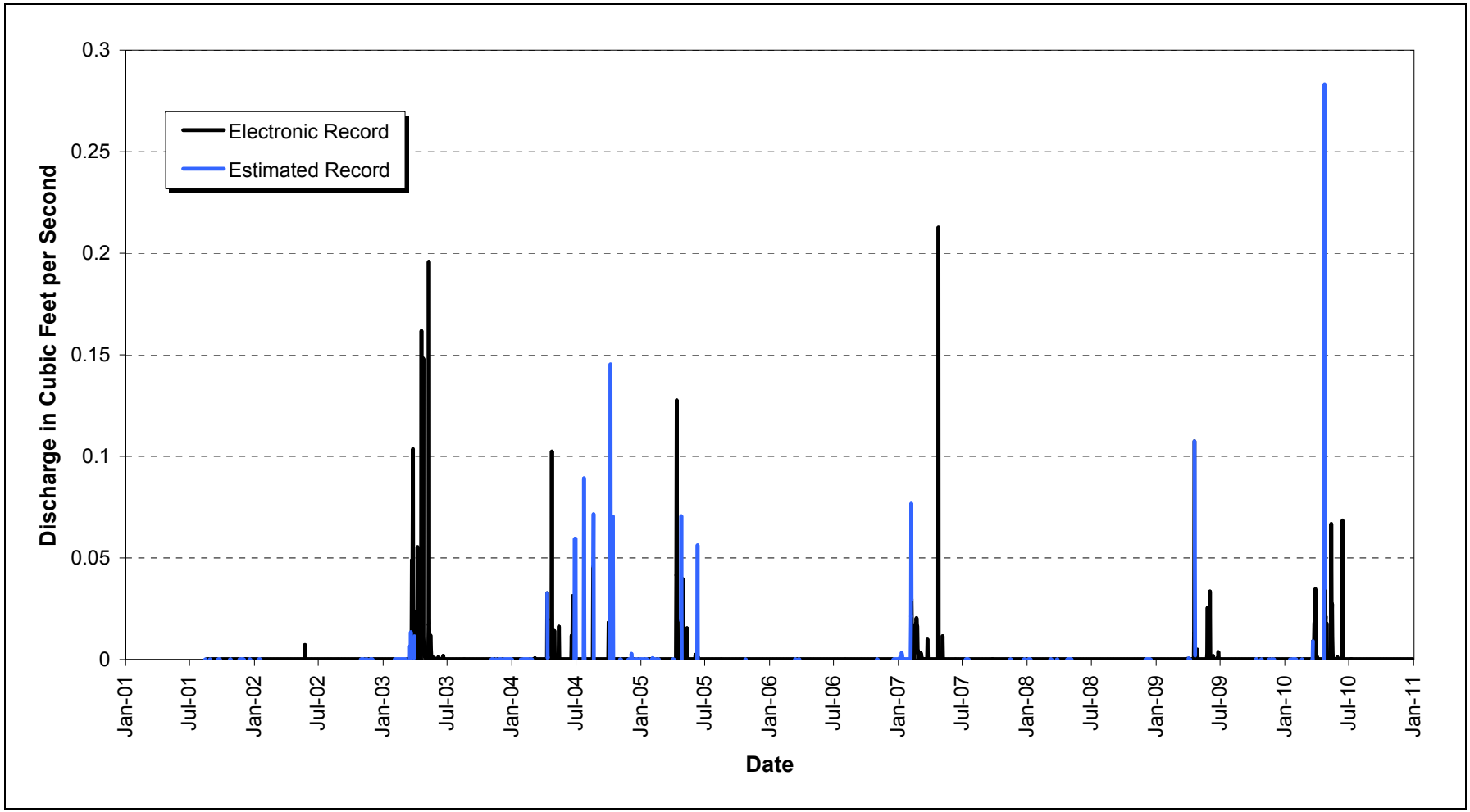


Figure 102. CY 2001−2010 Mean Daily Hydrograph at GS51: Ditch South of 903 Pad

GS59: Woman Creek Upstream of Antelope Springs Confluence

Location—Woman Creek 900 feet upstream of Antelope Springs confluence; State Plane: E2083228, N747139.

Drainage Area—The basin includes upstream reaches of Woman Creek; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—November 20, 2002, to current year.

Gage—Water-stage recorder and 1.5-foot Parshall flume.

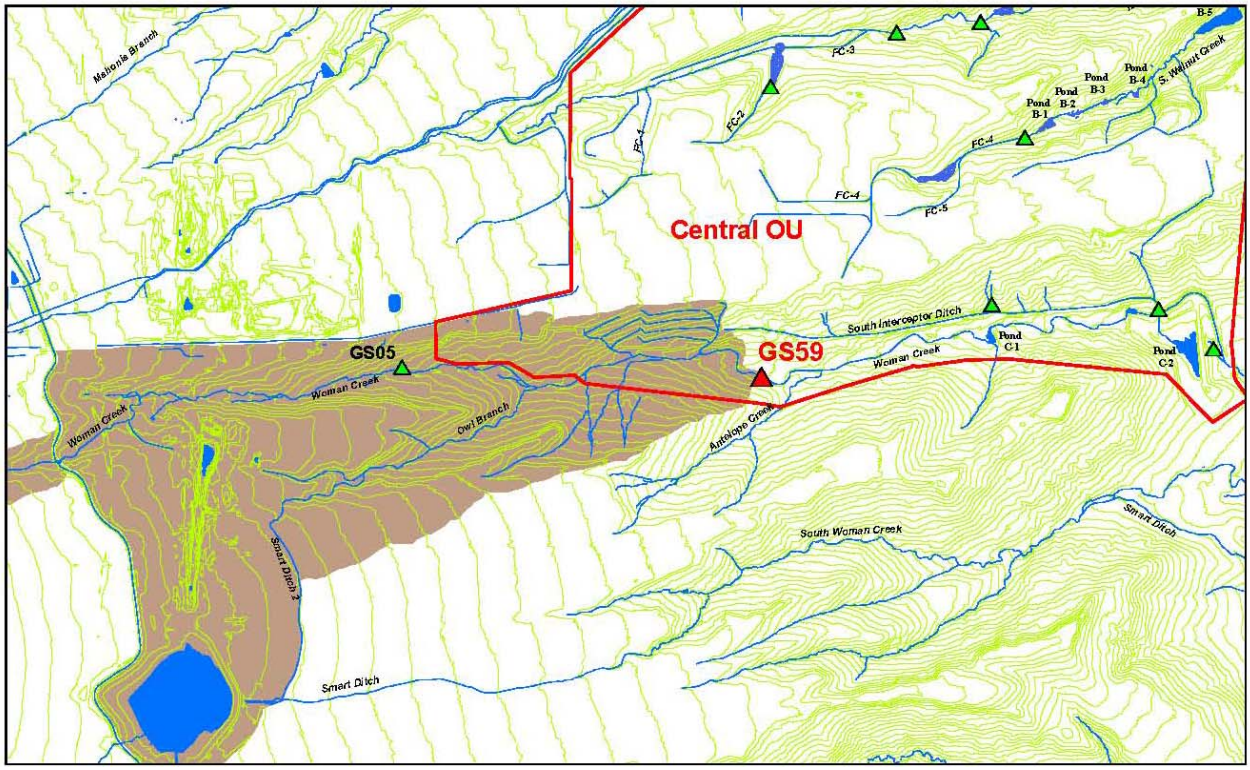


Figure 103. GS59 Drainage Area

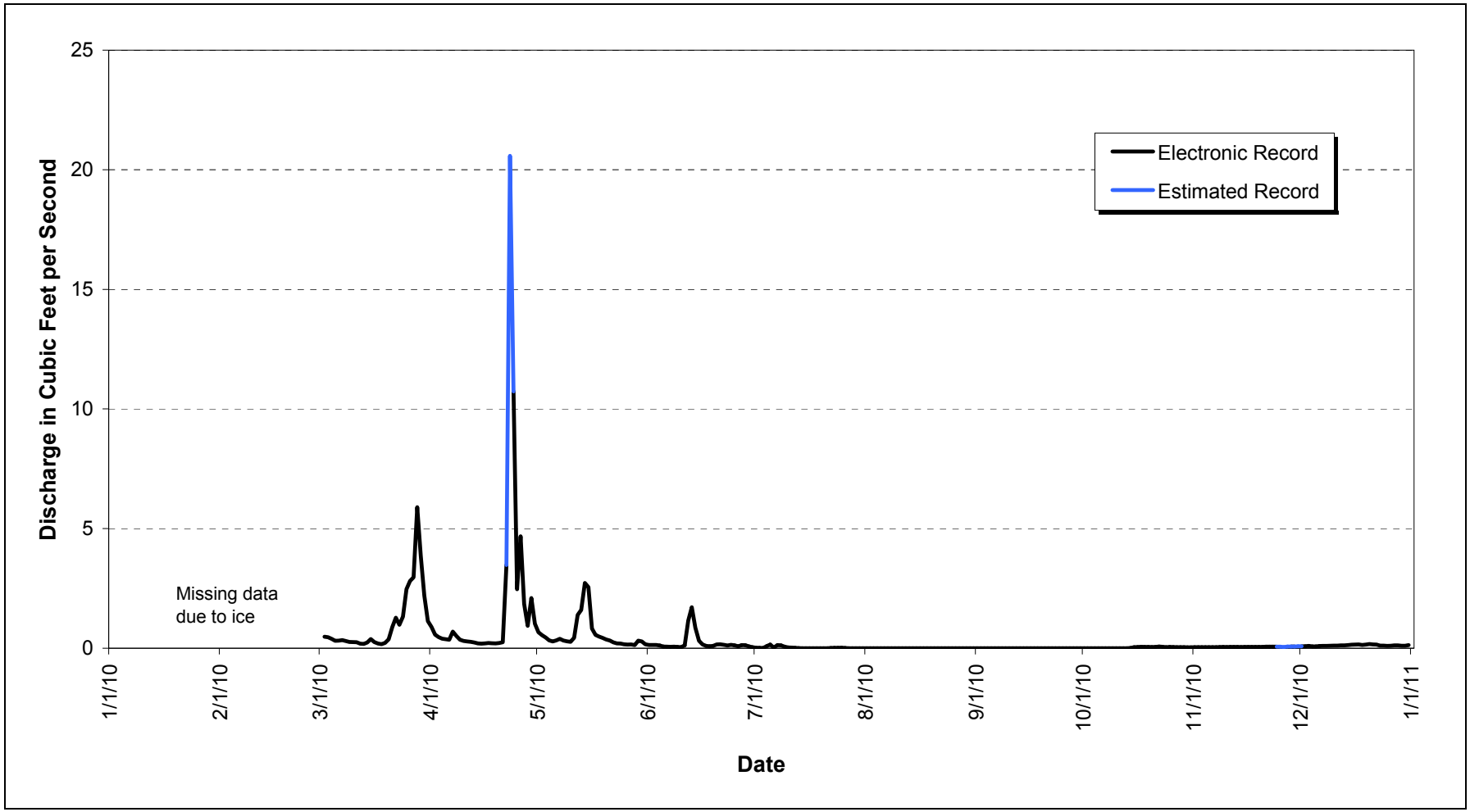


Figure 104. CY 2010 Mean Daily Hydrograph at GS59: Woman Creek Upstream of Antelope Springs Confluence

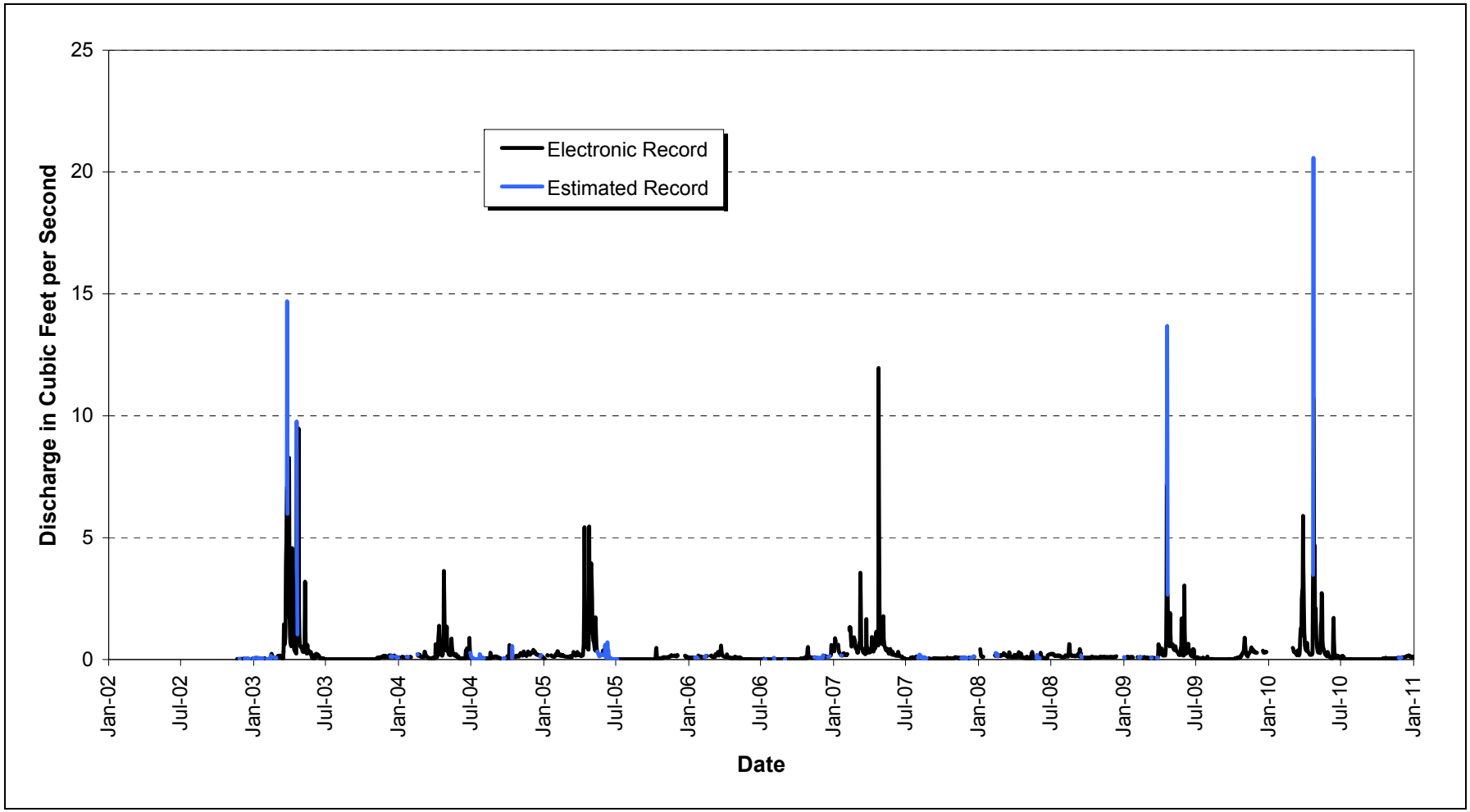


Figure 105. CY 2002−2010 Mean Daily Hydrograph at GS59: Woman Creek Upstream of Antelope Springs Confluence

B5INFLOW: South Walnut Creek Above Pond B-5

Location—South Walnut Creek 500 feet upstream of Pond B-5; State Plane: E2088676, N751358.

Drainage Area— The basin includes the central portion of the COU and the former B-Series Ponds (total of 260.3 acres).

Period of Record—June 17, 2010, to current year.

Gage—Water-stage recorder and 9-inch Parshall flume.

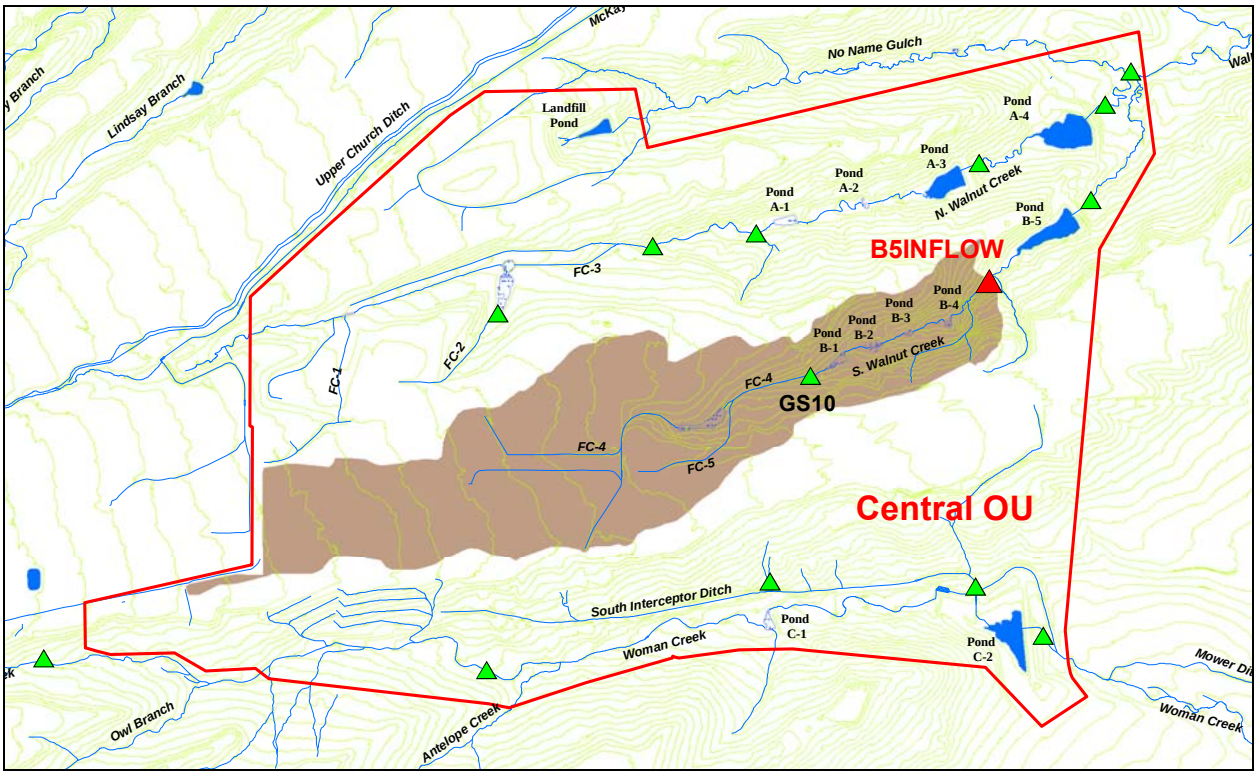


Figure 106. B5INFLOW Drainage Area

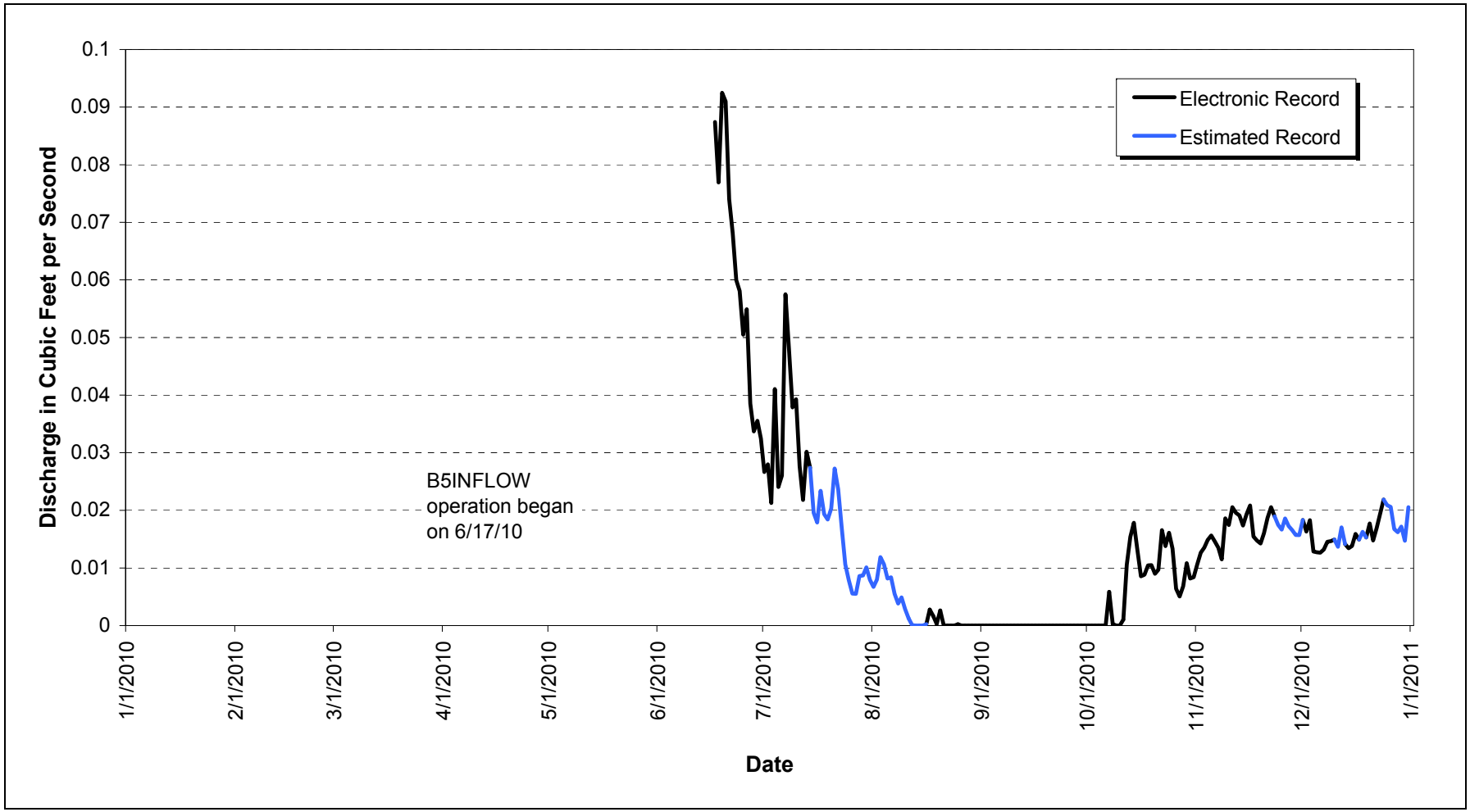


Figure 107. CY 2010 Mean Daily Hydrograph at B5INFLOW: South Walnut Creek Above Pond B-5

SW018: FC-2 at FC-2 Wetland

Location—FC-2 drainage just upstream of FC-2 wetland; State Plane: E2083351, N751006.

Drainage Area—The basin includes FC-2 areas tributary to North Walnut Creek (total of 42.4 acres).

Period of Record—October 10, 2003, to current year.

Gage—Water-stage recorder and 1-foot Parshall flume through September 12, 2006. One-foot H flume installed on September 13, 2006.

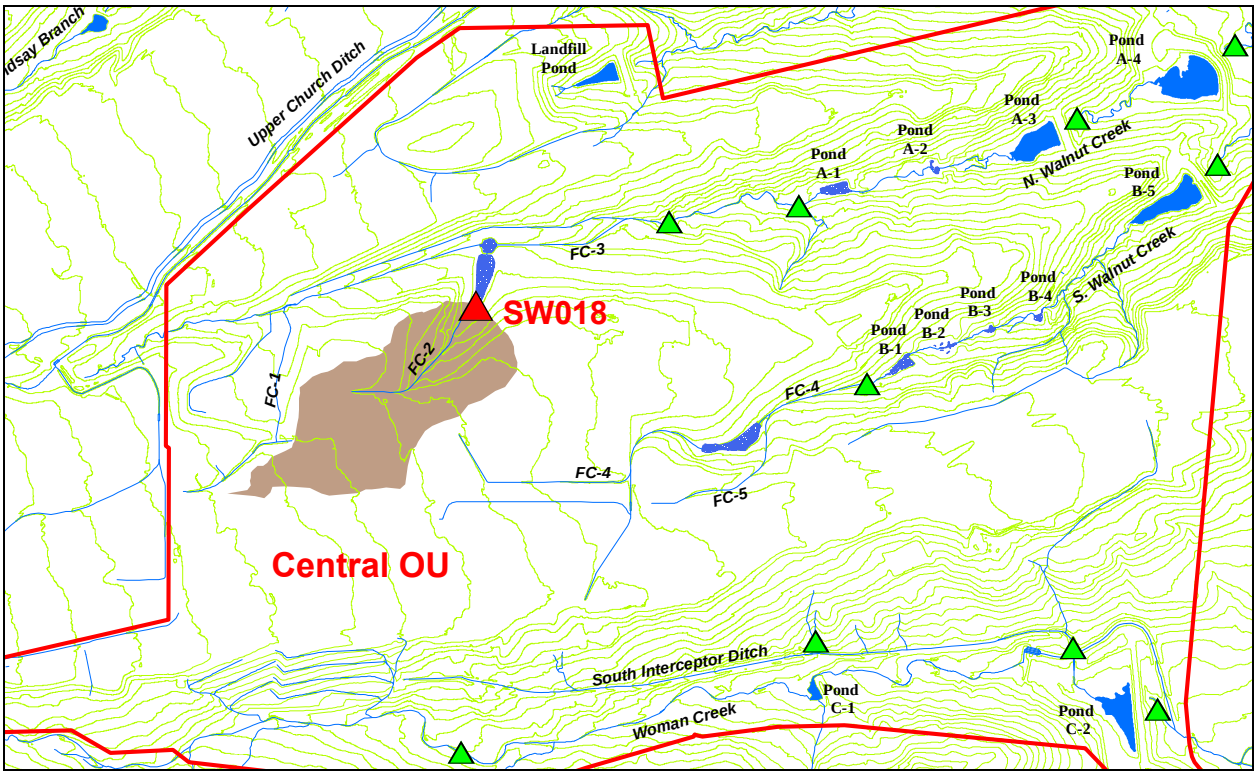


Figure 108. SW018 Drainage Area

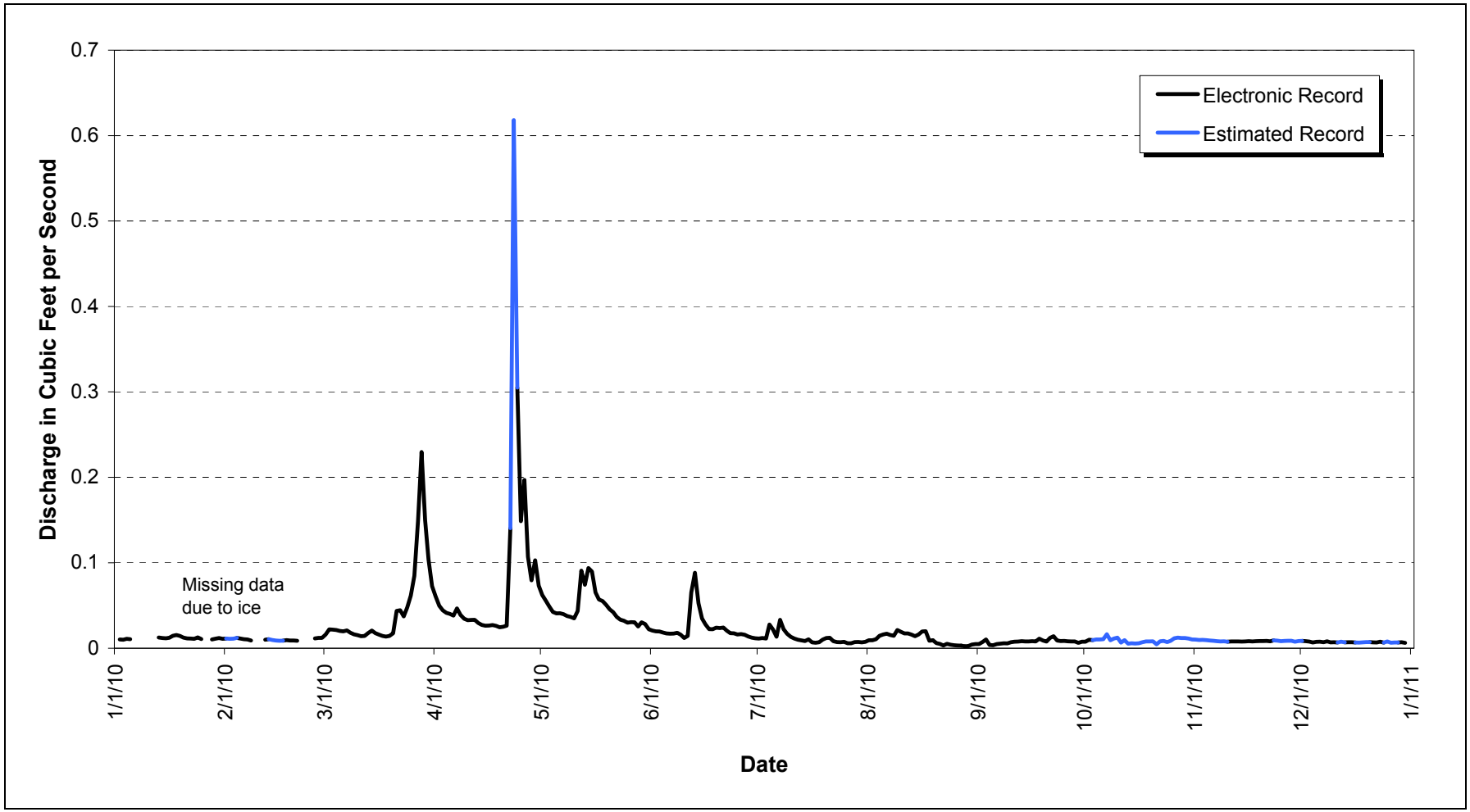


Figure 109. CY 2010 Mean Daily Hydrograph at SW018: FC-2 at FC-2 Wetland

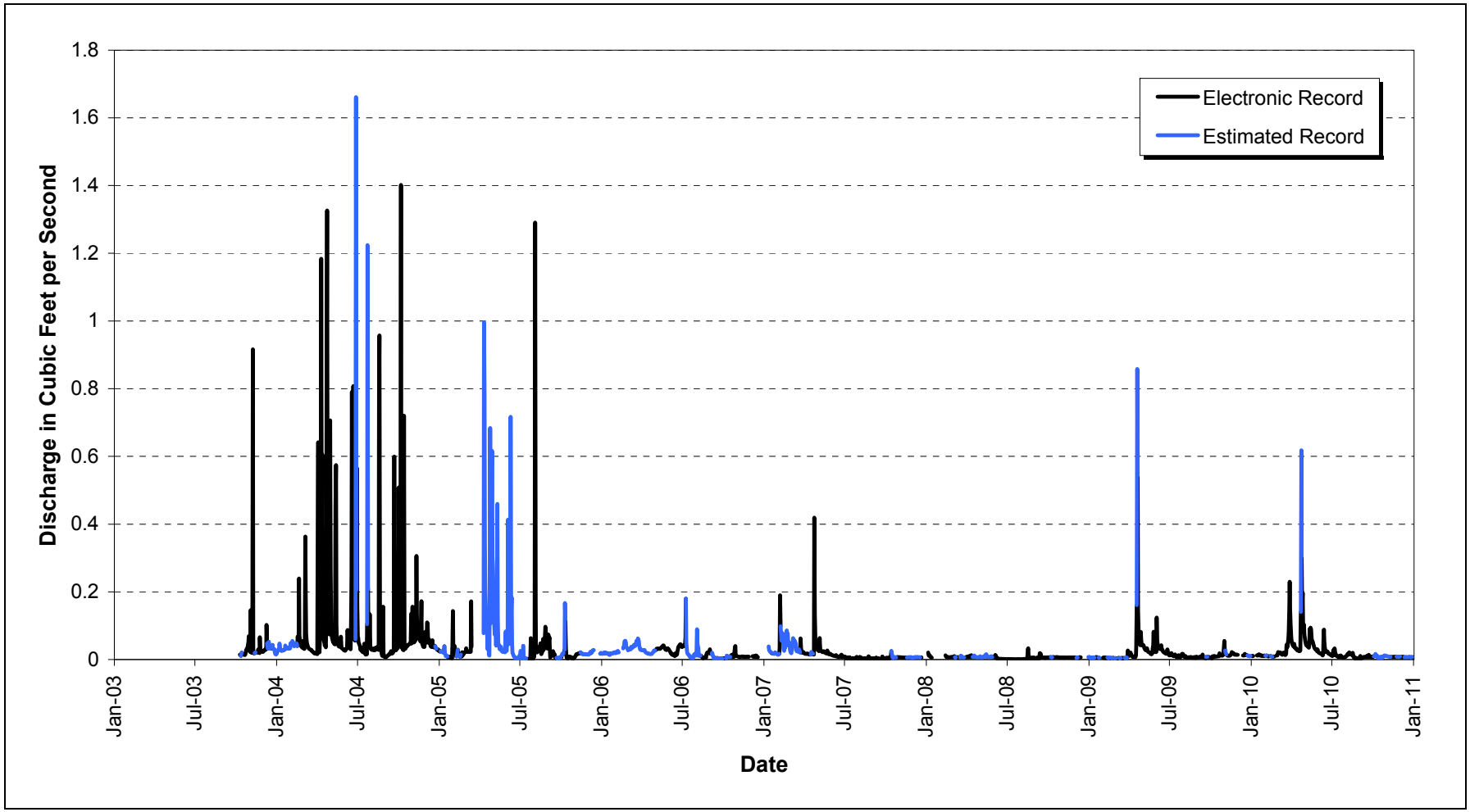


Figure 110. CY 2003−2010 Mean Daily Hydrograph at SW018: FC-2 at FC-2 Wetland

SW027: SID at Pond C-2

Location—East end of SID at Pond C-2; State Plane: E2088527, N748044.

Drainage Area—The basin includes a portion of the southern COU drained by the SID (total of 177.6 acres).

Period of Record—September 11, 1991, to current year.

Gage—Water-stage recorder and dual parallel 120° V-notch weirs.

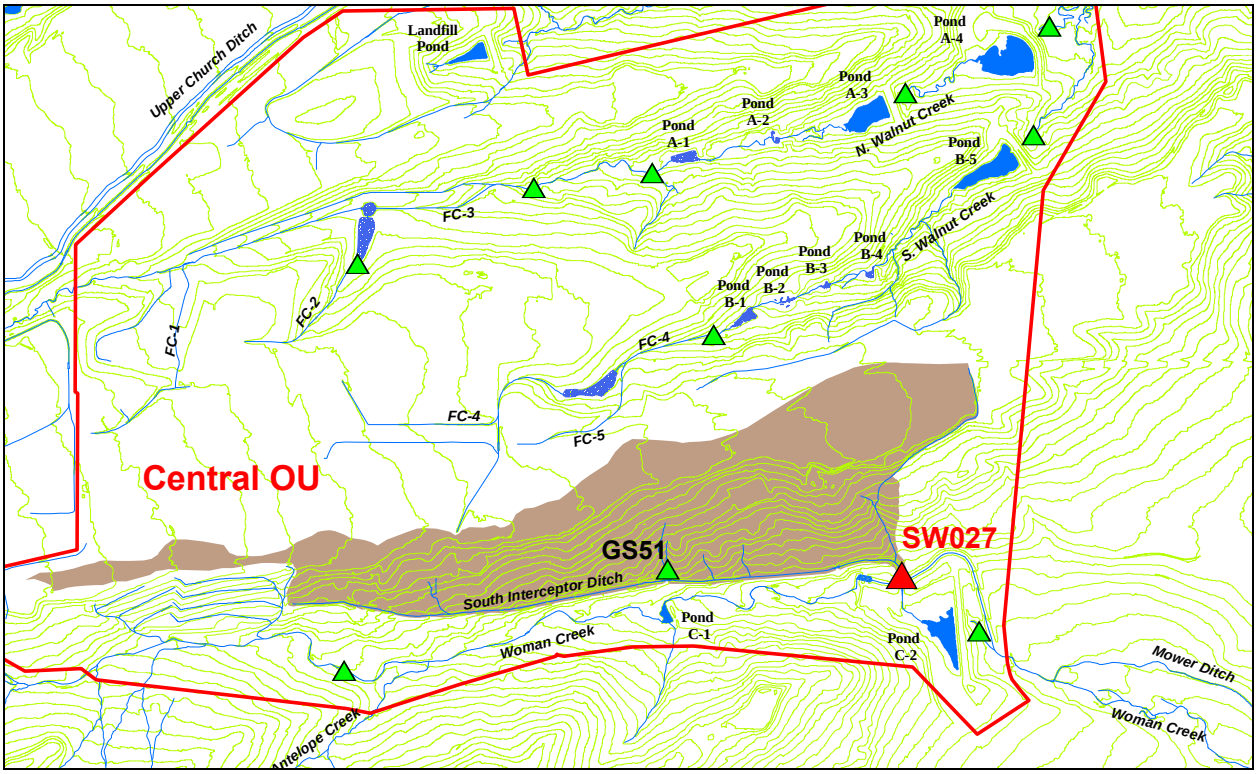


Figure 111. SW027 Drainage Area

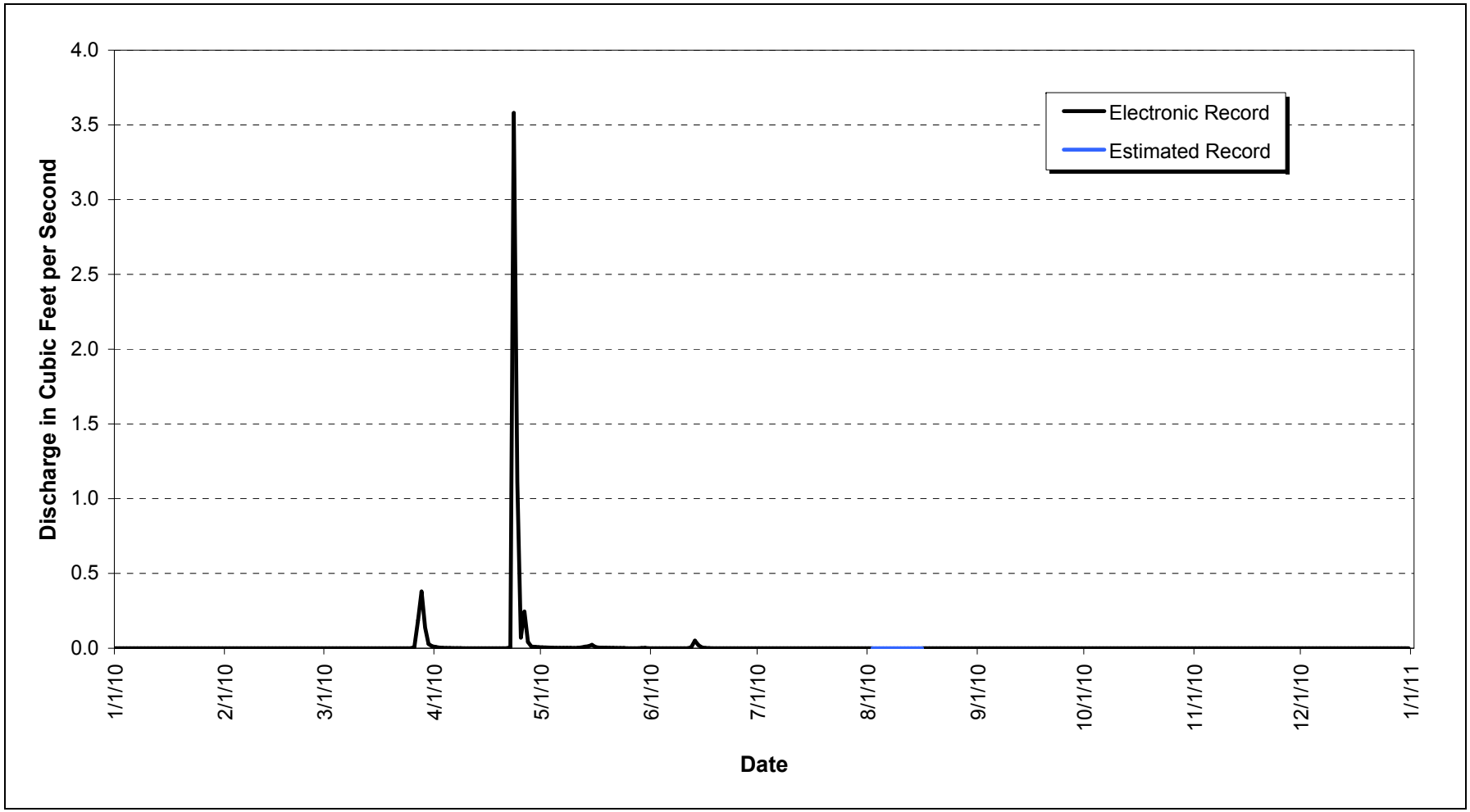


Figure 112. CY 2010 Mean Daily Hydrograph at SW027: SID at Pond C-2

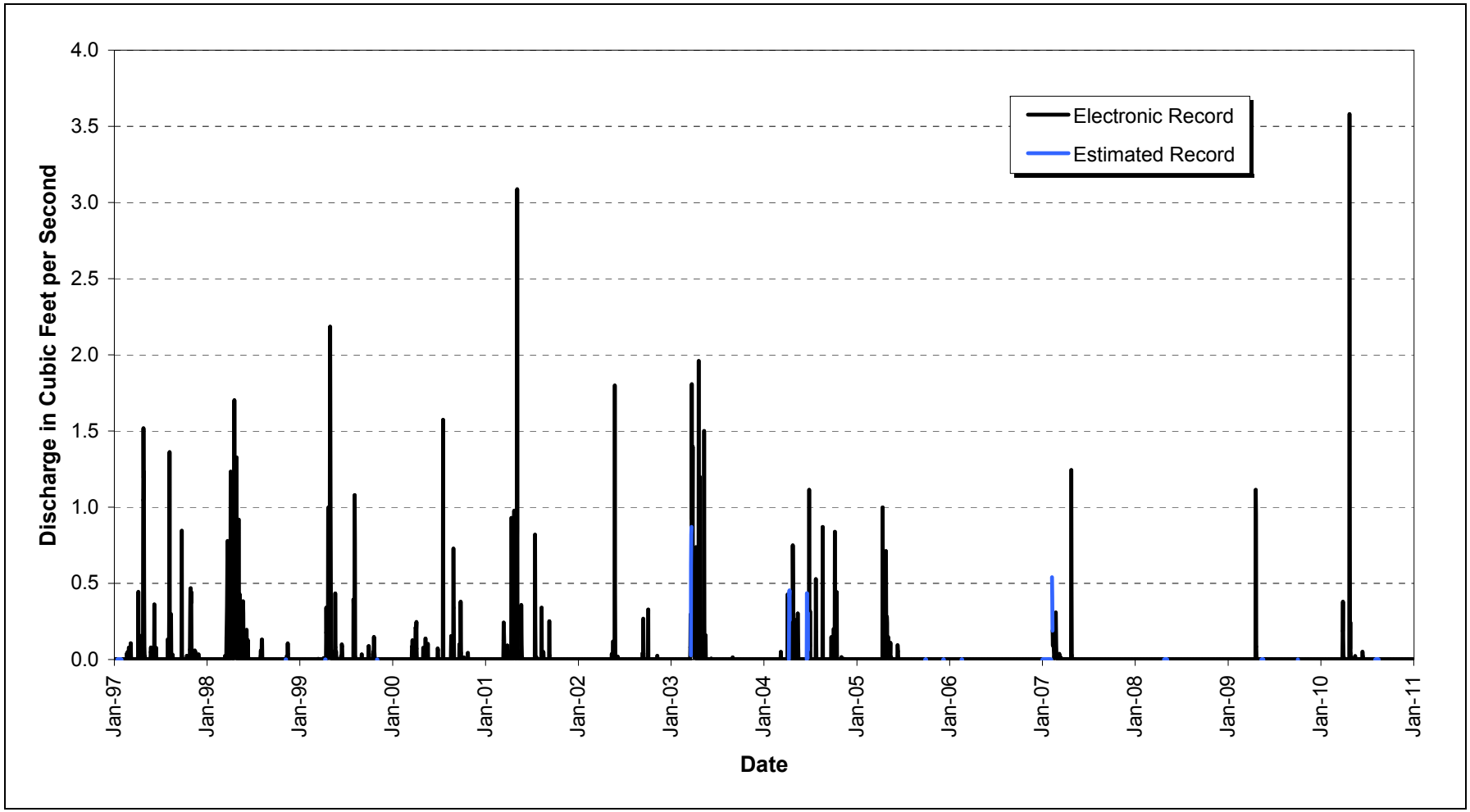


Figure 113. CY 1997−2010 Mean Daily Hydrograph at SW027: SID at Pond C-2

SW093: North Walnut Creek Upstream of Pond A-1

Location—North Walnut Creek 1,300 feet above Pond A-1; State Plane: E2085030, N751730.

Drainage Area—The basin includes the northwestern portion of the COU drained by FC-3 (total of 220.0 acres).

Period of Record—September 11, 1991, to current year.

Gage—Water-stage recorder and 36-inch suppressed, rectangular, sharp-crested weir to January 27, 2003; rated stream section during new flume construction (SW093T; January 27, 2003−May 29, 2003). Three-foot H flume starting May 29, 2003.

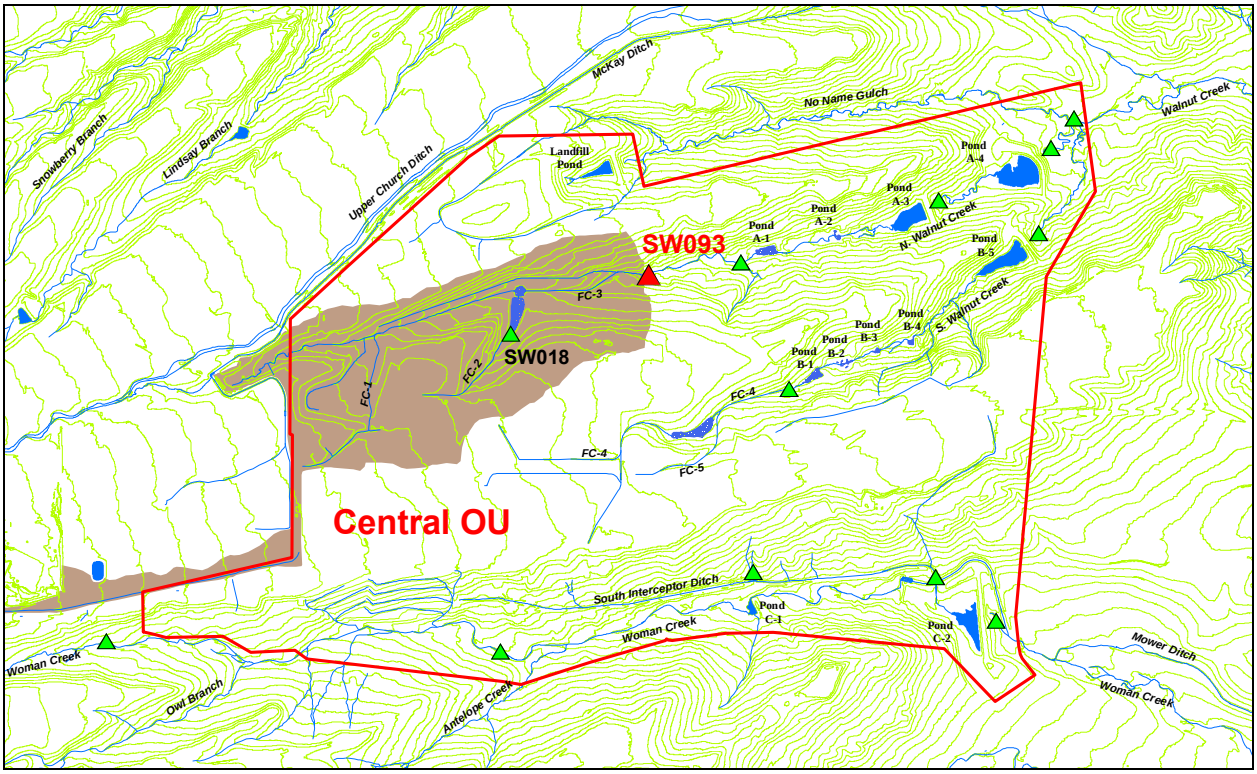


Figure 114. SW093 Drainage Area

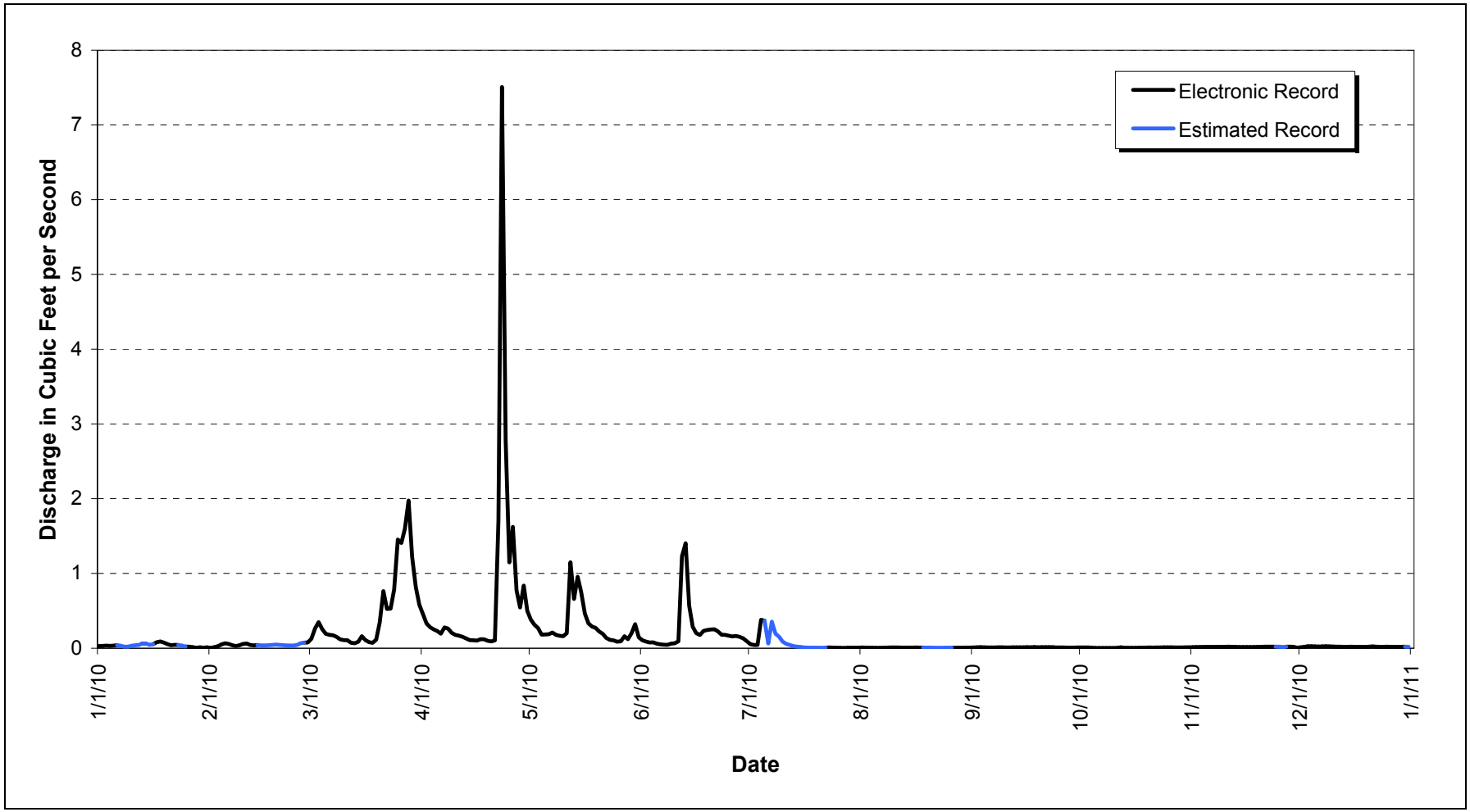


Figure 115. CY 2010 Mean Daily Hydrograph at SW093: North Walnut Creek Upstream of Pond A-1 Bypass

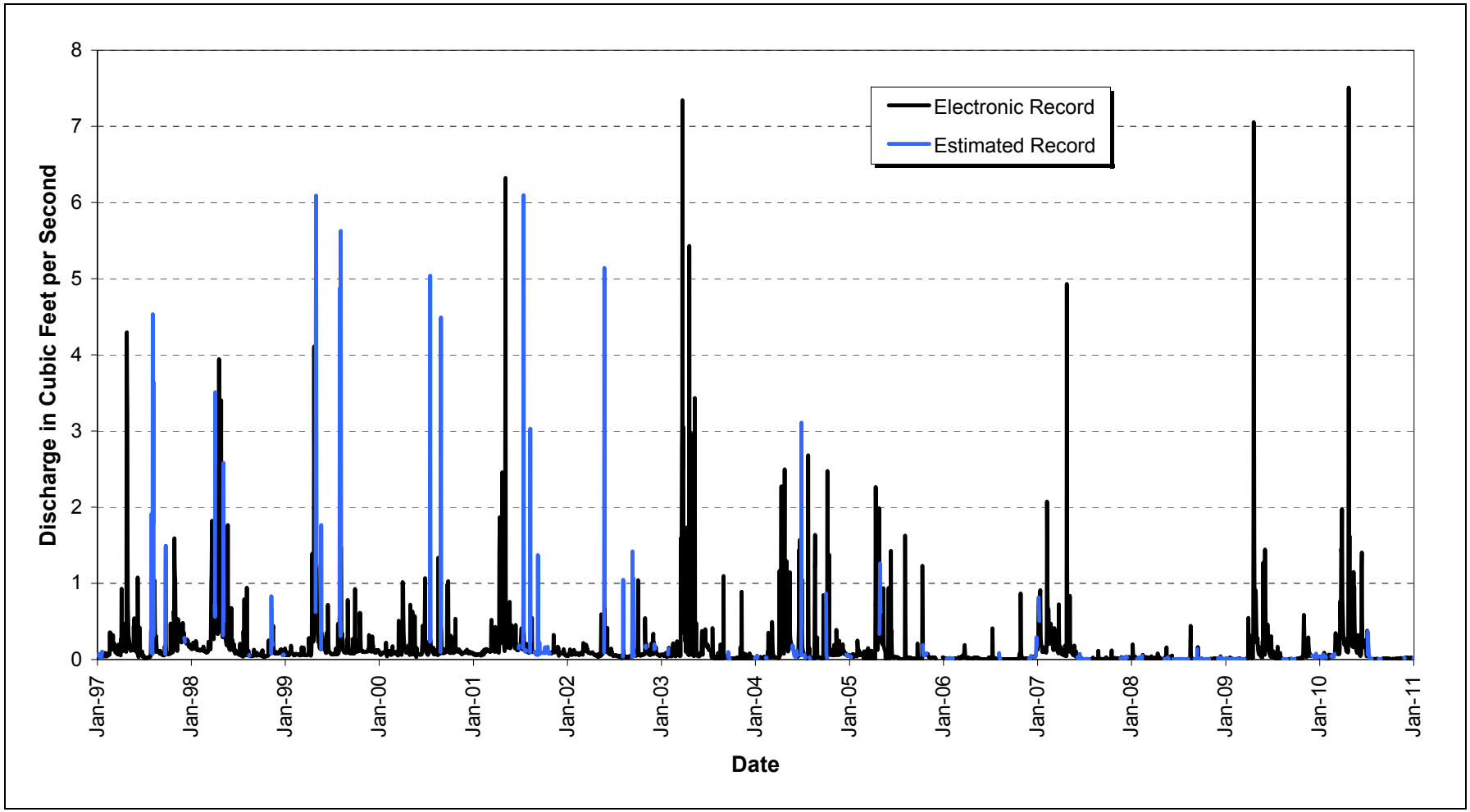


Figure 116. CY 1997−2010 Mean Daily Hydrograph at SW093: North Walnut Creek Upstream of Pond A-1 Bypass

3.1.3.4 Precipitation Data

During CY 2010, eight precipitation gages were operated as part of the automated surface-water monitoring network (Table 36 and Figure 117). The locations employ tipping-bucket rain gages generally mounted at ground level. Precipitation totals are logged on 5-minute intervals, 15-minute intervals, or both. The gages are not heated and will not accurately record equivalent precipitation for all snowfall events. The following sections present several figures (Figure 118, Figure 119, Figure 120, Figure 121, Figure 122, and Figure 123) summarizing the precipitation data collected for CY 1997−2010.

Table 36. Monitoring Network Precipitation Gage Information

Location Code (Surface-Water Gage)	Easting (State Plane)	Northing (State Plane)	Period of Operation
PG58 [GS01]	2093835.22	744921.16	10/11/96−current year
PG59 [GS03]	2093598.99	753629.51	4/1/96−current year
PG61 [GS05]	2078432.10	747285.45	4/1/96−current year
PG73 [GS13]	2086169.70	751862.47	9/27/05−current year
PG74 [GS59]	2083245.00	747172.00	9/5/06−current year
PG75 [SW018]	2083522.00	751181.00	3/27/08–current year
PG76 [NA]	2091963.00	752705.00	3/28/07−current year
PG77 [NA]	2087329.00	746937.00	8/23/07−current year

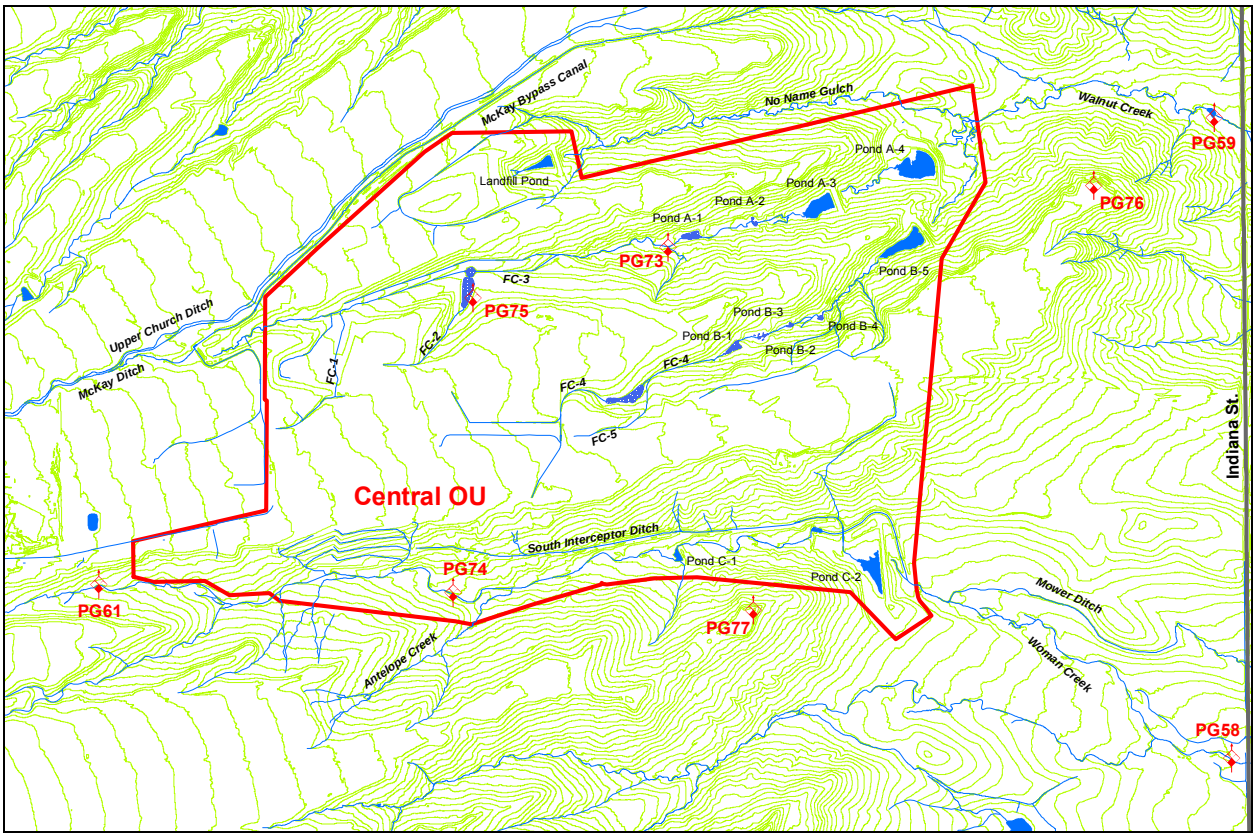
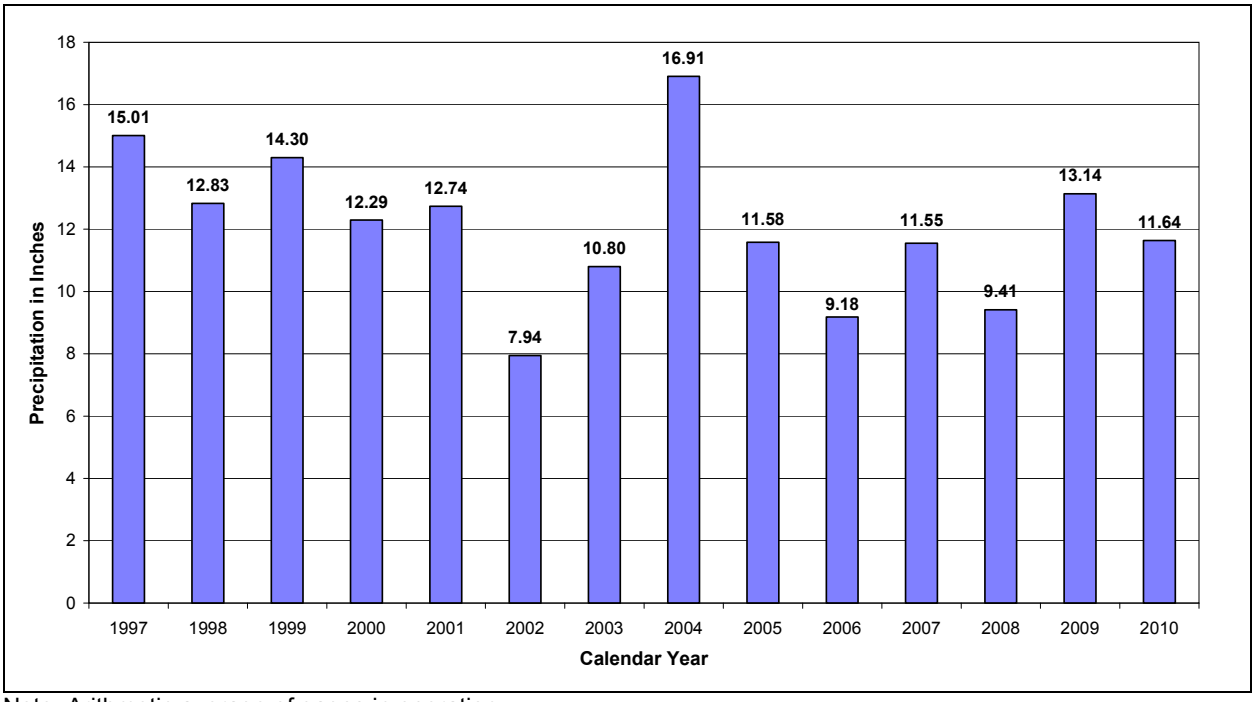


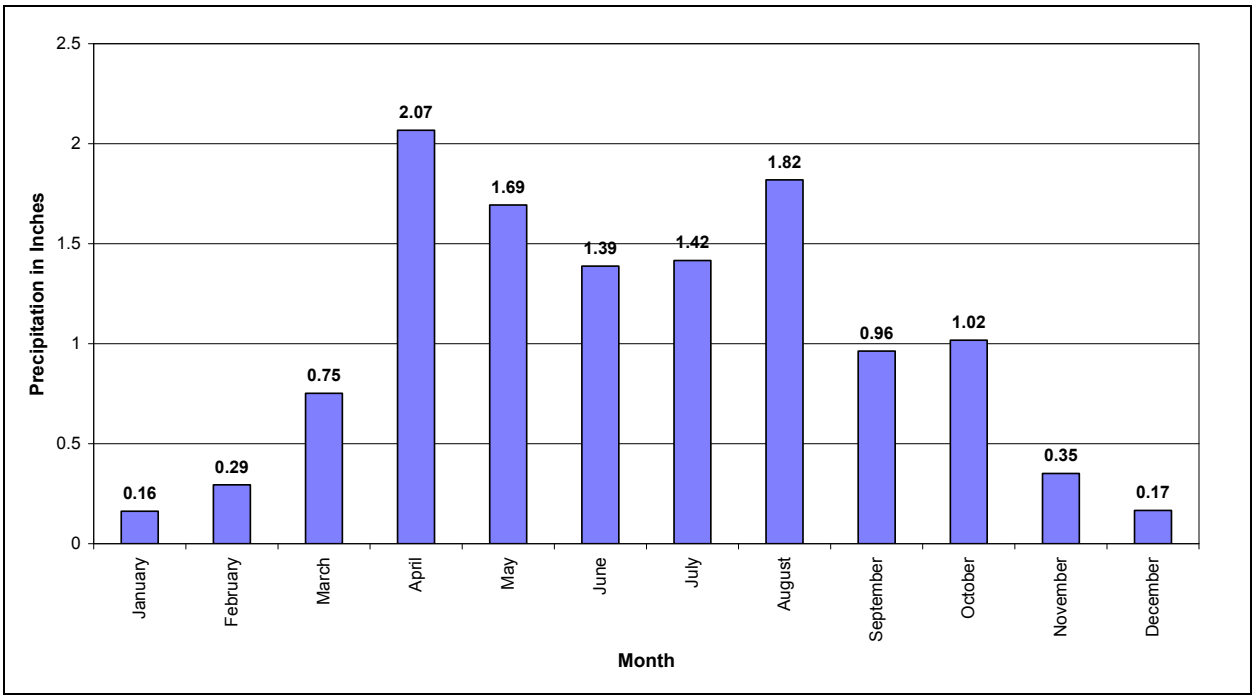
Figure 117. Site Precipitation Gages: CY 2010

CY 1997–2010 Summary



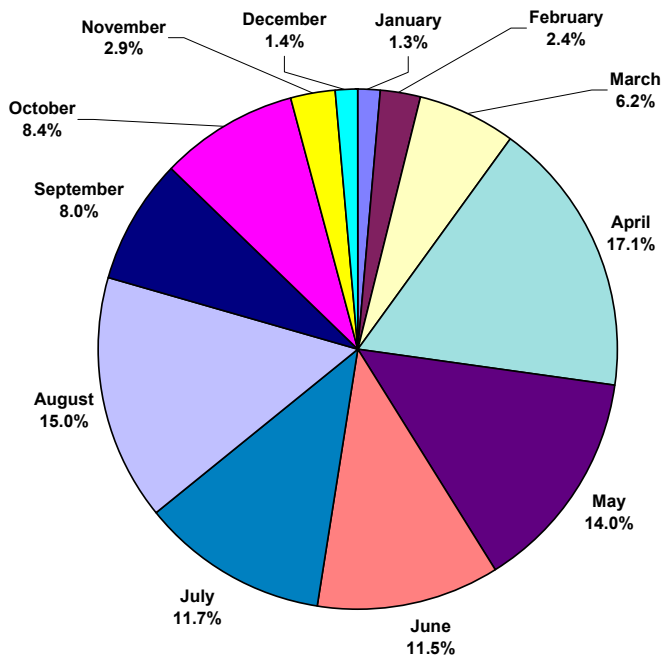
Note: Arithmetic average of gages in operation.

Figure 118. Annual Total Precipitation for CY 1997–2010



Note: Arithmetic average of gages in operation.

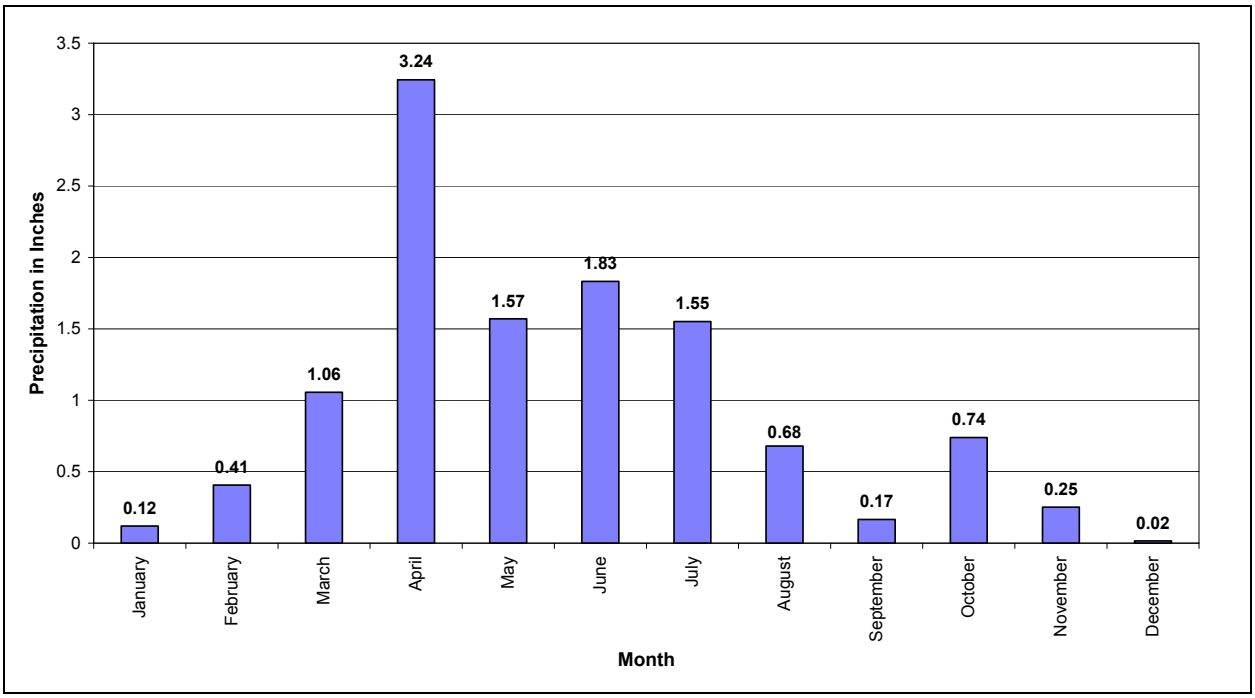
Figure 119. Average Monthly Precipitation for CY 1997–2010



Note: Arithmetic average of gages in operation.

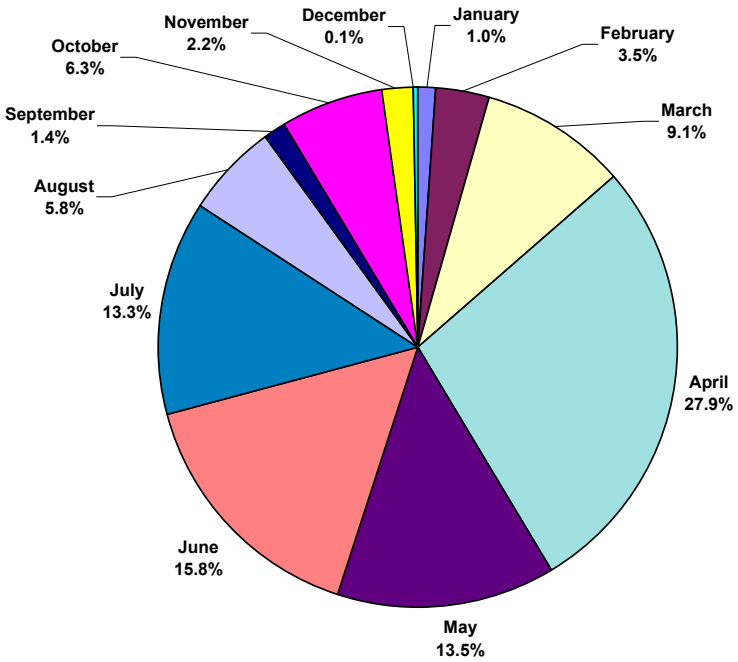
Figure 120. Relative Monthly Precipitation Totals for CY 1997–2010

CY 2010 Summary



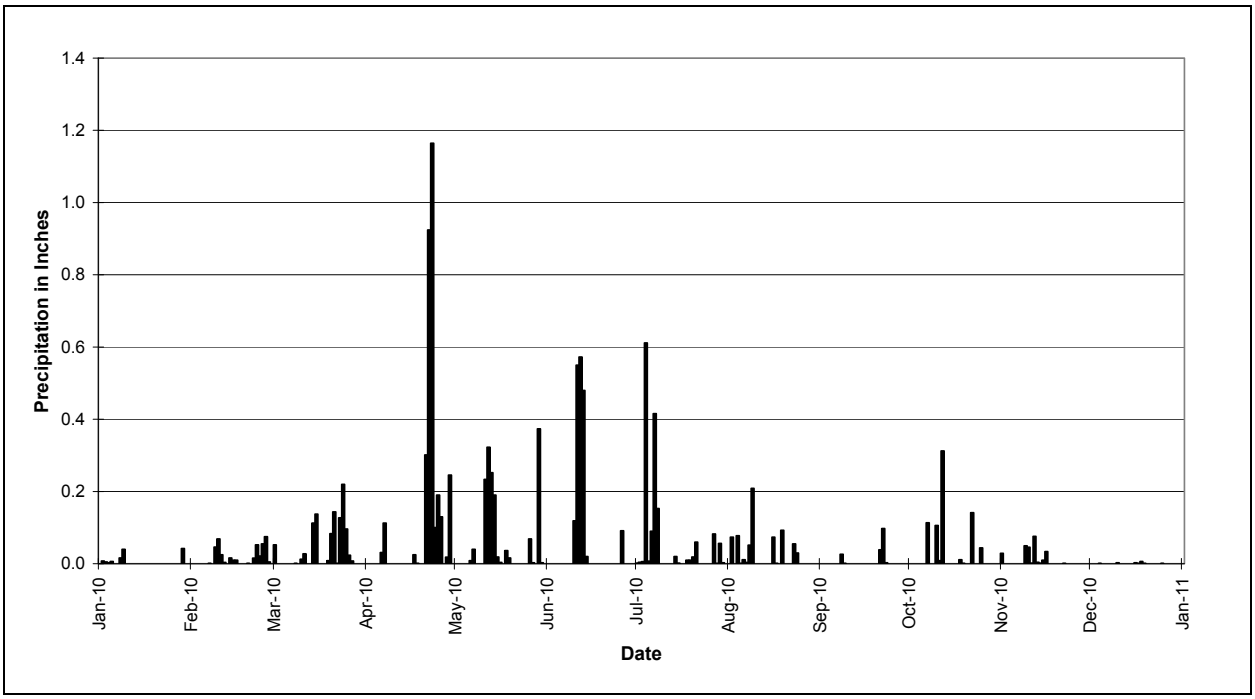
Note: Arithmetic average of gages in operation.

Figure 121. Monthly Precipitation for CY 2010



Note: Arithmetic average of gages in operation.

Figure 122. Relative Monthly Precipitation Volumes for CY 2010



Note: Arithmetic average of gages in operation.

Figure 123. Daily Precipitation Totals for CY 2010

3.1.3.5 Groundwater Flow

This section summarizes groundwater elevations and flow characteristics. Groundwater elevation data are discussed through the construction and interpretation of potentiometric surface maps and hydrographs. Groundwater flow characteristics are then assessed, including flow velocities.

Groundwater Elevations

Groundwater elevation data were manually collected at the start of the second and fourth quarters in 2010; these data are included in Appendix A. Prior to 2010, groundwater elevations were also monitored at selected wells using dedicated instrumentation. While this effort continued into 2010, failure of the dedicated equipment led to the collection of essentially no useful data. This topic is summarized in Appendix A.

The second and fourth quarter groundwater elevation data were plotted and hand-contoured to create potentiometric surface maps. The potentiometric surface map for second quarter CY 2010 is included as Figure 124, and the map for the fourth quarter of CY 2010 is included as Figure 125. These maps are derived from manual water level measurements.

All monitoring wells at Rocky Flats are screened within the UHSU. The UHSU encompasses unconsolidated surface materials such as Rocky Flats Alluvium, hillslope colluvium, valley-fill alluvium, and artificial fill (all of which are often referred to as "alluvium"), and underlying weathered bedrock (the Cretaceous-age Laramie Formation or the Cretaceous-age Arapahoe Formation). A well screened entirely within the weathered bedrock may yield different water levels than an adjacent well screened entirely within the alluvium.

Potentiometric surface maps for 2010 are based on many fewer locations than maps from pre-closure years and are, therefore, less detailed in comparison. Due to the distribution of groundwater contamination, the areas of interest in post-closure years are the former IA and adjacent areas; groundwater monitoring data from the unimpacted former Buffer Zone provide no meaningful value.

Several locations on the potentiometric maps are labeled as dry. Wells are labeled as dry if they are measured to be dry, or if the water level measured is below the bottom of the screened interval (water below the screen is stagnant and may not reflect the actual groundwater level). The locations labeled as dry may indicate areas where the UHSU is unsaturated. These areas are a result of limited groundwater, caused by a reduction in recharge from precipitation (e.g., droughts, such as that in 2002), the reduction in contributions from artificial sources (e.g., removal of water lines, foundation drains, and dust suppression water), or local conditions that may result from an engineered structure (such as the groundwater intercept trenches that collect groundwater and route it to the associated treatment systems). However, many wells in the monitoring network do not fully penetrate the UHSU; therefore, a location that is depicted as dry does not necessarily indicate that it is in an area of unsaturated UHSU, as the UHSU may be saturated at depths greater than that of the dry well.

Groundwater flow paths in 2010 are consistent with conditions in 2009, as estimated from the potentiometric surface maps (Figure 124 and Figure 125). In addition, unsaturated areas in 2010 are similar to several of those depicted in 2009. Well 95299, located adjacent to and downgradient of the ETPTS groundwater intercept trench, was dry. This area is typically dry due to the dewatering effects of that trench. Conversely, well 45608 remained artesian during second quarter CY 2010, as indicated on the potentiometric surface map and corresponding hydrograph. A discussion of the hydrographs is presented below and provides more detail on selected wells.

Consistent with conditions reported in 2008 and 2009 (DOE 2009d, 2010d), water levels in 2010 were no longer affected by Site closure activities. The last year in which groundwater levels clearly showed aftereffects of those activities was 2007 (DOE 2008c). Prior to closure, other influences—particularly, the addition of imported water to the hydrologic system (from leaks in the water distribution infrastructure, normal Site operations, and closure-related application of dust suppression waters), the limitation of direct recharge by impermeable surfaces, and the diversion of groundwater by engineered building foundation drains—were also major factors in some areas, but these influences no longer have a meaningful effect on groundwater levels. Instead, as with conditions reported since 2008, changes in water levels in 2010 were seasonally controlled, dependent on climatic factors (predominantly precipitation and evapotranspiration). Although there are exceptions, overall, the monitoring network indicates that water levels in 2010 were slightly higher in the second quarter than the fourth quarter. This is the usual pattern and is attributed to the fairly wet spring. March and April received a total of 4.3 inches of precipitation, much of it in late March.

Precipitation in 2010 was recorded at eight locations across the Site. The estimated "total" precipitation (i.e., as measured by unheated rain gages, which do not accurately reflect precipitation totals related to snowfall) recorded at the Site in CY 2010 was 11.64 inches. This value is about 4 percent less than the historical (1997−2009) average estimated total annual precipitation, which is 12.13 inches. Figure 118 summarizes precipitation totals for recent CYs and displays the total precipitation for 2010. (Note that the amount shown for 2003 incorporates March data from the Site's former 61-meter meteorology tower, which included a heated precipitation gage that recorded precipitation from the multi-foot March 2003 snowstorm more accurately than did the unheated gages operated by the Water Programs Group.) See Section 3.1.3.4 for additional discussion of precipitation.

Hydrographs

Water level measurements can provide fundamental indicators of the groundwater regime and are critical to a meaningful evaluation of groundwater quantity, quality, and flow. Hydrographs are used to evaluate the groundwater levels at Rocky Flats and are included in Appendix A. Selected hydrographs are discussed here, but it may be helpful to refer to the referenced hydrographs throughout the following discussion.

As in previous annual reports issued since the site was closed (DOE 2007c, 2008c, 2009d, 2010d), water level data for original and replacement wells are combined into a single hydrograph under the assumption that the corresponding data are continuous. As additional data are collected, this assumption may prove to be false at some locations, in which case the corresponding data will no longer be pooled. To date, this has not yet occurred at any well

location. Water level data used for these hydrographs include routine, pre-sampling, and any requested nonroutine measurements.

Water level elevations were calculated by subtracting the measured depth to water from the surveyed elevation of the top of the well casing. When wells were found to be dry, the water level posted on the hydrograph is equivalent to the elevation of the bottom of the well casing, as calculated from the total depth of well casing recorded during its installation. The same water level is posted when the measured water level is found to be below the bottom of the screened interval, because this water is not in hydraulic connection with saturated materials and is therefore likely not representative.

As noted in previous years, it took some time for water levels to stabilize following Site closure activities. The hydrographs confirm statements made above: this stabilization period has been completed. The monitoring network in general indicates that water levels in 2010 display seasonal variations with a strong correlation to precipitation events. For example, seasonal influences can be observed in the hydrographs of wells 80105, 80205, and 11104 monitoring the OLF. Some behavior appears to be in response to mechanisms other than seasonality (for example, see the hydrographs for wells 88104, B206989, and 23296), but in each case can be explained by considering local conditions, as discussed below.

Hydrographs that display seasonal patterns may be rapidly influenced by precipitation events. Seasonal influences are most notable in the spring months after heavy precipitation events; a total of approximately 3.24 inches of precipitation was observed at Rocky Flats during the month of April. The effect of this precipitation is evident in several hydrographs, but it is perhaps most apparent in those representing monitoring wells 70193, 70393, and 70693, each of which is located upgradient of the PLF.

In 2010, precipitation was recorded using data from eight tipping buckets across the Site. The total amount of precipitation recorded in 2010 was 11.64 inches. (Note that tipping buckets do not provide an accurate measure of snowfall; therefore, this value typically under-represents the actual amount of precipitation received.) The relationship between groundwater and precipitation can be complex because groundwater elevations tend to respond slowly to precipitation events. There was a total of 5.87 inches of precipitation observed throughout the months of March through May, which is represented by most hydrographs with a delayed response (see Section 3.1.3.4 for additional discussion of precipitation).

Table 37. Total Monthly Precipitation Data for 2010

Month	Precipitation (inches)
January	0.12
February	0.41
March	1.06
April	3.24
May	1.57
June	1.83
July	1.55
August	0.68
September	0.17
October	0.74
November	0.25
December	0.02
Total Annual	**11.64**

Note: Values are averaged from eight tipping bucket rain gauges across the Site. This total does not include snowfall totals.

Seasonal variations are apparent in almost all of the wells, with a few exceptions. Unsaturated areas were generally unchanged from those observed in 2009. For example, well 95299, which is located adjacent to and downgradient of the ETPTS groundwater intercept trench, was dry. This well has been observed to contain water only once since 2000 (in late 2006). This area is typically dry due to the dewatering effects of that trench. Conversely, well 90299, which is also usually dry, was recharged following the spring precipitation and provided samples in both the second and fourth quarters of 2010.

Well 45608, located on the constructed hillside south of former B991, ceased its artesian behavior in the spring of 2010. Beginning in May 2010, water levels were consistently measured below the top of well casing. The artesian flow previously observed has been interpreted as evidence that this well acts as an outlet for the water collected by the remnants of the French drain underlying this constructed hillside. Cessation of artesian flow appears correlated to the kink developing in this well, and therefore the change in flow conditions may be more a function of well or hillside condition than regional groundwater conditions.

The hydrographs for wells 23296, 88104, and B206989 all reflect rising water levels. Well 23296, located downgradient of the groundwater intercept trench feeding the ETPTS and adjacent to South Walnut Creek at the base of the former Pond B-2 dam, exhibited water levels that were above historical levels. These rising water levels date back to October 2008, which coincides with the Dam Breach project that started in September of that year. The rising water levels exhibited by the hydrograph for well 23296 are attributed to resumption of stream flows through South Walnut Creek, rather than routing this water around the ponds via the bypass pipeline as had been the practice in prior years. The water level in this well shows a spring-2010 increase that appears related to precipitation. (Note that due to the rising water levels following breaching of the adjacent dams, the casing of this well was extended in May.)

Well 88104 is located south of the buried remains of former B881. The corresponding hydrograph illustrates that the water level in this well has been rising, with a couple of interruptions, since 2005. This is attributed to groundwater in the pediment to the north being

intercepted by the footprint of former B883 and B881, which were connected by a tunnel. The preferential pathways likely represented by these features would act to route this groundwater to the south, toward the remnants of B881 and its immediate surroundings, such as the area monitored by well 88104. This groundwater has a surface expression as a seep that appears in the vicinity of the southern edge of the former building. The seep drains into and supports a marshy area where 88104 is located. As is evident from the discussion provided in Section 3.1.5.3, analytical data for samples collected from well 88104 do not suggest adverse impacts to surface water from the increased quantities of groundwater observed on the hydrograph for this well.

Well B206989 is located at the foot of the PLF dam and monitors the weathered bedrock. The hydrograph for this well also shows rising water levels that date back—again, with interruptions—to about 2009. This is attributed to a combination of effects: First, the Landfill Pond operates in flow-through, and has since shortly after site closure. This would act to keep the valley in which well B206989 is located more saturated than was the case prior to flow-through operation. Second, both 2009 and 2010 were characterized by wet springs, which would have recharged the groundwater monitored by this well. Finally, the groundwater sampling method employed at this well was changed in May 2010, as it was at all of the poorer-producing wells at the site. Previously, the well would dewater during sampling, and samples would be collected from the ensuing recharge, typically on a subsequent date. Since May 2010, samples are collected from the water initially present within the well casing, without first purging the well (which had typically caused it to dewater). By not repeatedly dewatering the well, the scarce formation water in this area is not repeatedly depleted, and water levels in this very poor producing well have been recovering to what is expected to be a more ambient elevation. This does not mean that the well will produce more water; rather, the ambient water level will be more reflective of undisturbed conditions within the adjacent weathered bedrock of the UHSU.

Wells 33502, 33604, 33703, and 33905 monitor the buried drainage that hosts the vinyl chloride (VC) plume upgradient of FC-2. Hydrographs for these wells, similar to other observations in 2010, show strong seasonal patterns, with sharp spring peaks and winter troughs in water levels. The casing of well 33703 is strongly kinked, preventing the measurement of water level after May 2010. This well is scheduled to be replaced in early 2011.

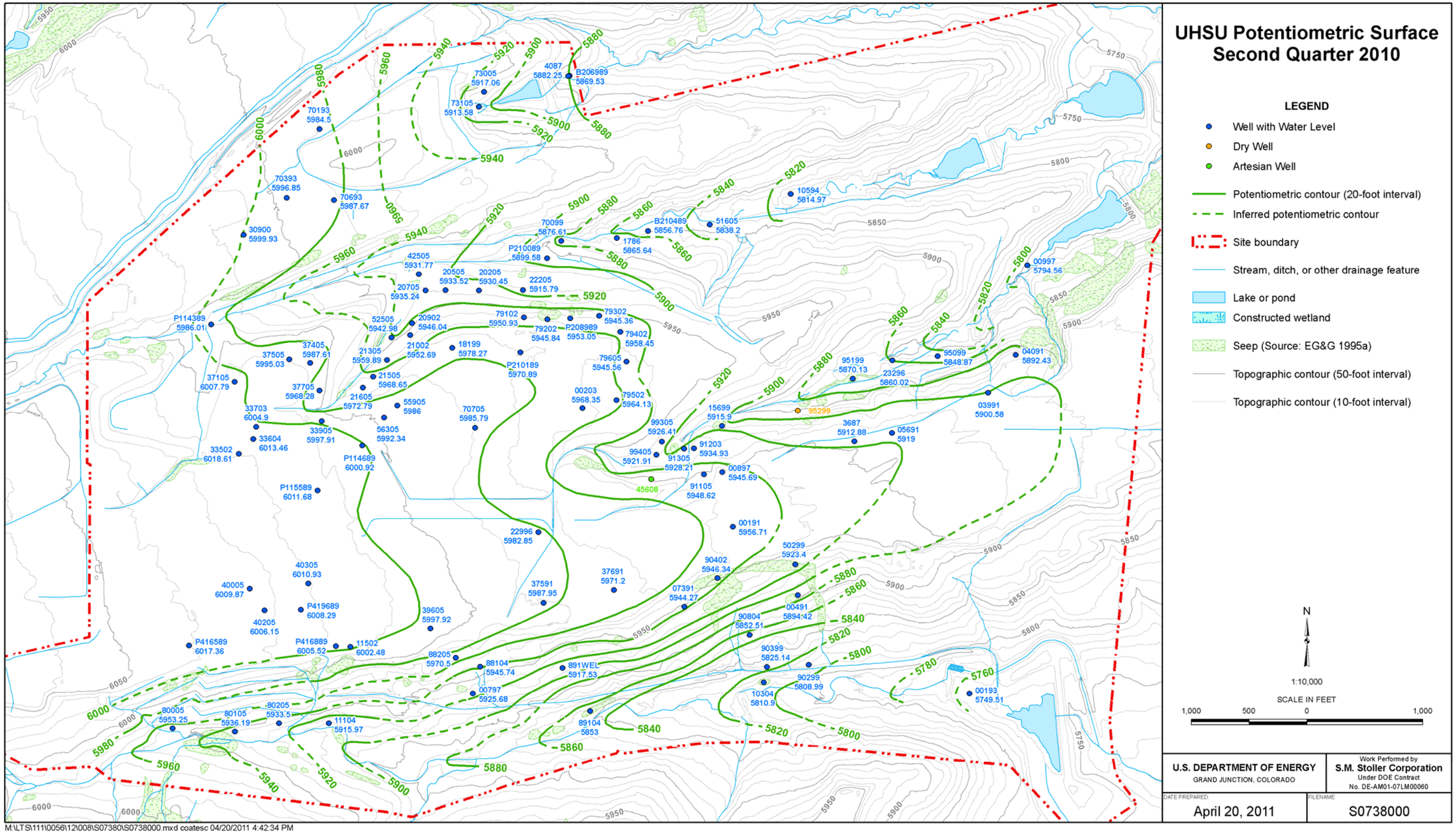


Figure 124. UHSU Potentiometric Contours: Second Quarter CY 2009

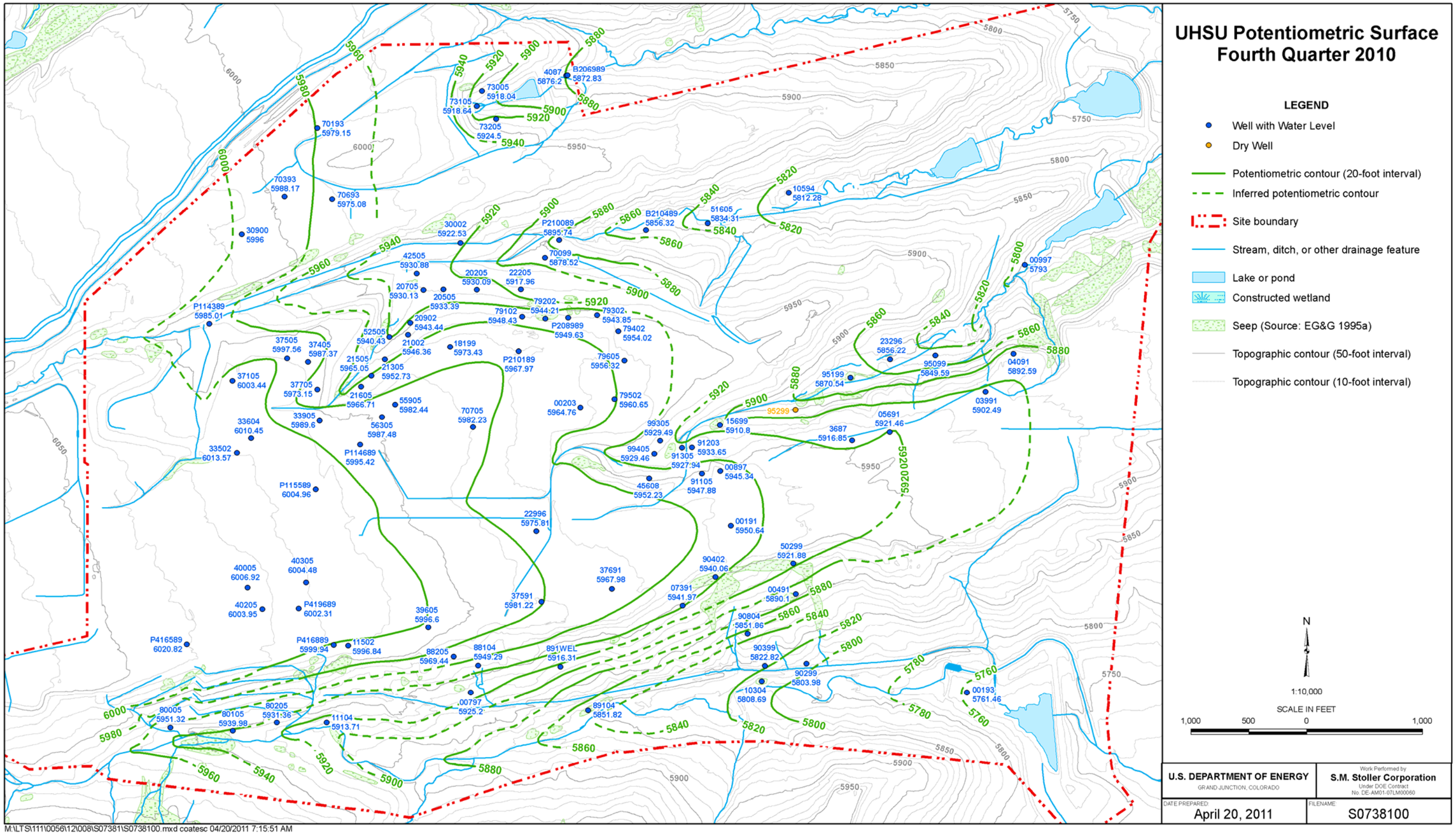


Figure 125. UHSU Potentiometric Contours: Fourth Quarter CY 2009

Groundwater Flow Velocities

Groundwater flow directions and velocities in 2010 are generally consistent with those reported in 2009. Flow directions, water level data, geological information, and completed well designs and locations support the selection of several well pairs for the calculation of linear groundwater flow velocities, also referred to as seepage velocities. In conjunction with the potentiometric surface maps, a pair of wells is potentially useful for these calculations if a line drawn between them is perpendicular (or nearly so) to the potentiometric contour lines between the two wells, and there are no intervening drainages or artificial groundwater control structures (such as the groundwater intercept trenches that are a component of three of the four treatment systems, and the GWIS at the PLF).

Well pairs selected for use in this report are the same as those selected in 2009.

The seepage velocity (v) may be calculated using the Darcy equation:

$$v = \left(K/n\right)\left(dh/dl\right)$$

where

K = hydraulic conductivity
n = effective porosity
dh/dl = hydraulic gradient.

This calculation is most sensitive to the hydraulic gradient and value of K used, because for all calculations of v in this report a porosity of 0.1 (consistent with previous Annual RFCA Groundwater Monitoring Reports as well as post-closure RFLMA reports) is used.

The hydraulic gradients were calculated from groundwater elevation data collected in the second and fourth quarters of 2010. (Note that because of an equipment malfunction, the groundwater elevation for well 30002 was not obtained during routine, second quarter water-level measurements. The water level measured during second quarter sampling in June was used instead.) Results of the hydraulic gradient calculation typically differ slightly when data are used from different quarters, but the differences are typically not large, with several exceptions. The hydraulic gradients calculated for well pair 40305-39605 for second and fourth quarters are 0.012 and 0.007, respectively. This relatively large variation is a result of the combination of fairly consistent water elevations in well 39605 during 2010, and more widely varying elevations in well 40305. The steeper gradient observed in second quarter is the result of the significantly higher water level seen in well 40305. The water elevation measured is one of the highest levels seen in this well since 2000. The water level in 40305 was more than 6 feet lower when it was measured in the fourth quarter, resulting in a lower gradient. Similarly, the gradients calculated for well pairs 79102-22205 (0.149 and 0.129) and 79502-99305 (0.071 and 0.059) indicated steeper gradients during second quarter than fourth. In both cases, elevation changes in the downgradient wells are reduced relative to those in the upgradient wells.

The opposite pattern is illustrated by some well pairs. Gradients calculated for well pair 40005-P419689 are 0.003 and 0.010 for second and fourth quarters, respectively. The same general explanation applies as above, but in this case the difference in water levels between wells in the fourth quarter is higher: the water level in the downgradient well, P419689, falls much more than

it does in the upgradient well (40005), resulting in a steeper gradient in the fourth quarter. For well pair 70393-70693, hydraulic gradients for second and fourth quarters are 0.022 and 0.032, respectively. While both wells show sharp declines in water level from second to fourth quarters, the variation during fourth quarter is more significant; thus, the steeper gradient during this time period.

Calculated seepage velocities are only useful as estimates. Table 38 presents the flow velocities calculated using the 2010 data for selected well pairs. These velocities are most often used to estimate the travel time of conservative (nonreactive) constituents. Reactive constituents tend to migrate more slowly than the calculated velocity. These calculated velocities do not take into account properties such as sorption and chemical reactions (e.g., precipitation, biodegradation, and volatilization) that can strongly influence the transport of groundwater contaminants.

For each well pair, the value of K, the hydraulic conductivity, selected for this calculation was based on the predominant lithologic unit comprising the flow path between the two wells. This is based on the core logs for the respective wells and the published geology (EG&G 1995b), as well as information from the hydrographs (i.e., whether the saturated interval is typically restricted to the bedrock or includes surficial materials). If more than one lithology is represented between the wells and, from the hydrographs, appears to comprise a meaningful fraction of the saturated interval, an average K was calculated from the lithologies. K values used for these calculations are from EG&G (1995a), Table G-2, with subsequently modified values for Rocky Flats Alluvium and valley-fill alluvium (RMRS 2000a; Safe Sites 2001, 2002).

One factor that may cause significant error in estimated seepage velocities is the presence of artificial fill in many portions of the former IA. The K value for Rocky Flats Alluvium is used because the source of the fill was typically deposits of Rocky Flats Alluvium. However, it is unlikely that the backfilled (i.e., reworked) alluvium has the internal structure or is as compacted as the original deposits, resulting in a higher effective porosity and K value than the published values for Rocky Flats Alluvium. Where well pairs cross former buildings that were backfilled with concrete rubble and alluvium, the effective porosity and K values will be higher still. For this report, well pairs crossing areas of sufficiently thick backfill deposits may use the K value for Rocky Flats Alluvium rather than that for the original lithology, under the assumption that the entire area of backfill/regrading has a hydraulic conductivity closer to that of Rocky Flats Alluvium than to a lower-permeability unit.

An example well pair illustrates some of the related difficulties. Well 18199 is located between former B776 and B771. It screens mainly sandstone of the Arapahoe Formation (the "No. 1 Sandstone"; EG&G 1995a) and Rocky Flats Alluvium. Groundwater in this area previously flowed toward the west as a result of the B771 foundation drain system. Following disruption of this drain, groundwater flow is anticipated to be more northerly, potentially through the rubble- and alluvium-backfilled subsurface remnants of B771. For this reason, well 20505 was selected as the downgradient well in this well pair. This well is screened in artificial fill, clays, claystone, and silty claystone. The transect from 18199 to 20505 is mostly occupied by the artificial fill of the B771 closure, and that fill is essentially reworked alluvium. During the fourth quarter of 2010, the water level in well 18199 was within the bedrock, while that in well 20505 was within the artificial fill. Therefore, an average hydraulic conductivity of the Arapahoe Formation No. 1 Sandstone (well 18199) and Rocky Flats Alluvium and claystone (well 20505) was used to calculate the fourth quarter seepage velocity between this well pair.

Table 38. Calculated Flow Velocities for 2010

Well Pair	Area	2010 Quarter	Geological Unit	WL Elevation, Well 1	WL Elevation, Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	Calculated K (cm/s)[a]	v (ft/yr)	Time to Traverse Transect (yr)
P115589-P114689	North IA	2	Qrf	6011.68	6000.92	10.76	550.14	0.020	4.18E-04	84.59	6.50
		4	Qrf	6004.96	5995.42	9.54	550.14	0.017	4.18E-04	75.00	7.34
P114689-21605	North IA/B559	2	Qrf/Qrf/KaKlclst	6000.92	5972.79	28.13	503.78	0.056	3.14E-04	181.24	2.78
		4	Qrf/Qrf/KaKlclst	5995.42	5966.71	28.71	503.78	0.057	3.14E-04	185.15	2.72
56305-21505	B559	2	Qrf/KaKlclst	5992.34	5968.65	23.69	319.61	0.074	2.09E-04	160.62	1.99
		4	Qrf/KaKlclst	5987.48	5965.05	22.43	319.61	0.070	2.09E-04	151.76	2.11
18199-20505	B771	2	Qrf/KaNo.1ss/ Qrf/KaKlclst	5978.27	5933.52	44.75	500.43	0.089	4.06E-04	375.84	1.33
		4	KaNo.1ss/Qrf/ KaKlclst	5973.43	5933.39	40.04	500.43	0.080	4.99E-04	412.86	1.21
P416589-80105	OLF	2	Qrf/Qrf/KaKlclst	6017.36	5936.19	81.17	846.63	0.096	3.14E-04	311.20	2.72
		4	Qrf/Qrf/KaKlclst	6020.82	5939.98	80.84	846.63	0.095	3.14E-04	310.21	2.73
40305-39605	South IA	2	Qrf/KaKlslt/ KaKlclst	6010.93	5997.92	13.01	1126.39	0.012	1.12E-04	13.40	84.05
		4	Qrf/KaKlslt/ KaKlclst	6004.48	5996.6	7.88	1126.39	0.007	1.12E-04	8.11	138.94
40005-P419689	South IA	2	Qrf/KaKlclst/ Qrf/KaNo.1ss	6009.87	6008.29	1.58	478.87	0.003	4.06E-04	13.87	34.53
		4	Qrf/KaKlclst/ Qrf/KaNo.1ss	6006.92	6002.31	4.61	478.87	0.010	4.06E-04	40.46	11.84
P419689-11502	South IA	2	Qrf/KaNo.1ss/ KaKlclst	6008.29	6002.48	5.81	535.27	0.011	3.02E-04	33.91	15.79
		4	Qrf/KaNo.1ss/ KaKlclst	6002.31	5996.84	5.47	535.27	0.010	3.02E-04	31.93	16.76
40305-22996	South IA/ 800 Area	2	Qrf/KaKlclst/Qrf	6010.93	5982.85	28.08	2037.05	0.014	3.14E-04	44.74	45.53
		4	Qrf/KaKlclst/ KaKlclst	6004.48	5975.81	28.67	2037.05	0.014	1.05E-04	15.31	133.02
88205-00797	881 Hillside	2	Qrf/KaKlclst/Qrf	5970.5	5925.68	44.82	343.12	0.131	3.14E-04	424.37	0.81
		4	Qrf/KaKlclst/Qrf	5969.44	5925.2	44.24	343.12	0.129	3.14E-04	418.88	0.82
00191-00491	903 Pad-Lip	2	Qrf/Qrf/KaKlclst	5956.71	5894.42	62.29	816.98	0.076	3.14E-04	247.48	3.30
		4	Qrf/KaKlclst	5950.64	5890.1	60.54	816.98	0.074	2.09E-04	160.58	5.09
07391-10304	Ryan's Pit/ Woman Ck.	2	Qrf/KaKlclst/ Qc/KaKlclst	5944.27	5810.9	133.37	948.74	0.141	1.28E-04	186.56	5.09
		4	Qrf/KaKlclst/ Qc/KaKlclst	5941.97	5808.69	133.28	948.74	0.140	1.28E-04	186.05	5.10

Table 38 (continued). Calculated Flow Velocities for 2010

Well Pair	Area	2010 Quarter	Geological Unit	WL Elevation, Well 1	WL Elevation, Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	Calculated K (cm/s)[a]	v (ft/yr)	Time to Traverse Transect (yr)
91105-91203	Oil Burn Pit #2	2	Qrf/KaKlslt/Qrf/KaKlclst	5948.62	5934.93	13.69	242.17	0.057	2.16E-04	126.58	1.91
		4	Qrf/KaKlslt/KaKlclst	5947.88	5933.65	14.23	242.17	0.059	1.12E-04	68.18	3.55
P210189-79102	SEPs	2	Qrf/KaKlslt/KaKlclst	5970.89	5950.93	19.96	301.98	0.066	1.12E-04	76.69	3.94
		4	Qrf/KaKlslt/KaKlclst	5967.97	5948.43	19.54	301.98	0.065	1.12E-04	74.98	4.03
79102-22205	North of SEPs	2	KaKlclst/KaKlslt	5950.93	5915.79	35.14	235.62	0.149	1.48E-05	22.90	10.29
		4	KaKlclst/KaKlslt	5948.43	5917.96	30.47	235.62	0.129	1.48E-05	19.80	11.90
79502-99305	SEPs/B991	2	Qrf/KaKlclst/Qrf/KaKlclst	5964.13	5926.41	37.72	532.37	0.071	2.09E-04	153.54	3.47
		4	KaKlclst/Qrf/KaKlclst	5960.65	5929.49	31.16	532.37	0.059	1.05E-04	63.68	8.36
70393-70693	PU&D/PLF	2	Qrf	5996.85	5987.67	9.18	410.48	0.022	4.18E-04	96.72	4.24
		4	Qrf	5988.17	5975.08	13.09	410.48	0.032	4.18E-04	137.92	2.98
30900-30002[b]	PU&D/North Walnut Creek	2	Qrf/KaNo.1ss/KaKlclst	5999.93	5927.74	72.19	1890.74	0.038	3.02E-04	119.28	15.85
		4	Qrf/KaNo.1ss/KaKlclst	5996	5922.53	73.47	1890.74	0.039	3.02E-04	121.42	15.57

[a] cm/s = centimeters per second
[b] Well 30002 water level elevation for second quarter 2010 was measured in June, rather than April as was that in well 30900. Refer to text for additional information.

As noted above, these calculated velocities are based in part on data displayed on the hydrographs: where water is shown above the bedrock contact, hydraulic conductivities for the unconsolidated surficial material (e.g., Rocky Flats Alluvium or colluvium), as well as bedrock to account for water flowing through this unit, are included for this calculation. If the hydrographs show that water is typically restricted to the bedrock, the K value for the generalized bedrock type at that well is selected. Note that, similar to the highly heterogeneous alluvial deposits, the bedrock lithologies are also variable (e.g., from claystone to silty claystone to clayey siltstone to siltstone), as is often reflected in cores from the screened interval of a given well; however, a single K value is selected to represent the well.

Table 38 presents the results of the calculation of seepage velocities. Refer to Figure 124 and Figure 125 for the locations of the wells. Estimated seepage velocities in 2010 range from a low of 8.11 feet per year (ft/yr) within the bedrock from well 40305 to well 39605 in the southern IA, to a high of 424.37 ft/yr within the artificial fill and bedrock from well 88205 to well 00797 in the 881 Hillside area. The corresponding travel time between each well in a well pair ranges from approximately 10 months (from well 88205 to well 00797) to over 139 years (from well 40305 to well 39605 in the southern IA). However, once again these are estimated velocities for pure water; and second, the hydraulic gradients can be seen to change significantly from season to season between wells in some well pairs as a result of seasonal recharge patterns, as discussed above. For example, the gradients mentioned above between wells 40005 and P419689 (0.003 and 0.010 for second and fourth quarters, respectively) lead to corresponding calculated velocities of 13.87 ft/yr and 40.46 ft/yr—travel times of over 34 years and about 12 years. As illustrated, these estimates are very sensitive to measured water levels.

In general, the velocities calculated for 2010 are comparable to those calculated prior to Site closure (e.g., K-H 2004b) and are also similar to those presented in 2009 (DOE 2010d). For a more detailed discussion of flow between well pairs by area, refer to the 2006 and 2007 annual reports (DOE 2007c, 2008c).

As in previous years, there are instances in which the estimated travel times for a given well pair vary widely between the second and fourth quarter. This is related to differences in gradient, as explained above; when water levels are very similar in both members of a well pair, the low gradient results in a slow travel time, and when levels are very different, the gradient is steeper. The well pairs discussed above in terms of gradients illustrate this scenario, as do other well pairs. Wells that may be of more interest due to contaminants in the groundwater monitored by them include well pair 00191–00491. The former well is near the 903 Pad Plume source area, and the latter is on the hillside southeast of the 903 Pad. The second-quarter travel time calculated for this well pair is 3.3 years, while the fourth-quarter travel time is estimated at slightly more than 5 years. (In 2009, both quarters yielded estimated travel times closer to 5 years.) Similarly, well pair 91105–91205 (Oil Burn Pit #2 source area and downgradient well, respectively) varies from slightly under 2 years to over 3.5 years; in 2009, both quarters yielded estimates exceeding 3.5 years. In this case, the second-quarter conditions leading to the estimate of shorter travel time may have been a factor in the increased contaminant concentrations reported at well 91203 in the fourth quarter of 2010. Refer to Section 3.1.5.3 and the text on groundwater plumes for additional discussion of conditions in these areas.

Velocities and travel times were estimated for the Ryan's Pit Plume area, where the source area is monitored by Evaluation well 07391, and the pathway to surface water is monitored by AOC well 10304. The travel times estimated in 2010 (just over 5 years in both second and fourth

quarters) are equivalent to those estimated in 2009 (DOE 2010d). Both of these wells were sampled in 2010. Data from AOC well 10304 did include a second-quarter detection of TCE that was well below the corresponding RFLMA Table 1 value (DOE 2007a), with an estimated (J-qualified) concentration of 0.68 µg/L. This is the second detection of TCE reported for this well, the first being from a sample collected in fourth-quarter 2007. TCE was not detected in the subsequent sample collected from this well in the fourth quarter of 2010. Given the consistent estimates of travel time, this TCE detection does not appear indicative of a change in flow conditions. See Section 3.1.5.3 for additional discussion of the 903 Pad/Ryan's Pit Plume.

Overall, groundwater flow paths and flow velocities in 2010 show little change from previous years.

3.1.3.6 Seeps

Seeps are common at the Rocky Flats Site. Seep distribution and occurrence are strongly controlled by geology and precipitation, and much of the discharge occurs at the contact between the Rocky Flats Alluvium and underlying claystone.

Seep locations posted on the second and fourth quarter CY 2010 potentiometric surface maps are from the 1995 Hydrogeologic Characterization Report (EG&G 1995a). Although this depiction of seeps has been the best available map of the seeps for the Site for several years, it is no longer accurate, having been most strongly affected by the removal of all artificial water sources, as well as land surface reconfiguration (e.g., excavations and placement of fill) in some areas. Thus, efforts to map existing seeps in the COU began in 2010. Although not a rigorous investigation, the project is designed to qualitatively establish the presence of seeps and document their general location.

One observation made during 2010 is that seeps often occur where former building foundations, footer drains, and other features remain that have created preferential pathways for groundwater to reach the surface. This observation supports the design of the monitoring network, which considered the anticipated post-closure groundwater flow directions.

Figure 126 presents the locations where seeps and wet areas were observed during CY 2010. Note that many of the wet areas observed were dry later in the year, including most seeps on the OLF and those identified near the former Building 771 area.

New seeps and wet areas have developed at several locations throughout the COU where wetlands are developing naturally. The *Rocky Flats, Colorado, Site Wetland Mitigation Monitoring and Management Plan* (DOE 2006b) provides guidance for monitoring mitigation wetlands and reporting. The 2010 results are presented in the *Rocky Flats, Colorado, Site, 2010 Annual Wetland Mitigation Monitoring Report* (DOE 2011c).

3.1.4 Surface-Water Data Interpretation and Evaluation

3.1.4.1 Surface Water Quality Summaries

This section presents water quality summaries for selected analytes for the period January 1, 1997, through December 31, 2010 (CY 1997–2010) for the locations operational in

quarters) are equivalent to those estimated in 2009 (DOE 2010d). Both of these wells were sampled in 2010. Data from AOC well 10304 did include a second-quarter detection of TCE that was well below the corresponding RFLMA Table 1 value (DOE 2007a), with an estimated (J-qualified) concentration of 0.68 µg/L. This is the second detection of TCE reported for this well, the first being from a sample collected in fourth-quarter 2007. TCE was not detected in the subsequent sample collected from this well in the fourth quarter of 2010. Given the consistent estimates of travel time, this TCE detection does not appear indicative of a change in flow conditions. See Section 3.1.5.3 for additional discussion of the 903 Pad/Ryan's Pit Plume.

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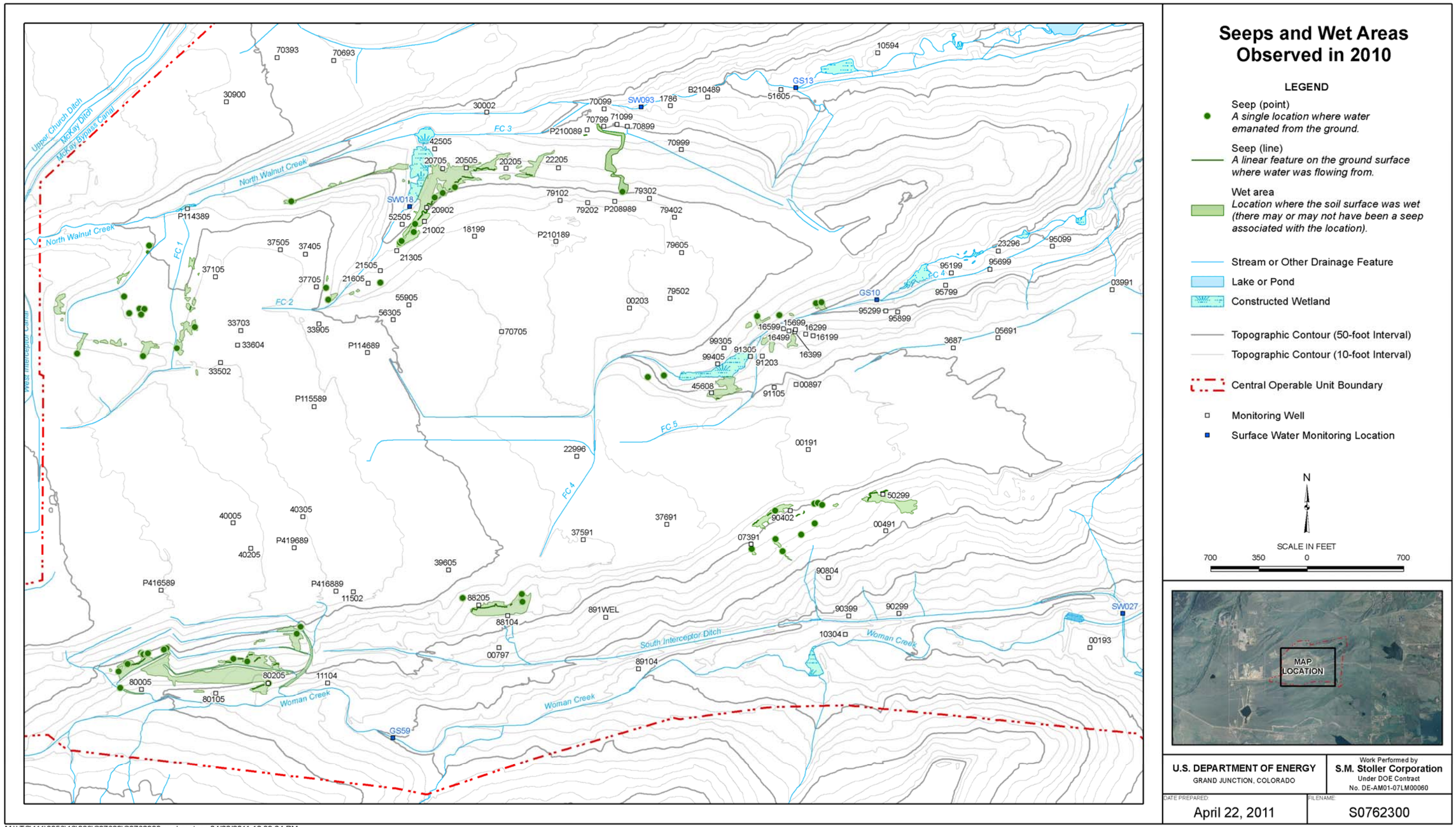

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Figure 126. Seeps and Wet Areas Observed in 2010

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CY 2010. Radionuclides summarized include Pu, Am,[13] and total U. Additionally, the POE metals (total beryllium [Be], dissolved cadmium [Cd], total chromium [Cr], and dissolved silver [Ag]) and nitrate+nitrite as N are also summarized. Additional analyses are also performed based on the specific monitoring objective. The results and evaluation for these additional analytes are presented in Section 3.1.2.1 through Section 3.1.2.11 by monitoring objective.

The summary values in this section should not be confused with the RFLMA required water-quality evaluations according to Attachment 2 in the RFLMA. The Pu, Am, and total U standards noted in this section apply only to POE (GS10, SW027, and SW093; Section 3.1.2.2) and POC (GS01, GS03, GS08, GS11, and GS31; Section 3.1.2.1) 30-day or 12-month rolling averages. Comparisons of standards to other summary statistics are noted in this section for reference only. POEs and POCs are highlighted in **bold** in the tables.

Radionuclides

The following summaries include all results that were not rejected through the validation process.[14] Data are generally presented to decimal places as reported by the laboratories. Accuracy should not be inferred; minimum detectable concentrations, activities, and analytical errors are often greater than the precision presented. When a negative radionuclide result (e.g., −0.002 pCi/L) is reported by the laboratory due to blank correction, a value of 0.0 pCi/L is used for calculation purposes. When a sample has a corresponding field duplicate, the value used in calculations is the arithmetic average of the "real" and "duplicate" values.[15] When a sample has multiple "real" analyses (e.g., Site requested "reruns"), the value used in calculations is the arithmetic average of the multiple "real" analyses.

The Pu/Am ratio is calculated for each sample by dividing the Pu result by the corresponding Am result. Ratios are only calculated for samples where *both* the Pu and Am results are greater than 0.015 pCi/L (generally the minimum detectable activity [MDA] for Pu and Am analyses) to exclude ratios for very low results with high relative error.

Each table includes only those locations where samples were collected that were analyzed for the referenced analyte. Maps are also included showing monitoring locations and the corresponding median values of the referenced parameter. Only locations that had four or more individual results are mapped.

Table 40 and Table 41 show that post-closure median Pu activities for all locations, except GS51, are below 0.15 pCi/L. After closure, significant reductions in 85th percentile and maximum Pu activities are noted, most significantly at COU locations GS10, GS51, and SW093. Figure 127 and Figure 128 show the pre- and post-closure median Pu activities, respectively.

[13] In this report, "plutonium" or "Pu" refers to plutonium-239,240; and "americium" or "Am" refers to americium-241.
[14] Summaries do not include supplemental post-closure grab samples for uranium from GS13 that were collected to assess modifications to the SPPTS; only routine continuous flow-paced samples are included.
[15] Arithmetic averaging of radionuclide pairs is performed only when the DER is less than 1.5. If the DER is greater than or equal to 1.5, the radionuclide results are determined to be nonrepresentative. These results are not used for the calculation of summary statistics. A more thorough discussion of data management is given in Appendix B.1, "Surface-Water Analytical Data Evaluation Methods."

Table 39. Summary Statistics for Pu-239,240 Analytical Results in CY 1997—October 13, 2005

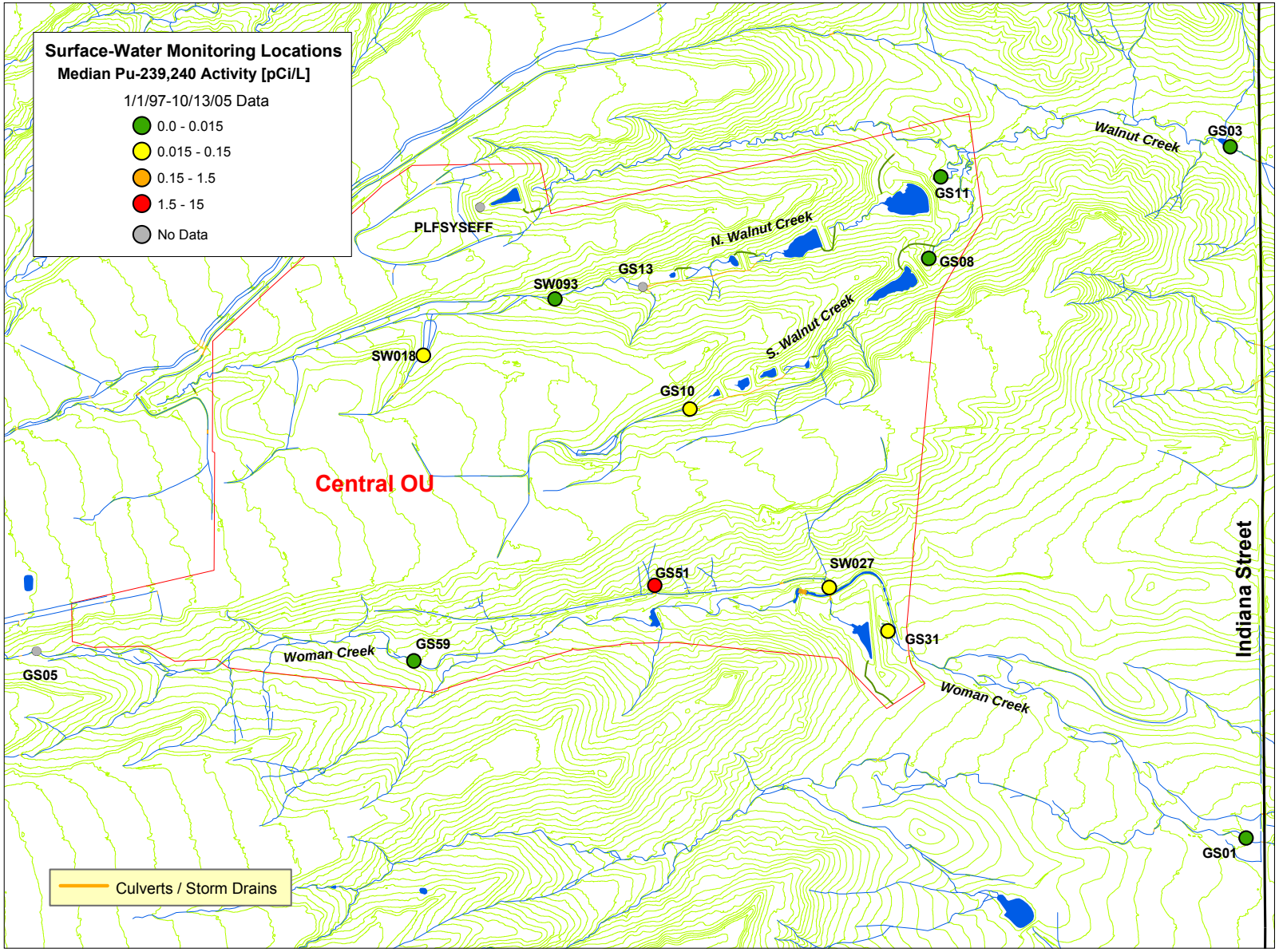
Location	Samples (N)	Median (pCi/L)	85th Percentile (pCi/L)	Maximum (pCi/L)
GS01	**165**	**0.002**	**0.008**	**0.024**
GS03	**257**	**0.005**	**0.016**	**0.220**
GS05	NA	NA	NA	NA
GS08	**118**	**0.004**	**0.013**	**0.864**
GS10	**266**	**0.054**	**0.207**	**2.27**
GS11	**89**	**0.002**	**0.009**	**0.070**
GS13	NA	NA	NA	NA
GS31	**26**	**0.017**	**0.094**	**0.348**
GS51	27	3.97	8.41	99.7
GS59	30	0.000	0.004	0.020
PLFSYSEFF	NA	NA	NA	NA
SW027	**71**	**0.049**	**0.199**	**13.2**
SW093	**284**	**0.010**	**0.063**	**4.18**

Notes: NA = Analyte not sampled; Bold- type = POC or POE

Table 40. Post-Closure Summary Statistics for Pu-239,240 Analytical Results (October 13, 2005−December 31, 2010)

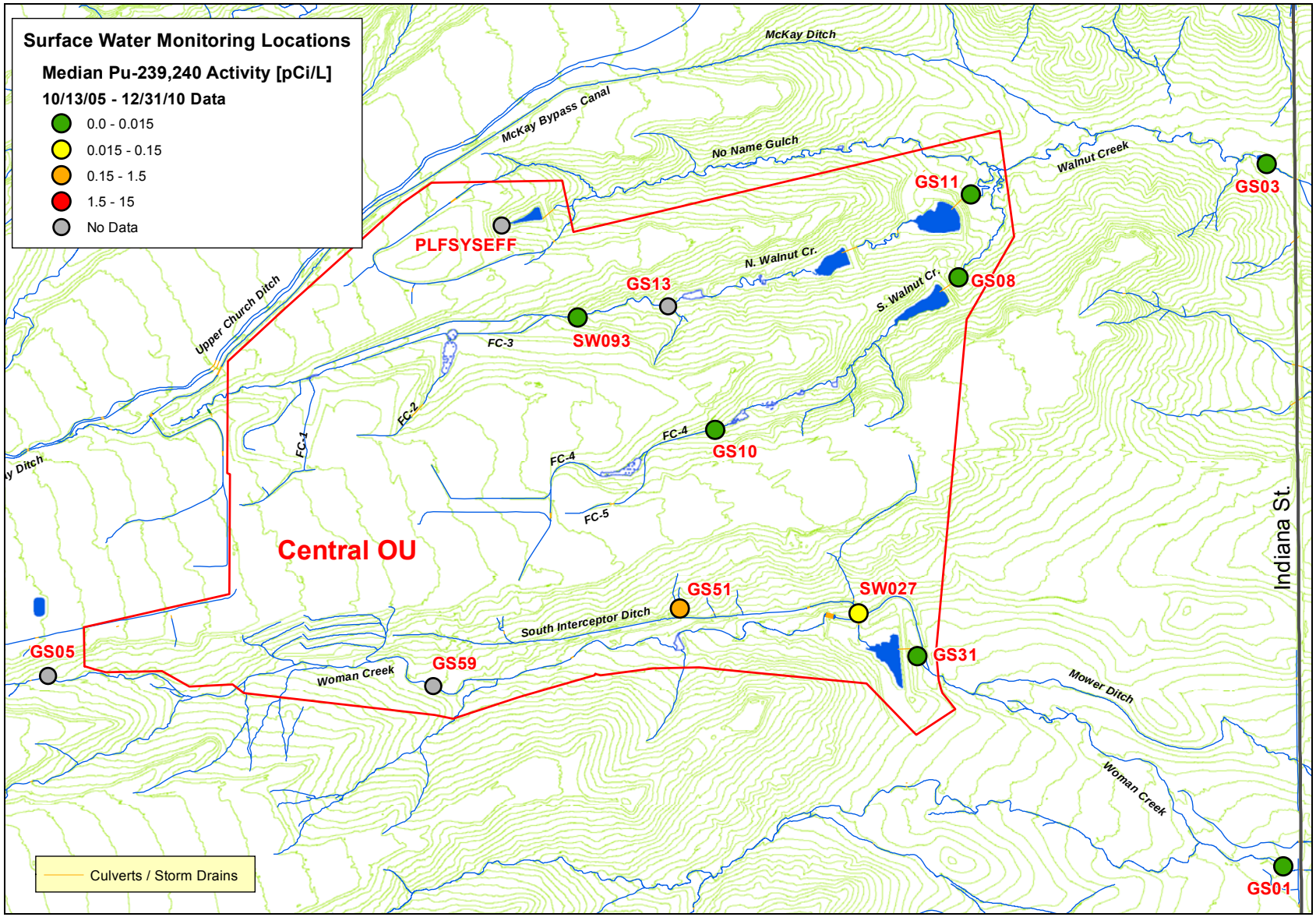
Location	Samples (N)	Median (pCi/L)	85th Percentile (pCi/L)	Maximum (pCi/L)
GS01	**82**	**0.002**	**0.008**	**0.025**
GS03	**58**	**0.003**	**0.007**	**0.036**
GS05	NA	NA	NA	NA
GS08	**26**	**0.003**	**0.008**	**0.017**
GS10	**87**	**0.008**	**0.027**	**0.079**
GS11	**29**	**0.003**	**0.008**	**0.046**
GS13	NA	NA	NA	NA
GS31	**10**	**0.003**	**0.014**	**0.023**
GS51	16	0.922	6.82	13.8
GS59	NA	NA	NA	NA
PLFSYSEFF	NA	NA	NA	NA
SW027	**9**	**0.092**	**0.260**	**0.300**
SW093	**83**	**0.009**	**0.028**	**0.861**

Notes: NA = Analyte not sampled; Bold type = POC or POE



Note: Only locations with four or more results are mapped.

Figure 127. Median Pu-239,240 Activities for CY 1997—October 13, 2005



Note: Only locations with four or more results are mapped.

Figure 128. Post-Closure Median Pu-239,240 Activities

Table 41 and Table 42 show that post-closure median Am activities for all locations, except GS51, are well below 0.15 pCi/L. After closure, significant reductions in 85th percentile and maximum Am activities are noted, most significantly at COU locations GS10, GS51, and SW093. Figure 129 and Figure 130 show median Am activities for pre- and post-closure, respectively.

Table 41. Summary Statistics for Am-241 Analytical Results in CY 1997—October 13, 2005

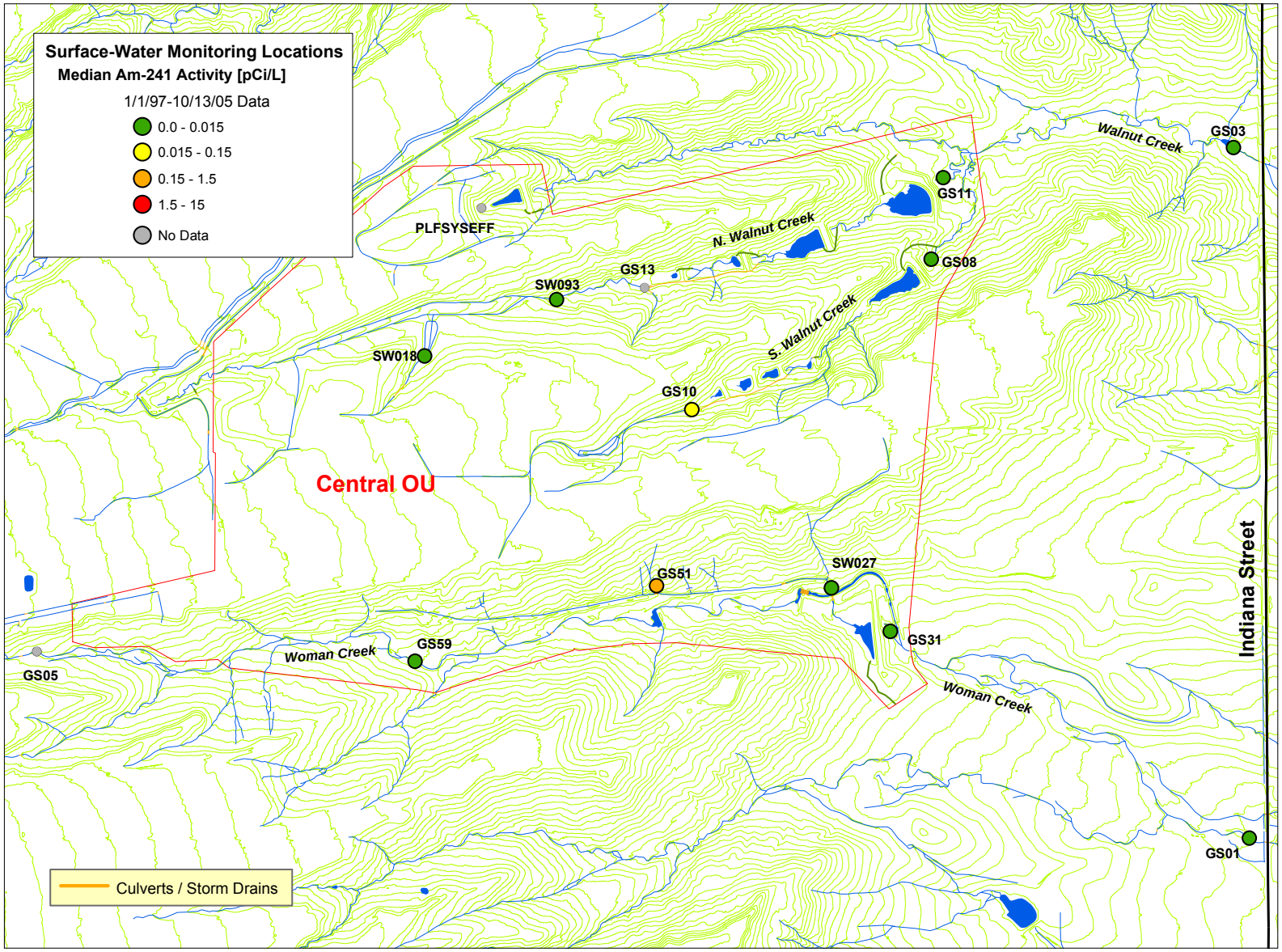
Location	Samples (N)	Median (pCi/L)	85th Percentile (pCi/L)	Maximum (pCi/L)
GS01	**164**	**0.001**	**0.008**	**0.054**
GS03	**258**	**0.006**	**0.018**	**0.066**
GS05	NA	NA	NA	NA
GS08	**118**	**0.006**	**0.015**	**0.275**
GS10	**259**	**0.057**	**0.193**	**8.39**
GS11	**88**	**0.003**	**0.010**	**0.047**
GS13	NA	NA	NA	NA
GS31	**26**	**0.009**	**0.020**	**0.116**
GS51	25	0.807	1.76	3.41
GS59	30	0.001	0.004	0.015
PLFSYSEFF	NA	NA	NA	NA
SW027	**71**	**0.009**	**0.045**	**2.33**
SW093	**279**	**0.012**	**0.052**	**14.1**

Notes: NA = Analyte not sampled
Bold type = POC or POE

Table 42. Post-Closure Summary Statistics for Am-241 Analytical Results (October 13, 2005−December 31, 2010)

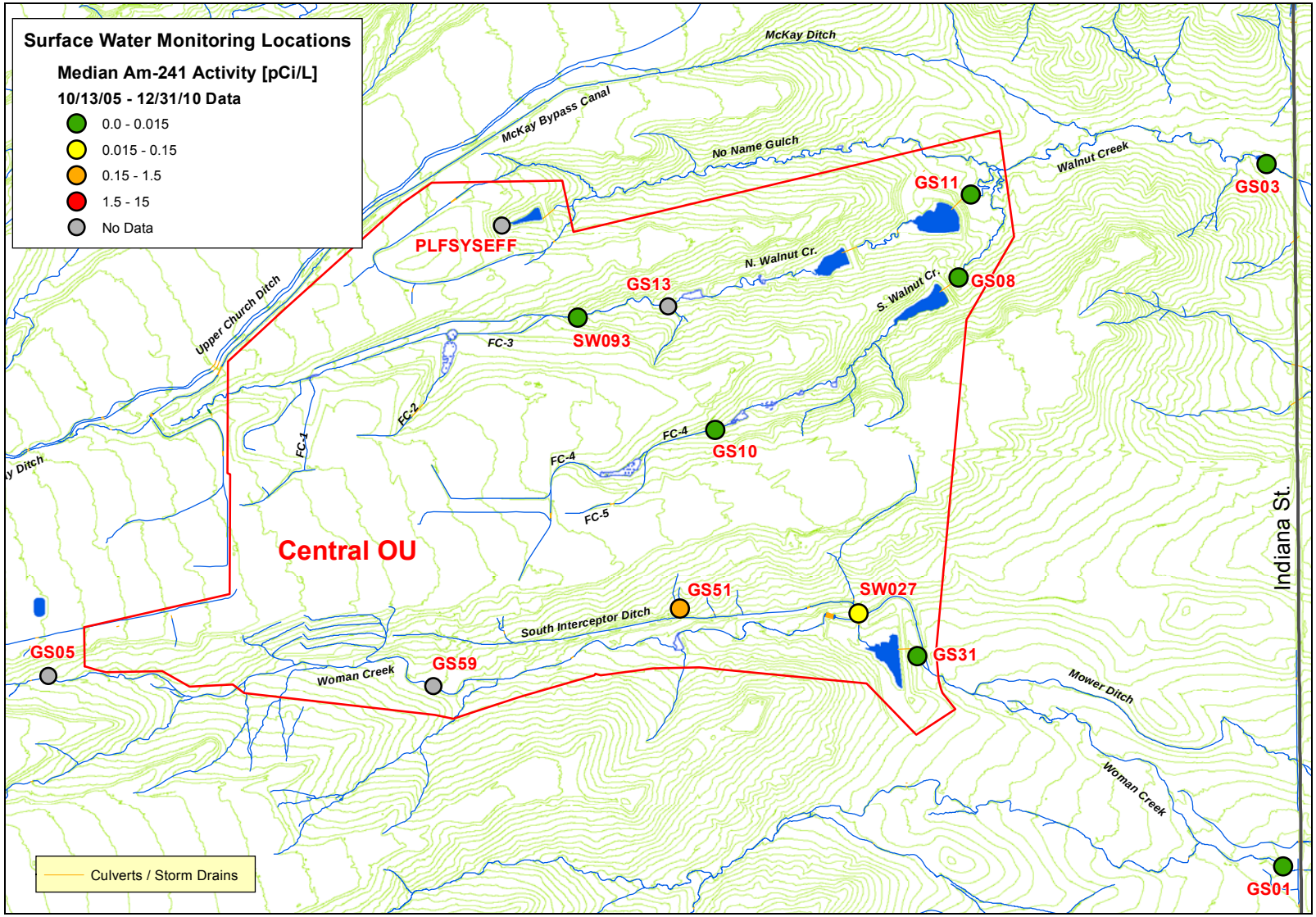
Location	Samples (N)	Median (pCi/L)	85th Percentile (pCi/L)	Maximum (pCi/L)
GS01	**82**	**0.001**	**0.007**	**0.057**
GS03	**58**	**0.002**	**0.007**	**0.027**
GS05	NA	NA	NA	NA
GS08	**26**	**0.001**	**0.009**	**0.012**
GS10	**87**	**0.006**	**0.027**	**0.074**
GS11	**29**	**0.003**	**0.005**	**0.027**
GS13	NA	NA	NA	NA
GS31	**10**	**0.003**	**0.006**	**0.008**
GS51	16	0.198	1.12	3.03
GS59	NA	NA	NA	NA
PLFSYSEFF	NA	NA	NA	NA
SW027	**9**	**0.016**	**0.048**	**0.053**
SW093	**83**	**0.007**	**0.019**	**0.357**

Notes: NA = Analyte not sampled
Bold type = POC or POE



Note: Only locations with four or more results are mapped.

Figure 129. Median Am-241 Activities for CY 1997—October 13, 2005



Note: Only locations with four or more results are mapped.

Figure 130. Post-Closure Median Am-241 Activities

Table 43 and Table 44 show that post-closure median total U concentrations for most locations are below the standard of 16.8 µg/L. Recent data from GS10, GS13, and SW093 show total U levels in excess of 16.8 µg/L. U activities at GS13 are known to be directly affected by groundwater associated with the SPPTS. Recent observations also indicate that SW093 is periodically influenced by surface seepage from the SPPTS hillside area. In addition, the measurements at GS10 and SW093 are influenced by contributions of naturally occurring U in groundwater and hydrologic changes post-closure. These U concentrations can also be seen in samples collected at downstream locations GS11, GS08, and GS03. Figure 131 and Figure 132 show median total U activities for pre- and post-closure, respectively.

Table 43. Summary Statistics for Total U Analytical Results in CY 1997—October 13, 2005

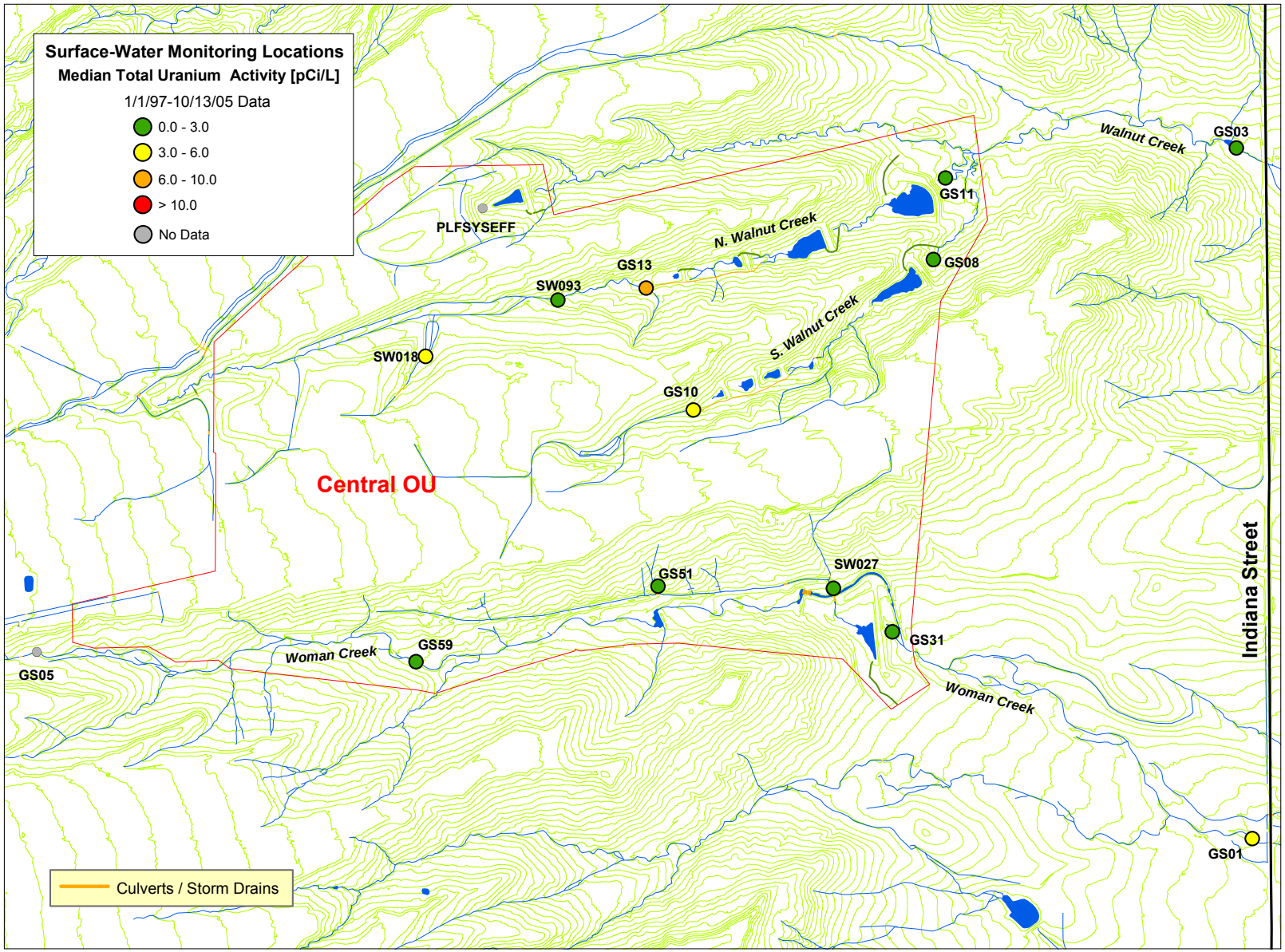
Location	Samples (N)	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
GS01	**53**	**4.29**	**6.51**	**11.9**
GS03	**78**	**2.37**	**4.48**	**7.64**
GS05	NA	NA	NA	NA
GS08	**118**	**1.83**	**3.09**	**9.88**
GS10	**266**	**4.48**	**7.15**	**20.5**
GS11	**89**	**3.00**	**4.29**	**5.62**
GS13	68	11.7	17.2	33.0
GS31	**26**	**3.48**	**4.22**	**6.27**
GS51	26	1.56	2.85	4.08
GS59	31	0.93	1.74	4.66
PLFSYSEFF	NA	NA	NA	NA
SW027	**71**	**2.06**	**4.47**	**8.70**
SW093	**284**	**3.99**	**6.35**	**11.1**

Notes: NA = Analyte not sampled
Bold type = POC or POE

Table 44. Post-Closure Summary Statistics for Total U Analytical Results (October 13, 2005−December 31, 2010)

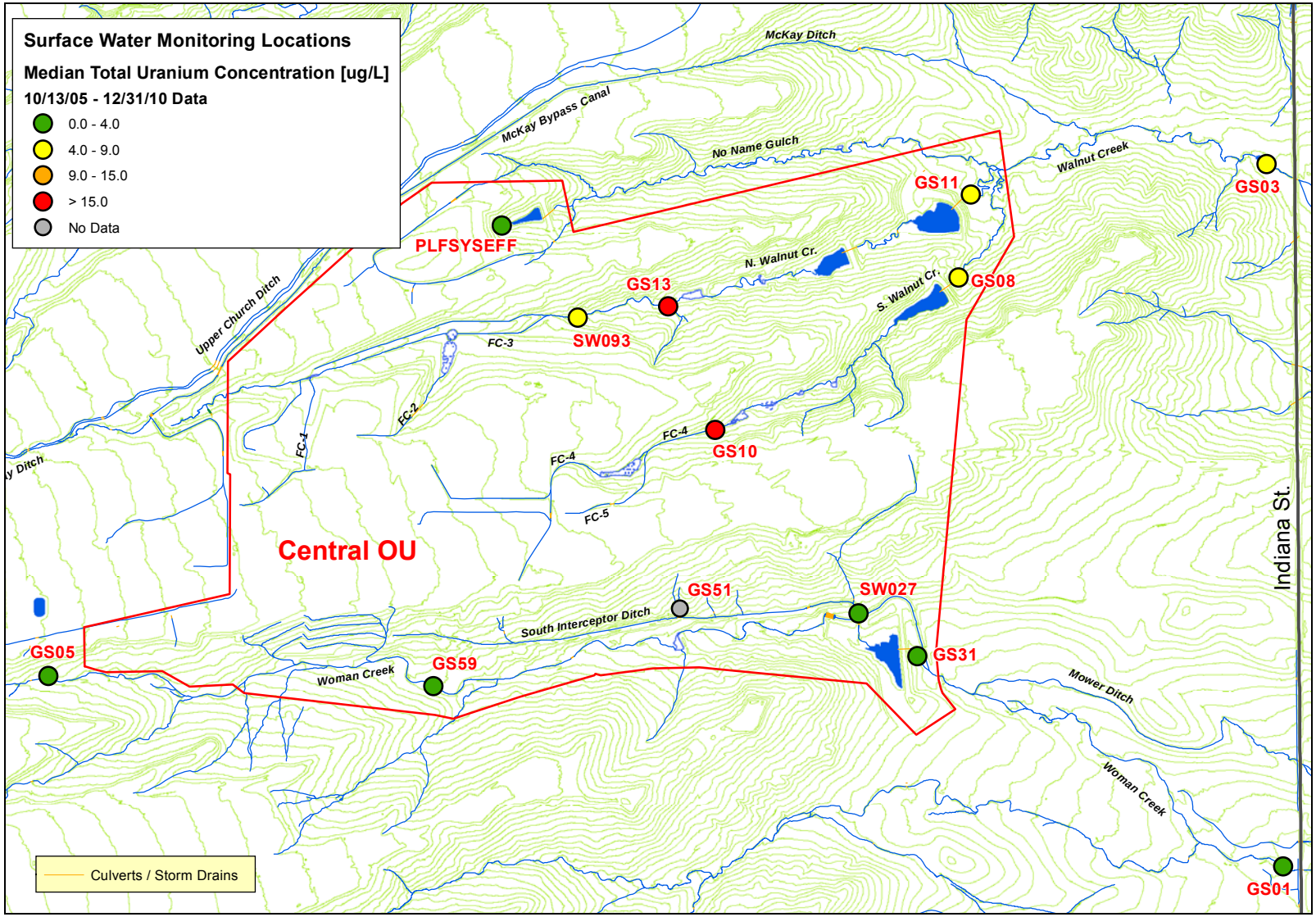
Location	Samples (N)	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
GS01	**82**	**3.69**	**6.54**	**9.09**
GS03	**58**	**5.54**	**8.29**	**10.2**
GS05	41	0.72	1.48	4.67
GS08	**26**	**8.83**	**13.5**	**15.1**
GS10	**87**	**16.5**	**22.8**	**41.9**
GS11	**29**	**6.57**	**10.1**	**11.8**
GS13	69	19.0	43.3	63.6
GS31	**10**	**2.66**	**5.19**	**5.66**
GS51	NA	NA	NA	NA
GS59	40	1.11	2.16	7.01
PLFSYSEFF	21	1.80	6.87	11.8
SW027	**9**	**3.36**	**6.08**	**7.07**
SW093	**83**	**8.11**	**11.9**	**23.4**

Notes: NA = Analyte not sampled
Bold type = POC or POE



Note: Only locations with four or more results are mapped.

Figure 131. Median Total U Activities for CY 1997—October 13, 2005



Note: Only locations with four or more results are mapped.

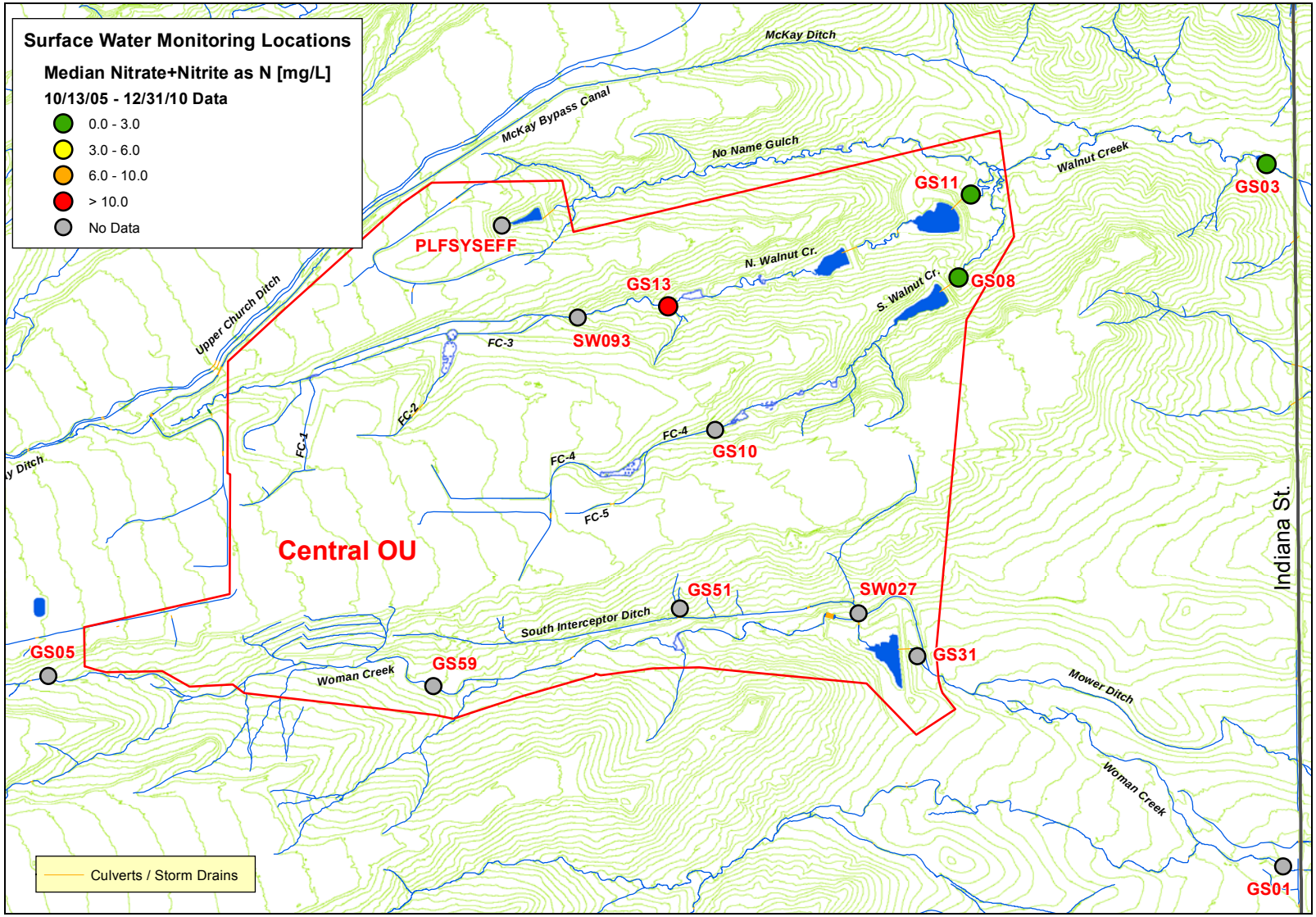
Figure 132. Post-Closure Median Total U Activities

Table 45 and Figure 133 show that post-closure median nitrate concentrations for most locations are below the standard of 10 mg/L. Location GS13 clearly shows the effects of groundwater associated with the SPPTS.

Table 45. Post-Closure Summary Statistics for Nitrate+Nitrite as Nitrogen Analytical Results (October 13, 2005−December 31, 2010)

Location	Samples (N)	Median (mg/L)	85th Percentile (mg/L)	Maximum (mg/L)
GS03	**36**	**0.30**	**3.59**	**6.55**
GS08	**26**	**0.11**	**0.34**	**0.73**
GS11	**29**	**1.62**	**5.95**	**8.20**
GS13	51	28.0	71.0	100

Notes: Bold type = POC or POE



Note: Only locations with four or more results are mapped.

Figure 133. Post-Closure Median Nitrate+Nitrite as Nitrogen Concentrations

Table 46 and Table 47 list the average Pu/Am activity ratios for locations where samples are analyzed for Pu and Am. A ratio greater than one indicates Pu activity in excess of Am activity. Conversely, a ratio less than one indicates Am activity in excess of Pu activity. Generally, Pu activities are greater than Am activities in surface water at the Site. Post-closure data show patterns similar to those of pre-closure data. Figure 134 and Figure 135 present pre- and post-closure average Am/Pu ratios, respectively.

Table 46. Average Pu/Am Ratios for Analytical Results in CY 1997—October 13, 2005

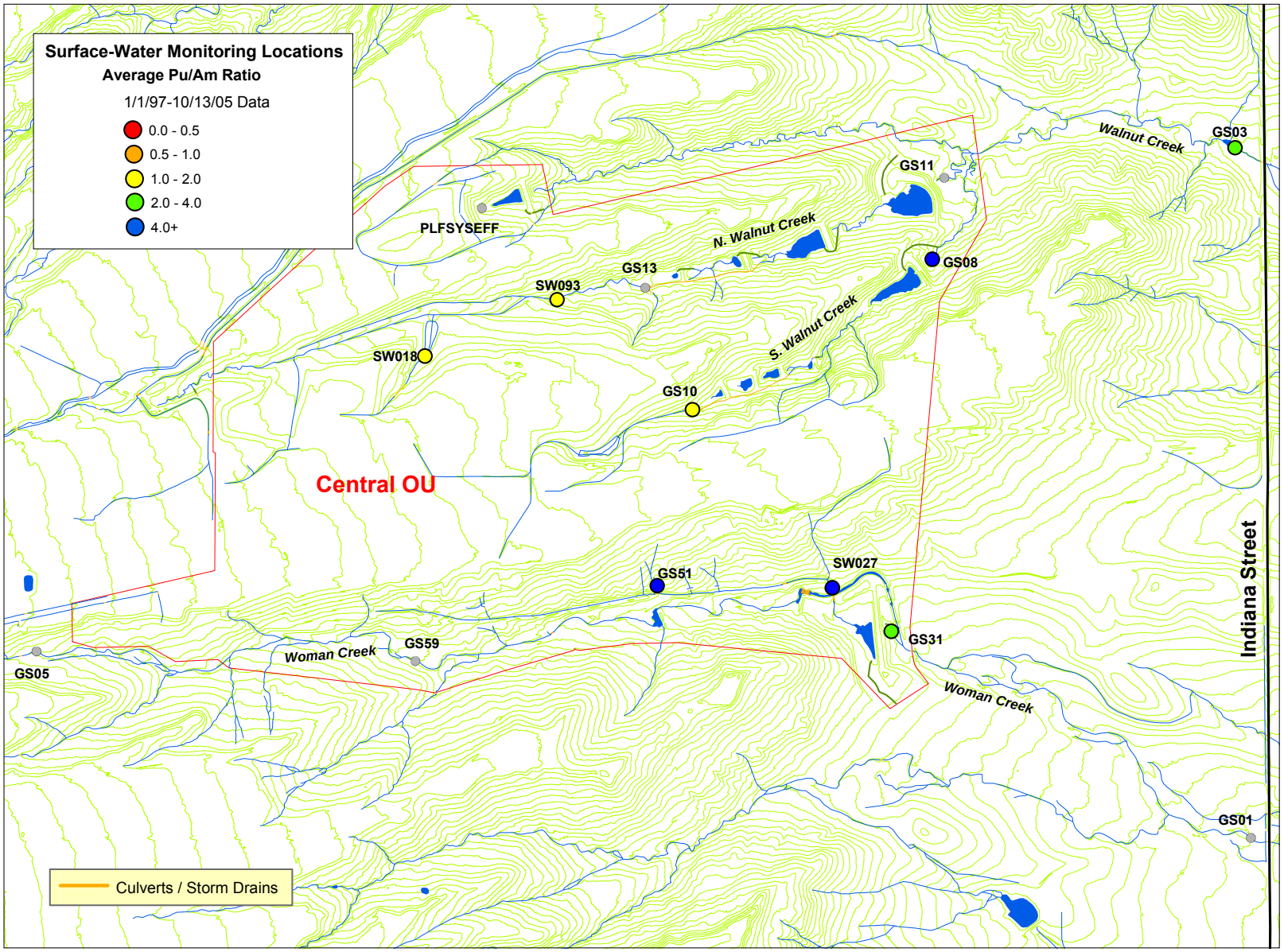
Location	Samples (N)[a]	Average Pu/Am Ratio
GS01	**1**	**1.5**
GS03	**14**	**2.1**
GS05	NA	NA
GS08	**5**	**8.9**
GS10	**196**	**1.3**
GS11	*	*
GS13	NA	NA
GS31	**4**	**3.9**
GS51	24	4.6
GS59	*	*
PLFSYSEFF	NA	NA
SW027	**26**	**4.9**
SW093	**95**	**1.8**

[a] Number of samples in which both Pu and Am activities were greater than 0.015 pCi/L
* No results greater than 0.015 pCi/L
Bold type = POC or POE
NA = Analyte not sampled

Table 47. Post-Closure Average Pu/Am Ratios for Analytical Results (October 13, 2005−December 31, 2010)

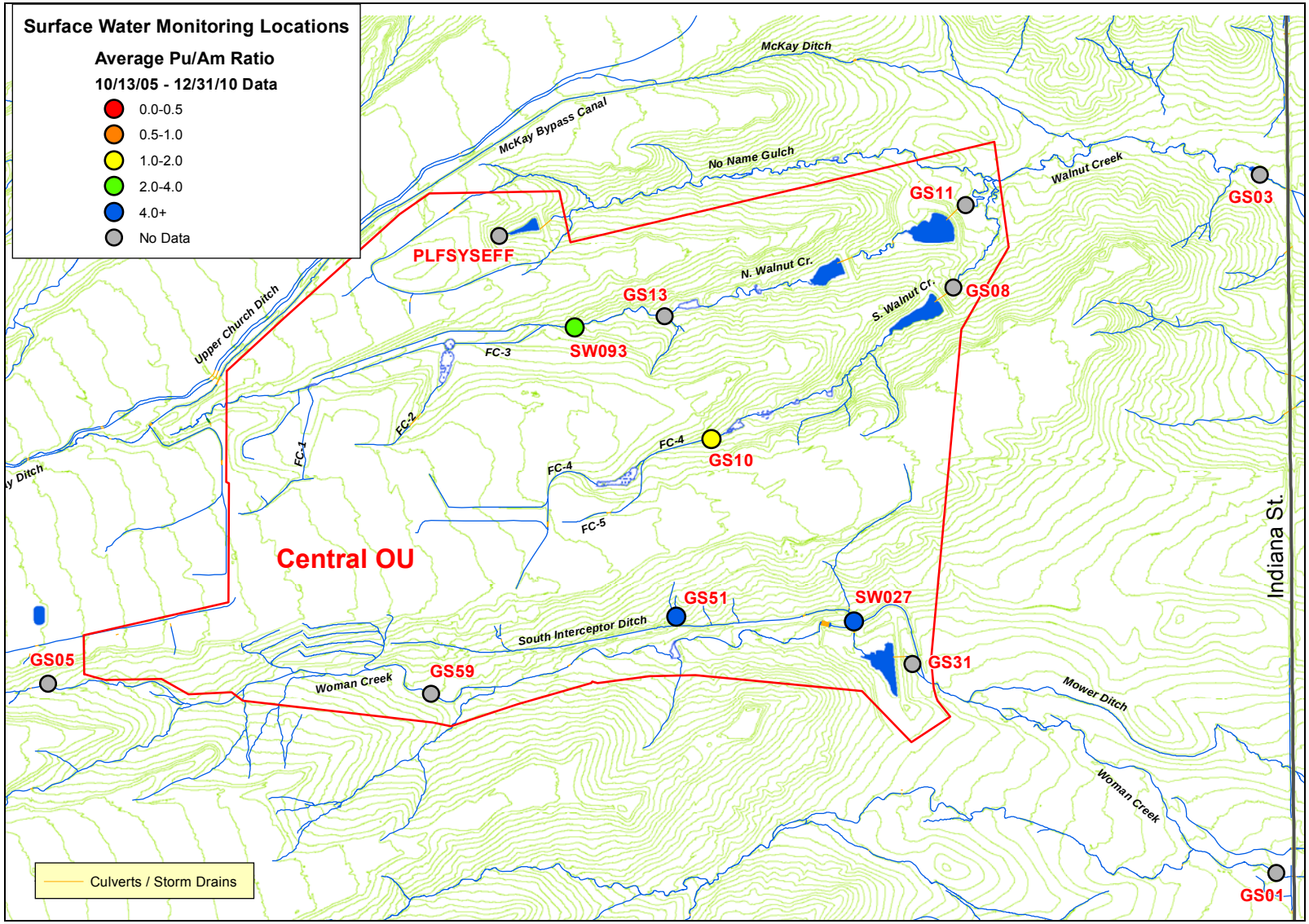
Location	Samples (N)[a]	Average Pu/Am Ratio
GS01	*	*
GS03	*	*
GS05	NA	NA
GS08	*	*
GS10	**17**	**1.2**
GS11	*	*
GS13	NA	NA
GS31	*	*
GS51	16	5.5
GS59	NA	NA
PLFSYSEFF	NA	NA
SW027	**5**	**5.2**
SW093	**12**	**2.1**

[a] Number of samples in which both Pu and Am activities were greater than 0.015 pCi/L
* No results greater than 0.015 pCi/L
Bold type = POC or POE
NA = Analyte not sampled



Note: Only locations with four or more results are mapped.

Figure 134. Average Pu/Am Ratios for CY 1997—October 13, 2005



Note: Only locations with four or more results are mapped.

Figure 135. Post-Closure Average Pu/Am Ratios

POE Metals

The following summaries include all results that were not rejected through the validation process. Data are generally presented to decimal places as reported by the laboratories. Accuracy should not be inferred; minimum detectable concentrations and analytical errors are often greater than the precision presented. When a nondetect is returned from the laboratory for metals analyses, one-half the detection limit is used for calculations. When a sample has a corresponding field duplicate, the value used in calculations is the arithmetic average of the "real" value and the "duplicate."[16] When a sample has multiple "real" analyses (Site-requested "reruns"), the value used in calculations is the arithmetic average of the multiple "real" analyses.

Table 48, Table 49, Table 50, Table 51, Table 52, and Table 53 present summary statistics for the POE metals. All three POEs generally show reduced metals concentrations post-closure.

Table 48. Summary Statistics for POE Metals Results from GS10 in CY 1997—October 13, 2005

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	263	32.3%	0.12	0.63	3.40
Dissolved Cd	259	59.1%	0.05	0.15	1.00
Total Cr	264	13.3%	2.40	9.72	80.10
Dissolved Ag	258	88.8%	0.11	0.18	1.10

Table 49. Post-Closure Summary Statistics for POE Metals Results from GS10 (October 13, 2005−December 31, 2010)

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	87	100.0%	0.50	0.50	0.50
Dissolved Cd	87	92.0%	0.06	0.06	0.34
Total Cr	87	78.2%	0.50	1.36	7.10
Dissolved Ag	87	98.9%	0.10	0.10	0.20

Table 50. Summary Statistics for POE Metals Results from SW027 in CY 1997—October 13, 2005

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	70	45.7%	0.09	0.41	1.30
Dissolved Cd	70	68.6%	0.05	0.13	0.70
Total Cr	70	8.6%	1.70	4.03	31.2
Dissolved Ag	68	85.3%	0.12	0.24	0.72

[16] Arithmetic averaging of metal pairs is performed only when the RPD is less than 100 percent. If the RPD is greater than or equal to 100 percent, the metal results are determined to be nonrepresentative. The results are then not used for the calculation of summary statistics.

Table 51. Post-Closure Summary Statistics for POE Metals Results from SW027 (October 13, 2005−December 31, 2010)

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	9	100.0%	0.50	0.50	0.50
Dissolved Cd	8	100.0%	0.06	0.06	0.06
Total Cr	9	55.6%	1.00	1.77	2.15
Dissolved Ag	8	100.0%	0.10	0.10	0.10

Notes: NA = not applicable

Table 52. Summary Statistics for POE Metals Results from SW093 in CY 1997—October 13, 2005

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	284	35.2%	0.11	0.55	2.10
Dissolved Cd	284	68.7%	0.05	0.14	2.20
Total Cr	283	16.3%	2.00	7.40	34.90
Dissolved Ag	280	89.6%	0.10	0.18	1.03

Table 53. Post-Closure Summary Statistics for POE Metals Results from SW093 (October 13, 2005−December 31, 2010)

Analyte	Samples (N)	Nondetect	Median (µg/L)	85th Percentile (µg/L)	Maximum (µg/L)
Total Be	83	100.0%	0.50	0.50	0.50
Dissolved Cd	83	91.6%	0.06	0.06	0.24
Total Cr	83	60.2%	1.00	1.90	25.7
Dissolved Ag	83	100.0%	0.10	0.10	0.10

3.1.4.2 Surface-Water Loading Analysis

This section provides a summary of radionuclide loads (Am, Pu, and total U) for RFLMA POEs and POCs.[17] These locations collect continuous flow-paced composite samples for laboratory analysis. The nature of the continuous sampling during all flow conditions allows for more accurate load estimations compared to storm-event or grab sampling.

This loading analysis should not be confused with demonstration of compliance at POCs and POEs. Compliance is demonstrated based on water activity or concentration (in pCi/L or µg/L, respectively) in comparison to applicable surface-water standards (see Section 3.1.2.1 and Section 3.1.2.2). This loading analysis is presented to show changes in the transport of Pu, Am, and U following Site closure. These changes in load, in conjunction with the successful demonstration of compliance, can be used to support conclusions regarding the success and continued performance of the remedy.

[17] This 2010 report includes slight revisions to the previously reported 2009 loads.

To calculate load, the activity for each composite sample (pCi/L) is multiplied by the corresponding stream discharge (liters [L]) during the composite sample period, to yield the load (pCi). The total pCi value is then converted to micrograms (µg) using the conversion factors in Table 54.[18] A detailed description of the method for load estimation is given in Appendix B.[19]

Table 54. Activity to Mass Conversion Factors for Pu, Am, and U Isotopes

Analyte	Mass/Activity (g/Ci)
Pu-239,240	14.085
Am-241	0.292
U-233,234	1.6 E+02
U-235	4.63 E+05
U-238	2.98 E+06

Note: Starting on 4/1/09, uranium was analyzed as total uranium in µg/L.

The Pu-239,240 conversion factor was derived from Table 2.7.2-2 in the April 1980 *Final Environmental Impact Statement (Final Statement to ERDA 1545-D)*, Rocky Flats Plant Site. The conversion factors for Am-241, U-233,234, U-235, and U-238 were taken from Title 40 *Code of Federal Regulations* Part 302.4 (40 CFR 302.4), Appendix B, October 7, 2000.[20]

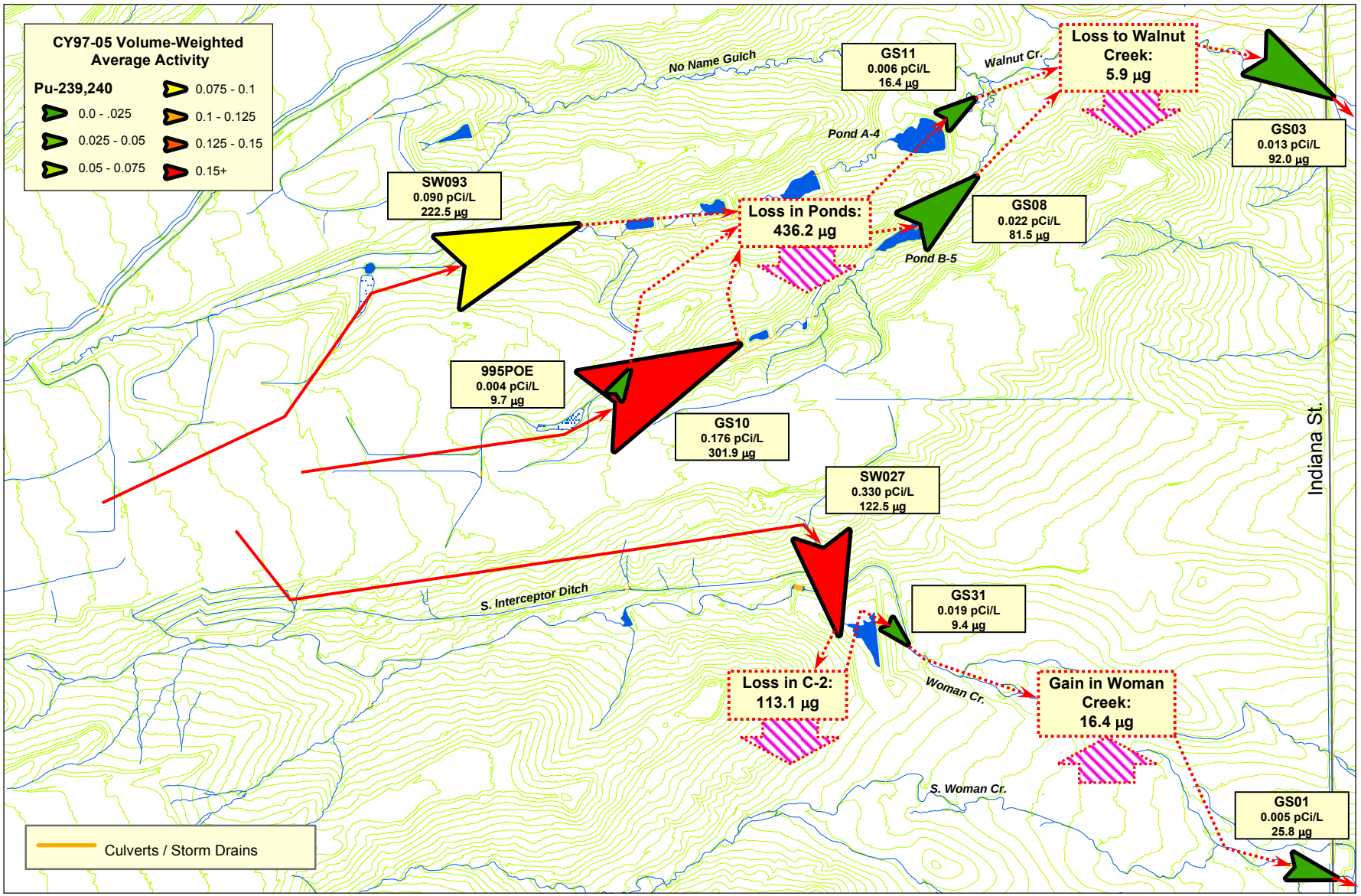
Site and Refuge Area

This section summarizes the calculated overall Pu and Am loads for selected locations. Total U data collection began at GS01 and GS03 just prior to CY 2003; therefore, only CY 2003−2010 data are shown. The following points are noted:

- Figure 136, Figure 137, Figure 138, and Figure 139 show a significant reduction in average annual Pu and Am load and activity from the COU, the terminal ponds, and Walnut Creek at Indiana Street post-closure. The load reductions are between 80 percent and 98 percent for all Walnut Creek locations affected directly by the former IA. Similarly, activity has been reduced between 23 percent and nearly 100 percent. For lower Woman Creek (GS01), however, loads are not reduced. This is likely due to transport of diffuse, low-level contamination in the much larger flow volumes measured at GS01, especially during CY 2007 and CY 2010; GS01 is not significantly affected by the former IA. GS01 post-closure volume-weighted average Pu and Am activities of 0.008 and 0.004 pCi/L, respectively, are significantly below the standard of 0.15 pCi/L and within the analytical measurement error for each analyte.
- For both Pu and Am, remedial actions, removal of impervious surfaces (reducing runoff), revegetation, and erosion control efforts have significantly improved water quality.
- Figure 140 and Figure 141 show a measurable increase in average annual total U concentration in Walnut Creek post-closure (15 percent–170 percent increase). This increase is likely due to the reduction of runoff in streamflow and the corresponding proportional increase of groundwater seepage with relatively high concentrations of naturally occurring U. Conversely, the reduction in overall stream flows has actually resulted in decreased total

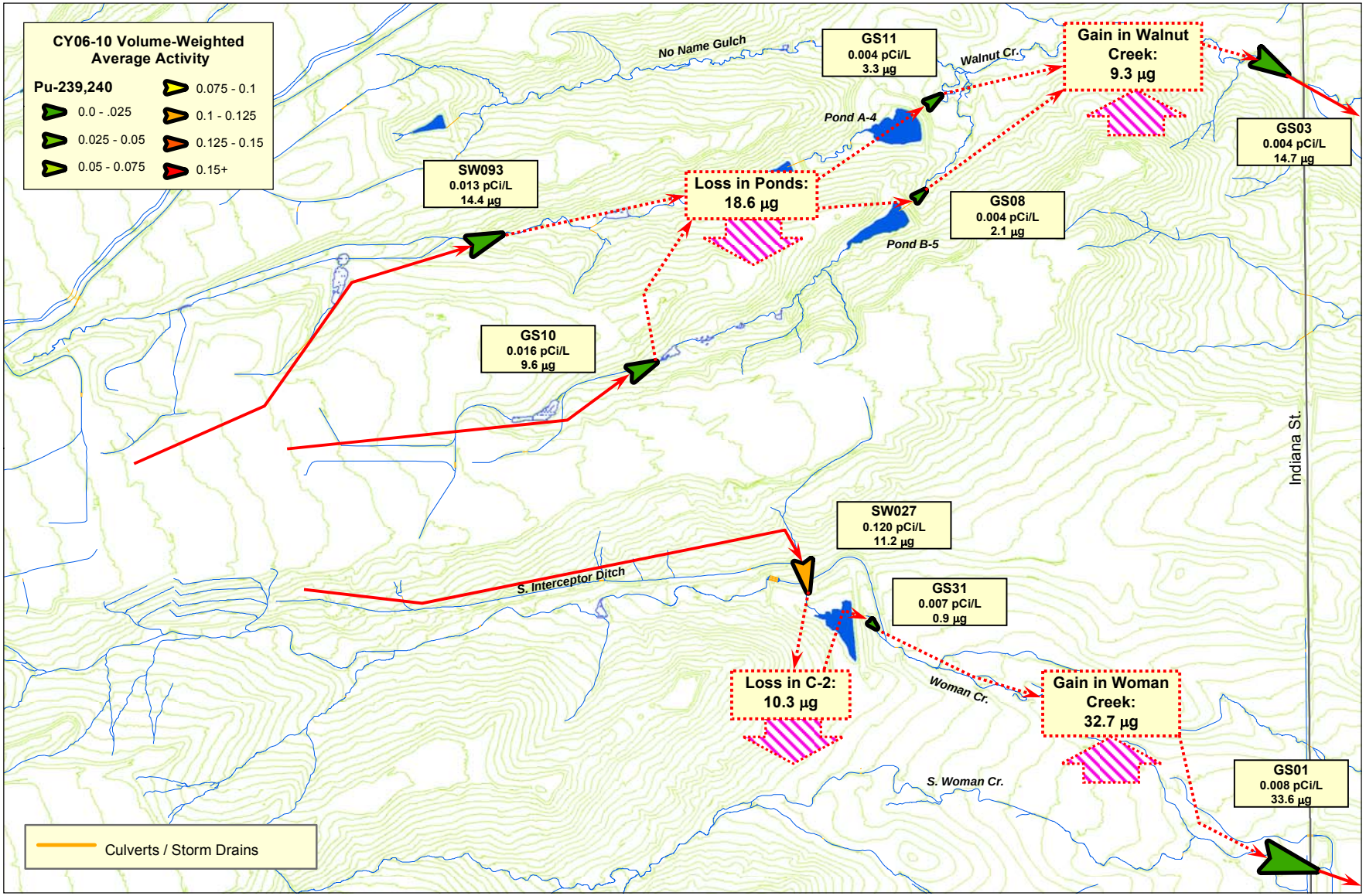
[18] In the following tables and plots, values are rounded for presentation.
[19] Data are generally presented at varying precision for presentation. Accuracy should not be inferred; both analytical and flow measurement error have not been quantified in this report.
[20] The U-234 conversion factor was used to represent U-233,234 due to the small relative abundance of U-233.

U loads (10 percent–72 percent reduction) in Walnut Creek at all locations except GS10 (8 percent increase). For lower Woman Creek (GS01), loads and concentrations have changed to a lesser extent (20 percent and 19 percent increase, respectively). This is likely due to transport of naturally occurring U in the much larger flow volumes measured at GS01, a location not significantly affected by the former IA.



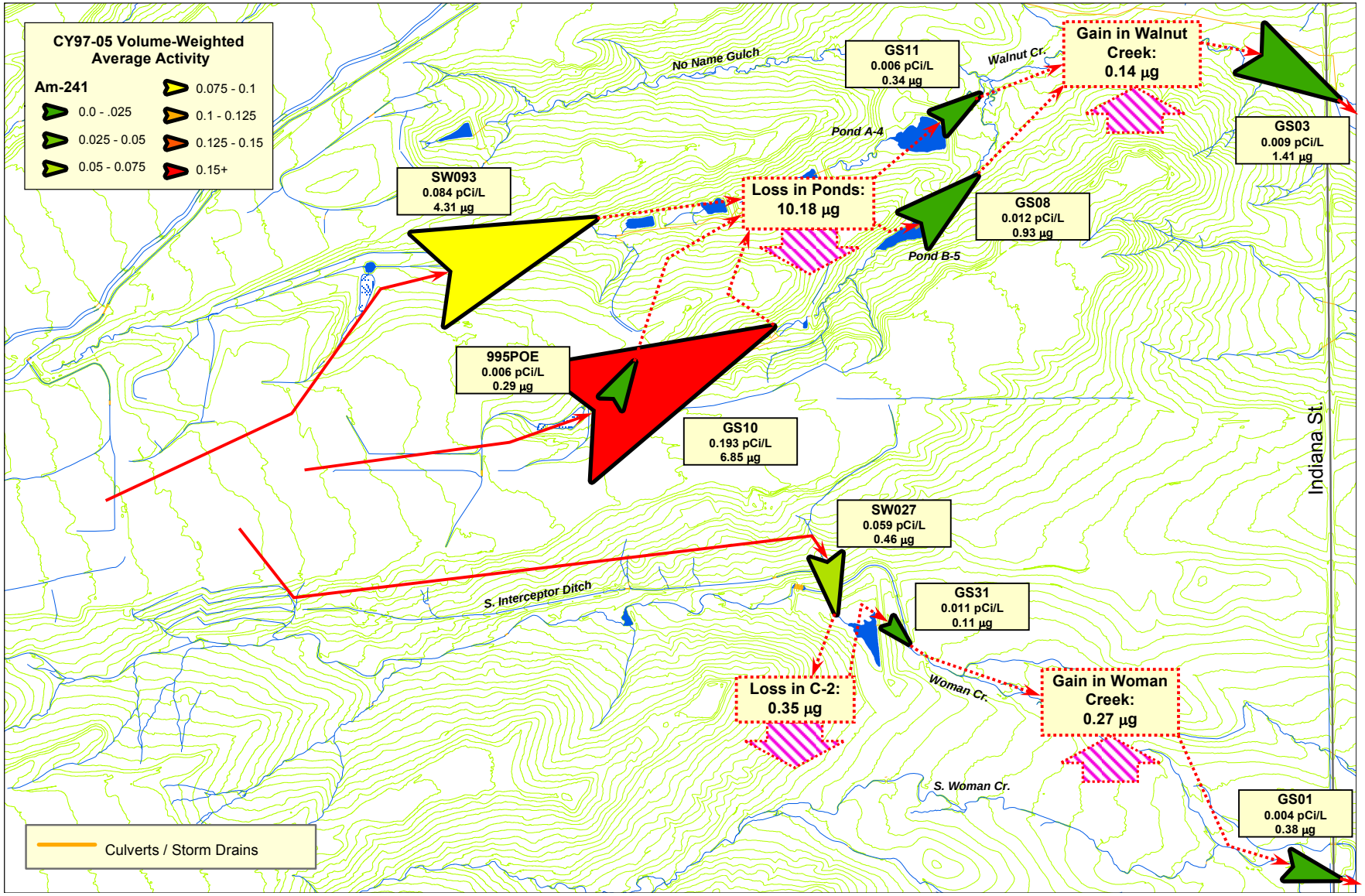
Note: Location symbols are displayed proportional to calculated average annual load and colored according to activity ranges in legend.

Figure 136. Relative Average Annual Pu Loading Schematic: CY 1997−2005



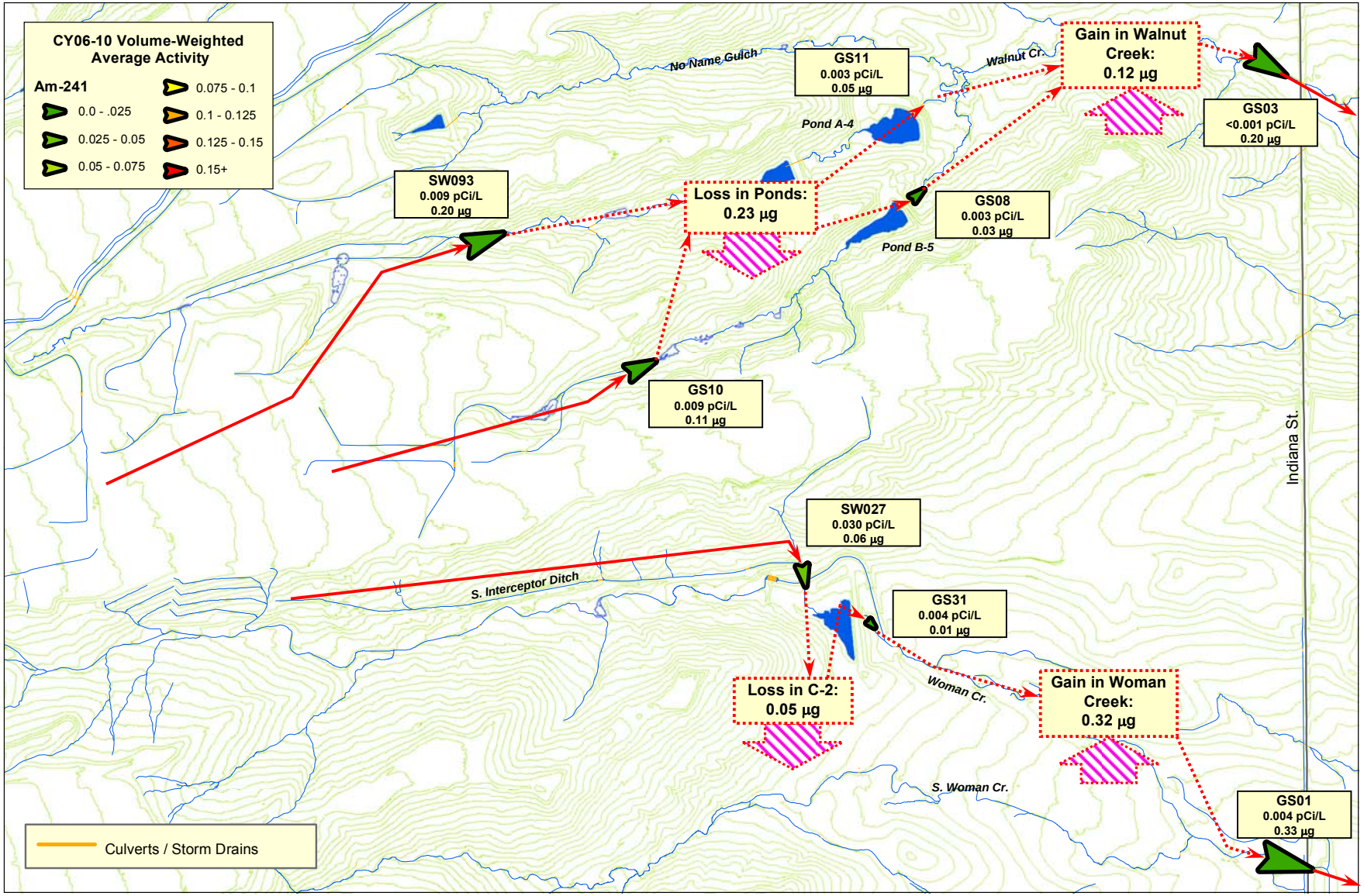
Note: Location symbols are displayed proportional to calculated average annual load and colored according to activity ranges in legend.

Figure 137. Relative Average Annual Pu Loading Schematic: CY 2006−2010



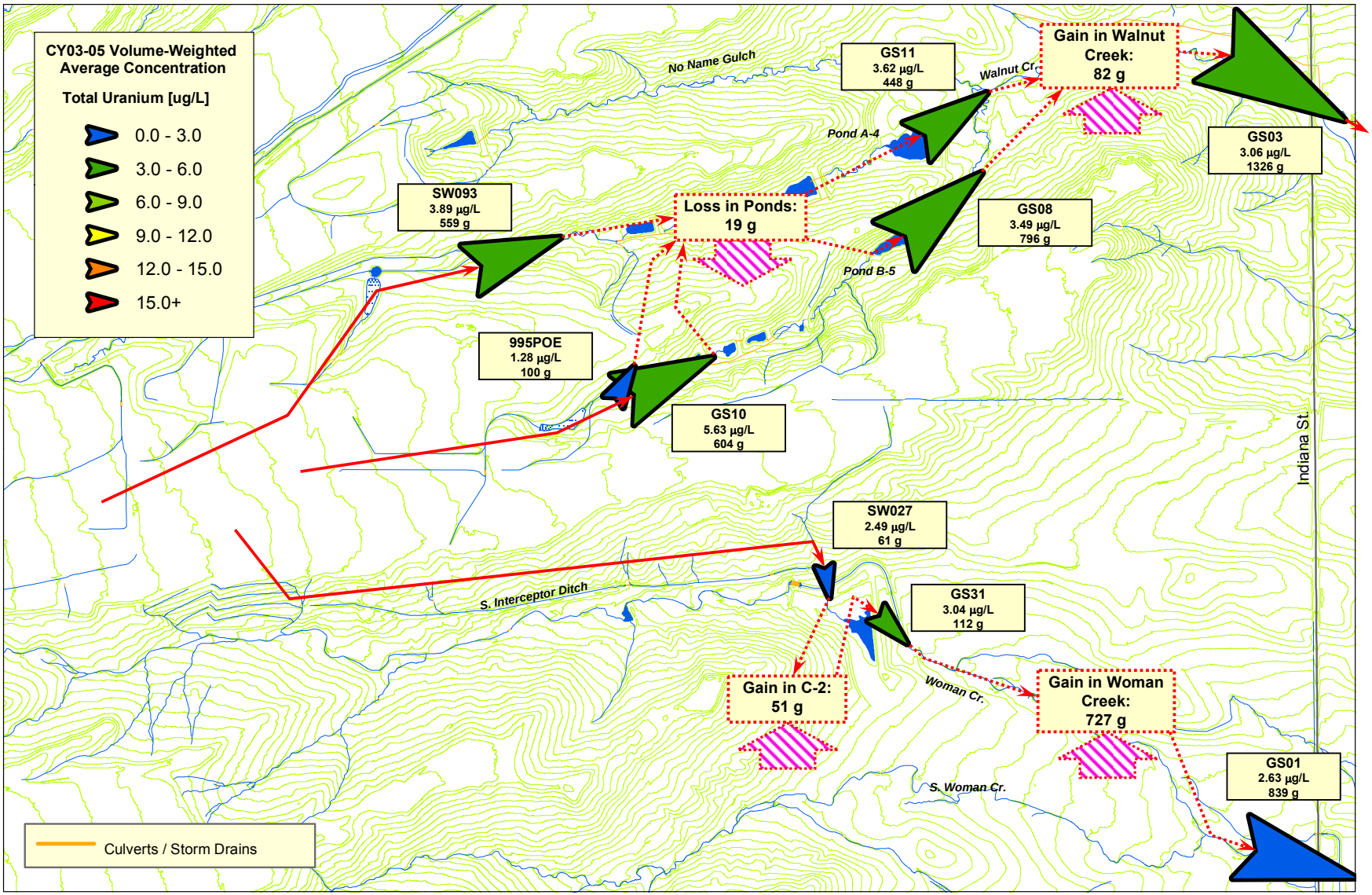
Note: Location symbols are displayed proportional to calculated average annual load and colored according to activity ranges in legend.

Figure 138. Relative Average Annual Am Loading Schematic: CY 1997−2005



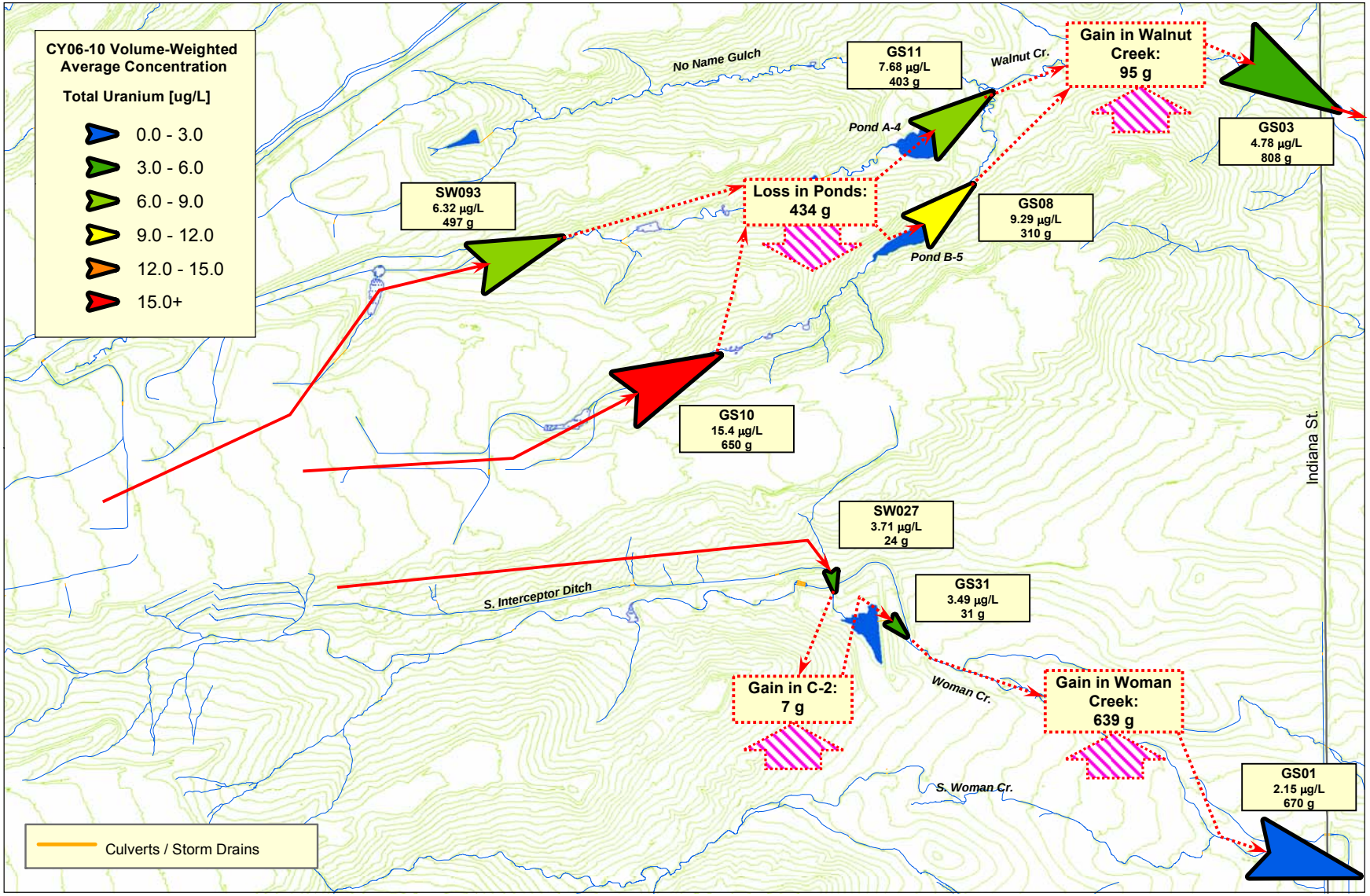
Note: Location symbols are displayed proportional to calculated average annual load and colored according to activity ranges in legend.

Figure 139. Relative Average Annual Am Loading Schematic: CY 2006−2010



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 140. Relative Average Annual Total U Loading Schematic: CY 2003−2005



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 141. Relative Average Annual Total U Loading Schematic: CY 2006−2010

Indiana Street POCs

This section summarizes the calculated Pu and Am loads from Walnut and Woman Creeks at Indiana Street. Figure 142, Figure 143, Figure 144, Figure 145, Figure 146, Figure 147, and Figure 148, as well as Table 55 and Table 56 present the load data. The following points are noted:

- Walnut Creek accounts for nearly 80 percent of both the Pu (Figure 144) and Am (Figure 146) loads at Indiana Street pre-closure. However, post-closure these proportions are essentially reversed as a result of the reduction in runoff and transport due to the effectiveness of remedial actions, revegetation, and erosion control measures.
- Both Pu and Am loads have decreased in recent years as Site closure activities have reduced discharge volumes, reduced sediment transport, and eliminated source terms (Figure 142).
- Figure 143 and Figure 145 show a significant post-closure reduction in both Pu and Am loads in Walnut Creek at Indiana Street (84 percent and 86 percent, respectively).
- The somewhat higher CY 2007 and CY 2010 Pu and Am loads in Woman Creek at Indiana Street (Figure 143 and Figure 145) can be attributed to high flow volumes at GS01.[21] Post-closure average annual volume-weighted Pu and Am activities at GS01 are 0.008 and 0.004 pCi/L, respectively; these activities are within the analytical measurement error range.
- Walnut Creek accounts for 61 percent of the pre-closure and 55 percent of the post-closure U loads at Indiana Street (Figure 148). Although U concentration has increased in Walnut Creek post-closure, reduced flow volumes have resulted in decreased average annual loads comparable to pre-closure loads.

[21] Measured flow volumes at GS01 in CY 2007 were the highest recorded to date. These volumes are attributed to a combination of large snow events and extensive flood irrigation from Rocky Flats Lake. Volumes in CY 2010 were also well above average due to a large storm event in April 2010.

Table 55. Off-Site Pu and Am Loads from Walnut and Woman Creeks: CY 1997–2010

Calendar Year	Pu-239,240 (µg)			Am-241 (µg)		
	Walnut Creek	Woman Creek	Total	Walnut Creek	Woman Creek	Total
1997	262.4	47.9	310.3	2.99	0.40	3.39
1998	172.2	55.4	227.6	2.66	0.99	3.65
1999	150.2	56.7	206.9	1.83	0.75	2.57
2000	26.0	6.1	32.1	0.74	0.18	0.92
2001	58.6	22.4	81.0	0.63	0.30	0.93
2002	37.4	0.8	38.2	0.37	0.03	0.40
2003	57.6	25.9	83.5	1.07	0.34	1.41
2004	33.1	4.7	37.8	0.70	0.15	0.86
2005	30.3	12.5	42.8	1.67	0.30	1.97
2006	0.0; No Flow	1.4	1.4	0.00; No Flow	0.13	0.13
2007	17.2	68.0	85.1	0.12	0.49	0.60
2008	0.0; No Flow	1.1	1.1	0.00; No Flow	0.02	0.02
2009	9.5	26.7	36.2	0.16	0.23	0.39
2010	46.9	70.6	117.5	0.71	0.78	1.49
Total	901.3	400.2	1,301.4	13.66	5.07	18.73

Note: During CY 1997, flows from Woman Creek were routinely diverted to Mower Ditch for subsequent monitoring at GS02. Therefore, the load calculated for Woman Creek at Indiana Street (GS01) includes the water that was measured at GS02. The estimated load diverted to GS02 is calculated by multiplying the CY 1997 volume-weighted activities at GS01 by the streamflow volume measured at GS02, and converting for units. This diverted load is then added to the calculated load at GS01 to obtain the total CY 1997 load at GS01. For subsequent water years, the Mower diversion structure has been upgraded and configured to prevent Woman Creek flows from entering the Mower Ditch.

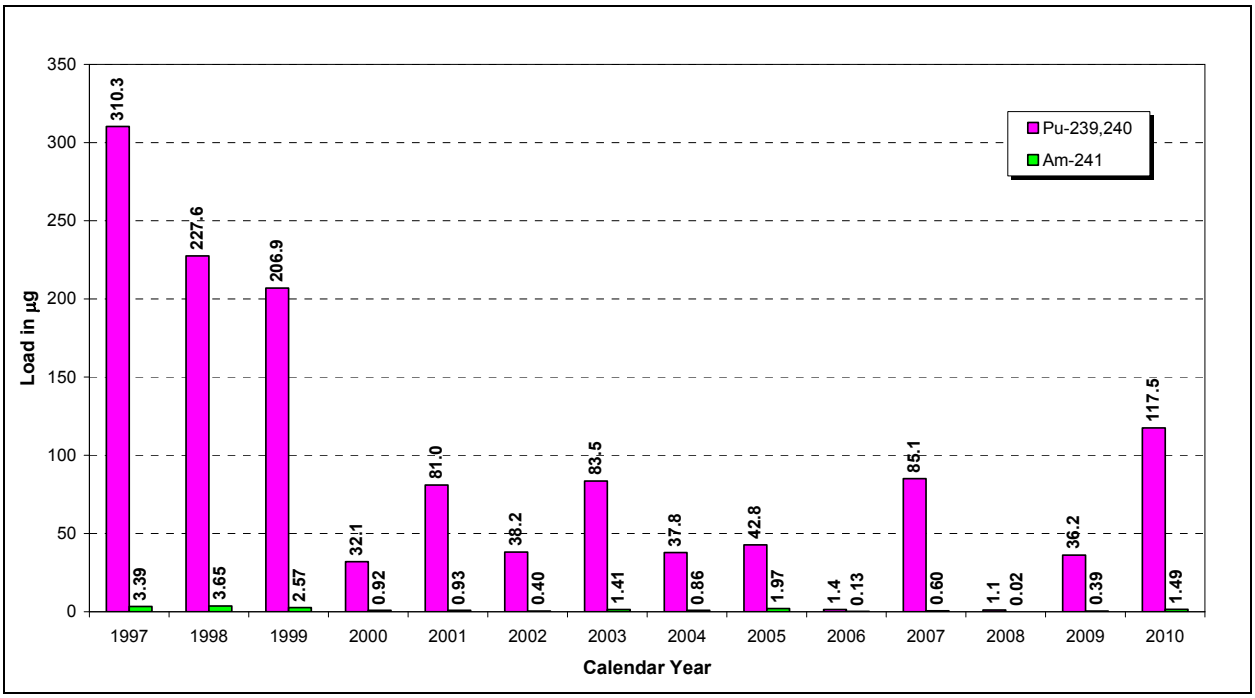


Figure 142. Combined Annual Pu and Am Loads from Walnut and Woman Creeks: CY 1997–2010

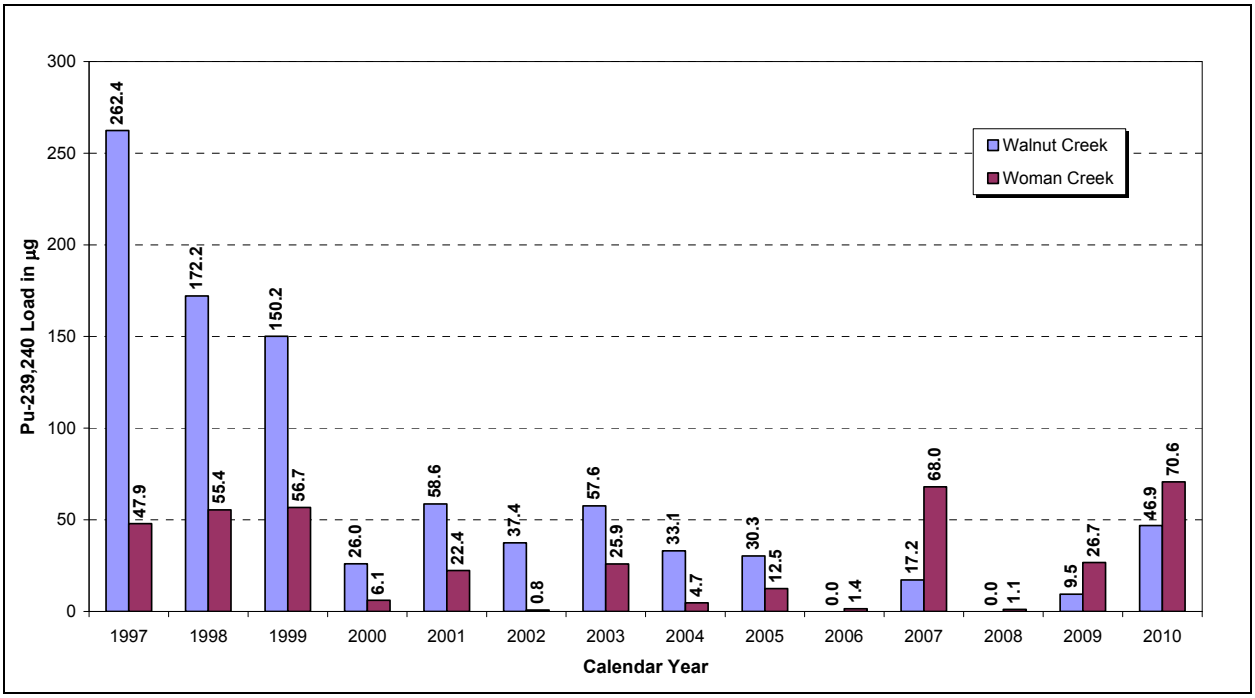
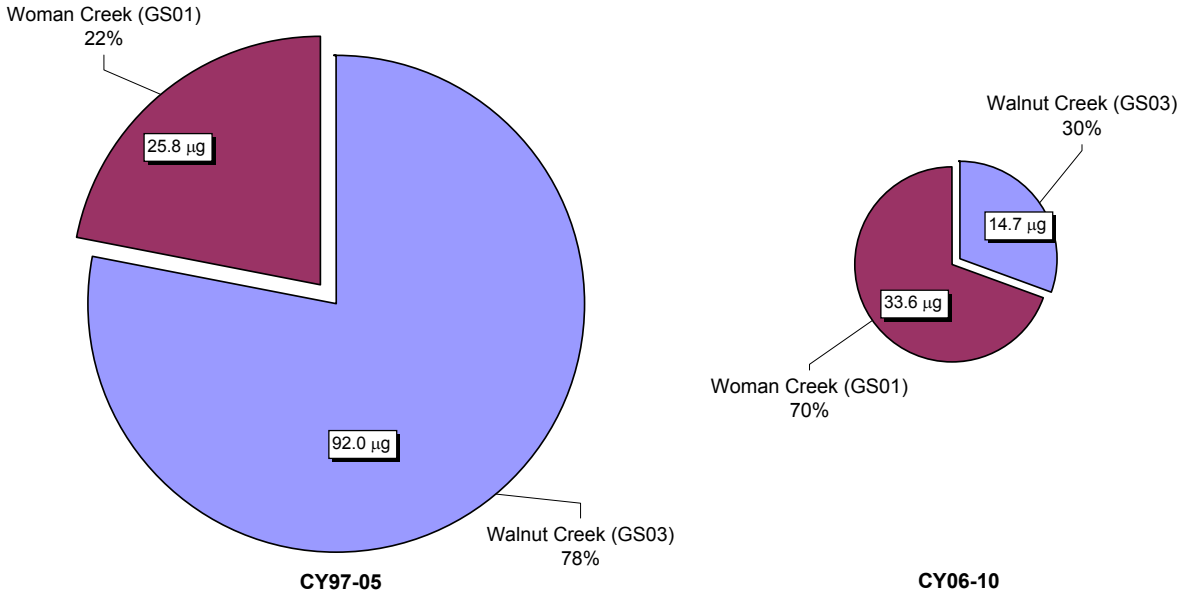


Figure 143. Annual Pu Loads from Walnut and Woman Creeks: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 144. Relative Average Annual Pu Load Totals from Walnut and Woman Creeks

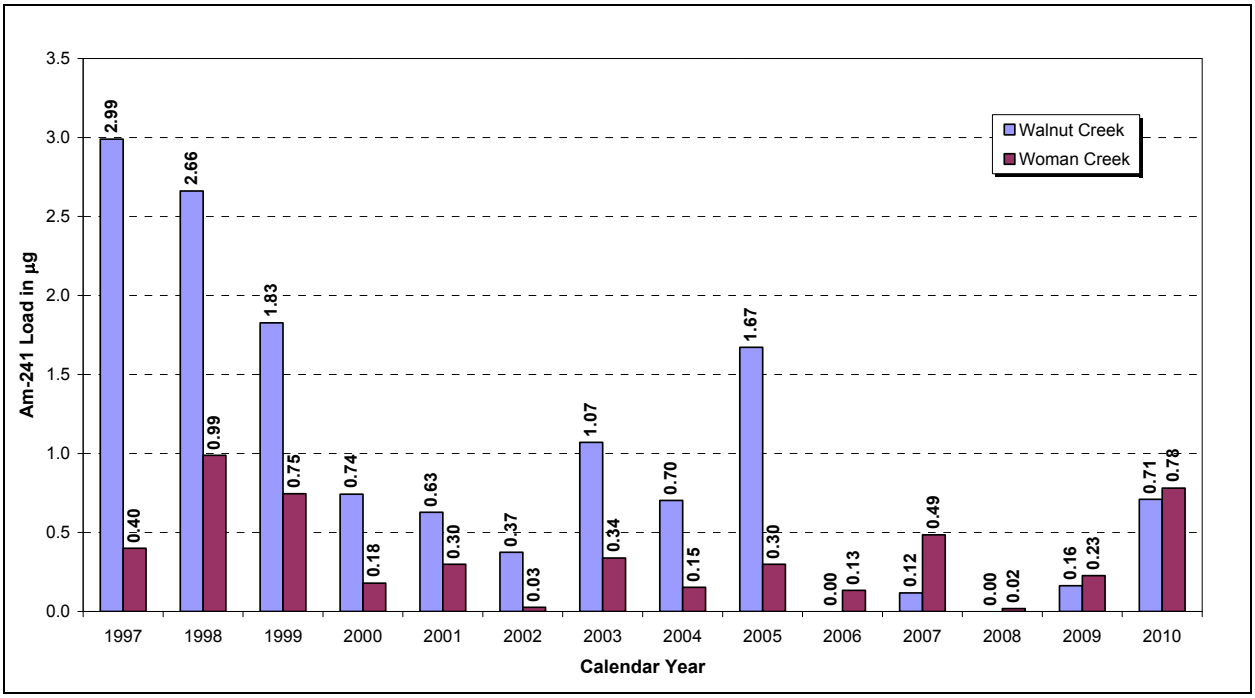
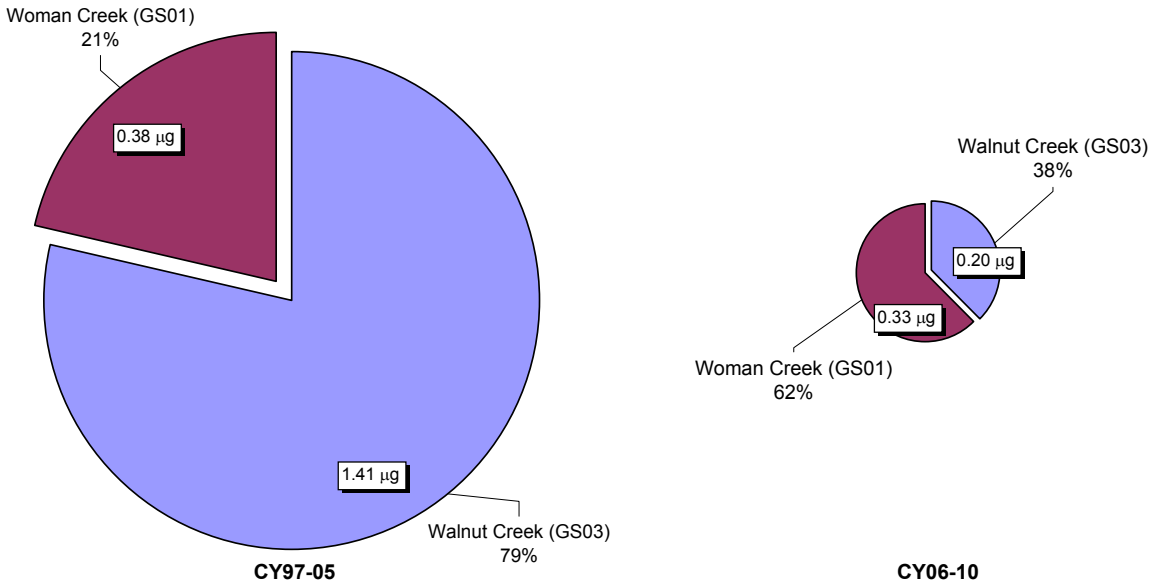


Figure 145. Annual Am Loads from Walnut and Woman Creeks: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 146. Relative Average Annual Am Load Totals from Walnut and Woman Creeks

Table 56. Total U Loads from Walnut and Woman Creeks: CY 2003−2010

Calendar Year	Total U (g)		
	Walnut Creek	**Woman Creek**	**Total**
2003	1,751	790	2,541
2004	744	808	1,551
2005	1,482	918	2,400
2006	0; No flow	235	235
2007	1,005	1,016	2,021
2008	0; No flow	174	174
2009	725	761	1,486
2010	2,311	1,162	3,473
Total	8,017	5,864	13,881

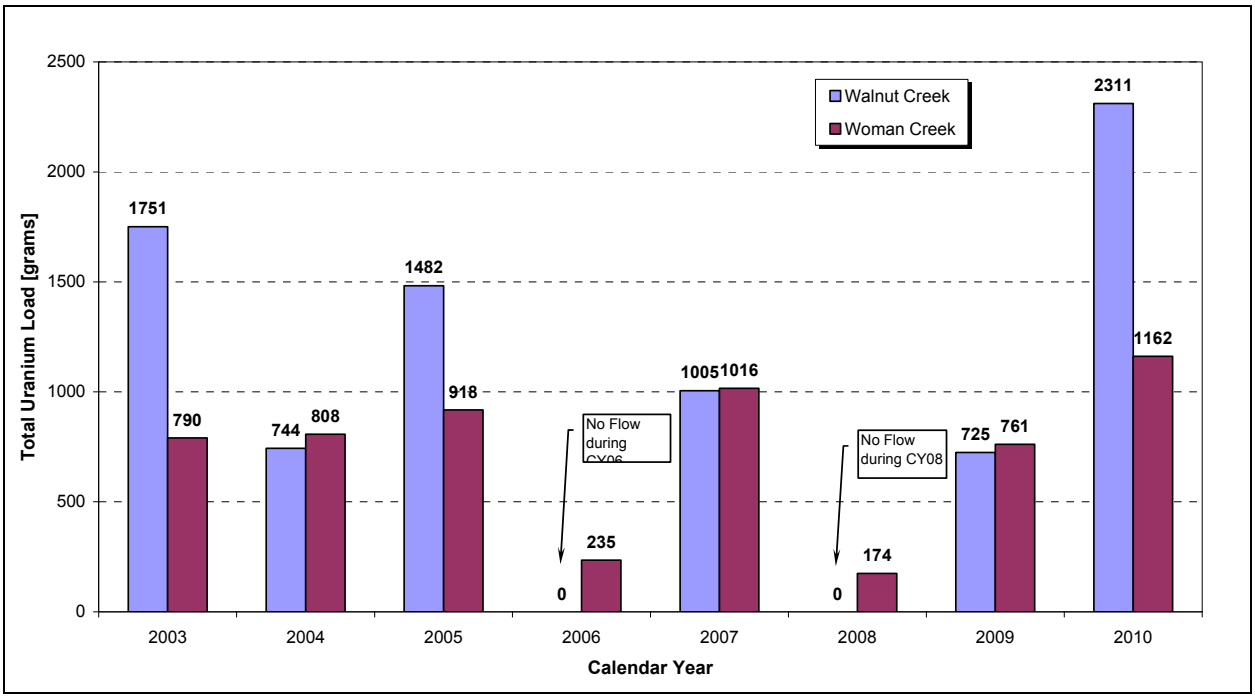


Figure 147. Annual Total U Loads from Walnut and Woman Creeks: CY 2003–2010

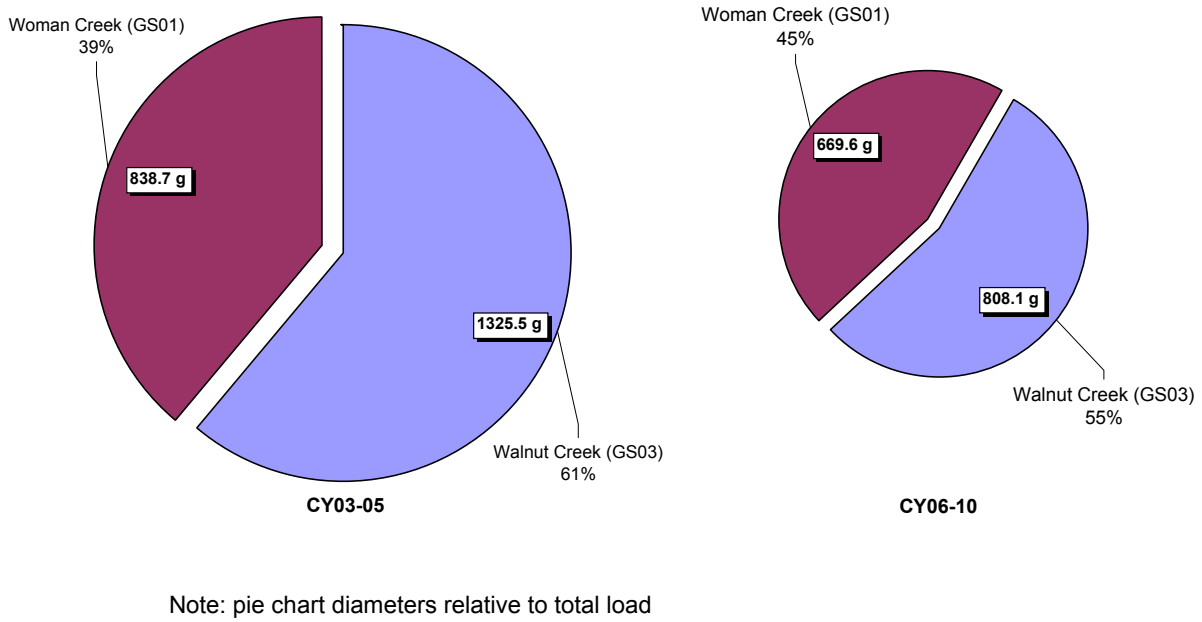


Figure 148. Relative Average Annual Total U Load Totals from Walnut and Woman Creeks

Lower Walnut Creek

This section summarizes the calculated Pu and Am loads in Walnut Creek at GS03 (Walnut Creek at Indiana Street), GS08 (Pond B-5 outlet), and GS11 (Pond A-4 outlet). The data are presented in Table 57, Table 58, and Table 59 and are depicted on Figure 149, Figure 150, Figure 151, Figure 152, Figure 153, Figure 154, and Figure 155. Total U data collection at GS03 began on November 5, 2002; thus, only CY 2003−2010 data are shown. The following points are noted:

- Annual Pu and Am loads vary by up to two orders of magnitude year to year (Figure 150 and Figure 152). The significant annual variability in Pu and Am loads is due mostly to water quality variation pre-closure. Post-closure, variation is due to large runoff variation and the very low measured activities with the inherent analytical error at such low levels.
- Pu and Am loads are generally decreasing at GS03 (Figure 149). The slight increase in Am loads at GS03 during CY 2005 is due to increased Am contributions to the A-series ponds related to the decontamination and decommissioning (D&D) of B771. Treatment of Pond A-4 water was successful in reducing Am levels well below the applicable standard (0.15 pCi/L), but the Am activity of the discharged water was somewhat higher than normal. Pond B-5 also showed some increased Am activity due to temporarily increased Am load associated with solids transport resulting from the construction of FC-4. These slightly higher Am activities were subsequently also measured at GS03 (Figure 152). The measurable increase in CY 2010 loads is primarily due to large flow volumes and not an increase in activity.
- Annual Pu and Am loads for all locations have been reduced post-closure (Figure 150 and Figure 152) due to the reduction of runoff and sediment transport resulting from the

effectiveness of remedial actions, revegetation, and erosion control measures. Load reductions range between 80 percent and 97 percent.

- Pre-closure Pu and Am loads from Pond B-5 are significantly greater than loads from Pond A-4 (Table 57 and Table 58), a result of both higher activities and larger discharge volumes. Post-closure loads from Pond A-4 are slightly greater than from Pond B-5. Post-closure load reductions range between 80 percent and 97 percent.
- Total Pu loads from Ponds A-4 and B-5 for the entire period of 1997 through 2010 are marginally greater than the loads at GS03 (Table 57), suggesting a small net loss of load to the Walnut Creek streambed below Ponds A-4 and B-5. This small loss may simply be an artifact of analytical measurement error.
- Total Am loads from Ponds A-4 and B-5 for the entire period of 1997 through 2010 are marginally less than the loads at GS03 (Table 58), indicating a net gain of load from tributaries and the Walnut Creek streambed below Ponds A-4 and B-5. This gain may simply be an artifact of analytical measurement error.
- Total U loads from Ponds A-4 and B-5 are slightly less than the loads at GS03 (Figure 155), indicating a small net gain of load from tributaries and seeps in Walnut Creek below Ponds A-4 and B-5. Post-closure reductions in U loads range between 10 percent and 61 percent depending on location; U load at GS03 has been reduced 39 percent.

Table 57. Pu Loads at GS03, GS08, and GS11: CY 1997–2010

Calendar Year	Pu-239,240 (µg)			
	Pond A-4 (GS11)	Pond B-5 (GS08)	Walnut Creek Terminal Ponds Total	POC GS03
1997	59.2	8.8	68.0	262.4
1998	20.0	22.4	42.4	172.2
1999	23.8	261.4	285.2	150.2
2000	28.4	244.6	273.0	26.0
2001	4.7	32.3	37.0	58.6
2002	0.1	7.8	7.9	37.4
2003	7.3	111.5	118.8	57.6
2004	2.2	27.1	29.3	33.1
2005	2.2	17.9	20.1	30.3
2006	0.0; No A-4 discharge	0.0; No B-5 discharge	0.0	0.0 No flow
2007	7.8	1.9	9.6	17.2
2008	0.0; No A-4 discharge	0.0; No B-5 discharge	0.0	0.0 No flow
2009	2.3	3.0	5.3	9.5
2010	6.4	5.4	11.9	46.9
Total	164.5	744.2	908.6	901.3

Table 58. Am Loads at GS03, GS08, and GS11: CY 1997–2010

Calendar Year	Am-241 (µg)			
	Pond A-4 (GS11)	Pond B-5 (GS08)	Walnut Creek Terminal Ponds Total	POC GS03
1997	0.70	0.25	0.95	2.99
1998	1.25	0.35	1.60	2.66
1999	0.20	1.81	2.01	1.83
2000	0.02	3.14	3.16	0.74
2001	0.11	0.46	0.57	0.63
2002	0.04	0.25	0.29	0.37
2003	0.18	0.54	0.72	1.07
2004	0.14	0.58	0.73	0.70
2005	0.43	0.97	1.39	1.67
2006	0.0 No A-4 discharge	0.0; No B-5 discharge	0.00	0.0 No flow
2007	0.02	0.03	0.05	0.12
2008	0.0 No A-4 discharge	0.0; No B-5 discharge	0.00	0.0 No flow
2009	0.09	0.02	0.11	0.16
2010	0.14	0.11	0.25	0.71
Total	3.33	8.51	11.84	13.66

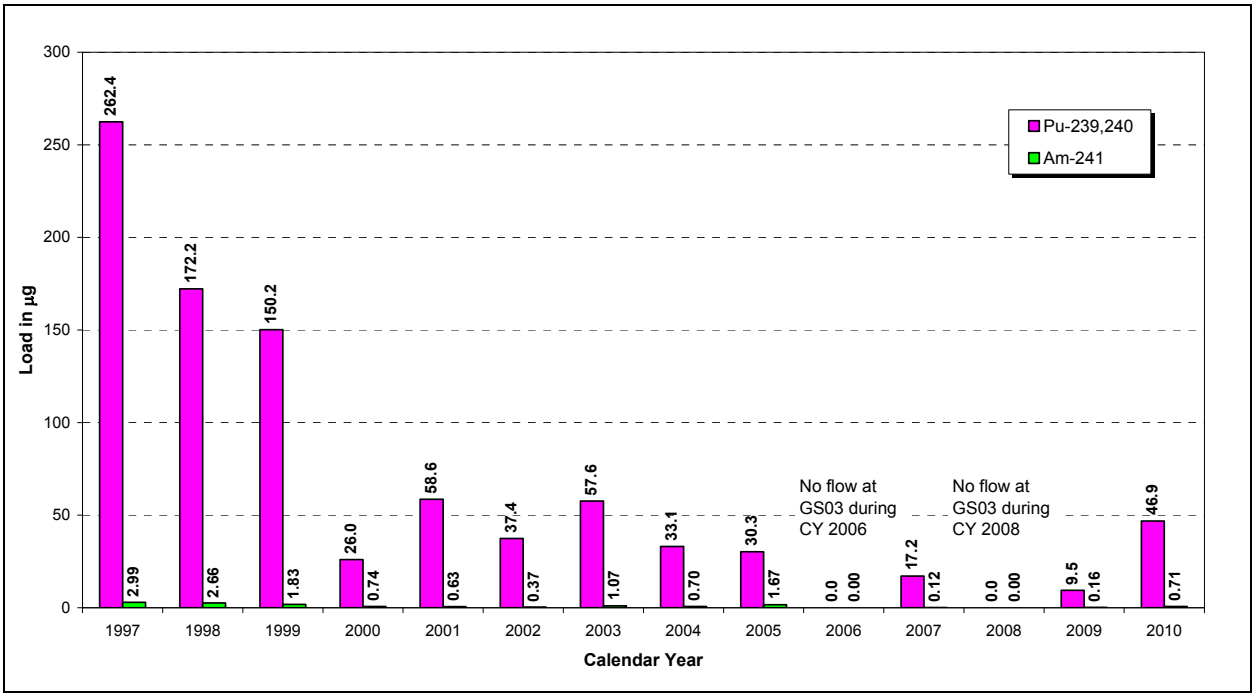


Figure 149. Annual Pu and Am Loads at GS03: CY 1997–2010

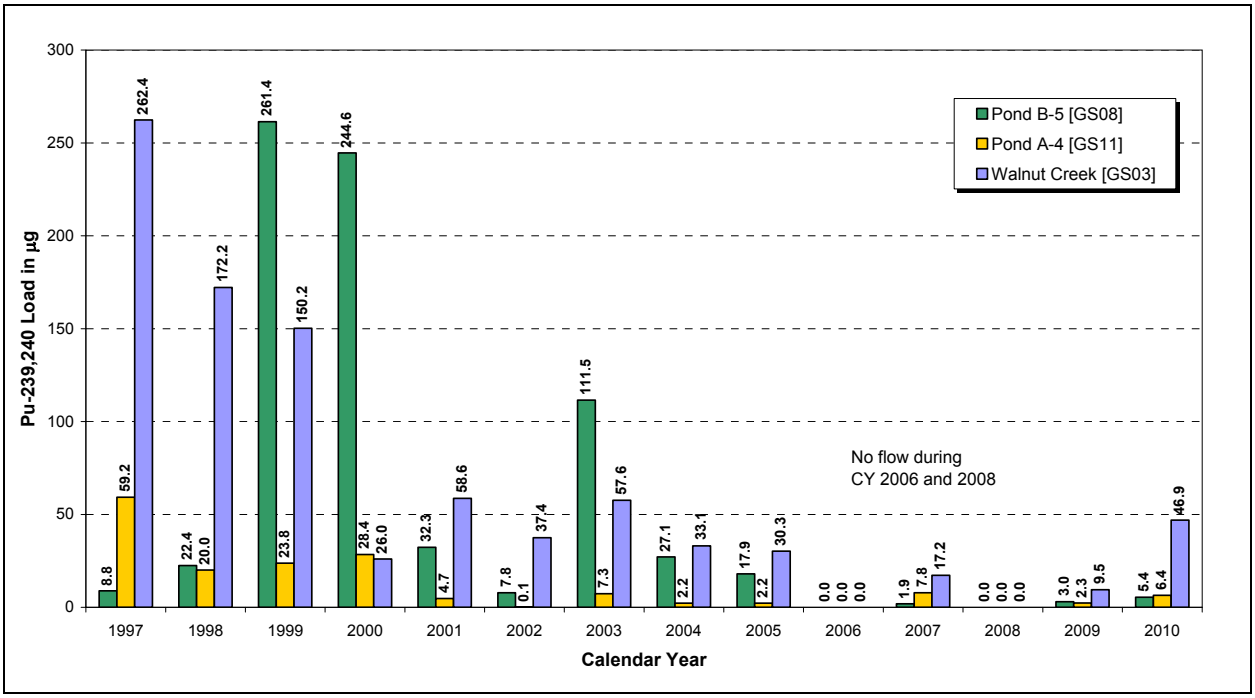
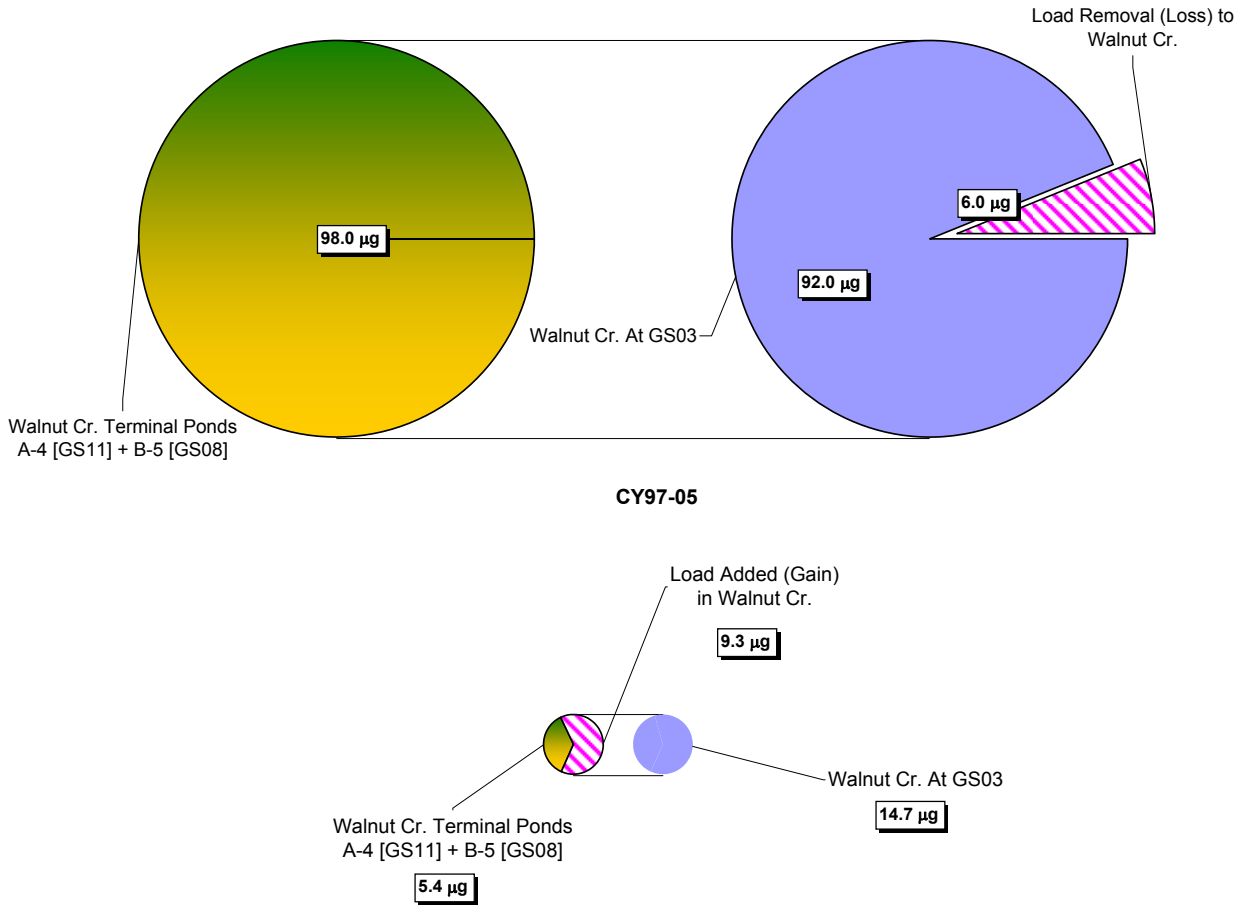


Figure 150. Annual Pu Loads at GS03, GS08, and GS11: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 151. Relative Average Annual Pu Load Totals at GS03, GS08, and GS11

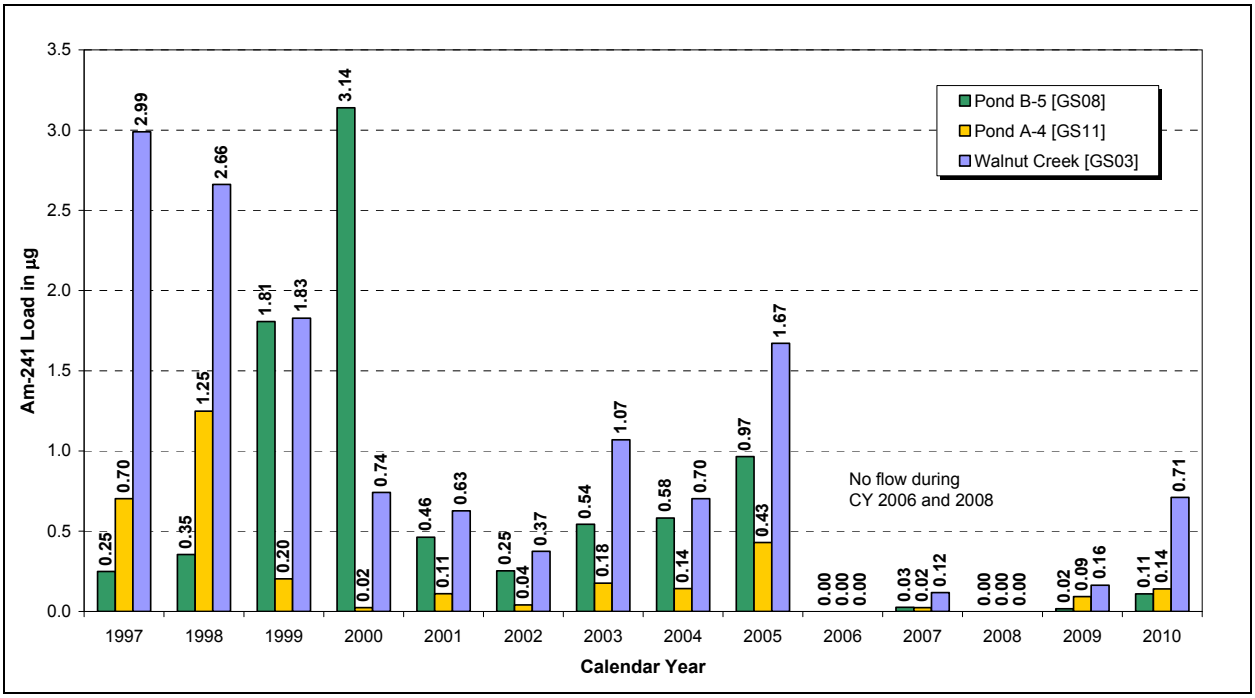
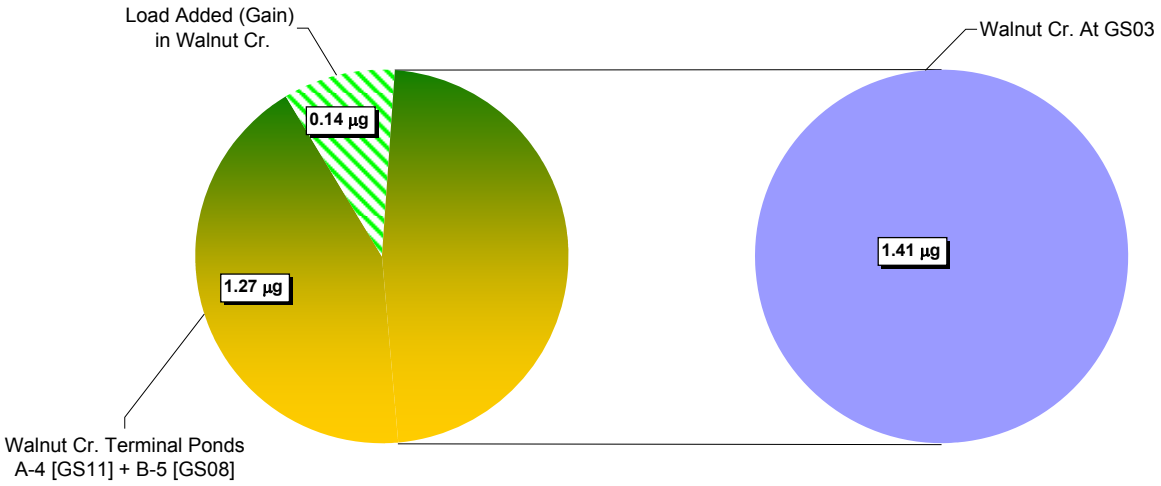
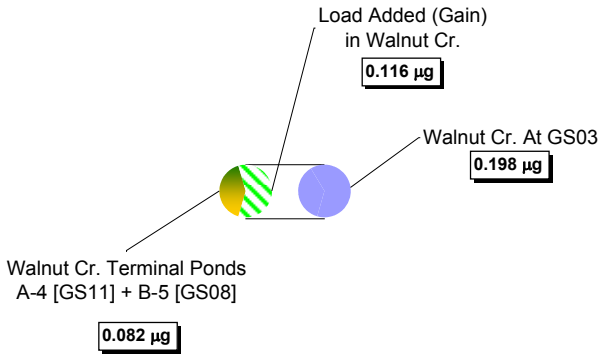


Figure 152. Annual Am Loads at GS03, GS08, and GS11: CY 1997–2010



CY97-05



CY06-10

Note: pie chart diameters relative to total load

Figure 153. Relative Average Annual Am Load Totals at GS03, GS08, and GS11

Table 59. Total U Loads at GS03, GS08, and GS11: CY 2003−2010

Calendar Year	Total U (g)			
	Pond A-4 (GS11)	Pond B-5 (GS08)	Walnut Creek Terminal Ponds Total	POC GS03
2003	865	610	1,474	1,751
2004	316	390	705	744
2005	165	1,389	1,554	1,482
2006	0; No A-4 discharge	0; No B-5 discharge	0	0 No flow
2007	411	481	892	1,005
2008	0; No A-4 discharge	0; No B-5 discharge	0	0 No flow
2009	405	322	728	725
2010	1,199	746	1,945	2,311
Total	3,360	3,937	7,298	8,017

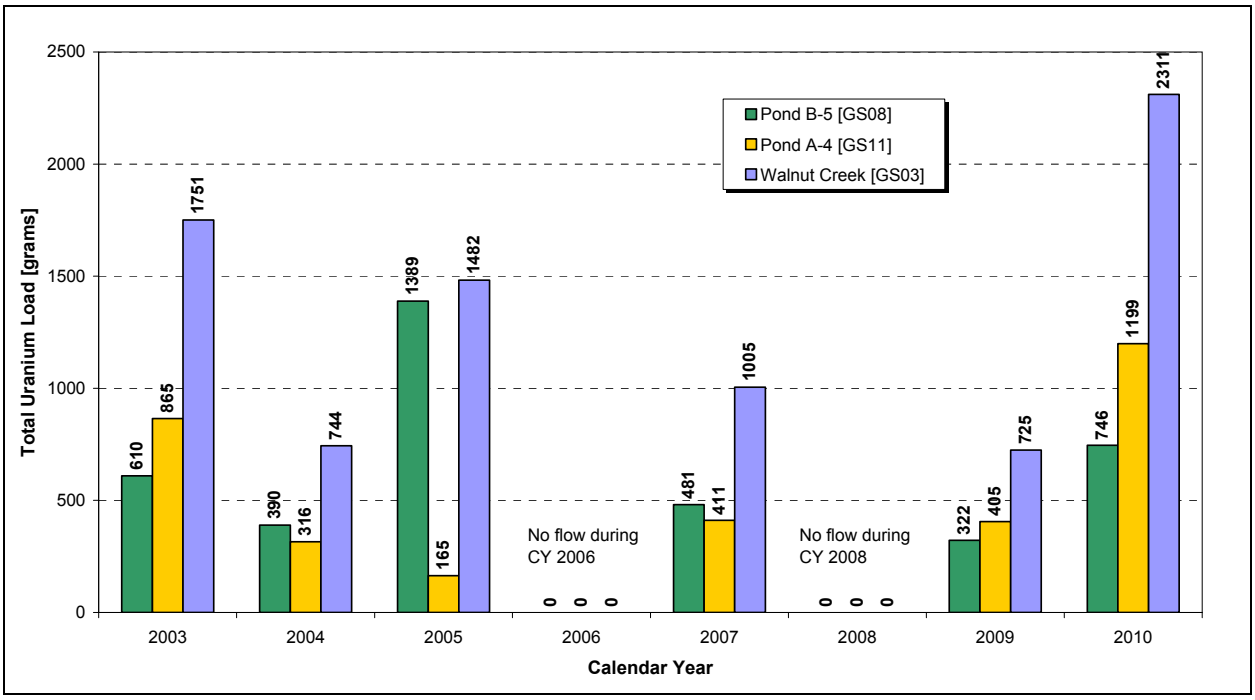


Figure 154. Annual Total U Loads at GS03, GS08, and GS11: CY 2003−2010

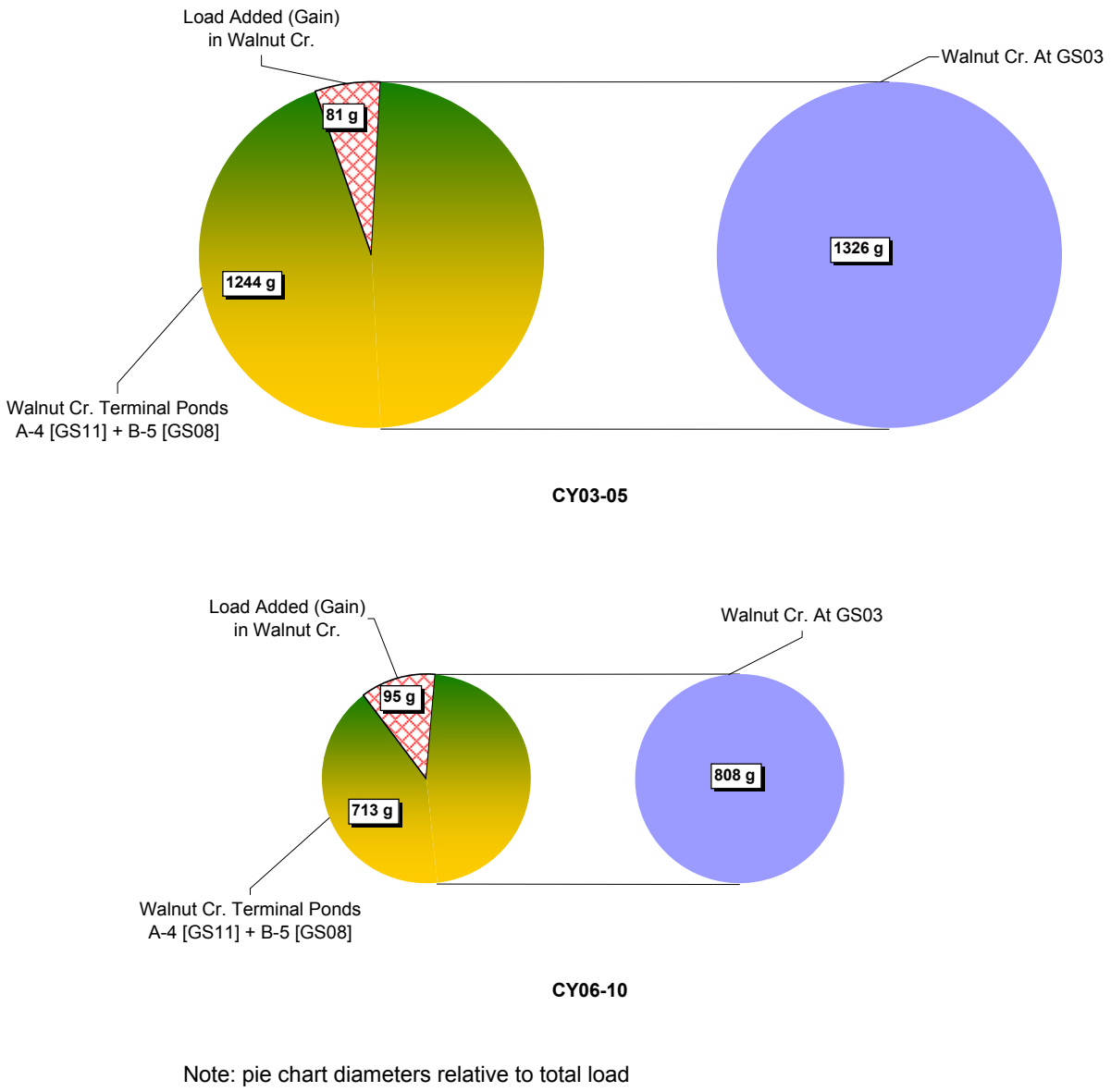


Figure 155. Relative Average Annual Total U Load Totals at GS03, GS08, and GS11

Lower Woman Creek

This section summarizes the calculated Pu, Am, and total U loads in Woman Creek at GS01 (Woman Creek at Indiana Street) and GS31 (Pond C-2 outlet). The data are presented in Table 60, Table 61, and Table 62, and depicted on Figure 156, Figure 157, Figure 158, Figure 159, Figure 160, Figure 161, and Figure 162. Total U data collection began at GS01 on February 3, 2003; therefore, only CY 2003−2010 data are shown. The following points are noted:

- Annual Pu and Am loads generally vary by up to two orders of magnitude year to year (Figure 157 and Figure 159). The significant annual variability in Pu and Am loads is likely due to large fluctuations in stream discharge volumes and the very low measured activities with inherent analytical error at such low levels.

- Pu and Am loads are variable at GS01 (Figure 156). During CY 2007 and CY 2010, there is a measurable load increase compared to adjacent years. This increase can be attributed to larger-than-normal flow volumes, and not increases in activity.
- Total Pu loads from Pond C-2 are less than the loads at GS01 (Table 60 and Figure 158), indicating a gain of load from the Woman Creek drainage. Post-closure, Pond C-2 accounts for less than 3 percent of the Pu load at GS01.
- Total Am loads from Pond C-2 are less than the loads at GS01 (Table 61 and Figure 160), also indicating a gain of load from the Woman Creek drainage. Post-closure, Pond C-2 accounts for approximately 3 percent of the Am load at GS01.
- Total U load for CY 2003−2010 from Pond C-2 is significantly less than the load at GS01 (Table 62 and Figure 162), indicating a gain of load most likely from naturally occurring U in the Woman Creek drainage. Post-closure, Pond C-2 accounts for less than 5 percent of the U load at GS01.

Table 60. Pu Loads at GS01 and GS31: CY 1997–2010

Calendar Year	Pu-239,240 (µg)	
	Pond C-2 (GS31)	POC GS01
1997	16.7	47.9
1998	2.2	55.4
1999	26.9	56.7
2000	0.0; No C-2 discharge	6.1
2001	11.0	22.4
2002	0.2	0.8
2003	11.0	25.9
2004	11.5	4.7
2005	5.0	12.5
2006	0.0; No C-2 discharge	1.4
2007	0.0; No C-2 discharge	68.0
2008	0.0; No C-2 discharge	1.1
2009	4.1	26.7
2010	0.4	70.6
Total	89.0	400.2

Note: During CY 1997 (through September 30, 1997), flows from Woman Creek were routinely diverted to Mower Ditch for subsequent monitoring at GS02 (discontinued location). Therefore, the load calculated for Woman Creek at Indiana Street (GS01) includes the water that was measured at GS02. The estimated load diverted to GS02 is calculated by multiplying the CY 1997 volume-weighted activities at GS01 by the streamflow volume measured at GS02, and converting for units. This diverted load is then added to the calculated load at GS01 to obtain the total CY 1997 load at GS01. For subsequent water years, the Mower diversion structure has been upgraded and configured to prevent Woman Creek flows from entering the Mower Ditch.

Table 61. Am Loads at GS01 and GS31: CY 1997–2010

Calendar Year	Am-241 (µg)	
	Pond C-2 (GS31)	**POC GS01**
1997	0.17	0.40
1998	0.27	0.99
1999	0.13	0.75
2000	0.00; No C-2 discharge	0.18
2001	0.14	0.30
2002	<0.01	0.03
2003	0.09	0.34
2004	0.11	0.15
2005	0.04	0.30
2006	0.0; No C-2 discharge	0.13
2007	0.0; No C-2 discharge	0.49
2008	0.0; No C-2 discharge	0.02
2009	0.03	0.23
2010	0.02	0.78
Total	1.00	5.07

Note: During CY 1997 (through September 30, 1997), flows from Woman Creek were routinely diverted to Mower Ditch for subsequent monitoring at GS02 (discontinued location). Therefore, the load calculated for Woman Creek at Indiana Street (GS01) includes the water that was measured at GS02. The estimated load diverted to GS02 is calculated by multiplying the CY 1997 volume-weighted activities at GS01 by the streamflow volume measured at GS02, and converting for units. This diverted load is then added to the calculated load at GS01 to obtain the total CY 1997 load at GS01. For subsequent water years, the Mower diversion structure has been upgraded and configured to prevent Woman Creek flows from entering the Mower Ditch.

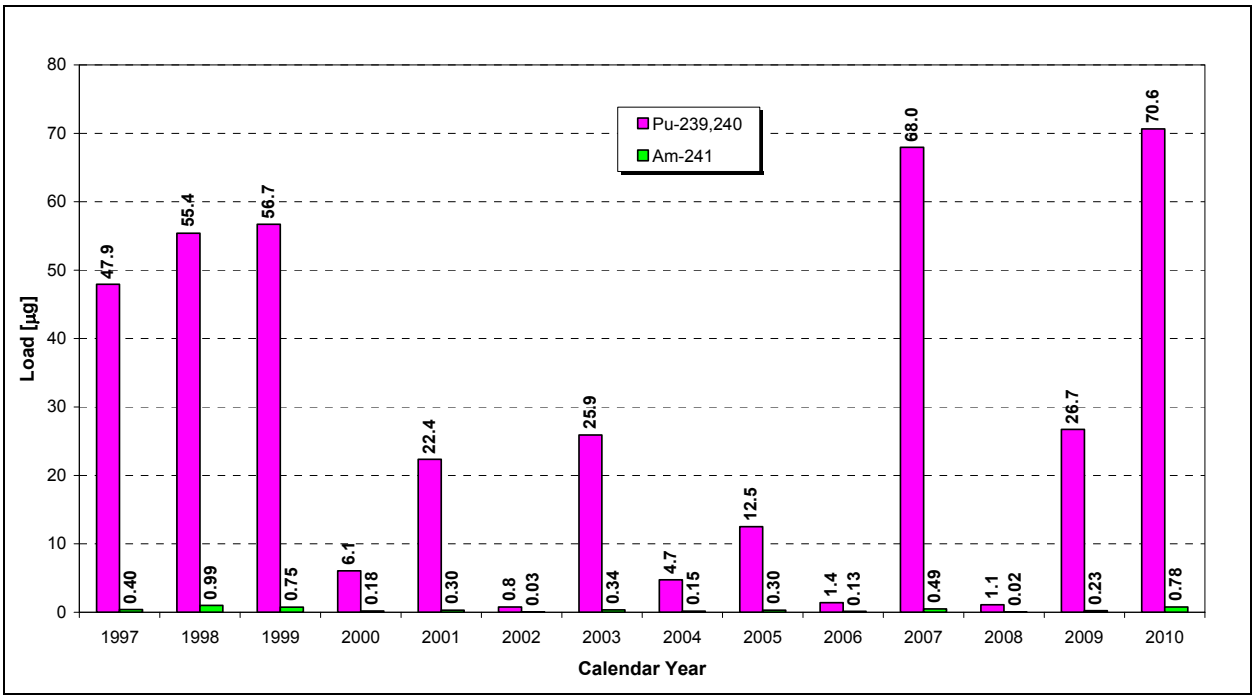


Figure 156. Annual Pu and Am Loads at GS01: CY 1997–2010

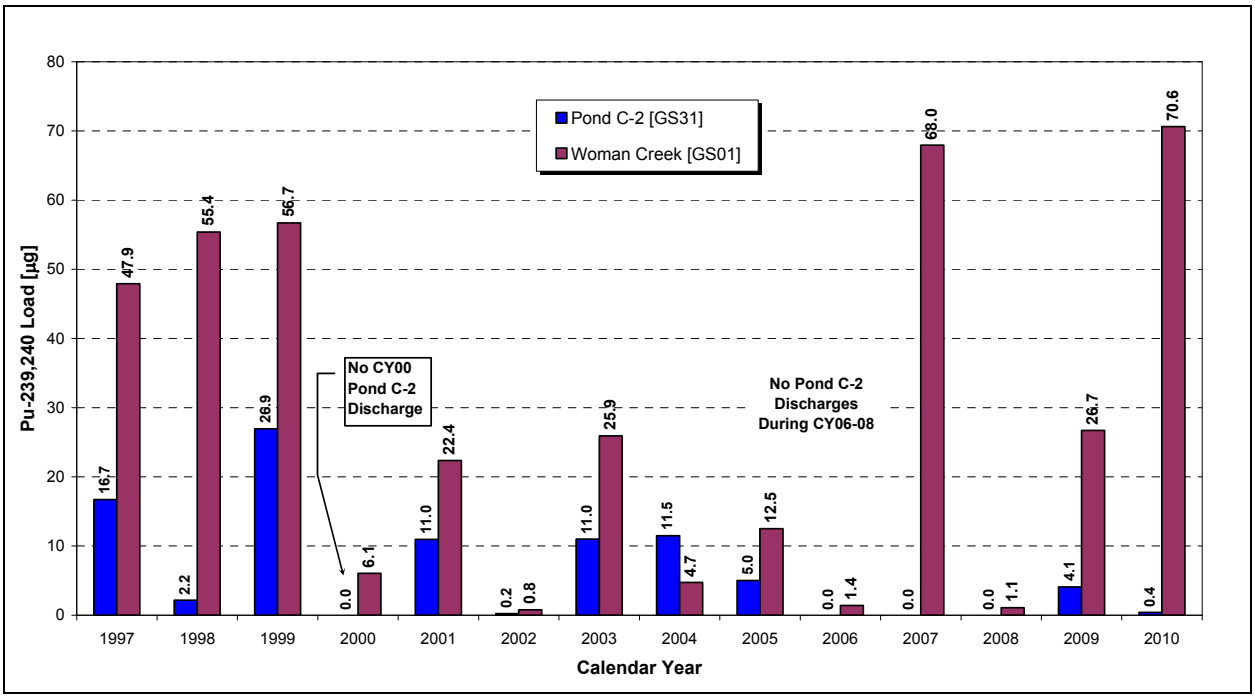
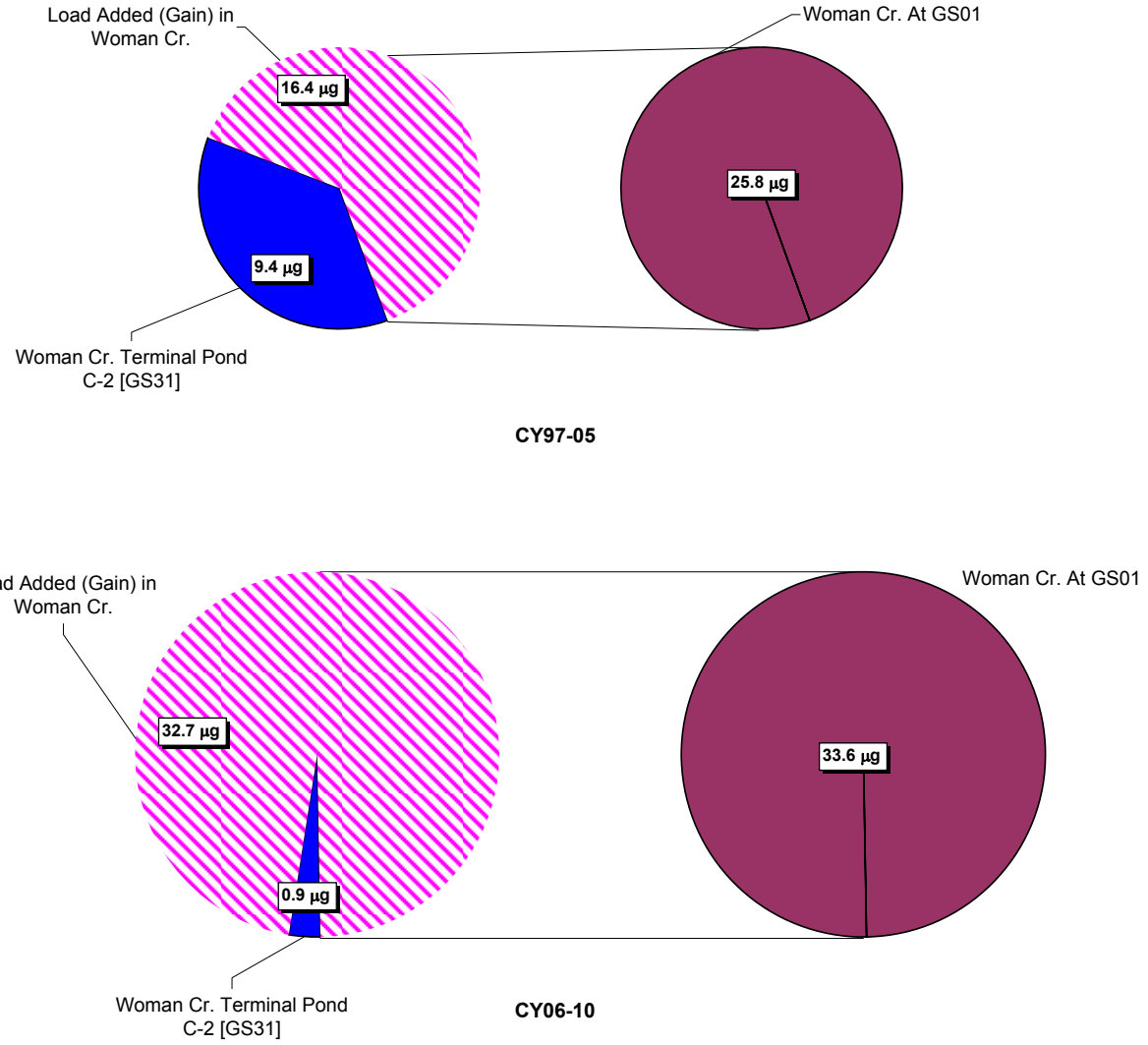


Figure 157. Annual Pu Loads at GS01 and GS31: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 158. Relative Average Annual Pu Load Totals at GS01 and GS31

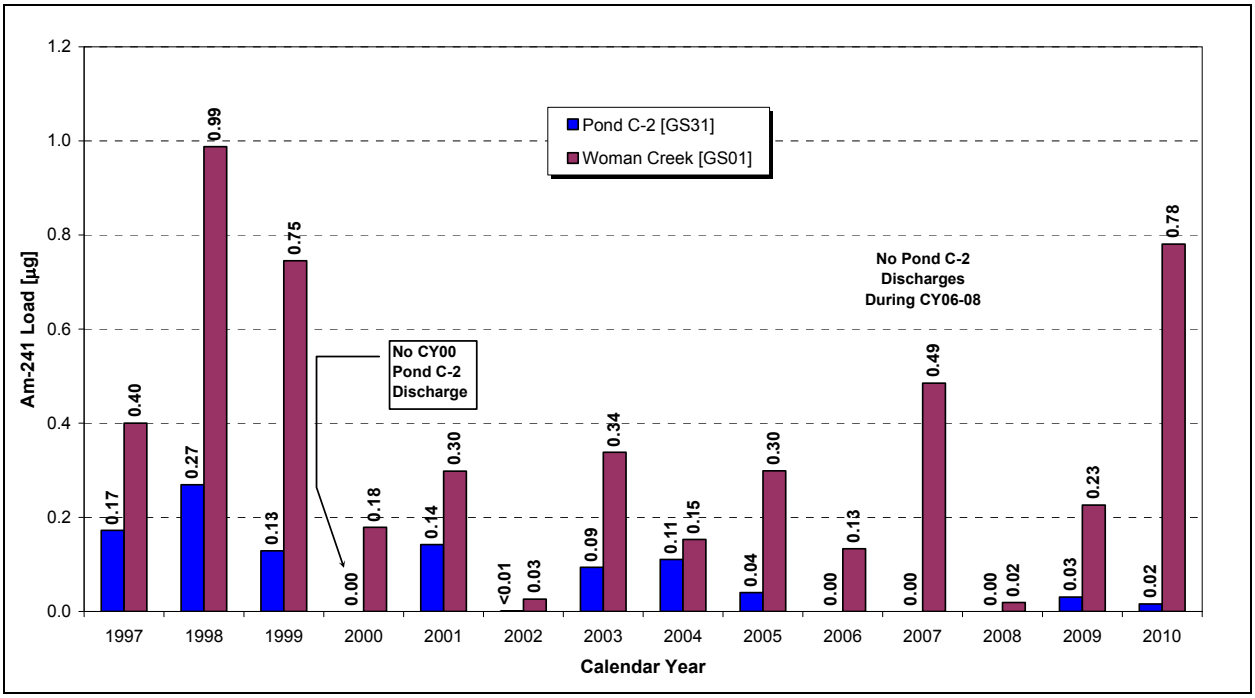
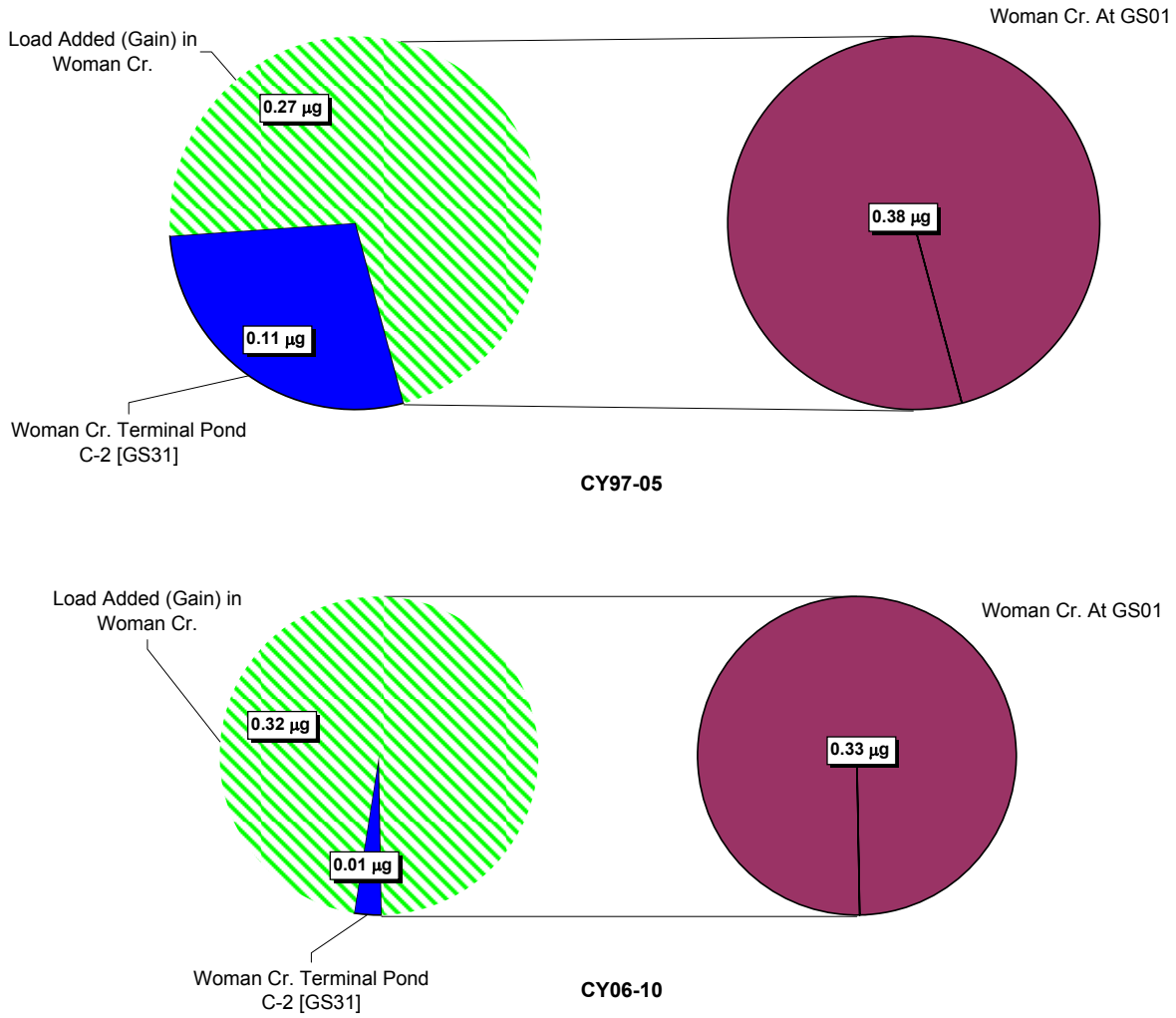


Figure 159. Annual Am Loads at GS01 and GS31: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 160. Relative Average Annual Am Load Totals at GS01 and GS31

Table 62. Total U Loads at GS01 and GS31: CY 2003−2010

Calendar Year	Total U (g)	
	Pond C-2 (GS31)	POC GS01
2003	129	790
2004	92	808
2005	115	918
2006	0; No C-2 discharge	235
2007	0; No C-2 discharge	1,016
2008	0; No C-2 discharge	174
2009	95	761
2010	61	1,162
Total	492	5,864

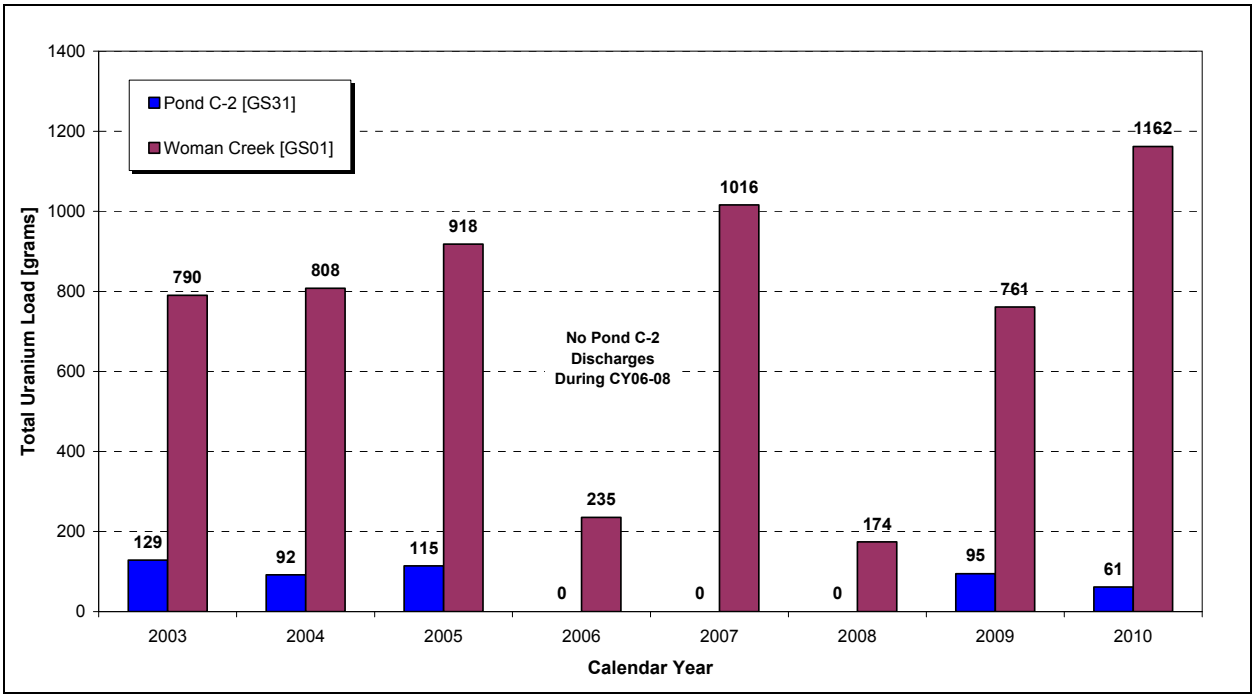


Figure 161. Annual Total U Loads at GS01 and GS31: CY 2003−2010

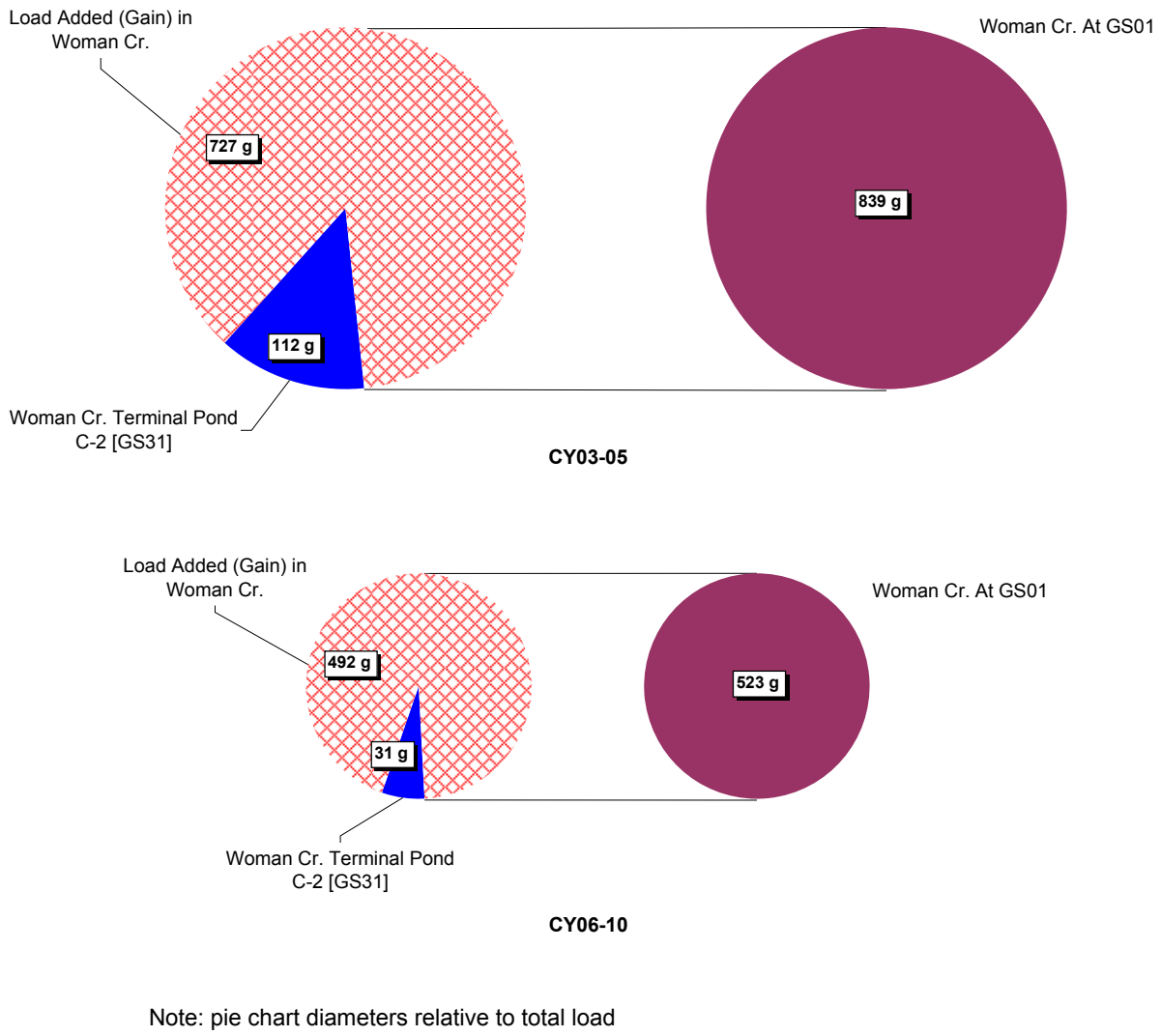


Figure 162. Relative Average Annual Total U Load Totals at GS01 and GS31

Terminal Ponds A-4, B-5, and C-2

This section summarizes the calculated Pu, Am, and total U loads from terminal Ponds A-4, B-5, and C-2. The data are presented in Table 63 and Table 64, and depicted on Figure 163, Figure 164, Figure 165, Figure 166, Figure 167, and Figure 168. The following points are noted:

- Annual Pu and Am loads vary significantly year to year (Figure 163 and Figure 165). A general reduction in Pu and Am loads is noted during active closure, with a significant reduction post-closure due to the reduction of runoff and sediment transport attributed to the effectiveness of remedial actions, revegetation, and erosion control measures.
- Pond B-5 accounts for most (76 percent) of the Pu load from the terminal ponds (Figure 164) pre-closure. With the reduction of both discharge volume and activity, Pond B-5 accounts for 33 percent of the post-closure load; Pond A-4 accounts for 53 percent of the post-closure Pu load due to larger discharge volumes, and not higher Pu activity. Post-closure Pu loads from the terminal ponds have been reduced 94 percent overall.

- Pond B-5 accounts for most (67 percent) of the Am load from the terminal ponds (Figure 166). With the reduction of both discharge volume and activity, Pond B-5 accounts for 33 percent of the post-closure load; Pond A-4 accounts for 57 percent of the post-closure Am load due to larger discharge volumes, and not higher Am activity. Post-closure Am loads from the terminal ponds have been reduced 93 percent overall.
- Pond A-4 accounts for a slim majority (46 percent) of the total U loads from the terminal ponds (Figure 168) pre-closure. Comparable proportions are noted post-closure. Post-closure U loads from the terminal ponds have been reduced 45 percent overall.

Table 63. Pu and Am Loads from Terminal Ponds A-4, B-5, and C-2: CY 1997–2010

Calendar Year	Pu-239,240 (µg)			Am-241 (µg)		
	Pond A-4 (GS11)	Pond B-5 (GS08)	Pond C-2 (GS31)	Pond A-4 (GS11)	Pond B-5 (GS08)	Pond C-2 (GS31)
1997	59.2	8.8	16.7	0.70	0.25	0.17
1998	20.0	22.4	2.2	1.25	0.35	0.27
1999	23.8	261.4	26.9	0.20	1.81	0.13
2000	28.4	244.6	0.0; No C-2 discharge	0.02	3.14	0.00; No C-2 discharge
2001	4.7	32.3	11.0	0.11	0.46	0.14
2002	0.1	7.8	0.2	0.04	0.25	<0.01
2003	7.3	111.5	11.0	0.18	0.54	0.09
2004	2.2	27.1	11.5	0.14	0.58	0.11
2005	2.2	17.9	5.0	0.43	0.97	0.04
2006	0.0; No A-4 discharge	0.0; No B-5 discharge	0.0; No C-2 discharge	0.00; No A-4 discharge	0.00; No B-5 discharge	0.0; No C-2 discharge
2007	7.8	1.9	0.0; No C-2 discharge	0.02	0.03	0.0; No C-2 discharge
2008	0.0; No A-4 discharge	0.0; No B-5 discharge	0.0; No C-2 discharge	0.00; No A-4 discharge	0.00; No B-5 discharge	0.0; No C-2 discharge
2009	2.3	3.0	4.1	0.09	0.02	0.03
2010	6.4	5.4	0.4	0.14	0.11	0.02
Total	164.5	744.2	89.0	3.33	8.51	1.00

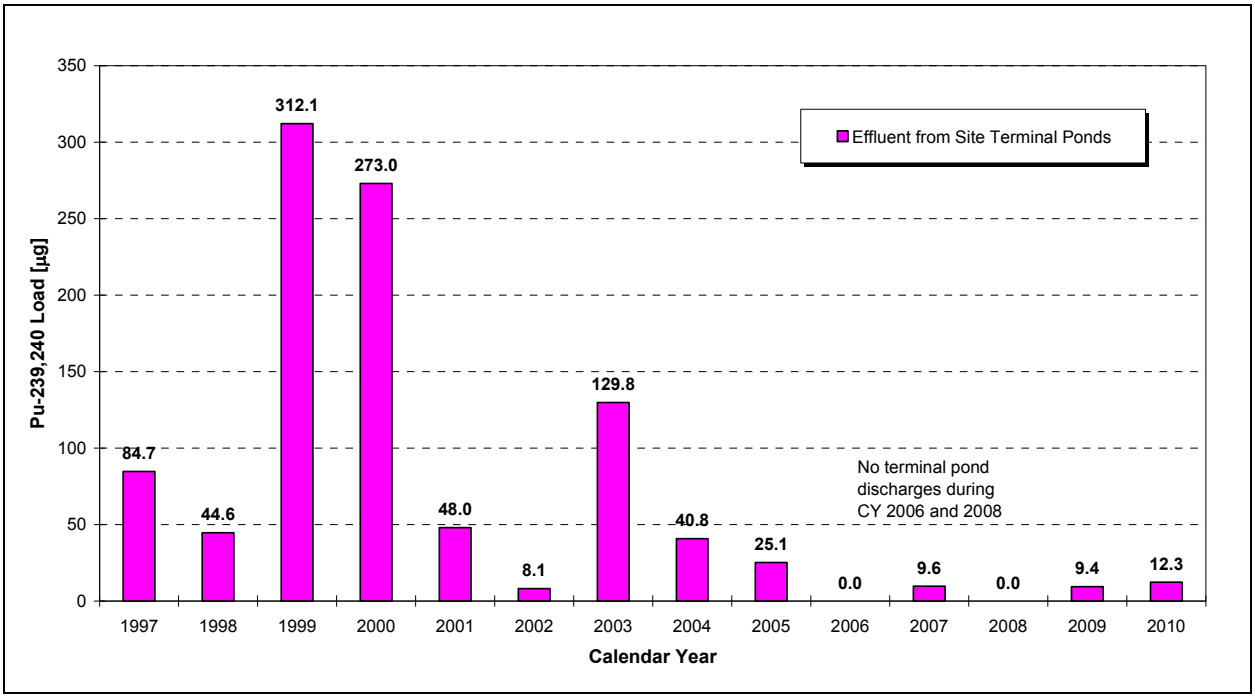
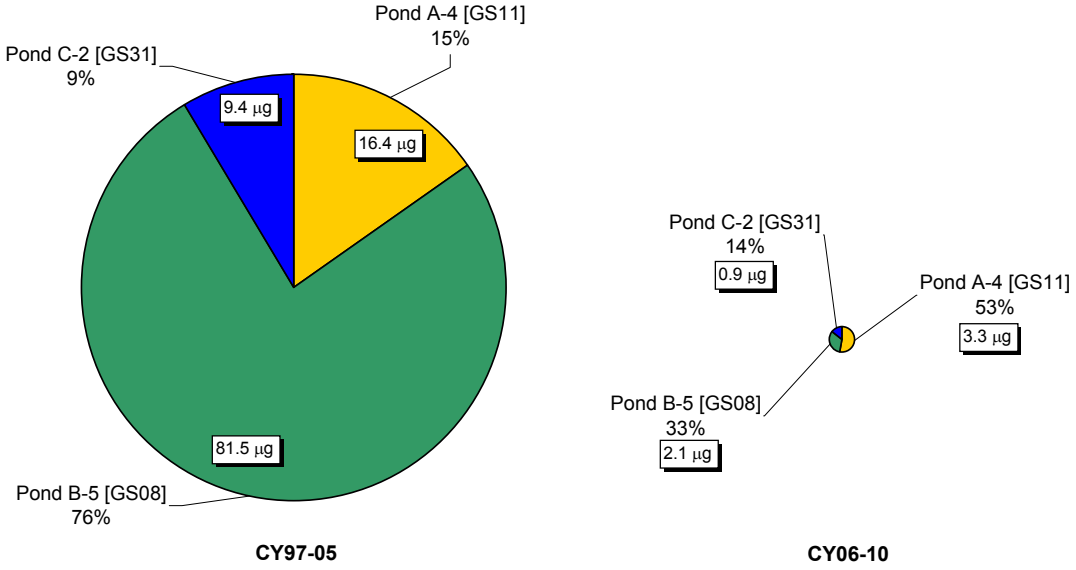


Figure 163. Annual Pu Loads from Terminal Ponds A-4, B-5, and C-2: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 164. Relative Average Annual Pu Load Totals from Terminal Ponds A-4, B-5, and C-2

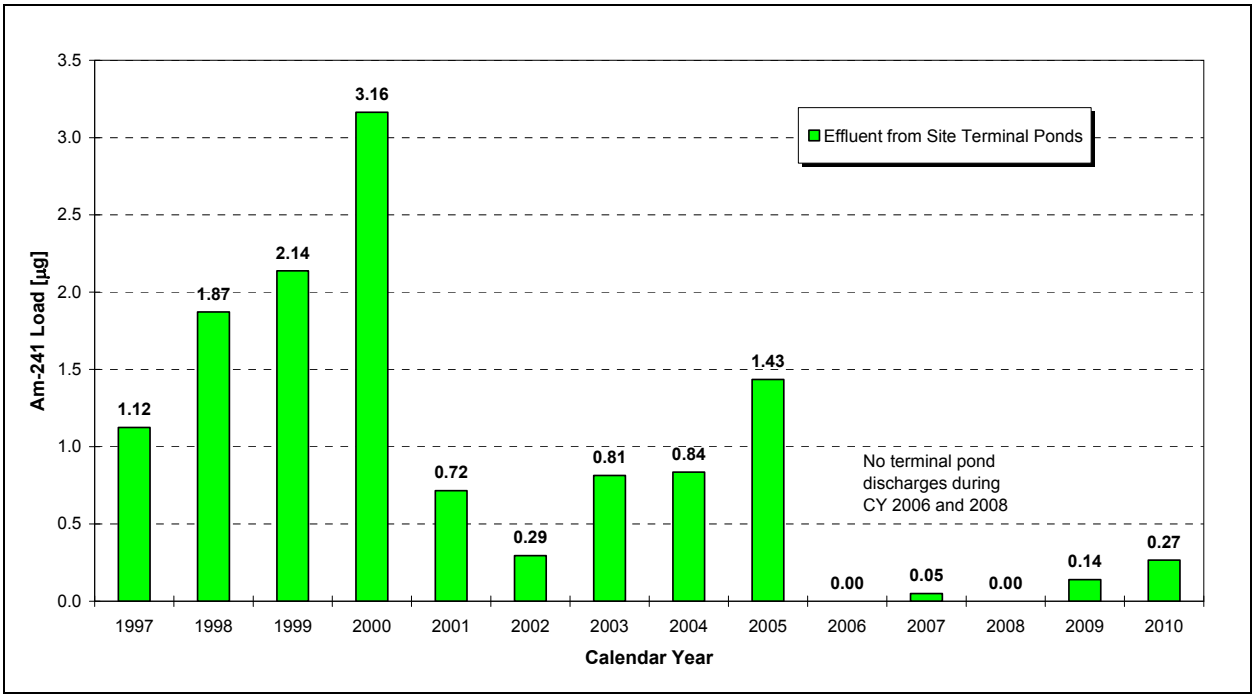
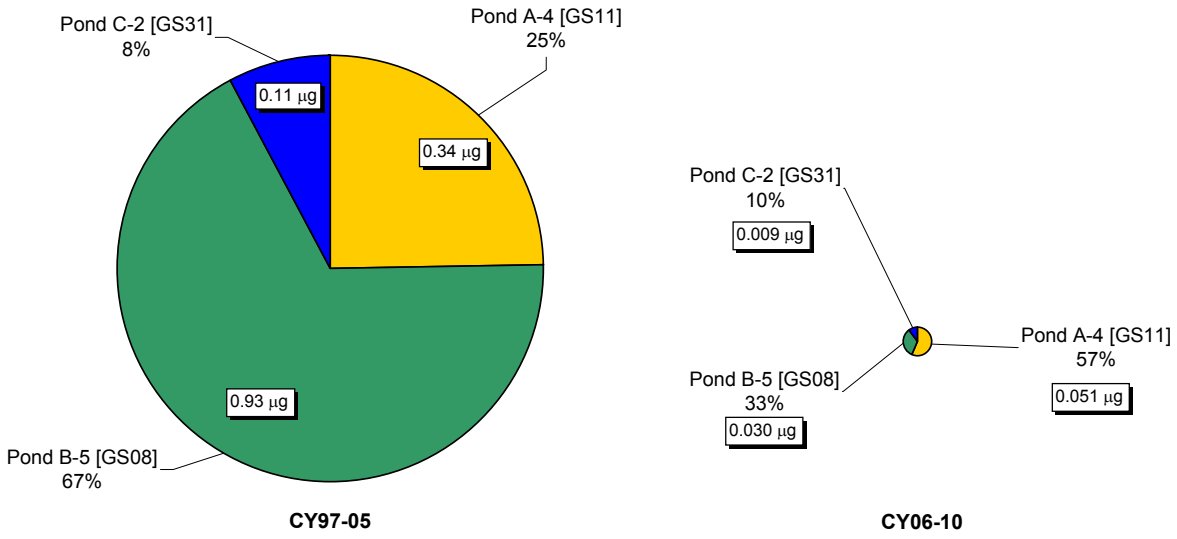


Figure 165. Annual Am Loads from Terminal Ponds A-4, B-5, and C-2: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 166. Relative Average Annual Am Load Totals from Terminal Ponds A-4, B-5, and C-2

Table 64. Total U Loads from Terminal Ponds A-4, B-5, and C-2: CY 1997–2010

Calendar Year	Total U (g)		
	Pond A-4 (GS11)	**Pond B-5 (GS08)**	**Pond C-2 (GS31)**
1997	1,365	252	231
1998	1,301	620	216
1999	633	809	189
2000	386	465	0; No C-2 discharge
2001	564	639	67
2002	132	258	1
2003	865	610	129
2004	316	390	92
2005	165	1,389	115
2006	0; No A-4 discharge	0; No B-5 discharge	0; No C-2 discharge
2007	411	481	0; No C-2 discharge
2008	0; No A-4 discharge	0; No B-5 discharge	0; No C-2 discharge
2009	405	322	95
2010	1,199	746	61
Total	7,742	6,981	1,195

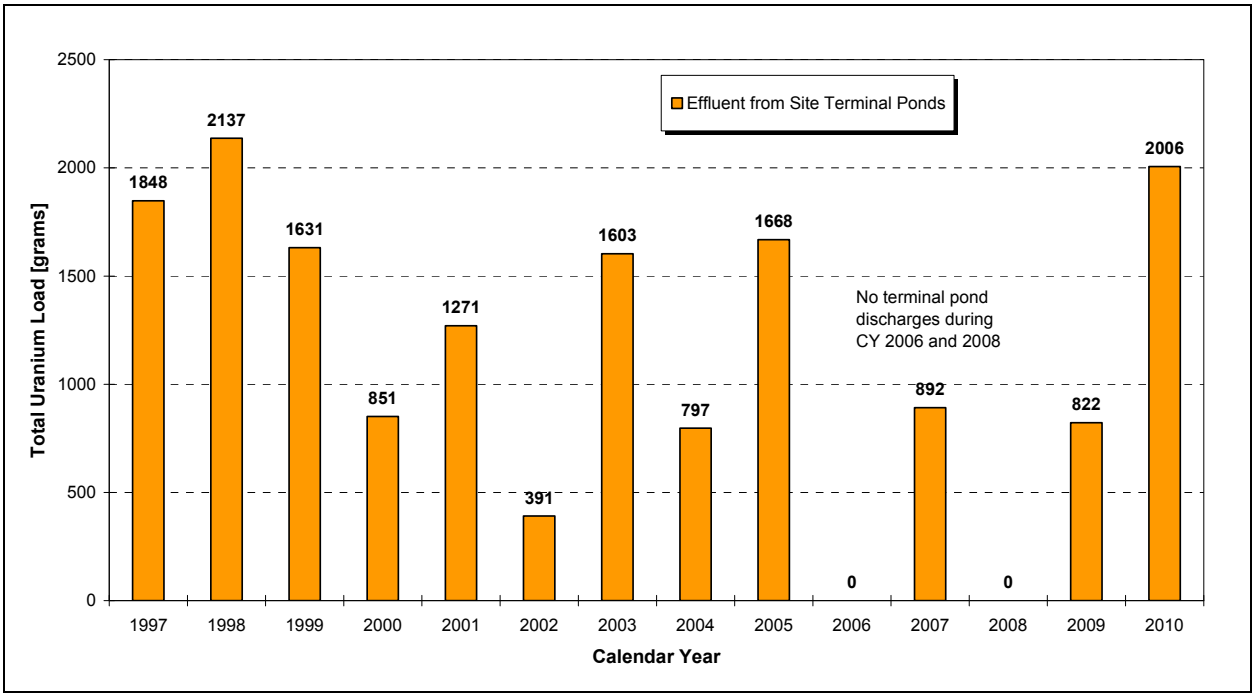
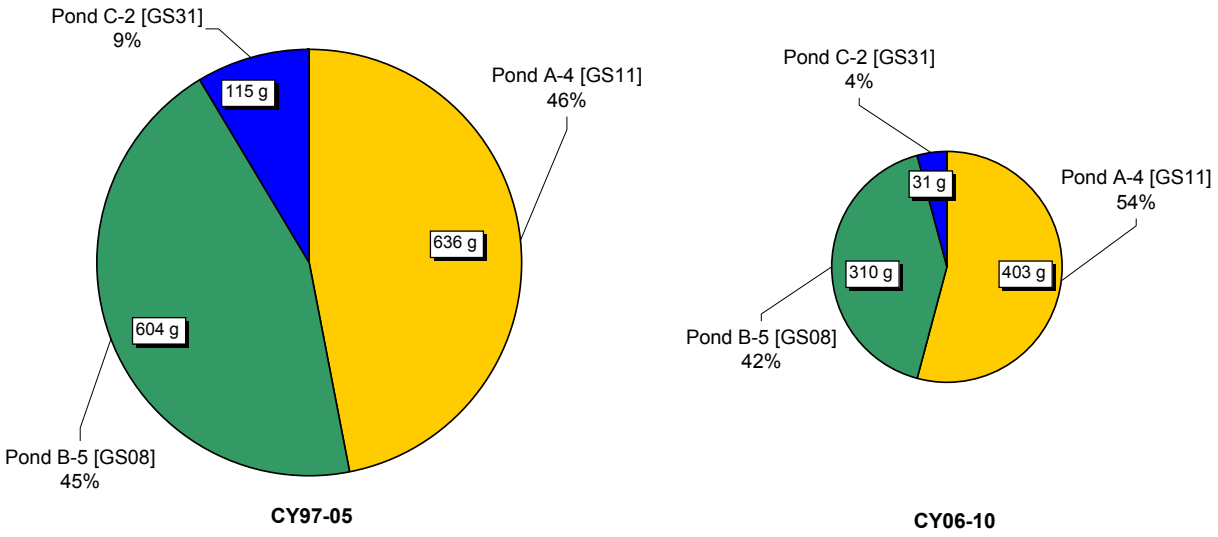


Figure 167. Annual Total U Loads from Terminal Ponds A-4, B-5, and C-2: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 168. Relative Average Annual Total U Load Totals from Terminal Ponds A-4, B-5, and C-2

A- and B-Series Ponds (POCs GS08 and GS11)

This section summarizes the calculated Pu, Am, and total U loads for the A- and B-series ponds. The data are presented in Table 65, Table 66, and Table 67, and are depicted on Figure 169, Figure 170, Figure 171, Figure 172, Figure 173, Figure 174, Figure 175, and Figure 176. Since water transfers occurred between ponds pre-closure, the load analysis is performed for both pond series combined. The influent load sources are GS10 and the former WWTP (South Walnut; WWTP removed in November 2004), and SW093 (North Walnut). The effluent loads are GS08 (Pond B-5 outlet) and GS11 (Pond A-4 outlet). The following points are noted:

- Table 65 shows GS10 with the highest influent Pu load for CY1997-2010. Post-closure Pu loads at GS10 have been reduced 97 percent.
- A significant increase in Pu loads to the ponds is noted during CY 2004 due to increased solids transport resulting from active building demolition and soil disturbance (Figure 169). With the implementation of remedial actions, erosion controls, revegetation, and soil stabilization, a significant reduction is noted for CY 2006−2010. Post-closure influent and effluent loads have been reduced by 95 percent and 94 percent, respectively.
- Table 66 shows GS10 with the highest influent Am load for CY1997−2010. Post-closure Am loads at GS10 have been reduced 98 percent.
- A measurable increase in Am loads to the ponds is noted during CY 2004. This increase was partly due to increased solids transport resulting from active building demolition and soil disturbance (Figure 171). Increased Am loads at SW093 were primarily due to contributions from B771 D&D during the July 2004–November 2004 period. The pathway causing these increased loads was eliminated in December 2004. With the implementation of remedial

actions, erosion controls, revegetation, and soil stabilization, a significant reduction is noted for CY 2006−2010. Post-closure influent and effluent loads have been reduced by 97 percent and 94 percent, respectively.

- Pre-closure annual Pu and Am loads vary significantly year to year (Figure 169 and Figure 171), primarily due to streamflow volume and solids transport variation. Post-closure loads show less variability.
- Pre-closure (Figure 173), GS10 shows the highest average annual influent total U concentration, while SW093 shows the highest average annual influent total U load (due to larger flow volumes at SW093). Post-closure (Figure 174), GS10 shows both the highest average annual concentration and load. Although U concentration has increased significantly, corresponding reductions in streamflow volume have actually resulted in a *decrease* in load. Post-closure influent load has been reduced by 14 percent.
- Pre-closure (Figure 173), GS11 shows the highest effluent average annual total U concentration and load. However, with the increased concentration in South Walnut Creek, GS08 shows the highest effluent average annual total U concentration post-closure. Again, although U activity has increased at both GS08 and GS11, corresponding reductions in discharge volume have resulted in a *decrease* in load. Post-closure effluent load has been reduced by 43 percent.

Table 65. Pu Load Summary for the A- and B-Series Ponds: CY 1997–2010

Calendar Year	Pu-239,240 (µg)				
	Influent (WWTP)	Influent (GS10)	Influent (SW093)	Effluent (GS08)	Effluent (GS11)
1997	11.2	576.0	164.2	8.8	59.2
1998	13.4	328.6	69.1	22.4	20.0
1999	19.4	307.9	127.8	261.4	23.8
2000	17.4	326.2	87.4	244.6	28.4
2001	11.3	141.4	44.4	32.3	4.7
2002	8.3	59.3	9.6	7.8	0.1
2003	3.8	207.2	140.1	111.5	7.3
2004	2.1	523.3	1,330.9	27.1	2.2
2005	0.0 WWTP removed	247.1	29.2	17.9	2.2
2006	0.0 WWTP removed	2.3	2.5	0.0; No B-5 discharge	0.0; No A-4 discharge
2007	0.0 WWTP removed	14.2	17.0	1.9	7.8
2008	0.0 WWTP removed	3.5	13.2	0.0; No B-5 discharge	0.0; No A-4 discharge
2009	0.0 WWTP removed	15.2	23.0	3.0	2.3
2010	0.0 WWTP removed	13.1	16.4	5.4	6.4
Total	86.9	2,765.4	2,075.0	744.2	164.5

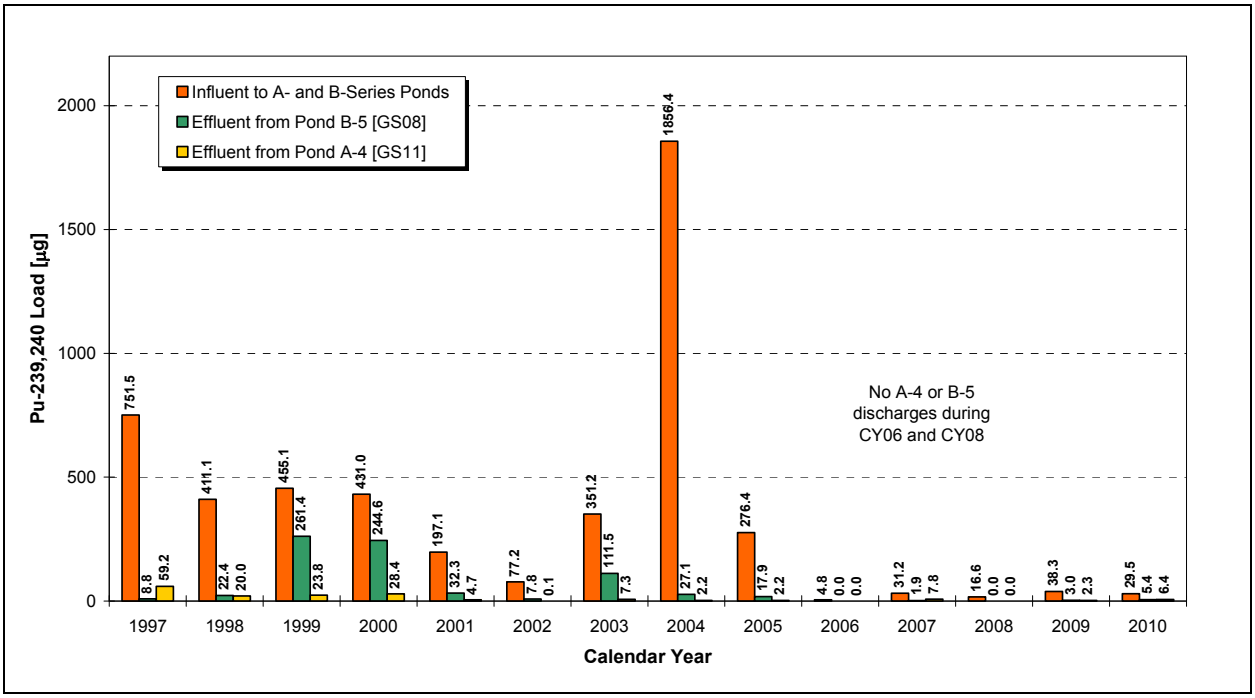
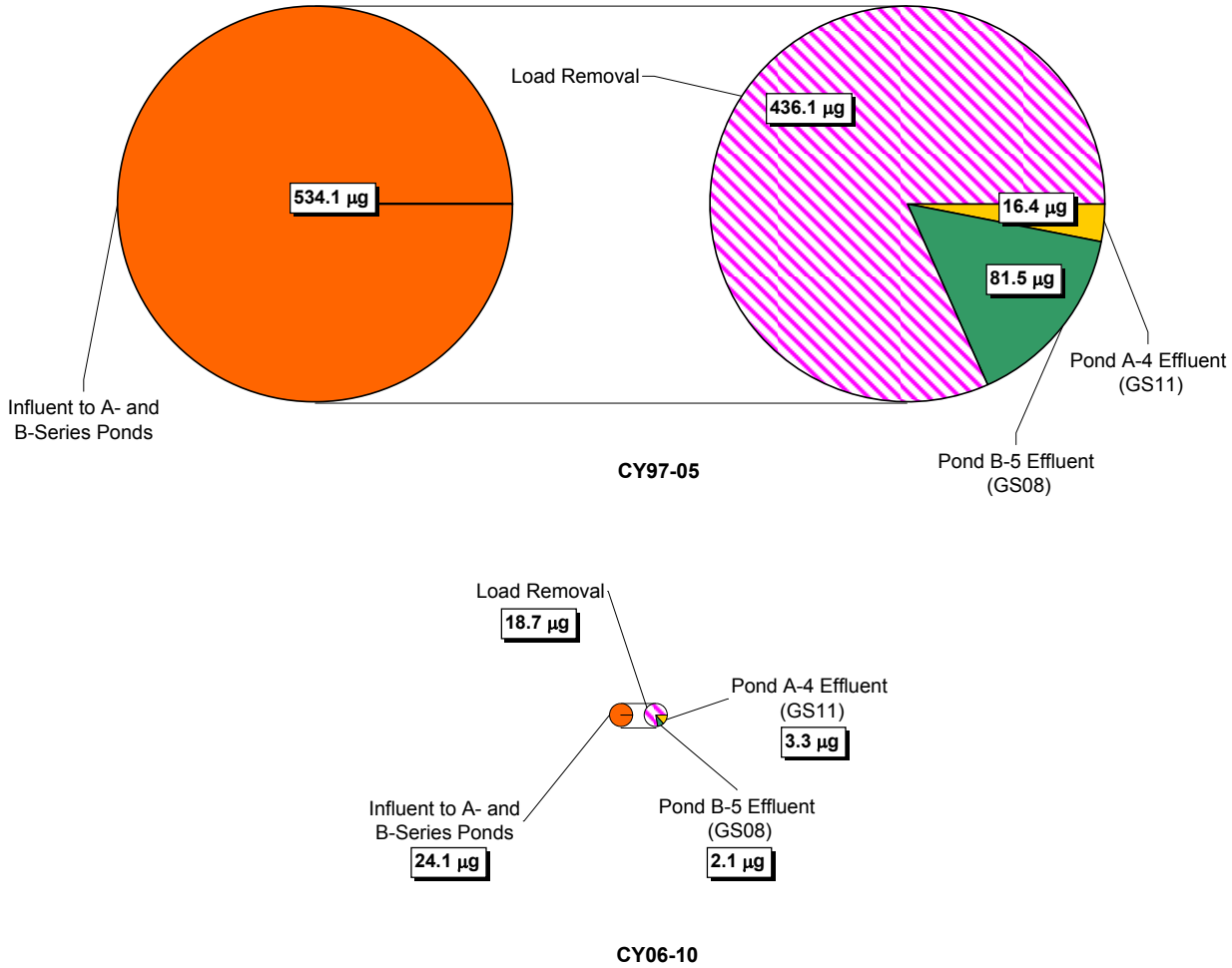


Figure 169. Annual Pu Loads for the A- and B-Series Ponds: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 170. Relative Average Annual Pu Load Totals for the A- and B-Series Ponds

Table 66. Am Load Summary for the A- and B-Series Ponds: CY 1997–2010

Calendar Year	Am-241 (µg)				
	Influent (WWTP)	Influent (GS10)	Influent (SW093)	Effluent (GS08)	Effluent (GS11)
1997	0.64	12.20	2.24	0.25	0.70
1998	0.32	4.69	1.30	0.35	1.25
1999	0.11	12.55	1.73	1.81	0.20
2000	0.29	14.57	0.98	3.14	0.02
2001	0.32	2.75	0.65	0.46	0.11
2002	0.20	1.76	0.52	0.25	0.04
2003	0.52	4.44	2.05	0.54	0.18
2004	0.25	4.68	28.48	0.58	0.14
2005	0.00 WWTP removed	3.98	0.82	0.97	0.43
2006	0.00 WWTP removed	0.04	0.02	0.00; No B-5 discharge	0.00; No A-4 discharge
2007	0.00 WWTP removed	0.14	0.28	0.03	0.02
2008	0.00 WWTP removed	0.09	0.15	0.00; No B-5 discharge	0.00; No A-4 discharge
2009	0.00 WWTP removed	0.15	0.21	0.02	0.09
2010	0.00 WWTP removed	0.15	0.35	0.11	0.14
Total	2.65	62.19	39.80	8.51	3.33

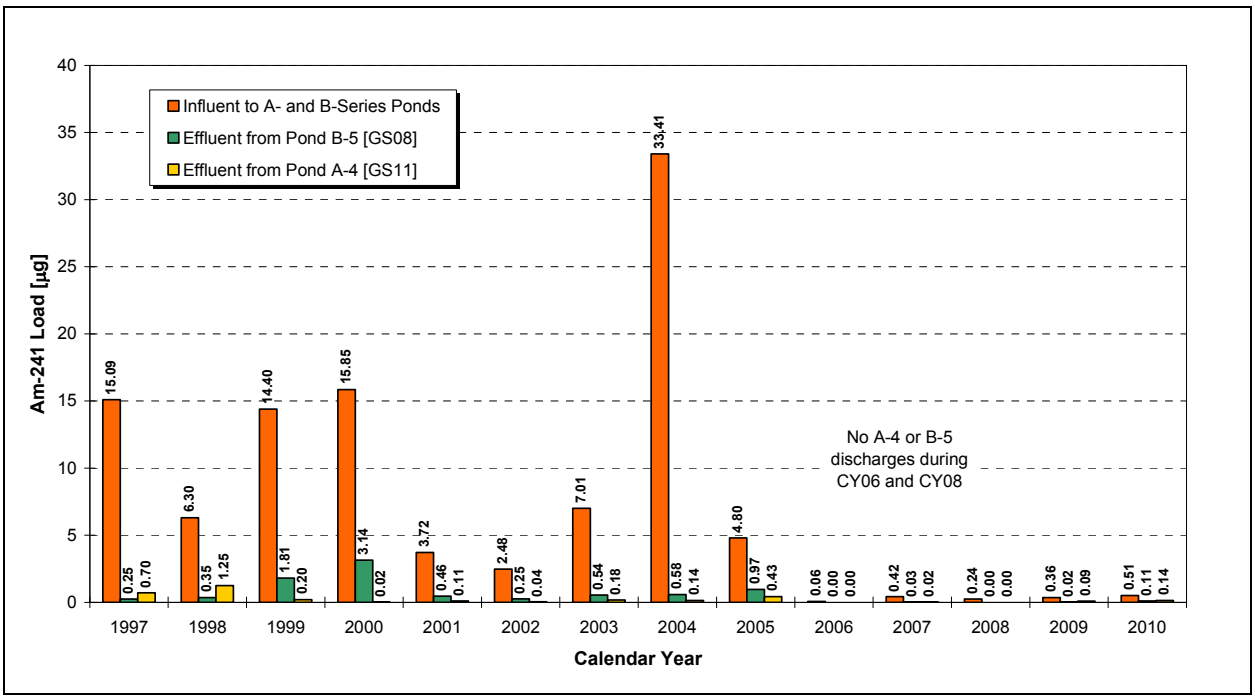
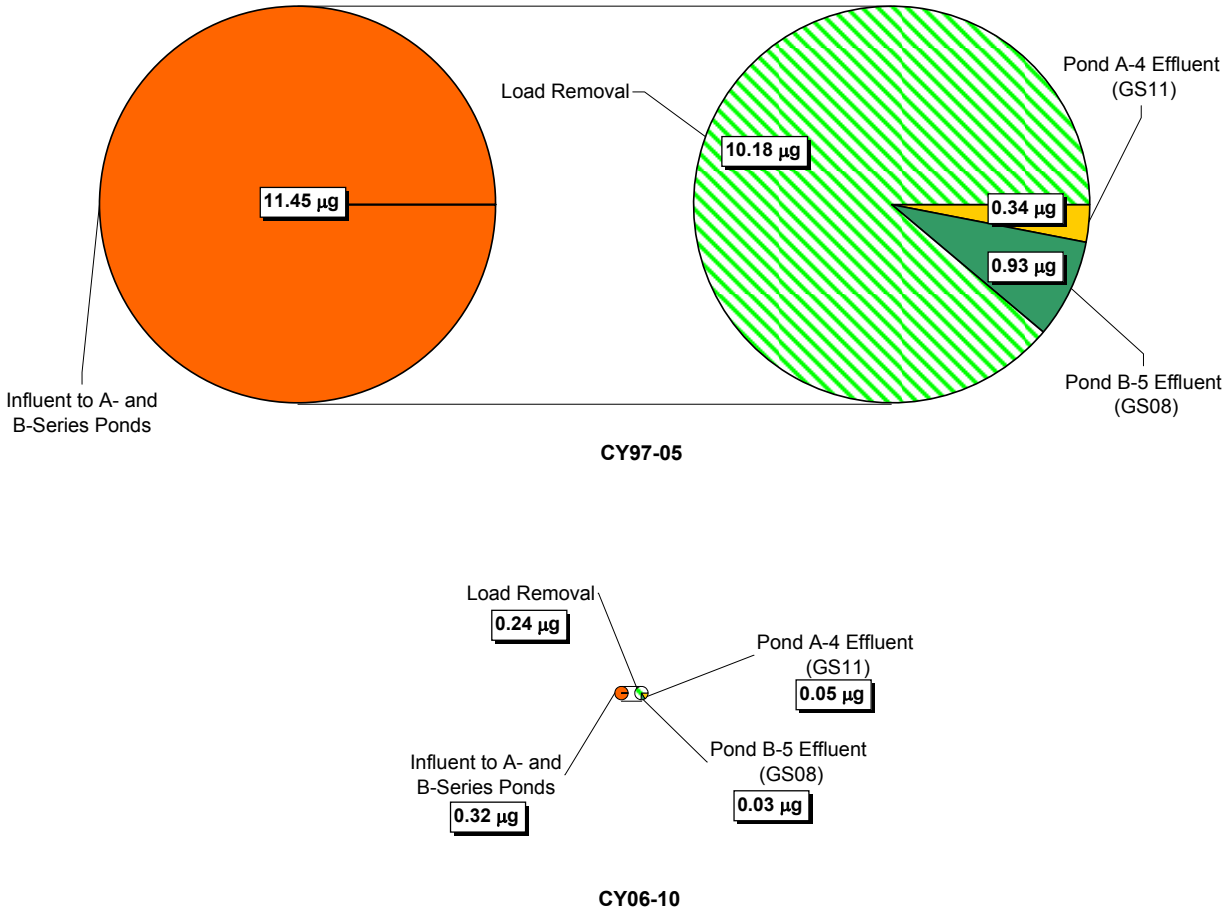
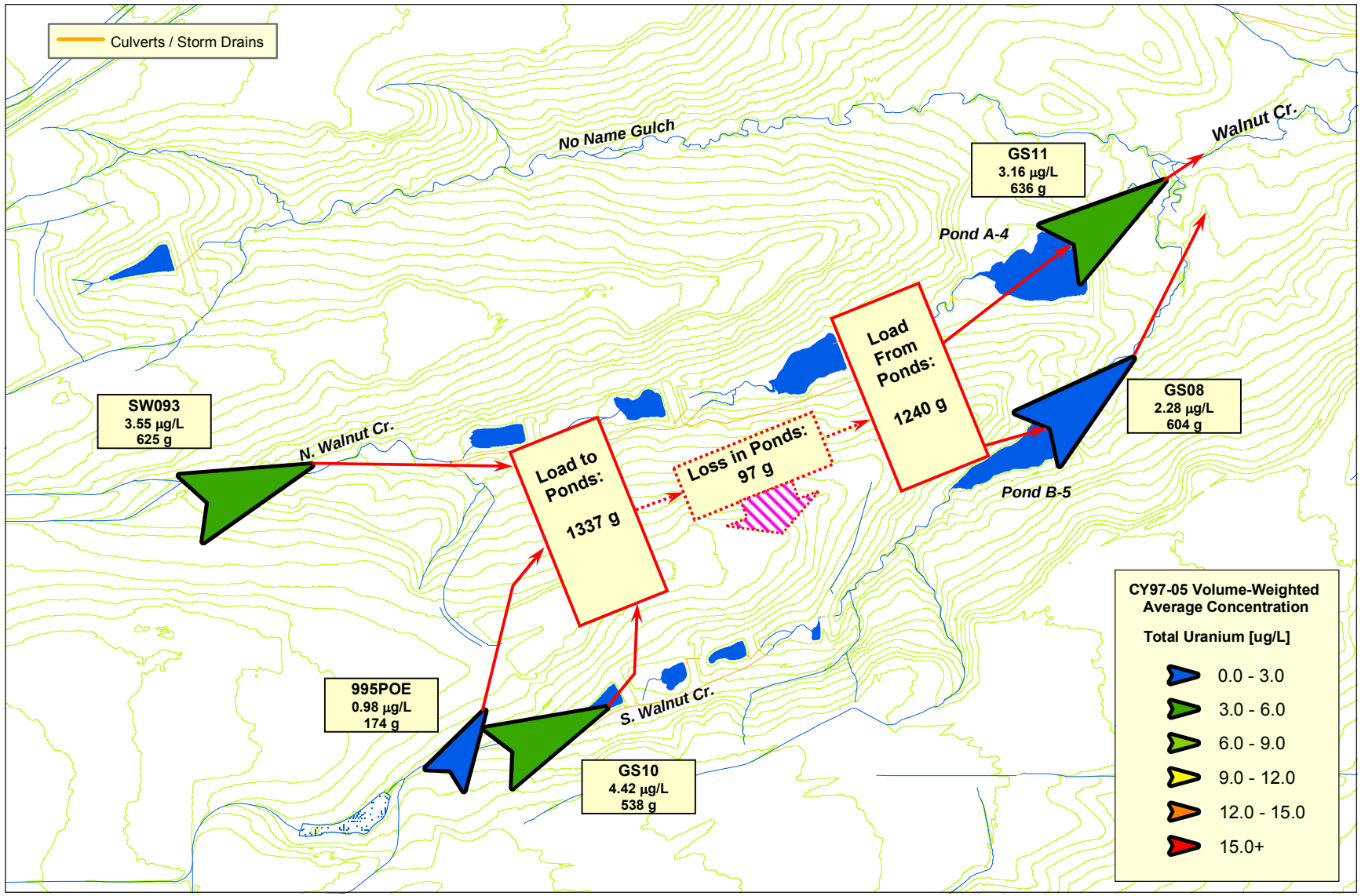


Figure 171. Annual Am Loads for the A- and B-Series Ponds: CY 1997–2010



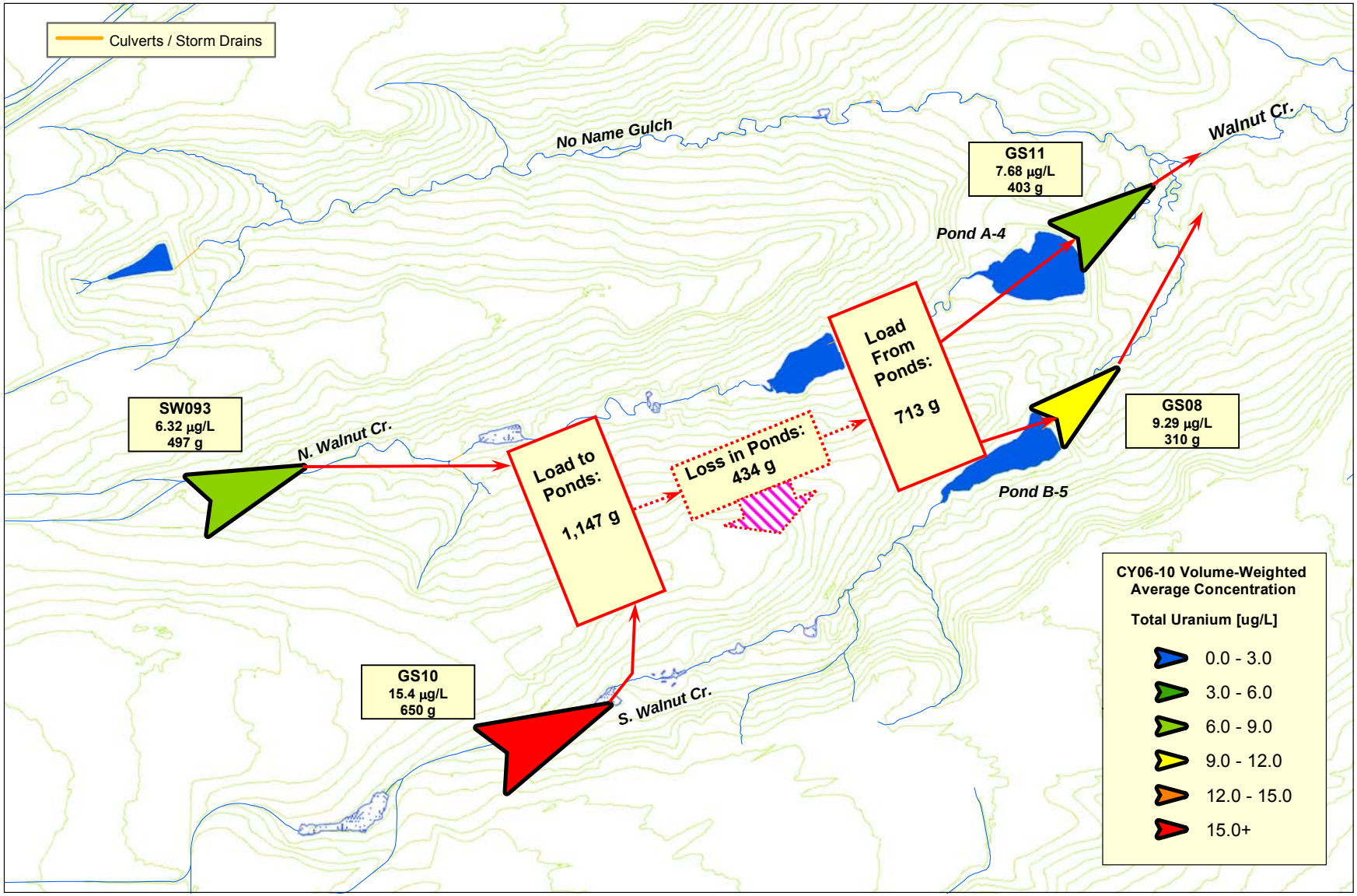
Note: pie chart diameters relative to total load

Figure 172. Relative Average Annual Am Load Totals for the A- and B-Series Ponds



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 173. Relative Average Annual Total U Loading Schematic for the A- and B-Series Ponds: CY 1997–2005



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 174. Relative Average Annual Total U Loading Schematic for the A- and B-Series Ponds: CY 2006–2010

Table 67. Total U Load Summary for the A- and B-Series Ponds: CY 1997–2010

Calendar Year	Total U (g)				
	Influent (WWTP)	Influent (GS10)	Influent (SW093)	Effluent (GS08)	Effluent (GS11)
1997	257	637	853	252	1,365
1998	467	631	797	620	1,301
1999	121	589	714	809	633
2000	103	379	485	465	386
2001	259	519	646	639	564
2002	61	279	450	258	132
2003	161	501	568	610	865
2004	139	430	575	390	316
2005	0 WWTP removed	879	534	1,389	165
2006	0 WWTP removed	230	171	0; No B-5 discharge	0; No A-4 discharge
2007	0 WWTP removed	830	540	481	411
2008	0 WWTP removed	275	154	0; No B-5 discharge	0; No A-4 discharge
2009	0 WWTP removed	756	574	322	405
2010	0 WWTP removed	1,158	1,047	746	1,199
Total	1,569	8,095	8,108	6,981	7,742

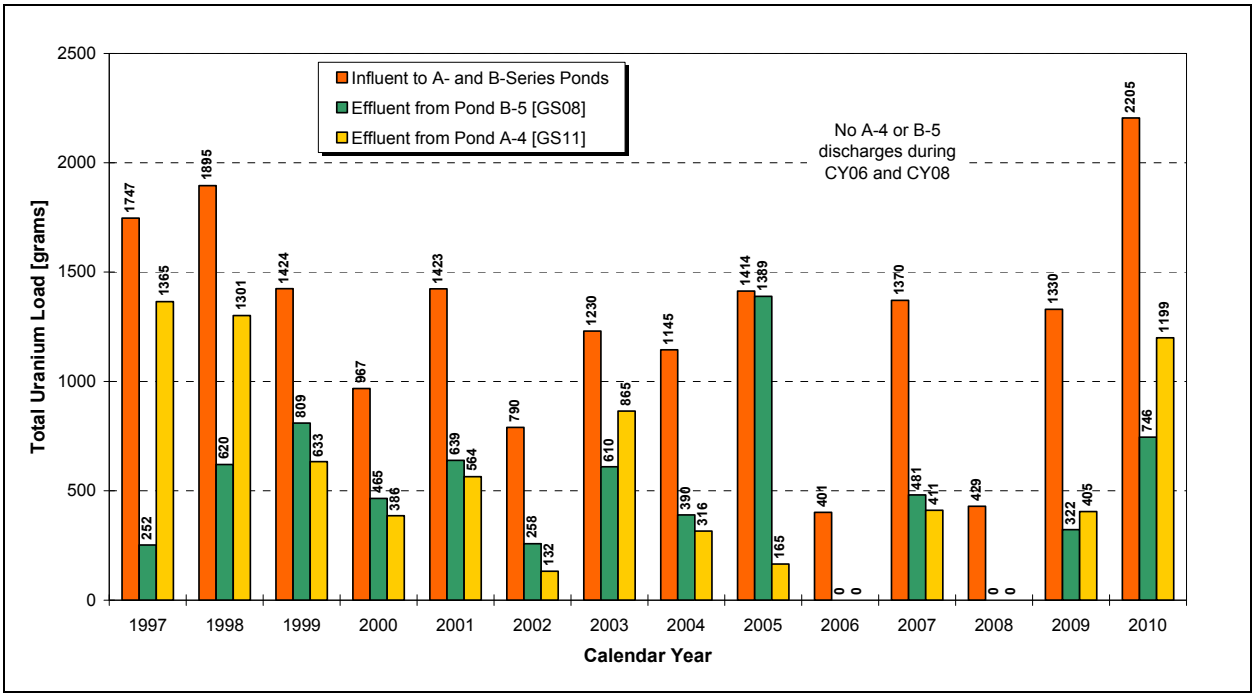
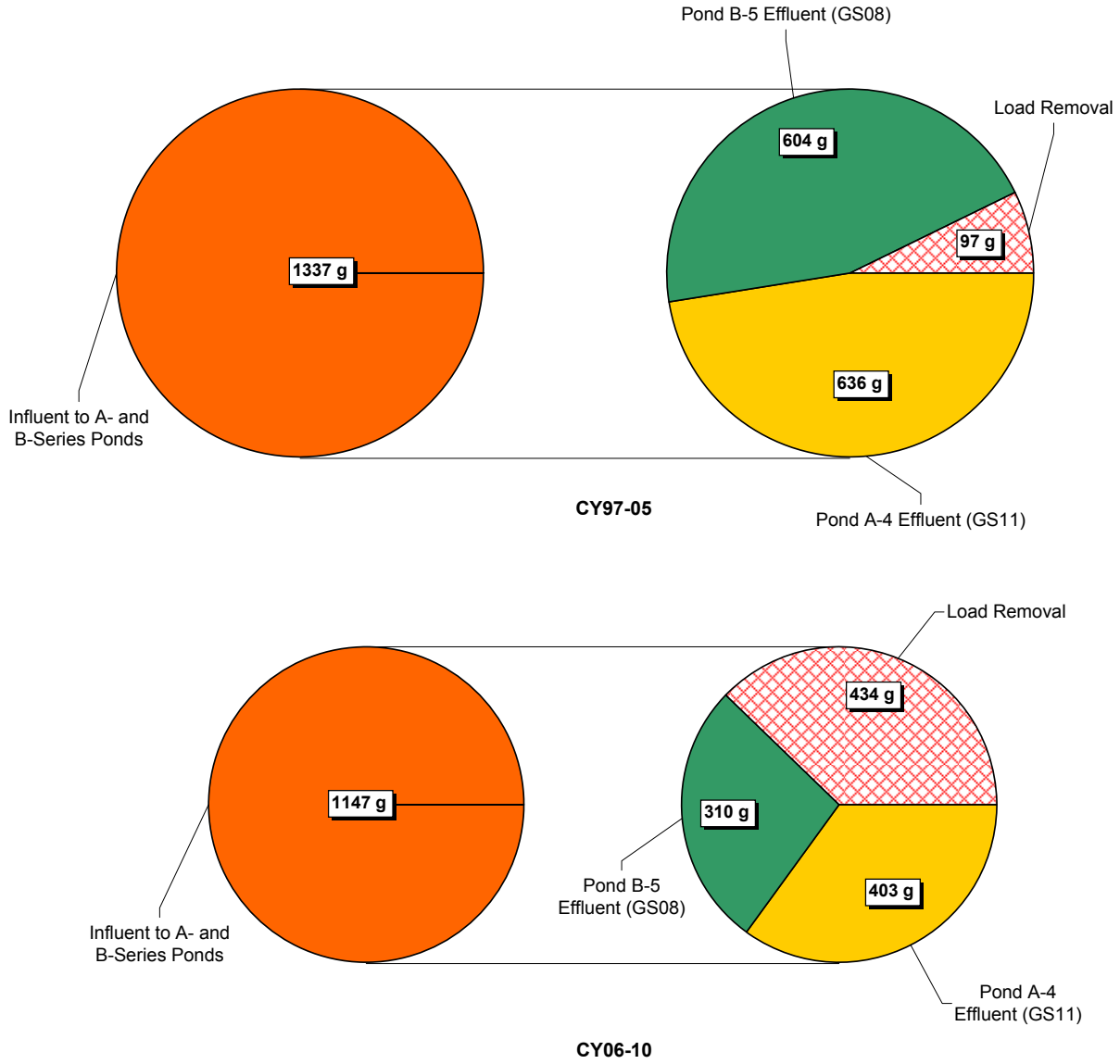


Figure 175. Annual Total U Loads for the A- and B-Series Ponds: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 176. Relative Average Annual Total U Load Totals for the A- and B-Series Ponds

Pond C-2 (POC GS31)

This section summarizes the calculated Pu, Am, and total U loads for Pond C-2. Data are presented in Table 68, Table 69, and Table 70, and depicted on Figure 177, Figure 178, Figure 179, Figure 180, Figure 181, Figure 182, Figure 183, and Figure 184. The influent load source is SW027 (SID at Pond C-2 inlet). The effluent loads are calculated at GS31 (Pond C-2 outlet). The following points are noted:

- Annual Pu and Am loads vary significantly year to year (Figure 177 and Figure 179). A significant increase in both Pu and Am loads influent to Pond C-2 is noted during CY 2004 due to increased solids transport from extensive soil disturbance in the drainage associated with the 903 Pad/Lip accelerated actions. With the enhanced implementation of erosion

controls, revegetation, and soil stabilization, a significant reduction is noted for CY 2005−2010. Post-closure influent and effluent Pu loads have been reduced by 91 percent and 90 percent, respectively. Similarly, Post-closure influent and effluent Am loads have been reduced by 87 percent and 91 percent, respectively.

- Annual total U loads also vary significantly year to year (Figure 183). Post-closure influent and effluent U loads have been reduced by 69 percent and 73 percent, respectively.
- There is a measurable pre-closure average annual total U load gain in Pond C-2 (Figure 181). This is likely due to seepage with naturally occurring U entering Pond C-2 from the Woman Creek Diversion Canal. Post-closure, there is a similar gain in total U in Pond C-2.

Table 68. Pu Load Summary for Terminal Pond C-2: CY 1997–2010

Calendar Year	Pu-239,240 (µg)	
	Influent (SW027)	Effluent (GS31)
1997	17.4	16.7
1998	87.7	2.2
1999	34.3	26.9
2000	67.2	0.0; No C-2 discharge
2001	10.7	11.0
2002	0.3	0.2
2003	45.1	11.0
2004	820.8	11.5
2005	18.6	5.0
2006	0.0; No flow	0.0; No C-2 discharge
2007	16.5	0.0; No C-2 discharge
2008	0.0; No flow	0.0; No C-2 discharge
2009	6.9	4.1
2010	32.4	0.4
Total	1,157.9	89.0

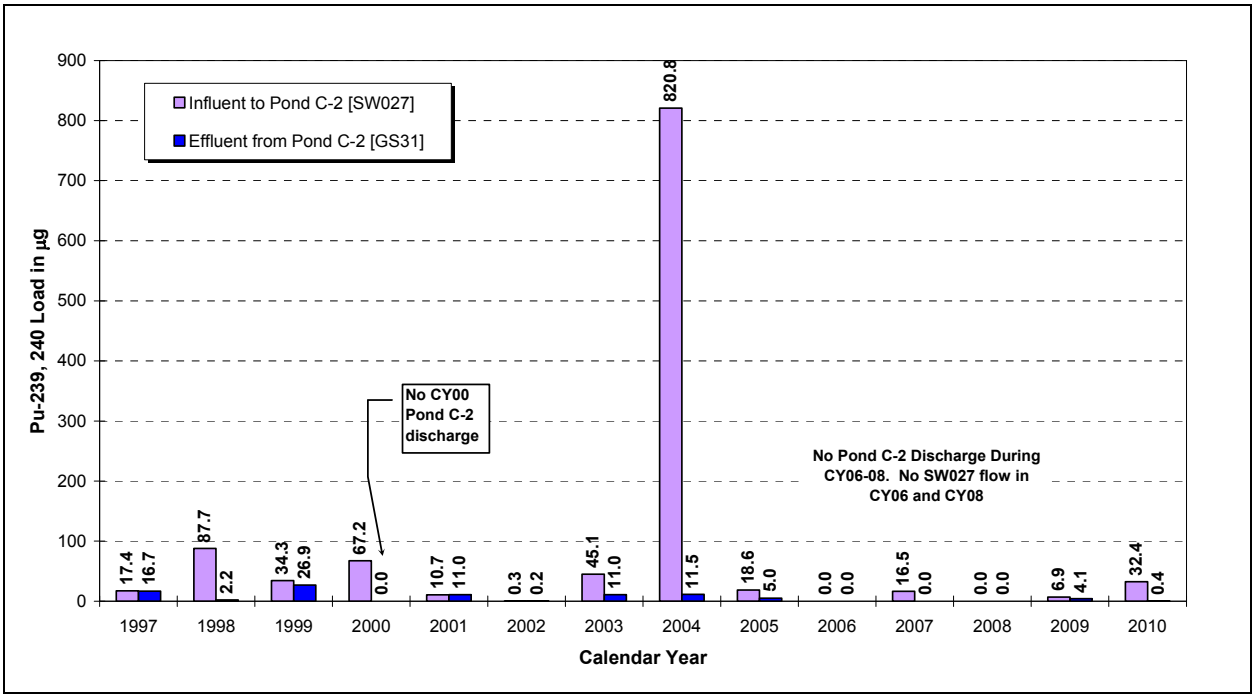
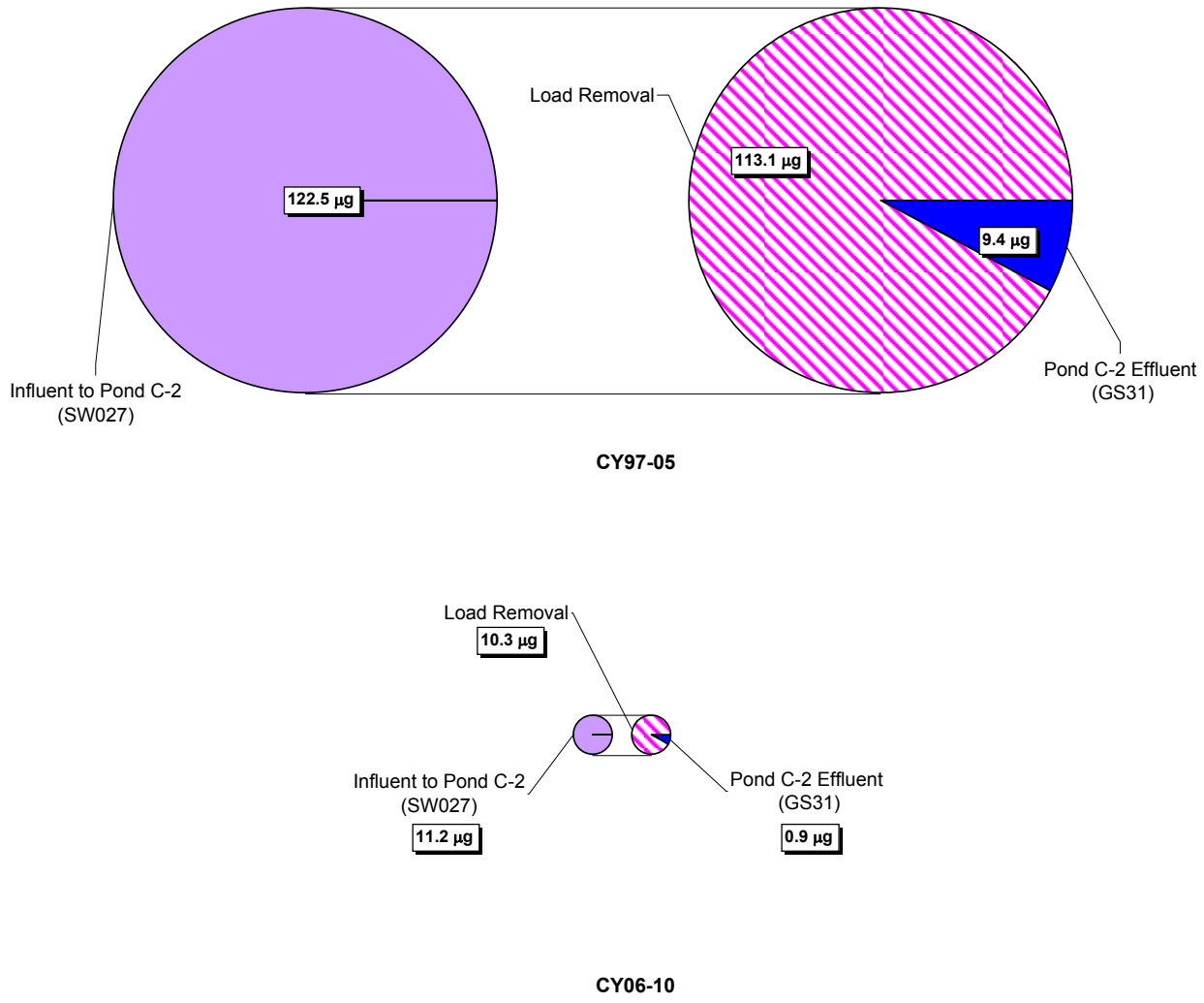


Figure 177. Annual Pu Loads for Pond C-2: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 178. Relative Average Annual Pu Load Totals for Pond C-2

Table 69. Am Load Summary for Terminal Pond C-2: CY 1997–2010

Calendar Year	Am-241 (µg)	
	Influent (SW027)	Effluent (GS31)
1997	0.08	0.17
1998	0.25	0.27
1999	0.20	0.13
2000	0.24	0.00; No C-2 discharge
2001	0.05	0.14
2002	0.00	<0.01
2003	0.12	0.09
2004	3.09	0.11
2005	0.05	0.04
2006	0.00; No flow	0.00; No C-2 discharge
2007	0.15	0.00; No C-2 discharge
2008	0.00; No flow	0.00; No C-2 discharge
2009	0.02	0.03
2010	0.12	0.02
Total	4.39	1.00

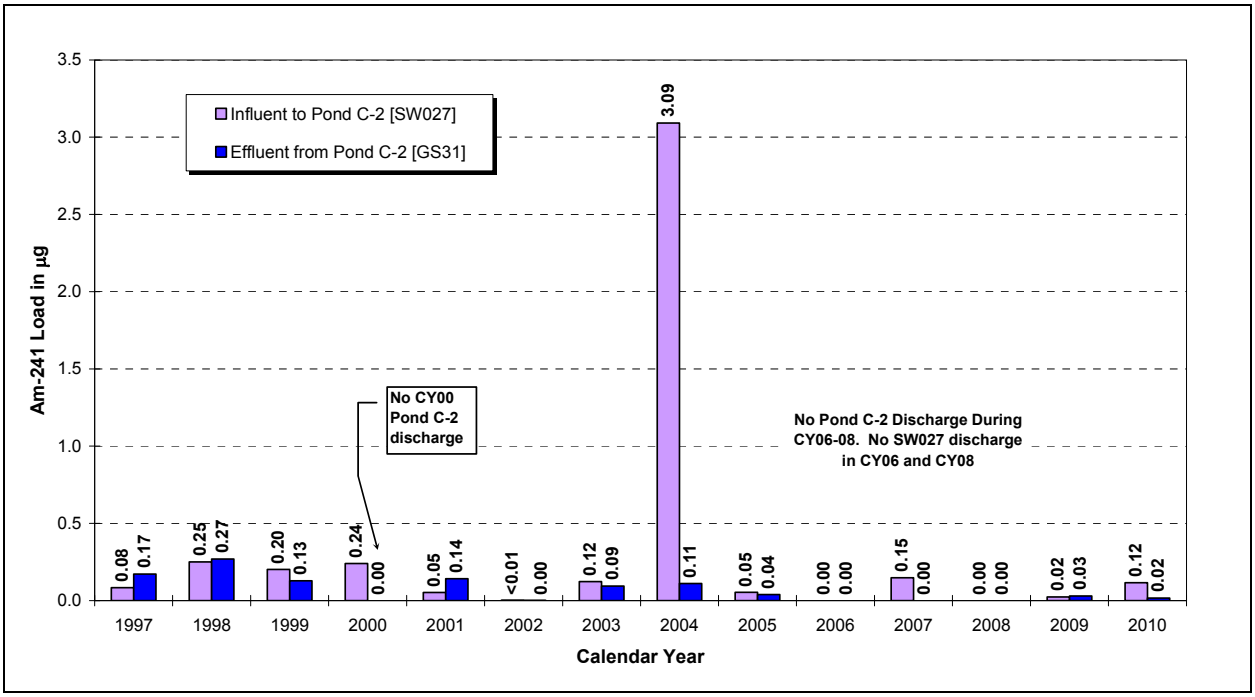
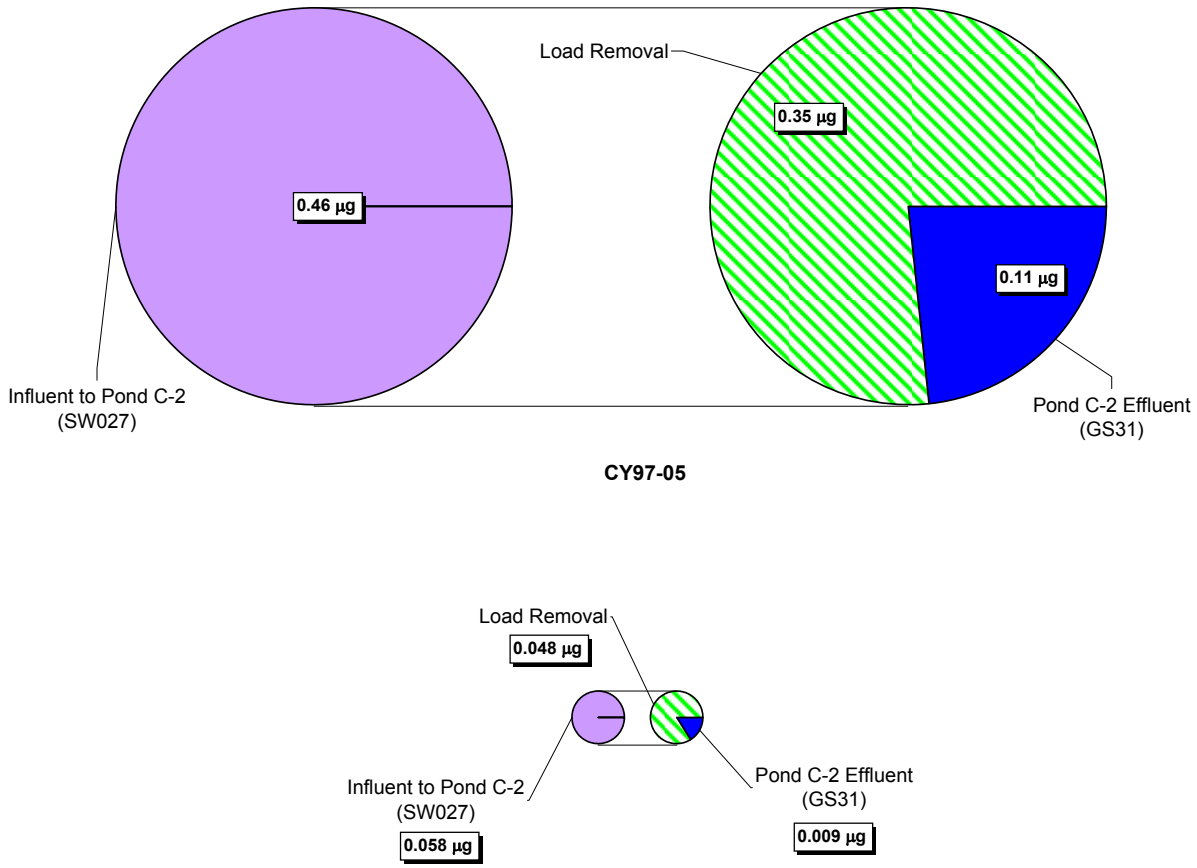


Figure 179. Annual Am Loads for Pond C-2: CY 1997–2010

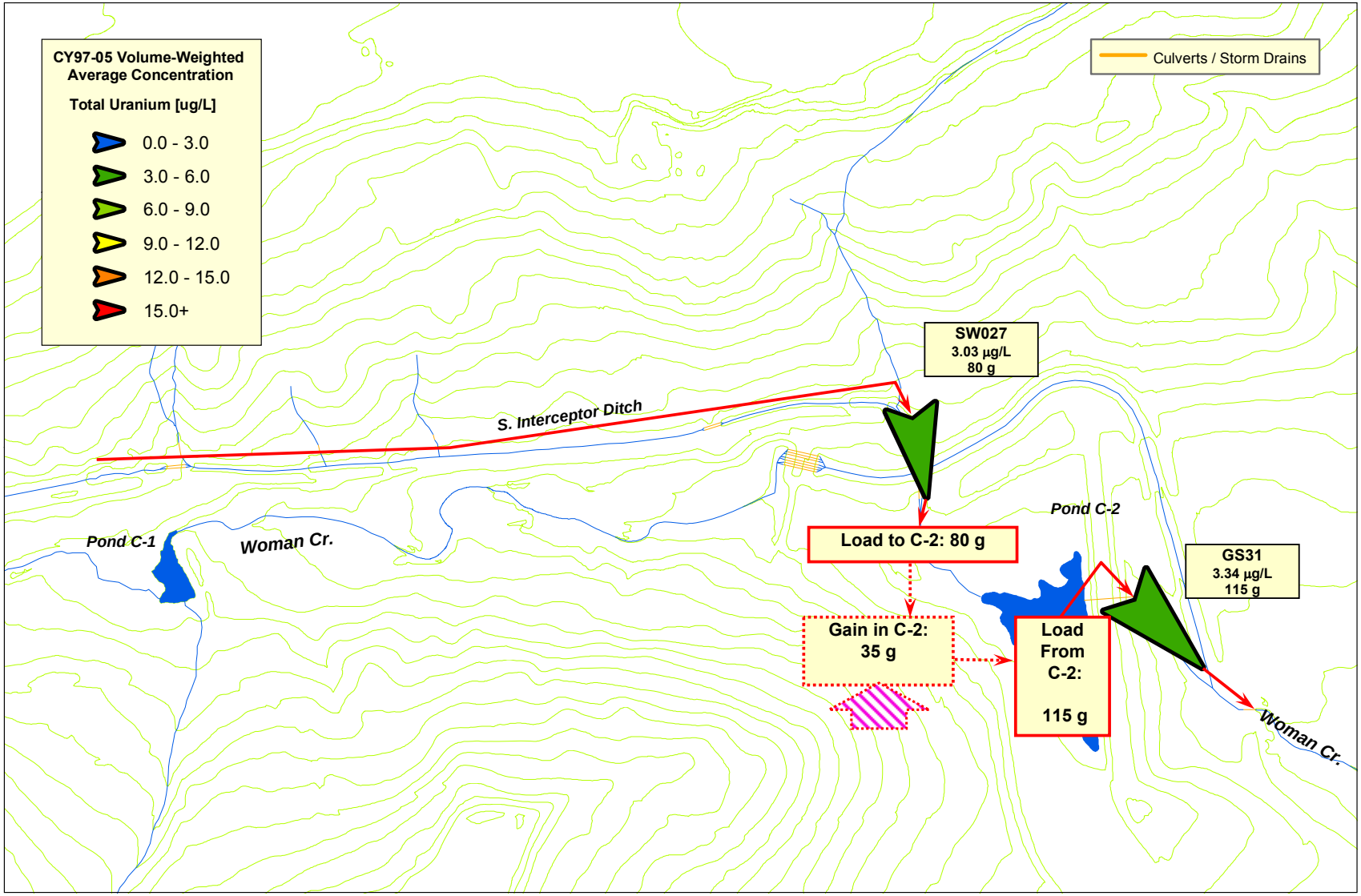


Note: pie chart diameters relative to total load

Figure 180. Relative Average Annual Am Load Totals for Pond C-2

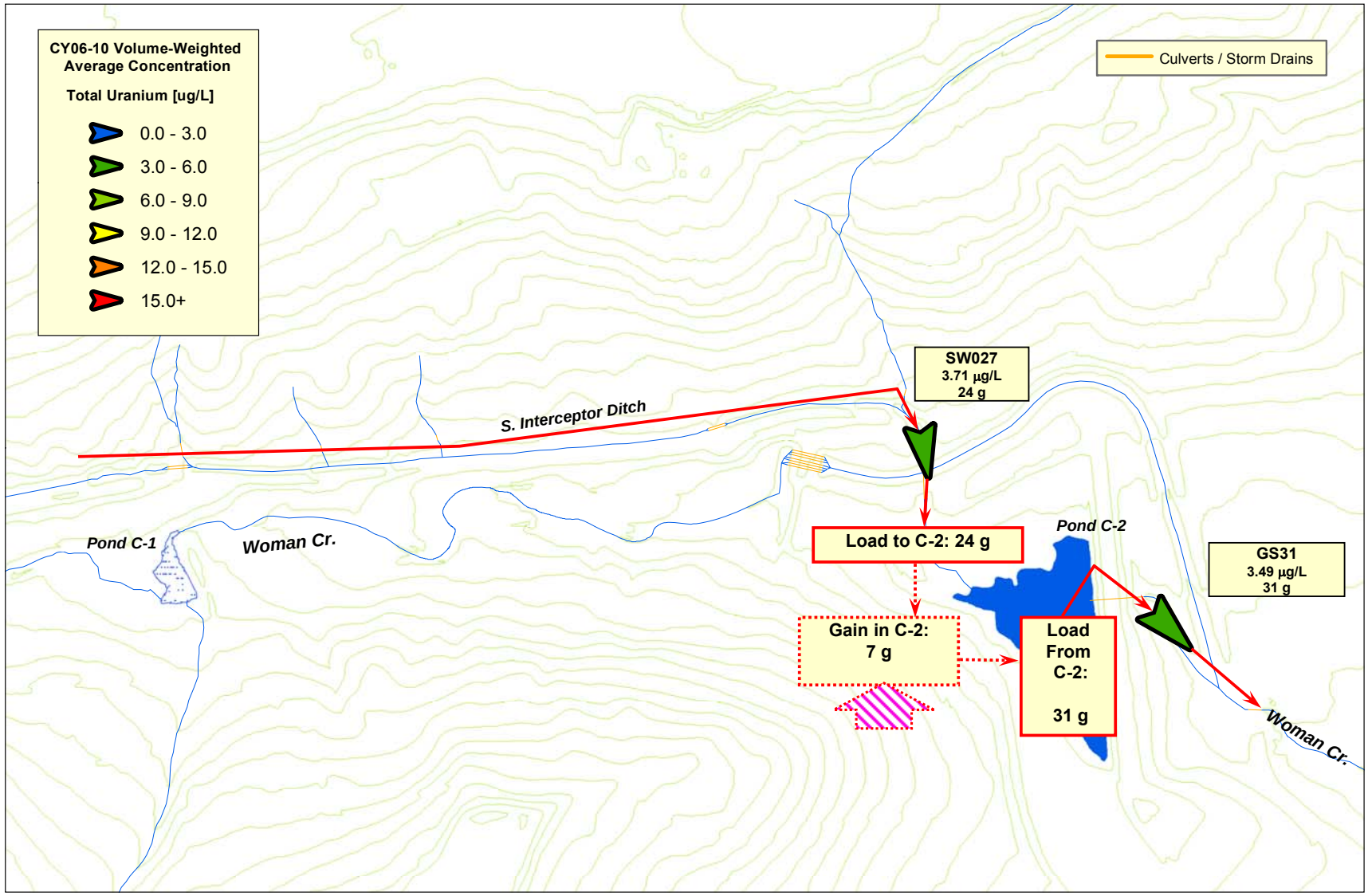
Table 70. Total U Load Summary for Terminal Pond C-2: CY 1997–2010

Calendar Year	Total U (g)	
	Influent (SW027)	Effluent (GS31)
1997	84	231
1998	239	216
1999	116	189
2000	22	0.00; No C-2 discharge
2001	66	67
2002	7	1
2003	111	129
2004	40	92
2005	33	115
2006	0; No flow	0; No C-2 discharge
2007	36	0; No C-2 discharge
2008	0; No flow	0; No C-2 discharge
2009	16	95
2010	70	61
Total	840	1,195



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 181. Relative Average Annual U Loading Schematic for Pond C-2: CY 1997–2005



Note: Location symbols are displayed proportional to calculated average annual load and colored according to concentration ranges in legend.

Figure 182. Relative Average Annual U Loading Schematic for Pond C-2: CY 2006–2010

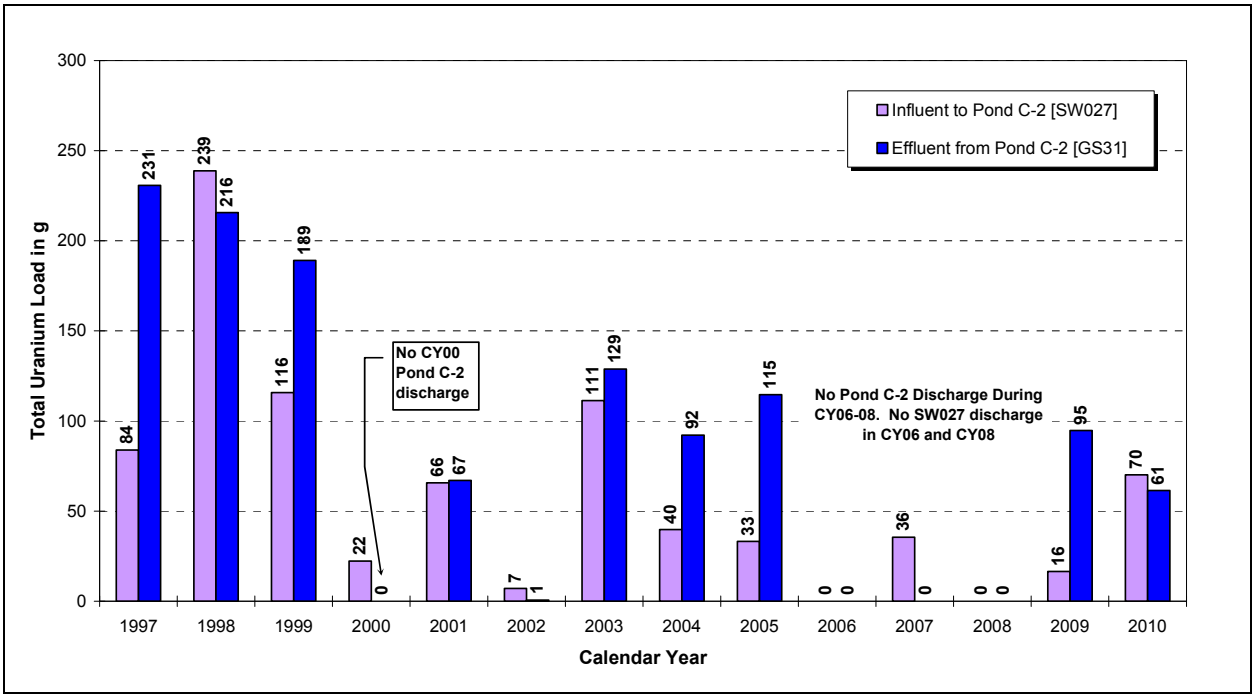
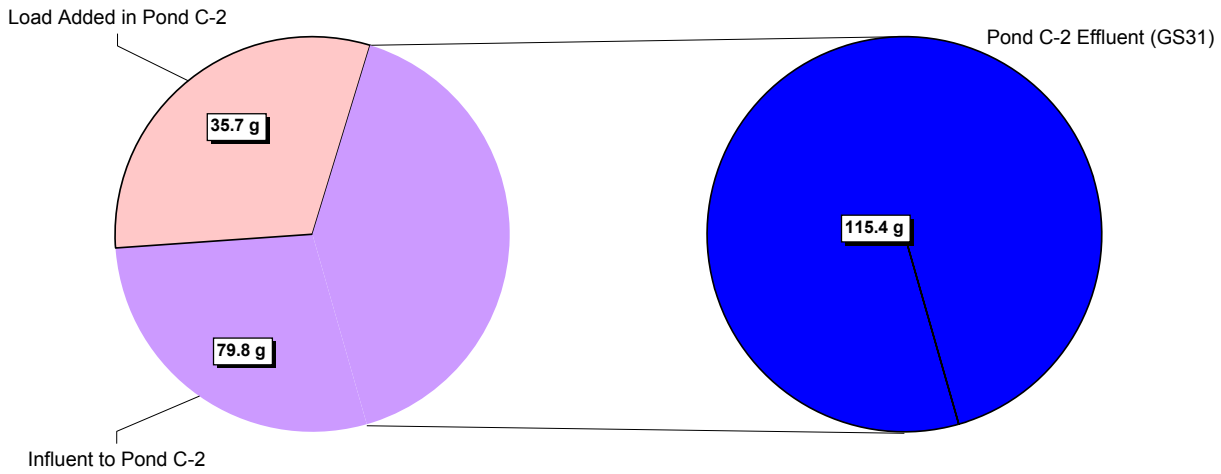
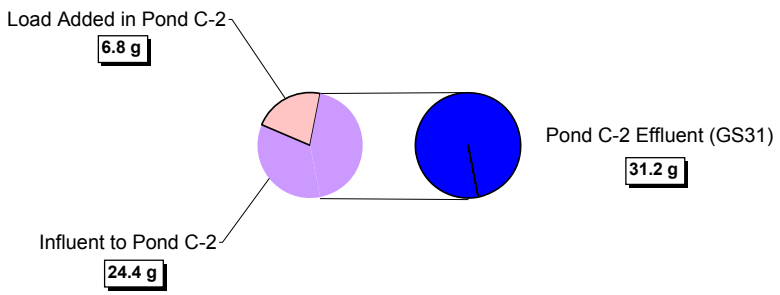


Figure 183. Annual Total U Loads for Pond C-2: CY 1997–2010



CY97-05



CY06-10

Note: pie chart diameters relative to total load

Figure 184. Relative Average Annual Total U Load Totals for Pond C-2

RFLMA Points of Evaluation

Major COU Drainages

This section summarizes the calculated Pu, Am, and total U loads for the three major COU drainages: North Walnut Creek (SW093), South Walnut Creek (GS10 and the former WWTP), and the SID (SW027). Data are presented in Table 71 and Table 72 and are depicted on Figure 185, Figure 186, Figure 187, Figure 188, Figure 189, Figure 190, Figure 191, Figure 192, Figure 193, and Figure 194. The following points are noted:

- Total Pu load varies year to year and shows a significant increase in CY 2004 due to extensive soil disturbance (Figure 185). With the implementation of remedial actions, erosion controls, revegetation, and soil stabilization, a significant reduction is noted for CY 2006−2010. Post-closure Pu loads have been reduced by 95 percent.
- Total Am load also varies year to year and shows a measurable increase in CY 2004 due to soil disturbance and contributions from the B771 area (Figure 187). With the implementation of remedial actions, erosion controls, revegetation, and soil stabilization, a significant reduction is noted for CY 2006−2010. Data from SW093 in CY 2005 (Figure 192) also clearly show that the B771 pathway elimination was successful. Post-closure Am loads have been reduced by 97 percent.
- South Walnut Creek accounts for a majority (47 percent) of the Pu load from the COU (Figure 186) pre-closure. Of the South Walnut Creek Pu load, GS10 accounted for 97 percent, and the former WWTP accounted for the remaining 3 percent. Post-closure, North Walnut Creek is the largest contributor (41 percent) of Pu load; this is attributed to larger streamflow volumes and not significantly higher activities.
- South Walnut Creek accounts for a majority (60 percent) of the Am load from the COU (Figure 188) pre-closure. Of the South Walnut Creek Am load, GS10 accounted for 96 percent, and the former WWTP accounted for the remaining 4 percent. Post-closure, North Walnut Creek accounts for the majority (55 percent) of the Am loads; this is attributed to larger streamflow volumes and not significantly higher activities.
- Annual total U loads are more consistent year to year (Figure 193). The load reductions in CY 2006 and 2008 are due to flow volume reduction and not a decrease in U concentration. Similarly, the load increase in CY 2010 is due to large flow volumes and not a significant increase in U concentration. Post-closure U loads have been reduced by 17 percent.
- Pre-closure total U loads are fairly evenly divided (44 percent to 50 percent) between North and South Walnut Creeks (Figure 194). Post-closure, proportions are similar.

Table 71. COU Pu and Am Loads: CY 1997–2010

Calendar Year	Pu-239,240 (µg)				Am-241 (µg)			
	North Walnut Creek (SW093)	South Walnut Creek (GS10)	South Walnut Creek (WWTP)	SID (SW027)	North Walnut Creek (SW093)	South Walnut Creek (GS10)	South Walnut Creek (WWTP)	SID (SW027)
1997	164.2	576.0	11.2	17.4	2.24	12.20	0.64	0.08
1998	69.1	328.6	13.4	87.7	1.30	4.69	0.32	0.25
1999	127.8	307.9	19.4	34.3	1.73	12.55	0.11	0.20
2000	87.4	326.2	17.4	67.2	0.98	14.57	0.29	0.24
2001	44.4	141.4	11.3	10.7	0.65	2.75	0.32	0.05
2002	9.6	59.3	8.3	0.3	0.52	1.76	0.20	0.00
2003	140.1	207.2	3.8	45.1	2.05	4.44	0.52	0.12
2004	1,330.9	523.3	2.1	820.8	28.48	4.68	0.25	3.09
2005	29.2	247.1	0.0; WWTP removed	18.6	0.82	3.98	0.00; WWTP removed	0.05
2006	2.5	2.3	0.0; WWTP removed	0.0; No flow	0.02	0.04	0.00; WWTP removed	0.00; No flow
2007	17.0	14.2	0.0; WWTP removed	16.5	0.28	0.14	0.00; WWTP removed	0.15
2008	13.2	3.5	0.0; WWTP removed	0.0; No flow	0.15	0.09	0.00; WWTP removed	0.00; No flow
2009	23.0	15.2	0.0; WWTP removed	6.9	0.21	0.15	0.00; WWTP removed	0.02
2010	16.4	13.1	0.0; WWTP removed	32.4	0.35	0.15	0.00; WWTP removed	0.12
Total	2,075.0	2,765.4	86.9	1,157.9	39.80	62.19	2.65	4.39

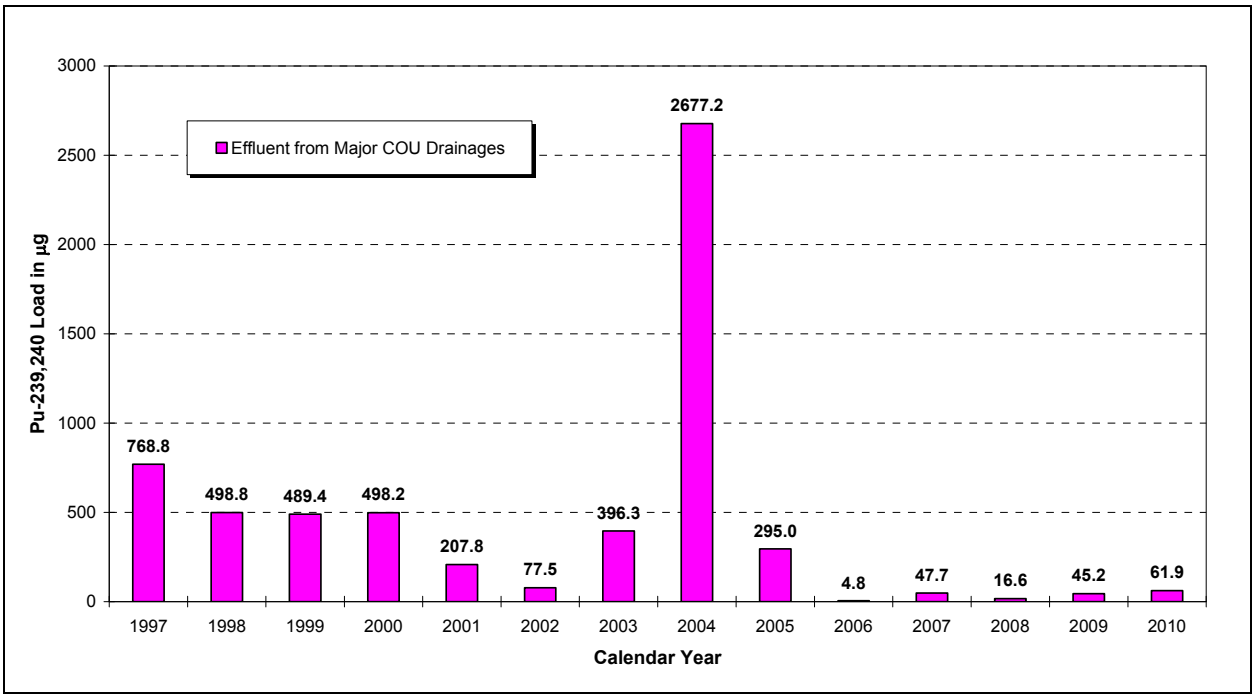
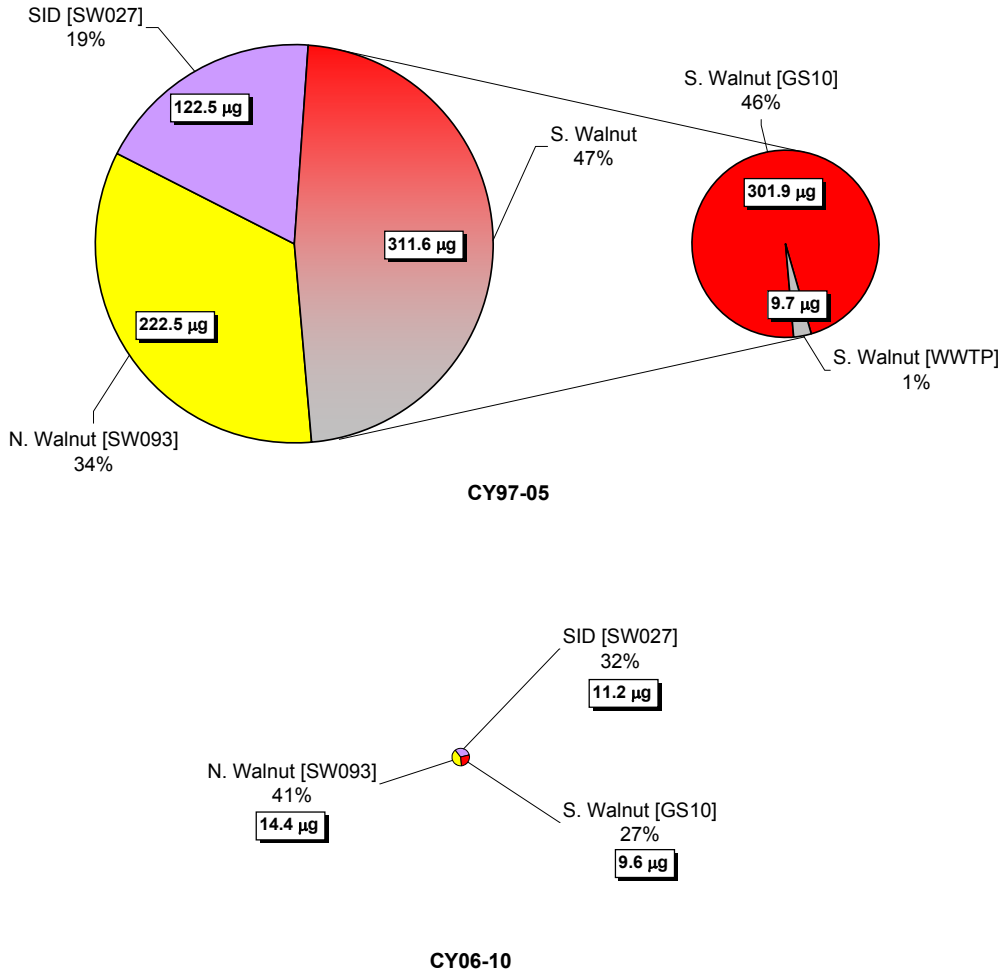


Figure 185. Combined Annual Pu Loads from Major COU Drainages and Former WWTP: CY 1997–2010



Note: pie chart diameters relative to total load

Figure 186. Relative Average Annual Pu Load Totals from Major COU Drainages and Former WWTP

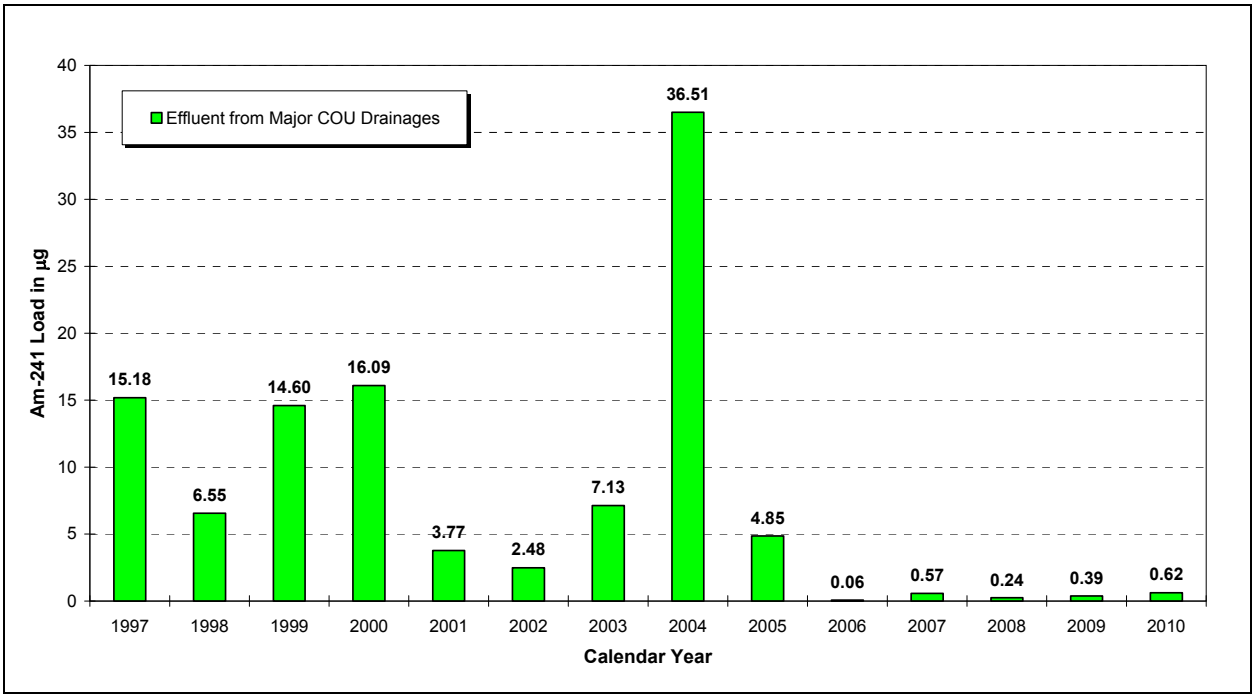
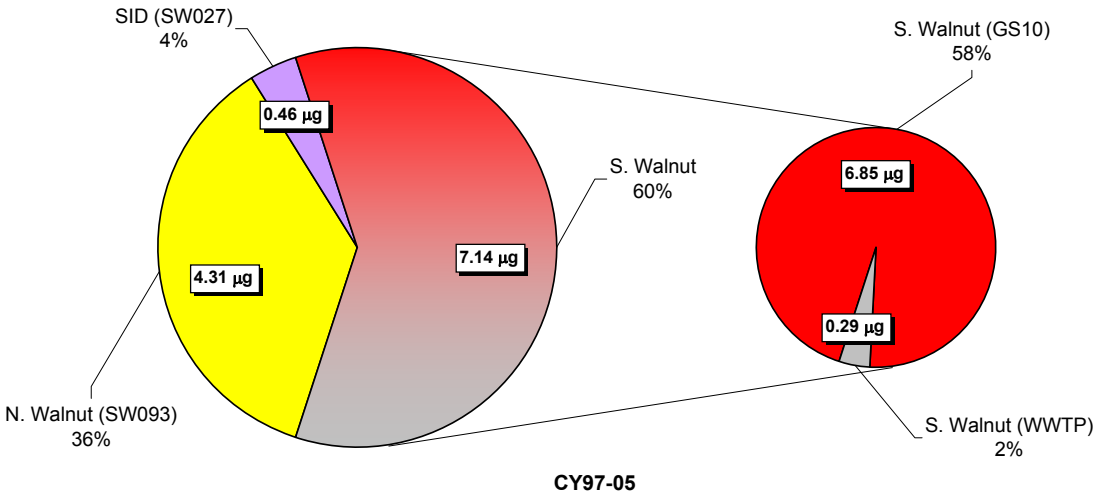
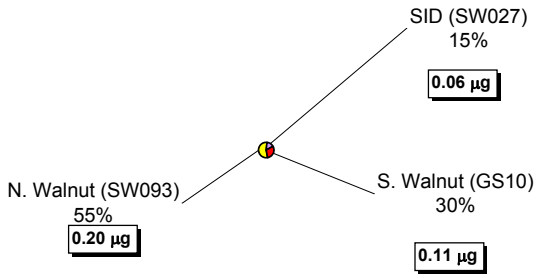


Figure 187. Annual Am Loads from Major COU Drainages and WWTP: CY 1997–2010



CY97-05



CY06-10

Note: pie chart diameters relative to total load

Figure 188. Relative Average Annual Am Load Totals from Major COU Drainages and WWTP

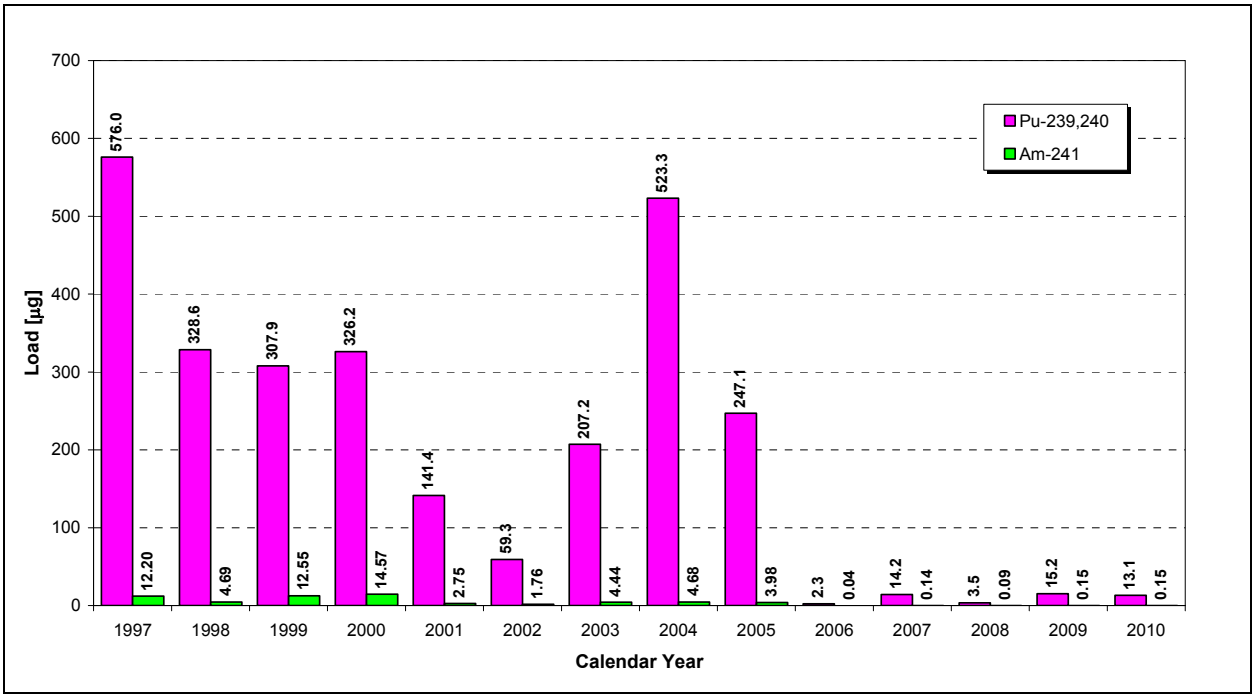


Figure 189. Annual Pu and Am Loads at GS10: CY 1997–2010

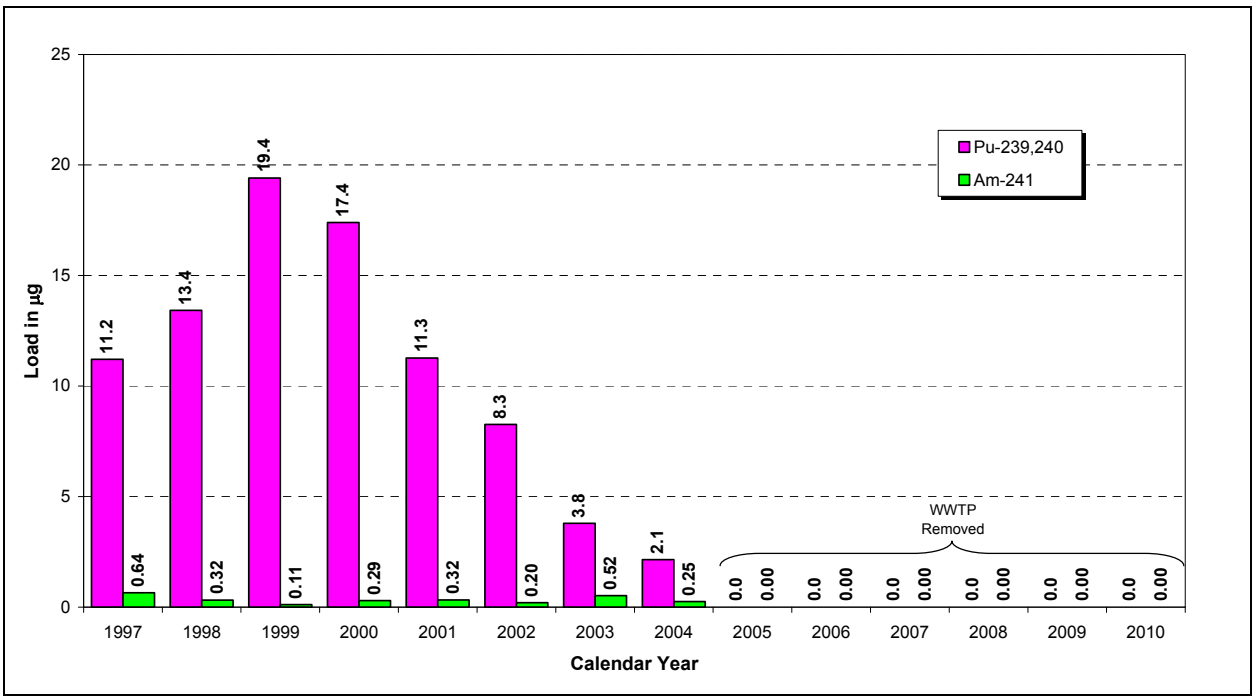


Figure 190. Annual Pu and Am Loads at the WWTP: CY 1997–2010

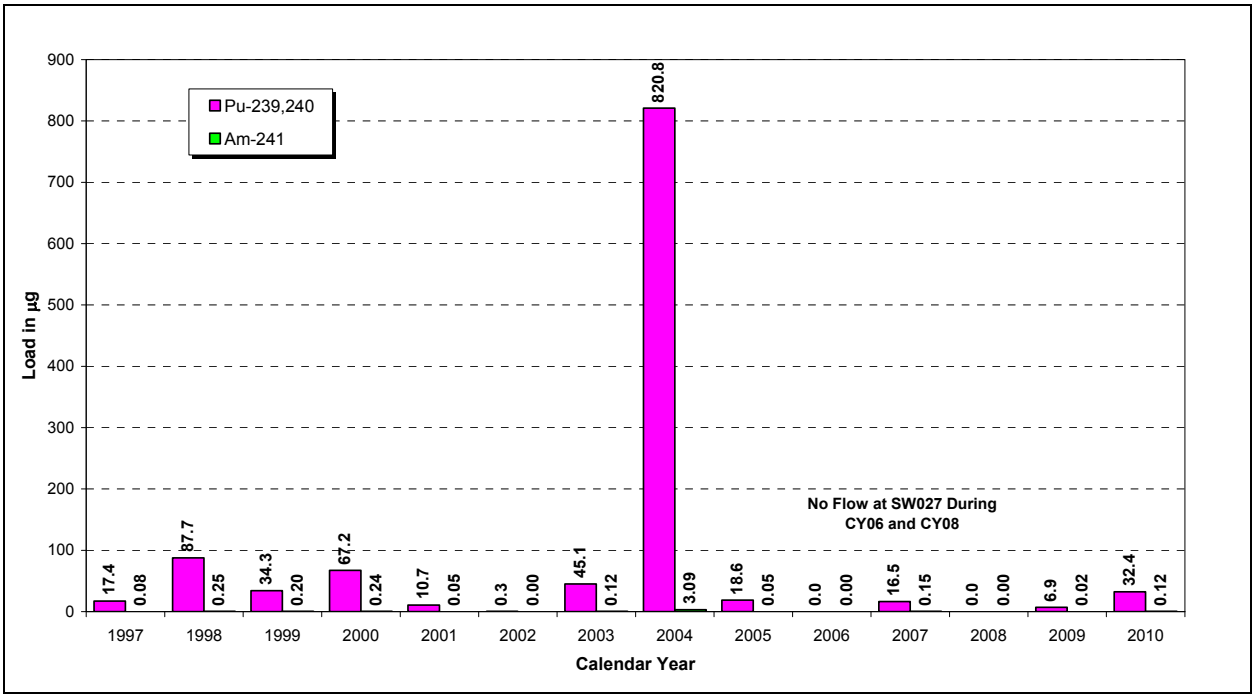


Figure 191. Annual Pu and Am Loads at SW027: CY 1997–2010

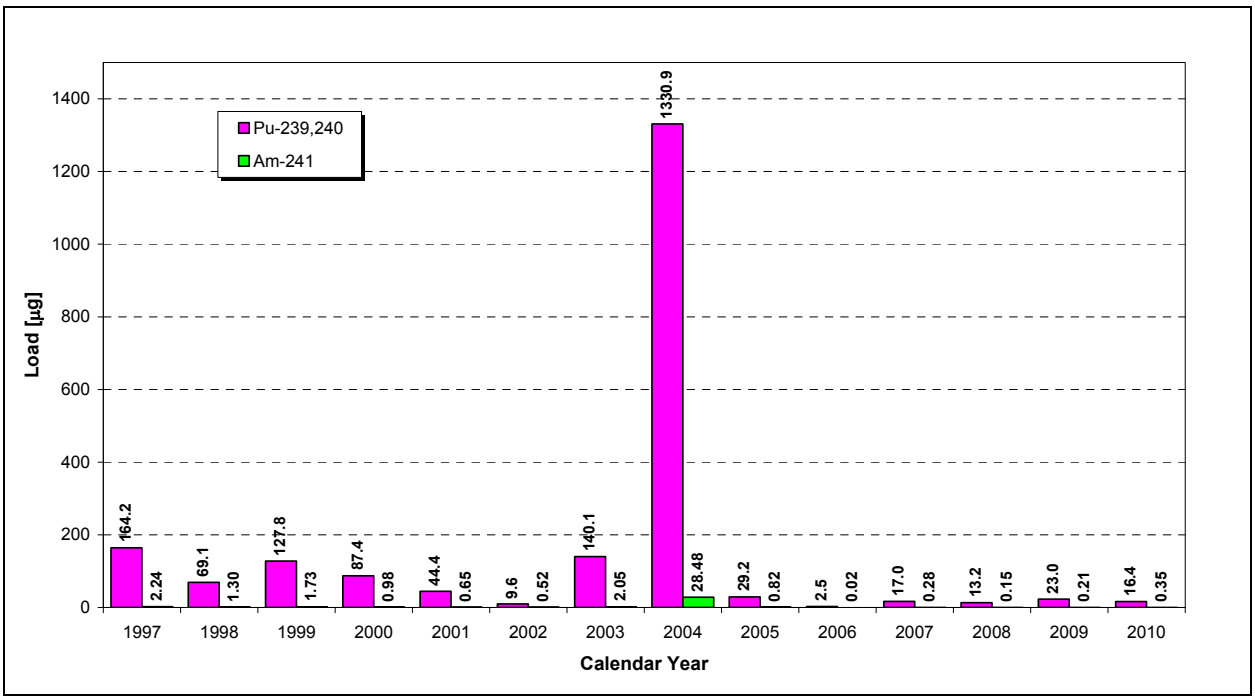


Figure 192. Annual Pu and Am Loads at SW093: CY 1997–2010

Table 72. COU Total U Loads: CY 1997–2010

Calendar Year	Total U (g)			
	North Walnut Creek (SW093)	South Walnut Creek (GS10)	South Walnut Creek (WWTP)	SID (SW027)
1997	853	637	257	84
1998	797	631	467	239
1999	714	589	121	116
2000	485	379	103	22
2001	646	519	259	66
2002	450	279	61	7
2003	568	501	161	111
2004	575	430	139	40
2005	534	879	0; WWTP removed	33
2006	171	230	0; WWTP removed	0; No flow
2007	540	830	0; WWTP removed	36
2008	154	275	0; WWTP removed	0; No flow
2009	574	756	0; WWTP removed	16
2010	1,047	1,158	0; WWTP removed	70
Total	8,108	8,095	1,569	840

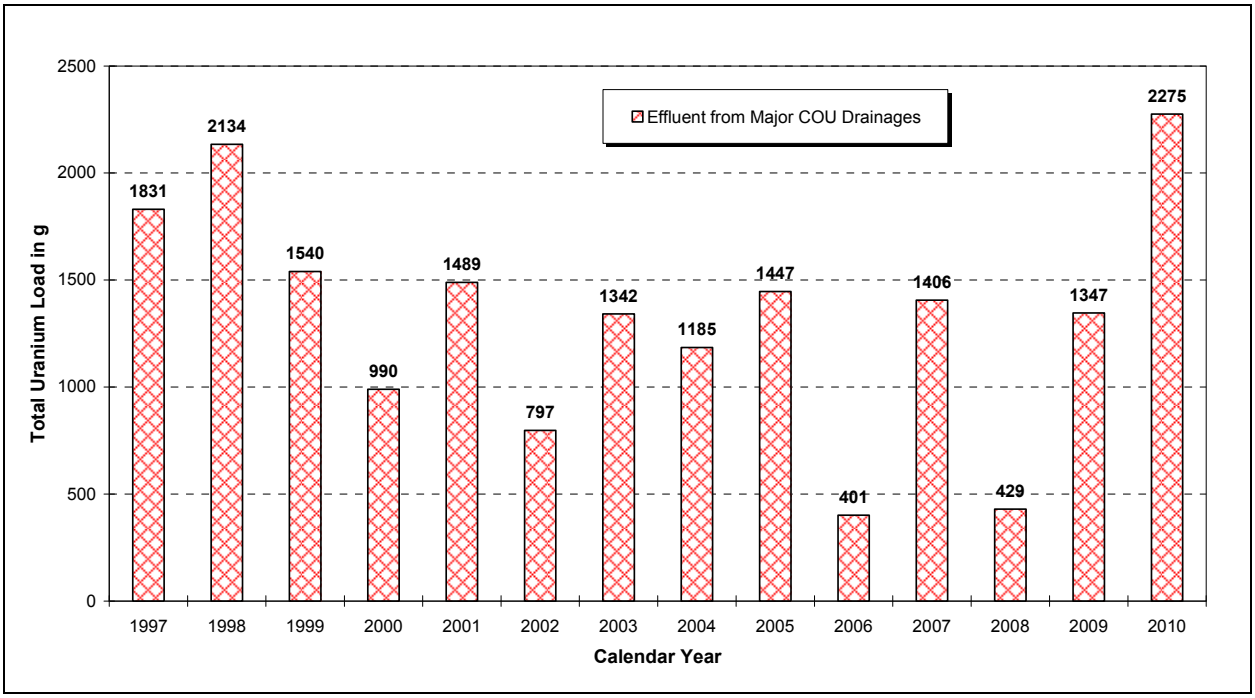


Figure 193. Annual Total U Loads from Major COU Drainages and Former WWTP: CY 1997–2010

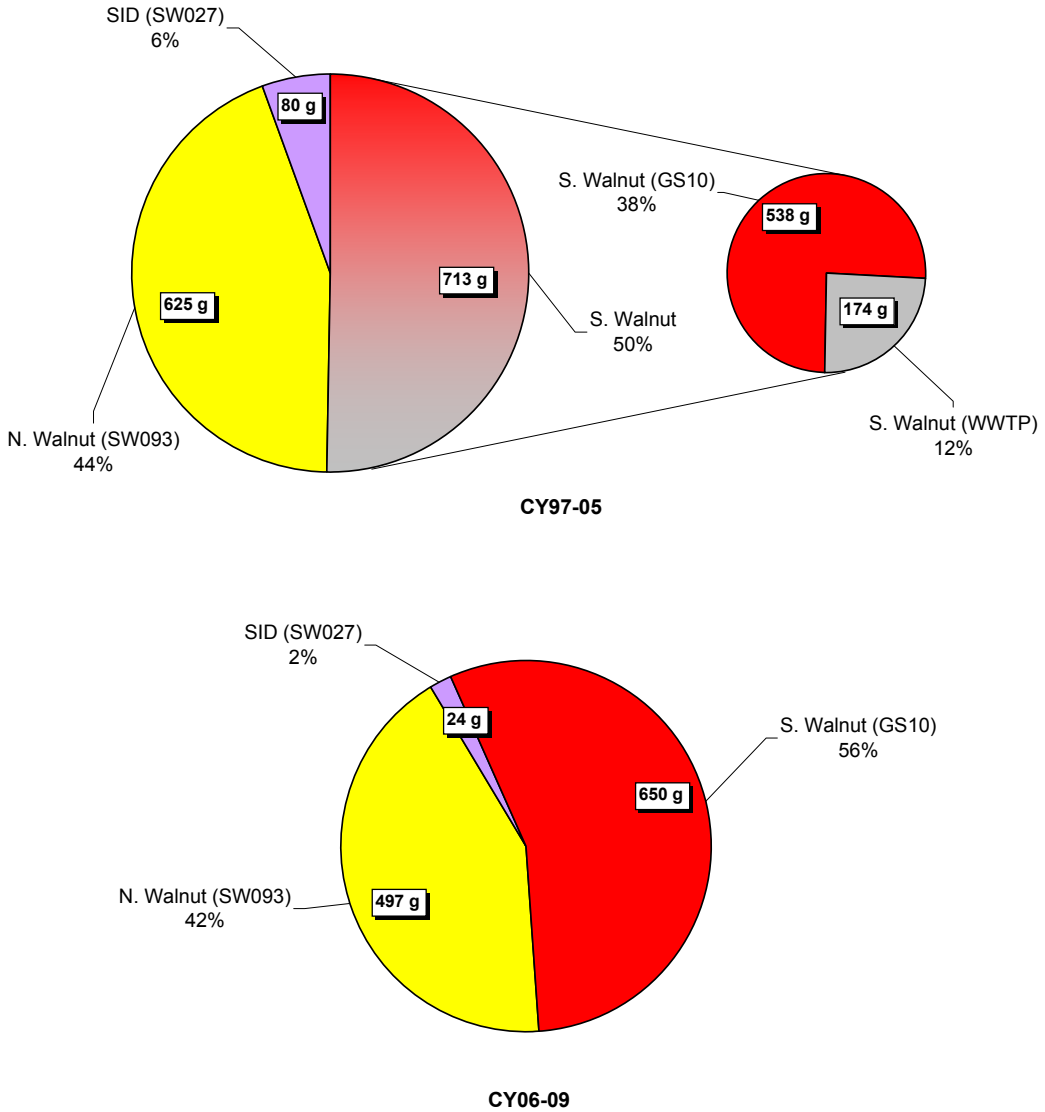


Figure 194. Relative Average Annual Total U Loads from Major COU Drainages and Former WWTP

3.1.5 Groundwater Data Interpretation and Evaluation

This section provides a summary of groundwater monitoring performed in 2010, separated into RFLMA-required and non-RFLMA-required. A discussion of groundwater conditions during 2010, focusing on the most important water-quality aspects in the areas of interest (i.e., the main plumes), is then presented.

3.1.5.1 RFLMA Groundwater Monitoring Activities of 2010

Routine activities of the groundwater monitoring program in 2010 included sample collection, water-level measurement, groundwater treatment system maintenance, and well maintenance.

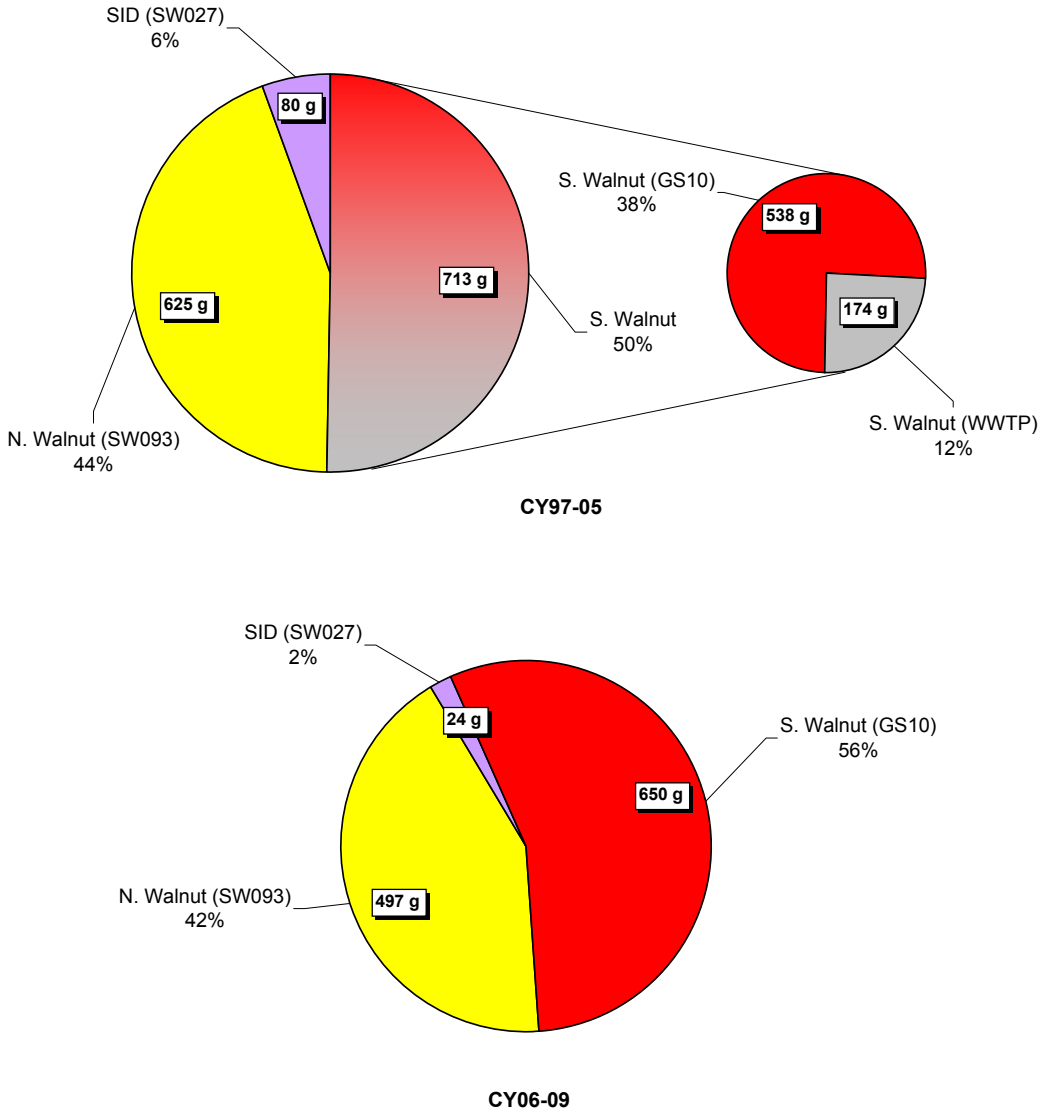


Figure 194. Relative Average Annual Total U Loads from Major COU Drainages and Former WWTP

3.1.5 Groundwater Data Interpretation and Evaluation

This section provides a summary of groundwater monitoring performed in 2010, separated into RFLMA-required and non-RFLMA-required. A discussion of groundwater conditions during 2010, focusing on the most important water-quality aspects in the areas of interest (i.e., the main plumes), is then presented.

3.1.5.1 RFLMA Groundwater Monitoring Activities of 2010

Routine activities of the groundwater monitoring program in 2010 included sample collection, water-level measurement, groundwater treatment system maintenance, and well maintenance.

"Groundwater" monitoring also includes monitoring activities at several surface-water locations, as well as at some locations that may not clearly belong to either category. (Examples of the former include groundwater treatment system-related performance monitoring locations within streams and ponds; examples of the latter include locations monitoring effluent from a treatment system.) However, because all of these locations support groundwater monitoring objectives, the data collected from them in support of these objectives are included as part of the groundwater discussion.

Special, non-RFLMA monitoring was also performed in 2010 to support various objectives. This is discussed in Section 3.1.5.2. The majority of this monitoring focused on the SPPTS. Validated analytical data and other information generated via RFLMA (i.e., routine) and non-RFLMA (i.e., nonroutine) sampling have been reported in the corresponding quarterly reports for 2010 (DOE 2010c, 2010e, 2011b) and are included in Appendix B for the fourth quarter of CY 2010. Unvalidated data are not reported but are summarized in this document.

There were no changes to the network of groundwater monitoring locations during 2010. The groundwater monitoring network set forth in RFLMA is subdivided and categorized as shown in Table 73.

Table 73. RFLMA Monitoring Classifications for the Groundwater Monitoring Network

Well Classification	General Objective	Number of Wells[a]	Monitoring Frequency
AOC	Monitor groundwater quality and water levels in a drainage downgradient of a contaminant plume or group of plumes	9	Semiannual (2x/year)
Boundary	Monitor groundwater quality and water levels in Woman Creek and Walnut Creek drainages at eastern (downgradient) Site boundary	2	Annual (1x/year)
Sentinel	Monitor groundwater quality and water levels near contaminant plume edges and in drainages	28	Semiannual (2x/year)
Evaluation	Monitor groundwater quality and water levels in or near contaminant source areas and in the former IA	42	Biennial (1x/every 2 years)
RCRA	Monitor groundwater quality and water levels upgradient and downgradient of the PLF and the OLF	10	Quarterly (4x/year)
Treatment System[b, c]	Monitor quality of groundwater treatment system influent, effluent, and downgradient surface water	9	Semiannual (2x/year)
Surface-Water Support[b]	Monitor quality of surface water downgradient of contaminant plume	1	Semiannual (2x/year)

[a]The numbers of locations listed are current through 2009.
[b]Treatment system and surface-water support locations are not monitoring wells but are included for completeness.
[c]The PLFTS is discussed separately.

Table 74 presents the full 2010 schedule for RFLMA groundwater sample collection, a subset of which is summarized in Table 75 as those scheduled samples that were not successfully collected (e.g., due to dry conditions). Corresponding analytical results are published in the associated quarterly reports (DOE 2010c, 2010e, 2011b) and Appendix B.

Table 74. Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2010 (by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
Boundary Wells	B	10394	2	2	2			
	B	41691	2	2	2			
Present Landfill	RCRA	70193	1,2,3,4			1,2,3,4		
	RCRA	70393	1,2,3,4			1,2,3,4		
	RCRA	70693	1,2,3,4			1,2,3,4		
	RCRA	73005	1,2,3,4			1,2,3,4		
	RCRA	73105	1,2,3,4			1,2,3,4		
	RCRA	73205	1,2,3,4			1,2,3,4		
	AOC	4087	2,4	2,4	2,4			
	AOC	B206989	2,4	2,4	2,4			
Original Landfill	RCRA	P416589	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80005	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80105	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80205	1,2,3,4			1,2,3,4		1,2,3,4
	AOC	11104	2,4	2,4				
MSPTS	S	15699	2,4					
	TS	MOUND R1-0	2,4					
	TS	MOUND R2-E	2,4					
	TS	GS10	2,4					
	E	00897	2					
ETPTS	S	04091	2,4					
	S	95099	2,4					
	S	95199	2,4					
	S	95299	2,4					
	S	23296	2,4	2,4				
	TS	ET INFLUENT	2,4					
	TS	ET EFFLUENT	2,4					
	TS	POM2	2,4					
	E	3687	2					
	E	05691	2					
	E	03991	2					
SPPTS	S	P210089	2,4	2,4	2,4			
	S	70099		2,4	2,4			
	TS	SPIN		2,4	2,4			
	TS	SPOUT		2,4	2,4			
	TS	GS13		2,4	2,4			
	E	P210189	2	2	2			
	E	79102	2	2	2			
	E	79202	2	2	2			
	E	P208989	2	2	2			
	E	79302		2	2			
	E	79402		2	2			
	E	79502		2	2			
	E	79605		2	2			
	E	00203	2	2	2			
	E	22205	2	2	2			

Table 74 (continued). Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2010 (by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
SPPTS	E	B210489		2	2			
	E	51605		2	2			
Drainages Below Impacted Areas	AOC	10594	2,4	2,4	2,4			
	AOC	00997	2,4	2,4	2,4			
	AOC	00193	2,4	2,4				
Former B371/374	S	37405	2,4	2,4	2,4		2,4	
	S	37505	2,4	2,4	2,4			
	S	37705	2,4	2,4	2,4		2,4	
Former B771/774	S	20205	2,4	2,4			2,4	
	S	20505	2,4	2,4			2,4	
	S	20705	2,4	2,4	2,4		2,4	
Former North-Central IA	S	52505	2,4					
	AOC	42505	2,4					
	E	P114689	2					
	E	P115589	2					
	E	70705	2	2				
	E	33905	2					
	E	21505	2					
	E	20902	2					
Former B559	E	55905	2	2	2			
	E	56305	2	2	2			
Former IHSS 118.1	SS	SW018	2,4					
	E	18199	2					
Former B444 Complex	S	11502	2,4	2,4				
	S	40305	2,4	2,4				
	E	40005	2	2				
	E	40205	2	2				
	E	P419689	2	2				
	E	P416889	2	2				
Former B881	S	00797	2,4	2,4				
	S	88104	2,4	2,4				
	E	88205	2	2				
Former B886	E	22996	2	2				
Former B991	S	99305	2,4	2,4	2,4			
	S	99405	2,4	2,4	2,4			
	S	91305	2,4	2,4	2,4			
Former Oil Burn Pit No. 1	S	33703	2,4					
	E	33502	2					
	E	33604	2					
Former Oil Burn Pit No. 2	S	91203	2,4					
	E	91105	2					
Former SW056	S	45608	2,4					
OU1 Plume	AOC	89104	2,4					
	E	891WEL	2					

Table 74 (continued). Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2010 (by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
903 Pad/Ryan's Pit Plume	S	90299	2,4					
	S	90399	2,4					
	AOC	10304	2,4	2,4	2,4			
903 Pad/Ryan's Pit Plume	E	00191	2					
	E	50299	2					
	E	90402	2					
	E	00491	2					
	E	07391	2	2				
	E	90804	2					
PU&D Yard Plume	S	30002	2,4					
	E	30900	2					

Notes: ID = Identification (name) of well/sampling location
Location classifications: AOC = Area of Concern, B = Boundary, S = Sentinel, E = Evaluation, RCRA = Resource Conservation and Recovery Act, and SS = Surface Water Support
Location types: TS = Treatment System, all others are groundwater monitoring wells or Surface Water Support
SVOCs = semivolatile organic compounds
2 (or other numeral) = Analyte requested for that quarter; if blank, analyte not requested

Table 75. Summary of RFLMA-Required Groundwater Samples Not Successfully Collected in 2010 (by Quarter)

Location		Analytes						Comments
ID	Classification	VOCs	U	Nitrate	Metals	Pu/Am	SVOCs	
4087	AOC	4	4	4				Dry well
95299	S	2, 4						Dry well

Notes: ID = Identification (name) of well/sampling location
RFLMA classifications: AOC = Area of Concern, S = Sentinel
SVOCs = semivolatile organic compounds
2 (or other numeral) in analyte column = Corresponding analyte requested in the indicated calendar quarter of 2010; if blank, analyte not requested

3.1.5.2 Non-RFLMA Groundwater Monitoring Activities of 2010

Non-RFLMA (i.e., nonroutine) groundwater monitoring was performed in 2010 in support of several data needs, which generally fall within the following two categories:

- Investigative sampling; and
- Performance sampling.

Table 76 summarizes non-RFLMA groundwater sample collection performed in 2010. In addition to this non-RFLMA sampling, additional non-RFLMA monitoring was performed through the sitewide measurement of water levels as discussed in Section 3.1.3.5.

As in recent years, most of the non-RFLMA monitoring performed in 2010 was focused on the SPPTS. Most of the additional analytical data collected for the SPPTS were generated by an in-house laboratory and cannot be validated. Due to the significant effort and unusual events related to that treatment system, this topic is discussed separately in Section 3.1.2.10.

3.1.5.3 Groundwater at the Rocky Flats Site: Discussion and Interpretations

This section presents a summary evaluation of groundwater quality at the Site during 2010. Groundwater quality is addressed first, followed by descriptions of special studies and activities. Included in the discussion of water quality are descriptions of the behavior of and any notable activities at the groundwater treatment systems during 2010.

Trend Plots

Numerous statistical trend plots were constructed for this report using analytical data collected from Sentinel, Evaluation, and RCRA wells (see Sections 3.1.2.8 and 3.1.2.9 for discussion of RCRA wells). Although not required by RFLMA, trend plots were also constructed for AOC wells. Trend plots and corresponding summary tables are presented in Appendix B. In addition to these statistical trend plots, many time-series plots were prepared and are included in this report.

The Sanitas software package (version 9.2.05; Sanitas Technologies 2009) was used for statistical calculations, including the ANOVA analyses and construction of statistical trend plots. (This is noted for the purpose of completeness only; this report does not make software recommendations.) For simplicity, trend calculations performed for any but RCRA wells assign the given well a downgradient position. This is appropriate because the fundamental objective of

the other wells is related to detection monitoring or the exit strategy; no interwell statistics were planned for these classes of wells (only intrawell assessment of the trend of an analyte over time at each given well). Only RCRA wells were assigned either upgradient or downgradient positions to support the related statistical evaluations, as described in Section 3.1.2.8 and Section 3.1.2.9.

Analytical data are handled as described in Section 3.1.1.2. Trends for wells sampled more than once a year are calculated and plotted using the S-K statistical method, as recommended for Rocky Flats groundwater data (K-H 2004a) and in accordance with the RFSOG (DOE 2011a). Trends calculated for wells that are sampled less than twice per year, removing aspects of seasonality, employ the Mann-Kendall (M-K) statistical method. S-K trends are only plotted where they are calculated to be at least 80 percent significant, and M-K trends are plotted if at least 95 percent significant.

Table 77 summarizes the results of these trend calculations. Only increasing and decreasing trends calculated to be at least 80 percent significant using the S-K test are included in this table. (Therefore, even if 95 percent significant, trends with zero slope are not included.) Monitoring well classifications that require statistical evaluation of concentration trends according to RFLMA (i.e., Sentinel and downgradient RCRA wells) are included, as are calculations for AOC wells. Refer to Appendix B for the trend plots and associated summary tables, and Figure 2 for well locations. Significant trends for selected analytes and locations are discussed later in this section in the context of their respective groundwater contaminant plumes.

Table 76. Summary of Non-RFLMA-Required Groundwater Samples Collected in CY 2010 (by Quarter)

Area	Location ID	Analytes[a]																	
		VOCs	U	Nitrate	NH_3-N	Metals	U isotopes	P	TOC	Se	TIC	Ca	Fe	Moist	TSS	*DNBART*	Chlorine	Sulfate	Bromine
SPPTS[b]	GS13		1(9), 2(6), 3(2), 4(3)	1(9), 2(7), 3(2), 4(3)			1	1(3), 2									2		
	ITSE		1				1												
	ITSW		1				1												
	SPIN		1(18), 2(13), 3(15) 4(9) (includes two sets of split samples collected in 2nd qtr)	1(18), 2(13), 3(15), 4(9) (includes two sets of split samples collected in 2nd qtr)	1(13), 2(13), 3(12)			1(2)	1(10)			1(11), 2(13), 3(13), 4(9)	1(13), 2(13), 3(13), 4(9)			1(3)			
	SPOUT		1(22), 2(20), 3(21), 4(16) (includes two sets of split samples collected in 2nd qtr)	1(22), 2(20), 3(21), 4(16) (includes two sets of split samples collected in 2nd qtr)	1(13), 2(13), 3(14), 4(9)		1	1(12), 2(13), 3(13), 4(9)	1(11), 2(13), 3(14), 4(9)	3		1(6)	1(13), 2(13), 3(13), 4(9)				2		1(4), 2(3)
	SPPDISCHARGE GALLERY		1(3), 2(2), 3, 4	1(3),2(2), 3, 4			1		3								2		
	SW093		1(5), 2(5), 3(6), 4(7)	1(5), 2(5), 3(6), 4(7)															
	SPCAE		1(18), 2(13), 3(15), 4(9) (includes two sets of split samples collected in 2nd qtr)	1(18), 2(13), 3(15), 4(9) (includes two sets of split samples collected in 2nd qtr)	1(13), 2(13), 3(13), 4(9)			1(12), 2(13), 3(13), 4(9)	1(13), 2(13), 3(14), 4(9)			1(3)	1(3)			1(10), 2(13), 3(13), 4(9)			
	SPZE		1(18), 2(14), 3(15), 4(8) (includes two sets of split samples collected in 2nd qtr)	1(18), 2(14), 3(15), 4(8) (includes two sets of split samples collected in 2nd qtr)	1(13), 2(13), 3(14), 4(8)				1(3)			1(13), 2(13), 3(13), 4(8)	1(13), 2(13), 3(13), 4(8)						
	SPILCA		1(14), 2(13), 3(12)	1(14), 2(13), 3(12)	1(13), 2(13), 3(12)			1(12), 2(13), 3(13), 4(9)	1(13), 2(13), 3(13), 4(9)			1(5)	1(5)						
	ITSS		1	1															
	RISERPIPE1		1(6), 2(4), 3	1(6), 2(4), 3	1(6), 2(4)				1(6), 2(4), 3								1(6), 2(3)	1(6), 2(4)	1(3)
	RISERPIPE2		1(6), 2(4), 3	1(6), 2(4), 3	1(6), 2(4)				1(6), 2(4), 3								1(6), 2(3)	1(6), 2(4)	1(3)
	RISERPIPE3		1(6), 2(4), 3	1(6), 2(4), 3	1(6), 2(4)				1(6), 2(4), 3								1(6), 2(3)	1(6), 2(4)	1(3)
	RISERPIPE4		1(6), 2(4), 3	1(6), 2(4), 3	1(6), 2(4)				1(6), 2(4), 3							1	1(5), 2(3)	1(5), 2(4)	1(3)
	SPCBE		1(12), 2(13), 3(11)	1(14), 2(13), 3(11)	1(11), 2(13), 3(11)				1(13), 2(13), 3(11)			1(3)	1(3)						
	SPDLI			1(7)					1(7)										
	SPDL2			1(7)					1(7)										
	SPDL4		1(2)	1(7)	1(2)				1(7)										
	SPRUNOFF1		2		2														
	1786	2, 3(3)	2	2															

Table 76 (continued). Summary of Non-RFLMA-Required Groundwater Samples Collected in CY 2010 (by Quarter)

Area	Location ID	Analytes[a]																	
		VOCs	U	Nitrate	NH_3-N	Metals	U isotopes	P	TOC	Se	TIC	Ca	Fe	Moist	TSS	*DNBART*	Chlorine	Sulfate	Bromine
ETPTS[c]	ET EFFLUENT	2, 3(3)																	
	ET INFLUENT	4																	
	ETPTSB4	2, 3(3), 4																	
	ETPTSDGOVER	2, 3(3)																	
	POM2	2, 3(3)					1												
MSPTS[d]	MOUND R1-0	2, 3(3)	4																
	MOUND R2-E	2, 3, 4	4																
	MSPTSCHAN1	2, 3																	
	MSPTSCHAN2	2, 3(2)																	
	GS10	3	1(5), 2(5), 3(6), 4(7)																
	11894	3		3															
	49192	4		3															
	91203	4																	
	B206989																		

Notes: [a] The numeral in the "analyte" column (e.g., 2) indicates the 2010 quarter in which the analyte was requested; if blank, analyte not requested. For those locations where more than one non-RFLMA-required sample was collected in the indicated quarter(s), the total number of non-RFLMA samples collected is indicated in parentheses.

[b] The Solar Ponds Plume Discharge Gallery (SPPDischargeGallery) is sampled in accordance with the RFSOG (DOE 2011a). Locations ITSW and ITSE are associated with the Phase I upgrades to the SPPTS and were sampled to evaluate system effectiveness (i.e., quality of additional water being captured by the Phase I upgrades). Locations SPIN, SPOUT, SPCAE, SPZE, and SPILCA are associated with the Phase II/III upgrades to the system and were sampled to evaluate the system effectiveness.

[c] The East Trenches Plume Treatment System (ETPTS) has several associated sampling locations.

[d] Several sampling locations are associated with the Mound Site Plume Treatment System to evaluate the effectiveness of groundwater treatment.

ID = Identification (name) of well/sampling location
Ca = calcium
Fe = iron
NH_3-N = ammonia (as nitrogen)
P = phosphate
Se = selenium
TOC = total organic carbon
VOCs = volatile organic compounds
TSS = total suspended solids

Table 77. Summary of Statistical Trend Calculations by Location

Well	General Location	Analyte	Trend	Significant at 95%?
Sentinel Wells				
00797	B881	**U**	**Increasing**	**Yes**
04091	East Trenches Plume	**Carbon tetrachloride**	**Decreasing**	**Yes[c]**
		PCE	**Decreasing**	**Yes[c]**
11502	B444	PCE	Decreasing	No
		U	Decreasing	No
15699	MSPTS	**1,1,1-TCA**	**Decreasing**	**Yes[c]**
		1,1-DCE	**Decreasing**	**Yes**
		1,2-DCA	Increasing	No
		Chloroform	**Decreasing**	**Yes[c]**
		cis-1,2-DCE	Increasing	No
		PCE	**Decreasing**	**Yes**
		TCE	**Decreasing**	**Yes**
		***trans*-1,2-DCE**	**Increasing**	**Yes[c]**
		VC	**Increasing**	**Yes[c]**
20205	B771	**PCE**	**Increasing**	**Yes[a,c]**
		U	**Increasing**	**Yes**
20505	B771	1,1-DCE	Increasing	No
		cis-1,2-DCE	Decreasing	No
		TCE	Decreasing	No
		U	Decreasing	No
20705	B371	**Am-241**	**Decreasing**	**Yes[d,e]**
		cis-1,2-DCE	Increasing	No
		U	**Increasing**	**Yes[b,d]**
		VC	Increasing	No
23296	ETPTS	**1,1-DCE**	**Increasing**	**Yes[c]**
		Carbon tet	**Decreasing**	**Yes[c]**
		Chloroform	**Decreasing**	**Yes[c]**
		***cis*-1,2-DCE**	**Increasing**	**Yes**
		PCE	**Decreasing**	**Yes**
		TCE	**Decreasing**	**Yes**
		***trans*-1,2-DCE**	**Increasing**	**Yes[c]**
		U	**Decreasing**	**Yes[b]**
33703	OBP#1	1,3-DCB	Increasing	No
		1,4-DCB	**Increasing**	**Yes**
		Chlorobenzene	**Decreasing**	**Yes**
		***cis*-1,2-DCE**	**Increasing**	**Yes[c]**
		***trans*-1,2-DCE**	**Increasing**	**Yes[c]**
		VC	**Increasing**	**Yes[c]**
37405	B371	**Nitrate**	**Increasing**	**Yes[b]**
		U	Decreasing	No
37505	B371	Nitrate	Decreasing	No
		PCE	Increasing	No
		U	**Increasing**	**Yes**
37705	B371	Nitrate	Increasing	No
		U	Increasing	No
40305	B444	*cis*-1,2-DCE	Decreasing	No
		PCE	**Increasing**	**Yes[c]**
		U	Increasing	No

Table 77 (continued). Summary of Statistical Trend Calculations by Location

Well	General Location	Analyte	Trend	Significant at 95%?
45608	Hillside south of B991	**1,1-DCE**	**Increasing**	**Yes[c]**
		cis-1,2-DCE	Decreasing	No
		PCE	**Increasing**	**Yes[c,d]**
		TCE	**Increasing**	**Yes[c,d]**
		***trans*-1,2-DCE**	**Decreasing**	**Yes[b]**
		VC	Increasing	No
52505	North-central IA	***cis*-1,2-DCE**	**Increasing**	**Yes[a,c]**
70099	SPPTS	**Nitrate**	**Decreasing**	**Yes**
		U	Increasing	No
88104	B881	**U**	**Decreasing**	**Yes[d]**
90299	903 Pad/Ryan's Pit Plume-SID	**Carbon tetrachloride**	**Decreasing**	**Yes[c]**
		Chloroform	**Decreasing**	**Yes[b]**
		TCE	**Decreasing**	**Yes**
90399	903 Pad/Ryan's Pit Plume-SID	**1,1-DCE**	**Increasing**	**Yes[a]**
		Carbon tetrachloride	Increasing	No
		Chloroform	Increasing	No
		***cis*-1,2-DCE**	**Increasing**	**Yes[b]**
		PCE	Increasing	No
		TCE	**Increasing**	**Yes[b]**
91203	OBP#2	1,1,1-TCA	Increasing	No
		1,1-DCE	**Increasing**	**Yes[a,c]**
		Carbon tetrachloride	Decreasing	No
		Chloroform	Decreasing	No
		***cis*-1,2-DCE**	**Increasing**	**Yes[c]**
		PCE	Increasing	No
		TCE	Increasing	No
91305	OBP#2	*cis*-1,2-DCE	Decreasing	No
		Nitrate	Increasing	No
		U	Decreasing	No
95199	ETPTS	1,1-DCE	Increasing	No
		cis-1,2-DCE	Increasing	No
		PCE	**Increasing**	**Yes**
		TCE	Increasing	No
99305	B991	***cis*-1,2-DCE**	**Increasing**	**Yes**
		Nitrate	Increasing	No
		PCE	**Increasing**	**Yes**
		TCE	**Increasing**	**Yes**
		U	**Increasing**	**Yes**
99405	B991	***cis*-1,2-DCE**	**Increasing**	**Yes[b,c]**
		Nitrate	Increasing	No
		TCE	**Increasing**	**Yes[c]**
		U	**Decreasing**	**Yes**
P210089	SPPTS	Nitrate	Increasing	No
		U	**Increasing**	**Yes**
RCRA Wells (Downgradient only)				
73005	PLF	B	Increasing	No
		Cr	**Increasing**	**Yes[a,c]**
		Se	Increasing	No
		U	Increasing	No
		Zn	Increasing	N
73105	PLF	**B**	**Increasing**	**Yes**
		U	Decreasing	No

Table 77 (continued). Summary of Statistical Trend Calculations by Location

Well	General Location	Analyte	Trend	Significant at 95%?
73205	PLF	B	Increasing	No
80005	OLF	**B**	**Decreasing**	**Yes**
80105	OLF	B	Decreasing	No
		U	Decreasing	No
80205	OLF	B	Increasing	No
		Cd	Increasing	No
		Se	Increasing	No
		U	**Decreasing**	**Yes[a]**
Evaluation Wells (Only trends that are 95% significant are shown)				
00491	903 Pad/Ryan's Pit Plume	**Chloroform**	**Decreasing**	**Yes**
00897	Mound Plume	**TCE**	**Decreasing**	**Yes**
3687	East Trenches Plume	**1,1-DCE**	**Increasing**	**Yes**
		***cis*-1,2-DCE**	**Increasing**	**Yes**
03991	East Trenches Plume	**Carbon tetrachloride**	**Decreasing**	**Yes**
		Chloroform	**Decreasing**	**Yes**
		PCE	**Decreasing**	**Yes**
		TCE	**Decreasing**	**Yes**
05691	East Trenches Plume	**Carbon tetrachloride**	**Decreasing**	**Yes**
		Chloroform	**Decreasing**	**Yes**
		***cis*-1,2-DCE**	**Decreasing**	**Yes**
		PCE	**Decreasing**	**Yes**
		TCE	**Decreasing**	**Yes**
07391	Ryan's Pit	**Chloroform**	**Decreasing**	**Yes**
		***cis*-1,2-DCE**	**Increasing**	**Yes**
22205	Solar Ponds Plume	**U**	**Increasing**	**Yes**
30900	PU&D Yard Plume	**1,1,1-TCA**	**Decreasing**	**Yes**
		***cis*-1,2-DCE**	**Increasing**	**Yes**
33502	OBP#1	**1,2,4-TCB**	**Decreasing**	**Yes[c]**
		Naphthalene	**Decreasing**	**Yes[c]**
		PCE	**Decreasing**	**Yes[c]**
33604	OBP#1	**TCE**	**Decreasing**	**Yes**
33905	Northern IA	**1,1-DCE**	**Decreasing**	**Yes**
		PCE	**Decreasing**	**Yes**
40005	B444	**U**	**Increasing**	**Yes**
40205	B444	**1,1-DCE**	**Decreasing**	**Yes**
		***cis*-1,2-DCE**	**Decreasing**	**Yes**
		PCE	**Decreasing**	**Yes**
79202	SEPs	**Carbon tetrachloride**	**Decreasing**	**Yes**
		Chloroform	**Decreasing**	**Yes**
		TCE	**Decreasing**	**Yes**
79302	SEPs	**U**	**Increasing**	**Yes**
79502	SEPs	**U**	**Decreasing**	**Yes**
88205	B881	***cis*-1,2-DCE**	**Increasing**	**Yes**
		TCE	**Increasing**	**Yes**
		Toluene	**Increasing**	**Yes**
		Total xylenes	**Increasing**	**Yes**
91105	OBP#2	**Carbon tetrachloride**	**Decreasing**	**Yes**
891WEL	OU-1	**Carbon tetrachloride**	**Decreasing**	**Yes**
		Chloroform	**Increasing**	**Yes[c]**
		***cis*-1,2-DCE**	**Increasing**	**Yes[c]**
		TCE	**Decreasing**	**Yes**

Table 77 (continued). Summary of Statistical Trend Calculations by Location

Well	General Location	Analyte	Trend	Significant at 95%?
P114689	Northern IA	**Carbon tetrachloride**	**Decreasing**	**Yes**
		TCE	**Increasing**	**Yes**
P208989	SEPs	**Chloroform**	**Increasing**	**Yes[c]**
P210189	SEPs	***cis*-1,2-DCE**	**Decreasing**	**Yes**
P416889	Southern IA	***cis*-1,2-DCE**	**Decreasing**	**Yes**
AOC Wells*				
00193	Woman Creek at Pond C-2	Uranium	Decreasing	No
00997	South Walnut Creek at Pond B-5	Nitrate	Decreasing	No
		Uranium	Increasing	No
4087	Landfill Pond Dam	Nitrate	Increasing	No
		Uranium	Decreasing	No
10304	Woman Creek at Pond C-1	Uranium	Increasing	No
10594	North Walnut Creek at Pond A-2	Nitrate	Increasing	No
		Uranium	**Decreasing**	**Yes[b]**
11104	Woman Creek below OLF	Uranium	Decreasing	No
B206989	Landfill Pond Dam	**Nitrate**	**Decreasing**	**Yes**
		Uranium	Decreasing	No

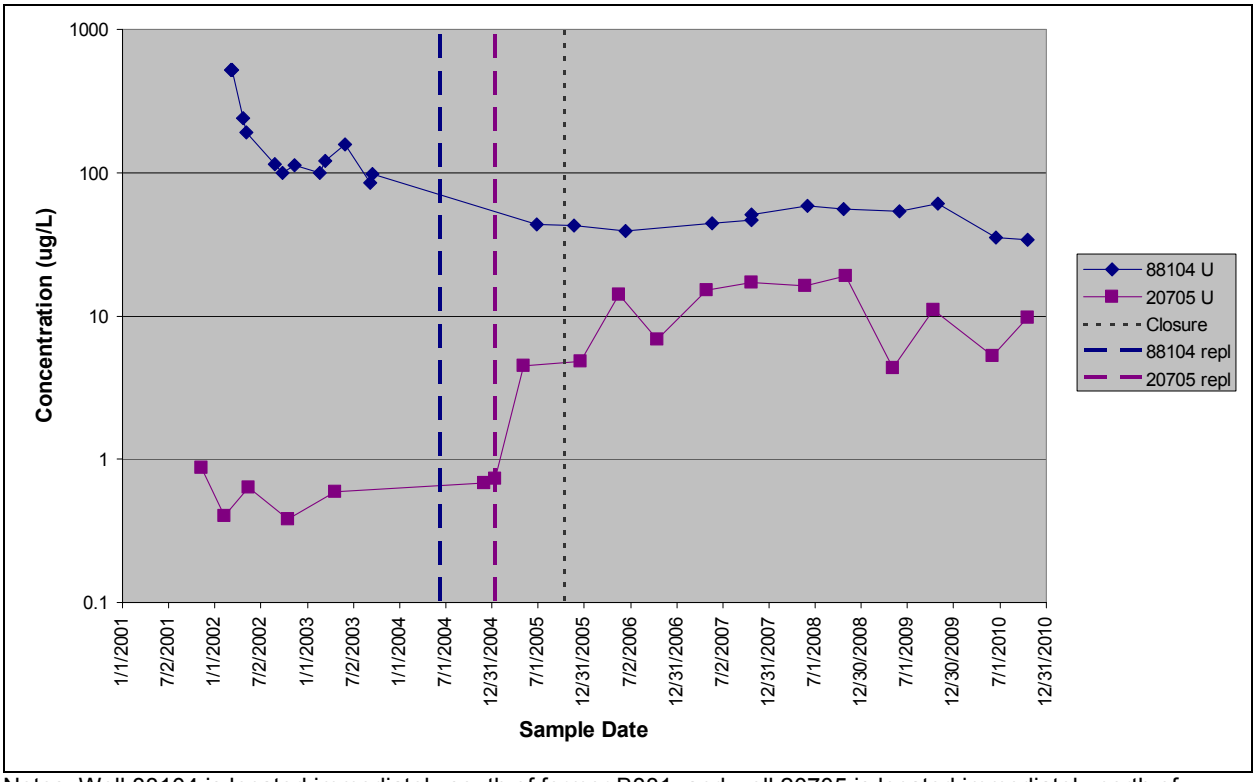
Notes: Only increasing and decreasing trends are included; indeterminate and zero-slope trends are not. Trends are listed if there is an 80% statistical significance; any decisions that may be made would be based on trends having a 95% significance. **Bold** entries designate those trends having a 95% significance; only these trends were assessed for applicability of the footnotes below.
DCA = dichloroethane; DCE = dichloroethene; DCB = dichlorobenzene; OBP = Oil Burn Pit;
PCE = tetrachloroethene; TCB = trichlorobenzene
* Calculating trends for AOC wells is not required by RFLMA, but is provided for informational purposes.
[a] Trend was not calculated to be significant at 80% level in previous (2009) report, but with 2010 data is now 95% significant.
[b] Trend was calculated to be significant in previous (2009) report, but at less than a 95% significance; it now meets the 95% level of significance.
[c] Trend calculated to be significant may not be valid because 25.0 percent or more of the analytical data used to calculate this trend are nondetects. See Section 3.1.1.2 for discussion of how nondetects were handled in trending calculations.
[d] Although the trend is calculated to have a 95% significance, the data used to calculate this trend may be affected by well replacement. Results for this constituent in samples from the original well are markedly different from those from the replacement well. These data sets may be separated in the future, rather than continue to be pooled, as additional data are collected from the replacement well and are sufficient for trending separately.
[e] Samples collected in 2005 were affected by very high turbidity (i.e., muddy water) immediately following installation of the replacement well. Thorough redevelopment reduced the turbidity and, therefore, the Am-241 as well.

As indicated in Table 77, there are a few instances in which a concentration trend did not meet the 95 percent level of significance using 2009 data, but with 2010 data that level was attained; these instances are identified in the table. There are also instances in which a trend that had been calculated to be significant no longer met that test when 2010 data were included in the calculation.

Additional data will be collected in accordance with RFLMA and will further refine the concentration trends. Given that much of the analytical data used in trend calculations were collected before the Site was closed, and in many cases are from wells that were replaced as Site closure proceeded, some instances of slope change due to well replacement are to be expected. This may impact analytical as well as water elevation data. Figure 195 is an example of data that appear (even on a logarithmic concentration scale) to be strongly impacted by well replacements,

as noted in the summary of calculated trends above. If one ignored the fact that these wells were replaced, one might conclude that uranium in well 88104 was on a decreasing trend, and in 20705 was increasing. However, considering the well replacements, it may be more reasonable to conclude that there is no clear trend as of 2010.

For a cross-walk of closure-era original and replacement wells, refer to the *Rocky Flats Site 2006 Integrated Monitoring Plan Background Document* (2006 IMP) (DOE 2006c, Appendix B, Table B-4); since that date, the only well replacement was the abandonment of well 45605 and its replacement with well 45608.



Notes: Well 88104 is located immediately south of former B881, and well 20705 is located immediately north of former B771. "Repl" = replacement; "Closure" = Site closure date (in this case, declaration that closure activities were complete). The date of well replacement is represented by the date the original well was abandoned, because this is the last possible date on which samples from the original location could have been collected.

Figure 195. Time-Series Plot Showing Possible Well-Replacement Artifacts in Concentration Data

Groundwater Plumes with Treatment Systems

Groundwater quality data were obtained for all monitored areas in 2010. Analytical data have been published in quarterly reports issued for 2010 (DOE 2010c, 2010e, 2011b), plus Appendix B, and will not be duplicated here. Appendix B also includes S-K trend plots for CY 2010.

Groundwater quality at the Site in 2010 was largely consistent with data reported in prior years (as can be deduced from the summary of statistical trends presented in Table 77). Generally, groundwater quality within plumes that were identified and characterized through the decades of

pre-closure groundwater monitoring at the Site has not changed much over the years since the Site was closed.

This section describes the general groundwater quality in various areas of interest across the Site, beginning with descriptions of conditions in 2010 at the three main groundwater contaminant plume treatment systems (MSPTS, ETPTS, and SPPTS).

Mound Plume, Oil Burn Pit #2 (OBP#2) Plume, and MSPTS

The Mound Plume (also called the Mound Site Plume) is located north of the former 903 Pad. The source of the plume is a former drum storage area ("the Mound") that was in use in the 1950s. Some of the drums leaked, creating a groundwater contaminant plume extending north toward South Walnut Creek. The drums were removed in 1970, and contaminated soils were removed in 1997. A groundwater treatment system was installed in 1998 to intercept and treat contaminated groundwater before it reaches the creek.

OBP#2 was located just west of the Mound source area, at the southeast corner of the former Protected Area fence. Groundwater monitoring of OBP#2 was not feasible due to security infrastructure until the Protected Area was decommissioned. Groundwater and soil were subsequently sampled, and elevated concentrations of VOCs were detected. This led to a source removal action in 2005 that addressed elevated concentrations in the soils. Supplemental carbon (in the form of Hydrogen Release Compound, HRC) was added to the backfill to enhance biodegradation of residual VOCs. Because the flow path for the OBP#2 Plume is toward FC-4 to the north (generally parallel to the flow direction of the nearby Mound Plume) and potentially along the preferential pathway provided by a utility corridor left by a former storm drain, a gravel drain was installed in 2005 as part of the OBP#2 remediation. This gravel drain intercepts and directs groundwater flowing northward from the OBP#2 source area into the MSPTS intercept trench, from which it is directed to the MSPTS for treatment.

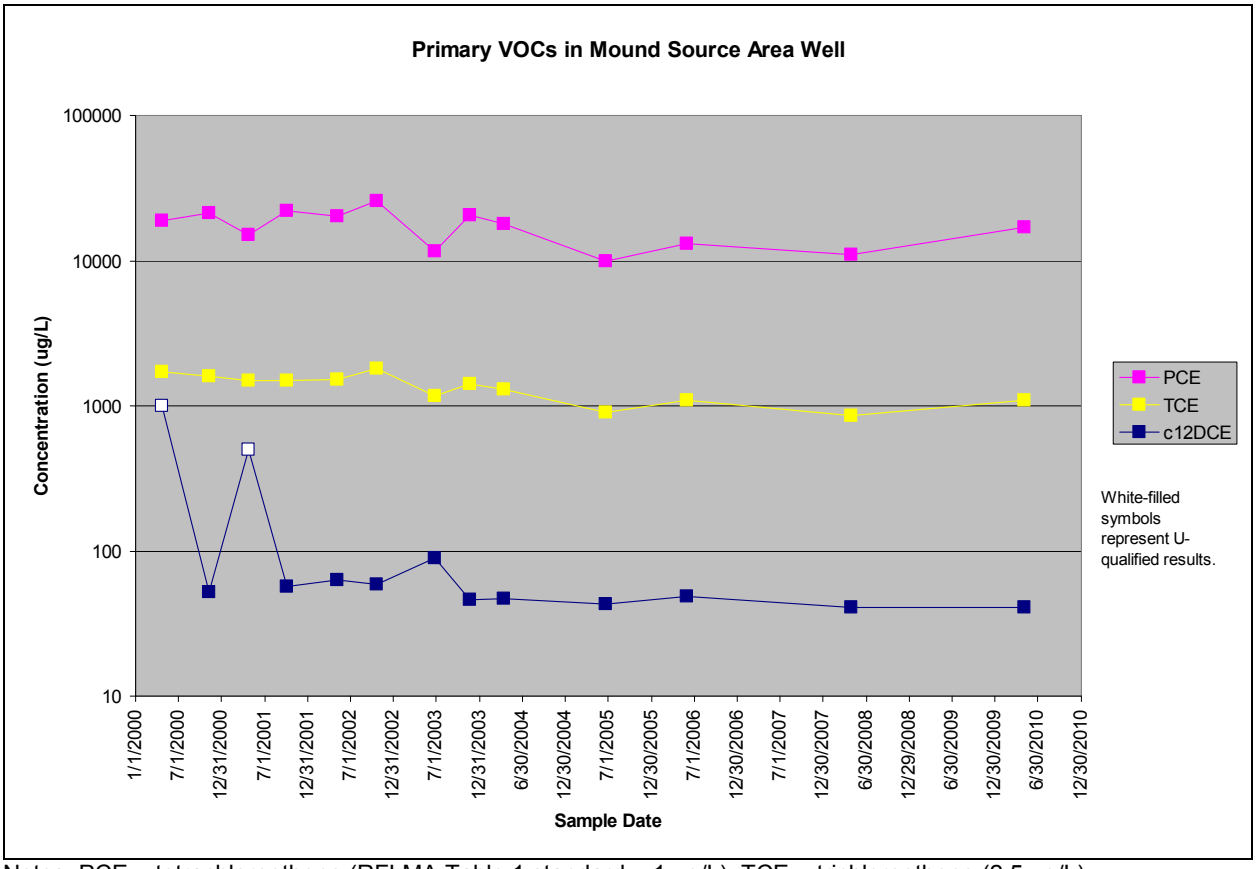
The following paragraphs describe these plumes and the MSPTS.

Mound Plume and OBP#2 Plume

Annual reports for 2006 and 2007 (DOE 2007c, 2008c) provide separate discussions of the Mound Plume and the nearby OBP#2 Plume. Because groundwater flow from the Mound Plume as well as the OBP#2 Plume is captured and treated by the MSPTS, the two plumes have since been discussed as a group. Refer to previous reports for additional detail on closure-era activities in these areas and their impacts on the local groundwater.

Consistent with the technical design of the groundwater monitoring network at the RFS, the two source-area wells, 00897 (Mound) and 91105 (OBP#2), are Evaluation wells that are scheduled for routine monitoring every other year. Both were sampled in 2010.

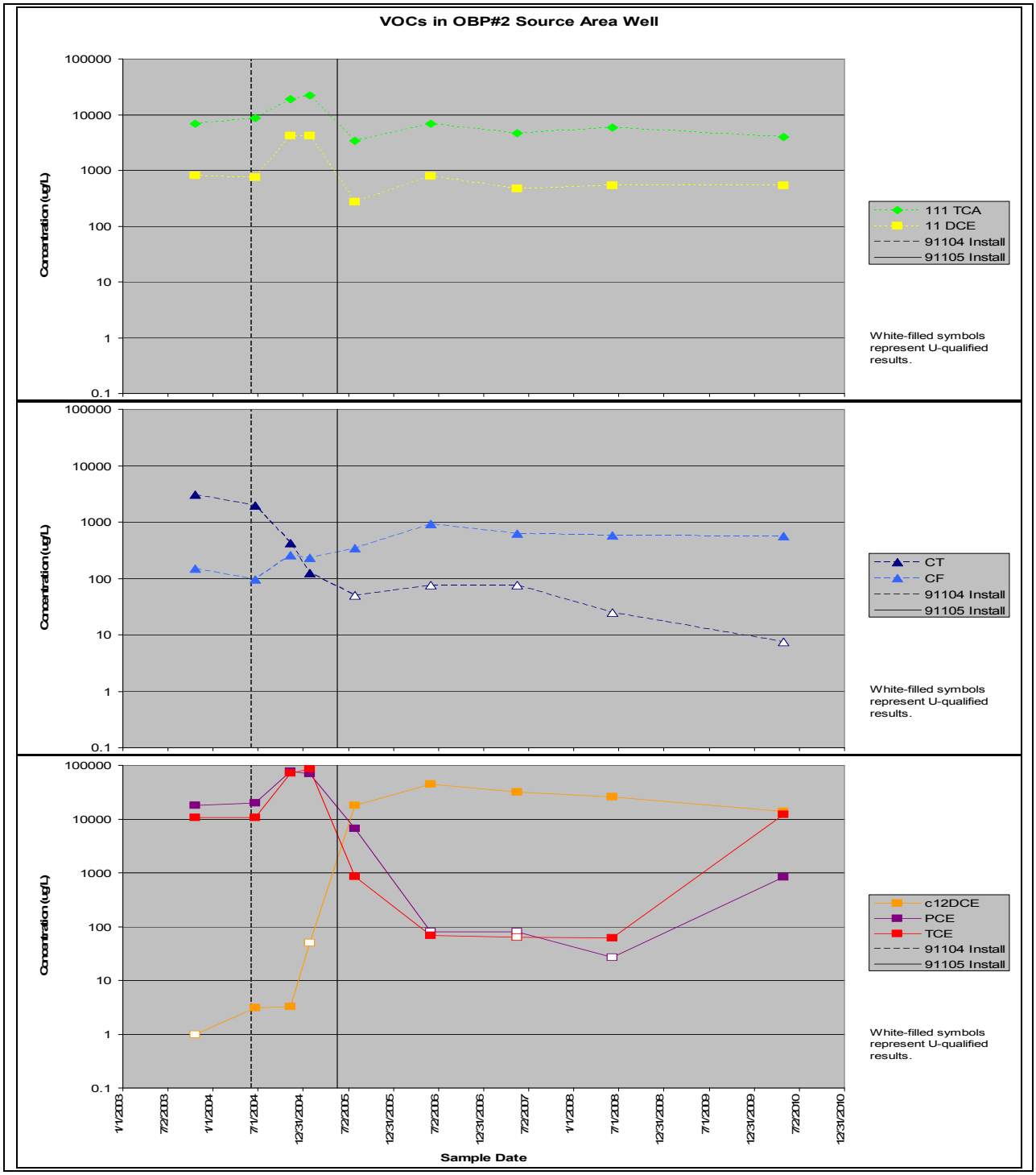
At its source area, the Mound Plume is characterized by elevated concentrations of PCE and TCE. As illustrated on Figure 196, concentrations of these constituents have remained fairly consistent since 2000, as has that of the primary metabolic byproduct from degradation of these compounds, *cis*-1,2-DCE. This suggests the degree to which these VOCs are degrading is low.



Notes: PCE = tetrachloroethene (RFLMA Table 1 standard = 1 µg/L); TCE = trichloroethene (2.5 µg/L); c12DCE = *cis*-1,2-dichloroethene (70 µg/L). Several results are qualified ("J," "D"), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 196. Primary VOCs in Mound Plume Source Area Well 00897

In contrast to the Mound source area, groundwater in the OBP#2 source area was originally characterized by elevated concentrations of 1,1,1-trichloroethane (TCA), PCE, TCE, and 1,1-dichloroethene (DCE). Since the source removal and addition of HRC to the backfill to enhance biodegradation of residual VOCs, concentrations of *cis*-1,2-DCE and other metabolic byproducts have increased in samples from the OBP#2 source-area well, while concentrations of certain parent compounds decreased (Figure 197). Well 91105 is the third to monitor the OBP#2 source area; the previous two (91103, 91104) were installed directly within the contaminated soils (and therefore produced samples with much higher concentrations of VOCs), while the current well is on the downgradient edge of the backfilled source-removal excavation.

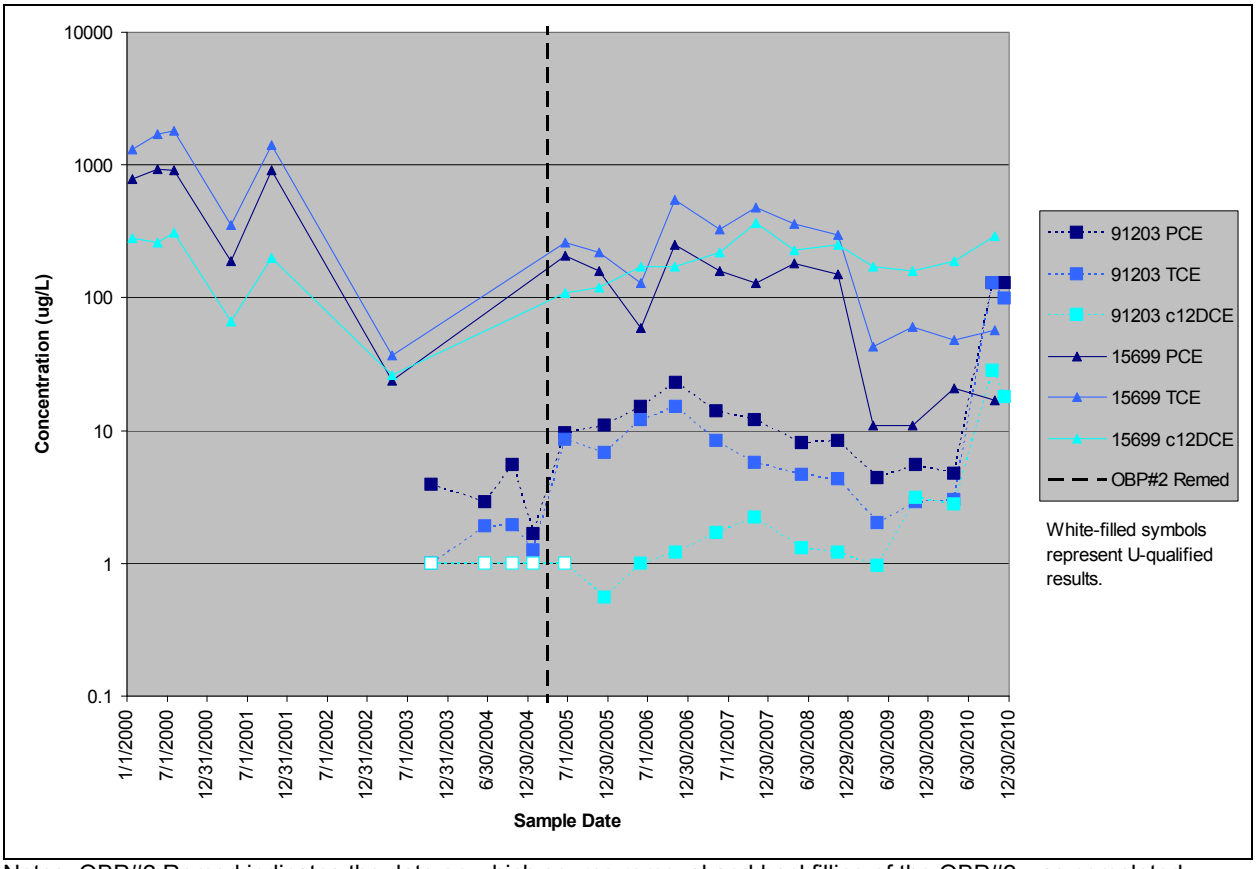


Notes: 111TCA = 1,1,1-trichloroethane (RFLMA Table 1 standard = 200 µg/L); 11DCE = 1,1-dichloroethene (7 µg/L); CT = carbon tetrachloride (1 µg/L); CF = chloroform (3.4 µg/L); c12DCE = *cis*-1,2-dichloroethene (70 µg/L); PCE = tetrachloroethene (1 µg/L); TCE = trichloroethene (2.5 µg/L). 91104 Install and 91105 Install are dates on which those wells replaced their predecessor wells. Several results are qualified ("J," "D"), but for simplicity are not shown differently. Note logarithmic concentration scales.

Figure 197. Primary VOCs in OBP#2 Source Area Well 91105 (and Predecessors)

As shown on Figure 197, the effects of source removal on concentrations of 1,1,1-TCA and 1,1-DCE in groundwater from the source area have been limited. However, concentrations of carbon tetrachloride have declined significantly as those of its primary daughter product, chloroform, have increased. Similarly, concentrations of PCE and TCE decreased sharply as those of primary daughter product *cis*-1,2-DCE (and vinyl chloride, not illustrated) increased following completion of the source removal. The data from samples collected in 2010 suggest concentrations of PCE and TCE are increasing, while those of associated daughter products *cis*-1,2-DCE and VC remain high but are decreasing somewhat. Additional samples from this well will assist in defining longer-term trends.

The Mound and OBP#2 Plumes are also monitored by Sentinel wells positioned downgradient of the source areas, along flow paths to surface water. Figure 198 displays reported concentrations of PCE, TCE, and *cis*-1,2-DCE in samples from Sentinel wells 15699 (downgradient of the Mound and MSPTS groundwater intercept trench) and 91203 (downgradient of OBP#2). As noted in previous annual reports (e.g., DOE 2010d), the concentrations of these constituents in samples from well 15699 that were collected prior to closure show fairly close correlation, and the relative concentration of each reflected its position in the degradation pathway of PCE. (With successive dechlorination, PCE is transformed to TCE and then to *cis*-1,2-DCE, 1,1-DCE, and VC [K-H 2004d, ATSDR 2007].) Since mid-2006, however, concentrations of these constituents have followed a different pattern: those of PCE and TCE have continued to show correlation, while concentrations of *cis*-1,2-DCE have increased relative to the parent compounds PCE and TCE; this increase has been especially evident since 2008. (Although not included on the figure, a similar pattern is evident for VC.) This is interpreted as a reflection of the reconfiguration of source waters to the MSPTS—i.e., the addition of the OBP#2 plume, which contains relatively higher concentrations of daughter products such as *cis*-1,2-DCE following the addition of HRC to the OBP#2 source-area backfill at the completion of source removal activities. Given that well 15699 is positioned downgradient of the MSPTS groundwater collection trench, this trench has received significantly more *cis*-1,2-DCE since 2006, and the trench is not lined, it is to be expected that samples from this well would show a change in water quality to similar to that of the MSPTS influent.

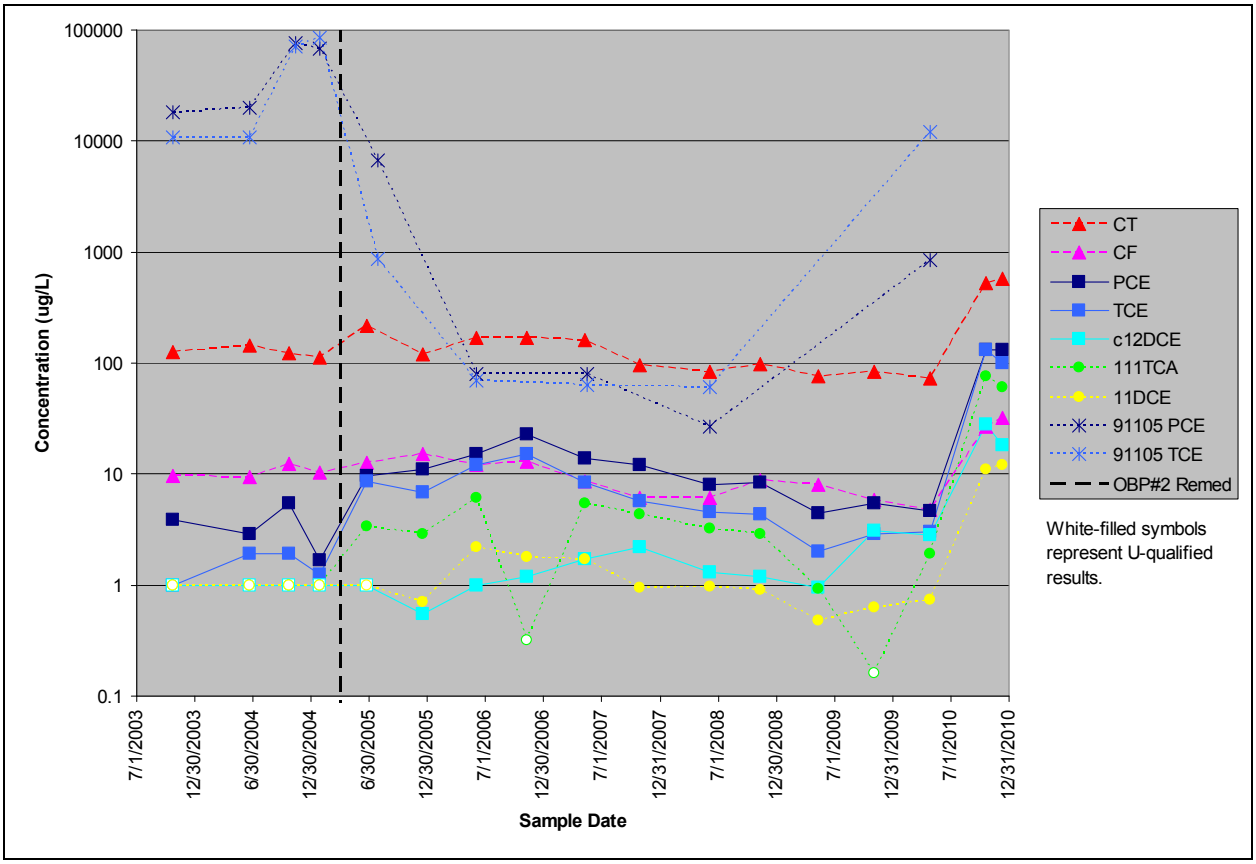


Notes: OBP#2 Remed indicates the date on which source removal and backfilling of the OBP#2 was completed (April 1, 2005). PCE (RFLMA Table 1 standard = 1 µg/L); TCE (2.5 µg/L); *cis*-1,2-DCE (c12DCE in the figure above, 70 µg/L). Several results are qualified ("J," "D"), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 198. VOC Concentrations in Samples from Mound Plume and OBP#2 Plume Downgradient Wells 15699 and 91203

Samples from well 91203 show an increase in the concentrations of some VOCs that generally coincides with the disruption associated with remediation of OBP#2 completed on April 1, 2005. These concentration increases leveled off and began to decrease somewhat, but more recently—particularly in the fourth quarter of 2010—concentrations of VOCs in samples from well 91203 were higher. Figure 199 focuses more closely on conditions at well 91203 and includes additional VOCs not typically detected, or present at relatively lower concentrations, in samples from well 15699: carbon tetrachloride, chloroform, 1,1,1-TCA, and 1,1-DCE. Some of these constituents, such as carbon tetrachloride, are also not as strongly elevated in samples from OBP#2 source-area well 91105 (Figure 197). Clearly visible on Figure 199 is the increase in VOC concentrations in the fourth quarter of 2010. (The initial results from the sample collected in that quarter, on October 20, 2010, appeared anomalous, triggering the collection—proactively, as it was not required by the RFLMA—of a confirmatory sample on December 13, 2010. This second sample confirmed the elevated VOC results.) Reasons for this increase are uncertain. The relatively higher snowmelt and rainfall received in the first half of 2010 may have mobilized residual contaminants in the vadose zone, essentially acting to flush them into the more mobile groundwater within the saturated zone. Supporting this mechanism is the fact that OBP#2 source area well 91105, which is located generally upgradient of well 91203, had increased concentrations of PCE and TCE in 2010 (Figure 197, Figure 199). However, unlike source-area

well 91105, downgradient well 91203 shows an increase in carbon tetrachloride, chloroform, and *cis*-1,2-DCE as well. Estimated travel times (discussed in Section 3.1.3.5 and summarized in Table 38) from well 91105 to 91203 typically have been in the range of 3.5 to 4 years but were estimated at under 2 years in the second quarter of 2010. As noted in Section 3.1.3.5, these calculated travel times are estimates only and apply to pure water, not dissolved constituents such as these VOCs, which would be retarded to some degree, taking longer to move the same distance. Therefore, given the travel time estimates, the elevated detections could relate to VOC source-removal activities in early 2005 or some other mechanism. Additional sampling may help to identify the cause of these increased concentrations.



NOTES: Data from OBP#2 source area well 91105 are designated as such, all other are from well 91203.
CT = carbon tetrachloride (RFLMA Table 1 standard = 1 µg/L); CF = chloroform (3.4 µg/L);
PCE = tetrachloroethene (1 µg/L); TCE = trichloroethene (2.5 µg/L); c12DCE = *cis*-1,2-dichloroethene (70 µg/L); 111TCA = 1,1,1-trichloroethane (200 µg/L); 11DCE = 1,1-dichloroethene (7 µg/L).
OBP#2 Remed = date on which source removal and backfilling of the OBP#2 was completed (April 1, 2005).
Several results are qualified ("J," "D"), but are not shown differently for the sake of simplicity. Note logarithmic concentration scales.

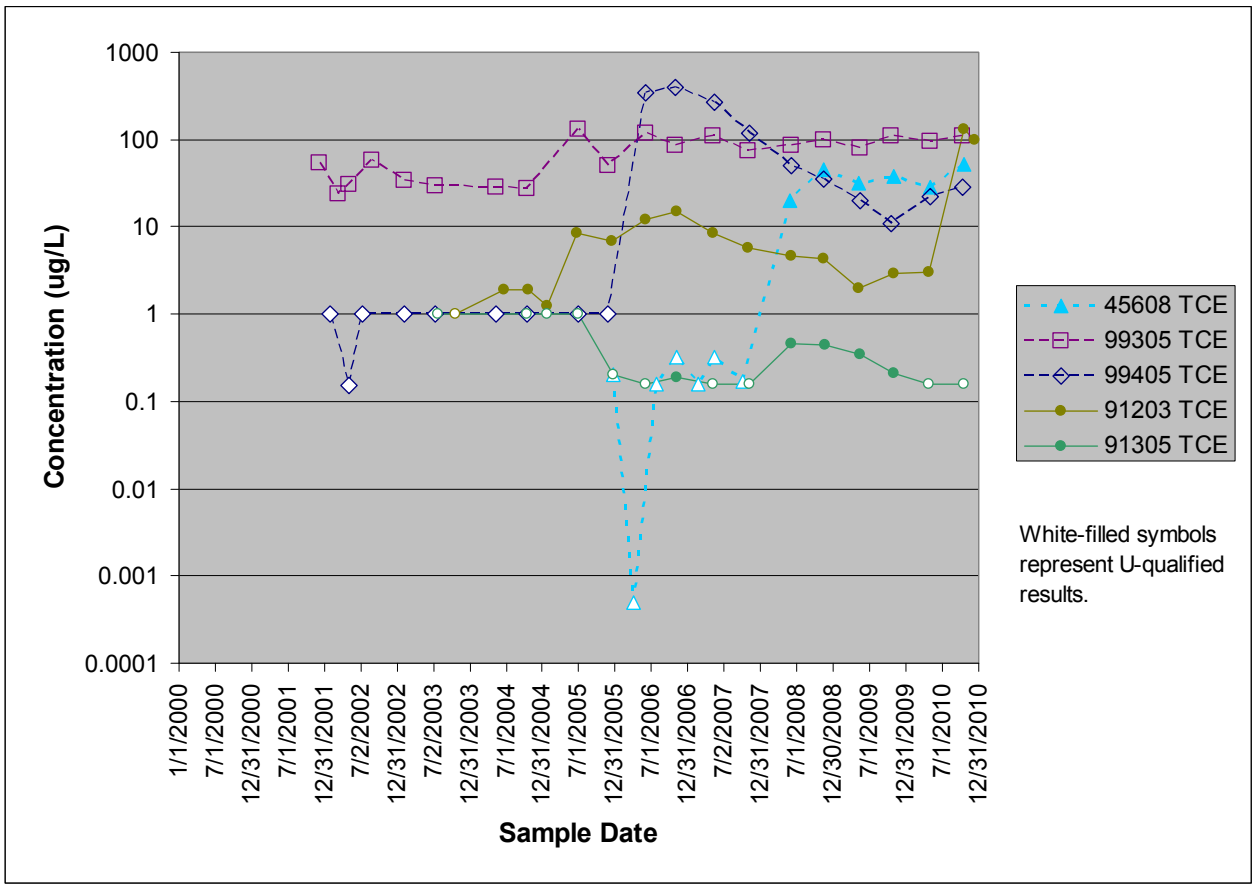
Figure 199. VOCs in Well 91203, Downgradient of OBP#2

S-K trend calculations indicate the presence of several statistically significant trends in monitoring wells at the Mound and OBP#2 plumes (Table 77 and Appendix B). Groundwater samples from Mound source-area well 00897 show a decreasing trend in TCE concentrations at a 95 percent level of significance (which is visually apparent on Figure 196), while OBP#2 source area well 91105 shows a similarly significant decreasing trend in carbon tetrachloride concentrations (see Figure 197). In a generally downgradient direction from the OBP#2 source

area, well 91203 data indicate a potential for increasing trends in 1,1,1-TCA, 1,1-DCE, *cis*-1,2-DCE, PCE, and TCE; however, each of these trends either reflects the presence of numerous nondetects in the data set or does not meet the 95 percent level of significance (Table 77). Data from this well also suggest a potential decreasing trend in the concentrations of carbon tetrachloride and chloroform, neither of which meets the 95 percent level of significance.

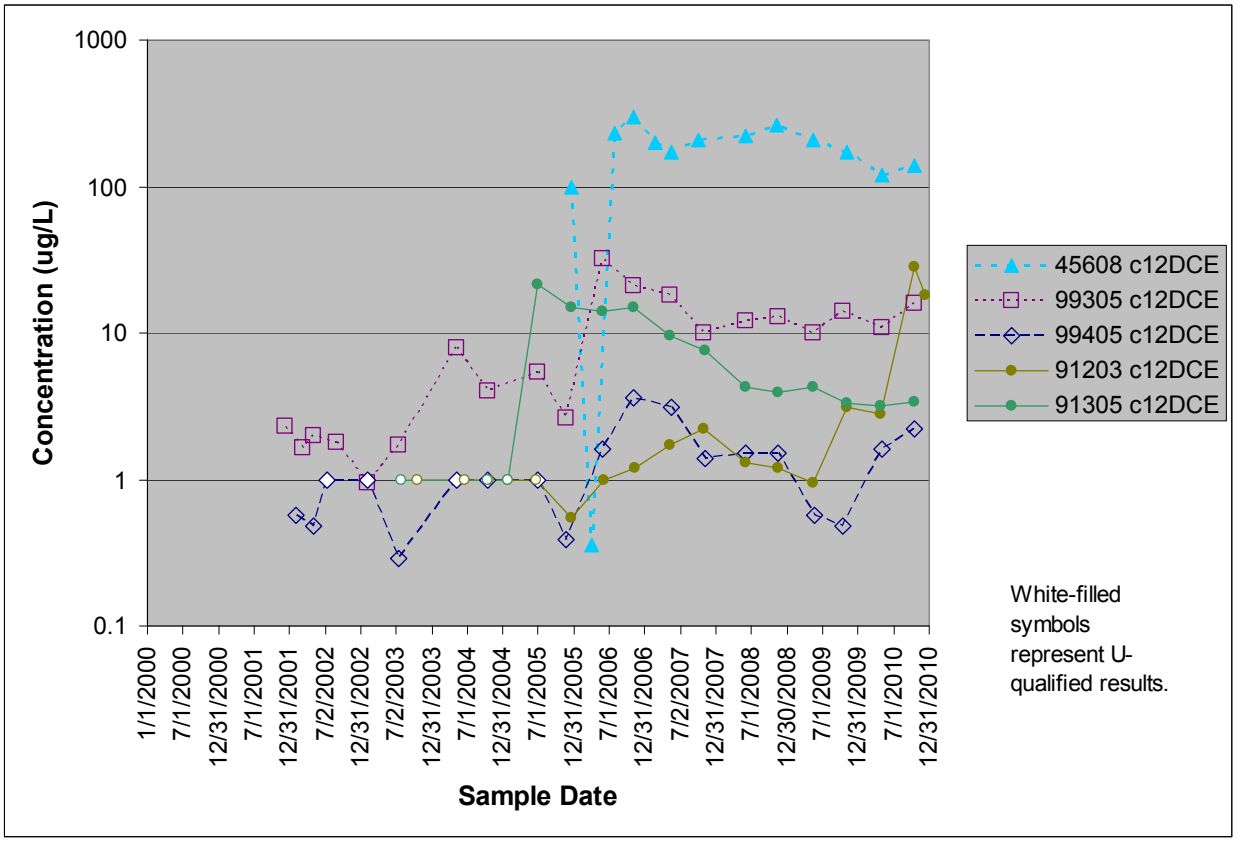
S-K trend calculations for analytical data from Sentinel well 15699 (Table 77 and Appendix B), located downgradient of the Mound plume and the MSPTS groundwater intercept trench, also identify several trends. Those meeting the 95 percent level of significance include increasing concentrations of daughter products *trans*-1,2-DCE and vinyl chloride (although both trends are based on numerous nondetects in the data set), and less-significant increasing trends in *cis*-1,2-DCE and 1,2-DCA. Decreasing trends with a 95 percent statistical significance are calculated for 1,1-DCE, PCE, and TCE; they are also calculated for 1,1,1-TCA and chloroform, but these two trends include numerous nondetects in the data set. The decreasing PCE and TCE trends are visually apparent on Figure 198.

Sentinel well 91305 is also located in this area, west of well 91203 and adjacent to FC-4. Concentrations of VOCs in samples from well 91305 do not suggest any increase similar to that observed at 91203. Data from this well suggest it monitors a mix of waters. Comparisons of degradation byproducts and parent compounds suggest the low concentrations of contaminants reported in well 91305 are contributed by the French-drain-affected hillside south of former B991 (located west-southwest of well 91305) as well as the B991 hillside itself (due west of the well). Additional contributions may be received from the OBP#2 source area to the south/southeast of well 91305. Figure 200 illustrates concentrations of TCE (a commonly used solvent during the production era, which in that sense is a parent compound, but is also a daughter product from the partial dechlorination of PCE) in samples from wells in this area, including 45608 (on the hillside south of B991), 99305 and 99405 (on the 991 hillside), 91203 (downgradient to side-gradient of OBP#2), and 91305. The time-series plots in this figure may be compared with those presented on Figure 201, which focuses on the daughter product *cis*-1,2-DCE. TCE concentrations in samples from well 91305 are lower than those reported by its neighbors, while *cis*-1,2-DCE concentrations are more comparable. The patterns in TCE time-series plots are most similar for wells 91305, 45608, and 99405. A relationship with well 99405 is reasonable, given this well's location at the valley bottom on the 991 hillside; also, the roughly 3- to 4-year delay between the TCE increase observed at well 99405 and that at well 91305 seems reasonable. The increase in TCE concentrations observed at well 45608 coincides with this well's replacement in 2008, an artificial influence that calls into question whether this increase can be reasonably considered representative of general groundwater conditions in this area. (Water quality at well 45608 is discussed further in the section on other plumes below.) With respect to *cis*-1,2-DCE, which increases in well 91305 before TCE increases, the patterns illustrated in the time-series plots are not as similar. The plot for well 91305 appears somewhat similar to that for well 99305, also on the 991 hillside but farther upgradient than its neighbor, 99405. The extensive reworking of the entire area as a part of closure precludes definitive explanation of the specific VOC sources monitored by well 91305. Monitoring will continue according to RFLMA, and additional data may help to explain specific relationships.



Notes: Applicable RFLMA surface-water action level for TCE: 2.5 µg/L (DOE 2007a). Several results are qualified (J) but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 200. Concentrations of TCE in Samples From Wells Near FC-4 Constructed Wetland



Notes: Applicable RFLMA surface-water action level for *cis*-1,2-DCE: 70 µg/L (DOE 2007a). Several results are qualified (J, D) but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 201. Concentrations of cis-*1,2-DCE in Samples From Wells Near FC-4 Constructed Wetland*

Mound Site Plume Treatment System

The MSPTS was the first groundwater intercept/treatment system installed at the Site to incorporate ZVI and is actually among the first of its type in the world. This work was completed in 1998. The first media replacement activity was conducted in the summer of 2006. Routine maintenance activities performed at the MSPTS in 2010 are discussed in Section 2.5.1.

As with all years from 2005 on, flow rates through the MSPTS in 2010 were above pre-2005 levels. This is attributed to the routing of groundwater flow from the OBP#2 area into the MSPTS intercept trench. (For additional background, see the 2005 Annual Report). Table 78 provides annual estimates of the volume of water treated by the MSPTS, which in 2010 is estimated at approximately 420,000 gallons. This represents a significant increase over the volumes treated in the past few years, and with respect to other post-closure years was second only to that treated in 2006. The general decline in MSPTS volumes that had been apparent since 2005 was reversed in 2010. This may be due to the wetter spring in 2010 together with more effective water management. Figure 202 presents the corresponding hydrograph, and Figure 203 provides a hydrograph for CY 2010. The lower flows evident on Figure 203 for the first part of 2010 are related to clogging of the media: The system at the time was operating in series flow configuration (i.e., all water was routed through Cell 1, then through Cell 2). As Cell 1 was more clogged, this slowed the flow rate through the system and caused influent water to back up in the

groundwater intercept trench. This flow configuration was then changed to parallel flow (in which the water was split, with a portion routed through Cell 1 and the balance through Cell 2), which allowed flows to be treated more quickly. In the future, this system will be operated primarily in a parallel, upflow configuration.

Table 78. Estimated Volumes of Water Treated by the MSPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000	258,000	660,000
2001	119,000	780,300
2002	53,000	833,000
2003	82,000	915,000
2004	86,000	1,001,000
2005	506,000	1,507,000
2006	430,000	1,937,000
2007	326,000	2,263,000
2008	358,000	2,621,000
2009	287,000	2,908,000
2010	420,000	3,328,000

Note: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005a, 2005b).

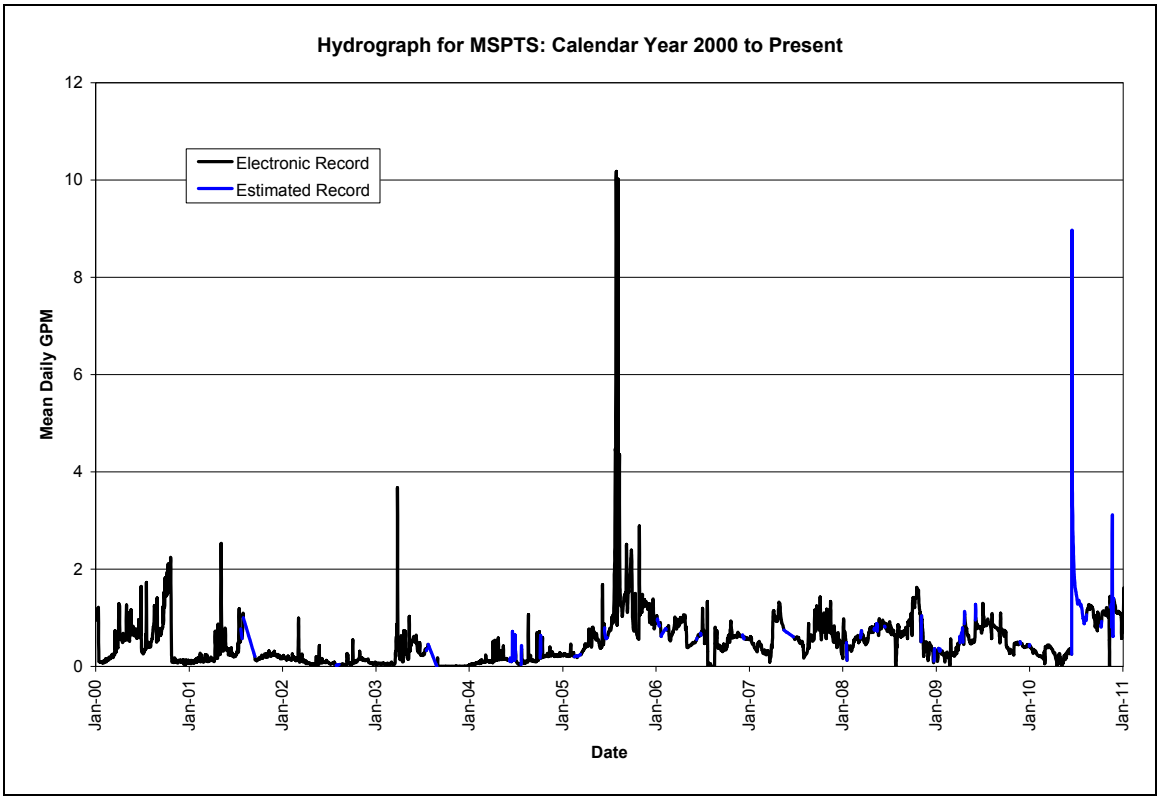


Figure 202. Hydrograph for MSPTS From 2000 Through 2010

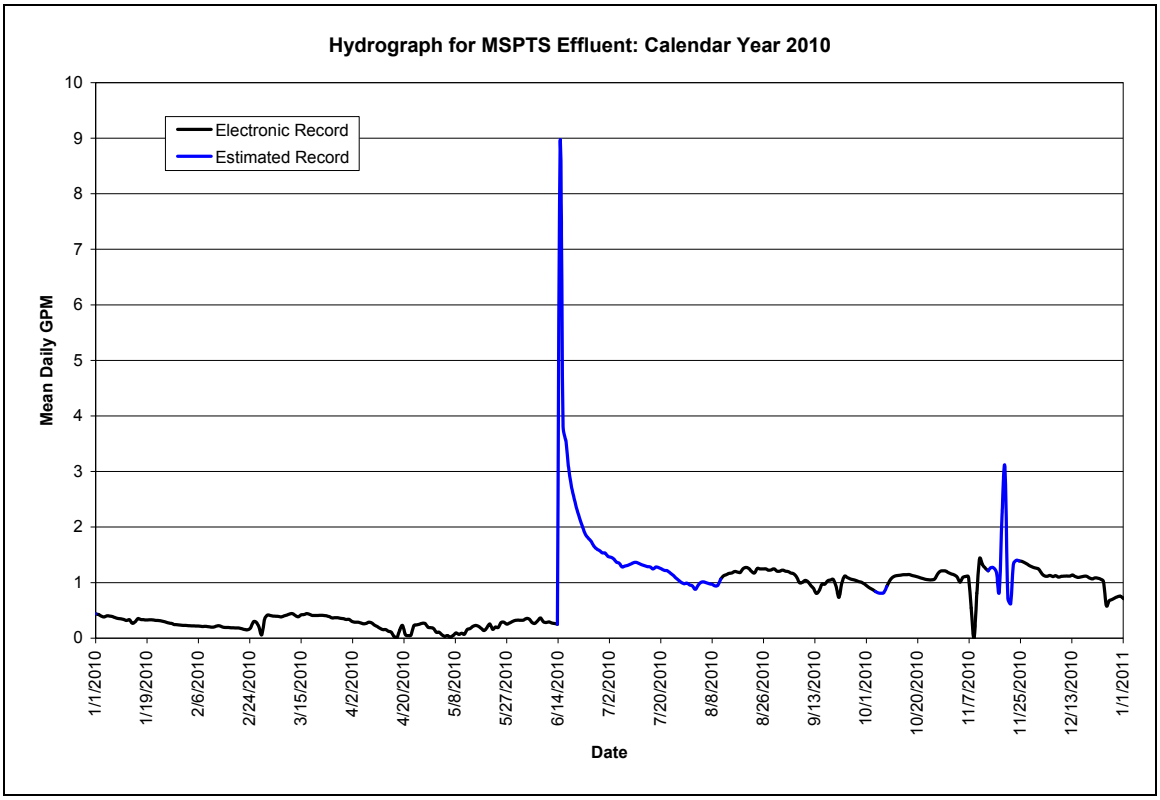


Figure 203. Hydrograph for MSPTS for CY 2010

The MSPTS was sampled twice in 2010 (April, October) in accordance with RFLMA. In response to results from the April event, additional samples were collected in June, July, August, and September 2010. Analytical data representing MSPTS influent and effluent continue to illustrate the dramatic effect the addition of OBP#2-related groundwater has on the system.

Nine VOCs were detected in 2010 in MSPTS influent at concentrations exceeding their respective Table 1 levels (DOE 2007a), an increase of two compared with results from samples collected in 2009. The VOCs that exceeded Table 1 levels in 2010 included 1,1,1-TCA, 1,1-DCE, carbon tetrachloride, chloroform, *cis*-1,2-DCE, methylene chloride, PCE, TCE, and VC. Of these, 1,1,1-TCA and methylene chloride were additions to the 2009 list. 1,1,1-TCA was included in the 2007 and 2008 lists of constituents exceeding Table 1 values in MSPTS influent but did not exceed that value in 2009. The presence of 1,1,1-TCA in MSPTS influent was not prevalent until 2007 and represents a primary contaminant from the OBP#2 source area. Methylene chloride has been inconsistently detected in system influent at concentrations above the Table 1 value: twice in 2000 it was reported at elevated concentrations, but on both occasions was both J- and B-qualified (estimated value, and also detected in the blank); it was also detected at concentrations exceeding the RFLMA Table 1 value in three samples in 2006, and detected in the single (J-qualified) sample in 2010.

Whereas in 2009 two VOCs were detected in MSPTS treated effluent at concentrations exceeding RFLMA Table 1 values, in 2010 eight VOCs exceeded their respective Table 1 values: 1,1-DCE, 1,2-DCA, chloroform, *cis*-1,2-DCE, methylene chloride, PCE, TCE, and VC. This behavior is related to the reduced treatment capacity of the ZVI media within the MSPTS

and the higher flow rates observed in 2010. However, some of these constituents are more recalcitrant; the reductive dechlorination of polychlorinated constituents (such as PCE, TCE, and carbon tetrachloride) occurs more readily than that of mono- and dichlorinated compounds (e.g., *cis*-1,2-DCE, VC, methylene chloride) (EPA 2000). Therefore, these partially chlorinated daughter products require a greater residence time in ZVI media for adequate treatment to be accomplished. However, under higher flow rates such as were observed in 2010, the residence time instead decreases. Due to observed clogging, the ZVI media was scheduled to be replaced, and consideration of additional measures was also begun; this subject is discussed more fully below. The applicable RFLMA values have changed for some VOCs (carbon tetrachloride, PCE, and TCE, among others) since the end of 2009 when several Temporary Modifications terminated and the underlying standards became applicable.

Table 79 summarizes MSPTS influent and effluent analytical data. Refer to the quarterly reports (DOE 2010c, 2010e, 2011b) and Appendix B for additional water-quality data for the MSPTS. Data representing MSPTS influent clearly show the influence of closure activities performed upgradient of the system, particularly the installation of an engineered preferential pathway (the backfilled storm drain corridor and associated cross-cutting gravel drain) that now routes groundwater impacted by the OBP#2 into the MSPTS groundwater intercept trench. (For more information on this feature, see K-H 2005c.) Because the OBP#2 source area was remediated and HRC was added to the backfill to stimulate biodegradation of residual VOCs, the concentrations of daughter products *cis*-1,2-DCE, 1,1-DCE, and VC in MSPTS influent have increased. As explained above, these represent some of the more recalcitrant constituents.

Figure 204 illustrates how concentrations of PCE, TCE, and *cis*-1,2-DCE in MSPTS influent and effluent were affected by closure activities. While closure-related work did not appear to affect influent concentrations of PCE or TCE markedly, those of *cis*-1,2-DCE increased by two to three orders of magnitude. More recently, 2010 saw a sharp increase in the parent compounds (PCE and TCE) in the system influent, potentially as a result of higher water levels acting to flush residual contamination from the vadose zone into the saturated zone. This is more easily visible on Figure 205, which focuses on the period from just before the OBP#2 remediation (completed April 1, 2005) to the end of 2010. Evidence for the greater difficulty in dechlorinating constituents with fewer chlorine atoms is also seen, as is the effect of higher flows/shorter residence times on treatment effectiveness: The 2010 increase in PCE and TCE at elevated flow rates led to a more effective treatment of PCE (four chlorine atoms) than TCE (three chlorine atoms), and *cis*-1,2-DCE (two chlorine atoms) treatment is strongly hampered by the shorter residence times. Figure 206 and Figure 207 provide similar depictions of time-series plots for the daughter products 1,1-DCE and VC in MSPTS influent and effluent. These figures further illustrate the challenges faced by the system in 2010.

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Table 79. Selected VOC Data (µg/L) from MSPTS Influent and Effluent

DATE	1,1,1-TCA		1,1-DCE		CT		CF		*cis*-1,2-DCE		MCl		PCE		TCE		VC	
	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E
1/27/2000	8 (J)	1 (U)	**10**	1 (U)	**110**	1 (U)	**25**	1 (U)	57	1	**5 (BJ)**	1 (B)	**120**	0.1 (J)	**150**	1 (U)	10 (U)	1 (U)
2/8/2000	9 (J)	1 (U)	**10**	1 (U)	**110**	1 (U)	**25**	1 (U)	59	2	**6 (JB)**	2 (B)	**96**	1 (U)	**140**	1 (U)	10 (U)	0.1 (J)
3/7/2000	9 (J)	1 (U)	**12**	1 (U)	**110**	1 (U)	**26**	1 (U)	62	2	14 (B)	0.9 (JB)	**100**	1 (U)	**160**	1 (U)	10 (U)	1 (U)
4/26/2000	7 (J)	1 (U)	**10**	1 (U)	**96**	1 (U)	**24**	1 (U)	61	4	20 (B)	0.8 (JB)	**110**	1 (U)	**140**	1 (U)	10 (U)	0.2 (J)
5/15/2000	6	1 (U)	**8**	1 (U)	**49 (D)**	1 (U)	**19**	1 (U)	42 (D)	3	0.1 (JB)	0.7 (BJ)	**68 (D)**	1 (U)	**87 (D)**	1 (U)	**0.3 (J)**	1 (U)
6/14/2000	8	1 (U)	**10**	1 (U)	**130**	1 (U)	**24**	1 (U)	42	1	3 (BJ)	0.2 (BJ)	**130**	1 (U)	**150**	1 (U)	10 (U)	1 (U)
7/19/2000	4 (J)	1 (U)	6	1 (U)	**63**	1 (U)	**12**	1 (U)	42	2	4 (JB)	0.9 (JB)	**64**	1 (U)	**79**	1 (U)	5 (U)	1 (U)
8/16/2000	10 (J)	1 (U)	**10 (J)**	1	**180**	1 (U)	**31**	1 (U)	39	1 (J)	23 (B)	0.3 (BJ)	**100**	1 (U)	**140**	1 (U)	10 (U)	1 (U)
9/13/2000	5.9	0.5 (U)	7	0.5 (U)	**122**	0.5 (U)	**25.4**	0.5 (U)	32.1	0.74	1 (U)	0.57	**65.3**	0.5 (U)	**99.9**	0.5 (U)	1 (U)	0.5 (U)
10/25/2000	6.3	0.5 (U)	**8**	0.5 (U)	**133**	0.5 (U)	**25.6**	0.5 (U)	37.3	0.69	1 (U)	0.5 (U)	**68.7**	0.33 (J)	**104**	0.5 (U)	1 (U)	0.5 (U)
4/19/2001	4 (D)	1 (U)	5 (D)	1 (U)	**73 (D)**	1 (U)	**20 (D)**	0.6 (J)	38 (D)	3	2 (U)	**6**	**44 (D)**	1 (U)	**76 (D)**	1 (U)	2 (U)	1 (U)
10/25/2001	3.4	1 (U)	5.1	1 (U)	**130**	1 (U)	**23**	1 (U)	23	0.9 (J)	1 (U)	1 (U)	**50**	1 (U)	**74**	1 (U)	1 (U)	1 (U)
4/25/2002	2.9	1 (U)	4.5	1 (U)	**110**	1 (U)	**26**	1 (U)	24	1.8	1 (U)	1 (U)	**41**	1 (U)	**76**	1 (U)	1 (U)	1 (U)
10/21/2002	2.6	1 (U)	1.06	1 (U)	**155**	1 (U)	**27.5**	1 (U)	11.3	1 (U)	1 (U)	1 (U)	**33.6**	1 (U)	**46.8**	1 (U)	1 (U)	1 (U)
4/17/2003	2.8	1 (U)	2.5	0.23 (J)	**73**	1 (U)	**19**	0.93 (J)	23	4.4	1 (U)	3.5 (B)	**31**	0.38 (J)	**38**	0.31 (J)	**0.81 (J)**	1 (U)
12/1/2003	2	1 (U)	2	1 (U)	**104 (D)**	1 (U)	**21.4**	1 (U)	9	1	1 (U)	1 (U)	**22.6**	1 (U)	**31.4**	1 (U)	1 (U)	1 (U)
6/9/2004	1.34	1 (U)	1.49	1 (U)	**91.9**	1 (U)	**22.4**	1 (U)	6.98	1 (U)	1 (U)	1 (U)	**21.5**	1 (U)	**28.3**	1 (U)	1 (U)	1 (U)
10/20/2004	2.07	1 (U)	2.47	1 (U)	**100**	1 (U)	**24.6**	1 (U)	5.59	0.83 (J)	1 (U)	1 (U)	**25.7**	0.72 (J)	**29.4**	2.74	1 (U)	1 (U)
6/21/2005	1 (U)	1 (U)	1.58	1 (U)	**110**	1 (U)	**30.4**	0.48 (J)	3.93	2.04	0.74 (J)	1 (U)	**29.1**	1.66	**34.9**	1.28	1 (U)	1 (U)
11/18/2005	11 (J)	1 (U)	5.2	0.67 (J)	**150**	1 (U)	**31**	0.42 (J)	20	6.3	1 (U)	1 (U)	**81**	4.5	**90**	1.6	1 (U)	1 (U)
4/25/2006	35	0.16 (U)	**18**	4.8	**81**	0.19 (U)	**56**	0.16 (U)	**920**	**390**	**20**	1.7	**150**	**5.7**	**150**	**7.6**	0.68 (U)	**5.6**
6/5/2006	27.4	1 (U)	1 (U)	1 (U)	**60.1**	1 (U)	**45**	1 (U)	**2040 (D)**	**793 (D)**	**27.2**	1 (U)	**125 (D)**	3	**158 (D)**	4.6	**6**	**8.6**
10/5/2006	53.3	1 (U)	**73.1**	1 (U)	**60.1**	1 (U)	**45.1**	1 (U)	**6580 (D)**	0.78 (J)	**6.9**	**7.3**	**87.2**	1 (U)	**93.7**	1 (U)	**26.1**	1 (U)
6/26/2007	11	0.43 (U)	5.2	1.4 (J)	3.4 (J)	0.51 (U)	**4.1**	0.43 (U)	**320**	**590**	0.32 (U)	2.6 (J)	**6.8**	0.53 (U)	**5.3**	0.43 (U)	**12**	**48**
7/24/2007	**290**	0.32 (U)	**95**	0.52 (J)	**48 (J)**	0.38 (U)	**77**	0.32 (U)	**6500**	**330**	21 (U)	**6.7**	**94**	0.4 (U)	**88**	0.32 (U)	**350**	**18**
8/6/2007	**370**	0.16 (U)	**99**	0.35 (J)	**58**	0.19 (U)	**99**	0.16 (U)	**7700**	**130**	8.5 (U)	3.3	**89**	0.2 (U)	**88**	0.16 (U)	**420**	**8.6**
8/16/2007	180	0.32 (U)	**47**	0.4 (J)	**24**	0.38 (U)	**67**	0.32 (U)	**4500**	**190**	4.1 (U)	5.4 (U)	**28**	0.4 (U)	**42**	0.32 (U)	**420**	**34**
10/9/2007	**300**	0.16 (U)	**93**	0.44 (J)	**42**	0.19 (U)	**88**	0.16 (U)	**5800**	**300**	13 (U)	**4.8**	**70**	0.2 (U)	**93**	0.16 (U)	**470**	**36**
11/8/2007	**270**	0.16 (U)	**94**	0.5 (J)	**40**	0.19 (U)	**85**	0.16 (U)	**5400**	**140**	13 (U)	**4.7**	**78**	0.2 (U)	**110**	0.16 (U)	**590**	**36**
4/29/2008	**340**	0.16 (U)	**94 (J)**	1.3 (J)	**30**	0.19 (U)	**100**	0.45 (J)	**5700**	**310**	**6.4 (J)**	**6.2 (J)**	**97**	0.32 (J)	**100**	0.56 (J)	**44**	**28**
11/11/2008	**310**	0.16 (U)	**71**	0.14 (U)	**35**	0.19 (U)	**80**	0.16 (U)	**5900**	2.2	9.2 (U)	1.3 (U)	**88**	0.2 (U)	**89**	0.17 (J)	**32 (J)**	**4.2 (J)**
4/21/2009	45	0.16 (U)	**27**	1.6	**7.2**	0.19 (U)	**8.6**	0.16 (U)	**1500**	**95**	1.6 (U)	4.1 (B)	**18**	0.53 (J)	**37**	1.9	**92**	**47**
10/26/2009	110	0.16 (U)	**36**	0.14 (U)	**27**	0.19 (U)	**19**	0.16 (U)	**2600**	1.8	1.6 (U)	0.46 (J)	**53**	0.2 (U)	**77**	0.58 (J)	**130 (J)**	**1.5 (J)**
4/27/2010	75	0.16 (U)	**25**	5.6	**3.3**	0.19 (U)	**6.3**	0.16 (U)	**1900**	**360**	2.1	0.82 (J)	**32**	0.2 (U)	**79**	**3.5**	**79**	**150**
6/22/2010	6	35	2.2	**24**	0.4	1.3 (U)	0.46	**9.9**	**110**	**1800**	0.39	5.6 (U)	**8.7**	**29**	**9.3**	**77**	**0.4**	**270**
7/28/2010	190	15	**42**	**8.5**	**11**	0.76 (U)	**22**	3.3 (J)	**2800**	**790**	**7.7**	**6.4**	**74**	**11**	**230**	**40**	**70**	**40**
8/26/2010	120	12	**22**	**12**	**9.7**	0.38 (U)	**15**	**3.5**	**1700**	**960**	3.1	4.3 (B)	**44**	**20**	**160**	**84**	**2**	**160**
9/29/2010	**220**	8.3	**43**	**10**	**19**	0.38 (U)	**27**	3	**2200**	**690**	1.6	0.64 (U)	**88**	**11**	**350**	**93**	**9**	**130**
10/28/2010	**400**	9.7	**68**	**7.5**	**27**	0.38 (U)	**49**	3.4	**3700**	**590**	3.2	2.2 (U)	**270**	**6.5**	**810**	**100**	**64**	**75**

Notes: 1,1,1-TCA = 1,1,1-trichloroethane; 1,1-DCE = 1,1-dichloroethene; CT = carbon tetrachloride; CF = chloroform; *cis*-1,2-DCE = *cis*-1,2-dichloroethene; MCl = methylene chloride; PCE = tetrachloroethene; TCE = trichloroethene; VC = vinyl chloride. R1-0 = influent, R2-E = effluent; formal sampling location names are Mound R1-0 and Mound R2-E. Shaded, bold value indicates detected concentration exceeds corresponding applicable level stipulated in RFLMA Attachment 2, Table 1 (DOE 2007a); if detection limit exceeded that concentration and constituent was qualified as nondetect, result is not highlighted as an exceedance. Lab and validation qualifiers (wherein the validation qualifier supersedes the lab qualifier if they differ): J = result is estimated below the sample quantitation limit; U = analyte not detected at the indicated concentration; B = chemical was also detected in the blank; D = analysis was performed at a dilution.

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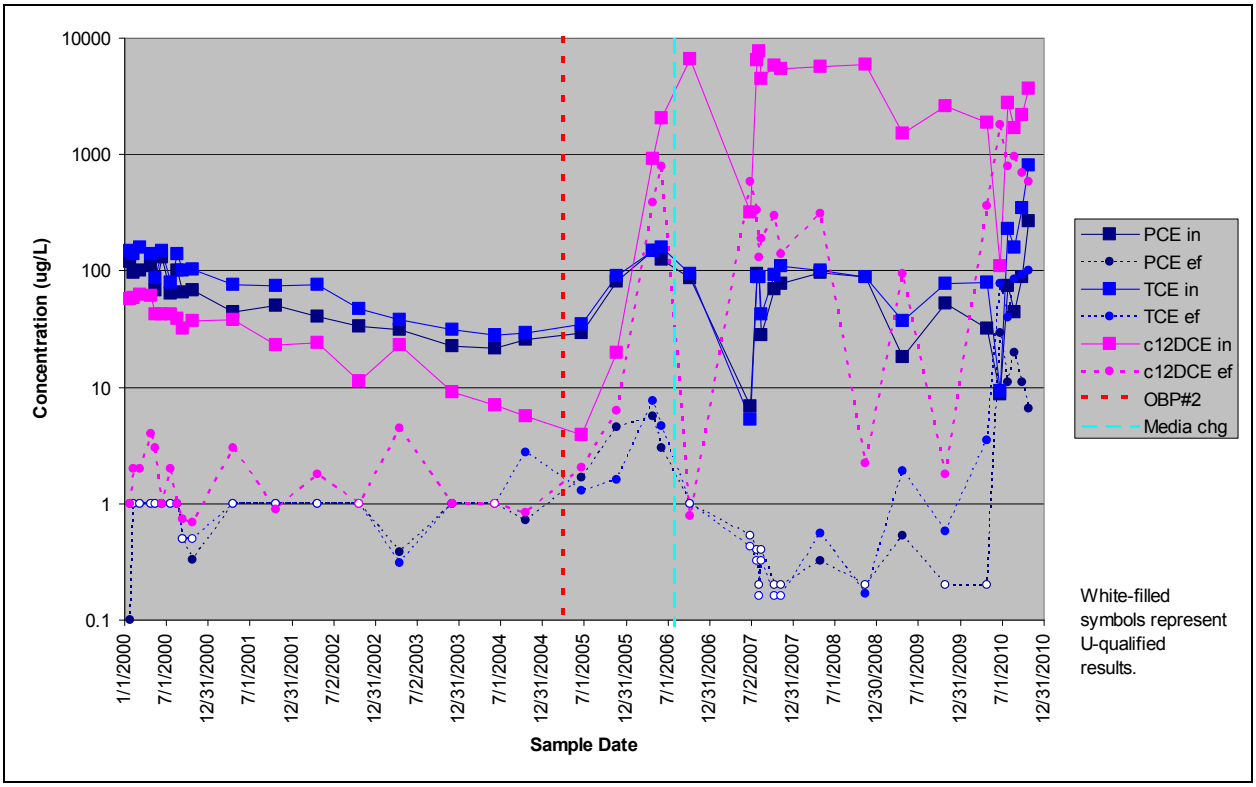
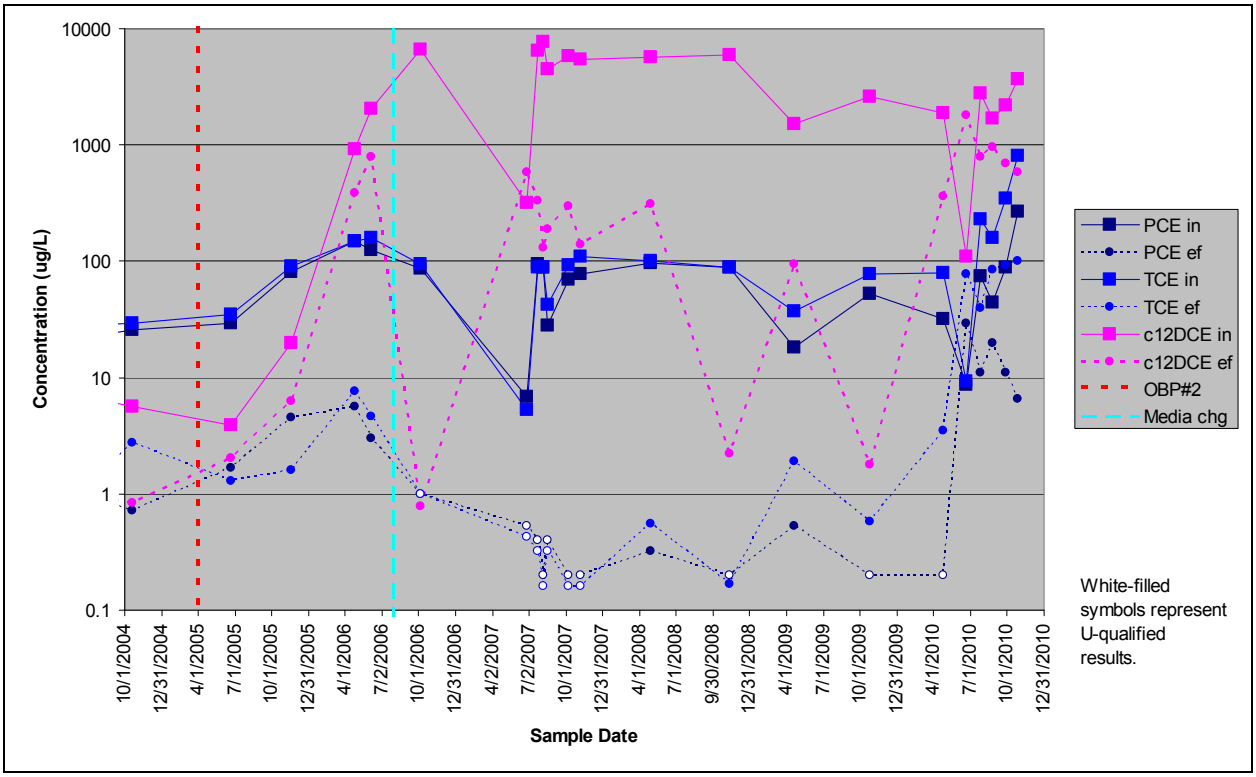


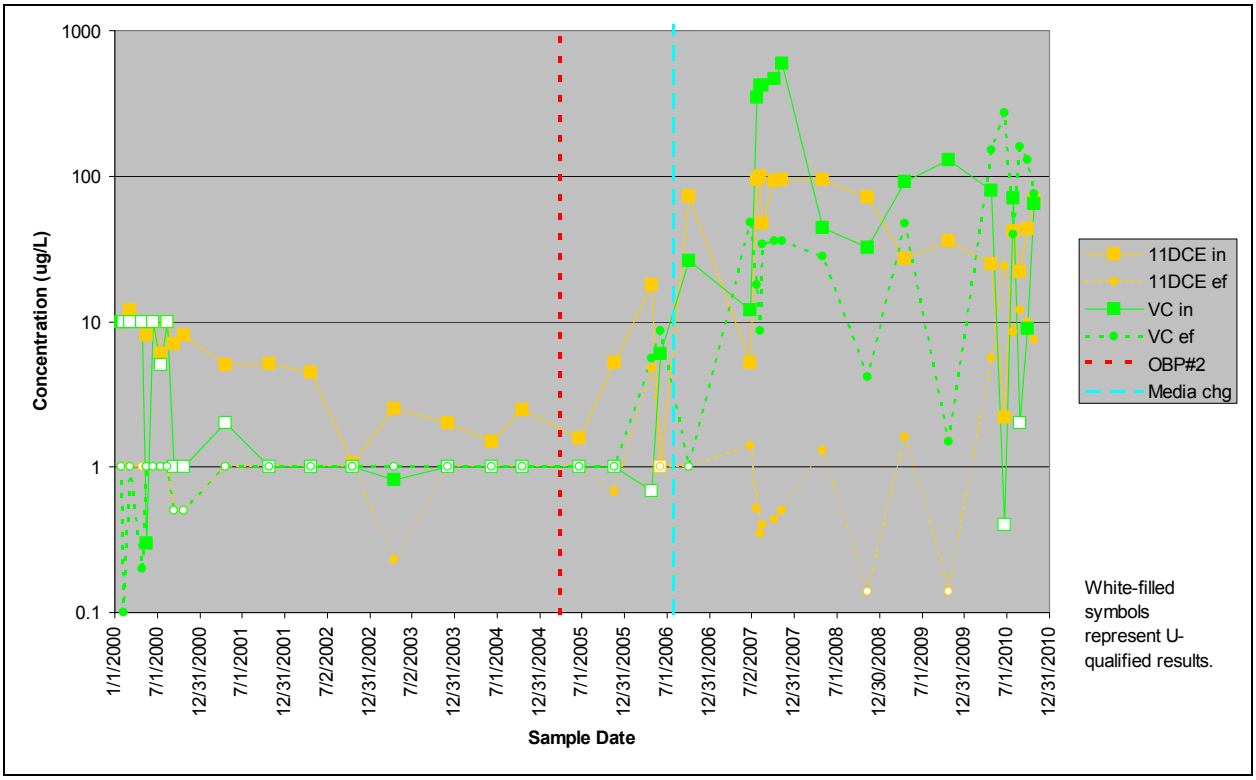
Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

Figure 204. Concentrations of PCE, TCE, and cis-1,2-DCE in MSPTS Influent and Effluent



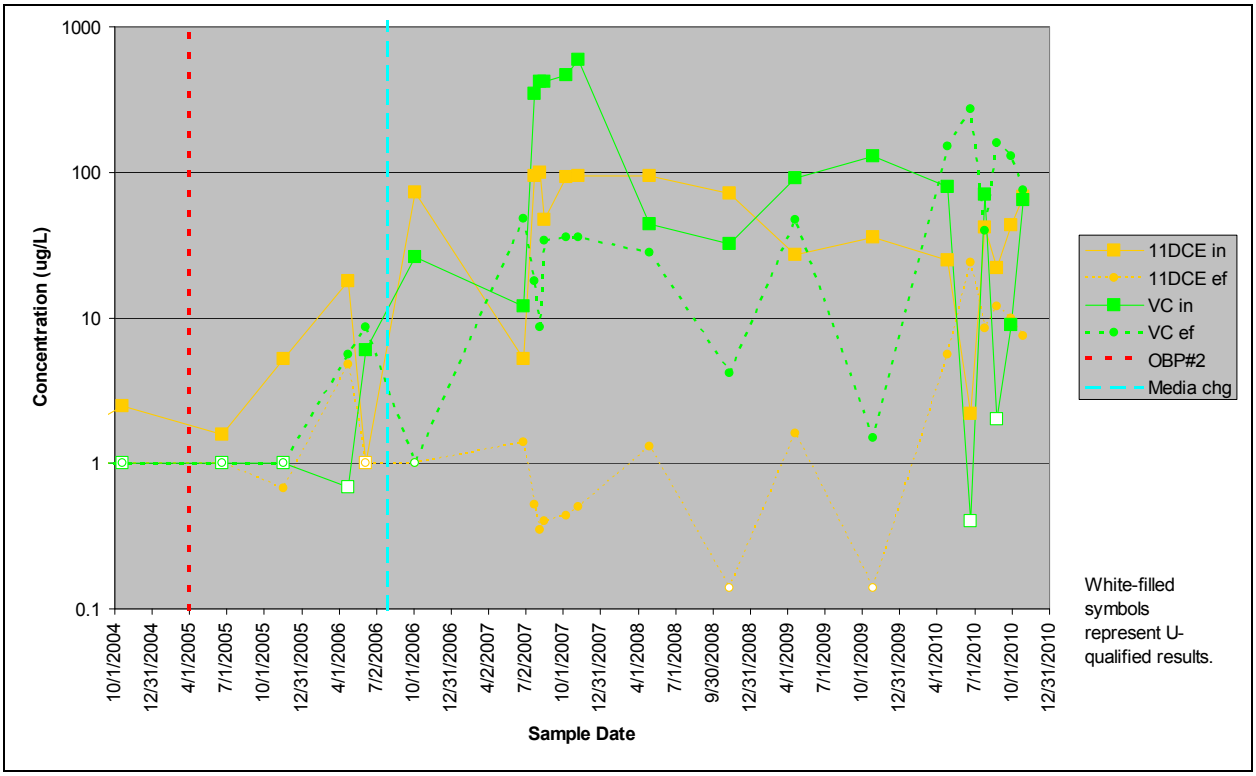
Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

Figure 205. Recent Concentrations of PCE, TCE, and cis-1,2-DCE in MSPTS Influent and Effluent



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): 1,1-DCE, 7; VC, 0.2; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

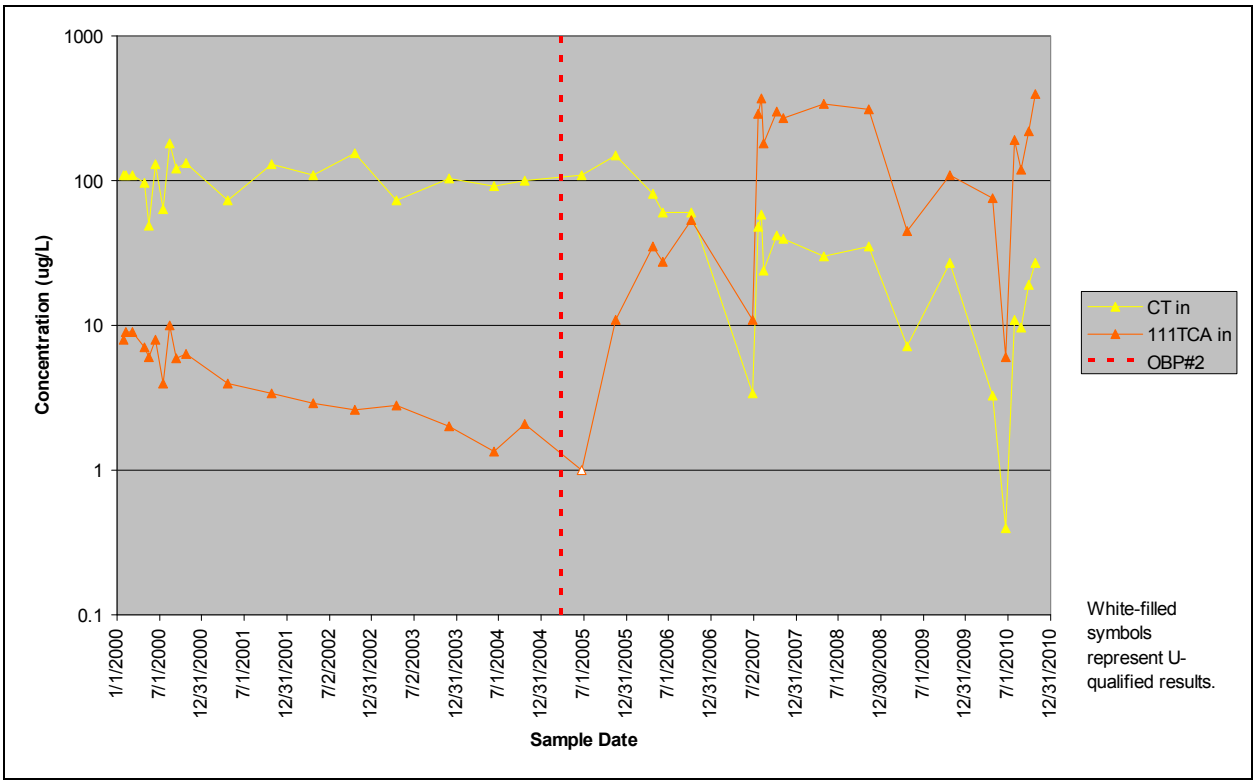
Figure 206. Concentrations of 1,1-DCE and VC in MSPTS Influent and Effluent



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): 1,1-DCE, 7; VC, 0.2; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

Figure 207. Recent Concentrations of 1,1-DCE and VC in MSPTS Influent and Effluent

Figure 208 provides time-series plots for carbon tetrachloride and 1,1,1-TCA in system influent. Carbon tetrachloride is not detected in system effluent, and the same typically applies to 1,1,1-TCA though this constituent was detected at concentrations lower than the RFLMA Table 1 value in the samples collected after May 2010. This figure shows the variable effect on influent contaminant distributions following the OBP#2-related work and the higher flows of 2010; it also illustrates a distinction between the Mound and OBP#2 plumes. The time-series plot for carbon tetrachloride in system influent shows carbon tetrachloride in groundwater from the OBP#2 source area has not contributed to an overall increase in the concentrations of this constituent; instead, overall concentrations of this compound have decreased. Even the high-water conditions in 2010 did not boost carbon tetrachloride concentrations in system influent to those seen prior to closure, before the system collection infrastructure was enhanced to receive the OBP#2 water. The time-series plot for 1,1,1-TCA shows the importance of this compound in distinguishing between the Mound and OBP#2 plumes. Additional time-series plots and discussion of these plumes are provided above, in the discussion of the Mound and OBP#2 Plumes.



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): CT = carbon tetrachloride, 1; 1,1,1-TCA, 200; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

Figure 208. Concentrations of Carbon Tetrachloride and 1,1,1-TCA in MSPTS Influent

Analytical results from the samples collected in April 2010 drove regulatory consultation, the results of which included monthly sampling at MSPTS locations as well as non-RFLMA locations. This activity is described in greater detail below.

In addition to the constituents summarized in Table 79, other VOCs were detected in MSPTS effluent in 2010 (see DOE 2010c, 2010e, 2011b and Appendix B.6 for the data). The only other VOC reported at a level exceeding the applicable RFLMA Table 1 concentration was 1,2-DCA. Three samples of effluent reported detections of 1,2-DCA exceeding the 1 µg/L RFLMA Table 1 value for this constituent. Collected in April, August, and September, the results ranged from 1.3 µg/L to 1.8 µg/L, and two were J-qualified.

Six grab samples for the analysis of VOCs were collected in 2010 at the surface water performance location for the MSPTS, surface-water station GS10. As in prior years, VOC detections were reported (Table 80). In the June 2010 sample, two constituents—TCE and vinyl chloride—exceeded the corresponding RFLMA Table 1 standard.

Table 80. Summary of VOCs Detected in 2010 at GS10

Date	Constituent	Result (µg/L)	Qualifier
4/27/2010	1,1,1-Trichloroethane	0.47	J
4/27/2010	*cis*-1,2-Dichloroethene	12	
4/27/2010	Trichloroethene	0.49	J
6/22/2010	1,1,1-Trichloroethane	1.5	
6/22/2010	1,1-Dichloroethene	0.58	J
6/22/2010	Chloroform	0.49	J
6/22/2010	*cis*-1,2-Dichloroethene	70	
6/22/2010	Tetrachloroethene	0.93	J
6/22/2010	***Trichloroethene***	***2.8***	
6/22/2010	***Vinyl chloride***	***0.69***	***J***
7/28/2010	1,1,1-Trichloroethane	0.54	J
7/28/2010	1,1-Dichloroethene	0.24	J
7/28/2010	Chloroform	0.18	J
7/28/2010	*cis*-1,2-Dichloroethene	42	
7/28/2010	Methylene chloride	0.36	J
7/28/2010	Tetrachloroethene	0.62	J
7/28/2010	Trichloroethene	2.2	
8/26/2010	*cis*-1,2-Dichloroethene	25	
8/26/2010	Tetrachloroethene	0.34	J
8/26/2010	Trichloroethene	1.8	
9/29/2010	*cis*-1,2-Dichloroethene	20	
9/29/2010	Trichloroethene	2.2	
10/28/2010	*cis*-1,2-Dichloroethene	11	
10/28/2010	Trichloroethene	1.3	

The detections reported in 2010 at GS10 exceed those in recent years, both in the number of constituents and, in several cases, the reported concentration. Detections in recent years have consistently included *cis*-1,2-DCE, plus two detections of 1,2-DCA (one each in 2007 and 2008) and one of TCE (in 2007).

The treatment media in the MSPTS will be replaced in early 2011. The effect of this replacement will be an improvement in the treatment effectiveness. In addition, a polishing component will be installed, as discussed in greater detail below.

MSPTS Regulatory Consultation and Effluent Polishing Component

Before groundwater from the OBP#2 source area was routed to the MSPTS for treatment, system effluent typically reported few, if any, detectable concentrations of VOCs. Since 2006, when the effects of increased contaminant load and flows to the MSPTS from the OBP#2 source area became evident, system effluent has contained residual VOCs (see preceding text and associated figures, and Table 79 for data summary). These constituents typically include low concentrations of parent compounds and more elevated concentrations of the daughter products *cis*-1,2-DCE and vinyl chloride. Concentrations in 2010 were elevated with respect to previous data, particularly for parent compounds. The presence of these VOCs is due to a combination of factors: With the addition of flows related to the OBP#2 area, the MSPTS now receives higher flows than before; this was particularly true in 2010. In addition, those flows contain higher concentrations of VOCs overall, as well as higher concentrations of metabolic byproducts. As discussed above, these byproducts, such as *cis*-1,2-DCE and vinyl chloride, are recalcitrant and

require more time within the ZVI media to be reductively dechlorinated. However, under conditions of higher flow rates, water instead is present within the media for a shorter time. Further exacerbating this limit on the degree to which the influent water was treated, the media in 2010 was increasingly clogged with mineral precipitates. This is a natural response to the general groundwater chemistry at Rocky Flats, which includes elevated concentrations of dissolved oxygen (which acts to form iron oxide and iron oxyhydroxide precipitates within the ZVI media), calcium, and carbonate (both of which react within the ZVI to form calcite, with the latter ion also reacting with dissolved iron from the ZVI to form siderite). These processes result in decreasing amounts of fresh ZVI available to treat the VOCs present in the influent stream and, at some point, the amount of fresh ZVI within the media is insufficient to meet the treatment needs. This point was reached in 2010.

The second quarter sample results, which are summarized above in Table 79 and are presented in full in DOE 2010e, led to consultation with CDPHE. (This consultation, summarized in Contact Record 2010-07, also included the subject of treatment at the ETPTS, which is discussed in the corresponding section below.) While it was recognized that the MSPTS media was in need of replacement, additional data were desired to assess how the VOC concentrations varied as the system effluent moved into the receiving Functional Channel. To support this evaluation, two non-RFLMA sampling points were selected within FC-4: MSPTSCHAN1 was located within FC-4 close to the MSPTS effluent discharge gallery where accessible, pooled water was visible among the riprap, but flow was not evident; MSPTSCHAN2 was located a short distance downstream of MSPTSCHAN1 in FC-4, and was the nearest point to MSPTSCHAN1 that had easily accessible, turbulently flowing water. These locations are illustrated in Figure 209.

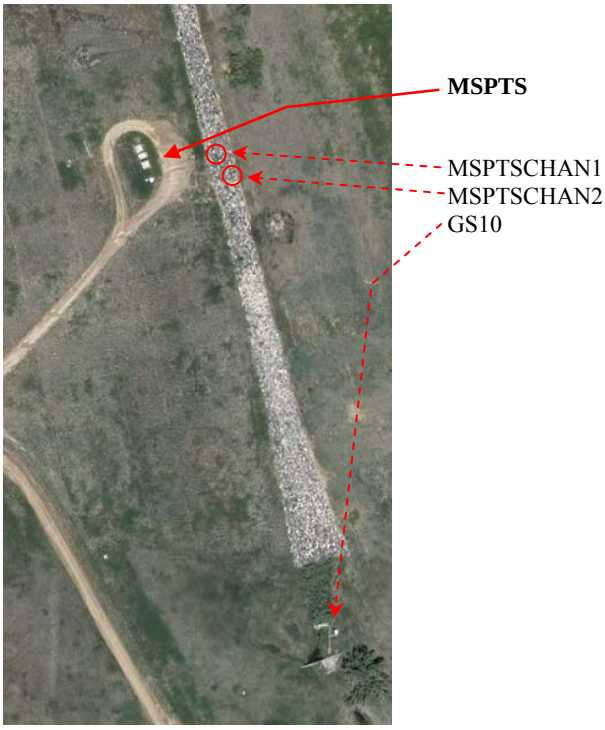


Figure 209. MSPTS With Approximate Locations of Extra Sampling Points With Respect to Treatment System and Surface Water Performance Location

In accordance with Contact Record 2010-07, additional samples were collected at the RFLMA locations and the extra locations identified above. This evaluation sampling occurred in June, July, August, September, and October. During each event, each location was visited for sampling. In June, conditions at MSPTSCHAN1 and MSPTSCHAN2 were as described above. During the July event these two locations presented accessible, standing water. In August and September, both of these locations were dry. During the October sampling event only MSPTSCHAN1 had water. Analytical results for these samples are summarized in Table 81; estimated flow rates and residence times corresponding to those sample dates are provided below in Table 82. For comparison, several additional values are provided that correspond to samples collected in 2008 and 2009. These data clearly show the change in conditions at the MSPTS in 2010: with the exception of the April 2010 figures, which are lower due to the series flow configuration that applied at that time and to the clogged media that acted to hold back the flow, flow rates in 2008 and 2009 were most often well below those in 2010, and as a result, the residence times were significantly longer. If the April 2010 values are omitted, the average flows for the 2010 samples (that is, an overall average of only those average flow figures corresponding to the samples collected over the year) are more than twice the flows in 2008, and more than 50 percent higher than those in 2009. Similarly, the average residence times (again, omitting the clog-related April data) for 2010, again averaging only the residence times estimated for the sample dates, are less than half the corresponding figure in 2008, and about 60 percent of the average for 2009 samples. Conditions such as these almost certainly would have challenged the MSPTS even if the treatment cells contained fresh ZVI, particularly given the high concentrations of recalcitrant compounds in MSPTS influent.

Table 81. Summary of Results From RFLMA and non-RFLMA Locations Used to Evaluate MSPTS

Constituent (RFLMA standard)	Month (2010)	R1-O (influent)	R2-E (effluent)	MSPTSCHAN1	MSPTSCHAN2	GS10
Chloroform (3.4)	June	0.46 (J)	**9.9**	1	0.54 (J)	0.49 (J)
	July	**22**	3.3 (J)	0.87 (J)	0.19 (J)	0.18 (J)
	Aug	**15**	**3.5**	NF	NF	ND
	Sept	**27**	3	NF	NF	ND
	Oct	**49**	**3.4**	1.2	NF	ND
cis-1,2-DCE (70)	June	**110**	**1800**	**160**	**84**	70
	July	**2800**	**790**	**200**	36	42
	Aug	**1700**	**960**	NF	NF	25
	Sept	**2200**	**690**	NF	NF	20
	Oct	**3700**	**590**	**300**	NF	11
PCE (1—PQL)	June	**8.7**	**29**	**2.4**	**1.2**	0.93 (J)
	July	**74**	**11**	**3.4**	0.57 (J)	0.62 (J)
	Aug	**44**	**20**	NF	NF	0.34 (J)
	Sept	**88**	**11**	NF	NF	ND
	Oct	**270**	**6.5**	**2.1**	NF	ND
TCE (2.5)	June	**9.3**	**77**	**7.3**	**3.8**	**2.8**
	July	**230**	**40**	**12**	2.2	2.2
	Aug	**160**	**84**	NF	NF	1.8
	Sept	**350**	**93**	NF	NF	2.2
	Oct	**810**	**100**	**40**	NA	1.3
Meth. Chloride (4.6)	June	0.39 (JB)	**5.6 (JB)**	0.62 (JB)	0.49 (JB)	0.49 (JB)
	July	**7.7 (J)**	**6.4**	0.83 (J)	0.36 (J)	0.36 (J)
	Aug	3.1 (JB)	4.3 (B)	NF	NF	ND
	Sept	ND	ND	NF	NF	ND
	Oct	ND	2.2	1	NF	ND
VC (0.2—PQL)	June	ND	**270**	**7.7**	**2.6**	**0.69 (J)**
	July	**70**	**40**	**13**	**0.6 (J)**	ND
	Aug	ND	**160**	NF	NF	ND
	Sept	**9**	**130**	NF	NF	ND
	Oct	**64**	**75**	**16**	NF	ND
1,1-DCE (7)	June	2.2	**24**	1.9	0.91 (J)	0.58 (J)
	July	**42**	**8.5**	2.1	0.33 (J)	0.24 (J)
	Aug	**22**	**12**	NF	NF	ND
	Sept	**43**	**10**	NF	NF	ND
	Oct	**68**	**7.5**	2.3	NF	ND

Notes: Constituents and corresponding RFLMA Table 1 values are as indicated. GS10 is surface water performance location. See text for descriptions of non-RFLMA locations MSPTSCHAN1 and MSPTSCHAN2. Shaded, bold values exceed corresponding RFLMA Table 1 value. NF = no flow (unable to sample). ND = nondetect. J = result is estimated; B = constituent was also detected in the blank.

Table 82. Flow Rates and Residence Times at the MSPTS in 2008, 2009, and 2010

MSPTS				
Sample Date	**Flow (avg., gpm)**	**Flow (annual avg. sample dates, gpm)**	**Estimated HRT (hours)**	**HRT (annual avg. sample dates, hours)**
4/29/2008	0.71	0.54	128.80	182.62
11/11/2008	0.38		236.44	
4/21/2009	1.12	0.85	80.78	118.01
10/26/2009	0.58		155.25	
4/27/2010	0.17[a]	1.36[b] (1.16)	528.00[a]	72.36[b] (148.30)
6/22/2010	2.27		39.75	
7/28/2010	1.08		84.00	
8/26/2010	1.23		73.50	
9/29/2010	1.02		89.11	
10/28/2010	1.20		75.46	

Notes: avg. = average; gpm = gallons per minute; annual avg. sample dates = average of the values corresponding to the samples listed for that year (not a true annual average for the year); HRT = hydraulic residence time. Average flow and corresponding HRT calculated from flow data corresponding to the specific sample date.

[a] Cell 1 was clogged, restricting water from flowing through the system; flow configuration was changed after this date, allowing water to flow through the cells more rapidly.

[b] Figure omits the anomalous value of April 27; value in parentheses corresponds to average calculated with that value included.

The GS10 sample results were evaluated in accordance with RFLMA Attachment 2, Figure 11. The concentrations do not exceed the 85th percentile of the results for the corresponding RFLMA standards in Attachment 2, Table 1.

These results demonstrate that residual VOCs in system effluent dissipate very quickly. As noted, the media at the MSPTS will be replaced in early 2011. Fresh media should significantly improve the treatment effectiveness at this system. Even so, due to the detections of VOCs in the effluent and the fact that the MSPTS was not designed to treat elevated concentrations of recalcitrant daughter products of chlorinated ethenes, the addition of an effluent polishing component was considered. The intent would be to further reduce residual concentrations of VOCs present in MSPTS effluent.

The effort to design an appropriate polishing component began in the latter half of 2010. The initial focus was on an engineered riffle system, such as that comprising the PLFTS. Design documents and calculations were reviewed for that system and used to draft a preliminary scale of an MSPTS polishing component. Outside expertise was secured via a firm experienced with air stripping technologies and theory. Staff for LM and the outside firm developed additional formulae and calculations that significantly expanded the scale of this component. The design criteria included a 3 gpm flow (which actually represents an estimated maximum that would only apply for a short duration) and the worst-case effluent concentrations in Table 79 and Table 81. Several resulting design options were generated and considered, varying based on such parameters as desired or available slope, the number and configuration (height and width) of the individual aerating steps, and the overall length of the unit; environmental conditions also affected the design, primarily with respect to the wind speed. For example, assuming a 10 mph wind speed, one design for a riffle system to provide polishing for such a flow would be approximately 8 feet wide, 60 feet long and include 37 steps, each 3 inches high. Although it would be desirable to cover the unit with grating to enhance safety and reduce the amount of

windblown debris that might accumulate on the steps, this would reduce the effective wind speed, requiring either omission of the grating or compensation via a larger riffle component. In addition, flows would be limited to 1 millimeter in depth, and the drip edge on each step—i.e., where the flow would depart one step and drop to the next—was of paramount importance in achieving the necessary turbulence and aeration. All of these requirements and the overall size added up to a polishing component that would be much larger and costly, and require much more maintenance, than was envisioned for a "passive" addition. One cost estimate, for example, was approximately $100,000 for construction alone, without grating, specialized drip edges, other additions that might be desired for maintenance or health and safety, or the associated operation and maintenance required.

The focus then moved to a more "off-the-shelf" alternative: a readily-available, prefabricated stacking tray or tower air stripper. The same flow and concentration figures were used to determine that the cost of the air stripper itself would be very reasonable—in the several thousand dollar range—but the cost for the solar power infrastructure required to support the associated blowers and pumps would be on the order of $375,000. This was infeasible, even without considering the cleaning and other maintenance needed for such a system.

Although polishing was desired, the alternatives described above were not feasible. Therefore, a third alternative was developed. First, standard landscaping mist nozzles and hose were used with a hand-held photoionization detector (PID) used for health-and-safety purposes to monitor breathing air for VOCs. Water from a treatment system was sprayed through the nozzles into a bucket, and the headspace was monitored with the PID to confirm that VOCs were being volatilized. As 2010 ended, this approach was being developed for additional testing; the intent was to install a successfully tested unit within the existing MSPTS effluent manhole and use a solar-powered pump to spray the water. Rather than design for worst-case flow and water quality, the unit would be tested and optimized in place under actual conditions. With respect to the two options described above, costs would be comparably low, and therefore the overall unit would be feasible to install and would provide improvements to the effluent water quality. The intent was to devise and test a near-scale unit, then install a more permanent air stripper informed by these test results as a part of the media replacement activity scheduled to be completed by March 31, 2011. Additional information, discussion, and resulting operational data from the air stripper will be provided in the 2011 Annual Report.

East Trenches Plume and Treatment System

The East Trenches Plume is an area of groundwater contamination named after several buried disposal trenches that contribute VOCs to groundwater. These trenches are located on the pediment south of South Walnut Creek, in former OU 2. The source of this plume is residual VOC contamination associated predominantly with Trenches T-3 and T-4, which were remediated in 1996. In addition, a portion of the 903 Pad Plume flows from its source area toward the northeast and merges with the East Trenches Plume. A treatment system (the ETPTS) was installed in 1999 to intercept and treat contaminated groundwater flowing toward the B-series ponds and South Walnut Creek.

East Trenches Plume

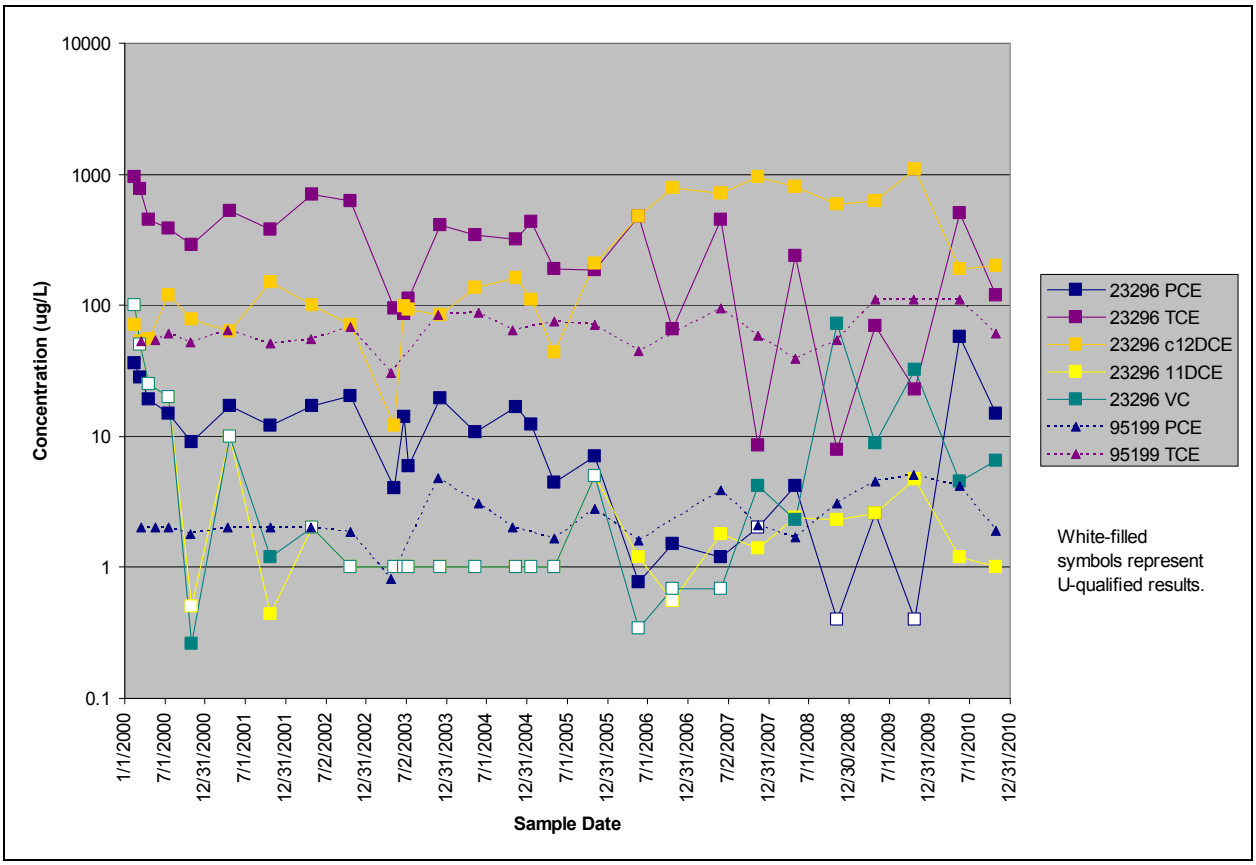
Evaluation wells 3687 and 05691 monitor the primary source areas of the East Trenches Plume, Trenches T-3 and T-4, respectively. More distal portions of the plume are monitored by Evaluation well 03991 and Sentinel well 04091 to the east-northeast. Sentinel wells 95099, 95199, 95299, and 23296 monitor the ETPTS and downgradient portions of the plume along South Walnut Creek. AOC well 00997, situated at the mouth of Pond B-5 in the South Walnut Creek drainage, also supports monitoring of this plume. Well 00191 monitors groundwater closest to the source area of the 903 Pad Plume and is discussed in the context of the 903 Pad/Ryan's Pit Plume later in this section.

All of the East Trenches Plume Evaluation wells were sampled once in 2010, and all Sentinel wells and the AOC well at Pond B-5 were sampled twice in 2010. Analytical data for these wells in 2010 were generally consistent with those from recent years.

Of the wells sampled along South Walnut Creek in support of the East Trenches Plume, well 95299 was dry, and RFLMA Table 1 standards were exceeded in samples from wells 23296 and 95199. This is consistent with past conditions, as is the fact that samples from well 23296 contained the highest concentrations of VOCs of this group of wells.

Figure 210 displays three VOCs that, since 2007, have been most commonly detected in one or both of wells 23296 and 95199 at concentrations exceeding the corresponding RFLMA action level: TCE, *cis*-1,2-DCE, and VC. Also displayed are PCE and 1,1-DCE at well 23296, and PCE at well 95199. Concentrations of *cis*-1,2-DCE in samples from well 23296 show a fairly gradual increase at this logarithmic scale, though the 2010 concentrations decrease to levels last observed in 2005; a somewhat similar pattern is also evident in concentrations of 1,1-DCE. (Statistical calculations confirm the visual appearance of trends in samples from well 23296, as noted in Table 77: S-K calculations indicate 95 percent significant increasing trends are present in 1,1-DCE and both 1,2-DCE isomers. In addition, similarly significant decreasing trends are calculated for carbon tetrachloride, chloroform, PCE, and TCE.) Conversely, compared with data for samples collected prior to about 2007 from well 23296, more recent concentrations of TCE, PCE, and VC have varied sharply from sample to sample. A seasonal pattern is apparent. Concentrations of VC are seen to vary inversely with those of PCE and TCE: concentrations of TCE and PCE are relatively higher, and concentrations of VC are relatively lower in the second calendar quarters, and then in the fourth quarters this is reversed. This may be attributed to seasonal effects on biodegradation, wherein reduced recharge in the fourth quarter allows waters to become more locally reducing; these geochemical conditions would be expected to promote increased levels of reductive dechlorination of parent compounds. The second quarter may be marked by more frequent precipitation and consequently greater amounts of oxygenated recharge, which would act to reduce this dechlorination and potentially flush contaminants into the saturated zone. However, given that *cis*-1,2-DCE and 1,1-DCE are intermediate metabolic byproducts between the parent compounds (PCE and TCE) and the final chlorinated byproduct (VC), one might expect those intermediate constituents to also reflect a seasonal pattern rather than that described above. Additional factors, therefore, must be affecting the concentrations reported in samples from well 23296. An alternative explanation may be that residual PCE and TCE are mobilized during relatively higher-water second quarters, increasing the relative concentrations of these constituents compared to that of VC. This explanation would require that these higher-water flows also contribute sufficient *cis*-1,2-DCE and 1,1-DCE to result in the

relatively uniform concentrations apparent in these constituents. Additional monitoring data may help to clarify factors affecting contaminant concentrations observed in groundwater samples from well 23296.



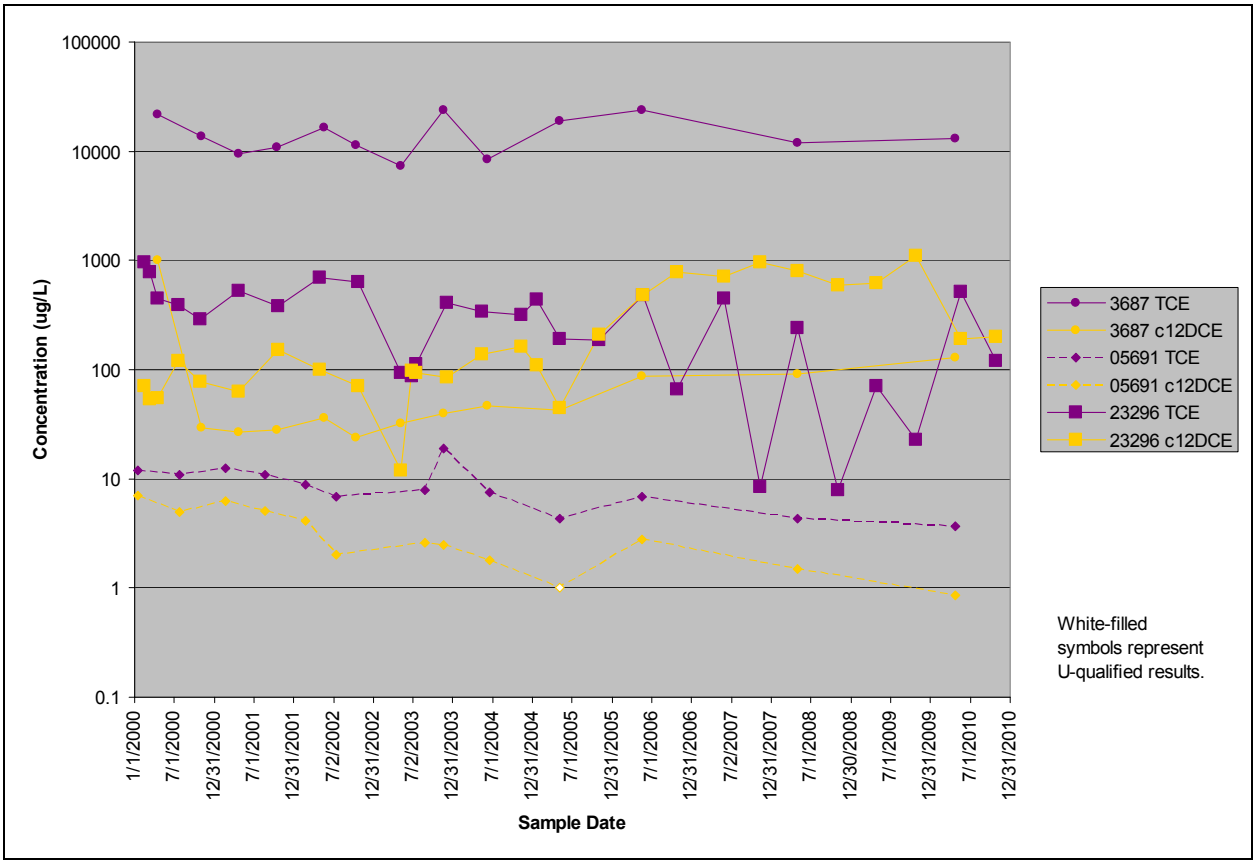
Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70; 1,1-DCE = 7; VC, 0.2. Several results are qualified ("J," "D"), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 210. Most Commonly Detected VOCs in Sentinel Wells Downgradient of the ETPTS

Concentrations of PCE and TCE in samples from well 95199 have been much more uniform than concentrations of constituents discussed above in well 23296, although an increasing trend in PCE concentrations at the 95 percent statistical significance is calculated for this well (Table 77). Little *cis*-1,2-DCE, 1,1-DCE, VC, or other metabolic byproducts from the degradation of PCE and TCE are reported in samples from well 95199. This well is deeper and a bit farther from flowing surface water than well 23296, and although both monitor groundwater within the unconsolidated surficial materials, this physical separation from the more sharply varying near-surface conditions may help to explain these differences. The location of well 23296 at the valley bottom may also provide additional organic carbon in the subsurface materials to support increased biodegradation.

Figure 211 illustrates how concentrations of a common solvent compound (TCE) and daughter product (*cis*-1,2-DCE) vary from the source area wells (Evaluation wells 3687 and 05691) to downgradient Sentinel well 23296. Concentrations of TCE are highest in samples from source-area well 3687 and have remained relatively consistent over the RFLMA period of record.

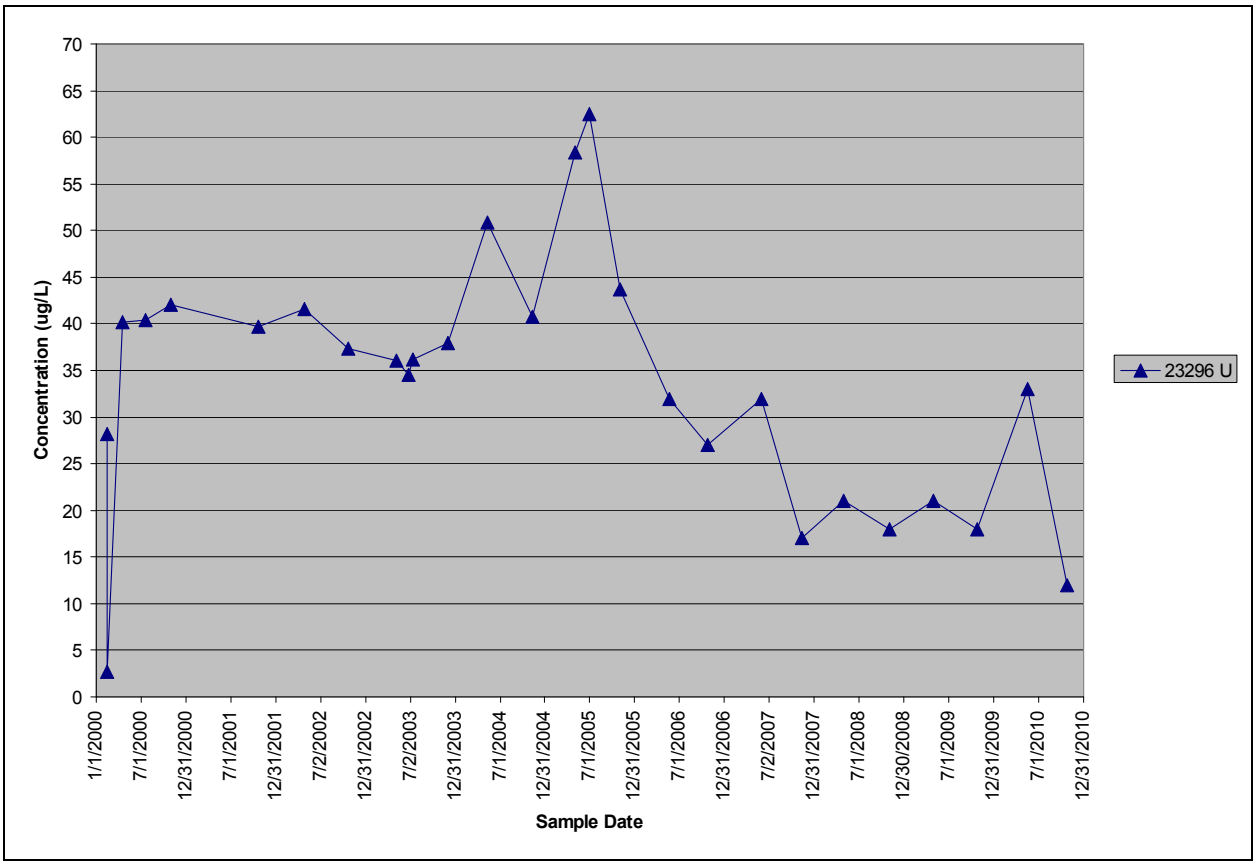
Conversely, concentrations of TCE in samples from well 05691 are several orders of magnitude lower and appear to be on a decreasing trend; this trend is confirmed by S-K trending results (Table 77) to meet the 95 percent level of significance. Concentrations of the daughter product *cis*-1,2-DCE in samples from these two source-area wells also differ in magnitude and trend: statistically significant trends are calculated for this constituent at each of these wells, but the trend is increasing in samples from well 3687 (as is that of 1,1-DCE, another daughter product on the same degradation pathway), and decreasing in samples from well 05691. As shown on Figure 211, by 2010 these opposing trends had led to a difference in *cis*-1,2-DCE concentrations of approximately two orders of magnitude (higher in well 3687, lower in well 05691).



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70. In addition to nondetects (U-qualified results), several other results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 211. Comparison of VOCs in East Trenches Source Area Wells and Downgradient Well 23296

Sentinel well 23296 is also monitored for U, for which S-K statistical calculations now indicate a decreasing trend with a 95 percent level of significance (Table 77). A decreasing trend was also indicated in calculations performed for the 2009 Annual Report (DOE 2010d), but the trend did not meet this level of significance. Figure 212 provides a time-series plot of U concentrations in samples from well 23296. With the exception of what appear to be seasonal increases in U concentrations in the second quarters of 2004, 2005, and 2010 (possibly 2007 as well)—none of which approach or exceed the U threshold of 120 µg/L—the visually apparent downward trend is fairly consistent. The results from 2004 and 2005 are most likely affected by closure activities, while the results from 2010 may reflect seasonal effects.



Note: U= uranium; applicable RFLMA value (µg/L; DOE 2007a) is the groundwater threshold of 120 µg/L.

Figure 212. Concentrations of Uranium in Samples From Well 23296

Evaluation well 03991, located near the eastern edge of the East Trenches Plume, was sampled in 2010 for analysis of VOCs. Data were generally consistent with previous results. Decreasing trends that meet the 95 percent level of statistical significance (Table 77) were identified for carbon tetrachloride, chloroform, PCE, and TCE. Of these, carbon tetrachloride is the constituent that has exceeded the corresponding RFLMA Table 1 value of 1 µg/L (the PQL). In 2010, the concentration at this well was measured at 3.5 µg/L, the lowest yet measured; the range has been 3.5 µg/L to 13 µg/L.

Sentinel well 04091 is located on the eastern edge of the East Trenches Plume and was sampled twice in 2010. No VOCs were detected in either sample. Samples from this well are represented by significant (at the 95 percent confidence level) decreasing trends for carbon tetrachloride and PCE. These constituents were most recently detected in samples from well 04091 in 2007.

AOC well 00997 is located near the inlet to Pond B-5. This well was sampled twice in 2010 (May and October). All constituents were below the RFLMA Table 1 levels or uranium threshold. No VOCs were detected. U was detected at concentrations of 18 µg/L in May and 14 µg/L in October, which is within the typical range at this well. Nitrate is also analyzed at this location, and in 2010 the results were 0.025 mg/L (estimated, J-qualified) in the second-quarter sample and nondetect in the fourth-quarter sample.

East Trenches Plume groundwater will continue to be monitored in accordance with RFLMA. As more data are collected, additional significant trends should become evident.

East Trenches Plume Treatment System

The ETPTS was installed in 1999. Its design is very similar to that of the MSPTS. However, the intercept trench for the ETPTS is 1,200 feet long, compared to the 220-foot-long MSPTS trench. The longer trench is required to intercept the broader East Trenches Plume as it flows toward South Walnut Creek and the B-series ponds.

The ETPTS treated approximately 1,606,000 gallons of water in 2010, almost four times the volume treated in 2009 and similar to the volumes treated in each of the final two pre-closure years, 2004 and 2005 (Table 83). This very large increase reverses the pattern of overall decreasing flows observed since closure and is attributed to the very wet spring and resulting groundwater recharge that continued to feed the system through the year. Figure 213 presents a hydrograph showing ETPTS flow estimates since January 2000. (Refer to the 2009 Annual Report [DOE 2010d] for information on correction of anomalous flows previously reported for the year 2006). The higher flows in 2010 are clearly evident on this figure.

Figure 214 provides a hydrograph for CY 2010 at the ETPTS and shows the effects of the higher precipitation and the lengthy discharge period that resulted. The potentiometric surface maps presented and discussed in Section 3.1.3.5 provide additional evidence of this recharge in the form of a higher water table.

Table 83. Estimated Volumes of Water Treated by the ETPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000	1,633,000	2,800,000
2001	1,900,000	4,700,000
2002	≤1,000,000	5,700,000
2003	2,100,000	7,800,000
2004	1,500,000	9,300,000
2005	1,800,000	11,100,000
2006	675,000	11,775,000
2007	951,000	12,726,000
2008	629,000	13,355,000
2009	406,000	13,761,000
2010	1,606,000	15,367,000

Note: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005a, 2005b).

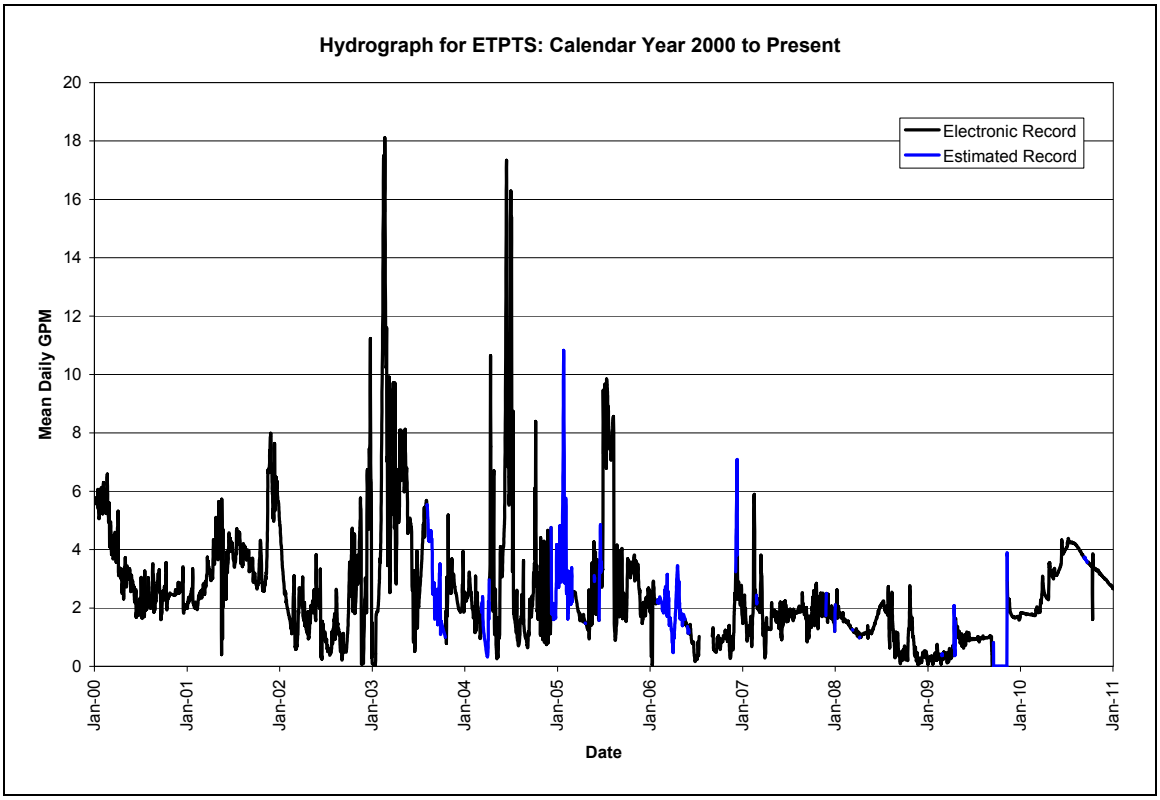


Figure 213. Hydrograph for ETPTS From 2000 through 2010

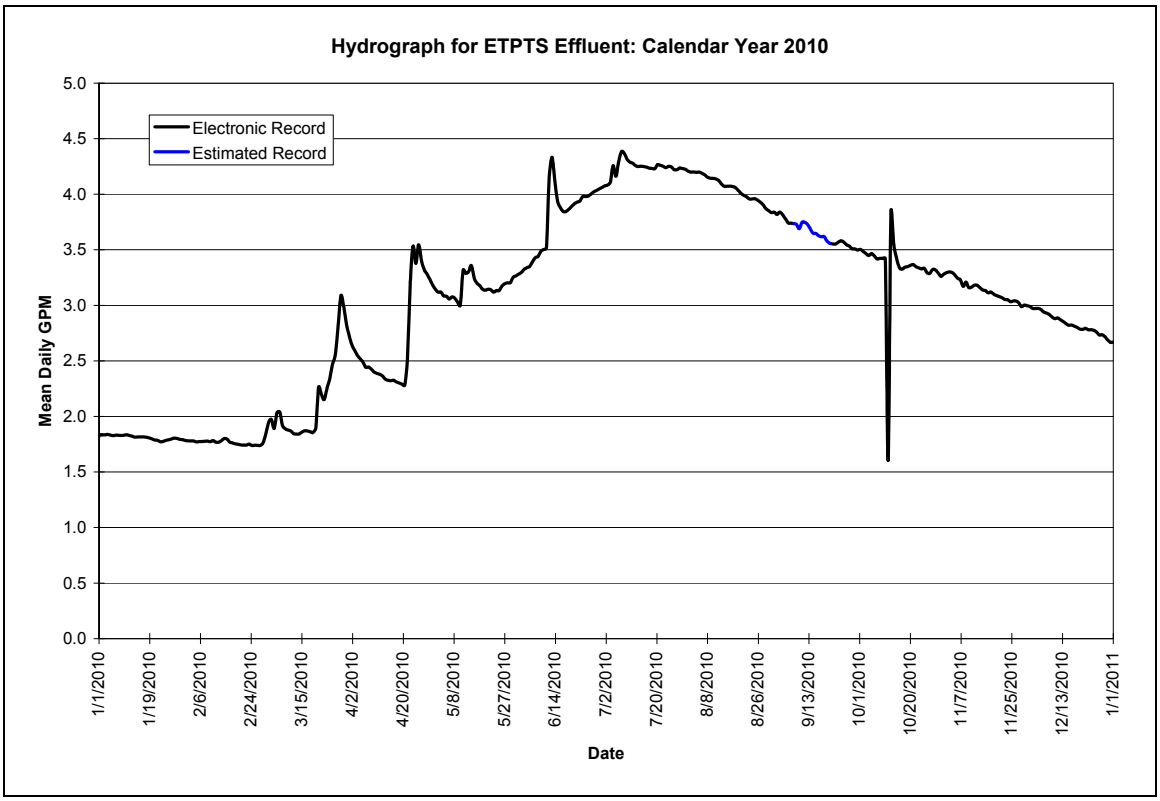


Figure 214. Hydrograph for ETPTS for CY 2010

Routine maintenance activities at the ETPTS were conducted through 2010, as discussed in Section 2.5. The ETPTS was sampled twice in 2010 for routine RFLMA requirements (May and October), and four additional times (June, July, August, and September) to support an evaluation similar to that described above for the MSPTS. This activity is discussed in greater detail below and in Contact Record 2010-07.

ETPTS effluent water quality in 2010 continued to reflect a dramatic reduction in VOC load, but some VOCs were detected in the effluent. Even though the media was replaced in late 2009, system effluent contained some VOCs at concentrations exceeding the respective RFLMA Table 1 values. The higher flow rates described above and illustrated on Figure 213 and Figure 214 would have reduced residence times and corresponding levels of treatment that would have extended through the fourth quarter. A summary of the VOCs that most commonly exceed RFLMA Table 1 values in system influent, plus *cis*-1,2-DCE and VC as dechlorination-related constituents, is presented in Table 84; refer to quarterly reports (DOE 2010c, 2010e, 2011b) and Appendix B.6 for additional data from 2010.

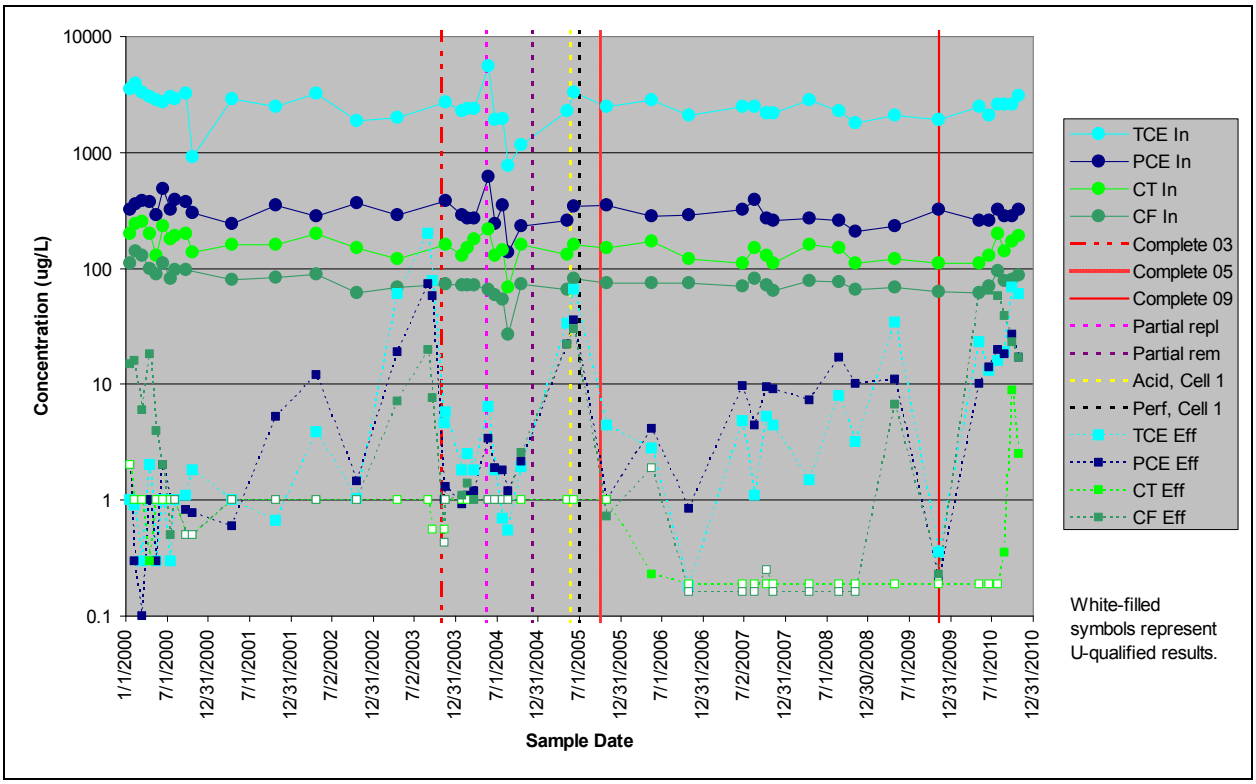
Table 84. Summary of Recent VOC Data From ETPTS Influent and Effluent

DATE	CT		CF		MCl		PCE		TCE		Cis-1,2-DCE		VC	
	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef
1/28/2004	**130**	1 (U)	**71**	1.1	5 (U)	**20**	**290**	0.93 (J)	**2300**	1.8	40	9.5	5 (U)	1 (U)
2/25/2004	**150**	1 (U)	**71**	1.4	2.7 (JB)	**19 (B)**	**270**	1.1	**2400**	2.5	40	10	10 (U)	1 (U)
3/22/2004	**180**	1 (U)	**71**	1	2.6 (JB)	**21**	**270**	1.2	**2400**	1.8	39	9.7	6.7 (U)	**0.39 (J)**
5/26/2004	**216**	1 (U)	**65.1**	1 (U)	1 (U)	**17**	**618 (D)**	3.38	**5510 (D)**	**6.36**	28	11.5	1 (U)	1 (U)
6/22/2004	**130**	1 (U)	**59**	1 (U)	**6.7 (JB)**	**14 (B)**	**240**	1.9	**1900**	1.8	29	8	10 (U)	1 (U)
7/29/2004	**142 (D)**	1 (U)	**54.1**	1 (U)	2.3	**14.1 (B)**	**354 (D)**	1.8	**1960 (D)**	0.69 (J)	29.4	7.7	1 (U)	1 (U)
8/19/2004	**68.1**	1 (U)	**26.6**	1 (U)	1 (U)	**13.7**	**137 (D)**	1.2	**774 (D)**	0.55 (J)	13.3	7.4	1 (U)	1 (U)
10/20/2004	**160**	1 (U)	**72.9**	2.56	1 (U)	**15.6**	**230 (D)**	**2.13**	**1170 (D)**	1.91	32.6	11.3	1 (U)	1 (U)
5/12/2005	**131**	1 (U)	**66**	**22.2**	1 (U)	**14.6**	**256 (D)**	**21.9**	**2280 (D)**	**33.1**	30.4	36.4	1 (U)	1 (U)
6/7/2005	**160**	1 (U)	**81**	**30**	10 (U)	**22 (B)**	**340**	**36**	**3300**	**66**	33	44	10 (U)	1 (U)
11/2/2005	**151**	1 (U)	**74.8**	0.73 (J)	250 (U)	**18.2**	**350**	1 (U)	**2500**	4.4	50.7	39.6	50 (U)	**1.2**
5/17/2006	**170**	0.23 (J)	**75 (J)**	1.9	0.32 (U)	**32**	**280**	4.1	**2800**	2.8	46	27	0.17 (U)	**0.77 (J)**
10/31/2006	**120**	0.19 (U)	**75**	0.16 (U)	6.4 (U)	0.32 (U)	**290**	0.85 (J)	**2100**	0.18 (J)	40 (J)	4.3 (J)	3.4 (U)	0.17 (U)
6/26/2007	**110**	0.19 (U)	**70**	0.16 (U)	1.6 (U)	0.32 (U)	**320**	**9.7**	**2500**	4.8	30	40	0.85 (U)	**1.2**
8/16/2007	**150**	0.19 (U)	**81**	0.16 (U)	**8 (JB)**	0.73 (JB)	**390**	4.4	**2500**	1.1	32	51	2.7 (U)	**1.7**
10/9/2007	**130**	0.19 (U)	**71**	0.25 (J)	3.2 (U)	1.7	**270**	**9.5**	**2200**	**5.3**	34	22	1.7 (U)	**0.43 (J)**
11/8/2007	**110**	0.19 (U)	**64**	0.16 (U)	3.2 (U)	0.32 (U)	**260**	**9.1**	**2200**	4.4	32	21	1.7 (U)	**0.46 (J)**
4/16/2008	**160**	0.19 (U)	**78**	0.16 (U)	**36 (B)**	1.5 (B)	**270**	**7.3**	**2800**	**1.5**	43	30	7.6 (U)	**1**
8/25/2008	**150**	0.19 (U)	**77**	0.16 (U)	1.6 (U)	0.89 (J)	**260**	**17**	**2300**	**7.9**	42	20	1.9 (U)	0.38 (U)
11/5/2008	**110**	0.19 (U)	**66**	0.16 (U)	**9.7 (J)**	0.88 (J)	**210**	**10**	**1800**	**3.2**	31	16	3.8 (U)	**0.5 (J)**
4/28/2009	**120**	0.19 (U)	**68**	**6.7 (J)**	8.9 (U)	4.5 (U)	**230**	**11 (J)**	**2100**	**34**	30	45	3.8 (U)	0.38 (U)
11/12/2009	**110**	0.19 (U)	**63 (J)**	0.23 (J)	0.32 (U)	**6.3 (J)**	**320**	0.2 (U)	**1900**	0.35 (J)	36	0.3 (J)	0.4 (U)	0.4 (U)
5/6/2010	**110**	0.19 (U)	**62**	**63**	2.3 (U)	**8.2 (B)**	**260**	**10**	**2500**	**23**	30	57	2 (U)	0.4 (U)
6/22/2010	**130**	0.19 (U)	**70**	**64**	2.1 (U)	**8.4 (B)**	**260**	**14**	**2100**	**13**	34	55	2.7 (U)	0.4 (U)
7/28/2010	**200**	0.19 (U)	**95**	**57**	3.7 (J)	**15**	**320**	**20**	**2600**	**16**	43	55	4 (U)	**0.76 (J)**
8/26/2010	**140**	0.35 (J)	**78**	**39**	**5.8 (JB)**	**19 (B)**	**280**	**18**	**2600**	**19**	37	56	4 (U)	0.4 (U)
9/29/2010	**170**	**8.8**	**79**	**23**	1.6 (U)	**14**	**280**	**27**	**2600**	**68**	39	50	2 (U)	0.4 (U)
10/28/2010	**190**	**2.5**	**87**	**17**	1.3 (U)	**11**	**320 (*)**	**17**	**3100**	**60**	44 (J)	59	1.6 (U)	**0.84 (J)**

Notes: Constituents and their respective, applicable RFLMA levels (µg/L; DOE 2007a): CT = carbon tetrachloride, 5; CF = chloroform, 3.4; MCl = methylene chloride, 4.6; PCE, 5; TCE, 5; *cis*-1,2-DCE, 70; VC, 0.2. ET In = influent (ET INFLUENT), ET Ef = effluent (ET EFFLUENT). Shaded, bold value indicates detected concentration exceeds corresponding RFLMA standard. Lab qualifiers: J = estimated value; U = analyte not detected at the indicated concentration; B = chemical was also detected in the blank; D = analysis was performed at a dilution.

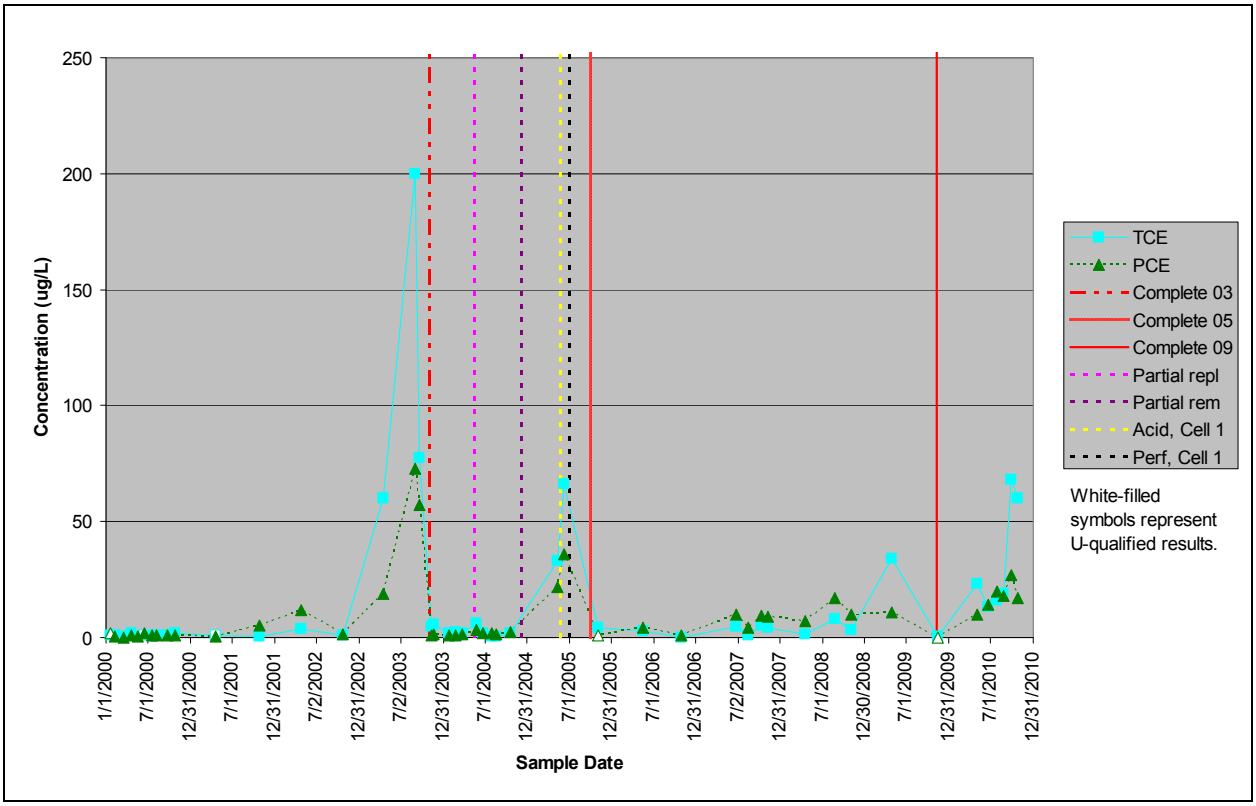
Several of the primary VOCs present in ETPTS influent are presented in the time-series plots in Figure 215. This figure is crowded, but it illustrates several conditions. First, influent concentrations have remained fairly consistent since 2000 for each of the VOCs illustrated. (However, note the slight increase in 2010, potentially related to enhanced mobilization of residual contaminants in the vadose zone because of the wetter conditions.) Conversely, concentrations in system effluent have varied widely, and not always with respect to media replacement or other maintenance activities. Although concentrations in system effluent demonstrate that the bulk of the VOCs is consistently removed from the influent, water quality of the effluent does not always meet treatment targets. These treatment targets—the RFLMA Table 1 values—have changed for some VOCs (carbon tetrachloride, PCE, and TCE, among others) since the end of 2009 when several Temporary Modifications terminated and the underlying standards became applicable.

Figure 216 provides a time-series plot showing only TCE and PCE in system effluent.



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; CT, 1; CF, 3.4. Complete (year abbreviation) = year in which complete media replacement was performed; Partial repl = partial media replacement (May 2004); Partial rem = partial media removal (December 2004); Acid, Cell 1 = acid treatment of Cell 1 media (May 2005); Perf, Cell 1 = perforation of Cell 1 media crust (June 2005). Dates for some activities are rounded to the month. Several results are qualified ("J," "D"), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 215. Primary VOCs in ETPTS Influent and Effluent



Notes: Complete (year abbreviation) = year in which complete media replacement was performed; Partial repl = partial media replacement (May 2004); Partial rem = partial media removal (December 2004); Acid, Cell 1 = acid treatment of Cell 1 media (May 2005); Perf, Cell 1 = perforation of Cell 1 media crust (June 2005). Dates for some activities are rounded to the month. Constituents and their respective RFLMA Table 1 standards (µg/L; DOE 2007a): TCE, 2.5; PCE, 1. In addition to nondetects (U-qualified results), several other results were J-qualified but for simplicity are not shown differently.

Figure 216. TCE and PCE in ETPTS Effluent

The performance monitoring location for the ETPTS is POM2, which is located in Pond B-4. Sampling at this location in support of the ETPTS began in 2005. Grab samples were collected from POM2 in May, June, July, August, September, and October 2010. (This monthly frequency supported the RFLMA requirements as well as the evaluation outlined in Contact Record 2010-07.) Several samples reported detections of VOCs at less than 1 µg/L (Table 85). In all cases the concentrations were J-qualified (estimated) and below the applicable RFLMA Table 1 levels.

Table 85. Summary of VOCs Detected in 2010 at POM2

Date	Constituent	Result (µg/L)	Qualifier
5/6/2010	Chloroform	0.22	J
5/6/2010	*cis*-1,2-Dichloroethene	0.32	J
5/6/2010	Trichloroethene	0.38	J
6/22/2010	Chloroform	0.3	J
6/22/2010	*cis*-1,2-Dichloroethene	0.3	J
7/28/2010	Chloroform	0.3	J
7/28/2010	*cis*-1,2-Dichloroethene	0.24	J
9/29/2010	Trichloroethene	0.21	J

Additional evaluation sampling of the ETPTS was performed in 2010, as noted above. This sampling was very similar to that performed at the MSPTS and described above in the corresponding text. VOCs have been routinely detected in ETPTS effluent since the system was installed in 1999 and have been reported and discussed as the data are issued. These residual VOCs typically include low concentrations of parent compounds as well as some daughter products (Table 84). Concentrations in 2010 were elevated with respect to many previous data, which is attributed to the corresponding flow conditions. The presence of these VOCs is due primarily to inadequate residence time within the treatment media, which was exacerbated by the relatively higher flows (and corresponding lower residence times) observed in 2010. As discussed in the text for the MSPTS, some of the constituents detected in the effluent are recalcitrant and require more time within the ZVI media to be reductively dechlorinated.

The second quarter sample results, which are summarized above in Table 84 and are presented in full in DOE 2010e, led to consultation with CDPHE. (This consultation, summarized in Contact Record 2010-07, also included the subject of treatment at the MSPTS, which is discussed in the corresponding section above.) As at the MSPTS, at the ETPTS additional data were desired to assess how the VOC concentrations varied as the system effluent moved into the receiving drainage. To support this evaluation, two non-RFLMA sampling points were selected beyond the ETPTS discharge gallery: ETPTSDGOVER was located at the overflow of the discharge gallery for this system, and ETPTSB4 was located where this overflow enters former Pond B-4. These locations are illustrated in Figure 217.

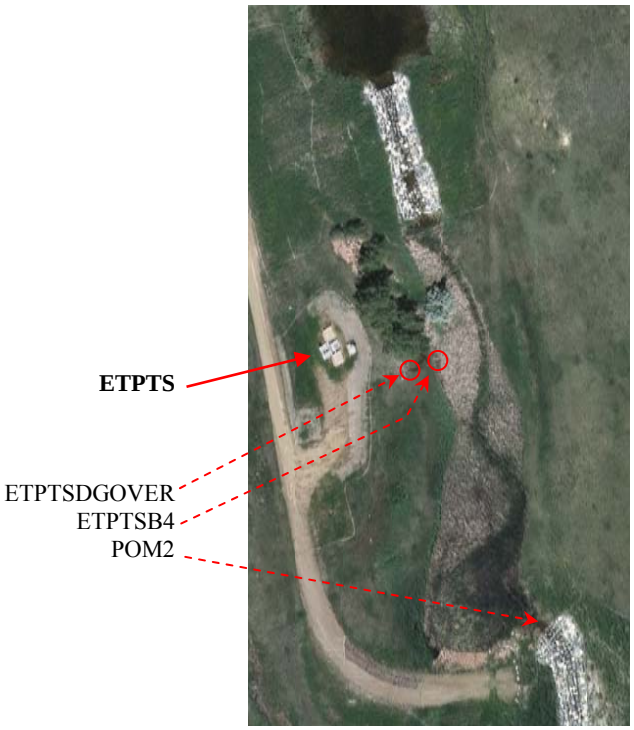


Figure 217. ETPTS With Approximate Locations of Extra Sampling Points With Respect to Treatment System and Surface Water Performance Location

In accordance with Contact Record 2010-07, additional samples were collected at the RFLMA locations and the extra locations identified above. This evaluation sampling occurred in June,

July, August, September, and October. During each event, each location was visited for sampling. Analytical results for these samples are summarized in Table 86. The estimated flow rates and residence times corresponding to those sample dates are provided below in Table 87. For comparison, several additional values are provided that correspond to samples collected in 2008 and 2009. These data clearly show how different conditions were at the ETPTS in 2010 compared to the two preceding years: without exception, flow rates in 2008 and 2009 were well below those in 2010, and the residence times in the earlier years were significantly longer. The average flows for the 2010 samples (i.e., an overall average of only those average flow figures corresponding to the samples collected over the year) are approximately four times higher than the 2008 average, and about twice that in 2009. Similarly, the average residence times for 2010 (again, averaging only the residence times estimated for the sample dates) are about a quarter of the corresponding figure in 2008, and under half the average for 2009 samples.

Table 86. Summary of Results From RFLMA and non-RFLMA Locations Used to Evaluate ETPTS

Constituent (RFLMA standard)	Month (2010)	ET Influent	ET Effluent	ETPTS DGOVER	ETPTS B4	POM2
Chloroform (3.4)	June	**70**	**64**	**60**	**10**	0.3 (J)
	July	**95**	**57**	**57**	**6.9**	0.3 (J)
	Aug	**78**	**39**	**39**	1.1	ND
	Sept	**79**	**23**	**18**	ND	ND
	Oct	**87**	**17**	**17**	ND	ND
PCE (1 - PQL)	June	**260**	**14**	**12**	**1.3**	ND
	July	**320**	**20**	**16**	**1.4**	ND
	Aug	**280**	**18**	**18**	0.94 (J)	ND
	Sept	**280**	**27**	**17**	0.53 (J)	ND
	Oct	**320**	**17**	**15**	0.99 (J)	ND
TCE (2.5)	June	**2100**	**13**	**11**	1.3	ND
	July	**2600**	**16**	**14**	1.5	ND
	Aug	**2600**	**19**	**19**	1.3	ND
	Sept	**2600**	**68**	**85**	**3.8**	0.21 (J)
	Oct	**3100**	**60**	**56**	**3.5**	ND
Meth. Chloride (4.6)	June	2.1 (JB)	**8.4 (B)**	**7.7 (B)**	1.6 (B)	ND
	July	3.7 (J)	**15**	**15**	2.8	ND
	Aug	**5.8 (JB)**	**19 (B)**	**19 (B)**	1.8 (B)	ND
	Sept	**ND**	**14**	**12**	ND	ND
	Oct	**ND**	**11**	**8.7**	ND	ND
VC (0.2 - PQL)	June	ND	ND	ND	ND	ND
	July	**0.76 (J)**	ND	**0.52 (J)**	ND	ND
	Aug	ND	ND	ND	ND	ND
	Sept	ND	ND	ND	ND	ND
	Oct	ND	**0.84 (J)**	**0.68 (J)**	ND	ND

Notes: Constituents and corresponding RFLMA Table 1 values are as indicated. POM2 is surface water performance location. See text for descriptions of non-RFLMA locations ETPTSDGOVER and ETPTSB4. Shaded, bold values exceed corresponding RFLMA Table 1 value. ND = nondetect. J = result is estimated; B = constituent was also detected in the blank.

Table 87. Flow Rates and Residence Times at the ETPTS in 2008, 2009, and 2010

ETPTS				
Sample Date	**Average Flow (gpm)**	**Flow (avg. sample dates, gpm)**	**Estimated HRT (hours)**	**HRT (est. avg. sample dates, hours)**
4/16/2008	1.08	0.93	131.59	156.68
8/25/2008	0.75		190.27	
11/5/2008	0.96		148.17	
4/28/2009	1.29	1.86	110.54	84.40
11/12/2009	2.43		58.25	
5/6/2010	3.09	3.67	46.00	39.17
6/22/2010	3.92		36.25	
7/28/2010	4.22		33.50	
8/26/2010	3.96		35.75	
9/29/2010	3.51		40.63	
10/28/2010	3.32		42.92	

Notes: avg. = average; gpm = gallons per minute; annual avg. sample dates = average of the values corresponding to the samples listed for that year (not a true annual average for the year); HRT = hydraulic residence time. Average flow and corresponding HRT calculated from flow data corresponding to the specific sample date.

The sample results were evaluated in accordance with RFLMA Attachment 2, Figure 11. The concentrations do not exceed the 85th percentile of the results for the corresponding RFLMA standards in Attachment 2, Table 1.

These results demonstrate that the residual VOCs in system effluent dissipate very quickly and do not represent a threat to surface water quality. Results from samples collected at POM2 show that the applicable RFLMA standards are being met consistently at this surface water performance location. The media at the ETPTS was replaced in 2009. The objective of the ETPTS is to protect surface water quality, and in this respect the system is performing adequately. Even so, efforts to optimize system performance will continue.

Solar Ponds Plume and Treatment System

The Solar Ponds Plume (SPP) is an area of elevated nitrate and U concentrations in groundwater. (**Note:** The analytical data report concentrations of nitrate+nitrite as nitrogen; this is typically referred to herein simply as nitrate.) Liquid wastes generated during the production era were stored in the former Solar Evaporation Ponds (SEPs), which were located on the pediment in the northeastern portion of the former IA. Leakage from these ponds over the years is the source of the groundwater plume. The following paragraphs describe the plume, the treatment system installed to address this contamination, and activities conducted in 2010 at this system.

Solar Ponds Plume

Groundwater in the SEP area is contaminated with nitrate and U. Groundwater in the westernmost portion of this area, generally coinciding with the location of former Pond 207C, is also contaminated with VOCs. However, due to the more localized nature of VOC contamination, it is not considered part of the SPP, but rather as a separate plume.

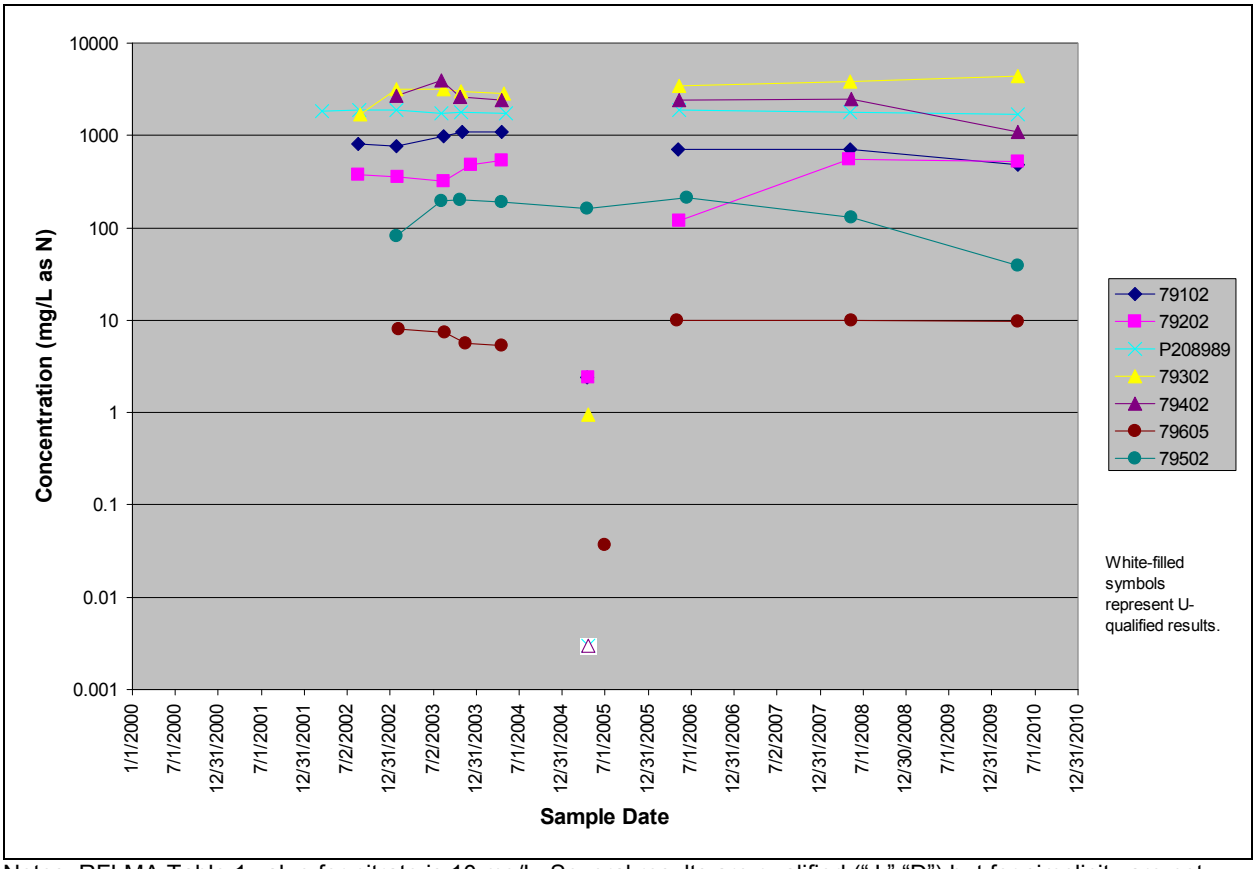
The source area of the SPP (the former SEPs) is monitored by a line of eight Evaluation wells installed immediately downgradient of the SEPs (generally along the north, east, and south sides of the former SEPs). Another Evaluation well is positioned at the south edge of former Pond 207C, in the vicinity of the VOC source area. This distribution effectively monitors groundwater flowing north/northeastward, the primary contaminant flow path, as well as eastward and southeastward, which are much less significant flow paths.

Additional wells monitoring the SPP are located at greater distances from the source. This includes Evaluation wells situated both upgradient and downgradient of the SPPTS groundwater intercept trench, Sentinel wells adjacent to that trench and in South Walnut Creek near former B991, and an AOC well near former Pond A-1.

In 2010, each of the Evaluation wells was sampled once, and the Sentinel and AOC wells were sampled twice in accordance with RFLMA.

The highest observed concentrations of nitrate in the source area were reported in samples from wells 79302 and 79402, both of which are situated in the vicinity of the northeastern corner of the former SEPs. Since late 2003, Evaluation well 79302 has consistently produced water with the highest concentration of nitrate; in 2010, the result was 4,400 mg/L nitrate (as N). Figure 218 illustrates concentrations of nitrate in these Evaluation wells. However, due to the consistently low concentrations of nitrate in samples from well 00203 (i.e., less than 10 mg/L except for the initial outlier of 20 mg/L in the first sample, collected in early 2003), which is located generally south of the former SEPs, data from this well are not illustrated. The gaps in the time-series plots shown on this figure are related to erroneous data (single-digit nondetects) reported for samples collected from these wells in April 2005. Although these results are included in the figure, they are not connected to the other data because they are considered anomalous and nonrepresentative. (Refer to the 2006 Annual Report, DOE 2007c, for additional discussion.)

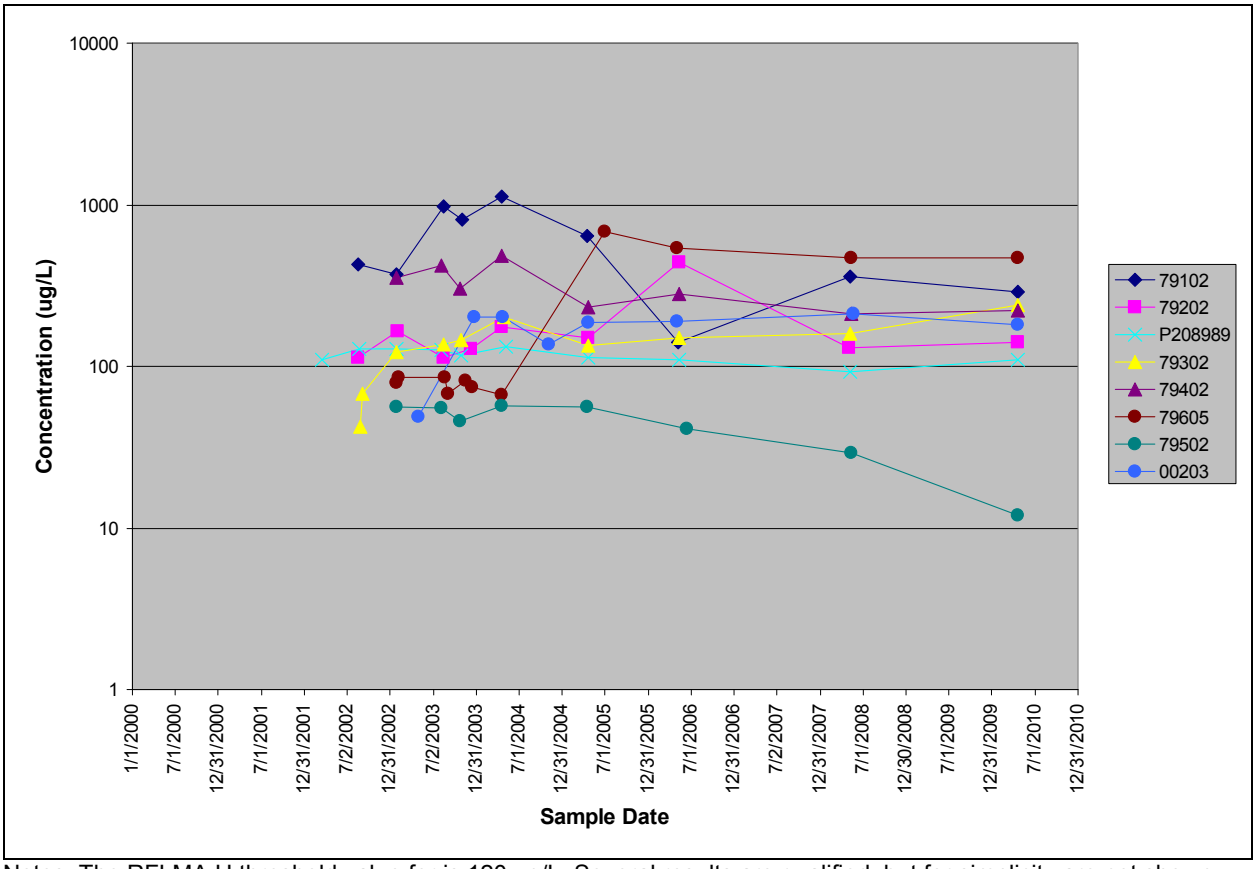
None of the time-series plots for nitrate corresponds to an increasing or decreasing trend meeting the 95 percent level of statistical significance. Instead, nitrate concentrations in samples collected from these wells appear fairly consistent. Some slight trends are visually suggested by the time-series plots (Figure 218), but will require additional data to confirm. Given that the nitrate-contaminated groundwater is present within relatively tight claystone with very low hydraulic conductivities, flushing or degrading the elevated nitrate will take some time.



Notes: RFLMA Table 1 value for nitrate is 10 mg/L. Several results are qualified ("J," "D") but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 218. Concentrations of Nitrate in SPP Source Area Evaluation Wells

As noted above, the former SEPs were also the source of uranium contamination in the groundwater. The highest concentration of U reported in 2010 from the source area was in a sample from Evaluation well 79605 (470 µg/L), which is located on the east edge of the former SEPs. Of the wells represented in Figure 219, this well has produced the samples with the highest concentrations of U since 2005, when the existing well was installed to replace damaged original well P207989 (which produced the samples shown through 2004, and was located not quite 5 feet away from the replacement well). Note that the effect of well replacement is obvious on the U time-series plot, but not on that for nitrate (Figure 218). This may be due to variations in the distribution of natural, rather than anthropogenic, U. Rocky Flats groundwater can contain elevated levels of natural (i.e., not Site-related) U attributable to the local geology, which hosts the U-bearing Schwartzwalder mine approximately 5 miles to the southwest of this well. Samples from well 79605 (and its predecessor) have not been analyzed using high-resolution isotopic methods, and the relative abundance of natural versus anthropogenic U at this location is not known. This also applies to groundwater samples from well 00203, which are low in nitrate but contain an average of about 170 µg/L to 185 µg/L of U, depending on whether the first sample collected from this well (approximately 50 µg/L) is included in the average.



Notes: The RFLMA U threshold value for is 120 µg/L. Several results are qualified, but for simplicity are not shown differently. Note logarithmic concentration scale.

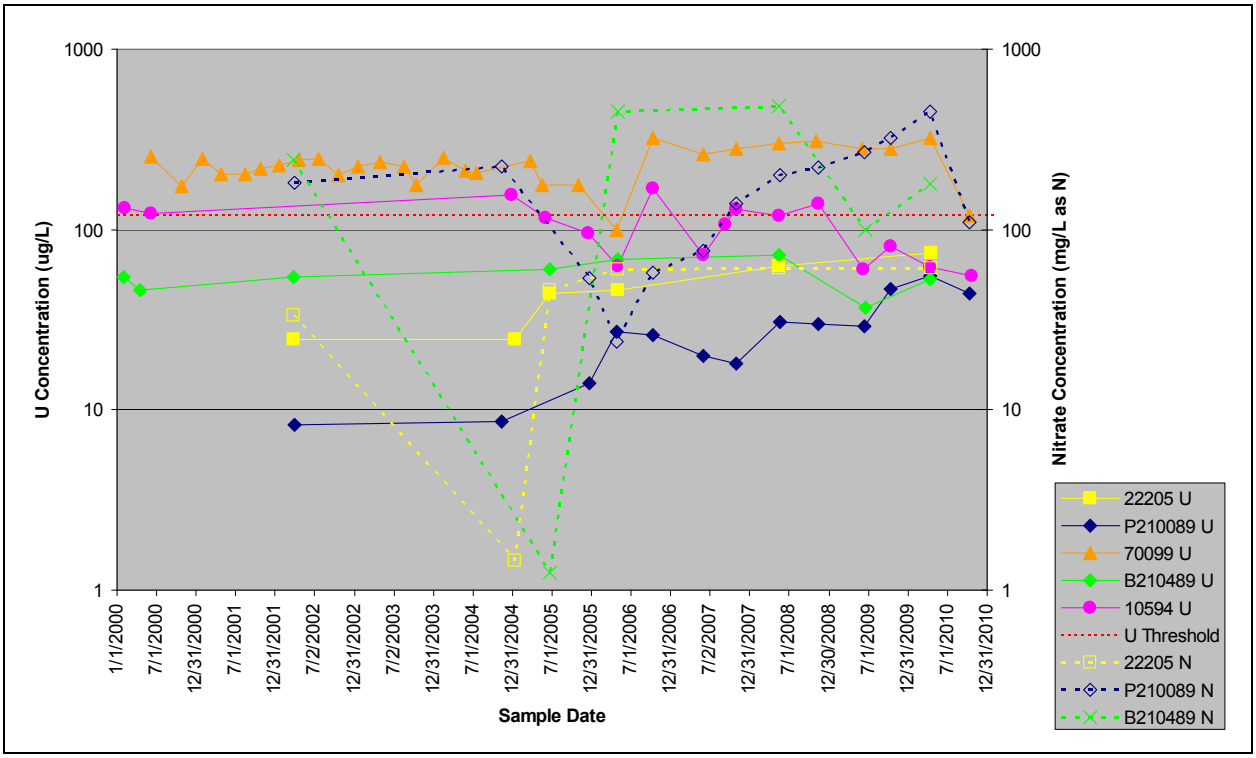
Figure 219. Concentrations of Uranium in SPP Source Area Evaluation Wells

Of the wells represented in Figure 219, trends with a 95 percent confidence are calculated for U in samples from well 79302 (increasing) and 79502 (decreasing).

Figure 220 displays U and nitrate concentrations from wells downgradient of the SPP source area. With respect to the SPPTS and associated groundwater intercept trench, wells that are illustrated include upgradient (22205), side-gradient (P210089 and, to some extent, 70099), and downgradient (B210489, 10594) wells. Nitrate data for wells 70099 and 10594 are not included because concentrations are low (nondetect to low single-digit mg/L). Data from wells 99305 and 99405, both located in the South Walnut Creek drainage adjacent to former B991, are not illustrated because nitrate concentrations are uniformly low—in 2010, the highest level reported was 2.6 mg/L—and U present in these wells has been repeatedly shown to be natural. Although several U results from AOC well 10594 have exceeded the 120 µg/L threshold, the last time that occurred was in 2008. Since the signing of RFLMA, no two consecutive routine samples from well 10594 have exceeded that concentration. If two consecutive routine samples exceed the threshold value in the future, a reportable condition as defined by RFLMA for AOC wells will exist at this well, and consultation with the regulators will follow. As has been reported previously (e.g., DOE 2008c), U in this well has been repeatedly characterized as 100 percent natural, most recently in September 2007.

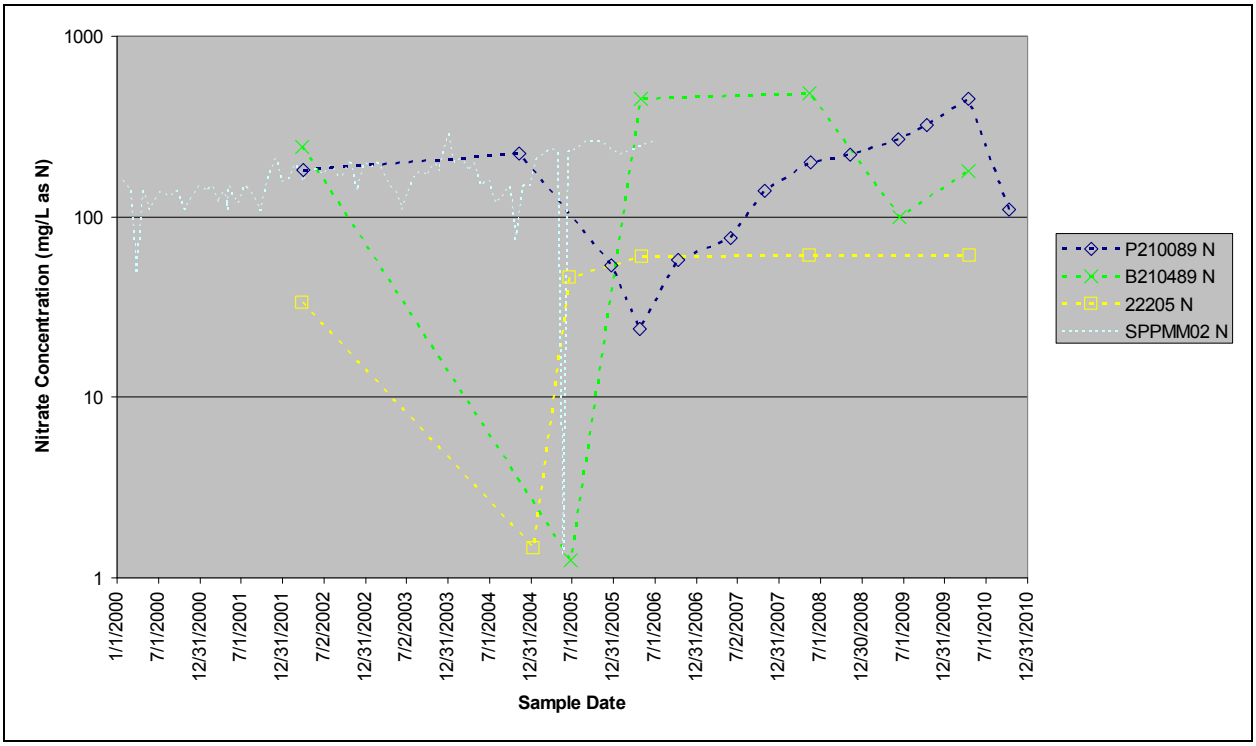
The variable concentrations of nitrate and U in several of these wells is evident on Figure 220. The wells nearest the source area (Evaluation well 22205 and Sentinel well P210089) do not produce groundwater samples with the highest concentrations of U; rather, this is the case with samples from well 70099, located near the northwestern end of the SPPTS groundwater intercept trench. Of all these wells, even most-distal well 10594 consistently produces samples with higher concentrations of U than does well P210089 and, until 2010, well 22205. Based on the current pattern, it appears concentrations of U in well P210089 will exceed those in well 10594 in the near future.

In contrast to the pattern described above for U, among these wells concentrations of nitrate are most often highest in wells P210089 and B210489 and, as noted above, are uniformly low in wells 70099 and 10594. Evaluation well B210489 is located near the SPP Discharge Gallery, and therefore may be receiving higher-nitrate groundwater from the area around that feature, given that it became saturated with higher-nitrate waters for years before the SPPTS upgrades (discussed below) were installed. Evidence for this is somewhat circumstantial but is found in the apparent correlation in the sharp decrease in nitrate concentrations that occurred during 2005−2006 in samples from wells 22205, B210489, P210089, and the original SPPTS influent monitoring point, the piezometer referred to for that purpose as SPPMM02 (Figure 221). The cause of this dip in concentrations may be dilution from dust-suppression waters being transported by ITS lines, bedding, and surrounding materials.



Note: U = total uranium, N = nitrate+nitrite as nitrogen. Note logarithmic concentration scales.

Figure 220. U and Nitrate Concentrations in Wells Downgradient of the Former SEPs



Note: N = nitrate+nitrite as nitrogen. SPPMM02 = original SPPTS influent monitoring location, a piezometer located near the true influent point. Note logarithmic concentration scale.

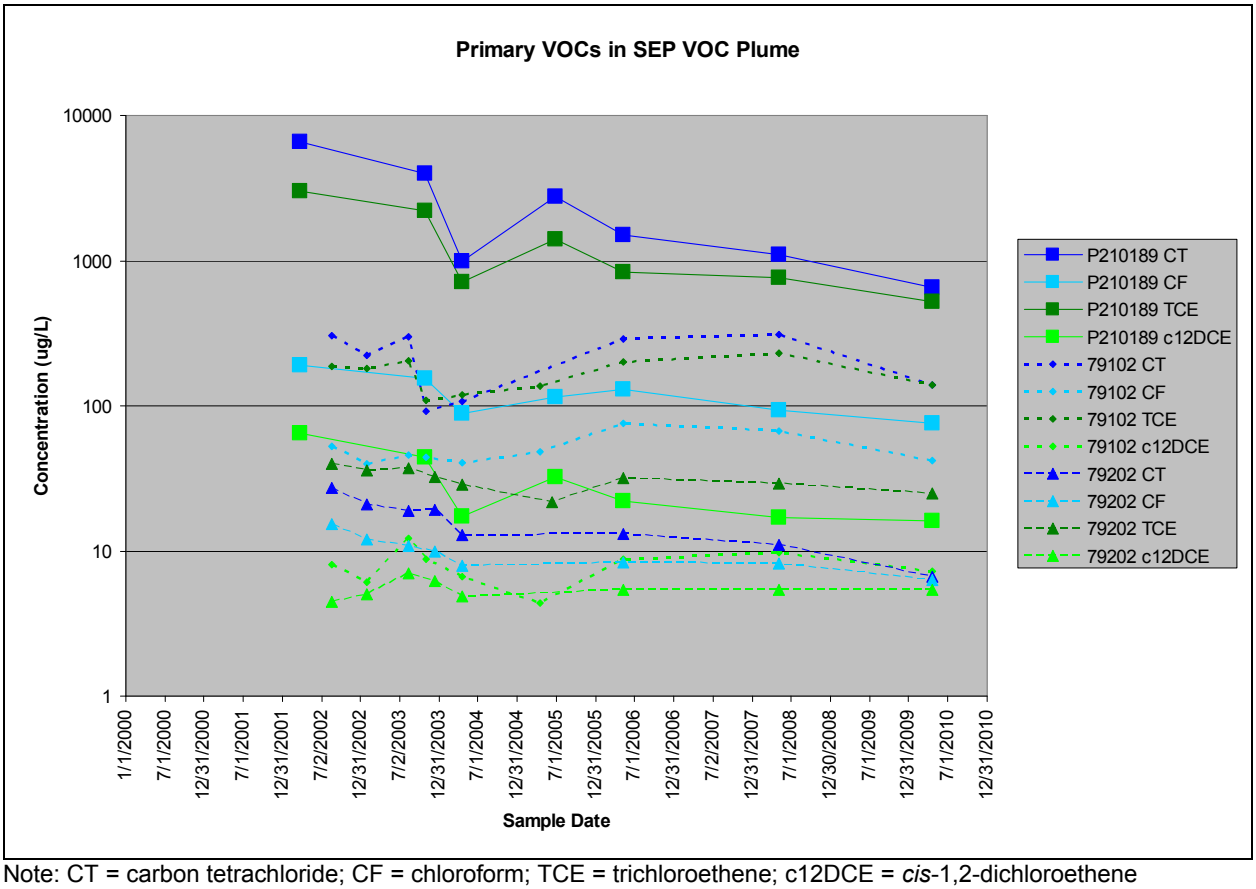
Figure 221. Nitrate Downgradient of the SEPs, Showing Correlation Among Wells and System Influent

Several trends meeting the 95 percent level of statistical significance are calculated for the well-analyte combinations displayed on Table 77. A decreasing trend in U is confirmed at well 10594, and an increasing trend in U is confirmed at wells 22205 and P210089 (see Table 77 and Appendix B). Not illustrated on the figure because concentrations are typically nondetect to low single-digits, a decreasing trend for nitrate in samples from well 70099 is also calculated. Additional years of data will help to clarify any patterns in contaminant concentrations and distributions that may be present in the wells illustrated on Figure 220.

Solar Ponds-Area VOC Plume

The VOC plume in the western SEP area was also monitored in 2010. Each of the Evaluation wells designated to monitor this plume was sampled once per the RFLMA. Results from those wells monitoring the source area are illustrated on Figure 222 and are generally consistent with previous data. Some decrease in concentration is apparent for VOCs in samples from well 79202, and a statistically significant (at the 95 percent level) decreasing trend is calculated for carbon tetrachloride, chloroform, and TCE at this location (see Table 77 and Appendix B). A similarly significant trend was calculated for *cis*-1,2-DCE at well P210189 (decreasing). Evaluation well P208989, which is located due east of well 79202 and on the north edge of the center of the former SEPs, also monitors VOCs but is not included on Figure 222. This well reported J-qualified detections, all below 1 µg/L, of 1,3-DCB, chloroform, PCE, and TCE in the sample collected in 2010. Results for chloroform at well P208989 were found to reflect a statistically significant (at 95 percent) increasing trend, but this may not be viable because the data set includes numerous nondetects. Downgradient (to the north) of the source area, the sample

collected from Evaluation well 22205 did not contain any confirmed detections of VOCs. Similarly, as in 2009, VOCs were not detected in samples collected in 2010 from Sentinel well P210089, which is located farther to the north/northeast of the VOC source area, nor were VOCs detected in AOC well 10594, located between former Ponds A-1 and A-2.



Note: CT = carbon tetrachloride; CF = chloroform; TCE = trichloroethene; c12DCE = *cis*-1,2-dichloroethene

Figure 222. Primary VOCs in the SEP-Area VOC Plume

Solar Ponds Plume Treatment System

Like the ETPTS, the SPPTS was installed in 1999. In basic terms, the system is very similar to the MSPTS and ETPTS, with an intercept trench (1,100 feet long) and two original treatment cells. However, unlike the ETPTS and MSPTS, this system is designed to treat water with elevated concentrations of nitrate and U rather than VOCs. As such, the treatment media in the original SPPTS treatment cells differs from the ZVI media in the MSPTS and ETPTS. The treatment media in these SPPTS cells consists of organic material (sawdust) with a small fraction of ZVI in the first cell and ZVI with pea gravel in the second cell.

Another difference between the SPPTS and the other two systems is that the water collected in the intercept trench is actively pumped into the treatment cells rather than flowing into the cells by gravity. This is accomplished using a solar-charged, battery-powered pump system. This component of the SPPTS, together with the collection well that houses the pump and is installed within the trench, was added in 2002.

Finally, the last major difference between the SPPTS and the other systems is the extensive study and effort that has been expended over the past several years to improve collection and treatment of contaminated groundwater by this system. Several factors drove these efforts, including (1) historically, concentrations of nitrate and uranium measured at the DG typically exceeded those in untreated influent to the system, even though this is where effluent confirmed to be adequately treated may surface following its discharge; (2) accessing and maintaining the treatment media and plumbing within the original structure is costly and difficult; and (3) the original treatment media used may not be optimal over the long term. In addition, operational difficulties were experienced in the spring of 2005 that forced a more immediate response (see DOE 2007c for discussion). Previous annual reports have discussed various components of the post-closure work (DOE 2007c, 2008c, 2009d, 2010d), which has included repairs, subsurface exploration, treatability studies, and the design and construction of system upgrades. Those upgrades, particularly their effects on water quality, are discussed at length below.

It is important to understand that perhaps the single and most fundamental challenge to achieving consistently reliable treatment by the SPPTS is the lack of electrical power. Although it supports many tools and critical components, several kilowatts of solar-based power cannot substitute for full-time, on-demand line power.

Maintenance activities at the SPPTS were conducted throughout 2010 and are reported in Section 2.5.3. The main focal point at the SPPTS in 2010 was continued optimization of the system, particularly the upgrades referred to as Phases II and III. Refer to that section for a discussion of operation and optimization activities. The text below provides a summary of the results related to water treatment.

The SPPTS treated approximately 738,000 gallons in 2010. This is the highest volume ever treated by this system (Table 88), a statement that previously had applied to the 2009 volume. In fact, the estimated volume treated in 2010 exceeded that treated in all of 2003, 2004, and 2005 combined. The increase in volume relative to previous years is again due to the installation of the Phase I groundwater collection sump and associated upgrades (see DOE 2009d) as well as the heavy spring 2010 precipitation. Figure 223 presents a hydrograph showing flow from January 2000 through the end of 2010. The hydrograph for CY 2010 is presented as Figure 224. The period of no flow in April in the latter figure is related to the biocide application reported in Section 2.5.3.

Table 88. Estimated Volumes of Water Treated by the SPPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000[a]	64,000	64,000
2001[a]	424,000	452,700
2002	5,600[b]	458,000
2003	340,000	797,000
2004	230,000	1,027,000
2005	140,000	1,167,000
2006	251,000	1,418,000
2007	244,000	1,662,000
2008	280,000	1,942,000
2009	524,000	2,466,000
2010	738,000	3,204,000

Notes: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005a, 2005b).

[a] Annual and cumulative volume estimates for 2000 and 2001 are suspect, as a sum of the volumes presented in each of the quarterly reports for 2000 and statements regarding the volume for 2001 disagree by approximately 35,000 gallons.

[b] Most of this volume was from the former Modular Storage Tanks (K-H 2003).

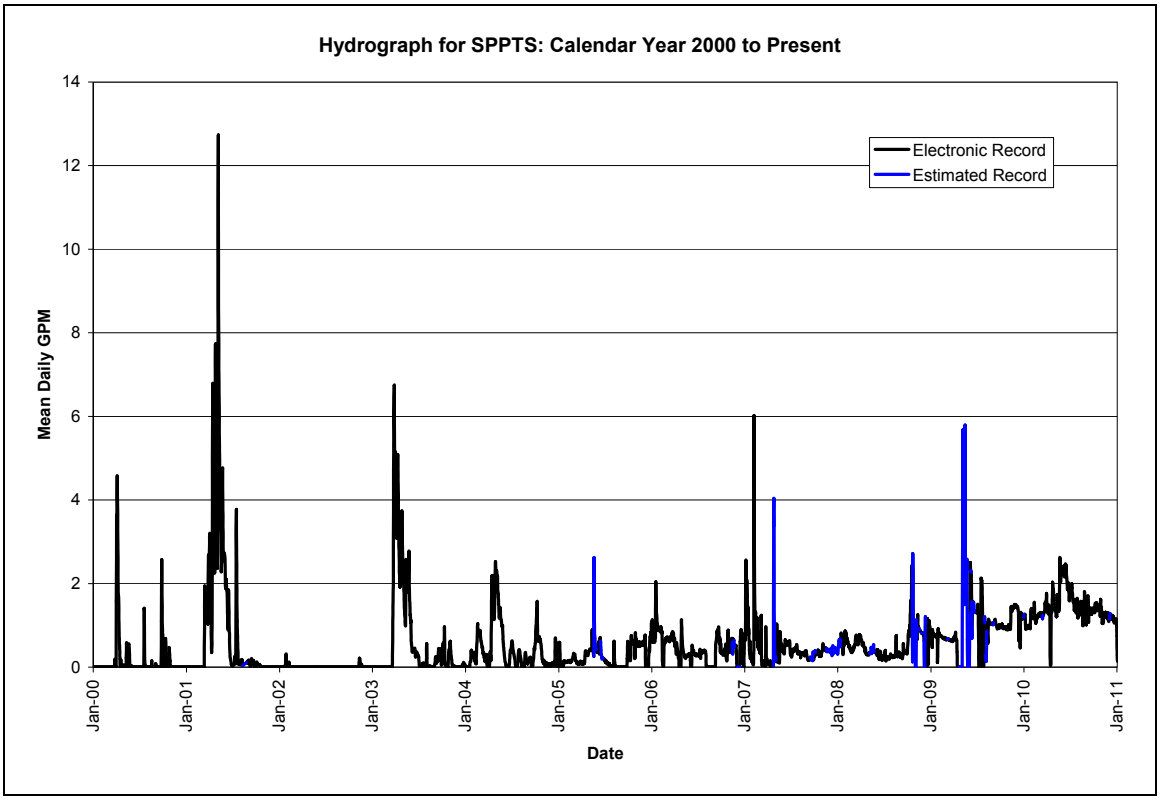


Figure 223. Hydrograph for SPPTS From 2000 Through 2010

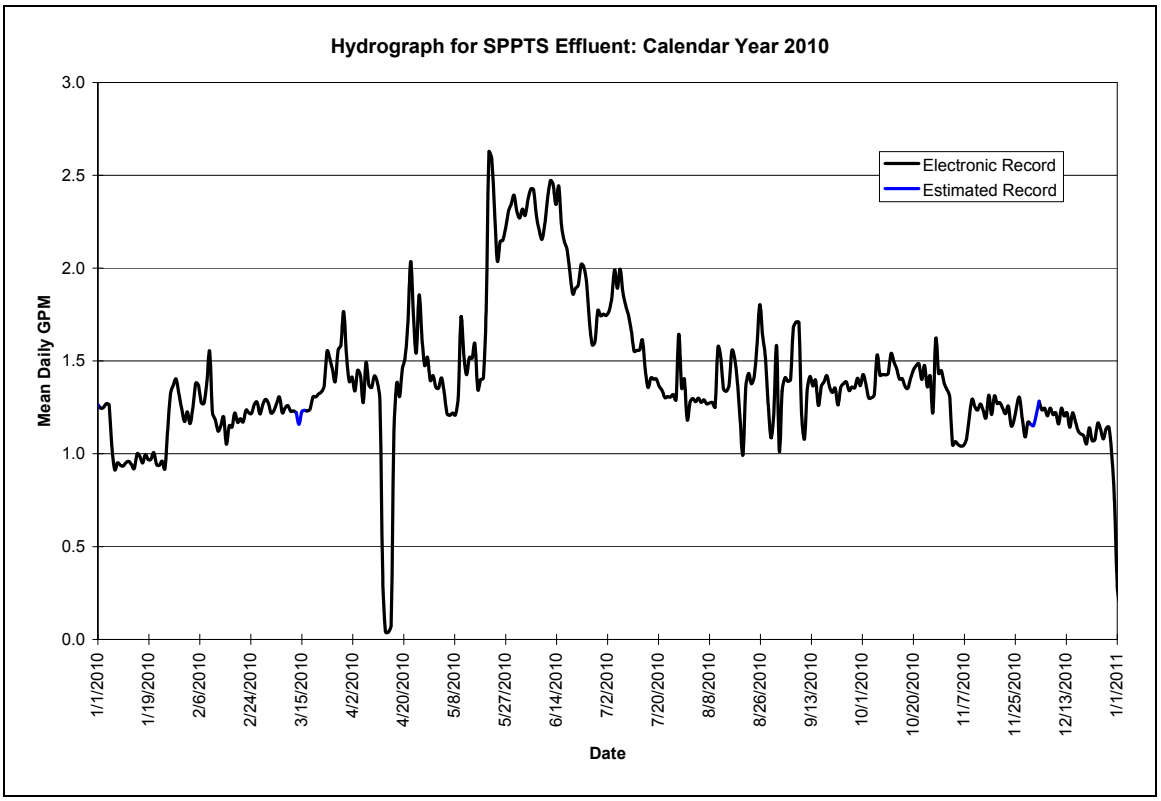
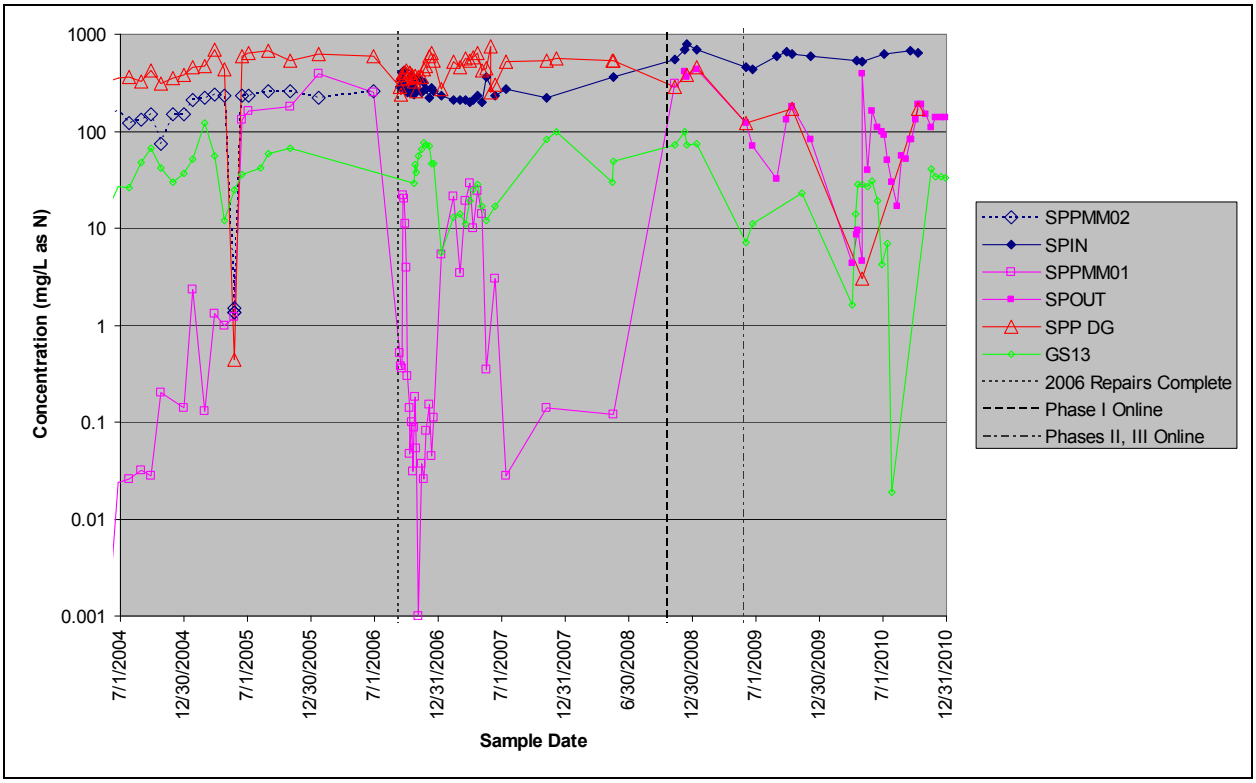


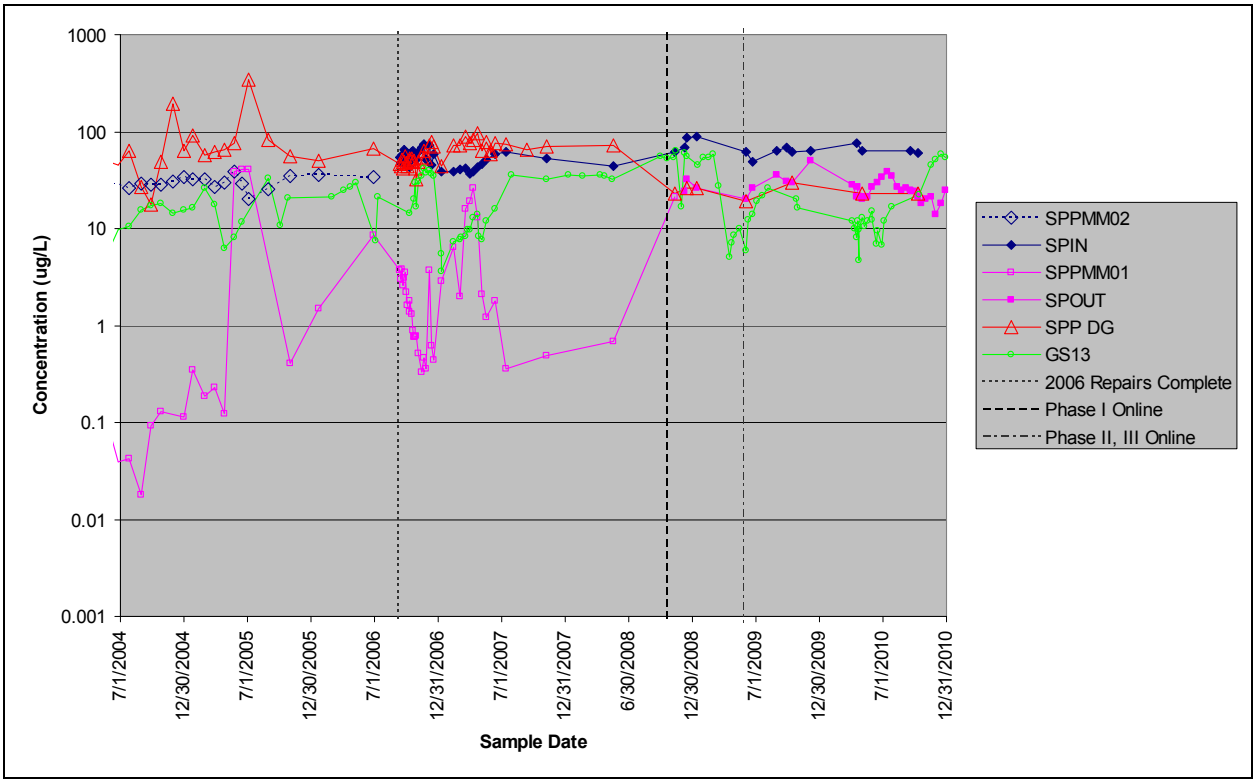
Figure 224. Hydrograph for SPPTS for CY 2010

Figure 225 provides an illustration of nitrate concentrations in SPPTS monitoring locations since mid-2004; Figure 226 shows a similar graph for U concentrations. (Only validated results from contract laboratories are included in these figures, not the supporting data generated by the Environmental Sciences Laboratory (ESL) in Grand Junction because those data cannot be validated. However, those data are useful and are considered separately as discussed below.) In both figures, the effects of valve changes made in mid-2005 are obvious on concentrations of these constituents in the effluent, and to some degree at the SPP Discharge Gallery (DG) and GS13 as well (see the 2006 Annual Report, DOE 2007c, for additional discussion of these events). The isolated late-2004 and mid-2005 spikes in U concentration at the DG (Figure 226) have been discussed previously (DOE 2010d) and are not addressed here.



Notes: SPPMM02 = historical "influent" monitoring location; SPIN = true system influent (collection well); SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; SPP DG = SPP Discharge Gallery; GS13 = surface water performance location. Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007c) for a more detailed discussion of location SPPMM02, as well as a discussion of the activities responsible for the abrupt concentration changes seen in data for May 24, 2005; and see the 2008 Annual Report (DOE 2009d) for more information on SPOUT. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. All data are from contract laboratories (not the ESL). Note logarithmic concentration scale.

Figure 225. Concentrations of Nitrate in Samples From SPPTS Monitoring Locations



Notes: SPPMM02 = historical "influent" monitoring location; SPIN = true system influent (collection well); SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; SPP DG = SPP Discharge Gallery; GS13 = surface water performance location. Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007c) for a more detailed discussion of location SPPMM02, as well as a discussion of the activities responsible for the abrupt concentration changes seen in data for May 24, 2005; and see the 2008 Annual Report (DOE 2009d) for more information on SPOUT. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. All data are from contract laboratories (not the ESL). Note logarithmic concentration scale.

Figure 226. Concentrations of U in Samples From SPPTS Monitoring Locations

Validated contract lab data indicate nitrate concentrations in 2010 at the performance monitoring location for the SPPTS, GS13, were within their typical range. However, given that the 10 mg/L drinking water standard now applies rather than the 100-mg/L Temporary Modification that expired at the end of CY 2009, GS13 now commonly exceeds the RFLMA Table 1 value for nitrate. A major factor in the numerical results for nitrate is the sampling methodology used for this analyte: nitrate samples are collected as grabs, whereas samples for the analysis of U are primarily collected as automated flow-weighted composite samples. The latter method is much more representative of actual overall conditions in surface water, including at GS13, because the sampling apparatus operates continually, regardless of weather conditions (except when frozen solid), hour, or date. This includes during high-flow conditions, such as during and after storms and periods of snow melt, when manual sampling is less likely. Conversely, grab samples are only collected when sampling personnel are instructed and able to visit the location, and many fewer grab samples are collected than are individual grabs within the automated composite samples. Samples for the analysis of nitrate are not collected using automated equipment because of the associated sample handling requirements: samples collected for the analysis of U need not be refrigerated, but samples collected for nitrate must be immediately refrigerated. Studies performed in Florida (Burke et al. 2002) have evaluated the collection of samples for the analysis

of nitrate using automated equipment such as that deployed at Rocky Flats, but without refrigeration; if retrieved, preserved, and shipped to the lab within 7 days, analytical results are equivalent to samples collected using the EPA-required refrigeration and preservation. Use of this method at Rocky Flats is under consideration and testing is planned. If employed, concentrations of nitrate reported at GS13 using the automated sampling equipment would be expected to contrast sharply (i.e., be much lower) with those obtained via grab samples.

Concentrations of U at GS13 were also within their typical range, though as discussed below, the average and median concentrations following installation of the Phase II and Phase III upgrades are now very similar to pre-closure conditions. In fact, concentrations of U in 2010 are somewhat lower than they were following site closure and prior to the installation of the Phase I upgrades.

Summary of SPPTS Upgrades

As noted above, several upgrades have been made to the SPPTS since site closure. These upgrades are summarized below in Table 89.

Table 89. Summary of SPPTS Construction and Upgrades

Upgrade Phase (Year Installed)	Summary Description	Summary of Associated Features and Nomenclature
"Phase 0" (1999)	Original SPPTS constructed: Groundwater intercept trench bisects previously installed French drain network called the Interceptor Trench System, or ITS, and feeds collected water by gravity through two cells operated in series: Cell 1 contains sawdust plus 10% ZVI for nitrate treatment; Cell 2 contains pea gravel and 15% ZVI for U treatment. Effluent is routed into a downgradient limb of the ITS and thence to a line to the subsurface discharge gallery.	SPPMM02 = "influent" location accessed at piezometer a.k.a. 71099 SPPMM01 = effluent location accessed in manhole SPP Discharge Gallery (a.k.a. DG) in valley bottom GS13 = surface water performance at mouth of Pond A-1
"Phase 0.1" (2002)	Collection well equipped with solar-powered pump is installed to deliver collected groundwater to cells.	SPIN (name later assigned to influent flow from this pump)
Phase I (2008)	Collection sump and gravel drain installed at terminal points of ITS, adjacent to location of former Interceptor Trench Pump House (ITPH).	ITSS = ITS Sump, the constructed sump that receives water collected by the upgrade ITS-E = east ITS line where it empties into ITSS ITS-W = west ITS line where it empties into ITSS
	Piping installed to transfer water from ITSS to SPIN, and to discharge treated system effluent from effluent manhole to DG; SPIN vault provides access point to flows from the former, and ITSS vault provides access to flows from the latter.	SPOUT = effluent location accessed in ITSS vault
Phase II (2009)	Easily accessible cell installed to treat U upstream of nitrate treatment; initially incorporates citrate dosing of influent.	SPZE = effluent from Phase II cell
Phase III (2009)	Installed: two pilot-scale nitrate treatment cells to evaluate alternative treatment approaches; associated vault to house carbon supply (added to one of the Phase III cells); vault to allow flow configuration, control, dosing, monitoring, programming, and telemetry infrastructure; associated water storage sump to provide influent in the event of dry conditions; and solar power and plumbing infrastructure to support all of this.	Cell A = pilot-scale nitrate treatment cell using inert media dosed with liquid carbon Cell B = pilot-scale nitrate treatment cell using organic (reactive) corn stover media SPILCA = dosed influent to Cell A SPCAE = effluent from Cell A SPCBE = effluent from Cell B
Phase IV (proposed)	Install full-scale nitrate system based on previous testing and results	To be determined

The first of these upgrades to be installed after Rocky Flats was closed was constructed in 2008. Additional components were installed to capture more of the contaminated groundwater and transfer it to the groundwater intercept trench, from which it would be routed to the treatment cells; in addition, a new line was installed to transport treated effluent from the system to the DG. These improvements are collectively referred to as the Phase I upgrades.

Two additional "phases" of upgrades were installed concurrently the following year, 2009. Phase II focused on making the U treatment cell more accessible and, based on successful laboratory testing, positioning this as the first step of the treatment train so that media beyond that component could be considered non-radioactive for waste disposal purposes. Phase III focused on the installation of two pilot-scale nitrate treatment cells to evaluate more effective and efficient methods of treating the nitrate. Both of these are discussed at greater length below and in Section 2.5.3.

The effects of the Phase I upgrades in late 2008 can be seen on Figure 225 and Figure 226 above, with concentrations of nitrate and U in system influent increasing significantly as the elevated flow rates and concentrations overwhelmed the system's capacity to provide effective treatment. While the system may have been able to treat these concentrations given sufficient residence time, the increased flow rates reduced residence time below that necessary to achieve satisfactory treatment. This in turn affected concentrations of nitrate and U reported at downgradient locations. The date of completion of Phases II and III is also indicated on both figures, and the resulting improvement in water quality at the DG is clearly evident: even though the system has not been operating ideally, concentrations of the target contaminants at the DG have dropped significantly. However, concentrations in system effluent are most often still above effluent target levels. Optimization efforts continued through 2010 on both of these upgrades to effect treatment improvements.

Since completion of Phases II and III, concentrations of nitrate and U at downgradient locations, particularly the DG but also including GS13, have been somewhat reduced, as seen on these figures. Table 90 presents summary statistics for concentrations of nitrate and U for the years 2000 through 2010 at several locations of interest. These statistics are shown for both contract laboratory-only results (i.e., without ESL data) and for combined contract laboratory and ESL data. (For economic reasons, the ESL was used to analyze the samples collected as often as weekly to evaluate the effects of the Phase I, II, and III upgrades and optimization efforts. Therefore, the data set is more robust if ESL data are also included.) These statistical results further confirm the patterns evident on Figure 225 and Figure 226. Concentrations of nitrate and U in system influent, as represented at SPIN, increased dramatically as a result of the Phase I upgrades, which focused on collecting additional contaminated groundwater. At the same time, despite the reduced treatment effectiveness documented at effluent monitoring locations SPPMM01 and SPOUT, relative to pre-Phase I levels the contaminant concentrations at the DG remain greatly reduced. This is because the contaminated groundwater that had been issuing untreated at the DG is now collected by Phase I and (at least partially) treated by the SPPTS, resulting in overall reduced contaminant loads at the DG. The effects of the Phase II and III upgrades can also be seen, as concentrations of nitrate measured at SPOUT and the DG dropped sharply. This effect is also evident in the summary statistics for surface water location GS13, where SPPTS performance is measured.

Table 90. Summary Statistics for U and Nitrate Concentrations From 2000 through 2010 at Historical and Current SPPTS Monitoring Locations

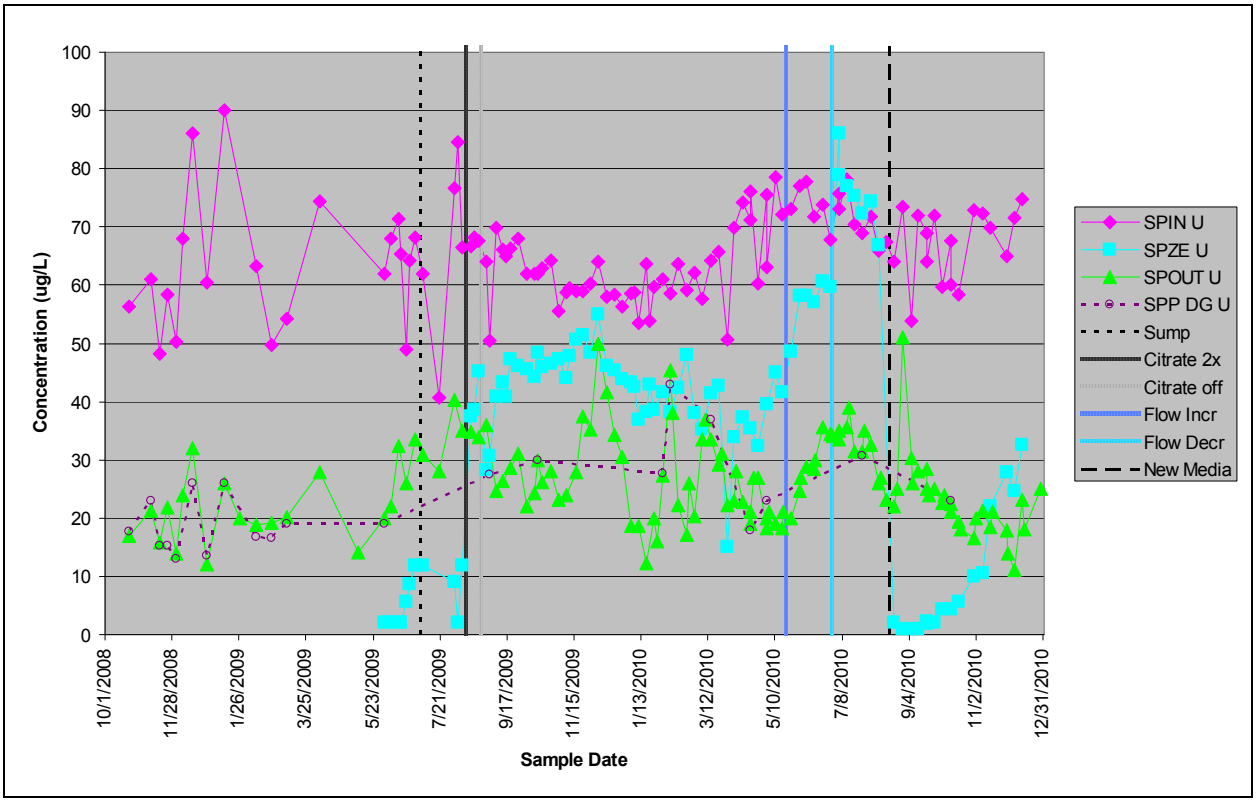
	Nitrate			Uranium		
SPIN	**Average**	**SD**	**Median**	**Average**	**SD**	**Median**
Pre-closure	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Post-closure, pre-Phase I	276.7	59.7	270.0	52.4	9.8	52.0
Post-Phase I	682.5	99.1	695.0	76.3	14.0	77.0
with ESL data	645.3	64.0	646.3	63.1	13.3	60.5
Post-Phase II, III	561.7	90.0	595.0	61.5	6.5	63.0
with ESL data	589.7	71.5	589.4	65.3	7.4	64.9
SPPMM02						
Pre-closure	160.7	45.9	156.0	28.4	4.6	28.8
Post-closure, pre-Phase I (n=3)	246.7	23.1	260.0	35.0	1.0	34.9
Post-Phase I	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
SPOUT						
Pre-closure	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Post-closure, pre-Phase I	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Post-Phase I (n=3)	403.3	40.4	410.0	27.3	4.2	26.0
with ESL data	393.5	100.6	421.0	20.3	5.5	20.0
Post-Phase II, III	102.5	51.9	101.5	32.2	10.2	30.5
with ESL data	83.4	66.4	70.2	26.9	7.5	26.0
SPPMM01						
Pre-closure	6.1	27.0	0.1	3.0	10.5	0.1
Post-closure, pre-Phase I	26.6	77.8	0.4	3.7	5.7	1.7
Post-Phase I (n=1)	310.0	*N/A*	310.0	21.0	*N/A*	21.0
with ESL data	283.0	112.8	329.2	16.7	3.0	15.5
SPP Discharge Gallery						
Pre-closure	259.9	123.2	233.0	52.8	44.7	43.3
Pre-closure without 3 U outliers	*N/A*	*N/A*	*N/A*	44.9	16.9	43.0
Post-closure, pre-Phase I	449.8	123.2	425.0	60.5	14.6	56.0
Post-Phase I (n=3)	376.7	85.0	380.0	25.0	1.7	26.0
with ESL data	379.7	117.9	385.1	18.4	4.6	16.7
Post-Phase II, III	145.0	35.4	145.0	24.5	7.8	24.5
with ESL data	57.6	63.8	28.0	27.0	7.3	25.3
GS13						
Pre-closure	24.9	17.6	23.0	12.1	6.1	11.8
Post-closure, pre-Phase I	41.2	26.2	38.0	23.0	13.1	21.4
Post-Phase I	80.3	13.2	74.0	38.3	22.6	52.3
with ESL data	88.5	61.4	75.0	36.1	18.7	38.1
Post-Phase II, III	13.7	8.2	11.0	17.0	6.2	17.7
with ESL data	18.5	13.4	18.1	18.1	11.9	15.1

Notes: SPIN = true system influent (collection well); SPPMM02 = historical "influent" monitoring location; SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; GS13 = surface water performance monitoring location. N/A indicates location was not monitored, or the indicated statistic cannot be calculated. Where three or fewer results form the basis for the statistics presented, the number of samples is indicated parenthetically (e.g., n = 3). Refer to 2009 Annual Report (DOE 2010d) for additional information on the outliers noted for the Discharge Gallery statistics. Closure date used is October 2005; Phase I date

Table 90 (continued). Summary Statistics for U and Nitrate Concentrations From 2000 through 2010 at Historical and Current SPPTS Monitoring Location

used is October 20, 2008. Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007c) for a more detailed discussion of location SPPMM02, and see the 2008 Annual Report (DOE 2009d) for more information on SPOUT. Data used to calculate the statistics were taken at face value, regardless of qualifier. This is largely irrelevant, but nitrate and U were frequently not detected prior to spring 2005 in effluent monitoring location SPPMM01, so the resulting statistically generated values would be expected to be biased high. Data from ESL are not validated, but typically correspond very closely to results from split samples sent to contract labs. ESL results for nitrate used to calculate the statistics include those for nitrate only as well as for nitrate plus nitrite.

The effects on water quality from the installation of these phased upgrades are illustrated graphically below. Figure 227 illustrates U concentrations at various locations via time-series plots and focuses on the Phase II Cell. The early (i.e., mid-2009) breakthrough of U in effluent from this treatment cell is obvious. This cell had initially removed U as designed, but within weeks the effluent sampled at SPZE (see Table 89) showed detectable concentrations of U. Over the subsequent months of 2009, the levels of U in effluent from the Phase II cell increased. Reasons for this behavior were not known.



Notes: U = uranium; SPIN = system influent; SPZE = effluent from Phase II Cell; SPOUT = system effluent; SPP DG = SPP Discharge Gallery. Sump = date of sump subsidence, Citrate 2x = date on which citrate dosing was doubled, Citrate off = date on which citrate dosing was discontinued; refer to DOE 2010d for additional discussion of and information on these events. Flow Incr = date on which flows through the Phase II cell were increased from approximately 1.5 gpm to approximately 2.4 gpm - 3 gpm; Flow Decr = date on which flows were reduced to approximately the previous rates. New Media = date on which Phase II Cell media replacement was completed and the cell was placed back into operation. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. Data are from contract laboratories as well as the ESL.

Figure 227. Concentrations of U in Effluent From the Phase II Cell

As reported in the 2009 Annual Report (DOE 2010d), four nonexclusive hypotheses were developed to explain the reduced effectiveness of the Phase II cell. One of these is physical, and the remaining three are chemical (based on passivation of the ZVI):

- Preferential flow paths had developed.
- The high concentrations of nitrate promote formation of precipitates such as ferric oxyhydroxides on the ZVI grains.
- Dosing with citrate resulted in precipitates coating the ZVI grains.
- The nitrate and/or citrate accelerated weathering of feldspars in the granitic pea gravels to clays that coated the ZVI grains.

Tracer testing and microscopy was performed in 2010. Results of these efforts led to two significant conclusions: First, a purely physical cause (i.e., preferential flow) was not indicated. Second, the condition of the media as examined microscopically indicated no unusual physical conditions and suggested the media should still be treating adequately.

As can be seen on Figure 227, U treatment by the Phase II cell (as measured at SPZE) was improving slightly in the spring of 2010, but then worsened. This decrease in treatment effectiveness is also expressed at SPOUT, and coincides with an operational change: flows through the system, including the Phase II cell as the first component in the system, were increased in late May to manage the heavy spring recharge. That extra water had collected in the SPPTS intercept trench and had to be managed—i.e., fed through the system for treatment. These data also illustrate that when flow rates were decreased again at the end of June, concentrations at SPOUT gradually decreased. However, by July the Phase II cell was no longer effectively removing U, and media replacement was scheduled.

The media replacement was planned and completed the following month, in August 2010. Several adjustments to the media and operation were made in order to address or inform the assessment of the above hypotheses:

- Citrate dosing was not performed;
- A quartzitic pea gravel was used rather than the feldspathic gravel used originally;
- A fresh lot of ZVI was used;
- The ZVI ratio in the media was increased.

The new media, installation of which was completed in mid-August 2010, had an immediate effect on U concentrations measured at SPZE and, to a lesser degree, at SPOUT. Given the large volume of the original SPPTS structure, considerable time is necessary to drain the water within, which leads to a delay in responses measured at SPOUT.

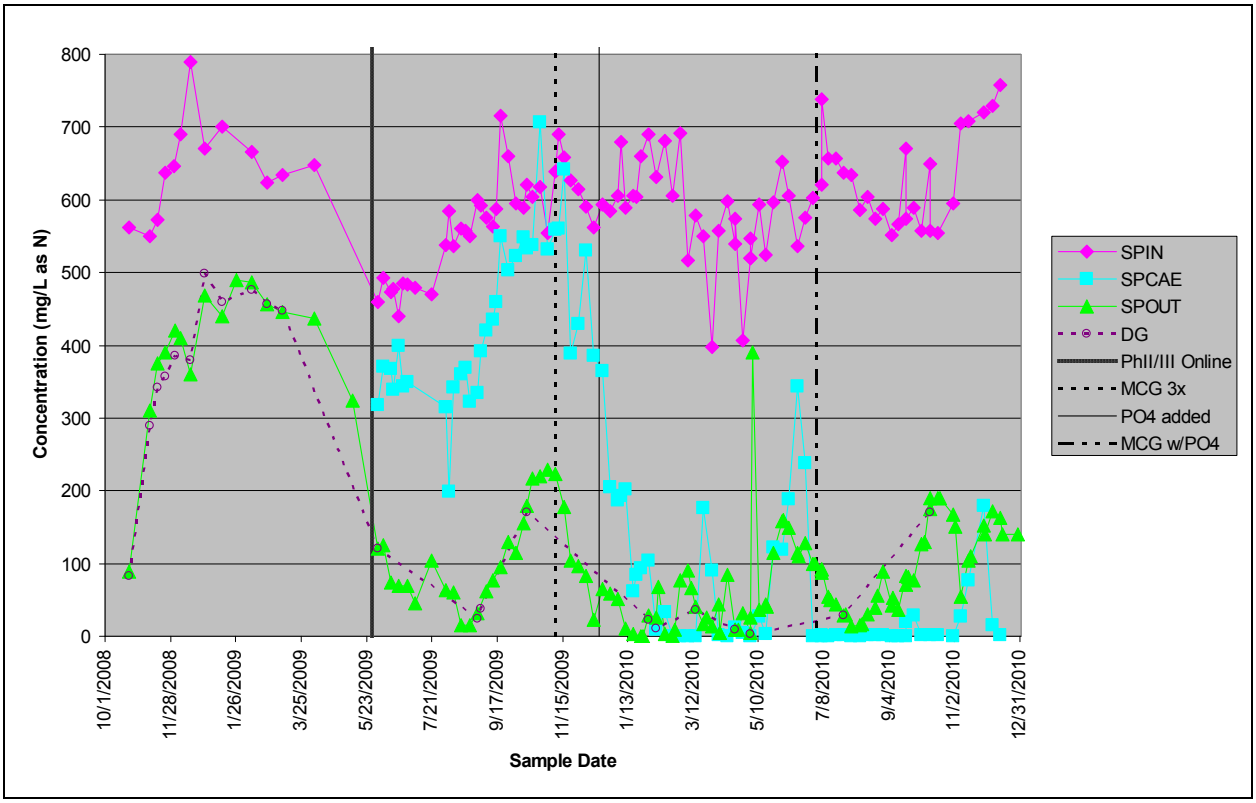
Figure 227 also illustrates U concentrations in effluent from that cell, as measured at SPZE, were increasing as 2011 drew to a close. Reasons for this were uncertain, but several mechanisms that had been under consideration as reasons for the failure of the initial media can be ruled out. Weathering of feldspars in the granitic pea gravel cannot be the cause, as the replacement pea gravel is composed of crushed quartzite. In addition, citrate dosing was never implemented after being discontinued in 2009, eliminating that as a factor. Instead, the causes for reduced U treatment appear limited to the naturally elevated concentrations in groundwater of dissolved

oxygen (DO) and major ions such as calcium and carbonate, and the elevated concentrations of nitrate from the SPP. Given that the MSPTS and ETPTS use pure ZVI to treat groundwater of a similar character but without the nitrate, and perform acceptable treatment for some years, by process of elimination it would appear that the cause for the quick reduction in effective U treatment by the SPPTS Phase II cell is the elevated nitrate in the influent. The elevated major ions and DO likely play a part, but nitrate is suggested as the primary factor. This is surprising, given that untreated, high-nitrate water collected from SPIN was used in lengthy laboratory tests to assess whether U could be treated as a first step (rather than following nitrate treatment); in those tests, U removal was excellent and early breakthrough of U, with or without citrate dosing, was not experienced. However, the scale of these laboratory tests was necessarily small, so scaling up to full-size may have posed complications unforeseen in the lab tests.

The treatment performance of the Phase II cell with the replacement media is improved relative to that of the initial batch of media, but by late 2010 was no longer meeting targets. Therefore, as 2010 ended, efforts were underway to assess possible treatment alternatives or adjustments that would meet those targets and could be implemented at the SPPTS. As previously noted, a fundamental limitation on feasible solutions is the lack of electrical power other than solar. Results of this consideration will be provided in the 2011 Annual Report.

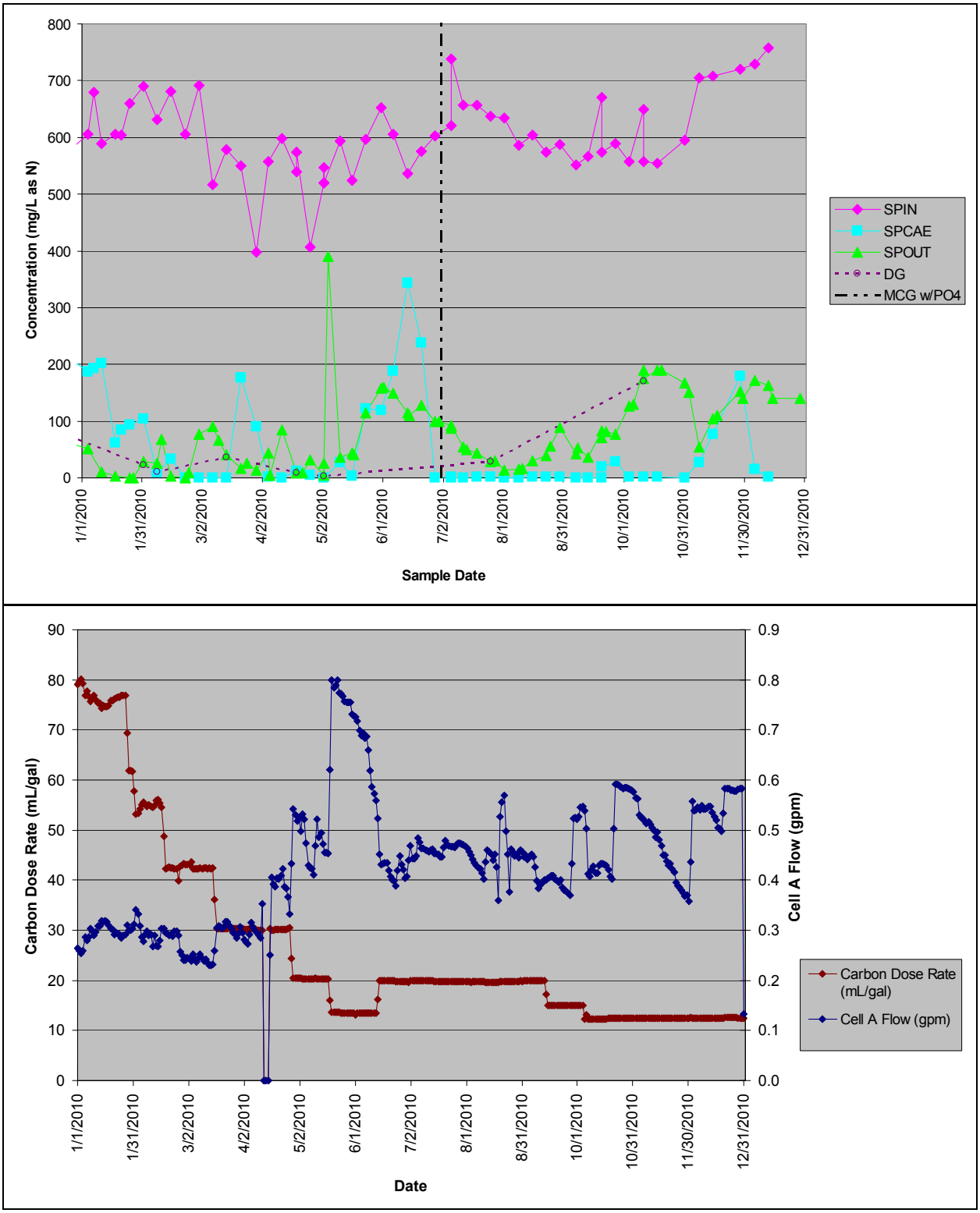
Operation and optimization of the two pilot-scale Phase III cells continued in 2010. Cell A, which is filled with an inert plastic media and cell influent is dosed with a liquid carbon source (MicroCg, a proprietary blend manufactured by EOS), continued to outperform Cell B. The latter cell is filled with organic media, corn stover. The primary differences are in available surface area for the denitrifying bacteria and the quality and bioavailability of the carbon. The inert media in Cell A provides a much higher surface area (a principal design requirement of inert media), and the liquid carbon is more bioavailable than is the plant matter in Cell B. Therefore, it is to be expected that Cell A would be able to effectively treat greater flows than Cell B.

Analytical data collected from the installation of Phase I through the end of 2010 are illustrated on Figure 228. Figure 229 focuses on conditions in CY2010, showing these analytical data together with dose rates for the liquid carbon and Cell A influent flow rates. Flow through Cell A was continuous, and typically represented about a third of the total SPPTS flow, as can be seen when comparing the SPPTS hydrograph in Figure 224 with the Cell A flows presented in Figure 229.



Notes: SPIN = system influent; SPCAE = effluent from Phase III Cell A; SPOUT = system effluent; DG = SPP Discharge Gallery. PhII/III Online = date on which the Phase II and Phase III components were put online. MCG 3x = date on which the carbon dose rate was approximately tripled in an effort to boost the population of denitrifying bacteria; PO4 added is date on which phosphate addition began, via separate dosing; MCG w/PO4 is date on which custom-blended MCG with PO4 began to be used. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. Data are from contract laboratories as well as the ESL.

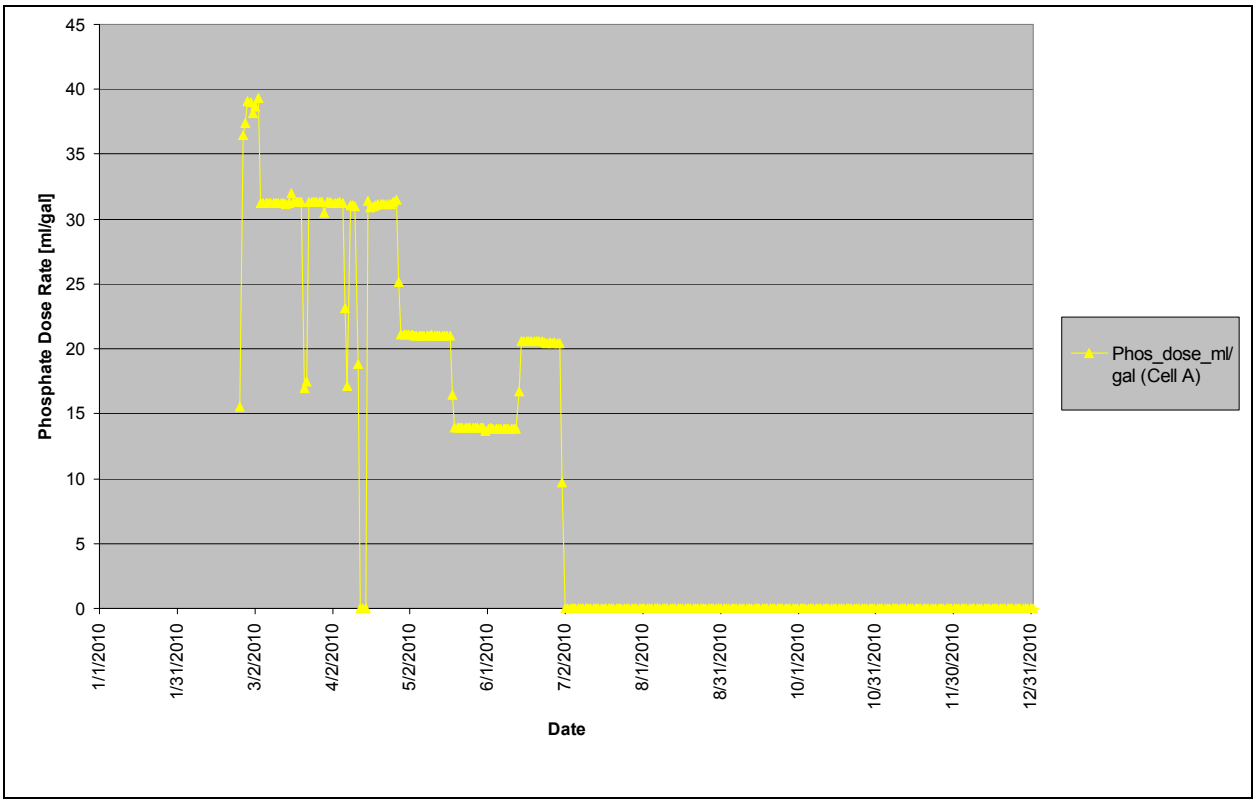
Figure 228. Concentrations of Nitrate in Effluent From Phase III Cell A



Notes: Top portion: SPIN = system influent; SPCAE = effluent from Phase III Cell A; SPOUT = system effluent; DG = SPP Discharge Gallery. MCG w/PO4 is date on which custom blend of liquid carbon with added phosphorus began to be used. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. Data are from contract laboratories as well as the ESL.
Bottom portion: dose rate is in units of mL MCG per gallon of influent water.

Figure 229. Cell A Nitrate, Carbon Dose Rates, and Flow Rates in CY 2010

As shown on Figure 229, optimization efforts focusing on carbon dose rates and influent flow rates were conducted through the year. This also occurred with phosphorus dose rates in the first portion of 2010, which led to the use of Rocky Flats-specific, custom-blended MicroCg beginning on July 1. This is illustrated below on Figure 230; the zero values shown from July onward correspond to the switch to the custom-blended carbon.



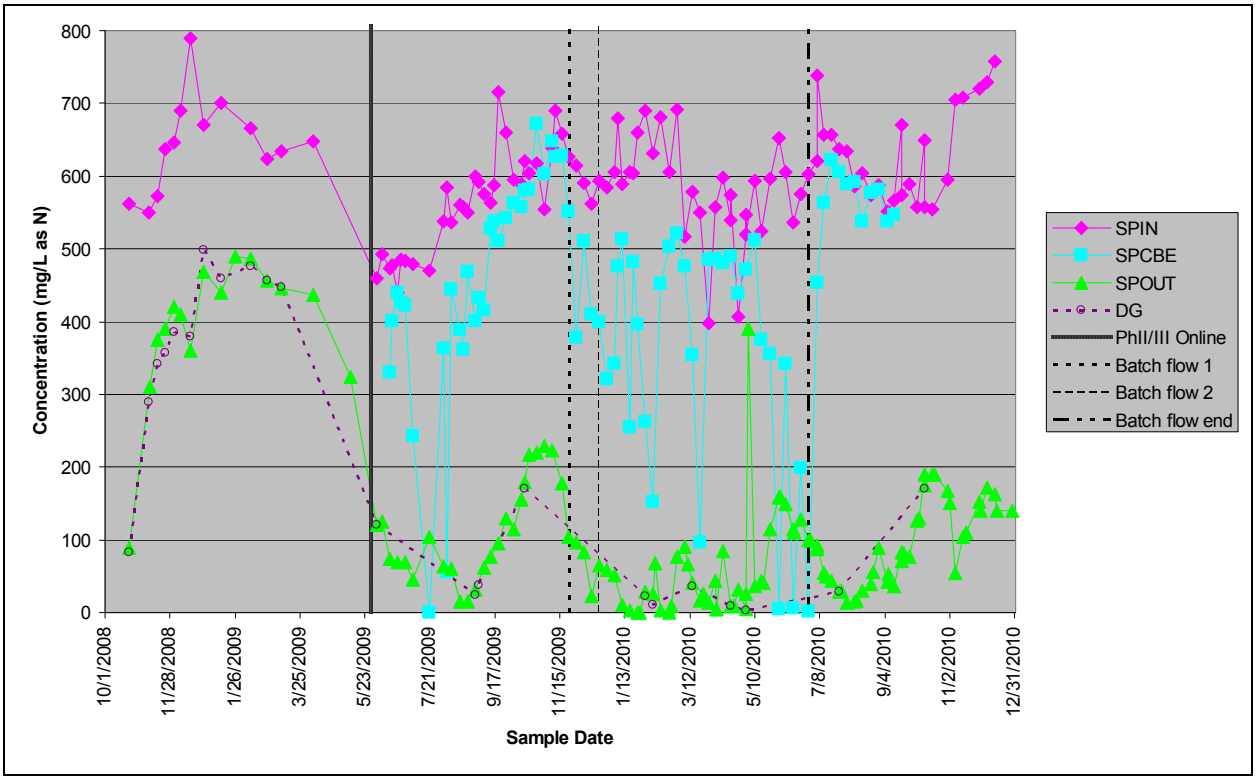
Notes: Phos_dose_ml/gal = dose rate for separately-dosed phosphate solution, is in units of mL per gallon of influent water. Influent was not dosed prior to Feb 25, 2010, in an attempt to depend solely on naturally occurring phosphorus. Dosing was deactivated on July 1, when a carbon source that contained phosphorus at the optimized ratio began to be used.

Figure 230. Cell A Phosphate Dose Rates in CY 2010

Another important Cell A attribute that was tested and optimized was recirculation: Cell A is equipped with a recirculation pump that is designed to enhance flow through the cell, based on the fact that denitrifying bacteria thrive under higher velocity flows than Cell A would otherwise present. Although this recirculation pump does not provide flows in the optimal range for these bacteria, it does improve conditions. Testing of the pump was performed by installing two clear, in-line, media-filled pipe segments of differing diameters that were operated in series. The contents of these pipes were visually examined for biofilm development on the media within the pipes. (This component was installed on October 23, 2009, and is referred to as the flow loop in DOE 2010d) The pipe segments, which had diameters of 2 inches and 4 inches and were plumbed directly to the pump, were routinely inspected. Rates of biofilm development on the media did not appear to vary from the larger pipe (in which water moved more slowly) to the narrower pipe (with faster flows). Samples were collected from the end point of each of these pipe segments and showed no significant differences. Recirculation was also tested by turning the pump off for a time, and then back on. When the pump was deactivated between July 15 and

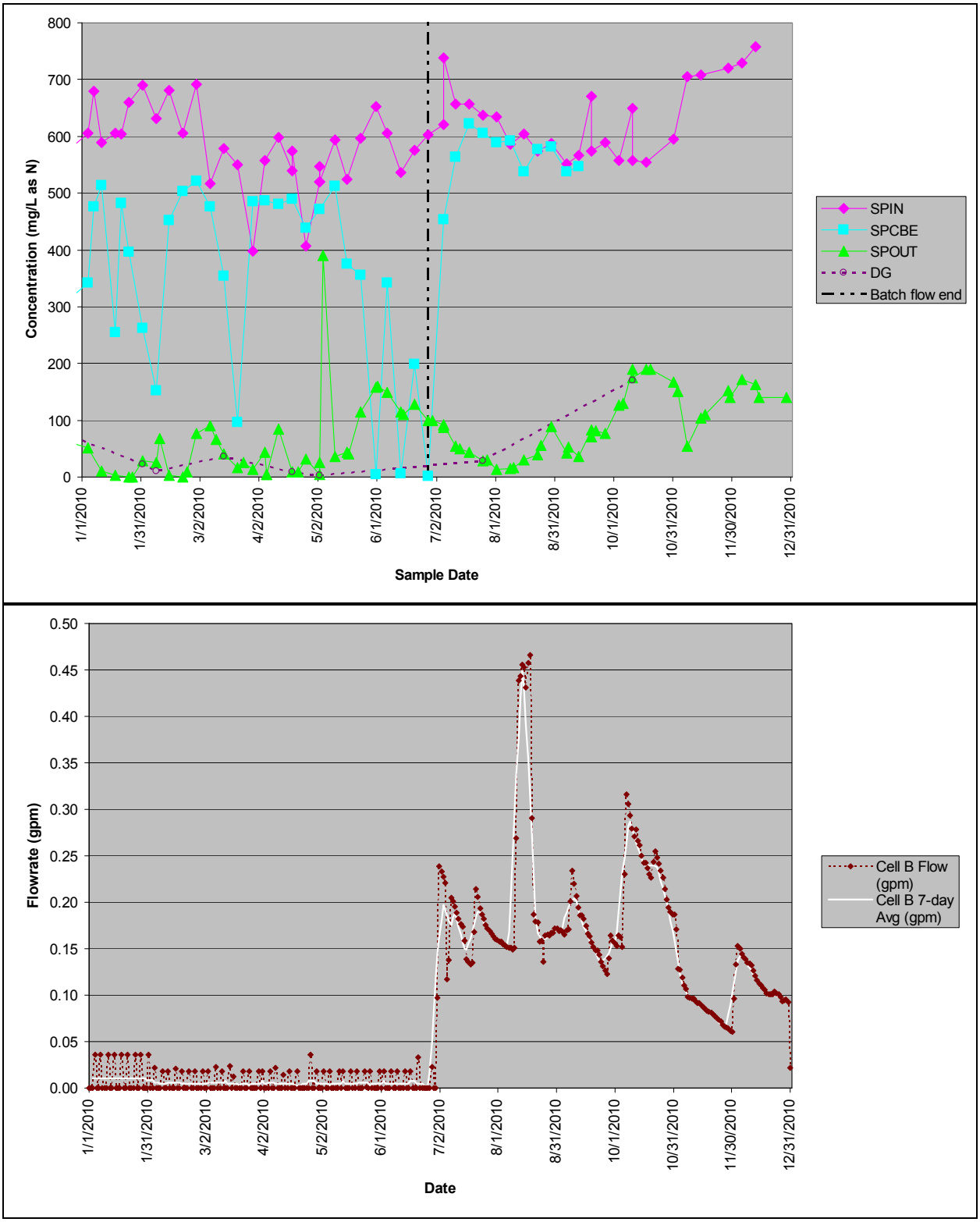
August 18, 2010, certain indicators—such as smell and water appearance, as well as changes in other chemical parameters not illustrated on Figure 229—showed that the cell operated more effectively under the higher flow rates afforded by the recirculation pump. Recirculation was then restored and maintained through the rest of 2010.

Cell B optimization efforts were much more limited. By design, this cell was testing a more passive, flow-through organic media as opposed to the active approach of Cell A. No additional amendments were provided to Cell B via the influent, nor was water within the cell recirculated. In contrast to Cell A, flow through Cell B was neither continuous nor a significant fraction of overall SPPTS flows. Figure 231 illustrates the overall performance of this cell, and Figure 232 focuses on 2010 data and corresponding flows. Reduced treatment in winter months was attributed to heat loss: although insulation was installed over the cell, it continued to lose heat that was not adequately replenished under the batch-flow operations. Adding a small (e.g., 26 gallons) aliquot of relatively warmer groundwater twice weekly was insufficient to keep the cell contents warm, and denitrifying bacteria do not function well in cold temperatures. However, this would not be sufficient to explain the reduced treatment during summer months. As illustrated in both figures, there were occasions when the cell treated flows adequately and effluent targets (10 mg/L nitrate) were met, but performance was very inconsistent. The timing of sampling vs. addition of influent may have played a role, but this seems implausible given the extremely small volume of these additions compared to the overall size of the cell, unless preferential flow paths were present within the media that caused some influent to flow straight to the effluent sampling point. This was not tested, but again the very small volume of the additions and the fact that effluent samples were collected using consistent methods and from the same point suggests such an explanation has some flaws. Average flow rates on a gallon-per-minute basis under batch flow operations began at approximately 0.01 gpm and were later halved to approximately 0.005 gpm, which is slightly less than 4 teaspoons per minute.



Notes: SPIN = system influent; SPCBE = effluent from Phase III Cell B; SPOUT = system effluent; DG = SPP Discharge Gallery. PhII/III Online = date on which the Phase II and Phase III components were put online. Batch flow 1 provided approximately 105 gallons per week; batch flow 2 approximately halved that to 52 gallons per week; batch flow was ended and continuous flows resumed when indicated. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. Data are from contract laboratories as well as the ESL.

Figure 231. Concentrations of Nitrate in Effluent From Phase III Cell B



Notes: Top portion: SPIN = system influent; SPCBE = effluent from Phase III Cell B; SPOUT = system effluent; DG = SPP Discharge Gallery. Batch flow was ended and continuous flows resumed when indicated. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. Data are from contract laboratories as well as the ESL.

Bottom portion: during batch flow operation, two pulses of influent (batches) per week were added to the cell.

Figure 232. Cell B Nitrate and Flow Rates in CY 2010

The results illustrated above may be used in considering the design requirements of a full-scale nitrate treatment cell based on the Cell B approach. Cell B contains approximately 140 cubic feet of corn stover. Ignoring the inconsistency with which effective treatment was demonstrated and increasing this volume sufficiently to treat the entire SPPTS flow (assuming an average flow rate of 1.6 gpm), simple mathematical extrapolation suggests a media volume of about 45,000 cubic feet, or approximately 3 times the entire volume of the original structure (including treatment cells and overburden), would be required. This depends on treatment performance meeting critical assumptions, most especially that treatment would be consistently effective, flows would not exceed 1.6 gpm, and preferential flow would not be present. To provide a safety margin and to accommodate periods of higher flow, the volume would be increased significantly, perhaps to 5 times the volume of the existing structure, or about 75,000 cubic feet. Some method of hydraulic control would need to be incorporated, because to achieve effective treatment, the influent must flow through the entire bulk of the irregular organic media, not along preferential pathways. Upflow configuration enhances flow dynamics, but additional engineering would be required to provide dependable flow control, which would further increase the size and complexity of the treatment cell. Therefore, in June 2010 it was concluded that the Cell B approach would not be feasible for treating SPPTS influent. However, rather than discontinue operation of this cell, continuous flow was resumed under the assumption that the cell was still providing some useful treatment. In September 2010 periodic sampling of the effluent from Cell B was curtailed.

As 2010 ended, efforts were underway to design a full-scale nitrate treatment cell based on the Cell A treatment methodology. Results will be reported in 2011. In the interim, the SPPTS continues to operate, and efforts to further optimize the performance of Cells A, B, and the Phase II cell will continue.

Other Plumes

In accordance with RFLMA, the source areas as well as downgradient contaminant migration pathways for other groundwater contaminant plumes at Rocky Flats were monitored during 2010.

This section presents a summary discussion of data collected in 2010 from several plumes/areas of interest. These include the 903 Pad/Ryan's Pit Plume, the collection of small plumes collectively referred to as the IA Plume, the VC Plume (or OBP#1 Plume) located south of the former B371 complex, the IHSS 118.1 Plume (also called the carbon tetrachloride plume) located north-northwest of former B776, the PU&D Yard Plume, and the OU 1 Plume. A short summary of data from other locations of special interest is then presented.

903 Pad/Ryan's Pit Plume

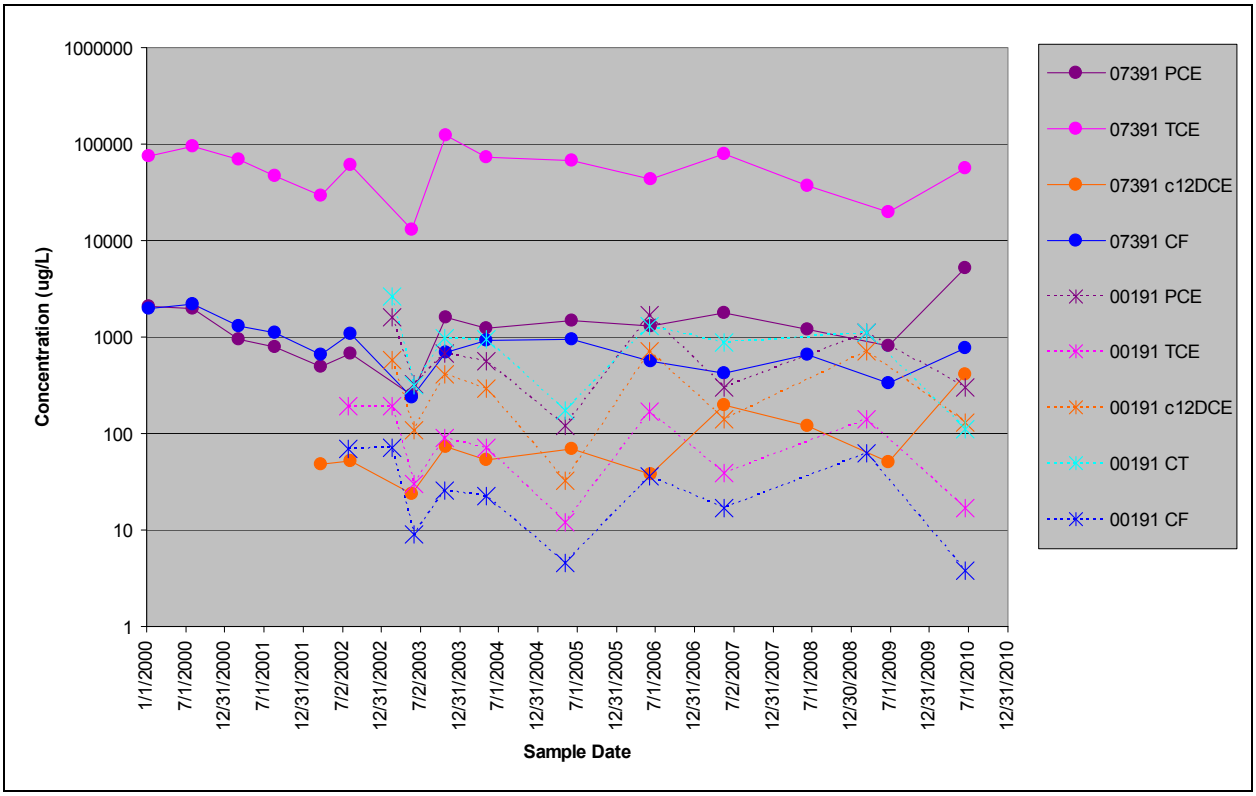
The source areas and downgradient portions of the 903 Pad/Ryan's Pit Plume were monitored in June 2010. (Sentinel and AOC wells monitoring this plume were also sampled in October 2010.) Water quality was generally consistent with previous data. As expected, the two source-area wells, Evaluation wells 00191 just east of the former 903 Pad and 07391 just south of former Ryan's Pit, produced samples with the highest overall concentrations of contaminants. Concentrations of TCE from well 07391 are approximately 2 orders of magnitude higher than

any other VOCs reported in this plume, including at well 00191. As is typical for these source areas, the 903 Pad components are primarily carbon tetrachloride and PCE, while the main constituent in groundwater from the Ryan's Pit source area is TCE. The concentration of the metabolic byproduct *cis*-1,2-DCE increased somewhat in both source-area wells, and in 2010 was slightly higher than that of carbon tetrachloride in the samples from well 00191 (130 µg/L vs. 110 µg/L). This may be related to application of HRC in both source areas just prior to closure.

Also as expected, terminal well 10304, an AOC well located on the northern bank of and along the flow path to Woman Creek, produced samples with the lowest concentrations of VOCs. Samples collected from this well in 2010 yielded a single, J-qualified detection of TCE reported at an estimated concentration of 0.68 µg/L. However, wells between the source areas and this AOC well produce samples with VOC concentrations that often do not reflect their relative distance from the source areas. Sentinel well 90399, which is located on the north side of the SID, next-farthest from the source areas, produced samples with concentrations of VOCs that exceed those reported in wells that are closer to the source areas and, with respect to certain VOCs, even including well 00191. This is also consistent with previous data.

Ryan's Pit source-area well 07391 reported a concentration of PCE (5,200 µg/L) that was above the previous range for this well (250 µg/L to 2,100 µg/L since the year 2000). The concentration of TCE was consistent with that of previous years, being reported at 56,000 µg/L (TCE has ranged from 13,000 µg/L to 124,000 µg/L). An increase in reductive dechlorination of the residual source material may be indicated by the somewhat stronger increase in *cis*-1,2-DCE, which was reported in the 2010 sample at a concentration of 410 µg/L; this constituent is calculated to be on an increasing trend at the 95 percent confidence (Table 77). The range for this constituent since 2002 has been 24 µg/L to 200 µg/L (prior to 2002, detection limits reported for this compound were 1,000 µg/L and 5,000 µg/L, and therefore samples from 2000 until 2002 are represented solely by nondetects). Even so, given that PCE more than doubled and both it and TCE are reported in the thousands to tens of thousands of micrograms per liter, the higher concentration reported for this daughter product does not suggest a substantial increase in biodegradation of parent compounds. Time-series plots of the primary constituents are presented in Figure 233. (Carbon tetrachloride is omitted for 07391, because results for this constituent reported since 2000 consist of nondetects at detection limits ranging from 1 µg/L to 5,000 µg/L, and a single detection in 2003 of 7.1 µg/L.) A second trend meeting the 95 percent level of significance is calculated for chloroform in samples from well 07391, where it is decreasing in concentration.

No similarly significant increasing or decreasing trends are calculated for well 00191. Concentrations of the primary VOCs in samples from this well are also illustrated on Figure 233. Carbon tetrachloride is the VOC present at the highest concentrations at this location, but these concentrations are typically 1 to 2 orders of magnitude lower than those of the primary contaminant, TCE, at well 07391. Concentrations of PCE at location 00191 are occasionally greater than at 07391, but not in 2010; the same applies to concentrations of *cis*-1,2-DCE.



Notes: c12DCE = *cis*-1,2-DCE; CF = chloroform; CT = carbon tetrachloride. Several results are qualified but for simplicity are not shown differently. Note logarithmic concentration scale.

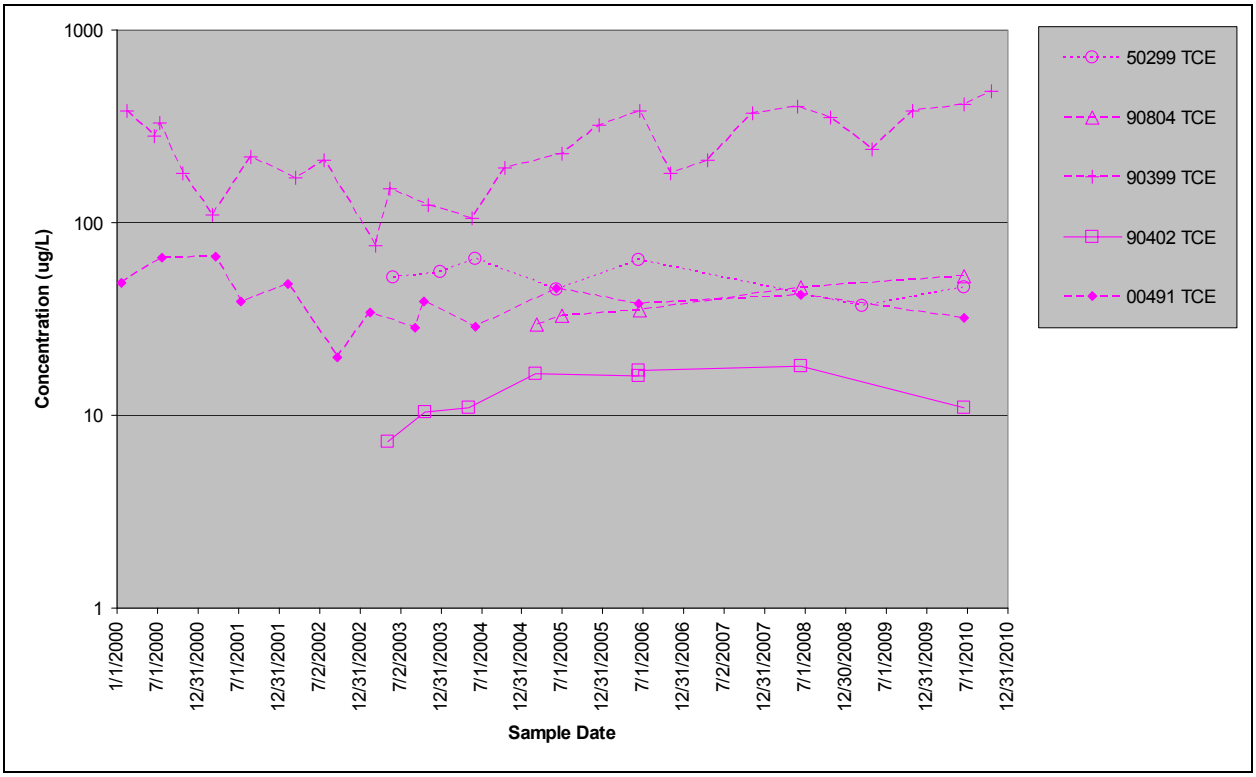
Figure 233. Primary VOCs in 903 Pad/Ryan's Pit Plume Source Area Wells

In addition to the source area wells and the AOC well identified above, other wells monitoring this plume along the pathway to Woman Creek include Evaluation wells 90402, 00491, 50299, 90804, and Sentinel wells 90299 and 90399. Of these, trends meeting the 95 percent level of statistical significance (Table 77) are calculated for well 00491 (chloroform; decreasing), 90399 (1,1-DCE, *cis*-1,2-DCE, and TCE; all increasing), and 90299 (carbon tetrachloride, chloroform, and TCE; all decreasing). Some of these trends are questionable due to the presence of nondetects in the data set.

The unusual distribution of TCE illustrates the point made above regarding concentrations not decreasing with increasing distance from the source area. Time-series plots of TCE are provided below in Figure 234. Except for source area well 07391, concentrations of TCE appear highest in well 90399, which is located farthest from the source area, and lowest in well 90402, which is closest to the sources but side-gradient with respect to former Ryan's Pit. Between these two wells, the concentrations of TCE in samples from wells 50299, 00491, and 90804 have varied inconsistently. Time-series plots of carbon tetrachloride (Figure 235) illustrate a different pattern, with well 50299 reporting the highest concentrations, though in 2010 results from Sentinel well 90399 were essentially equivalent.

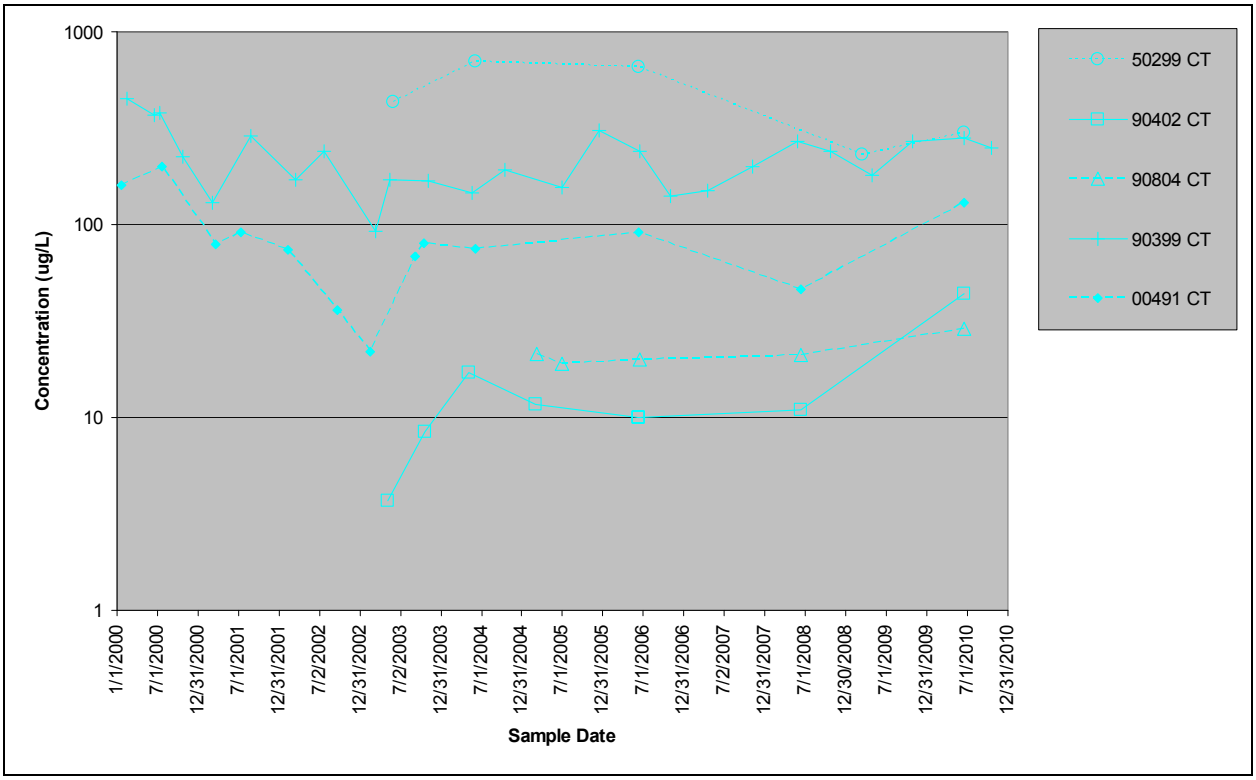
Finally, time-series plots for chloroform in samples from the same wells are presented in Figure 236. Chloroform is the first metabolic byproduct formed from the dechlorination of carbon tetrachloride, but was also used in various processes at Rocky Flats. (Therefore, its presence is not necessarily indicative of dechlorination.) This plot shows concentrations of

chloroform are essentially equivalent in groundwater collected from wells 90399, 00491, and 50299. The first of these is located at the SID, while the other two are east of former Ryan's Pit, just south of the pediment top. Concentrations of this constituent in samples from wells 90804 and 90402 are significantly lower than in the other three wells.



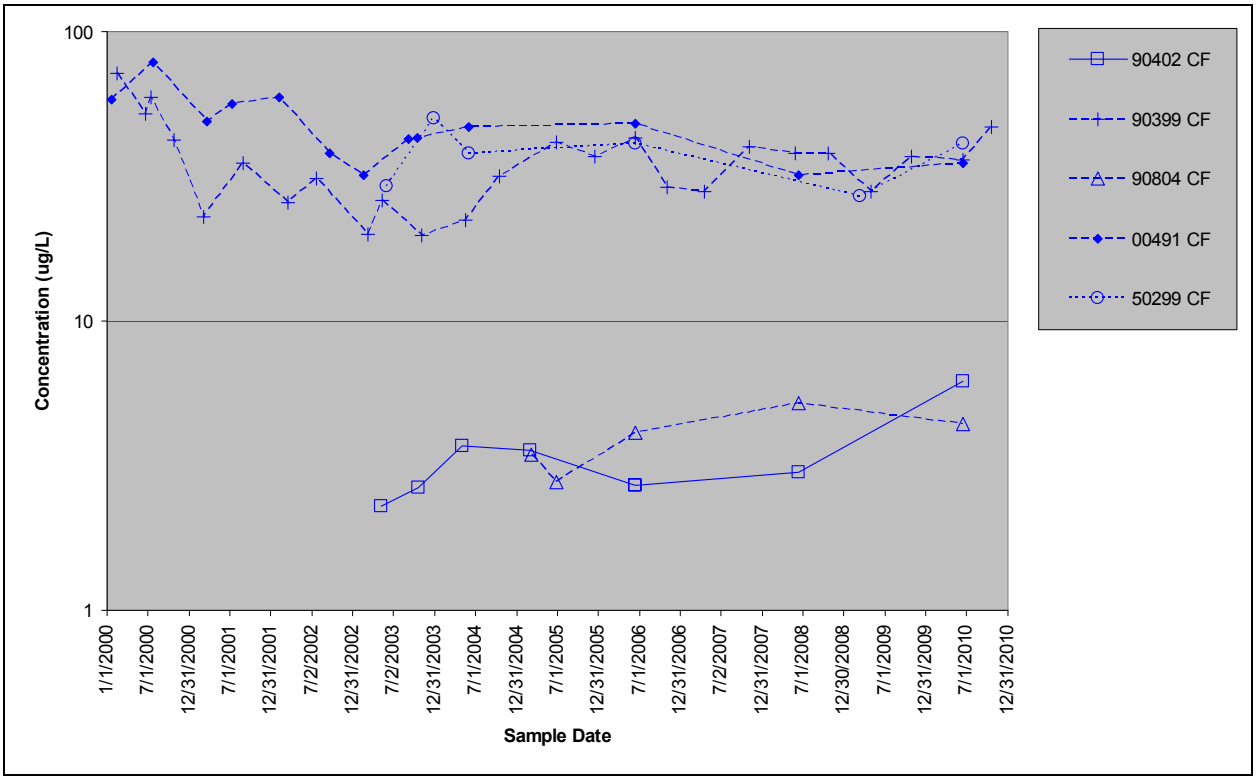
Notes: Several results are qualified but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 234. TCE in Samples From Wells Within the 903 Pad/Ryan's Pit Plume



Notes: CT = carbon tetrachloride. Several results are qualified but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 235. Carbon Tetrachloride in Samples From Wells Within the 903 Pad/Ryan's Pit Plume

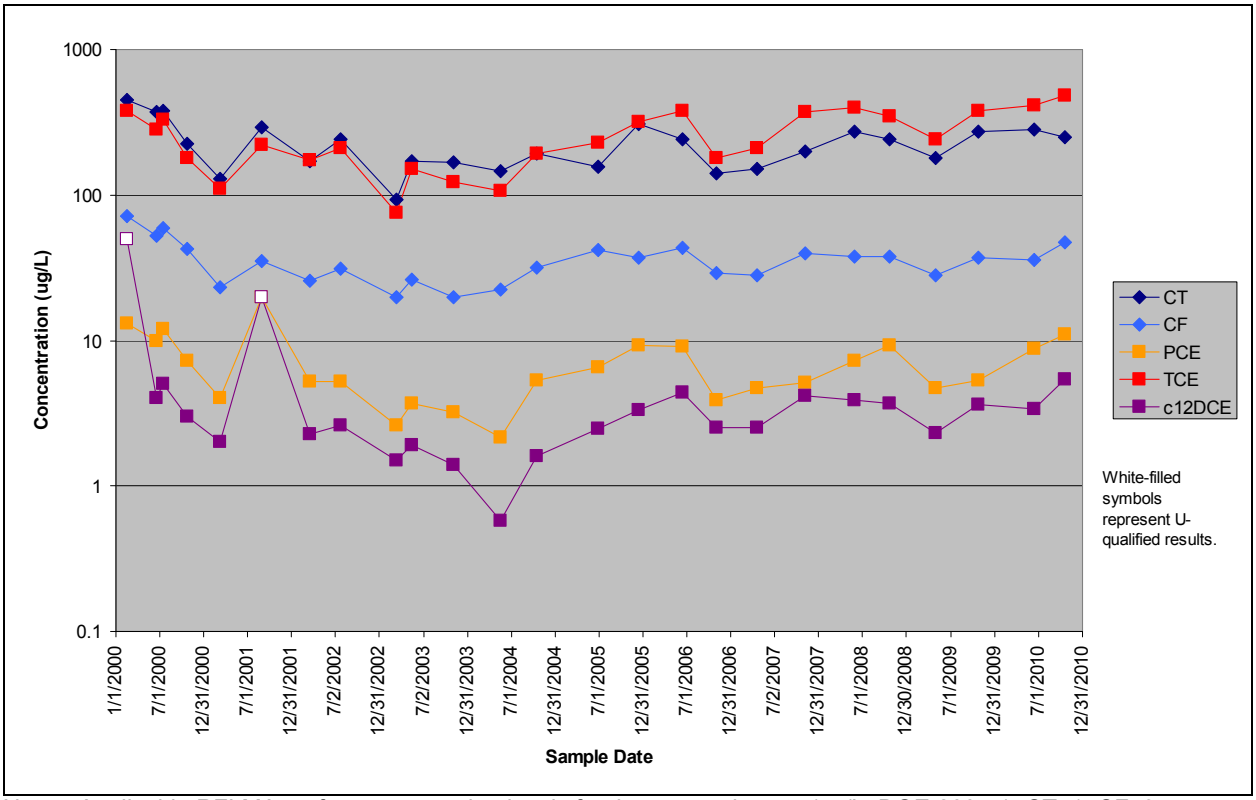


Notes: CF = chloroform. Several results are qualified but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 236. Chloroform in Samples From Wells Within the 903 Pad/Ryan's Pit Plume

Downgradient Sentinel well 90299, which is typically dry, was recharged by the significantly higher precipitation in the spring of 2010 and produced samples in both sampling events (second and fourth quarters). The last time this well produced samples was in 2007. Consistent with its position on the margin of the plume, only three detections of VOCs, all at very low concentrations, were reported in 2010. Chloroform was detected in the second quarter, and TCE in both quarters; the TCE result in June of 1.4 µg/L was the only result not J-qualified, and was the highest concentration reported of any VOC detected in samples from this well.

Because of the importance of Sentinel well 90399, a series of time-series plots is provided showing the main VOCs present in samples from this well (Figure 237). Concentrations of these constituents have remained fairly consistent over the past several years. As shown, concentrations of carbon tetrachloride and TCE—the two dominant VOCs in the two source areas for the 903 Pad/Ryan's Pit Plume—are very similar, supporting the conclusion that both source areas contribute to the contamination reported in samples from this well. While biodegradation of the PCE to TCE may also be contributing to the higher TCE concentrations, previous reports and technical studies (K-H 2004d; ATSDR 2007) suggest this mechanism would be of minor importance in this area.



Notes: Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): CT, 1; CF, 3.4; PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70. In addition to the nondetects ("U"-qualified results), several other results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 237. VOCs in Downgradient 903 Pad/Ryan's Pit Plume Well 90399

The AOC well at the mouth of Pond C-2, 00193, also supports the monitoring of the 903 Pad/Ryan's Pit Plume. The sample collected in June 2010 from this well reported a J-qualified detection of TCE with a concentration estimated at 0.23 µg/L. No other VOC detections were reported in 2010. The highest concentration of any VOC in the data set for this location is 12 µg/L of *cis*-1,2-DCE in a sample collected in May 2008. This constituent has been detected on three occasions, most recently in April 2009 (0.17 µg/L, J-qualified). TCE is the VOC detected most frequently at this location; it has been detected in five samples, the earliest of which was collected in May 2003. None of the reported concentrations of any VOC detected in samples from this well has exceeded the applicable RFLMA Table 1 value for the corresponding constituent.

U concentrations reported in samples collected in 2010 from AOC well 00191 were consistent with previous data. Samples from this well have reported U concentrations ranging from 36 µg/L to just over 93 µg/L; results in 2010 were 74 µg/L and 63 µg/L for the second and fourth quarters, respectively.

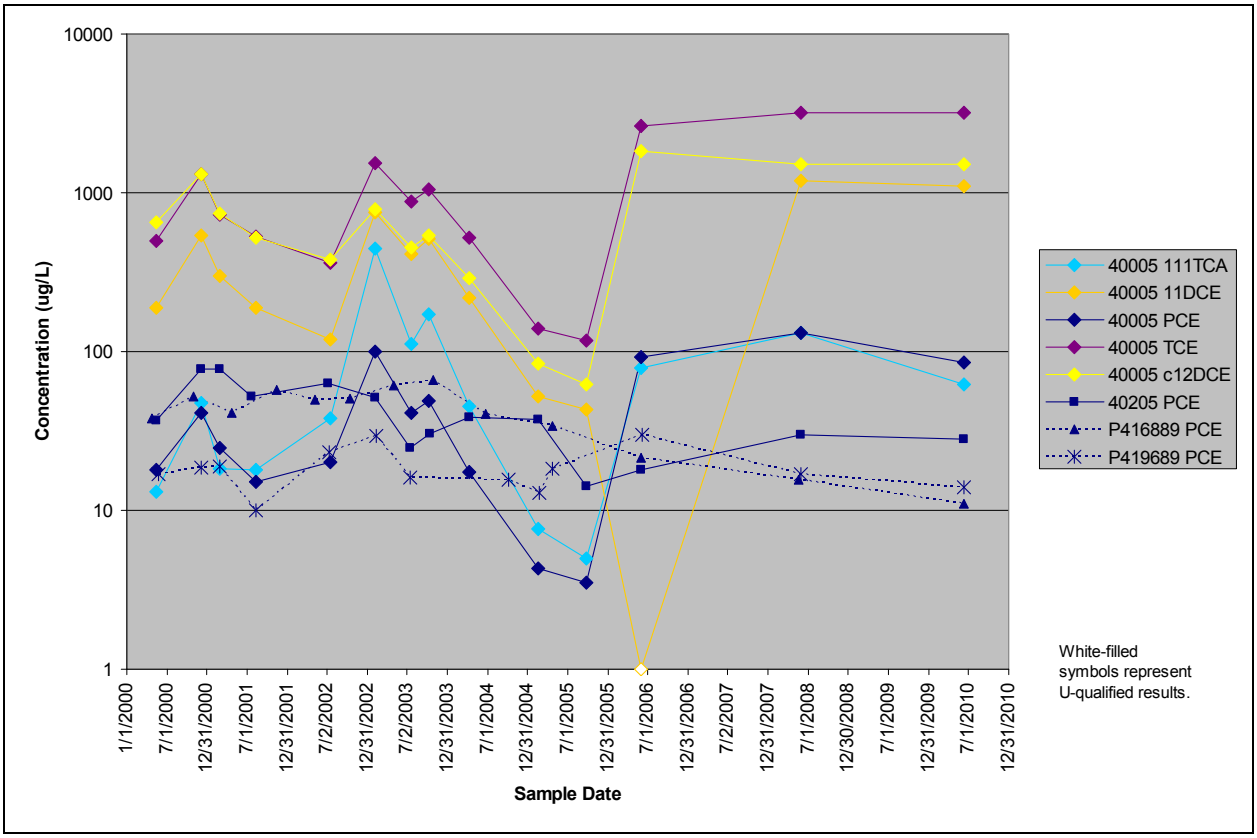
IA Plume

The IA Plume is actually a collection of several small VOC plumes grouped together for convenience and, in some cases, because of uncertainties regarding specific sources. This

discussion defines the IA Plume as three loosely defined segments: the South, Central, and North IA Plumes.

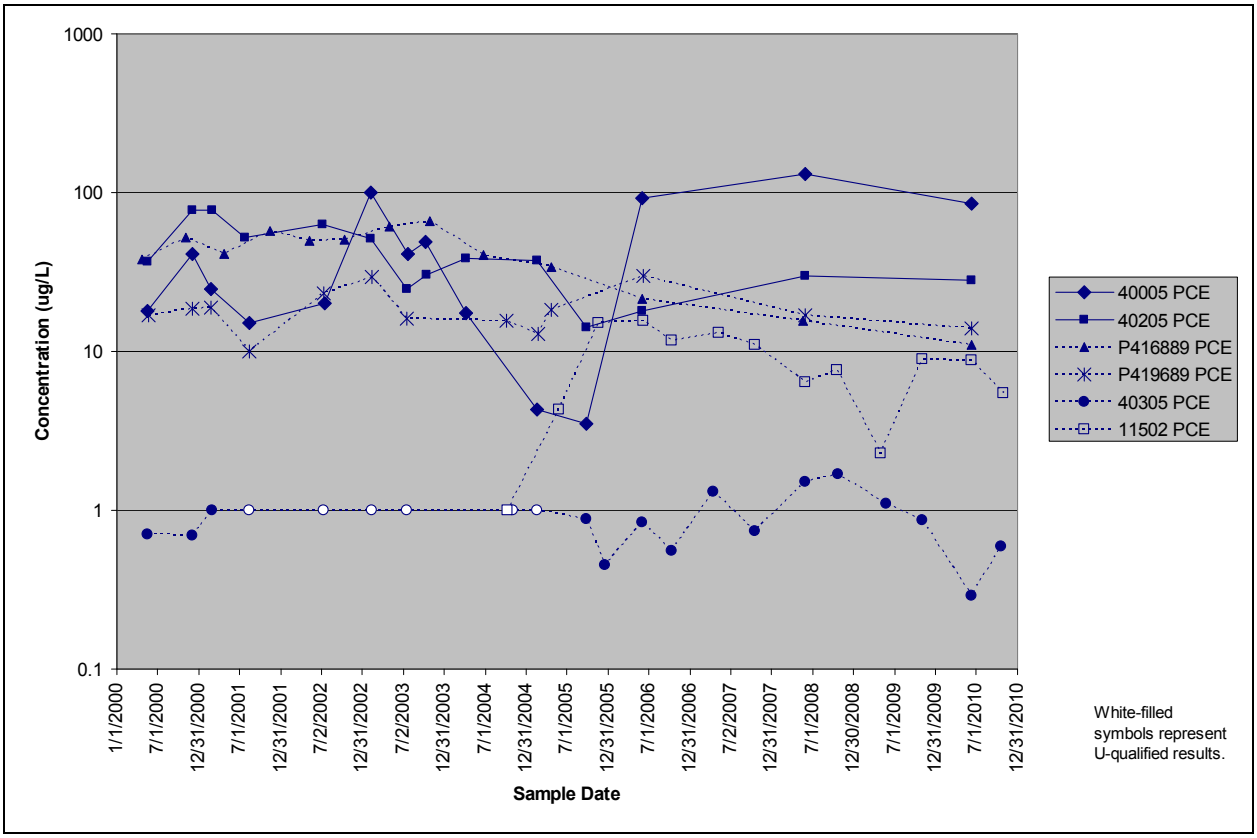
The pathway to surface water for the southern portion of the IA Plume is monitored by AOC well 11104. One VOC detection was reported in 2010. The May sample reported an estimated (J-qualified) concentration of 1,3-DCB of 0.64 µg/L (RFLMA Table 1 standard is 94 µg/L). Concentrations of U, samples for which are collected because of the proximity of the OLF and former B444, continue to be well below the U threshold of 120 µg/L; the highest concentration in 2010 was reported at 33 µg/L. A decreasing trend in U is suggested at this well, but does not meet the 95 percent level of statistical significance (Table 77).

Upgradient of well 11104, wells monitoring the South IA Plume include Sentinel wells 11502 and 40305, and Evaluation wells 40005, 40205, P419689, and P416889. Each of these wells was sampled in 2010 in accordance with RFLMA. Results are consistent with past data. As with results prior to closure, the highest VOC concentrations of these wells are reported at Evaluation well 40005 (Figure 238). With the exception of the anomalous nondetect in 2006, VOCs in well 40005 are distributed fairly uniformly. The fact that the concentrations of daughter products such as *cis*-1,2-DCE and 1,1-DCE are not increasing as those of parent compounds like PCE and TCE decrease suggests minimal degradation is occurring. VOC concentrations in groundwater downgradient of this location appear to vary inconsistently from location to location. However, with the post-closure stabilization of hydrologic conditions evident now for the past few years, as illustrated more clearly on Figure 239, the previous, apparently random "trends" in PCE concentrations that were typical prior to closure have since become more uniform. The well closest to the local source area (40005) produces samples with the highest concentrations of PCE, and locations increasingly farther downgradient from this well produce samples with successively lower concentrations of PCE. Concentrations of PCE reported in samples from Sentinel wells monitoring this area, including side-gradient 40305 and downgradient 11502, support this pattern. Note that PCE in well 40305 is calculated to be on an increasing trend with a 95 percent level of statistical significance (Table 77), but the data set includes numerous nondetects, and in 2010 the lowest concentration of PCE at this location since 2000 was reported (Figure 239).



Notes: Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): 1,1,1-TCA, 200; 1,1-DCE, 7; PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70. In addition to the nondetects ("U"-qualified results), several other results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 238. VOCs in South IA Plume



Notes: Applicable RFLMA surface-water action level for PCE (µg/L; DOE 2007a) is 1. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 239. PCE in South IA Plume

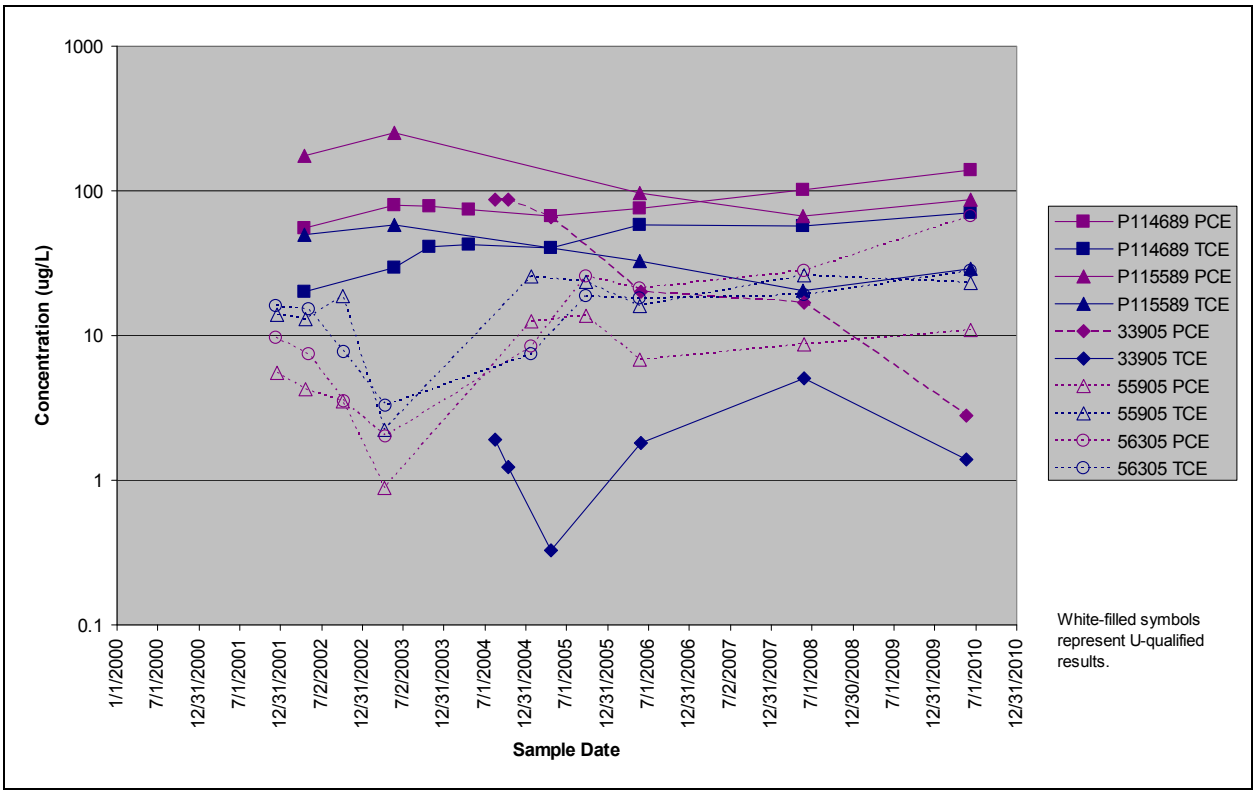
Of the wells illustrated in the time-series plots above for the South IA Plume, statistical trends in VOC concentrations having a 95 percent level of significance are also calculated for 40205 (1,1-DCE, *cis*-1,2-DCE, and PCE; all decreasing) and P416889 (*cis*-1,2-DCE, decreasing). In addition, an increasing trend in U concentrations meeting the same level of significance is calculated for well 40005, but the highest detection reported has been 1.4 µg/L. In 2010, the concentration of U at this well was reported at 1.1 µg/L. (Refer to Appendix B for plots of statistically calculated trends.)

The central portion of the IA Plume, for the purposes of this report, is monitored by Evaluation wells P115589, P114689, 70705, 33905, 55905, and 56305. Each of these wells was sampled in 2010. Some of these wells also have certain building-specific objectives: well 70705 monitors downgradient of former B707, and wells 55905 and 56305 monitor former B559.

Several time-series plots were constructed for the Central IA Plume. A selection of these is provided here. Of the wells in this grouping, P114689 monitors groundwater with the highest concentrations of VOCs. Because these wells do not all monitor a single source area, but rather several small sources and commingled plumes, clear contaminant distribution patterns can be difficult to distinguish.

Time-series plots of PCE and TCE concentrations in samples from wells P114689, P115589, 55905, and 56305 (Figure 240) illustrate a distinction that existed prior to site closure between

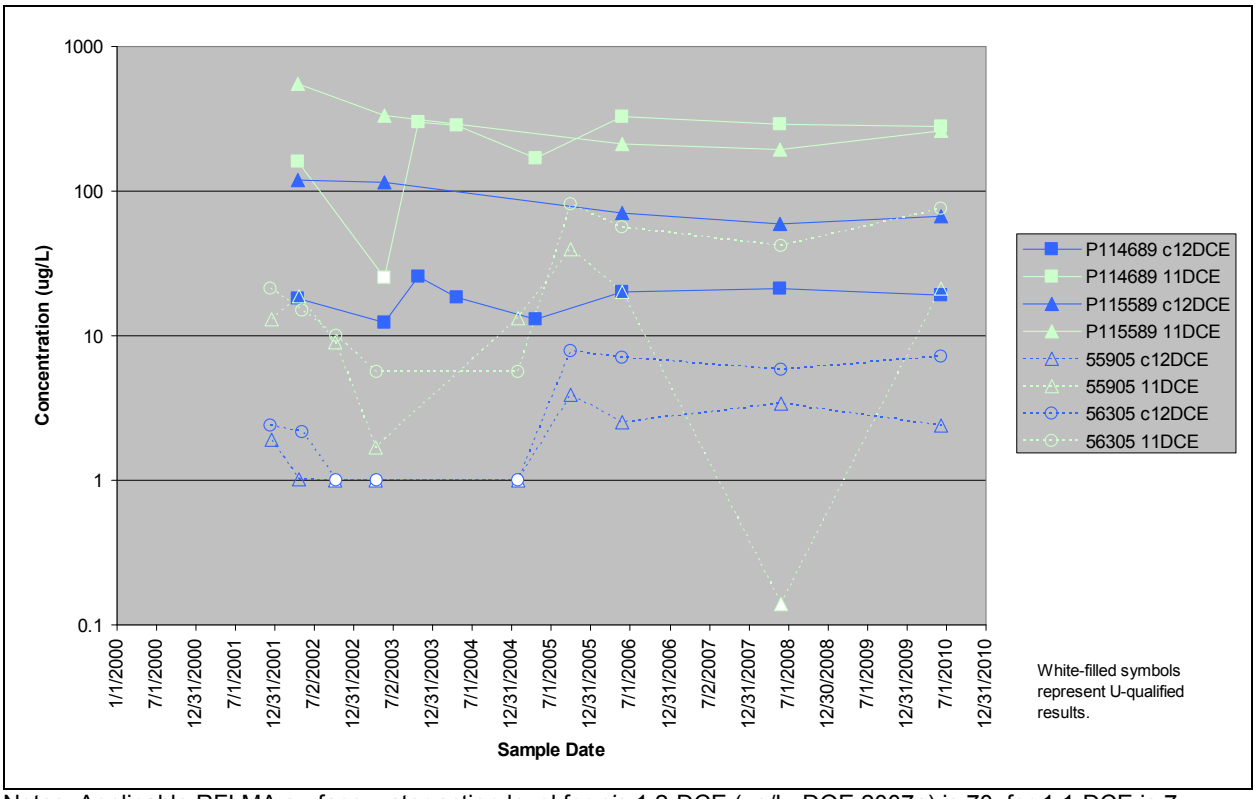
the two more centralized wells (P114689 and P115589) as compared to the two B559-area wells. Since closure, concentrations of these constituents are more similar. Concentrations of TCE in samples from well P114689 are on an increasing trend at the 95 percent level of significance; an increasing trend in PCE concentrations here is also visible but does not meet that level of statistical significance. Concentrations of PCE in samples from well 33905, located just south of FC-2, north of P115589 and northwest of P114689, illustrate a decreasing trend that meets the 95 percent level of significance. Concentrations of TCE in this well vary differently, and do not follow the relatively consistent decreasing pattern observed in PCE concentrations. Additional data will help to illustrate relationships and will also support the calculation of additional statistically significant trends.



Notes: Applicable RFLMA surface-water action level for PCE (µg/L; DOE 2007a) is 1, for TCE is 2.5. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 240. PCE and TCE in Central IA Plume Wells

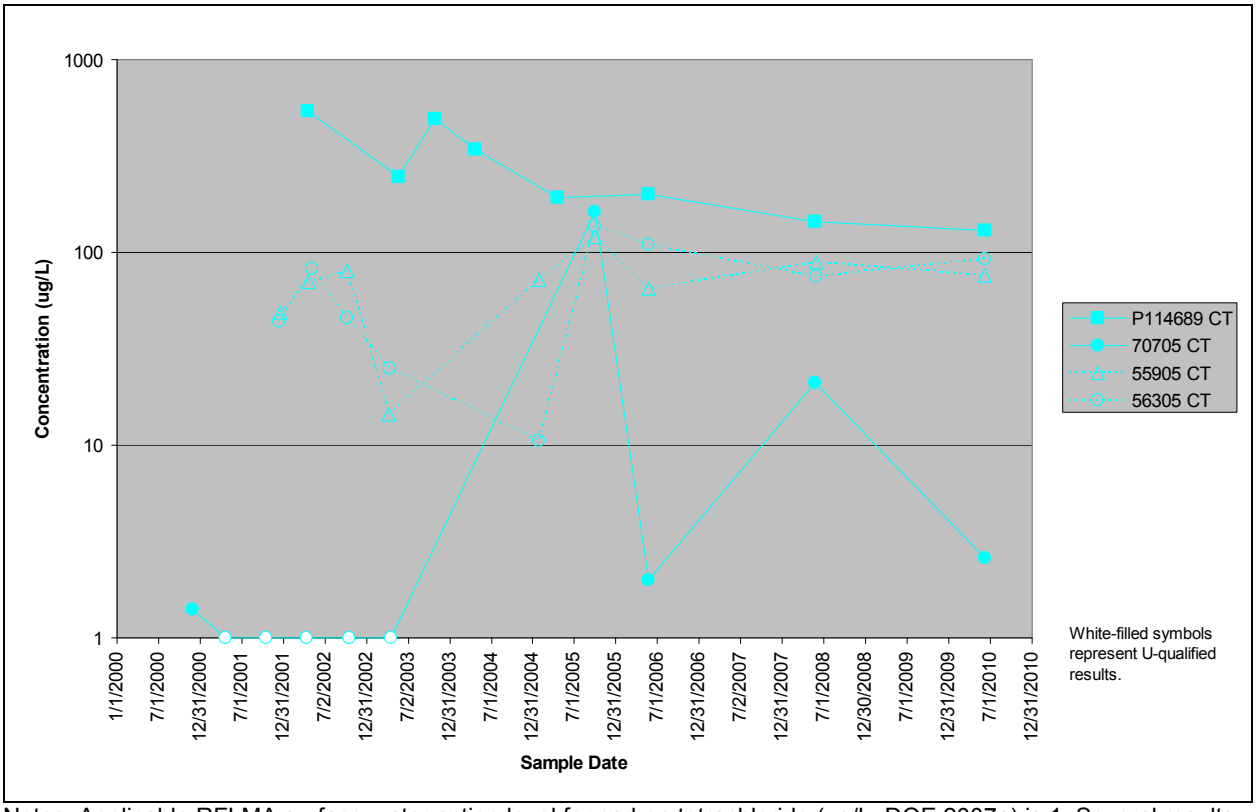
Concentrations of *cis*-1,2-DCE and 1,1-DCE—primary metabolic products from dechlorination of PCE and TCE—in selected Central IA Plume wells are illustrated in Figure 241. Not shown on the time-series plots due to their significantly lower concentrations are results from well 33905, where concentrations of 1,1-DCE are on a decreasing trend with 95 percent significance (Table 77); concentrations have dropped from 7.5 µg/L in 2004 to nondetect in 2010 (with a detection limit of 0.23 µg/L). Concentrations of *cis*-1,2-DCE at this location have varied irregularly between a range of 0.5 µg/L (the result in 2010) to 3.1 µg/L. Daughter-product concentrations appear to have increased somewhat in the B559 area at closure but have not continued to increase. These results are consistent with previous findings that the typical, aerobic groundwater conditions at Rocky Flats do not enhance biodegradation of chlorinated compounds (Kaiser-Hill 2004d).



Notes: Applicable RFLMA surface-water action level for *cis*-1,2-DCE (µg/L; DOE 2007a) is 70, for 1,1-DCE is 7. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 241. Concentrations of cis-*1,2-DCE and 1,1-DCE in Central IA Plume Wells*

Carbon tetrachloride is a primary VOC constituent in several Central IA Plume wells (Figure 242). Data from well P114689 for this constituent support the calculation of a decreasing trend meeting the 95 percent level of significance. The distribution of this compound varies from that of PCE and TCE; for example, the RFLMA data set for well P115589 does not include any detections of carbon tetrachloride. Similarly, well 70705, located on the eastern side of former B707, has reported varying concentrations of carbon tetrachloride but comparatively low concentrations of PCE (up to 2.6 µg/L, and half of the results are nondetects) and TCE (to 1.4 µg/L, again with half the results being nondetects). These varied conditions are evidence for multiple contaminant sources contributing to what is collectively termed the IA Plume.

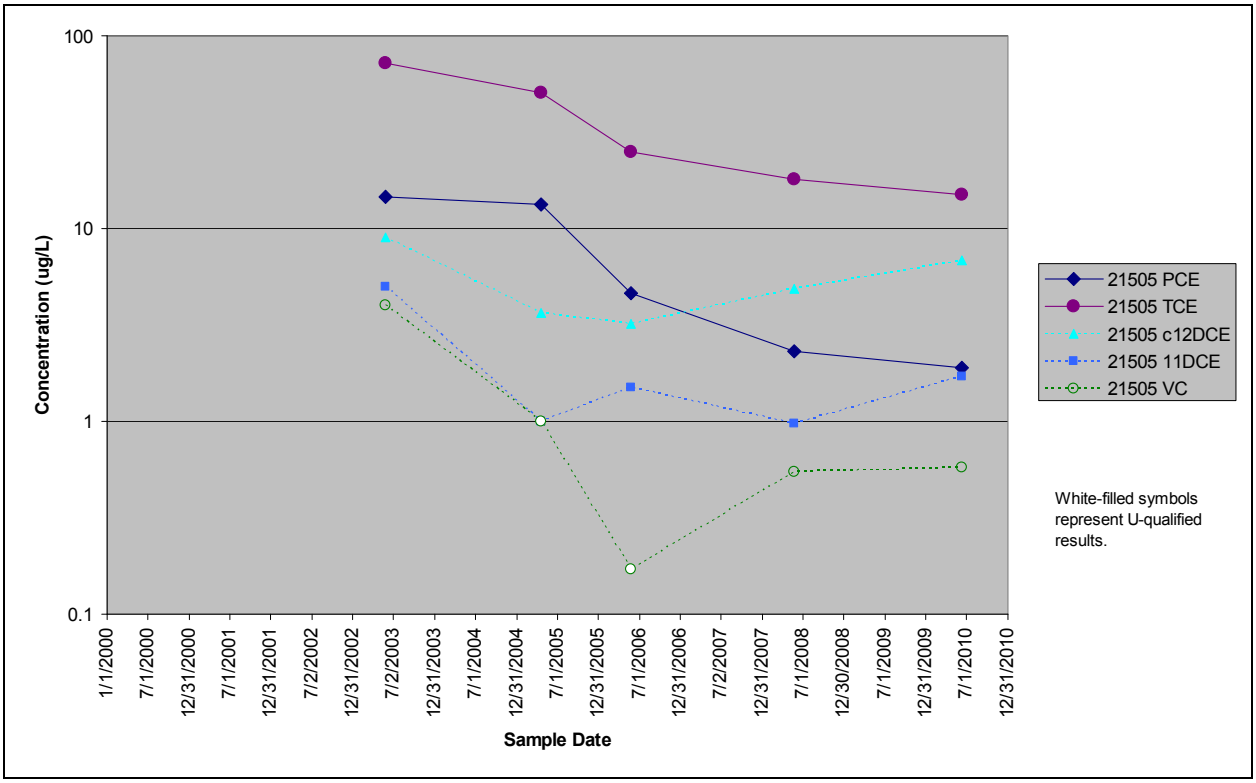


Notes: Applicable RFLMA surface-water action level for carbon tetrachloride (µg/L; DOE 2007a) is 1. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 242. Carbon Tetrachloride in Central IA Plume Wells

Wells monitoring the North IA Plume were also sampled in 2010. These include Evaluation well 21505 and Sentinel well 52505 along FC-2, and AOC well 42505. Although they also monitor the North IA Plume, wells 18199, 20902, 20705, 20505, and 20205 are discussed below in the context of the IHSS 118.1 Plume; and wells 33502, 33604, and 33703 are discussed in the section on the Vinyl Chloride Plume.

Evaluation well 21505 was sampled in June 2010. Results were generally consistent with previous data, although the results for PCE and TCE were both lower than in previous samples in the data set. This location is adjacent to a marshy area that is between the only two locations at which good evidence for biodegradation was identified prior to site closure (Kaiser-Hill 2004d): well 33502, which monitors the Vinyl Chloride Plume within a buried drainage, and the predecessor to well 52505 (well 1986). Concentration data from well 21505 suggest that conditions at this location may also be conducive to biodegradation of chlorinated compounds, as concentrations of primary contaminants (in this case, PCE and TCE) are decreasing somewhat as those of their metabolic byproducts (*cis*-1,2-DCE and 1,1-DCE) increase slightly (Figure 243). Concentrations of VC, the terminal chlorinated byproduct in the PCE/TCE degradation pathway, do not define a clear pattern.



Notes: Applicable RFLMA surface-water action level for PCE (µg/L; DOE 2007a) is 1, TCE is 2.5, *cis*-1,2-DCE is 70, 1,1-DCE is 7, and VC is 0.2. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 243. VOC Concentrations in North IA Plume Well 21505, Showing Evidence of Biodegradation

The terminal end of the North IA Plume is monitored by Sentinel well 52505 and AOC well 42505. Both of these wells were sampled twice in 2010 (June and October). Concentrations of VOCs at well 52505 remain very low, with fewer detections reported in 2010 than in 2009. Only *cis*-1,2-DCE was detected in 2010, at J-qualified concentrations of 0.34 µg/L and 0.65 µg/L in June and October, respectively. (The RFLMA standard for this constituent is 70 µg/L.) The detections of VC reported in samples from this well in fourth-quarter 2007 and 2008 were not repeated in 2009 or 2010.

VOC detections in samples from well 42505 were also reduced relative to the results in 2009. In the June sample, 1,3-DCB was reported at a J-qualified concentration of 0.47 µg/L (RFLMA standard is 94 µg/L), and in the October sample, TCE was reported at a J-qualified concentration of 0.22 µg/L (RFLMA standard is 2.5 µg/L).

In accordance with RFLMA requirements, analytical data from Sentinel well 52505 were analyzed for trend. An increasing trend in *cis*-1,2-DCE was calculated to meet the 95 percent level of significance but is based on a data set in which more than half the results are nondetects. Although not required by the RFLMA, data from AOC well 42505 were also analyzed for trend; no statistically significant increasing or decreasing trends were indicated.

VC Plume

The VC Plume emanates from OBP#1 and nearby metal disposal/destruction sites. These source areas were on the margin of a valley that was filled during construction of the B371 complex and became the site of Sage Avenue and the Portal 2 parking lots, among other facilities. The plume resides within the buried drainage, and groundwater flow appears to be routed by that feature. This is the only Rocky Flats area where VC is confirmed to be present at such elevated concentrations, which is indicative of the active biodegradation occurring here.

The VC Plume is monitored by source-area Evaluation wells 33502 and 33604 (33502 is located some 175 feet upgradient of 33604) and Sentinel well 33703 (approximately 110 feet downgradient of 33604). Both Evaluation wells were sampled in May 2010, and the Sentinel well was sampled in May and October 2010.

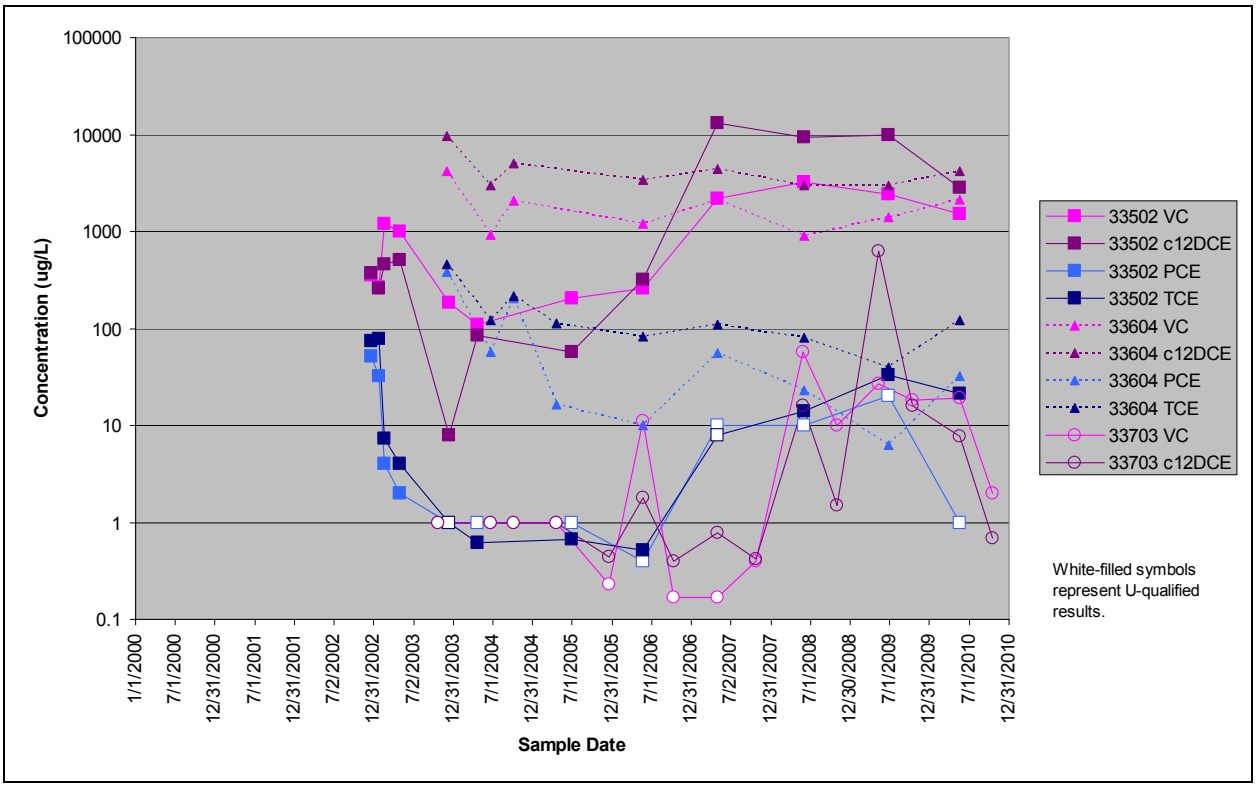
Well 33502 is one of only two locations where strong evidence for biodegradation was found (K-H 2004d); the second location identified in that report is well 1986, the predecessor to well 52505, as discussed above. (If it had existed at the time of that study, well 33604 almost certainly would have provided similarly strong evidence for biodegradation.) This is a likely explanation for both the high concentrations of VC and *cis*-1,2-DCE as well as the extremely limited aerial extent over which these concentrations have been observed. This biodegradation is probably a result of the decomposing organic remains of the vegetation that once grew within the now-buried valley. This process would consume oxygen, providing an anaerobic environment and carbon source suitable for the naturally-occurring bacteria that perform reductive dechlorination of the solvents most commonly found at the Site. Parent compounds, including PCE and TCE, are also detected in the groundwater in this area but at much lower concentrations than those of the metabolic byproducts. While VC and *cis*-1,2-DCE are reported in groundwater samples from source-area wells 33502 and 33604 at concentrations in the hundreds to thousands of micrograms per liter, PCE and TCE are typically reported in the tens to hundreds (and PCE is frequently not detected in samples from well 33502, as has been the case since late 2003, including the sample collected in 2010).

A time-series plot of the concentrations of primary parent and daughter compounds in source-area wells 33502 and 33604 and downgradient well 33703 is presented as Figure 244. Concentrations of TCE in samples from well 33502 remain near their 2002 highs, as has been the case since 2007, though results from 2010 are slightly lower. Concentrations of the metabolic byproducts *cis*-1,2-DCE and VC both remain above concentrations reported prior to 2007. A decreasing trend in PCE concentrations that meets the 95 percent level of significance is indicated for this well, but the data set contains numerous nondetects; this trend may not be real. (Refer to Appendix B for plots of statistically-calculated trends.)

At well 33604, concentrations have been more uniform, particularly with respect to the daughter products. Concentrations of the constituents shown in Figure 244 for this well are within their historical ranges. Even so, a decreasing trend with a 95 percent significance is calculated for TCE.

Concentrations of *cis*-1,2-DCE and VC in samples from Sentinel well 33703 have varied; following 2 years of second-quarter increases, in fourth quarter 2010 their concentrations were lower than in any sample collected since 2007. Even so, the data for well 33703 support the

calculation of increasing trends for these constituents (as well as for the isomer *trans*-1,2-DCE), but the many nondetects in the data set suggest these trends may not be viable. (**Note:** Sentinel well 33703 has developed a subsurface kink in its casing that is worsening to the point that sample collection may soon be impossible. This well will be replaced in early 2011.) The time-series plots displayed in Figure 244 suggest any geochemical changes that may have been due to the removal of impermeable surfaces over this area have not led to sharp reductions in the rates of reductive dechlorination in the source area.



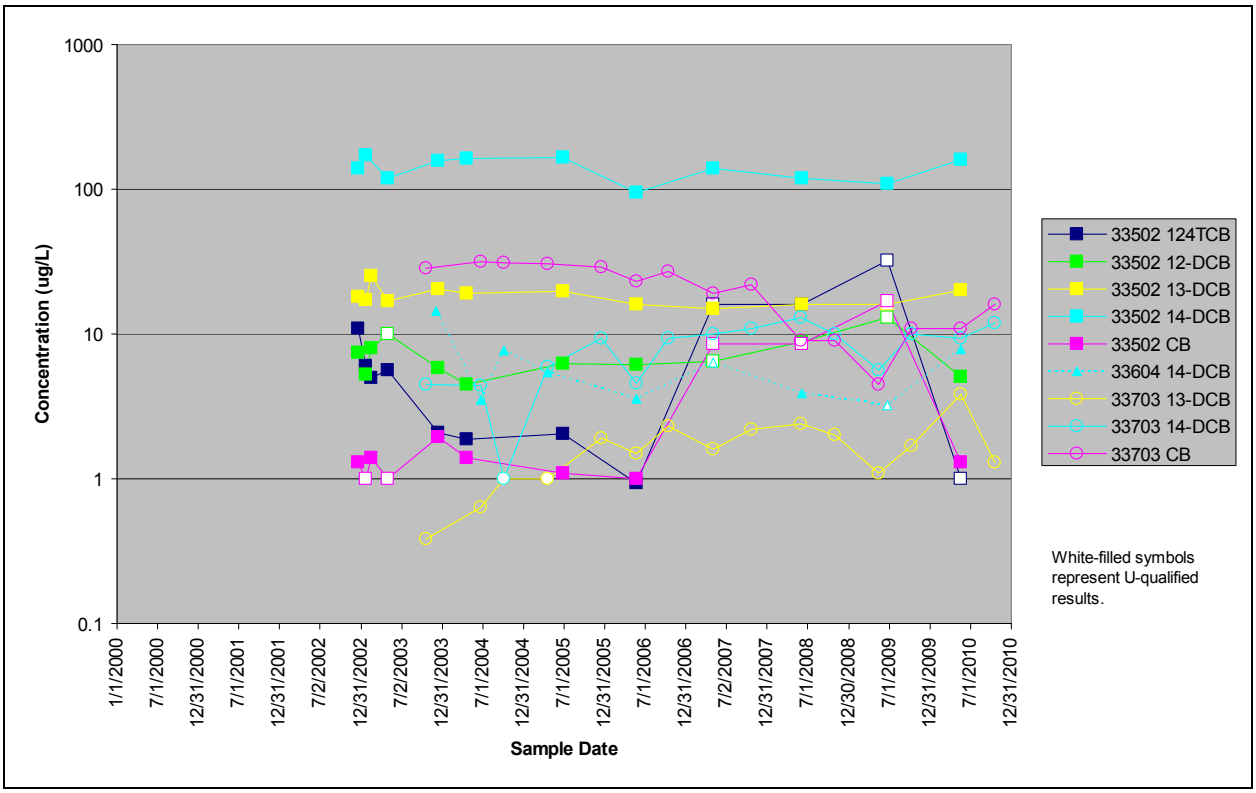
Notes: VC = vinyl chloride; c12DCE = *cis*-1,2-DCE. Applicable RFLMA surface water action levels for these constituents (µg/L; DOE 2007a): VC, 0.2; *cis*-1,2-DCE, 70; PCE, 1; TCE, 2.5. In addition to the nondetects ("U"-qualified results), several other results were qualified (J, D), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 244. Primary VOCs in the VC Plume Source Area

The parent compounds PCE and TCE were reported as nondetects in both samples collected in 2010 from Sentinel well 33703. As noted in the 2009 Annual Report (DOE 2010d), the fact that the Vinyl Chloride Plume is dominated by partially dechlorinated metabolic byproducts rather than the corresponding parent products (such as PCE and TCE) means that the concentrations of these latter constituents would be reduced. The detections of TCE reported in 2009, which were the first such detections reported at this well, were not repeated in 2010.

Several chlorinated benzene compounds are also detected in samples from VC Plume wells. These most commonly include one or more of the following: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and chlorobenzene. These compounds are industrial and agricultural chemicals; one of the primary uses for several are as pesticides or insecticides. Figure 245 presents time-series plots for the most commonly detected

of these compounds in the three VC Plume wells. No 1,2,4-trichlorobenzene has been detected in samples from wells 33604 or 33703, and the last time it was reported in a sample from well 33502 was May 2006. (A decreasing trend that is 95 percent significant is calculated for 1,2,4-TCB at this location, but a third of the results in the data set are nondetects.) This compound can be degraded anaerobically to both 1,2-DCB and 1,4-DCB, which then can degrade to chlorobenzene (USGS 2006). The relatively consistent concentrations of 1,2-DCB and 1,4-DCB (and probably chlorobenzene as well) suggest that 1,2,4-TCB degradation did not result in an increase in these daughter products at well 33502. Nearest well 33604 has also not shown a clear increasing trend in either of these constituents: 1,2-DCB has not yet been detected, concentrations of 1,4-DCB are low and inconsistent, and chlorobenzene has only been detected once (in 2003). Although 1,2-DCB is infrequently detected at Sentinel well 33703, concentrations of 1,4-DCB have increased in samples collected this location, and an increasing trend meeting the 95 percent level of significance is calculated for 1,4-DCB (Table 77). A similarly significant, decreasing trend is calculated at this well for chlorobenzene, but data reported since mid-2009 suggest that concentrations of this constituent may be rebounding.



Notes: Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): VC, 0.2; *cis*-1,2-DCE, 70; PCE, 1; TCE, 2.5. In addition to the nondetects ("U"-qualified results), several other results were qualified (J, D), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 245. Chlorinated Benzene Compounds in Samples From VC Plume Wells

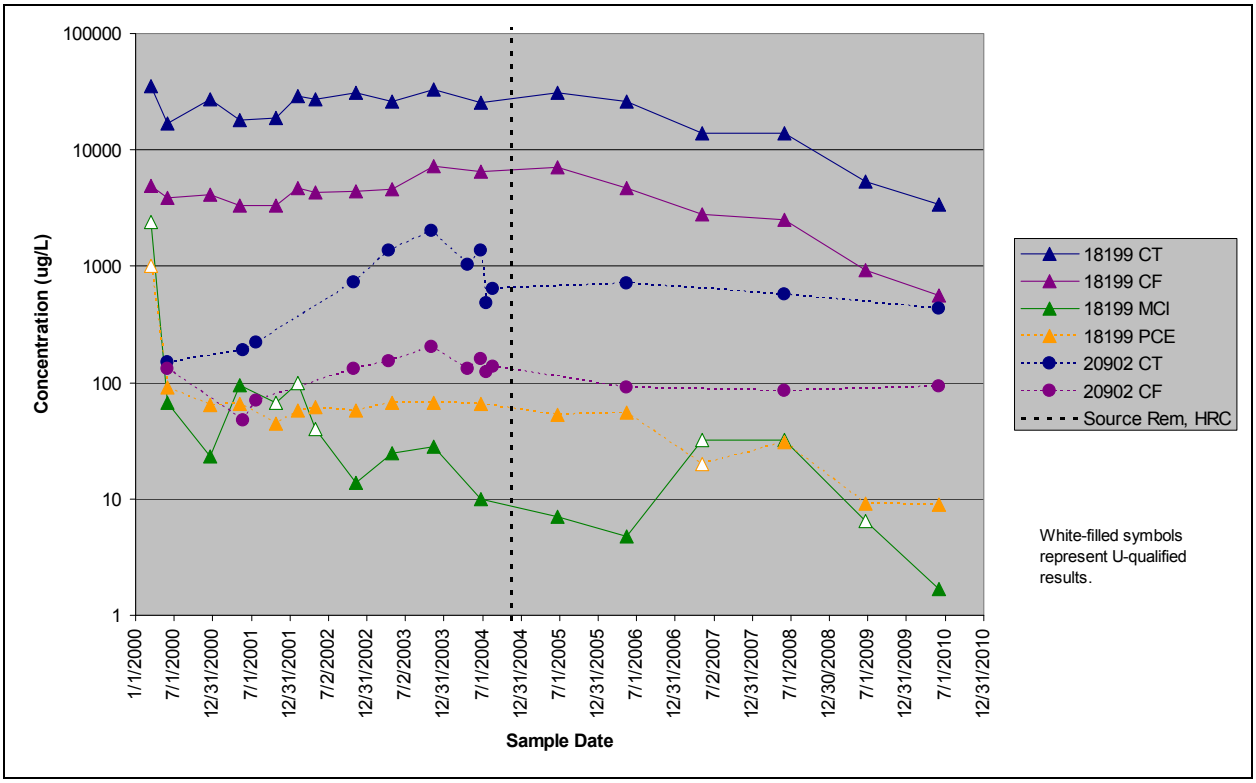
IHSS 118.1 (Carbon Tetrachloride) Plume

Former IHSS 118.1 is the source of a plume of groundwater contaminated with carbon tetrachloride. In late 2004, dense, nonaqueous phase liquid source material was removed along

with an adjacent subsurface tank group referred to as B730. The carbon source HRC was added to the backfill material to enhance biodegradation of residual contamination.

Evaluation well 18199, installed in 1999 to characterize the source area, is located immediately north of the former IHSS, roughly 80 to 90 feet north-northwest of the area in which free-phase carbon tetrachloride was present and perhaps 30 feet north of the source-removal excavation boundaries. The plume has been mapped to extend to Evaluation well 20902, located approximately 350 feet to the northwest. Both of these wells were sampled in June 2010. The three Sentinel wells generally north of the source area, along the northern side of former B771, were also sampled and support the evaluation of this plume to determine whether a more northerly groundwater flow path from the IHSS 118.1 source area is indicated. (With the closure of B771 and abandonment of the associated foundation drain system, the anticipated flow path for this plume was more northerly).

As stated in the 2009 Annual Report (DOE 2010d) and supported by data from samples collected in 2010 from well 18199, concentrations of carbon tetrachloride and chloroform, the primary contaminants in this plume, appear to be decreasing in groundwater in the source area (Figure 246). The visually apparent decreasing concentrations in samples from this well do not yet support the calculation of a decreasing trend that meets the 95 percent level of significance. (Refer to Appendix B for plots of statistically calculated trends.) Increased rates of biodegradation do not appear to be the mechanism of this decrease: there are no evident increasing trends in the concentrations of the principal carbon tetrachloride daughter products, chloroform, methylene chloride, and chloromethane (the terminal daughter products, methane and CO_2, are not analyzed). Data for other daughter products, such as (for PCE) TCE and *cis*-1,2-DCE, are most often not detected. Concentrations of the primary compounds, carbon tetrachloride and chloroform, in samples from well 20902 appear more uniform since an increase that ended in the 2003–2004 time frame (Figure 246). Here, a slight increase in the daughter product (chloroform) with respect to the parent (carbon tetrachloride) may be indicated, but if present, it is slight. Additional samples will help to confirm the presence of longer-term trends in contaminant concentrations.



Notes: CT = carbon tetrachloride; CF = chloroform; MCl = methylene chloride; Source Rem, HRC = date on which source removal and backfilling with soil and HRC was completed. Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): CT, 1; CF, 3.4; MCl, 4.6; PCE, 1. Several results were qualified (J, D, E, and, for methylene chloride in particular, B), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 246. Concentrations of VOCs in the IHSS 118.1 Plume

Sentinel wells 20705, 20505, and 20205, all of which are located generally north of IHSS 118.1 and the former B771 complex, are monitored to evaluate the effects on groundwater of the closure of B771 and to determine whether a more northerly groundwater flow path from the IHSS 118.1 source area is indicated. As in 2009, such a path is not suggested by analytical data collected in 2010, which are generally consistent with pre-closure results. The three detections of low concentrations of carbon tetrachloride reported in 2008 and early 2009 were not confirmed in 2010. (In each of these cases, the reported concentrations were estimated at less than 1 µg/L.) The only detection of chloroform in 2010 was reported at an estimated (J-qualified) concentration of 0.78 µg/L in the fourth-quarter sample collected from well 20205, which is located at the eastern end of this line of three wells, just north (downgradient) of former Bowman's Pond and B774. This compound was also detected at estimated concentrations (less than 1 µg/L) in both samples collected in 2008 from this well.

Seepage velocities summarized in Table 38 are similar to those calculated in previous years and indicate that contaminants in the groundwater migrating from source area well 18199 to downgradient well 20505 could have been detected in this downgradient well as early as 2006. Based on the analytical data collected through 2010, this has still not occurred. While it would take some time for groundwater to saturate the backfill of the former B771 area, observations of seeps on this hillside (see Section 3.1.3.6) suggest that has been completed. Elevated concentrations of IHSS 118.1 Plume contaminants have not been detected in samples collected

from downgradient well 20505. This may be evidence of contaminant retardation, or it could indicate that groundwater is being diverted in another direction or that these constituents are being degraded before they reach well 20505. While the flow path from 18199 to 20505 appears reasonable, groundwater may be diverted (for example, around the sides of the building) by the presence of disrupted foundation drains and associated corridors, the backfilled B771, and backfilled/disrupted subsurface utility corridors. Evidence for this may be represented by the relatively consistent concentrations of these contaminants in well 20902, which was downgradient of the source area before the foundation drains were disrupted and the building was removed. There is insufficient well control to determine more accurately the flow path(s) from the IHSS 118.1 source area. These wells will continue to be monitored and the data assessed to evaluate the potential for contaminant migration from IHSS 118.1 to this area.

Consistent with previous years, other VOCs that are less representative of the IHSS 118.1 Plume were detected in samples from some of these Sentinel wells. In particular, the same Bowman's Pond–area well reported continued detections of PCE, though at lower concentrations than in recent years: The highest concentration in 2010 was 1.4 µg/L. TCE was also detected at this location in the fourth-quarter sample, again at a relatively low concentration (estimated at 0.41 µg/L). Well 20505, which is closer to the predicted northerly flow path from IHSS 118.1, had detections of VOCs in both samples collected in 2010: TCE (to 1.4 µg/L), 1,1-DCE (to 2.6 µg/L), *cis*-1,2-DCE (to 9.1 µg/L), and VC (to 2.5 µg/L). Well 20705, the westernmost of this line of wells and located nearest FC-2, also reported detections of daughter products: *cis*-1,2-DCE (to an estimated 0.51 µg/L), VC (single, fourth-quarter detection estimated at 0.78 µg/L), and methylene chloride (single, fourth-quarter detection estimated at 0.33 µg/L). These results suggest that the former B771 hillside does not represent a significant pathway for VOC migration.

Several trends were calculated for these three Sentinel wells (Table 77; Appendix B). Those that are at least 95 percent statistically significant include PCE (increasing at well 20205, but the data set contains numerous nondetects) and U (increasing at both 20205 and 20705). Time-series plots of U concentrations in samples from all three of these wells are provide below in Figure 247. From this figure, it can be seen that concentrations of U in samples from wells 20505 and 20705 are similar, while those from well 20205 contain higher concentrations of U. Even so, these values are well below the U threshold.

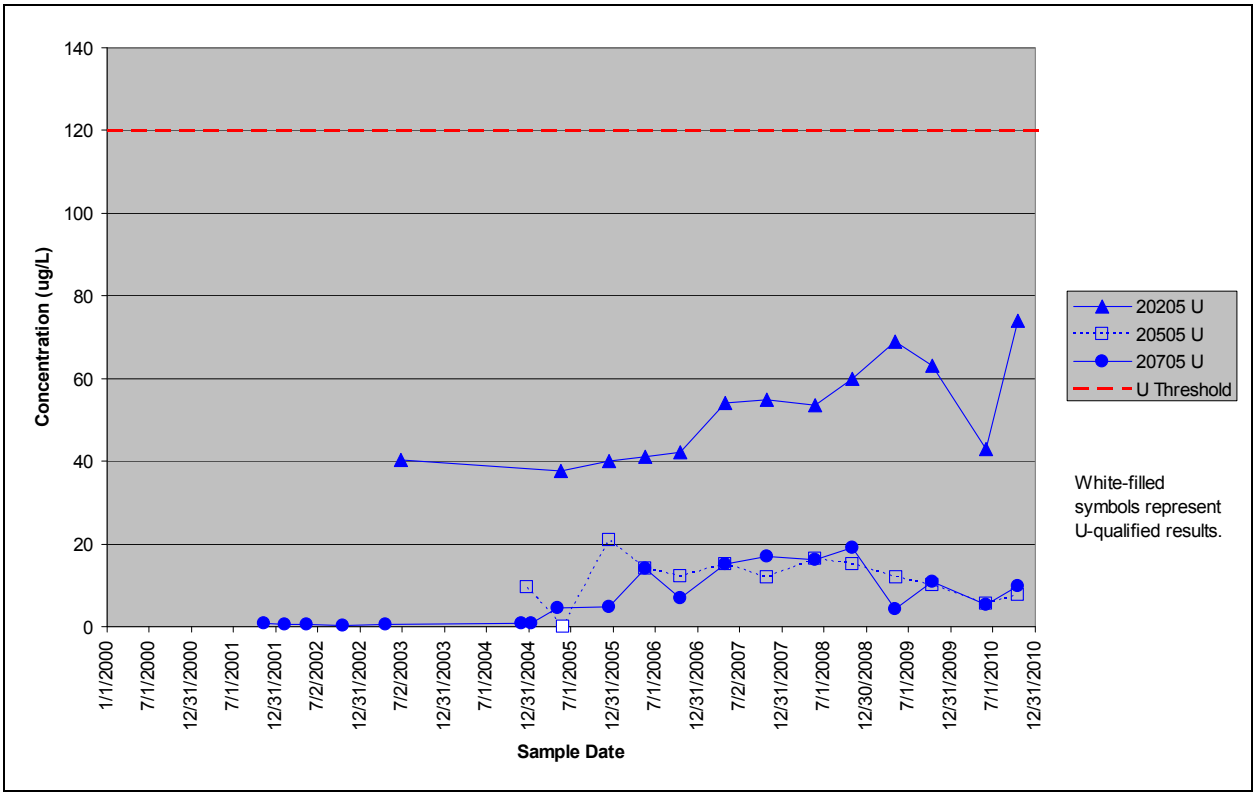


Figure 247. U in Groundwater Along North Side of Former B771

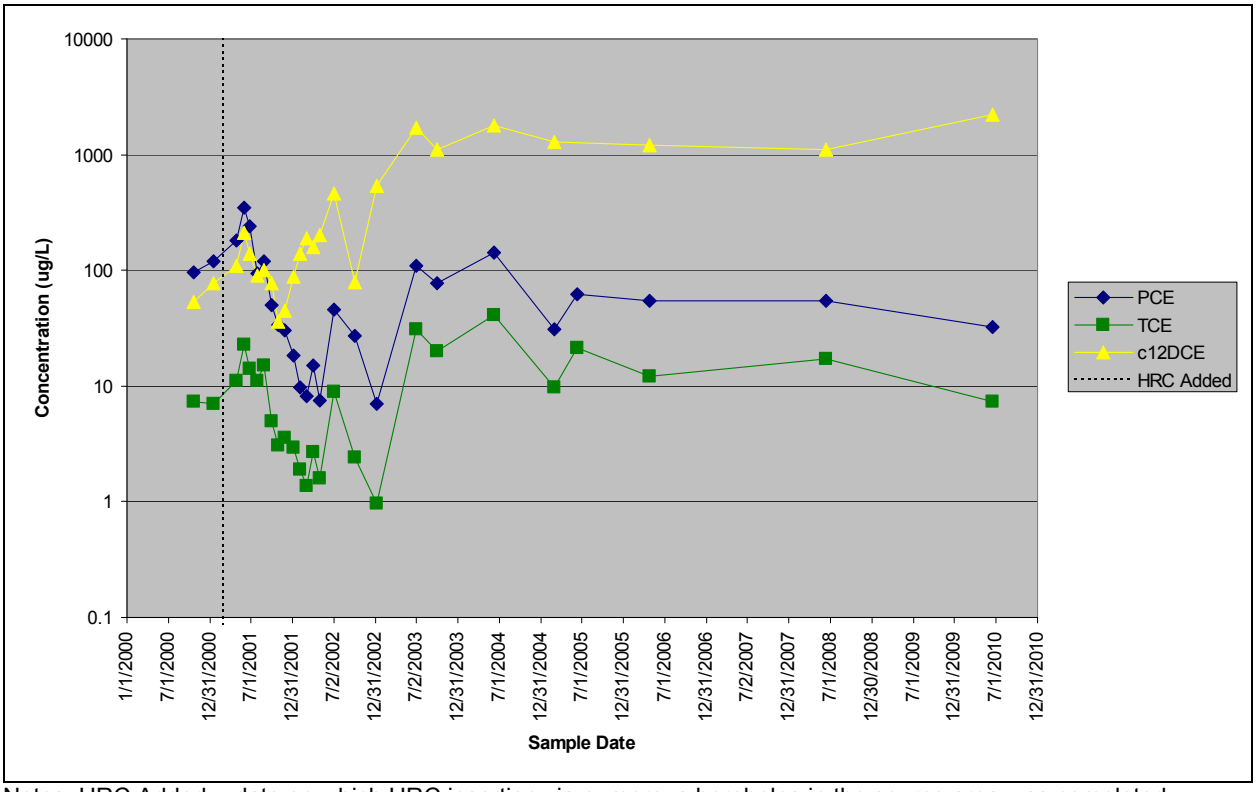
These wells will continue to be monitored, and the data will be evaluated in accordance with RFLMA.

PU&D Yard Plume

The PU&D Yard Plume is an area of groundwater with low concentrations of primarily PCE-family VOCs (PCE, TCE, and *cis*-1,2-DCE). This area was the site of the first application of the proprietary carbon source HRC performed at Rocky Flats, which took the form of a treatability study begun in early 2001 (K-H 2001, 2002; see K-H 2005b for a final summary report on this study). This plume is monitored by Evaluation well 30900 in the source area and Sentinel well 30002 to the east, at the margin of North Walnut Creek. In addition, upgradient PLF RCRA wells 70393 and 70693 monitor the plume as it flows toward the PLF. Each of these wells was monitored in 2010 in accordance with RFLMA.

Source area Evaluation well 30900 produced samples in June 2010 that contained fairly typical concentrations of VOCs. However, the concentration of *cis*-1,2-DCE, 2,200 µg/L, represented the highest concentration of that constituent reported to date in the source-area well (Figure 248). (The previous high concentration was 1,780 µg/L reported in June 2004, which in turn represented a new high since the 1,700 µg/L reported in July 2003. Note that these elevated concentrations were measured in samples collected during the relatively warmer and higher-water periods. Conversely, the 2005 and 2006 samples were collected in March and April, respectively. Samples were not collected in 2007, and the 2008 sample was collected in June—but that was a relatively dry year.) This increase in a primary daughter product from the

breakdown of PCE and TCE is coupled with a mild decrease in the concentrations of these parent compounds. This potentially signifies a mid-2010 boost to dechlorination rates in this area. The spring 2010 precipitation was greater than usual, as illustrated by the hydrograph for this well (Appendix A): the highest water level yet measured in this well was recorded in this time period. Therefore, the warmer conditions coupled with the higher water table may have acted to stimulate the naturally occurring bacteria that have been dechlorinating the parent compounds. As suggested in previous reports (e.g., K-H 2005b), a higher water table may flush additional electron donor material (HRC, if any yet remains in the soil column; otherwise, humic or other carbon-rich substances) as well as VOCs through the source area, helping to provide nutrients to these bacteria. Even if no HRC remains, one would expect locally reducing geochemical conditions to persist here for some time.



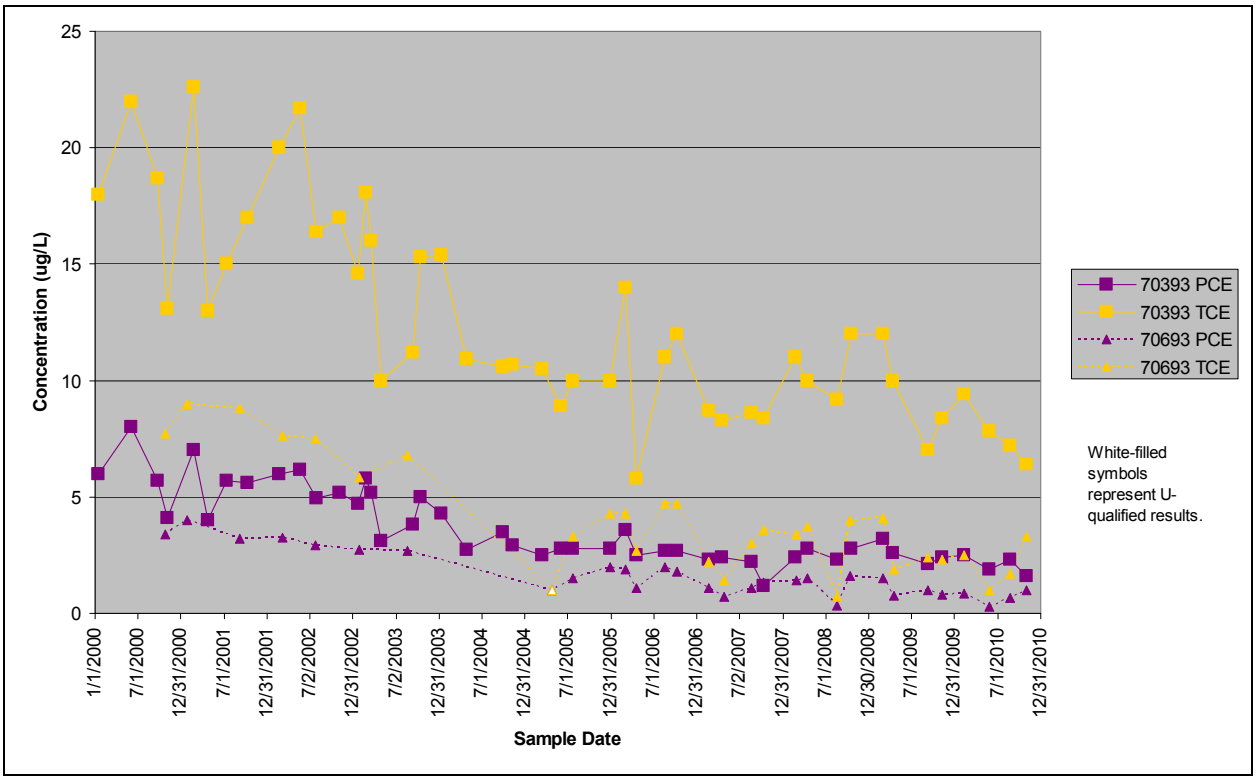
Notes: HRC Added = date on which HRC insertion via numerous boreholes in the source area was completed. Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70. Several results were qualified (J, D, E), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 248. Primary VOCs in the PU&D Yard Plume Source Area

Samples from Sentinel well 30002 were collected in May and October 2010. The fourth-quarter sample reported a single VOC detection of 1,3-DCB at an estimated (J-qualified) concentration of 0.63 µg/L. This constituent was also detected in the fourth-quarter 2008 sample. The corresponding RFLMA Table 1 value is 94 µg/L. No other VOCs were detected at this location.

RCRA wells 70393 and 70693, which are sampled quarterly, continue to be impacted by the PU&D Yard Plume. Time-series plots of PCE and TCE in these wells is presented as Figure 249. Detections of *cis*-1,2-DCE are infrequent. From 2003 through 2009, only TCE concentrations in

samples from well 70393 exceeded the then-applicable RFLMA Table 1 standards. However, with the expiration of Temporary Modifications for both PCE and TCE, the basis of comparison has changed; the applicable value for PCE is 1 µg/L, and for TCE is 2.5 µg/L (DOE 2007a). So, although concentrations of these constituents were on the whole very similar in 2010 to those reported in recent years, there were more cases in which they exceeded the applicable standards. Each of the four quarterly samples collected from well 70393 exceeded the RFLMA standard for PCE and TCE, while the fourth-quarter sample from well 70693 exceeded the standard for TCE. As illustrated on Figure 249, a decreasing trend in the concentration of both of these analytes at both wells remains visually apparent. As upgradient RCRA wells, trending is not required; however, statistical trend calculations were performed (Appendix B), and results indicate decreasing trends meeting the 95 percent level of confidence for both constituents at both wells. Whether application of HRC to the PU&D Yard Plume source area has contributed to these apparent declining concentrations is not known, but the infrequency with which the metabolic byproducts of PCE are detected suggests its effects on groundwater monitored by these two RCRA wells are minimal.



Notes: Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): PCE, 1; TCE, 2.5. Several results were qualified as estimated (J), but for simplicity are not shown differently.

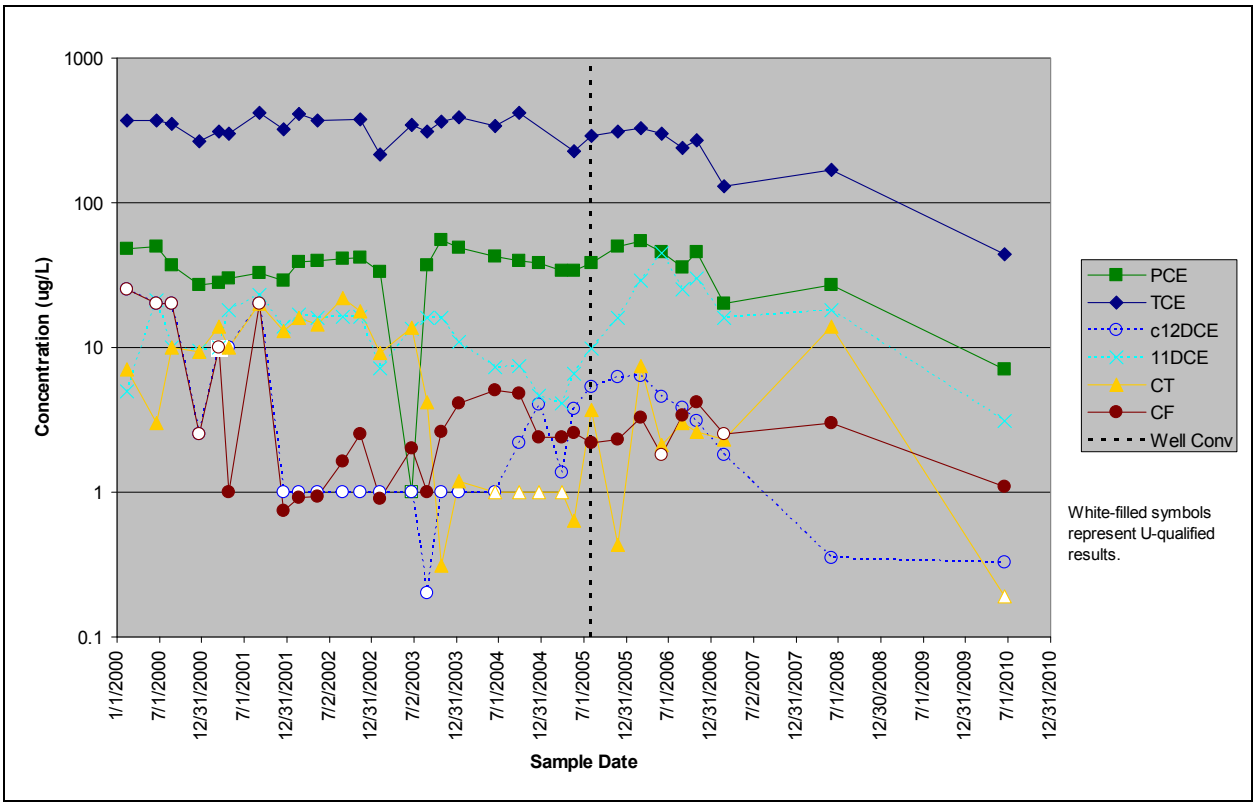
Figure 249. Concentrations of Primary PU&D Yard Plume Source Area VOCs in Upgradient PLF RCRA Wells

OU 1 Plume

The OU 1 Plume is located on the 881 Hillside, east of former B881 and immediately south of the former Contractor Yard. Its source area, former IHSS 119.1, was a drum and scrap metal storage area. This source area is monitored by Evaluation well 891WEL (the modification of

which, in 2005, has been detailed in previous documents, e.g., DOE 2006c), and the pathway to surface water is monitored by AOC well 89104, located to the south adjacent to Woman Creek (Figure 2).

Evaluation well 891WEL was sampled in June 2010, and AOC well 89104 was sampled in May and October 2010. Concentrations of the primary VOCs in the Evaluation well were decreased relative to most past results (Figure 250), and several trends meeting the 95 percent level of statistical significance are calculated: carbon tetrachloride and TCE are shown to be on decreasing trends, while chloroform and *cis*-1,2-DCE are calculated to be on increasing trends (Table 78; Appendix B). Of these, trends for chloroform and *cis*-1,2-DCE are suspect due to the numerous nondetects in the dataset; the calculated decreasing trend for TCE is clearly evident on the time-series plots of Figure 250.



Notes: Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; 1,1-DCE, 7; CT, 1; CF, 3.4. Well conv = date on which the former industrial pump-operated collection well was converted to a more standard, manually sampled well. Several results were qualified (D, J), but for simplicity are not shown differently. Note logarithmic concentration scale.

Figure 250. Primary VOCs in the OU1 Plume

No VOCs were detected in the samples collected in 2010 from AOC well 89104. These results are consistent with previous data. Two validated detections of VOCs have been reported at this well: methylene chloride in 2006 (which was qualified as estimated and also with an indication that this compound was also detected in the blank), and 1,3-DCB in 2009 (also estimated). The OU1 Plume will continue to be monitored in accordance with RFLMA.

Other Areas

In addition to the major plumes discussed above, other areas warrant mention because they may be of interest. These are summarized below.

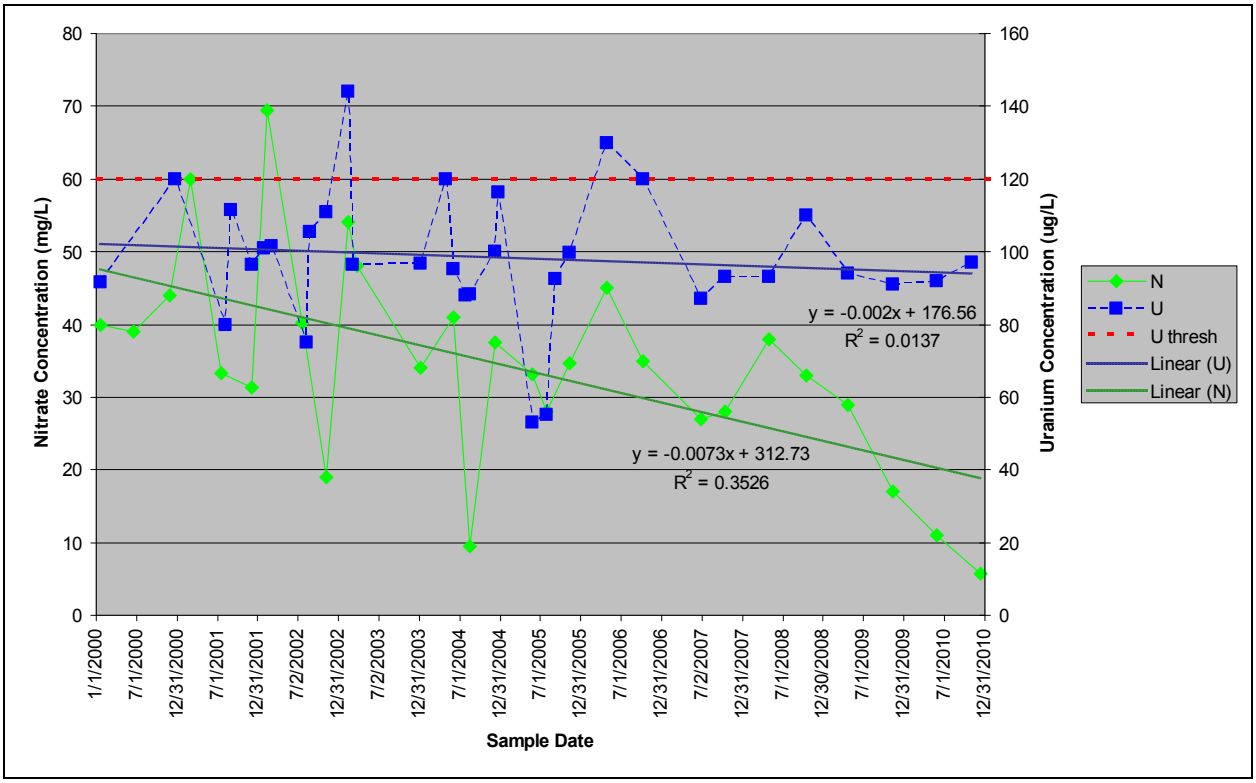
AOC well B206989: This well is located east of the Landfill Pond dam. Well B206989 entered a reportable condition in 2007 due to concentrations of nitrate that exceeded the applicable RFLMA Table 1 standard of 10 mg/L for that location. (The Temporary Modification value of 100 mg/L nitrate, effective through the end of CY 2009, did not apply to the No Name Gulch drainage.) Concentrations of nitrate that exceeded 10 mg/L in samples from this well were neither new nor unexpected; instead, the reportable condition was set up by the well being reclassified from a Sentinel well to an AOC well upon the signing of RFLMA. (The former classification has no reportable conditions, while the latter does.) Rather than waiting for two successive samples to exceed the 10 mg/L standard, upon receipt of the first results after RFLMA went into effect (which exceeded the applicable RFLMA standard, as expected), LM held discussions with CDPHE, and Contact Record 2007-06 was issued to document the resulting agreement.

As reported in the 2008 Annual Report (DOE 2009d), concentrations of nitrate in the well had met the 80 percent level of significance for a decreasing trend. Additional discussions were held with CDPHE. As a result, in 2009 surface water was sampled at two locations in No Name Gulch downstream of the well (DOE 2010d). Nitrate was not detected in either sample.

In 2009, the decreasing trend was calculated to meet the 95 percent level of significance, and data collected in 2010 continue to support this (see Table 77 and Appendix B.3). The results for the second-quarter 2010 sample were reported at a concentration of 11 mg/L, while the fourth-quarter sample was reported at a new low since 2000 of 5.7 mg/L. That result represents the second time since 2000 that groundwater from well B206989 has contained concentrations of nitrate that are below the 10 mg/L standard.

Concentrations of U in groundwater samples from well B206989 have not exceeded the 120 µg/L total U threshold since 2006, and a reportable condition for U at this location has not yet existed. S-K trending for U (Appendix B.3) indicates that the data show a decreasing trend, but at a significance that is below 95 percent.

Figure 251 provides updated time-series plots of nitrate and U in groundwater samples collected through the end of 2010 from well B206989. The trend lines shown on this figure for each constituent are simple regression curves; the associated negative slopes indicate the general trends are decreasing, but the low R^2 values for each of these trend lines confirm the data are widely variable. The trend tables and plots in Appendix B offer more valid statistical results.



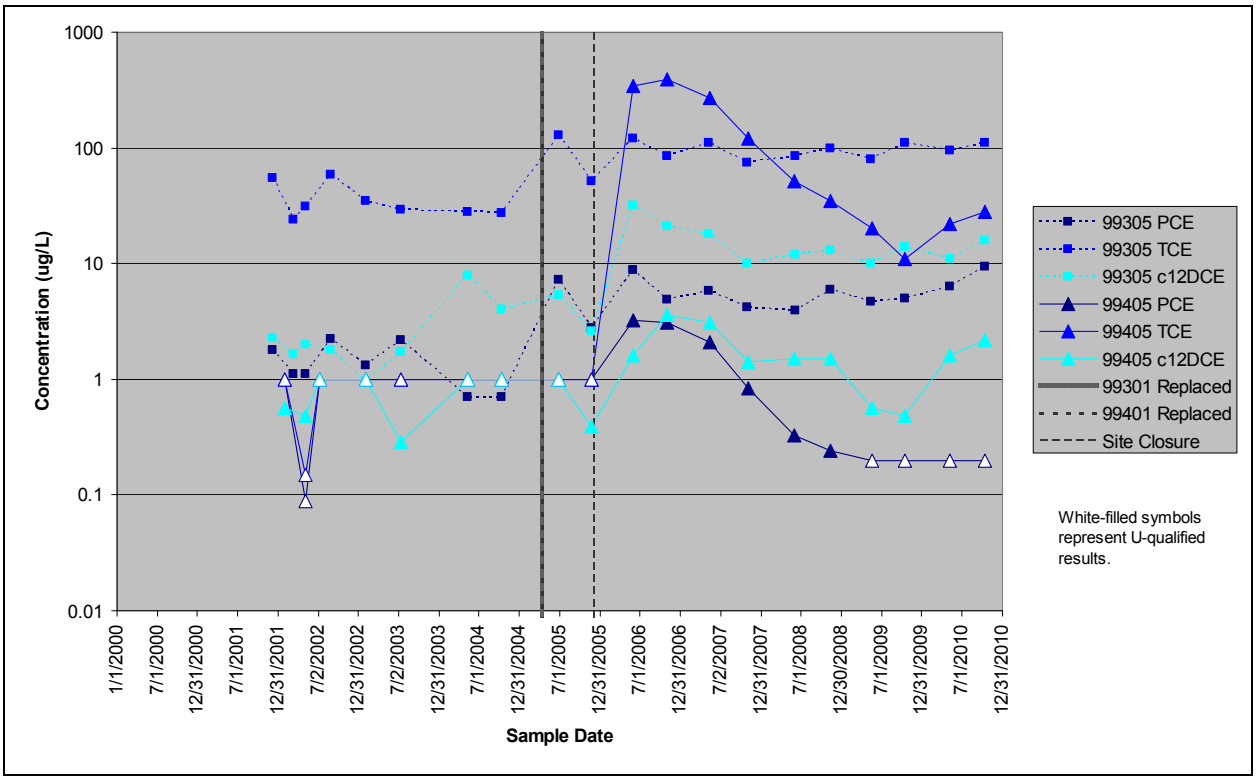
Notes: N = nitrate, U = uranium, U thresh = uranium threshold. The applicable action level for nitrate is 10 mg/L; that for U is 120 µg/L (DOE 2007a). Simple linear regression trend lines are shown for each, together with the corresponding equation and correlation coefficient. Note the use of two *y* axes to help illustrate the concentrations of the different constituents.

Figure 251. Concentrations of Nitrate and U in Groundwater Samples From AOC Well B206989

Former B991: Groundwater samples from wells 99305 and 99405 are monitored for VOCs, nitrate, and U. Both of these wells are located near the eastern edge of former B991, with well 99405 positioned in the east loading dock area (i.e., slightly southwest of well 99305 and closer to FC-4 and the valley bottom). Samples collected in May and October 2010 continued the post-closure pattern of higher concentrations of VOCs than were typical prior to closure. The noteworthy constituents include PCE, TCE, and *cis*-1,2-DCE, although concentrations of PCE and *cis*-1,2-DCE in samples from well 99405 have frequently been estimated or nondetect.

Figure 252 illustrates results for these constituents in both wells, together with the dates of well replacements (when 99305 replaced 99301 and 99405 replaced 99401) and site closure. As shown on this figure, VOC-related water quality changes occurred suddenly and uniformly for these three constituents at well 99405. Conversely, at well 99305 concentrations of these constituents appear to have started to increase earlier, but their increase was not as sharp and was not followed by steady declines. From 2006 through 2009, VOC concentrations in samples from well 99405 were clearly decreasing, but data from 2010 reversed this trend for PCE and TCE. These compounds increased slightly in concentration, but *cis*-1,2-DCE remained nondetect. Concentrations of these constituents in samples from well 99305 were not previously decreasing, as they were at 99405, but with 2010 data it appears that PCE in particular is showing a slight increasing trend. The visible trends in VOC concentrations over the entire data set are confirmed by statistical calculations: at well 99305, trends meeting the 95 percent level of significance are calculated for *cis*-1,2-DCE, PCE, and TCE (all increasing); at well 99405, similarly significant

trends are calculated for increasing *cis*-1,2-DCE and TCE. The trends for TCE and *cis*-1,2-DCE at well 99405 are suspect due to the numerous nondetects in the data set.



Notes: c12DCE = *cis*-1,2-DCE. Applicable RFLMA action levels for these constituents (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70. In addition to the nondetects ("U"-qualified results), several other results were qualified (J), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 252. Concentrations of Primary VOCs in B991-Area Groundwater

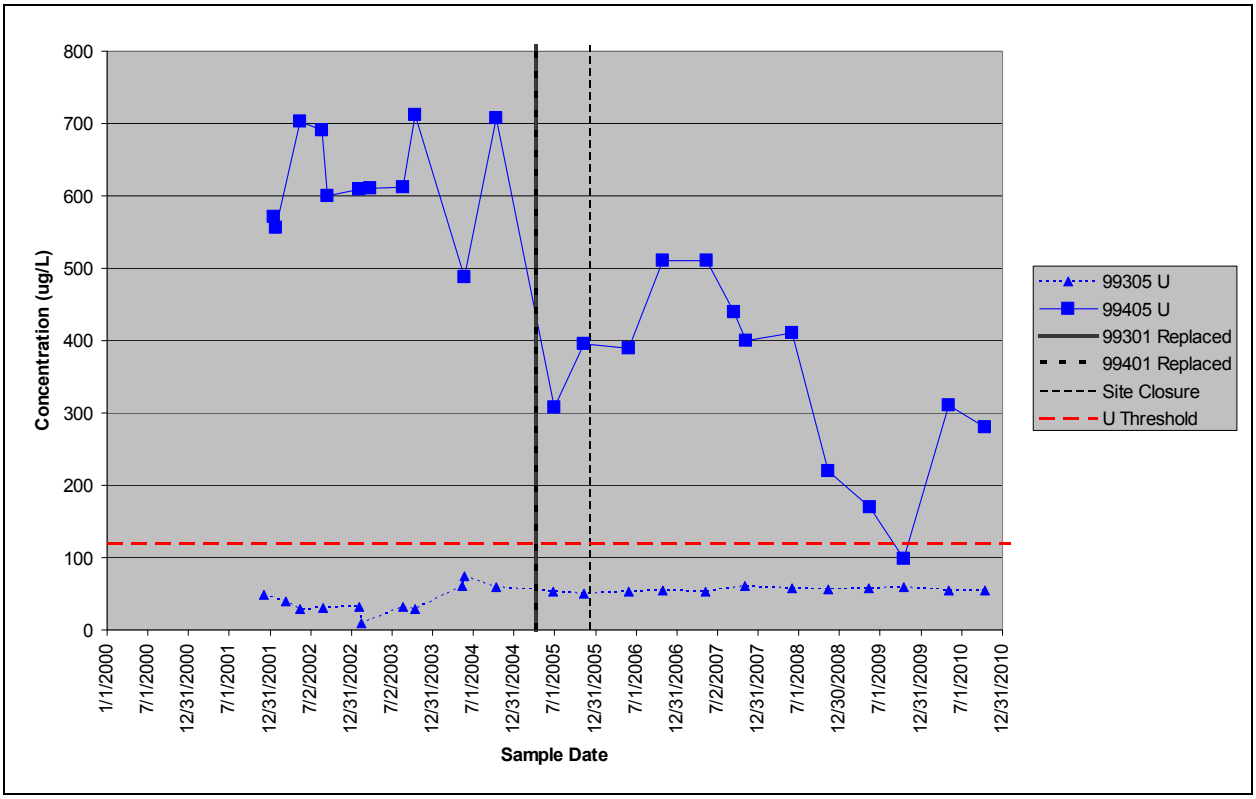
The dates of well replacement do not appear to be a factor in the water quality illustrated for well 99405; the observed changes instead relate to other activities performed to close the Site. Conversely, well replacement appears to coincide with the changes observed at well 99305, at least for PCE and TCE; the increases in *cis*-1,2-DCE concentrations appear to occur over two distinct steps. The mechanism for these increases is not known, but greater impacts would be expected at that location from B991 D&D than from well replacement.

Concentrations of U in samples collected from 2006 through 2009 at well 99405 displayed a remarkable decrease (Figure 253), but in 2010 the concentrations increased to levels that were still lower than—but generally more consistent with—previous conditions. From an overall high in the 700 µg/L range prior to closure, in 2009 the concentration of U at this location had decreased to 98 µg/L. In 2010 the results were 310 µg/L and 280 µg/L for the May and October samples, respectively. Although concentrations have been variable, the overall trend in U concentrations at well 99405 is visually evident, and this decreasing trend is confirmed to have a statistical significance of 95 percent (Table 77, Appendix B).

Mechanisms responsible for the variability in U concentrations are not certain. The springs of 2009 and 2010 were both relatively moist, yet concentrations of U did not behave similarly, so

relatively significant changes in climate would not be an obvious cause. Other possible mechanisms include hydrologic and geochemical changes that have occurred as a result of Site closure, such as removal of the water supply, associated leakage, and chlorinated water; removal of impermeable surfaces and resumption of direct recharge of groundwater by precipitation; removal of foundation drains; and so on, with possible changes in redox conditions as a result of some of these factors. This location has been analyzed on multiple occasions for signs of U contamination through high-resolution isotopic analyses, and in each instance the results have shown the U to be 100 percent natural—i.e., there has been no site-related U contamination in the samples.

Unlike conditions at well 99405, concentrations of U at nearby well 99305 have always been much lower and, since 2004, have been very uniform, despite the fact that these wells are only about 115 feet apart. Results in 2010 are consistent with previous data, with reported concentrations in the second and fourth quarter samples at 55 µg/L and 54 µg/L, respectively. Even so, trend calculations meeting the 95 percent level of significance indicate that U is on an increasing trend.



Notes: Applicable RFLMA action level (µg/L; DOE 2007a) for U (threshold), 120. U data include results for U-mass and converted isotopic activities. Several results were qualified (J, B, N, and, for two U-235 results, U) but for simplicity are not shown differently.

Figure 253. Concentrations of U in B991 Sentinel Wells

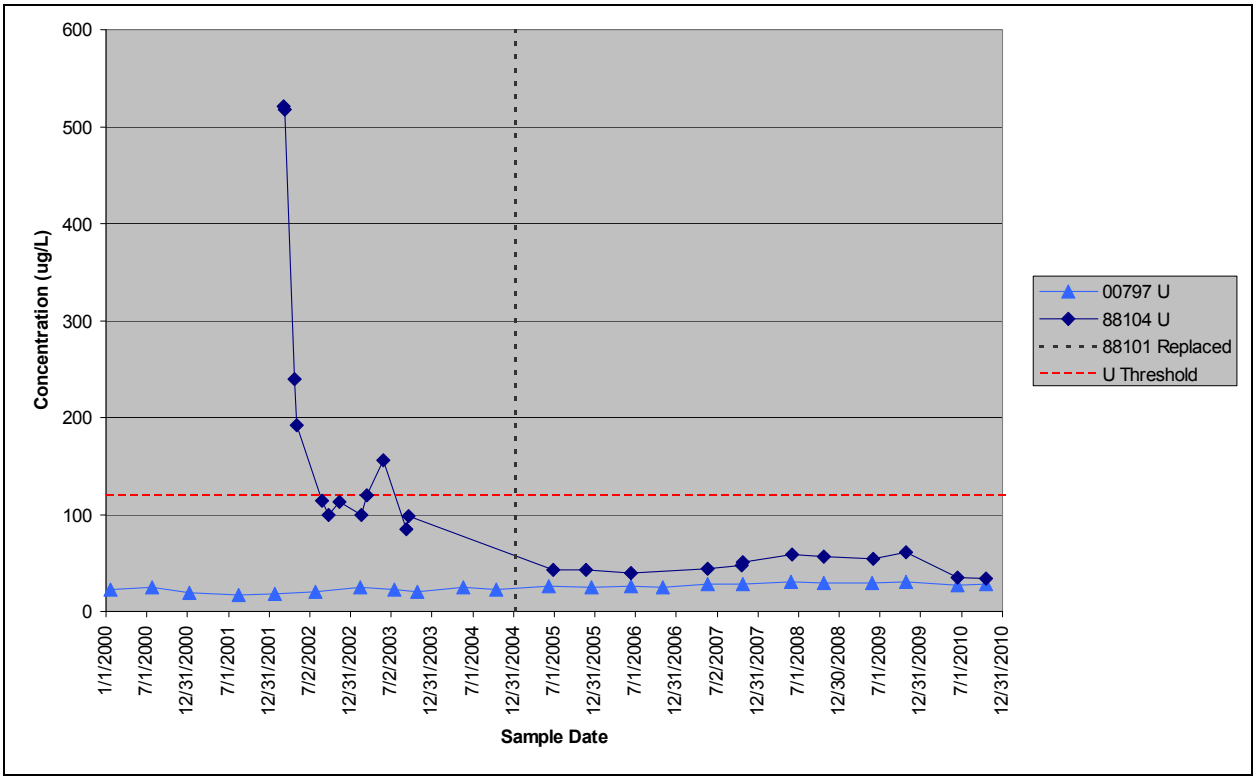
Both of the B991 wells are also monitored for nitrate to evaluate the potential for migration of the SPP toward South Walnut Creek. As noted above in the discussion of the SPP, concentrations of nitrate reported for samples from these wells continue to indicate this is not an

effective pathway for migration of the SPP constituents. The samples collected in 2010 gave results that were consistent with previous data; the highest concentration reported was 2.6 mg/L.

Former B881 and 800 Area: Consistent with recent annual reports (e.g., DOE 2007c, 2008c, 2009d, 2010d), S-K calculations performed in 2010 indicate there is a statistically significant (at the 95 percent confidence level) decreasing trend for U in Sentinel well 88104, while in Sentinel well 00797 the trend for this analyte is increasing (Table 77, Appendix B). The trend calculated for well 88104 is complicated by the well replacement performed in 2004, when well 88101 was replaced with well 88104. The replacement well is located approximately 110 feet south of the original location, which was adjacent to the southern side of the building. Concentrations of U in the original well (88101) had decreased significantly between the installation and final sampling of that well (from a maximum concentration of approximately 521 µg/L in March 2001, to approximately 85 µg/L in September 2003), and concentrations of U in the replacement well have actually been fairly uniform, ranging from 34 µg/L to 61 µg/L (Figure 254). The 2010 results of samples from well 88104 were 35 µg/L and 34 µg/L for the second and fourth quarter samples, respectively, and represent a visible decrease in concentrations. Nearby, samples from Evaluation well 88205 frequently had nondetect concentrations of U, as was the case with the last two samples collected (in 2008 and in 2010). This well is located adjacent to the small, former B887 and the associated underground RCRA waste storage tanks that were near the southwest corner of B881.

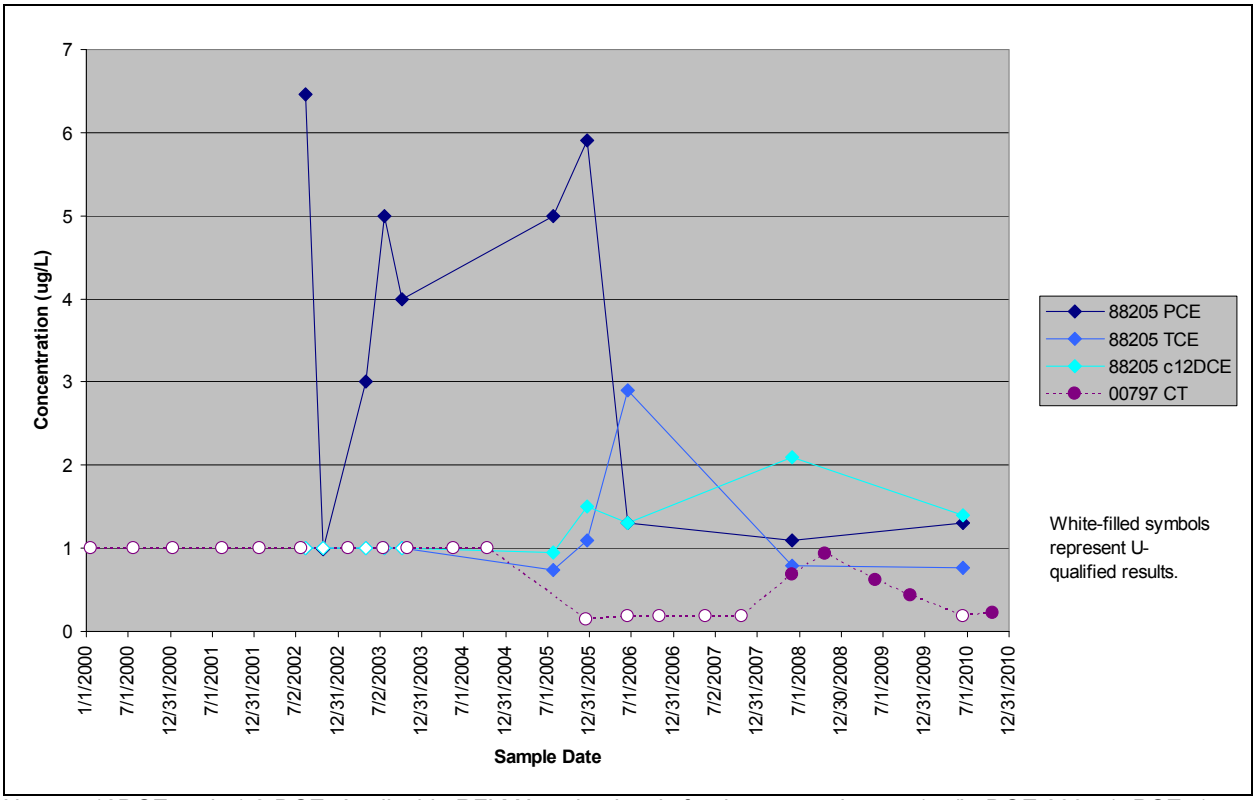
Concentrations of U in samples from Sentinel well 00797, located approximately 250 feet south of well 88104, have ranged between slightly less than 17 µg/L to 29 µg/L since 2000. As illustrated on Figure 254, concentrations of U at wells 88104 and 00797 are below the U threshold. (This also applies to samples from well 88205, given that U is frequently not detected, but a time-series plot is not presented for this well because of these low to nondetect concentrations.)

Wells monitoring the area downgradient of former B881 are also sampled for VOCs. However, few VOCs are routinely detected. Most common detections include *cis*-1,2-DCE, PCE, and TCE in samples from well 88205; and carbon tetrachloride from well 00797. Nondetects for these constituents are also common. Detections of VOCs in samples from well 88104 are infrequent, with the samples collected in 2010 reporting one detection of 1,3-DCB (second quarter, 1.4 µg/L) and one detection of bromoform (fourth quarter, 0.35 µg/L, J-qualified). Figure 255 shows time-series plots of the most commonly detected VOCs in samples from wells 88205 and 00797.



Notes: Applicable RFLMA action level (µg/L; DOE 2007a) for U (threshold), 120. U data include results for U-mass and converted isotopic activities. Several results were qualified (J, B, N, and, for two U-235 results, U) but are not shown differently for simplicity.

Figure 254. Concentrations of U in Samples From B881 Sentinel Wells



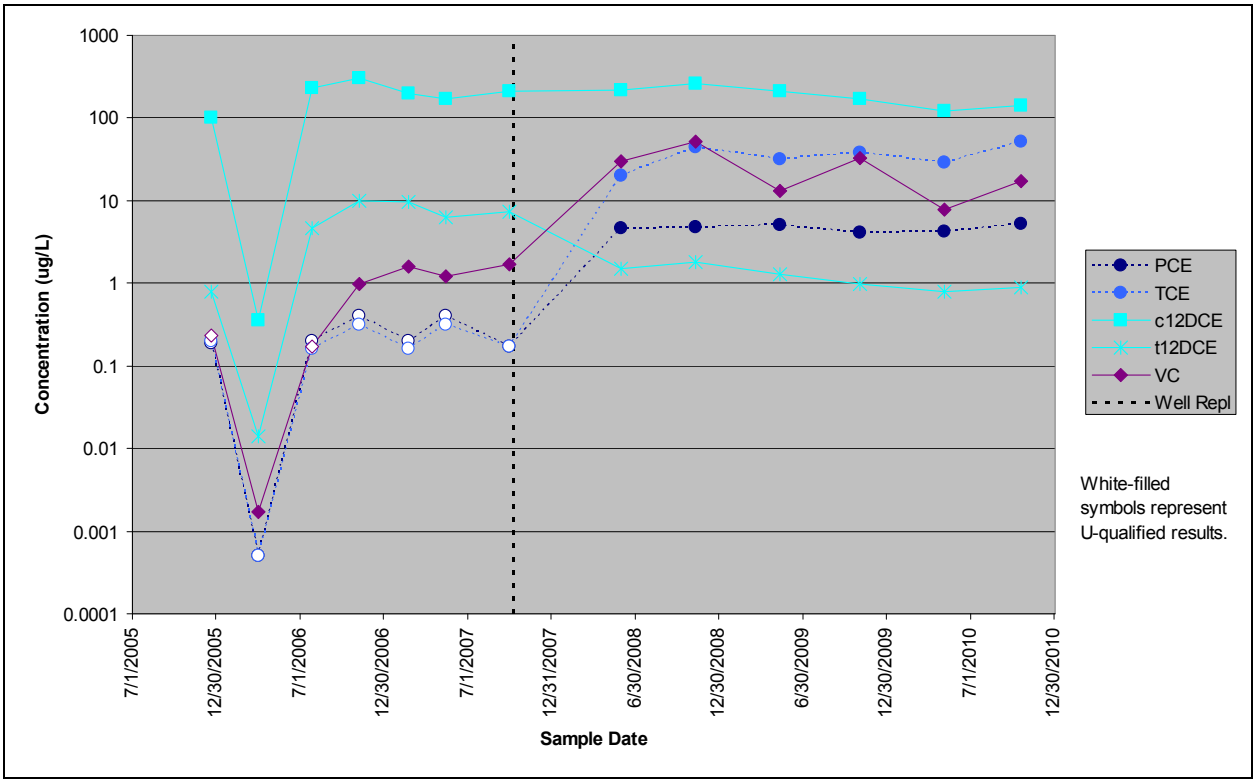
Notes: c12DCE = *cis*-1,2-DCE. Applicable RFLMA action levels for these constituents (µg/L; DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70. In addition to the nondetects ("U"-qualified results), several other results were qualified (J), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 255. Concentrations of Primary VOCs in B881-Area Groundwater

Elsewhere in the former 800 Area, Evaluation well 22996 monitors groundwater downgradient of former B886, as well as other 800-Area buildings that are farther upgradient (such as B865 and B883). This well is sampled for VOCs and U. Detections of VOCs are infrequent. TCE is the most commonly detected VOC, with four detections reported since 2000, including one in the sample collected in May 2010. This sample reported a concentration of TCE estimated (J qualified) at 0.23 µg/L. For the first time since 2000, PCE was also detected in this well, at an estimated concentration of 0.24 µg/L. Concentrations of U at this location are consistently low, typically in the single-digit range. In the May 2010 sample, the concentration was reported at 8.5 µg/L.

Hillside south of former B991: The hillside south of former B991 contains the remains of a French drain that was installed during the construction of the hillside to stabilize it. The outfall from this drain was removed prior to closure, and the drain was interrupted because the outfall (former surface water location SW056) produced water containing VOCs. For that reason, when the French drain was removed, HRC was added to the backfill to stimulate biodegradation of VOCs. Sentinel well 45605 was installed to monitor groundwater adjacent to the drain interruption, but the hillside slumped. The area was regraded, and Sentinel well 45608 was installed to replace the abandoned 45605. For more detail on the hillside and French drain, see the 2006 Annual Report (DOE 2007c); for information on the well abandonment and hillside regrading, see the 2007 and 2008 Annual Reports (DOE 2008c, 2009d).

Well 45608 was sampled twice in 2010 (May, October). The continuing detections of 1,2-DCE and VC are an indication that biodegradation is still occurring upgradient of the well, though whether this is due to placement of HRC in the drain backfill is unknown. Water quality at this location changed in late 2007 (Figure 256). Well replacement, reconfiguration of the hillside during the regrading performed in 2007, and/or consumption of the HRC added to backfill may be factors in the changes visible on this figure.



Notes: c12DCE = *cis*-1,2-DCE; t2DCE = *trans*-1,2-DCE; Well Repl = date on which well 45605 was abandoned, with subsequent samples collected from its replacement, well 45608. RFLMA Table 1 values (DOE 2007a): PCE, 1; TCE, 2.5; *cis*-1,2-DCE, 70; *trans*-1,2-DCE, 100; VC, 0.2. In addition to the nondetects ("U"-qualified results), several other results were qualified (J, D), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 256. Concentrations of VOCs in Groundwater South of Former B991

Circumstantial evidence suggests that well replacement may play a significant part in observed changes in contaminant distribution. Lines of evidence include the water level in the replacement well, which has always been higher than in the original well; and the replacement well was strongly artesian, at least into 2010 (it has since stopped flowing freely). However, due to the regraded hillside, the top of the well casing for the replacement well is at a lower elevation than was the case for the original well, which would be a factor in the artesian behavior of the former well (though this would not affect the absolute water level). PCE and TCE were not detected in samples collected before 2008 from the original well but have been consistently detected in samples collected since that date from the replacement well. At the same time, concentrations of VC increased by an order of magnitude, and those of *trans*-1,2-DCE decreased overall by almost as much. These constituents, including PCE and TCE, were consistently detected in samples collected from the original drain outfall, SW056; the concentrations of PCE and TCE prior to the drain's removal were consistent with the results for these constituents in samples from

well 45608 (see DOE 2005b for tabulated data from SW056). Concentrations of VC in the replacement well are seen to vary seasonally, being slightly higher in fourth quarter samples than in second quarter samples. As discussed above with respect to ETPTS-area well 23296, this may be related to the relatively drier conditions in the typical fourth quarter allowing the water longer residence time in areas of active dechlorination; even so, a similar pattern is not suggested by other daughter products, nor is a reverse pattern suggested by the parent products. If anything, TCE concentrations follow a similar but more muted seasonal pattern, though this compound is both a metabolic byproduct of PCE as well as a solvent used during Site operation.

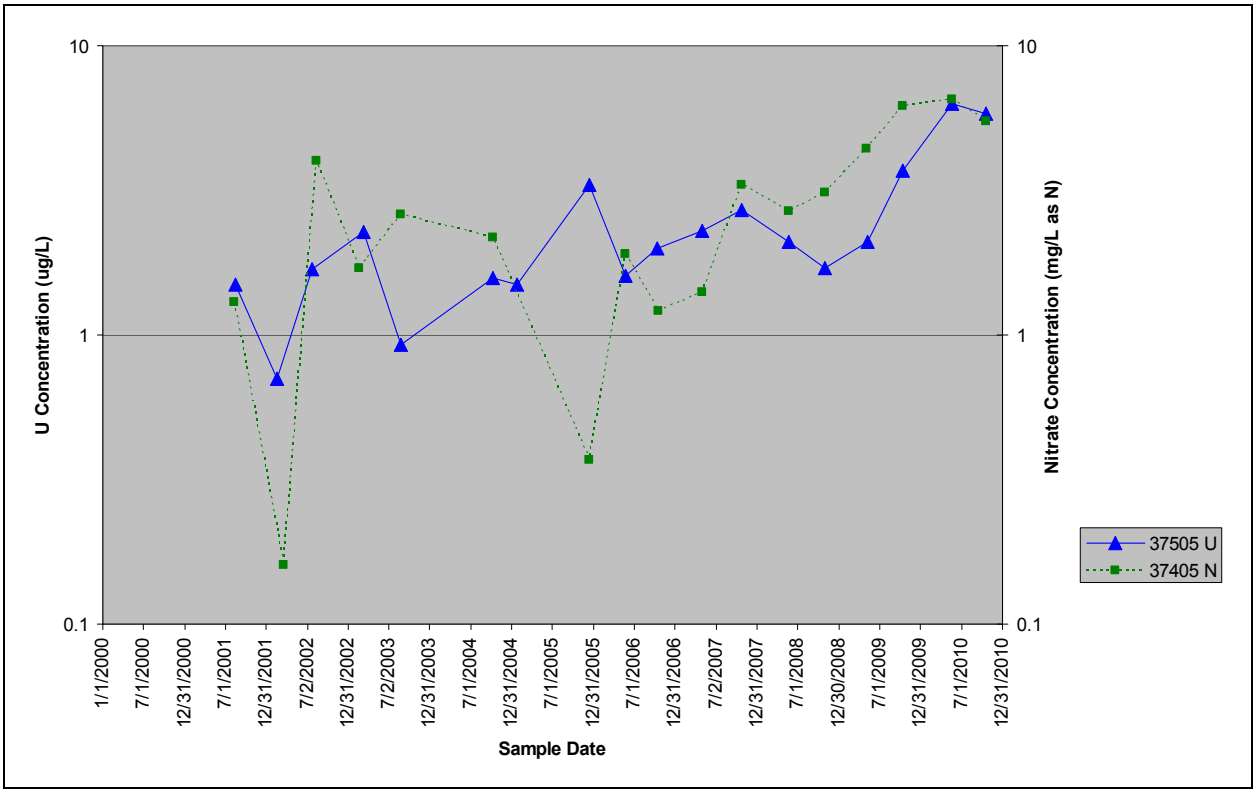
Trends identified as statistically significant with a 95 percent level of confidence include increasing 1,1-DCE, PCE, and TCE; and decreasing *trans*-1,2-DCE (Table 77). Note that all but the *trans* -1,2-DCE trend is complicated by the presence of numerous nondetects in the data set, making the associated trends suspect. Additional data may assist in confirming the various trends and patterns; well 45608 will continue to be monitored according to RFLMA.

Areas monitored for Plutonium and Americium: Groundwater immediately downgradient of the former B371 and B771 complexes is monitored for Pu and Am due to the production-era missions of these buildings. Although abundant technical research (much of which focused specifically on Rocky Flats) has indicated that the groundwater regime does not constitute a meaningful migration pathway for these constituents, these analytes were included in the RFLMA monitoring for these wells to provide stakeholder assurance. Therefore, it is not surprising that the groundwater monitoring wells at Rocky Flats that are sampled for Pu and Am consistently report results for these constituents that are qualified as nondetects.

In 2010, without exception, the five wells monitored for Pu and Am (Sentinel wells 20205, 20505, and 20705 at former B771; and 37405 and 37705 at former B371) reported values qualified as nondetects for these radionuclides. Reported values ranged from –0.00392 pCi/L to 0.0133 pCi/L, again all qualified as nondetects. (As an activity-based analysis that is compared against the activity in a laboratory blank, the analysis always generates a number.) In fact, the only Pu or Am results reported since Site closure that are not qualified as nondetects have been three J-qualified results in samples collected in December 2005, the highest activity of which was 0.0238 pCi/L (representing Am in a sample from well 20705).

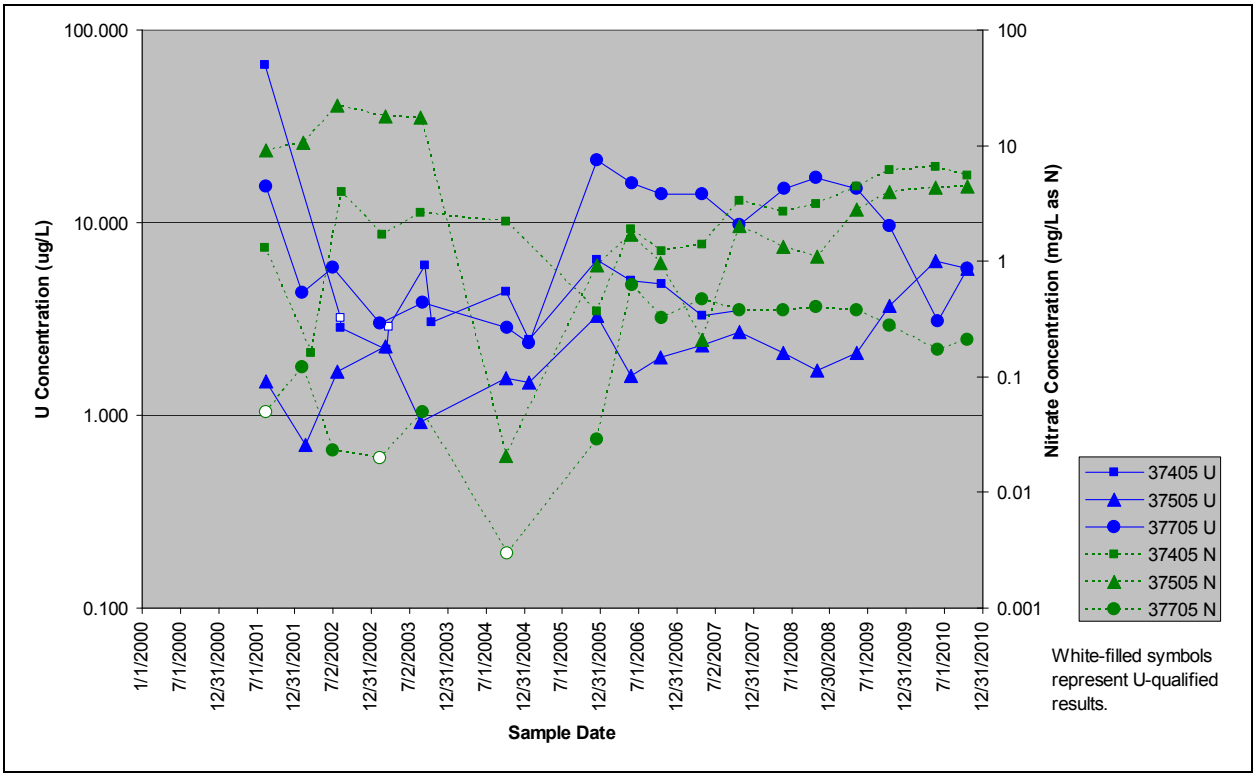
These areas are also monitored for other constituents. The groundwater downgradient of the former B771 complex is discussed above in the context of the IHSS 118.1 Plume and will not be repeated here. Groundwater at the former B371 complex is also analyzed for VOCs, nitrate, and U. Of the VOCs, the most commonly reported detection (consistently reported at J-qualified concentrations below 1 µg/L) is of PCE in samples collected from well 37505. The highest concentration reported in 2010 was estimated at 0.62 µg/L. VOCs were not detected in 2010 in samples collected from wells 37405 and 37705 and historically have been detected only rarely in samples from these wells.

S-K trending results (see summary in Table 77, and Appendix B) indicate an increasing trend meeting the 95 percent level of confidence for nitrate in samples from well 37405 and for U in samples from well 37505. These data are presented below in time-series plots (Figure 257). For context, Figure 258 includes concentrations of these constituents reported in samples from each of the 371-area wells.



Notes: U data include results for U-mass and converted isotopic activities. Several results were qualified but are not shown differently for simplicity. Note logarithmic concentration scales.

Figure 257. Concentrations of U and Nitrate With Significant Trends in Samples From B371 Sentinel Wells



Notes: U data include results for U-mass and converted isotopic activities. Several results were qualified but are not shown differently for simplicity. Note logarithmic concentration scales.

Figure 258. Concentrations of U and Nitrate in Samples From B371 Sentinel Wells

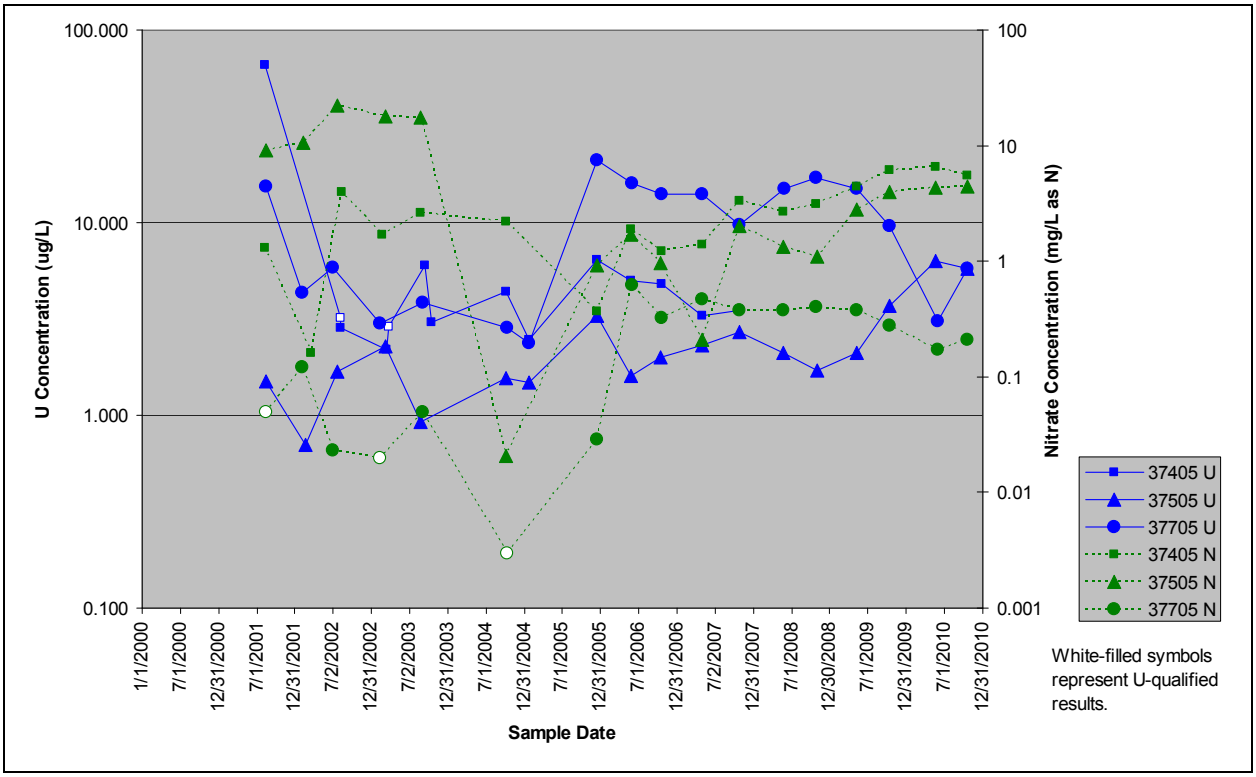
East Government property boundary (former Rocky Flats Environmental Technology Site [RFETS] boundary): Boundary wells 10394 (Woman Creek and Indiana Street) and 41691 (Walnut Creek and Indiana Street) are located far outside the DOE-controlled area of the COU, on refuge lands managed by the U.S. Fish and Wildlife Service. Monitoring these wells is not required to support the remedy, and the associated groundwater data do not support technical objectives of the RFS monitoring network. Nonetheless, they are monitored to meet operational requirements stipulated in RFLMA.

These wells were each sampled once in 2010 (June). As in 2006 and 2009, results included detections of 1,3-DCB, an insecticide that is also used to make herbicides, at both wells. The applicable RFLMA standard for this constituent is 94 µg/L, and the reported concentrations in the 2010 samples were 0.52 µg/L (estimated) at well 10394 and 1.5 µg/L at well 41691. Nitrate was detected at an estimated concentration of 0.021 mg/L at well 41691. Concentrations of U were within their previously reported ranges at these locations (8.3 µg/L at well 41691 and 3.7 µg/L at well 10394).

3.2 Ecological Monitoring

3.2.1 Introduction

The Ecology group conducts ecological monitoring of the Site's ecological resources to ensure regulatory compliance and to preserve, protect, and manage those resources. Ecological



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3.2 Ecological Monitoring

3.2.1 Introduction

The Ecology group conducts ecological monitoring of the Site's ecological resources to ensure regulatory compliance and to preserve, protect, and manage those resources. Ecological

monitoring is an integral aspect of determining whether the management objectives and goals for the natural resources at the Site are being achieved. This report summarizes the results of the ecological monitoring that was conducted at the Site during 2010. It includes a brief summary of the monitoring conducted for Preble's meadow jumping mouse (*Zapus hudsonius preblei*; Preble's mouse) mitigation and wetland mitigation activities; however, the details of those monitoring efforts are summarized in separate regulatory reports provided to the appropriate agencies.

At an elevation of approximately 6,000 feet, the Site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and its proximity to the mountain front. The POU, the area surrounding the COU (the general area where the former IA was once located), is one of the largest remaining undeveloped tracts of its kind along the Colorado Piedmont. A number of plant communities present in the COU and POU have been identified as increasingly rare and unique by the Colorado Natural Heritage Program (CNHP 1994, 1995). These communities include the xeric tallgrass prairie, tall upland shrubland, wetlands, and Great Plains riparian woodland communities. Small inclusions of a number of other increasingly rare plant communities are also found on the Site. Many of these communities support populations of increasingly rare animals as well, including the federally protected Preble's mouse, and other uncommon species such as the grasshopper sparrow (*Ammodramus savannarum*), loggerhead shrike (*Lanius ludovicianus*), Merriam's shrew (*Sorex merriami*), black-crowned night heron (*Nycticorax nycticorax*), hops blue butterfly (*Celastrina sp.*), and Arogos skipper (*Atrytone arogos*).

During 2007, transfer of portions of the POU was made to USFWS to create the Rocky Flats National Wildlife Refuge. As a result, the total acreage managed by LM is now approximately 1,308 acres in the COU and 484 acres in the POU. A summary of the highlights from the 2010 field season is provided in the following sections. Full, detailed summaries, methodology, and analyses for each field monitoring effort are presented as stand-alone reports on the Ecology DVD included with this report.

3.2.2 Vegetation Monitoring

Vegetation monitoring reported here is conducted at the Site to provide information necessary for management of the natural resources. Objectives of the vegetation monitoring in 2010 were to:

- Identify any new plant species not found at the Site previously.
- Identify and document infestations of selected noxious weeds at the Site to assist with the planning of noxious weed control applications.
- Document and track herbicide applications in 2010.
- Document where revegetation activities were conducted in 2010.
- Evaluate the success of revegetation activities at the Site.
- Conduct photomonitoring for visual documentation of changes in vegetation establishment at the Site.

3.2.2.1 Site Flora

The complete list of plant species known to be at the Site at the end of 2010 is available on the Ecology DVD included with this report. The Site species list includes the complete flora of both the COU and the POU. The vascular flora of the Site consists of 632 species of plants. Two new records of vascular plant species for the Site flora are reported. Common teasel (*Dipsacus fullonum*), a noxious weed, was found growing in a wetland area in Rock Creek near the Lindsay Ranch on the Refuge. The patch of plants was small enough that eradication is possible before the species spreads throughout the drainage. The USFWS was contacted and informed of the population. This species is common on surrounding lands, and future monitoring will continue to look for it elsewhere at the Site. Yellow cress (*Rorippa teres*), a small mustard plant, was found growing along the pond margin in the mud flats at Pond A-2. The species is a native wetland plant. The following taxonomic names will be used at the Site for the new plant species records[22]:

Family	Scientific Name	Speccode	Common Name
Dipsacaceae	*Dipsacus fullonum* L.	DIFU1	Common Teasel
Brassicaceae	*Rorippa teres* (Michaux) Stuckey	ROTE1	Yellow Cress

Voucher specimens of the species will be deposited at the University of Colorado Herbarium in Boulder, Colorado.

3.2.2.2 Weed Mapping and Weed Control

Resource management is an important concern at the Site with a goal to protect and sustain the native ecological resources that make the Site so unique along the Front Range. One of the challenges at the Site is to manage the ecological resources with a limited set of management tools. Currently, most efforts focus on the control or eradication of the weed species themselves, with little emphasis on trying to improve conditions for the desired native species. Two of the key tools for grassland management, fire and grazing, are not currently allowed at the Site. As a result, management of the ecological resources in the COU is largely limited to controlling the noxious weeds themselves. The Comprehensive Conservation Plan (USFWS 2005), developed by USFWS for management of the Rocky Flats National Wildlife Refuge, has identified the full range of Integrated Pest Management tools for use at the Refuge for controlling weeds. This includes administrative, cultural, biological (including grazing), mechanical (including prescribed fire), and chemical as viable tools for controlling noxious weeds and ecosystem management. Thus, there may be a greater opportunity for some of these other resource management tools to be used in the future.

The methods used for weed mapping are provided in the full report on the Ecology DVD included with this report.

Figure 259 and Figure 260 show the 2010 weed distribution maps for diffuse knapweed (*Centaurea diffusa*) and Dalmatian toadflax (*Linaria dalmatica*), respectively. Table 91 shows

[22] Nomenclature follows GPFA (1986), Weber (1976), Weber (1990), Weber and Wittmann (1992), and Weber and Wittmann (2001), in that order of determination. Species were verified at the University of Colorado Herbarium in, Boulder, Colorado.

the estimated total acreage and acreage-by-density categories for each species, based on the mapping data from 2007 through 2010. The total area of the COU is approximately 1,308 acres. In 2010, diffuse knapweed was observed on approximately 230 acres at various levels of infestation. Dalmatian toadflax was mapped on approximately 168 acres in 2010. Both species showed a decrease in acreage compared to the 2009 mapping data. Annual fluctuations in the abundance of many grassland species are not uncommon as they respond to changes in temperature, precipitation amounts, timing of precipitation, and other environmental factors.

Additional species that were mapped based on fortuitous observations in 2010 included Scotch thistle (*Onopordum acanthium*), Dame's rocket (*Hesperis matronalis*), leafy spurge (*Euphorbia uralensis*), tall mustard (*Cardaria chalepensis*), whitetop (*Cardaria draba*), and wild carrot (*Daucus carota*). No acreages are provided for these species since the polygons simply show the general location of the infestations. Figure 261 shows the locations of these species as mapped in 2010.

During 2010, approximately 264 acres were treated with herbicides at the Site via ground application (Figure 262). Table 92 lists the target species, herbicides used, application rates, and the approximate timing of the application during the year. (**Note:** Multiple herbicides are listed at some locations. This does not mean that each herbicide was used across that entire location. Rather, depending on site-specific characteristics such as target weed species, the locations of water bodies, soil types, and the professional judgment of the licensed herbicide applicator, different herbicides were used within that location to provide the control needed.)

In 2007, a small patch of leafy spurge, a state-listed noxious weed, was documented for the first time at the Site. This patch was sprayed in 2007 to control its spread. In 2008, two additional small patches of leafy spurge were found in the northern COU. Because these new patches of leafy spurge had already started going to seed when they were discovered, the seedheads were cut off, bagged, and sent to the landfill for burial. These three locations and an additional location were sprayed with Plateau herbicide in 2009 to control the infestations. Observations in 2010 showed no leafy spurge plants flowered at any of the known locations. No plants were observed at one location, and a few small rosettes were starting to come up in October 2010 at the other locations. Additional control is planned for 2011 to eradicate the leafy spurge. Hand control and weed-whacking were also used to control some small patches of Scotch thistle, tall mustard, tamarisk (*Tamarix ramosissima*), and whitetop in 2010.

Biocontrol insects continue to be used at the Site. Stem-mining beetles (*Mecinus janthinus*) were released several years ago at a few locations to help control Dalmatian toadflax. Additional beetles were obtained from the Colorado Department of Agriculture in 2010 and released at two locations. Examination of several populations of Dalmatian toadflax at the site (both in the COU and POU) in 2010 showed that the beetles have essentially spread across the site. At nearly every location beetles were observed on the plants. Therefore, no future releases are planned, and the hope is that the beetles will continue to increase and expand, ultimately controlling the Dalmatian toadflax to a level at which herbicide applications are not required.

Table 91. COU Noxious Weed Acreage Summary (2007–2010)

Species	Density (acres)				Total	% of Total COU
	High	Medium	Low	Scattered		
Diffuse knapweed						
2007	2.2	41.2	248.8	167.7	459.9	35
2008	1.8	20.6	110.0	147.5	279.9	21
2009	1.6	44.6	231.2	147.5	424.9	32
2010	0.1	10.6	155.0	64.3	230.1	18
Dalmatian toadflax						
2007	77.1	51.0	0.0	109.0	237.1	18
2008	0	0	54.3	151.8	206.1	16
2009	2.1	16.8	56.5	386.7	462.1	35
2010	0.0	2.1	64.2	101.4	167.7	13
The total acreage of the COU is 1,308 acres.						

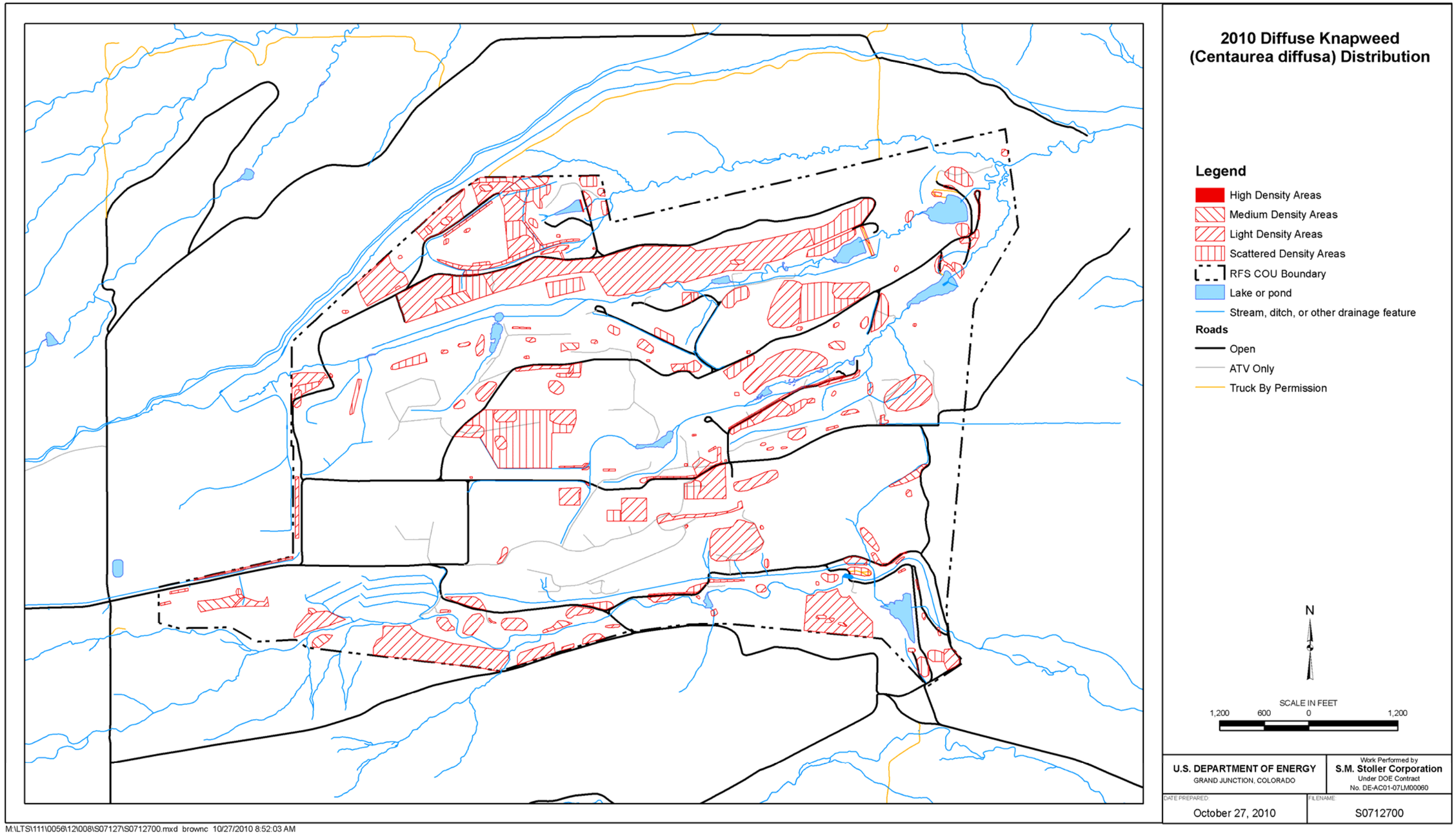

*Figure 259. 2010 Diffuse Knapweed (*Centaurea diffusa*) Distribution at Rocky Flats*

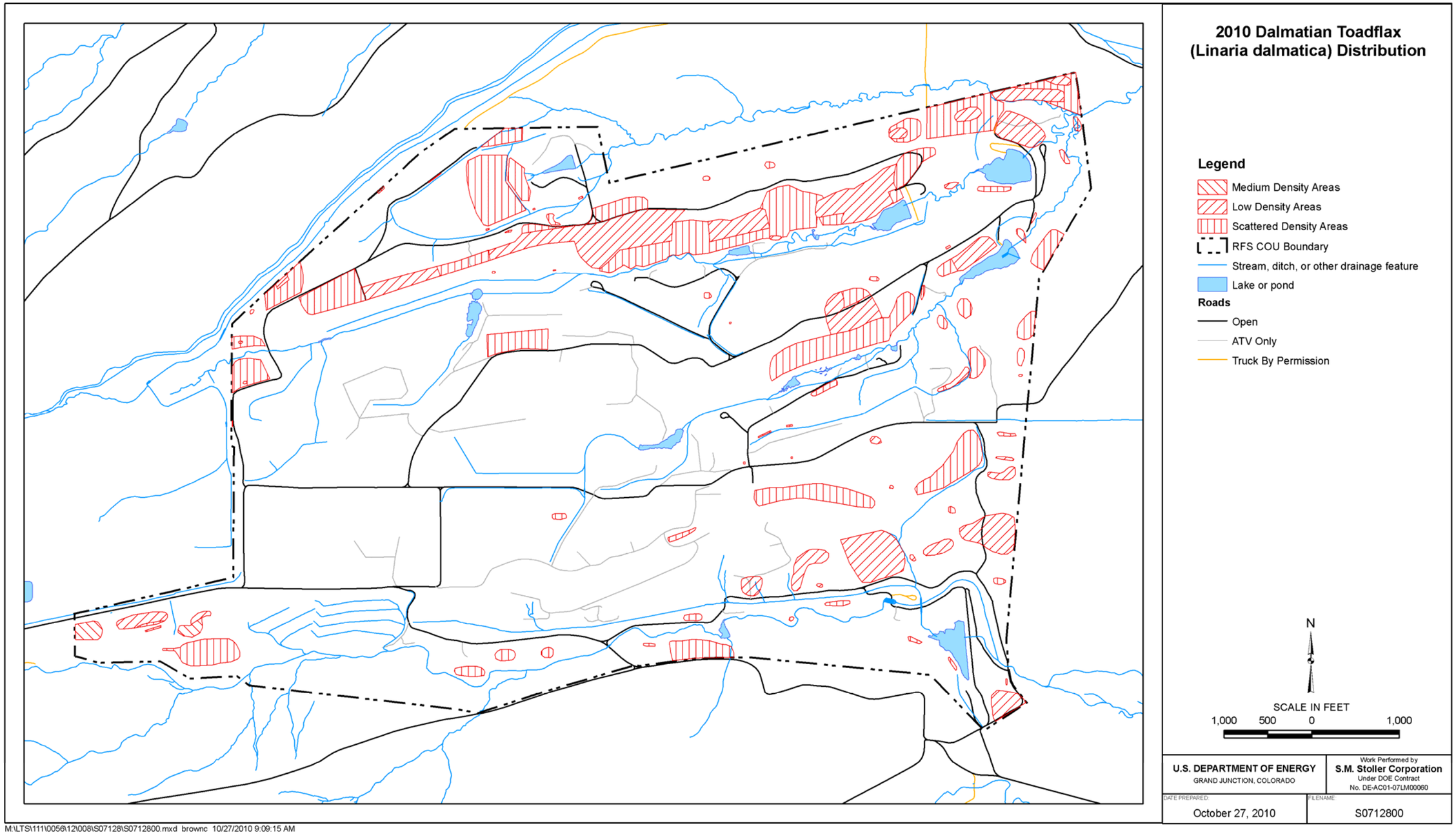

*Figure 260. 2010 Dalmation Toadflax (*Linaria dalmatica*) Distribution at Rocky Flats*

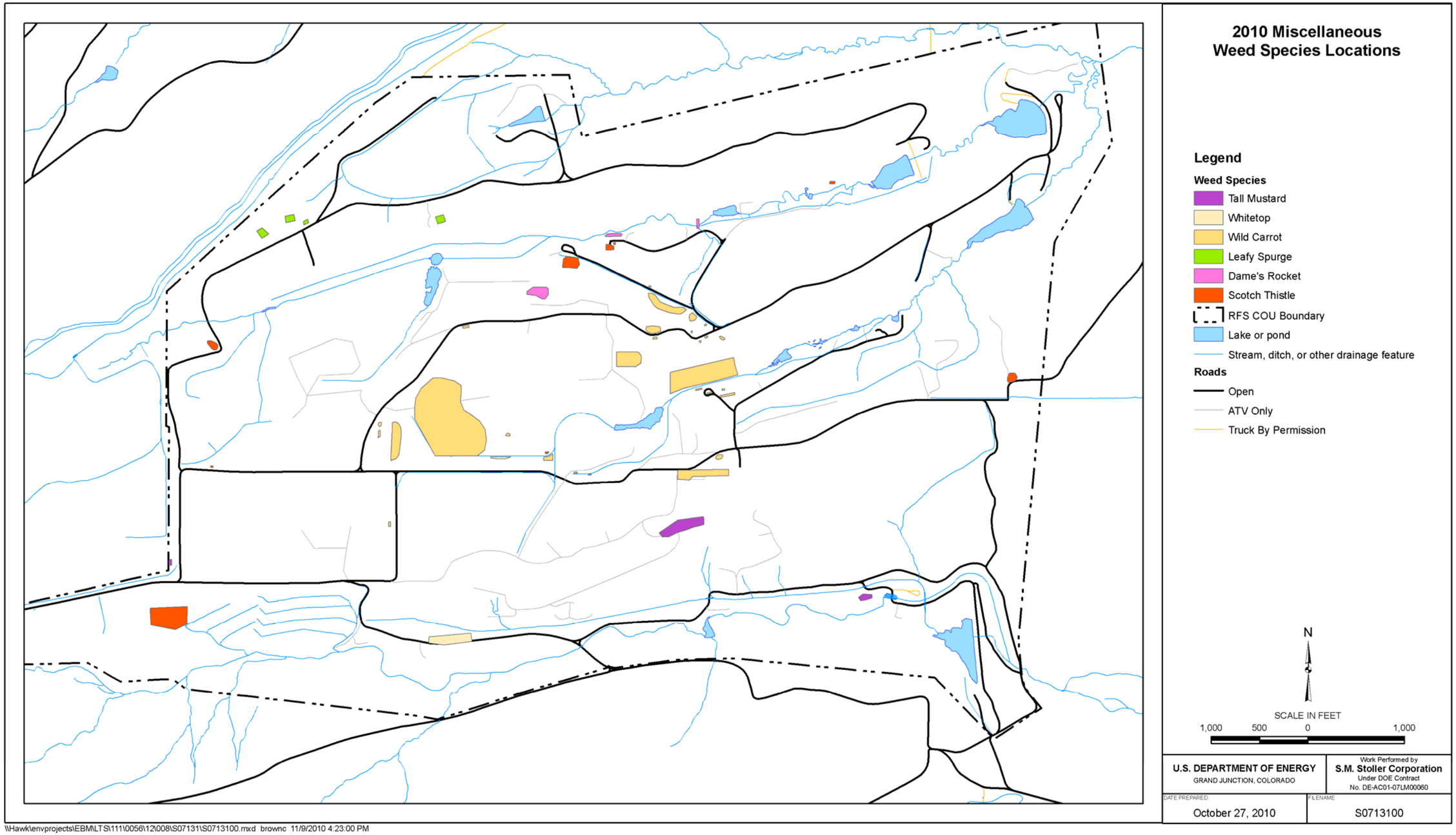

Figure 261. 2010 Miscellaneous Noxious Weed Locations at Rocky Flats

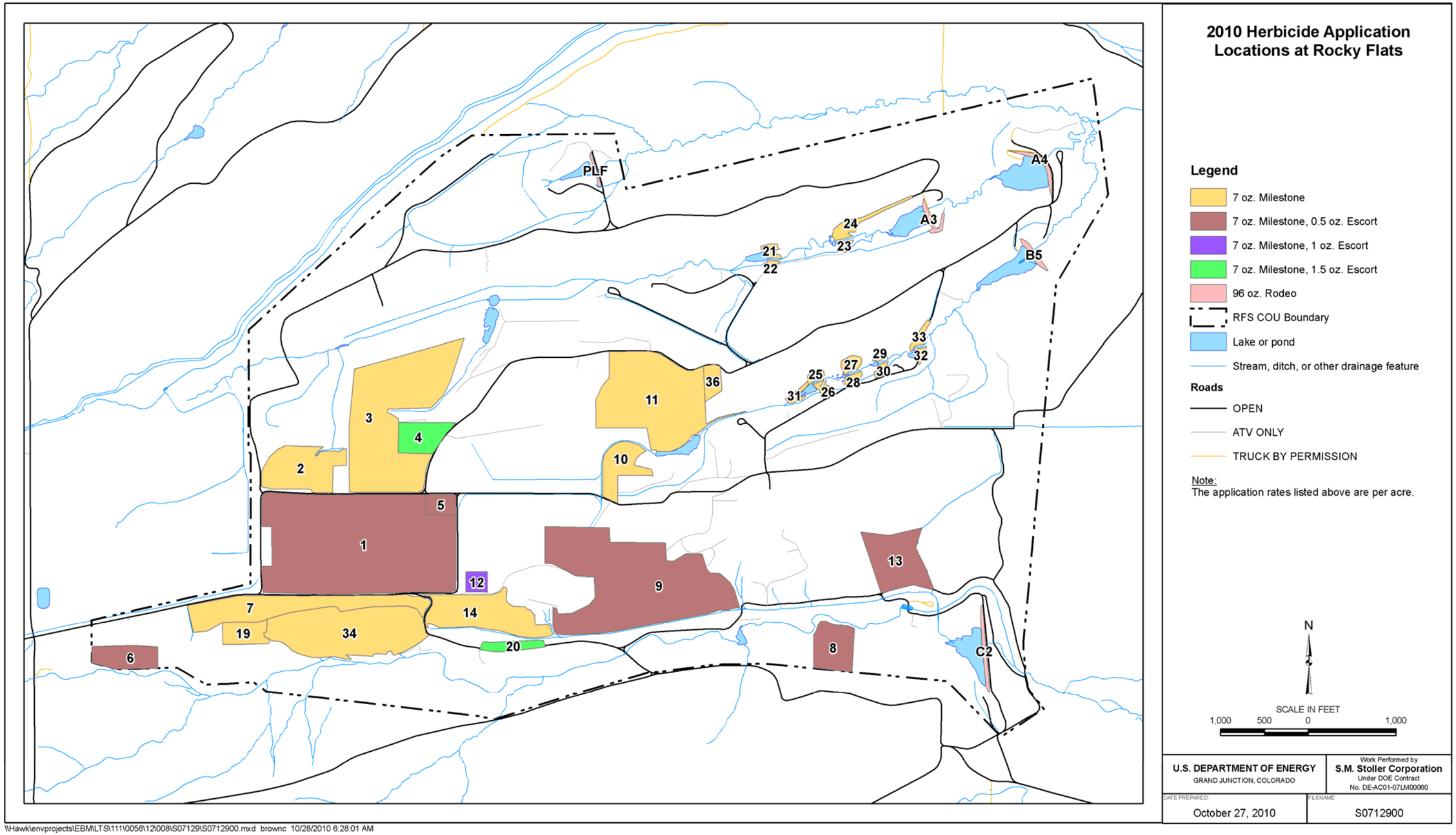

Figure 262. 2010 Herbicide Application Locations at the Rocky Flats Site

Table 92. FY 2010 Herbicide Application Summary

Location	Target Species[a]	Treatment	Actual Acreage Treated[b]	Time of Year Treated
1	CEDI1	7 oz. Milestone, 0.5 oz. Escort	57.00	Spring 2010
2	CEDI1	7 oz. Milestone	9.50	Spring 2010
3	CEDI1	7 oz. Milestone	34.00	Spring 2010
4	CADR1	7 oz. Milestone, 1.5 oz. Escort	4.25	Spring 2010
5	CADR1	7 oz. Milestone, 0.5 oz. Escort	2.00	Spring 2010
6	CEDI1, VETH1	7 oz. Milestone, 0.5 oz. Escort	5.00	Spring 2010
7	CEDI1	7 oz. Milestone	13.00	Spring 2010
8	CEDI1, VETH1	7 oz. Milestone, 0.5 oz. Escort	6.00	Spring 2010
9	CEDI1	7 oz. Milestone, 0.5 oz. Escort	42.00	Spring 2010
10	CEDI1	7 oz. Milestone	4.80	Spring 2010
11	CEDI1, DACA1	7 oz. Milestone	26.00	Spring 2010
12	CADR1	7 oz. Milestone, 1 oz. Escort	1.50	Spring 2010
13	CEDI1, VETH1	7 oz. Milestone, 0.5 oz. Escort	9.50	Spring 2010
14	CIAR1	7 oz. Milestone	11.00	Spring 2010
19	CEDI1, VETH1, ONAC1	7 oz. Milestone	3.50	Spring 2010
20	CADR1	7 oz. Milestone, 1.5 oz. Escort	2.00	Spring 2010
21	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.50	Spring 2010
22	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.30	Spring 2010
23	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.30	Spring 2010
24	CEDI1, CIAR1, MEOF1	7 oz. Milestone	1.75	Spring 2010
25	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.50	Spring 2010
26	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.60	Spring 2010
27	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.75	Spring 2010
28	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.50	Spring 2010
29	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.40	Spring 2010
30	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.50	Spring 2010
31	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.25	Spring 2010
32	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.25	Spring 2010
33	CEDI1, CIAR1, MEOF1	7 oz. Milestone	0.75	Spring 2010
34	CEDI1	7 oz. Milestone	21.50	Spring 2010
36	CEDI1, DACA1	7 oz. Milestone	1.60	Spring 2010
Riprap Dam Faces	Total Kill	96 oz/acre Rodeo	2.9	Spring 2010
		Total Area Treated in 2009	264.4	

Note: oz. = ounces
[a] Species Codes: CADR1 = whitetop, CEDI1 = diffuse knapweed, CIAR1 = Canada thistle, DACA1 = wild carrot, MEOF1 = yellow sweetclover, ONAC1 = scotch thistle, VETH1 = common mullein
[b] Acreages based on billing statements, not original GPS locations provided to subcontractor.

Collections and transplants from other established populations of various biocontrols at the site may continue to be made to further establish populations elsewhere across the site. Additional biocontrol insects for different weed species may be released as they become available. The integrated weed management approach at the site continues to address noxious weed issues through mapping and the use of various control methods.

A new noxious weed at the Site was observed in late August near the Lindsay Ranch in the POU on the Refuge. Common teasel has never been found at the Site previously, but approximately two dozen plants, already having flowered and gone to seed, were observed along the main branch of Rock Creek. USFWS was notified of the observation, and it was suggested that control

should be implemented to prevent the species from spreading throughout the adjacent wetlands and downstream.

Site ecology personnel participated in the Rocky Flats Weed Symposium held March 5, 2010, at the Broomfield Auditorium. A presentation entitled "Weed Control at Rocky Flats" was given discussing weed control activities at the Rocky Flats Site, both historically and ongoing. The purpose of the conference was to bring together surrounding landowners in the Rocky Flats area for networking and potentially to work toward more coordinated efforts for controlling noxious weeds.

3.2.2.3 Revegetation Activities in 2010

During winter, early spring, and fall 2010, interseeding was conducted on approximately 29 acres at the Site where vegetation cover was still sparse. At most of these locations, the seed was broadcast using an all-terrain-vehicle broadcast seeder. At some locations the seed was harrowed where conditions would allow.

For the past several years the Jefferson County Nature Association has been conducting volunteer seed-picking days to provide local ecotype seed for inclusion in the revegetation efforts at the Rocky Flats Site and other nearby revegetation projects. The seed provided to the Site has been interseeded into revegetation areas to provide more local genotypes in these areas. Until recently, forbs have not been desirable because of the need to conduct weed control at many of the revegetation locations. However, as the prairie grasses continue to establish, the introduction of forbs (wildflowers) is becoming more desirable to increase the diversity of plant life and increase habitat for other wildlife and insect species. In late 2009, four forb "nursery" areas were established (Figure 263). The forb seed collected in fall 2009 was broadcast throughout these four locations in the hope of establishing pockets, or islands, of forbs that could then expand outward. Weed control in these areas will be conducted by hand or by mowing/weed-whacking. The common forb species that were hand collected and broadcast into these areas included golden aster (*Chrysopsis villosa*), blazing star (*Liatris punctata*), groundsel (*Senecio spartioides*), and Porter's aster (*Aster porteri*).

In June 2010, the volunteers collected needle-and-thread grass (*Stipa comata*) and New Mexico feathergrass (*Stipa neomexicana*), both native grasses that occur on the prairie at the Site. These species are rarely available commercially, and when they are available, they are expensive. So the volunteers hand collected the seeds, and these were then hand broadcast into three locations for establishment (Figure 263). As with the forb islands, it is hoped that these species will establish at these locations and expand outward.

3.2.2.4 Revegetation Monitoring

As part of the cleanup and closure of the Site, the buildings, roads, and other infrastructure in the IA were removed. Approximately 650 acres were disturbed during cleanup activities, which were completed in fall 2005. Revegetation of the disturbed areas was conducted to prevent erosion and sedimentation of the Site streams and to meet water quality standards. Reestablishment of native plant species is also desirable to benefit wildlife and provide desirable vegetation and ground cover adjacent to the Rocky Flats National Wildlife Refuge. As part of the revegetation process, monitoring is conducted to determine whether success criteria, as stated in the *Rocky Flats,*

Colorado, Site Revegetation Plan (Revegetation Plan; DOE 2009b) are being met as well as to determine whether management of these revegetation areas is needed.

The success criteria from the Revegetation Plan are:

- The revegetation site will have a minimum of 30 percent relative foliar cover of live desired species (seeded or nonseeded native species). Relative cover is defined as the percentage of cover of a given species divided by the total amount of vegetation cover present. Example: Species A has 20 percent absolute cover, and total vegetation cover (all individual species cover values summed) is 80 percent. Relative cover = (20/80) × 100 = 25%.
- The revegetation site will have a minimum of 70 percent total ground cover that comprises litter cover, current-year live vegetation basal cover, and rock cover.
- A minimum of 50 percent of the seeded native species will be present at the revegetation site.
- No single species will contribute more than 45 percent of the relative foliar cover (except in areas where dominance by a single species is appropriate for long-term wildlife and habitat management objectives).

This report section summarizes the revegetation monitoring results for data collected during 2010. The objective of the revegetation monitoring in 2010 was to assess the success of the revegetation efforts. The methods and the large data summary tables are not presented here but may be found in the full report on the Ecology DVD included with this report. Figure 264 shows the locations at the Site where revegetation monitoring was conducted in 2010.

Species richness in 2010 ranged from a low of 11 species in unit L40 to a high of 32 species in unit L55 (the "L" is not shown for each location in Figure 264). The wide range in the number of species present is attributable to a number of factors, including how long ago the area was revegetated, the size of the location, the number of quadrats sampled in the location, the degree of disturbance in the area prior to revegetation, and the management actions (e.g., weed control) that have been conducted in the area. Fourteen different seeded graminoid species had become established and were growing at some locations in 2010. These included slender wheatgrass (*Agropyron caninum = Agropyron trachycaulum*), thickspike wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*Agropyron smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), side-oats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), Canada wildrye (*Elymus canadensis*), junegrass (*Koleria pyramidata*), switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), sand dropseed (*Sporobolus cryptandrus*), and green needlegrass (*Stipa viridula*). Only western wheatgrass was established at all 25 locations. Several noxious weeds were also found in the revegetation areas. These included downy brome (*Bromus tectorum*), filaree (*Erodium cicutarium*), diffuse knapweed, Canada thistle (*Cirsium arvense*), chicory (*Cichorium intybus*), Dalmatian toadflax, and bindweed (*Convolvulus arvensis*). Downy brome averaged approximately 6.7 percent cover across all the sites combined, and the remainder of the weed species together averaged approximately 2.2 percent. Weeds will continue to be managed as needed to keep noxious weed populations down in the revegetation areas and enable the desired seeded species to become established more quickly and compete with the weeds.

Slightly different seed mixes were used at the revegetation locations depending on the year they were seeded and the slope position. According to a success criterion in the Revegetation Plan, at

least 50 percent of the seeded species must be present in an area for it to be considered successful. Twenty one locations (84 percent) had 50 percent or more seeded species present in 2010 and have thus met this success criterion (Table 93). One unit, L41, has failed to meet this criterion for the past 3 years (including 2010), even though it was seeded in 2002 and is the oldest revegetation unit within the COU. A major cause of the low percentage of seeded species present is that this was one of the few locations where topsoil was brought in as a test for the first revegetation effort after one of the initial buildings was taken down during closure. As a result, the non-native graminoid species that were present in the seed bank (sheep fescue [*Festuca ovina*], smooth brome [*Bromus inermis*], and intermediate wheatgrass [*Agropyron intermedium*]) now dominate the area. Additionally, the soil texture of unit L41 is quite different from Rocky Flats Alluvium, which is present elsewhere on the pediment at the Site. The xeric seed mix was designed for the typical rocky pediment surfaces at the Site; many of the species in the mix typically do not thrive in this finer-textured soil type and have never established. Because many of the species in the original seed mix have not established, it is unlikely that this area will ever meet the criterion of 50 percent seeded species present. If the species in the mesic seed mix (all of which were also in the seeded xeric seed mix) that would typically grow in this soil type at the site were used for comparison, five of seven seeded species (71 percent) are present, and the area would meet the criterion. Therefore, unit L41 will be considered to have met this criterion, since it is unlikely that it ever will achieve success using the original seed mix as a basis. This increases the number of units to 22 (88 percent) that met this criterion in 2010.

For the locations that did not meet this criterion in 2010, factors that may explain why many of the seeded species have not become established include inadequate or uneven initial seeding, poor soil conditions, competition from the more aggressive graminoid species in the seed mix, and drought. The monitoring method may also contribute to the lack of seeded species present, because the measure is based solely on the species list generated from the quadrat sampling. Given the small size of the total area measured on the ground through the quadrat method, it is possible that more of the seeded species are present at the revegetation locations but are simply outside the "footprint" of the randomly located quadrats in 2010. In 2011, additional observations beyond the "footprint" of the quadrats may be made.

Ground cover protection from rock, litter, and current-year live vegetation varied from 62 percent to over 100 percent at the revegetation locations in 2010. The occasional values over 100 percent are the result of the class system used for estimating cover, which estimates cover values into a range and uses the midpoint of the cover class for analysis. The Revegetation Plan states that a minimum of 70 percent total ground cover comprising litter cover, current-year live vegetation basal cover, and rock cover is to be present to help prevent erosion. Nineteen of the 25 locations (76 percent) met this criterion in 2010 (Table 93). Where overall cover is less than 70 percent, additional erosion control measures such as wattles and hay bales are in place to protect the areas and prevent erosion—or, bands of established vegetation are present between the revegetation areas and water resources.

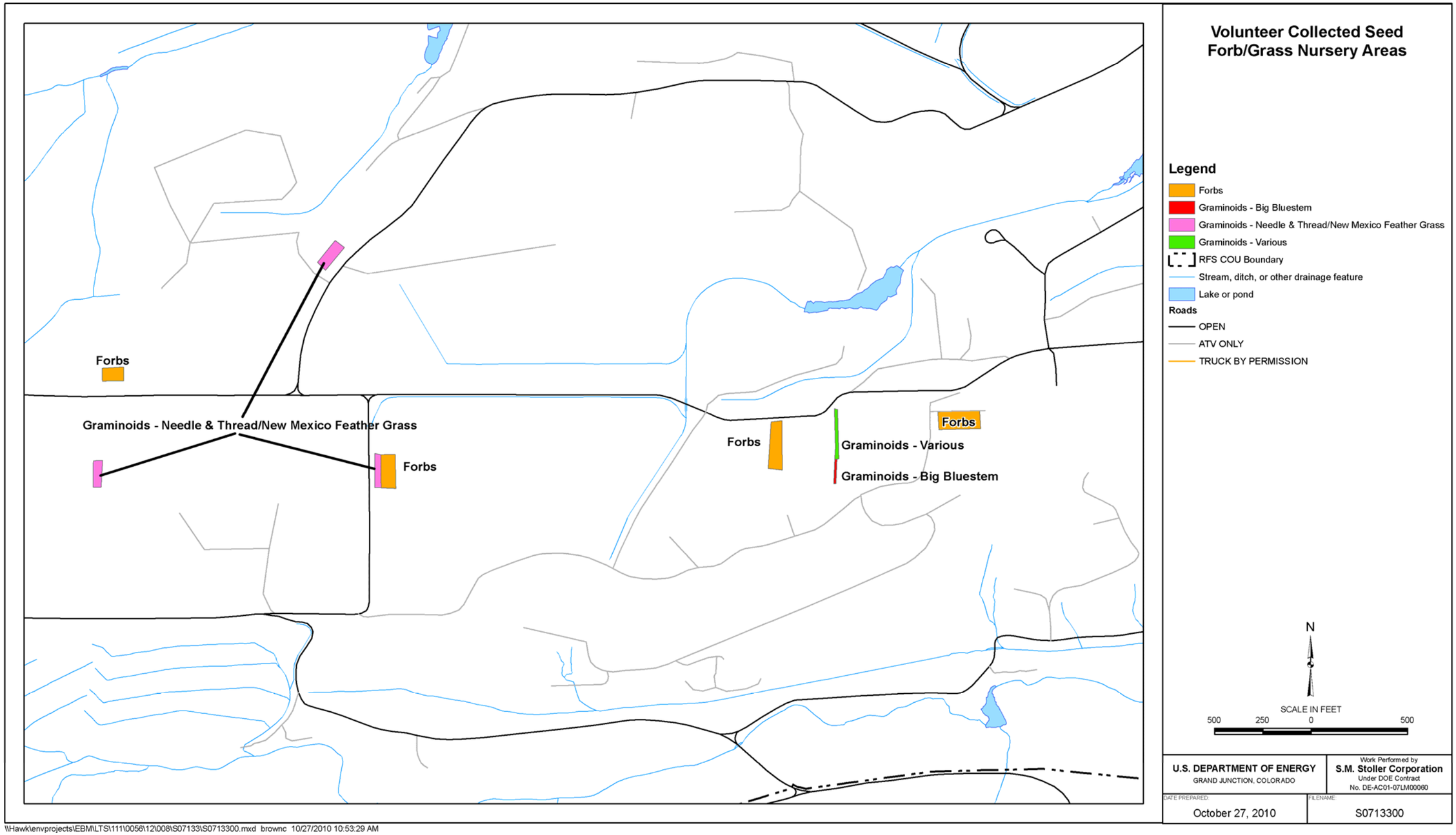

Figure 263. Volunteer Collected Seed Forb/Grass Nursery Areas

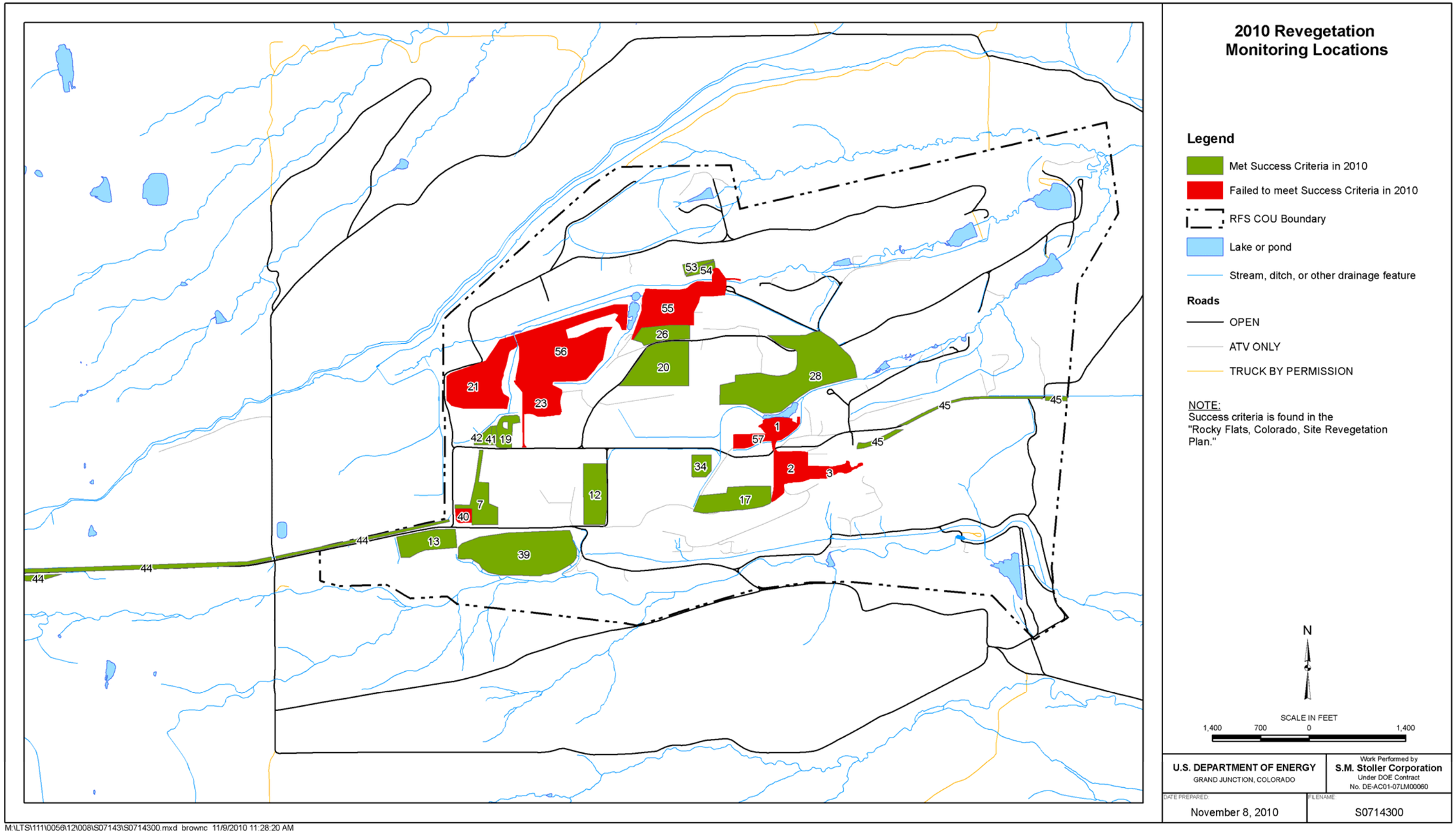

Figure 264. 2010 Revegetation Monitoring Locations

Table 93. Success Criteria Evaluation Summary 2010

Location	>30% Relative Cover of Desired Species	>70% Total Ground Cover (Litter, Rock, and Basal Veg Cover)	50% or More of Seeded Species Present	No Single Species With >45% Relative Foliar Cover	PASS/FAIL
L1	PASS	FAIL	PASS	PASS	FAIL
L2	PASS	FAIL	PASS	PASS	FAIL
L3	PASS	FAIL	PASS	PASS	FAIL
L7	PASS	PASS	PASS	PASS	PASS
L12	PASS	PASS	PASS	PASS	PASS
L13	PASS	PASS	PASS	PASS	PASS
L17	PASS	PASS	PASS	PASS	PASS
L19	PASS	PASS	PASS	PASS	PASS
L20	PASS	PASS	PASS	PASS	PASS
L21	PASS	FAIL	PASS	PASS	FAIL
L23	PASS	PASS	FAIL	PASS	FAIL
L26	PASS	PASS	PASS	PASS	PASS
L28	PASS	PASS	PASS	PASS	PASS
L34	PASS	PASS	PASS	PASS	PASS
L39	PASS	PASS	PASS	PASS	PASS
L40	PASS	PASS	FAIL	FAIL	FAIL
L41	PASS	PASS	PASS	PASS	PASS
L42	PASS	PASS	PASS	PASS	PASS
L44	PASS	PASS	PASS	PASS	PASS
L45	PASS	PASS	PASS	PASS	PASS
L53	PASS	PASS	PASS	PASS	PASS
L54	PASS	PASS	PASS	PASS	PASS
L55	PASS	FAIL	PASS	PASS	FAIL
L56	PASS	FAIL	PASS	PASS	FAIL
L57	PASS	PASS	FAIL	FAIL	FAIL
% Passing	100	76	84	76	64

Yellow-shaded cells indicate all success criteria were met in 2010.

Blue-shaded cells indicate all success criteria would be met in 2010 if the criterion of >45% cover of a single species was removed. As described in the text, these areas are considered to have passed as of 2010.

Green-shaded cells indicate all success criteria would be met in 2010 if the criterion of >50% of seed species present was removed for this location. As described in the text, this area is considered to have passed as of 2010.

The third success criterion states that a minimum of 30 percent relative cover of desired species must be present, and the fourth criterion states that no single species should constitute more than 45 percent of the total relative cover. Total relative vegetation cover of desired (native) species was greater than 30 percent at 100 percent (25) of the locations monitored in 2010 (Table 94). Six of the 25 revegetation locations (24 percent) had a single species that constituted greater than 45 percent of the relative cover in 2010 (Table 93). Four of these locations were dominated by western wheatgrass, one of the seeded native species. At the other two locations, buffalo grass and slender wheatgrass, also seeded native species, provided greater than 45 percent of the relative cover. Four of these locations—L7, L26, L44, and L45—failed to meet all four success criteria solely because they each had a single species that covered greater than 45 percent of the area (Table 93). At each of these locations the dominant species was western wheatgrass (62, 69, 46, and 57 percent total relative cover, respectively). Regarding the use of the success criteria, the Revegetation Plan states:

> "Success criteria and monitoring are an important component of a revegetation project. . . *These success criteria are provided as initial guidance; however, common sense combined with scientific data must be applied to final evaluations to determine whether further management actions are required*" [emphasis added].

Additionally, the Revegetation Plan's success criterion regarding dominance by a single species states that "[n]o single species will contribute more than 45 percent of the relative foliar cover (*except in areas where dominance by a single species is appropriate for long-term wildlife and habitat management objectives*)" [emphasis added].

Western wheatgrass is a desirable native species. At locations that fail only this last criterion but otherwise have a good stand of vegetation, several questions are worth considering:

- Is the dominance of these areas by a single species (with greater than 45 percent relative foliar cover) detrimental to long-term wildlife and habitat management?
- Is the dominance by these species likely to change in the future?
- Is there any other reason not to pass these four locations in 2010, just because they failed this last criterion?

One way to answer the first question is to evaluate the dominance of relative foliar cover of native species on the undisturbed native grassland areas of the Site. Do native species account for greater than 45 percent of the cover at some locations on the native grasslands? Monitoring in 2009 at two reference locations in native grassland used for Preble's mouse mitigation monitoring showed that western wheatgrass provided, respectively, 54 and 59 percent relative foliar cover (Table 94; OLF and A-Ponds reference areas). At TR06, a xeric grassland monitoring location, data collected over multiple years showed that needle-and-thread grass, a native grassland species, consistently provided greater than 45 percent relative foliar cover (Table 94). Because it is not uncommon for some of the native graminoid species to dominate the foliar cover at some locations, it is unlikely that the dominance of western wheatgrass at revegetation areas L7, L26, L44, and L45, will be detrimental to long-term wildlife and habitat management.

Relative foliar cover of different species and overall vegetation cover also fluctuate in response to environmental conditions, such as temperature and the amount and timing of precipitation. Table 94 shows some of this fluctuation for western wheatgrass at TR02 and TR04 (both mesic grassland monitoring locations) and the OLF revegetation area, for needle-and-thread grass at TR06 and TR11 (mesic grassland monitoring locations), for Japanese brome (*Bromus japonicus*) at TR11, and for overall foliar cover at TR02. Annual fluctuations in species cover are common in response to changing environmental conditions. Although locations L7, L26, L44, and L45, were dominated by species with greater than 45 percent cover in 2010, this may change over time as environmental conditions change. Given the evidence that dominance by a single species occurs on the native prairie, and annual fluctuations in foliar cover are common, there is no practical reason these locations cannot be considered to have passed all four criteria in 2010.

Table 94. Relative Foliar Cover of Selected Species on Native Grasslands at Rocky Flats

Location	Species	1993	1994	1995	1998	1999	2000	2001	2007	2008	2009	2010
TR02	*Agropyron smithii*	40.5	33.0	31.5		23.5	23.2					
TR02	*Total Foliar Cover*	68.2	88.0	97.2		77.4	71.6					
TR04	*Agropyron smithii*	28.6	15.7	19.3		13.7	10.0					
TR06	*Stipa comata*	61.5	62.4	49.4	50.8			45.7				
TR11	*Stipa comata*	11.6	8.7	3.2		6.6	12.6					
TR11	*Bromus japonicus*	3.0	25.8	39.1		19.2	4.5					
OLF Reference Area	*Agropyron smithii*								21.8	33.4	59.0	33.3
A-Ponds Reference Area	*Agropyron smithii*										54.2	18.0

These data are from various other studies that have been conducted at Rocky Flats. The sporadic nature of the timing of some studies is a result of the purpose of the individual studies. See the text for more information.

David Buckner, an ecologist under contract with EPA, conducted revegetation monitoring for EPA at Rocky Flats in 2009 and 2010. He noted similar conditions in the revegetation areas they sampled and has no concerns for areas with greater than 45 percent cover by a single species. In the 2010 report, he states, "The single sample showed that western wheatgrass comprised half of the cover, and though slightly in excess of the 45 percent DOE criterion, it is not likely that this represents a problem situation. Many native stands on finer-textured soils 'naturally' have as much western wheatgrass as is present here, or more" (EPA 2010a).

Table 93 and Figure 264 show which revegetation locations monitored in 2010 met or failed to meet the criteria listed. Sixteen of the 25 locations (64 percent; approximately 105 acres) met all four criteria in 2010 (including locations L7, L26, L41, L44, and L45, for the reasons described above). These areas have established good stands of vegetation that should be sustainable in the future. Areas that did not meet success criteria in 2010 need more time. A good stand of vegetation often takes 4 to 6 years to become established. Of those revegetation units that did not pass in 2010, units L1, L2, L3, L23, and L57 were reworked with additional soil amendments in either 2007 or 2008. Thus, they are only in their second or third year of revegetation. At units L21, L55, and L56, the soil conditions are very poor, and it has taken longer for the vegetation to establish. Additional seeding at these units along with unit L40 should help to increase vegetation cover.

3.2.2.5 Original Landfill Revegetation Monitoring

The OLF (unit L39, Figure 6) is one of two landfills at the Site. The vegetation at the Present Landfill met success criteria in 2009 and was not monitored in 2010 as part of this monitoring effort. The OLF was revegetated during Site closure, and vegetation is monitored as part of the overall revegetation monitoring and as specified in the M&M Plan for the OLF. In addition to this monitoring, the M&M Plan requires qualitative quarterly vegetation surveys that are reported in the quarterly and annual Rocky Flats Legacy Management Reports.

Total species richness in 2010 was 23 species. The percentage of seeded species present in 2010 was 86 percent. Thus, this criterion was met in 2010. The seeded species observed in 2010 included slender wheatgrass, western wheatgrass, side-oats grama, blue grama, buffalo grass, and green needlegrass. Ground cover protection from rock, litter, and current-year live vegetation averaged 84 percent, exceeding the success criterion of 70 percent. The percent relative cover of desired species on the OLF in 2010 was 88 percent, exceeding the required 30 percent. None of the species present on the OLF contributed more than 45 percent of the total relative cover and thus met this criterion. In 2010, all four success criteria were met on the OLF (Table 93). Tables with additional summary information, maps, and photomonitoring results for the OLF are available on the Ecology DVD included with this report.

Across most of the OLF the revegetation has been successful. At some localized areas where soil was recently disturbed during maintenance or repair activities, the vegetation is still somewhat sparse. Quarterly vegetation surveys are conducted on the OLF and will continue in accordance with the M&M Plan. However, because the revegetation success criteria have been met this year, annual vegetation monitoring per the Plan will not be continued in the future. Instead, the OLF may be incorporated into a multiyear monitoring rotation to document the long-term successional changes on the revegetation areas at the Site.

3.2.2.6 EPA Revegetation Assessments

In 2009 and 2010, EPA conducted their own revegetation monitoring to assess the status of the revegetation efforts at the Rocky Flats Site. The EPA reports for each year are available on the Ecology DVD included with this report.

3.2.2.7 Photomonitoring Results

Photomonitoring results are presented on the Ecology DVD included with this report.

3.2.3 Wildlife Monitoring

During 2010, wildlife surveys at the Site consisted of observing black-tailed prairie dogs (*Cynomys ludovicianus*), monitoring mountain bluebird (*Sialia currucoides*) boxes, and observing active raptor nests. More-detailed information for the wildlife monitoring is presented in the Ecology DVD included with this report.

3.2.3.1 Prairie Dog Monitoring

Black-tailed prairie dogs are not uncommon at the Site. Prairie dog towns in the upper elevations of the COU and POU are scarce due to the abundance of rocks in the pediment soils. However, they are common in the lower-elevation, deeper-soil areas on the eastern half of the POU and in one upper-elevation surface in the northeast corner of the POU where the soils are less rocky. Several prairie dog towns have existed for many years at these locations. From an ecological standpoint, the prairie dogs are an important component of the ecosystem, providing food for raptors and coyotes, and also a source of natural disturbance to the vegetation communities where the prairie dog towns are located. In recent years, conflicts between people and prairie dogs have increased along the Front Range. Prairie dogs are perceived as hindering recreational use and harming the quality of habitat on public lands. Numerous municipalities along the Front Range have instituted relocation programs to avoid or limit the outright killing of the prairie dogs. Several of these programs have resulted in prairie dogs being moved just outside the boundaries of the POU on the Site's eastern and northern boundaries. At some off-site locations, the increase in prairie dog populations has denuded the landscape and created bare soil areas that become sources of large dust clouds during high winds.

The primary concern with the prairie dog colonies at the Site is the potential for the prairie dogs to create an erosional surface by removing vegetation cover. Two landfills are present at the Site, the Original Landfill and Present Landfill. The M&M Plans for both landfills prohibit the presence of burrowing animals on the landfill covers. Additionally, infrastructure is buried at some locations in the former Industrial Area (within the COU), and the prairie dogs' natural tendency to dig makes them undesirable at these locations. Thus, from a management standpoint, it is important to monitor the locations and abundance of prairie dogs at the Site.

Figure 265 shows the locations of prairie dog towns in the COU and on the adjacent POU property as of 2008. In July 2009, no prairie dogs were present at either of the two southern locations, and only three or four individuals were observed at the northern location. Investigation of the prairie dogs' disappearance revealed that an outbreak of plague had occurred in the colonies east of the POU on the adjacent Westminster Hills Open Space/Dog Park (Jefferson

County 2009). Plague is an infectious disease caused by *Yersinia pestis*, a bacterium found in fleas that pass on the bacterium to wild rodents by biting them. Prairie dogs are susceptible to plague, and it is not uncommon for colonies to be wiped out by plague every few years.

Throughout the remainder of 2009, no prairie dogs were observed within the COU. In 2010, observations of the towns throughout the year have shown that no prairie dogs have returned to the two southern locations shown, and only a few individuals have been seen at the northern location on the Refuge. In spring of 2010, three individual prairie dogs were observed roaming along the roads at the Site (Figure 265). They typically travel beyond their existing towns in search of other potential burrow locations at this time of year. However, except for the sightings at the north town, observations throughout the remainder of the year across the COU and at the previously occupied prairie dog towns have shown no presence of the animals. Fortuitous monitoring of these locations will continue throughout the year to determine whether the prairie dogs have returned.

3.2.3.2 Mountain Bluebird Nest Box Monitoring

All eight of the functioning nest boxes in the COU (one was destroyed when the tree fell over) showed evidence of nesting activity in 2010. Five boxes were used by house wrens (*Troglodytes aedon*), two with active nests (birds were observed entering and exiting the nest box, so it was presumed active) and three filled with twigs. The male house wrens fill nesting cavities with twigs, and the female then selects which ones are suitable for nesting. The other three nest boxes had active tree swallow (*Tachycineta bicolor*) nests in them. No mountain bluebirds were observed nesting in any of the nest boxes in 2010. General observations at the Site in spring 2010 did not note any mountain bluebirds migrating through this year. However, in October, some mountain bluebirds were observed at the Site, evidently starting their migration south. Monitoring of nesting activity in the nest boxes will continue in the future and additional nest boxes may be installed as funding allows.

3.2.3.3 Raptor Nesting Observations

Figure 266 shows the locations of three active raptor nests within the COU and one outside the COU on the Refuge. Two great-horned owl (*Bubo virginianus*) nests were present in the COU this year—one in North Walnut Creek and one in Woman Creek. Each nest had a pair of young birds that fledged. The owls in North Walnut Creek nested in an abandoned red-tailed hawk (*Buteo jamaicensis*) nest in the top of a plains cottonwood (*Populus deltoides*) tree. This nest is approximately 200 feet from the Solar Ponds Plume Treatment System (SPPTS), where work is conducted daily during the work week. This nest even had a nesting deterrent in the tree, which consisted of a rope tossed over a branch (just beneath the nest) with large trash bags tied into it and pulled into the top of the tree. In the past, the flapping of the trash bags had created enough noise and disturbance to prevent hawks from nesting there. However, it did not work as a deterrent for the owls, as they did not seem to mind the flapping bags or constant activity at the SPPTS. The owls were often observed watching the activities at the SPPTS or sleeping. The owl nest in Woman Creek was west of the C-2 Pond along the road in a peachleaf willow (*Salixamygdaloides*) tree. The young owls at both locations left their nests during the week of May 24, 2010.

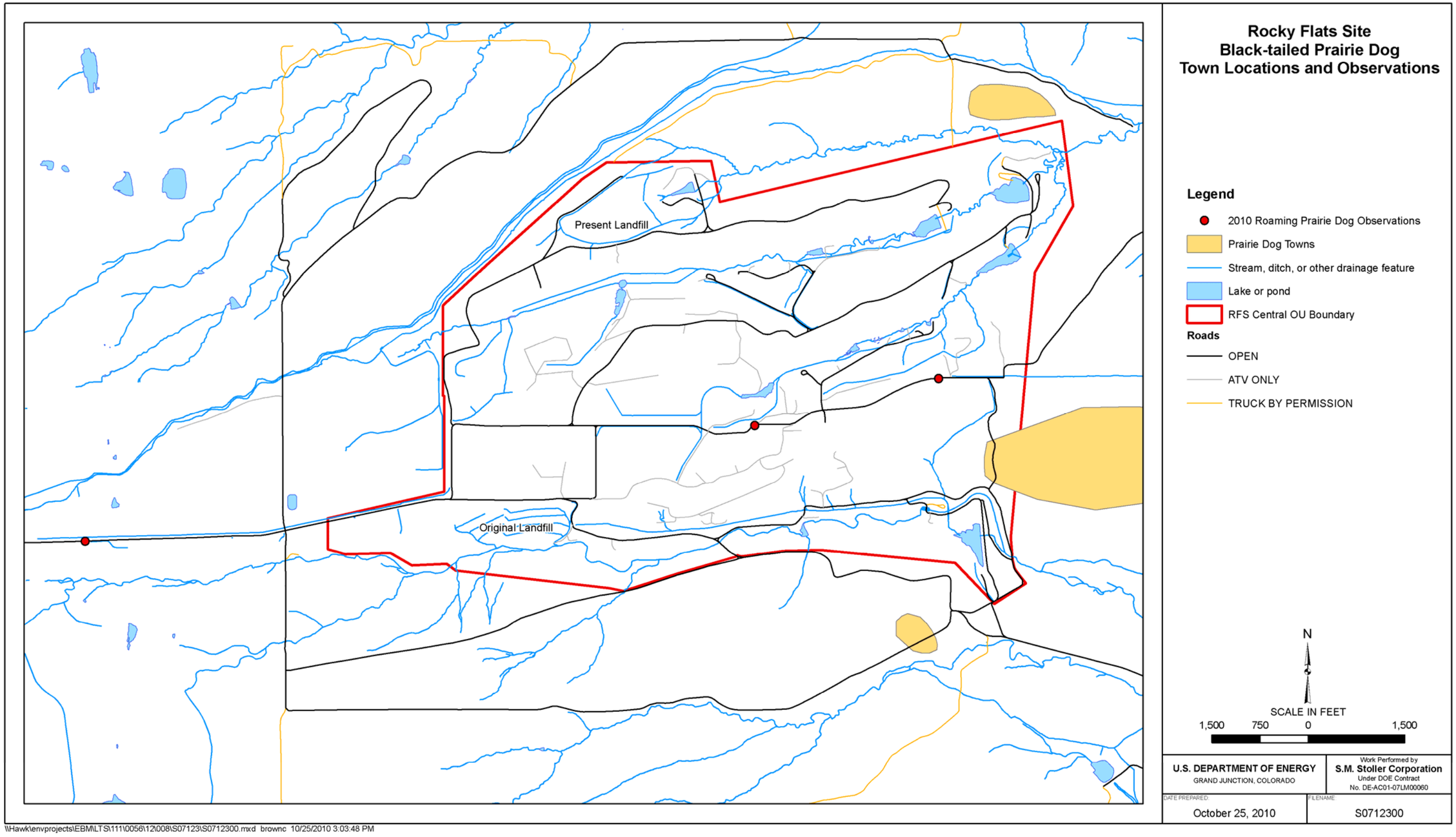

Figure 265. Rocky Flats Site Black-tailed Prairie Dog Town Locations and Observations

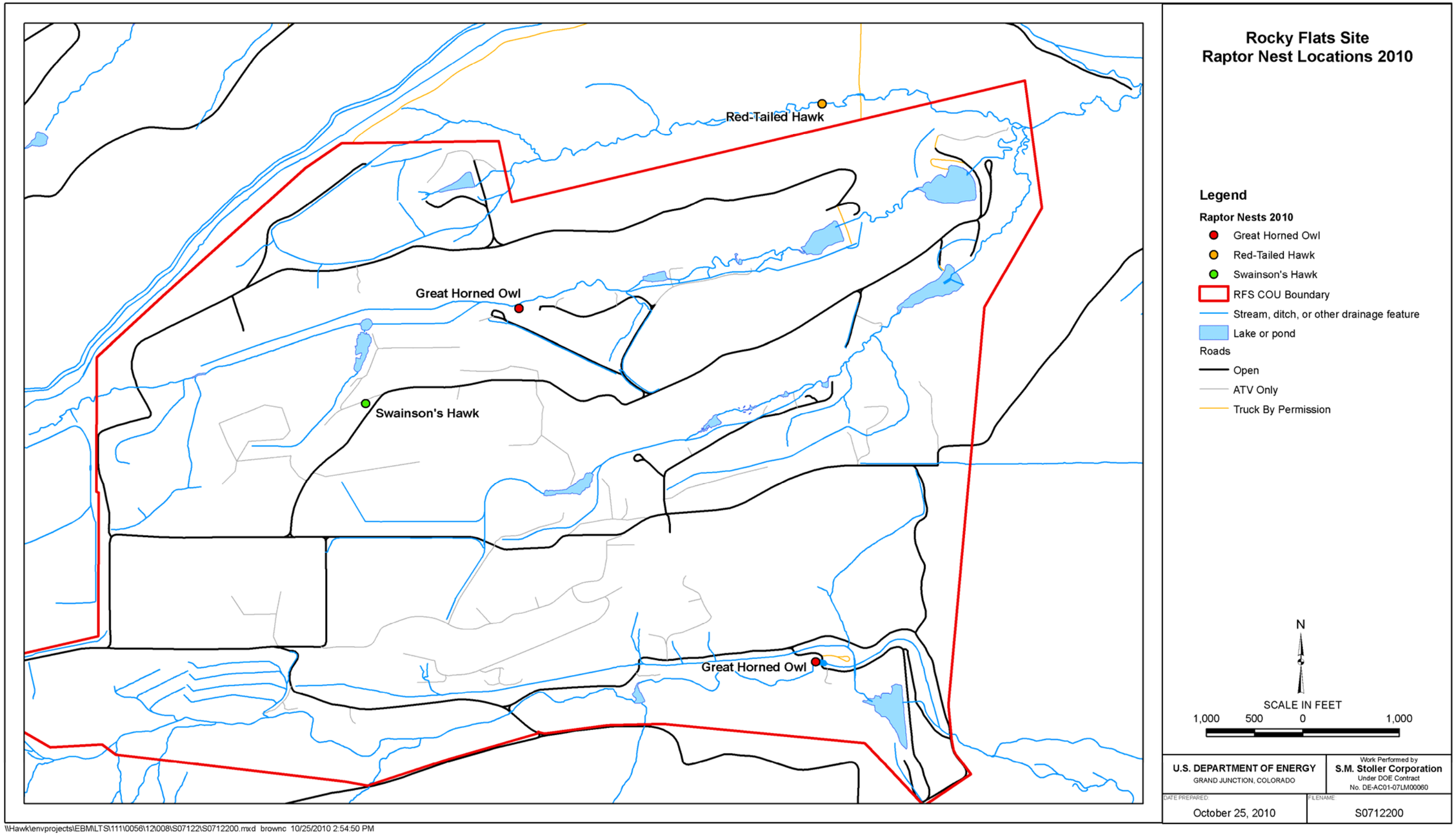

Figure 266. Rocky Flats Site Raptor Nest Locations 2010

A pair of Swainson's hawks (*Buteo swainsoni*) built a nest in the top of a plains cottonwood tree near the center of the COU along a road. The nest was first observed being built the week of May 10. A single bird fledged, and it left the nest by the end of August.

A red-tailed hawk nest was also observed north of the COU fence on the RFNWR in the No Name Gulch drainage downstream of the Present Landfill. It is not known if any young fledged from this nest.

3.2.3.4 Elk Observations

Over the past decade, the elk (*Cervus elaphus*) population has continued to increase at the Site. Throughout the final few years of site closure activities, elk were observed coming on Site during the spring to calve in the upper drainages of Rock Creek, where abundant cover is available in the shrublands and riparian woodlands. Since site closure, fewer people are working at the Site, and the elk population continues to increase each year. No census data are available, but fortuitous observations of the elk herd continues to suggest a general increase in the number of individuals present at the Site. Additionally, they tend to be staying longer during the year. In the early years, they stayed only during the spring and early summer months then left the Site. In 2010, elk were observed throughout most of the year. Observations of 20 to 40 elk in a herd are not uncommon at the Site, with 7 to 9 young of the year running with the group. Bull elk with large racks and occasional bugling in the fall have also been observed.

3.2.4 Regulatory Mitigation Monitoring Summary

3.2.4.1 Preble's Meadow Jumping Mouse Mitigation Monitoring

The Preble's meadow jumping mouse is a federally listed threatened species under the Endangered Species Act that lives in most of the stream drainages at the Site. Prior to site closure, DOE conducted Section 7 consultation with the USFWS on a Programmatic Biological Assessment (PBA) that addressed closure and post-closure activities that could have a potential impact on the Preble's mouse. The resulting Biological Opinion gave approval for the activities listed in the PBA. Mitigation was required for impacts to Preble's mouse habitat. As part of the mitigation process, monitoring of the mitigation efforts and reporting was also required. In 2010, vegetation monitoring and photopoint monitoring was conducted at various Preble's mouse mitigation locations in the COU. The results were summarized in an annual report that is due to the USFWS by December 1 each year. Although the 2010 results are not discussed in this annual report, they are available in the *2010 USFWS Biological Opinion Reports for the Rocky Flats Site* (DOE 2010g).

3.2.4.2 Wetland Mitigation Monitoring

During the cleanup and closure of the Site, approximately 7.8 acres of wetlands were disturbed. In order to maintain a "no net loss" of wetlands at the Site, several mitigation wetlands were constructed to create or reestablish 7.8 acres of wetlands. Additionally new seeps and wet areas have developed at several locations throughout the COU where wetlands are developing naturally. DOE also paid for the Standley Lake Wetland Mitigation Bank that could be used if in situ wetland mitigation did not provide the total number of needed acres on site. The *Rocky Flats, Colorado, Site Wetland Mitigation Monitoring and Management Plan* (DOE 2006b)

provides guidance for monitoring the mitigation wetlands and reporting. During 2010, a total of 87 mitigation locations were monitored. Of these, 58 had final wetland delineations conducted. The remaining 29 locations will continue to be monitored until the final delineations on them are completed in the next few years. The 2010 results are not presented here, but are found in the *Rocky Flats, Colorado, Site, 2010 Annual Wetland Mitigation Monitoring Report* (DOE 2011c). This report is due to the EPA by March 1 each year.

3.2.5 Summary

The Ecology Program at the Site conducts monitoring of the ecological resources to ensure regulatory compliance and to preserve, protect, and manage those resources. Proactive management of the natural resources is critical to the long-term sustainability of the ecosystems at the Site. Noxious weeds continue to be a top priority, as does the revegetation of the COU. Data from 2010 documented the continuing establishment of vegetation at revegetation locations; several met success criteria. Noxious weed control activities and additional revegetation activities were conducted during 2010 to improve and enhance the vegetation at the Site. The monitoring results continue to provide useful information for management activities. Full, detailed reports and analyses for each field monitoring effort are presented as stand-alone reports on the Ecology DVD included with this report.

3.3 Data Management

3.3.1 Water Data

Data from samples submitted to an analytical laboratory are received in both hard copy and electronic data deliverable formats. The electronic data are loaded into an Oracle-based relational database. The environmental monitoring data are accessible using the SEEPro application. The hard-copy analytical reports are archived in the records library in Grand Junction, Colorado, along with the original field data forms and other relevant hard-copy forms or documents containing project data. Well construction and lithology logs are maintained for previously drilled wells and are produced for all new wells drilled. These logs are archived in the records library and can also be accessed electronically via the SEEPro database and the Geospatial Environmental Mapping System.

SEEPro uses Oracle software for data management and Microsoft Access for data retrieval and display. It compiles water quality, air quality, field parameter, sample-tracking, sample location, and water-level data for groundwater, surface water, boreholes, soils, and sediment samples. Field parameter data include such information as sample location, sample date, pH, turbidity, conductivity, and temperature. Chemical information (Chemical Abstracts Service registry numbers, analytical results, and detection limits) is also included. Data managers follow specific procedures for verification of database information received from subcontractors or verification of data input directly into SEEPro. These procedures provide quality assurance (QA) documentation, which ensures that available data have been incorporated and entered or uploaded properly into SEEPro. Data integrity is maintained with standardized error-checking routines used when loading data into SEEPro. Other procedures address database system security and software change control.

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The Site field data are entered through the FieldPar field data entry system. This system is a data entry module that is compatible with the SEEPro database and is used in the office by field personnel. The samplers verify data entered into FieldPar before loading the data into the main SEEPro database.

Spatial information for air and water data features is located in the LM GIS database. Some of the data features included are monitoring locations, potentiometric surfaces, plume configurations, streams/creeks, lakes/ponds, topographic contours, and historical Site facilities. This system uses an ESRI ArcGIS suite of software to store and present data. Automated monitoring locations and other sample location data features are derived from location information stored in the SEEPro database.

Analytical results for water samples for the fourth quarter of CY 2010 are provided in Appendix B.

3.3.2 Ecology Data

Ecological data have been collected at the Site for many years. Since the early 1990s, ecological data have been kept in electronic files for easier access, retrieval, and analysis. In the mid-1990s, the Sitewide Ecological Database (SED) was established as a master data set for the various types of ecological data collected at the Site. The SED is a Microsoft Access database that contains all quality-assured ecological data for RFETS from early 1993 through the end of 2001. Data that did not meet the QA objectives are not included in the database. Ecology data in the SED include vegetation monitoring, weed control and controlled burn vegetation monitoring, wildlife surveys (including birds, small mammals, frogs, insects, and fish), Preble's mouse habitat characterization and telemetry tracking, a small amount of soil characterization survey data (for revegetation issues), and a few other types of ecological data. The SED does not contain data on potential contaminants, nor is it linked to any GIS or other geospatial tool. The data in the SED are primarily observational or catch-and-release; they are considered raw data taken directly from field logbooks and datasheets. The SED is not intended as a reference for the layperson. It is a repository of quality-assured raw field data collected by Site ecologists and cannot be taken out of context of the methods used to collect the data. Data collection methods are not stored in the database, they are described in reports and field sampling plans.

From 2002 to the present, the ecology data have been stored as separate data sets by sample type, event, and year. Depending on the data set, the data may be in a Microsoft Access database or in a Microsoft Excel spreadsheet format. The nonspatial electronic ecology data are stored on the servers at the Site in Westminster, Colorado, or on backup electronic media.

Spatial ecology data for the Site are available for several data types and are stored in the GIS on the servers in Grand Junction, Colorado. The types of ecological spatial data that are available include annual weed distribution data (for selected species), annual weed control locations, biocontrol release locations, vegetation and wildlife monitoring locations (transect endpoints and sample points), vegetation community classifications, Preble's mouse habitat, wetland locations, wildfire/prescribed burn locations, Preble's mouse and wetland mitigation work, and rare plant locations. These data are available in various ArcGIS-compatible formats. In addition to these types of spatial data, orthorectified aerial and satellite imagery is also available for the Site for different time frames, including pre- and post-closure.

3.4 Validation and Data Quality Assessment

Data validation and verification (V&V) during CY 2010 was performed by Legacy Management Support contractor personnel at the Grand Junction, Colorado, office. Data quality assessment (DQA) is performed by personnel at the Site. The following section distinguishes DQA from data validation and discusses the technical basis, equations, and criteria used in the DQA of the water sampling analytical data.

3.4.1 General Discussion

Data validation is the principal means of assessing the usability of water analytical data. Validation also improves overall data quality by allowing the laboratory coordinator to closely monitor laboratory performance and to provide feedback to each laboratory regarding its ability to produce quality data that meets subcontract requirements. The laboratory coordinator may also use the results of data validation to direct analytical work to laboratories that demonstrate superior performance by generating timely, high-quality analytical data for the Site.

Data validation is a rigorous data review performed by the laboratory coordinator or designee on all of the water analytical data generated by the Site. Additionally, the Site lead may request a secondary detailed validation on a case-by-case basis. Data validation is currently performed as specified in Stoller *Environmental Procedures Catalog* (LMS/PRO/S04325), "Standard Practice for Validation of Laboratory Data." This procedure is based on the following EPA documents:

- EPA 2010b, *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, USEPA-540-R-10-011, October;
- EPA 2008, *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, USEPA-540-R-08-01, June;
- EPA 2001, *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review*, EPA-540-R-00/006, June; and
- EPA 1997, *Evaluation of Radiochemical Data Usability*, Office of Environmental Management, ES/ER/MS-5, April.

All water analytical data collected by the Site are considered valid unless data validation identifies analytical problems that require the data to be qualified. When it is necessary to qualify individual data records, standard qualifier codes (alphanumeric validation codes) are applied.

Common data qualifiers used by LM are defined below. Refer to *Environmental Procedures Catalog*, "Standard Practice for Validation of Laboratory Data" for formal definitions.

- U For organic and inorganic analytes, the analyte was not detected at a concentration greater than the method detection limit. For radiochemistry, the analyte was not detected at a concentration greater than the decision-level concentration.
- J The associated numerical value is an estimated quantity.
- R The data are unusable (analyte may or may not be present). Resampling and reanalysis are necessary for verification.

Data validation includes the evaluation of laboratory Quality Control (QC) data such as method blanks, laboratory control samples (LCSs), and spike recoveries. Adherence to sample and extract holding times, standard analytical methods, contractual requirements, and proper documentation are also verified.

Although DQA and data validation examine some of the same QC data, they do so from different perspectives. DQA (in this report) looks at the overall quality of an entire year of water data, in contrast to validation, which looks at the analytical details of individual data packages. Data validation focuses on laboratory performance, while DQA focuses on interpretation of data describing QC samples that originated in the field, such as field duplicate samples and equipment rinsate samples.

In contrast to data validation, the DQA performed by personnel at the Site does not assign data qualifiers to individual analytical results or data packages. DQA is a second level of QA intended to be a general assessment of how well the water data collection program is operating. The DQA is performed by evaluating water quality data in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

3.4.2 PARCC Parameters

Use of the PARCC parameters for DQA has been promoted by EPA guidance documents. Accuracy and precision are quantitative measures. Representativeness and comparability are qualitative measures. Completeness is a combination of both quantitative and qualitative measures.

Site personnel evaluate the PARCC parameters by following guidelines published in these former QC documents:

- RMRS 1998, *Procedure for Evaluation of Data for Usability*;
- RMRS 2000b, *Quality Assurance Program Plan for the Automated Surface-Water Monitoring Program*, RF/RMRS-2000-013, Revision 0 ; and
- RMRS 2001, *Quality Assurance Program Plan for the Groundwater Monitoring Program Rocky Flats Environmental Technology Site*.

The following sections discuss the PARCC parameters and the types of data available to assess them.

3.4.2.1 Criteria for Precision

The precision of a measurement is an expression of the agreement between duplicate measurements of the same property taken under similar conditions. Precision can be expressed quantitatively by the relative percent difference (RPD) between real and field duplicate samples for metals, VOCs, polychlorinated biphenyls, and water quality parameters (WQPs) as defined by the following equation:

$$RPD = \frac{|(S - D)|}{(S + D)/2} \times 100$$

where: S = Concentration of analyte in the real sample,
D = Concentration of analyte in the duplicate sample, and
RPD = relative percent difference.
Nondetects are not included.

The Site uses the duplicate error ratio (DER) to quantify the precision of radionuclide activity data:

$$DER = \frac{|(S - D)|}{\sqrt{\left[(TPU_S)^2 + (TPU_D)^2\right]}}$$

where: DER = Duplicate error ratio,
S = Sample result,
D = Duplicate (or lab replicate) result,
TPU_S = Total propagated uncertainty of the sample,
TPU_D = Total propagated uncertainty of the duplicate.

Because total propagated uncertainty is seldom reported with radionuclide activity data, the two-sigma error or random counting error has been substituted for total propagated uncertainty in the U, Am, and Pu calculations made for this report.

The Site QC criterion for water RPDs is that individual RPDs should be ≤30 percent. The analogous criterion for DERs is ≤1.96. The overall goal for the water data set is to have 85 percent of the RPD and DER values comply with the QC criteria.

3.4.2.2 Criteria for Accuracy

Accuracy is the degree of agreement for a measurement with an accepted reference or true value and is a measure of the bias in a system. The closer the measurement is to the true value, the more accurate the measurement. The Site validation process is the principal means for evaluating the accuracy of analytical results.

Because the Site V&V process compares the actual analytical methods used by each laboratory to the contract-required analytical methods, the Site does not repeat this evaluation.

Matrix spike (MS) and matrix spike duplicate (MSD) recoveries are reported by the analytical laboratories for most nonradionuclide analytical suites. Criteria for acceptable MS recoveries vary between laboratories, depending on the analyte and the analytical method. The Site criterion for acceptable MS results ranges from 75 to 125 percent recovery.

LCS recoveries for radionuclides are often available for water quality data. Laboratories in practice will commonly accept LCS values in the range of 70 to 130 percent. LCS percent recoveries between the 70 to 130 percent laboratory range and the 75 to 125 percent QC range required by the Site laboratory contracts are examined by data validators for acceptability on an analyte-by-analyte basis. The Site criterion for acceptable LCS recoveries ranges from 75 to 125 percent recovery.

Because some laboratories reported LCS results in picocuries per liter, while others calculated percent recovery, the Site uses the “relative bias” reporting criterion. The relative bias criterion is

defined in the Basic Ordering Agreement by the following formula (see Page J-6 of the National Basic Ordering Agreement, Section 2.3.2.5):

Relative Bias = (Observed – Known) ÷ Known

where: Observed = measured activity of LCS standard (pCi/L),
Known = known activity of LCS standard (pCi/L).

Acceptable values for relative bias results range from –0.25 to +0.25.

3.4.2.3 Criteria for Representativeness

Representativeness in DQA is limited to an evaluation of whether analytical results for field samples are truly representative of environmental concentrations, or whether they may have been influenced by the introduction of contamination during collection and handling. The potential introduction of contamination is commonly evaluated by examination of the analytical results for equipment rinsates.

Equipment rinsates are used to assess the efficacy of the process used to clean and decontaminate water sampling equipment. Analytes detected in rinsate samples indicate possible cross-contamination between environmental samples. Rinsates are samples of analyte-free distilled or deionized water that has been poured over or through decontaminated sampling equipment and subsequently handled in the same manner as environmental samples. For flow-paced composite samples that are collected over time in carboys, a location-specific "rinse carboy" is prepared using distilled water. This carboy is treated the same as other surface-water samples from that location and analyzed for the same parameters. Analytical data for these rinse carboys are used to assess how well the carboys were cleaned between field deployments and to determine whether contamination was introduced during sample preparation.

Although rinsates are used specifically as indicators of cross-contamination from improper decontamination of equipment, they are carried through the entire sampling, shipping, and laboratory process. Therefore, they are good indicators of potential contamination introduced during any of these steps.

3.4.2.4 Criteria for Completeness

A qualitative measure of completeness is the rate of successful sampling. The DQA verifies that all planned samples were collected, unless insufficient water was available for sampling. The completeness goal for successful sampling is the collection of at least 90 percent of the planned samples. However, the availability of water is outside the control of the Site. If all required stations were visited, sampling completeness is considered acceptable.

Completeness as a quantitative measure of data quality may be expressed as the percentage of valid or acceptable data obtained from a measurement system. The Site tracks analytical laboratory performance through both the shipment of samples to the laboratory and the receipt of data from the laboratory. The Site also evaluates data completeness using the following formula:

$$Completeness = DP_u = \frac{DP_t - DP_n}{DP_t} \times 100$$

where: DP_u = Percentage of usable data points
DP_t = Total number of data points
DP_n = Nonusable (rejected) data points

The completeness criterion is having ≥90 percent valid samples.

3.4.2.5 Criteria for Comparability

Comparability is a qualitative parameter. Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Samples are collected in accordance with Site standard operating procedures, transported according to Site standard operating procedures and U.S. Department of Transportation shipping regulations, and analyzed using standard EPA or nationally recognized analytical methods. These criteria help to ensure comparability of results with other analyses performed in a similar manner.

The laboratory coordinator or designee verifies that laboratory analyses are performed according to the standard protocols specified by the Site subcontract to each laboratory. Therefore, the analytical results should be comparable to data produced by similar methods.

3.4.3 Water DQA Results for CY 2010

Data used to evaluate the PARCC parameters are included in the available CY 2010 analytical data generated by the laboratories. These include analyses of field duplicate and rinsate QC samples submitted to the laboratory, and laboratory-generated QA/QC samples such as LCSs. ***This PARCC evaluation is limited to analyses at routine RFLMA locations, for samples collected by routine protocol, and for analytes that are listed in Table 1 of RFLMA Attachment 2***.[23] By limiting the evaluation to RFLMA locations, sample protocols, and analytes, more targeted and accurate assessment is made for analytes that have water quality standards applicable to the Site. The DQA of these analyses is discussed below by each PARCC parameter.

During CY 2010, 114 locations were sampled one or more times. This resulted in a total of 497 water samples collected.[24] During CY 2010, 1,237 bottles of water were submitted to analytical laboratories for analysis. Table 95 breaks this data down by sample type.

Table 95. CY 2010 Sample Type Breakdown

	Unique Water Samples	Unique Bottle Codes
Primary samples (REALs)	469	1,098
Field duplicates (DUPs)	28	80
Rinsates (RNSs)	20	59
Totals	517	1,237

[23] Hardness and total suspended solids are also included, though these analytes are not listed in Table 1 of RFLMA Attachment 2.
[24] This is the sum of real and duplicate samples for unique sampling events.

3.4.3.1 Precision During CY 2010

DERs are indicators of precision for radionuclide analyses. The QC criterion for precision requires that individual DER values should be ≤1.96, and overall the data set should have ≥85 percent compliance with the criterion. Appendix Table B−1 is a tabulation of the DER values for CY 2010 radionuclide analyses. The table has been sorted by the DER parameter so that the range of values is apparent. The DER range is from 0.06 to 1.47.

Table 96 summarizes the DER findings of Table B−1 and indicates if the 85 percent goal has been met. Overall, 100 percent of the DER data are in compliance with the criterion, indicating excellent precision for radionuclide analyses.

Table 96. Summary of DER Values

Analyte Group	Total Number of DER Results	Number of Unacceptable Results DER >1.96	Number of Acceptable Results	Percentage Acceptable	Goal Met
Radionuclides	20	0	20	100	Yes

The RPD between real and field duplicate sample results is an indicator of precision for nonradionuclide analyses. Individual RPD values should be ≤30 percent, and at least 85 percent of the RPDs should comply with the criterion. Appendix Table B−2 tabulates RPD values and is sorted first by analyte suite, then by RPD, in order to highlight the RPD range of each suite. RPD values ranged from 0.0 percent to 95.8 percent for metals, 0.5 percent to 115 percent for WQPs, and 0.0 percent to 72.7 percent for VOCs/SVOCs.

Table 97 summarizes the RPD findings of Table B−2 and indicates if the 85 percent goal has been met. During CY 2010, the RPD goal was met for all analyte groups. Overall, the nonradionuclide data had 94.2 percent acceptable RPDs and therefore exceeded the 85 percent goal.

Table 97. Summary of RPD Values

Analyte Group	Total Number of RPD Results	Number of Unacceptable Results RPD >30%	Number of Acceptable Results	Percentage Acceptable	Goal Met
Metals	39	2	37	94.9	Yes
WQPs	7	1	6	85.7	Yes
VOCs/SVOCs	40	2	38	95.0	Yes
Totals	86	5	81	94.2	Yes (overall)

3.4.3.2 Accuracy During CY 2010

MS recoveries provide another measure of accuracy. Appendix Table B−3 displays recoveries for 1,536 MS and MSD analytical records for metals, VOCs/SVOCs, and WQPs. These data are summarized in Table 98. All individual suites met the goal with greater than 90 percent of their spike recoveries falling in the acceptable range. Overall, across all analytical suites, the percentage of acceptable MS/MSD results was 96.7 percent.

Table 98. Summary of MS and MSD Recovery Data

Analyte Group	Total Number of MS & MSD Results	Number of Low Results Below 75%	Number of High Results Above 125%	Number Acceptable	Percentage Acceptable	Goal Met
Metals	578	4	0	574	99.3	Yes
WQPs	118	5	0	113	95.8	Yes
VOCs/SVOCs	840	33	8	799	95.1	Yes
Totals	1,536	42	8	1,486	96.7	Yes (overall)

Appendix Table B−4 contains 156 relative bias values for LCSs. These are used by the Site to evaluate the accuracy of radionuclide analyses. The QC criterion for the acceptable range of relative bias values is from –0.25 to +0.25. During CY 2010, the bias ranged from −0.25 to +0.140. All of the data met the QC criterion.

LCS results for nonradionuclide suites were available for metals, VOCs/SVOCs, and WQPs (including anions). These LCS recoveries are tabulated in Appendix Table B−5, which is sorted by analyte group, then by percent recovery. There are 430 LCS data records for metals. The LCS recoveries for metals fell in the range 80.4 percent to 116 percent and were all within the 75 percent to 125 percent acceptable QC range. There are 1,077 LCS data records for VOCs/SVOCs. LCS recoveries for VOCs/SVOCs fell between 34.0 percent and 130 percent. Fifty-three records are outside the 75 percent to 125 percent acceptable QC range (95.1 percent acceptable). There are 164 LCS data records for WQPs. LCS recoveries for WQPs fell between 88 percent and 114 percent and were all acceptable. Overall for nonradionuclides, 96.8 percent of the LCS recoveries indicate that CY 2010 water analytical data for metals, VOCs/SVOCs, and WQPs are of high accuracy.

Another aspect of accuracy is "rejected data." Out of 10,308 analytical records representing reals, duplicates, and rinsates during CY 2010, one record was rejected (R qualified) during data V&V. Another way to state this is that 99.99 percent of the analytical data collected during the year were considered to be valid and usable.

3.4.3.3 Representativeness During CY 2010

As defined earlier, representativeness is an evaluation of the sampling procedure for its ability to reflect the true concentrations of contaminants in water. The Site uses equipment rinsate samples (and "rinse carboys") to determine whether contamination is introduced from improper or incomplete decontamination of the sampling equipment.

During CY 2010 a total of 435 rinsate analytical records were generated for metals, radionuclides, VOCs/SVOCs, and WQPs. The majority of these records lack evidence of contamination. The remaining 10 records are tabulated in Appendix Table B−6. Three of these are "B"-qualified metals data, which constitute only weak evidence of contamination. The B qualifier for inorganics indicates that the concentrations are above the instrument detection limit but below the contract required detection limit. All the remaining records are "J"-qualified, indicating an estimated value.

Overall, there is very little evidence of introduced contamination during CY 2010 water sampling and shipping activities. Most of the 435 rinsate records appear to be clean. Therefore, water quality data for the year are judged to be representative of the actual water concentrations.

Because all required sampling locations were visited, and the samples that could be collected were analyzed, analyses for the year are judged to be representative with respect to spatial coverage.

3.4.3.4 Completeness During CY 2010

If sufficient water is available for sampling, the goal is to have 100 percent successful sampling of all required locations. However, the availability of water is beyond the control of the samplers. Surface-water monitoring during CY 2010 targeted sampling at 17 RFLMA surface-water sampling locations. In actuality, samples were collected at 16 sites and were submitted to the laboratory for analysis; one location, PLFPONDEFF was not required to be sampled in CY 2010 according to the RFLMA monitoring protocols. Groundwater monitoring during CY 2010 targeted sampling at 91 wells. In actuality, samples were collected at 90 wells and were submitted to the laboratory for analysis. One location, Sentinel well 95299, was dry. Treatment system monitoring during CY 2010 targeted sampling at eight locations; samples were collected at all eight locations and were submitted to the laboratory for analysis. Because dry locations do not count against sampling success rates (being beyond the control of samplers), success rates for surface water, groundwater, and treatment system sampling are all 100 percent.

V&V completeness is summarized in Table 99. This table compiles, by analyte group, the total number of data points for reals, duplicates, and rinsate samples. It then subtracts rejected data points (one for 2010) as well as points that lack validation qualifiers (zero for 2010). The result is the net number of usable validated or verified data points, and this is expressed as percent usable data, or percent V&V completeness. The QC goal for completeness is ≥90 percent.

Table 99. Summary of V&V Data Completeness

Analyte Group	Number of Data Points	Number of Unvalidated Points	Number Rejected	Net Usable Points	Percent Completeness	Goal Met
Metals	1,229	0	0	1,229	100.0	Yes
Radionuclides	268	0	0	268	100.0	Yes
WQPs	225	0	1	224	99.6	Yes
VOCs/SVOCs	8,586	0	0	8,586	100.0	Yes
	Sum of Number of Data Points	**Sum of Number of Unvalidated Points**	**Sum of Number Rejected**	**Sum of Net Usable Points**	**Overall Completeness**	**Goal Met**
Totals	**10,308**	**0**	**1**	**10,308**	**99.99**	**Yes**

Validation completeness for all suites was nearly 100.0 percent and exceeded the completeness goal. Therefore, from the perspective of V&V completeness, the CY 2010 water data are acceptable.

Another measure of completeness is that an adequate number of QC samples (field duplicates and equipment rinsates) must be collected to meet QC requirements. The recommended frequency for collecting duplicate samples is 1 duplicate (DUP) per 20 or fewer primary (REAL) water samples. In other words, duplicates should be collected at a 5 percent or greater frequency per REAL sample. Like duplicates, rinsate samples (RNS) are also to be collected at a 5 percent or greater rate.

The sample collection frequencies of REAL, DUP, and RNS samples are tabulated by analyte group in Table 100. The ratios of REAL/DUP samples shown meet water program QC goals with 1 DUP per 13.4 REALs. Across all analyte suites and samples collected during the year, the overall frequency of duplicates was 7.46 percent, exceeding program goals (≥5 percent).

The ratios of REAL/RNS samples shown in Table 100 did not quite meet water program QC goals with 1 RNS per 21.1 REALs. Across all analyte suites and samples collected during the year, the overall frequency of rinsates was 4.73 percent, just missing program goals (≥5 percent). This deficiency is due to the use of dedicated sampling equipment at many wells; since the equipment is dedicated, RNSs are not required to indicate effective equipment decon between sampling events.

Table 100. Summary of Field QC Samples and Data Records

Analyte Group	Number of Locations Sampled for REALs	Number of Locations Sampled for DUPs	Ratio REALs/ DUPs (Goal <20)	Ratio REALs/ RNSs (Goal <20)	Number REAL Records	Number DUP Records	Number RNS Records	Total Records
Metals	75	17	9.68	13.8	1,045	108	76	1,229
Radionuclides	11	8	11.2	9.33	224	20	24	268
WQPs	42	7	23.4	42.2	211	9	5	225
VOCs/SVOCs	94	11	14.1	23.4	7,708	548	330	8,586
		Totals	**13.4**	**21.1**	**9,188**	**685**	**435**	**10,428**
		Percentages				**7.46%**	**4.73%**	

3.4.3.5 Comparability During CY 2010

No significant changes were made to water sampling or analytical procedures during CY 2010. Therefore, the analytical data generated during the year should be generally comparable to corresponding analyses from previous years.

4.0 References

ATSDR (Agency for Toxic Substances and Disease Registry), 2007. *Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present Day Conditions*, Chapter D, "Properties and Degradation Pathways of Common Organic Compounds in Groundwater," Atlanta, Georgia, September.

Burke, Patricia M., Steven Hill, Nenad Iricanin, Cynthia Douglas, Patrick Essex, and Danielle Tharin, 2002. "Evaluation of preservation methods for nutrient species collected by automatic samplers," *Environmental Monitoring and Assessment*, 80 (2): 149–173, December.

Carter, R.W. and J. Davidian, 1968. *General Procedure for Gaging Streams: U.S. Geological Survey Techniques of Water-Resources Investigations*, Book 3, Chapter A6.

CDPHE (Colorado Department of Public Health and Environment), DOE (U.S. Department of Energy), and EPA (U.S. Environmental Protection Agency), 1996. *Final Rocky Flats Cleanup Agreement*, Federal Facility Agreement and Consent Order, CERCLA VIII-96-21 RCRA (3008[h]) VIII-96-01, State of Colorado Docket #96-07-19-01, July 19.

CNHP (Colorado Natural Heritage Program), 1994. *Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation*, Phase 1: Rock Creek, Final Report, Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

CNHP (Colorado Natural Heritage Program), 1995. *Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation*, Phase 2: The Buffer Zone, Final Report, Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

DOE (U.S. Department of Energy), 2004. *Final Interim Measures/Interim Remedial Action for IHSS 114 and RCRA Closure of the RFETS Present Landfill*, "Appendix B: Post-Accelerated Action Monitoring and Long-Term Surveillance and Monitoring Considerations," Golden, Colorado.

DOE (U.S. Department of Energy), 2005a. *Final Interim Measure/Interim Remedial Action for the Original Landfill (Including IHSS Group SW-2; IHSS 115, Original Landfill and IHSS 196, Filter Backwash Pond),* March 10.

DOE (U.S. Department of Energy), 2005b. *Closeout Report for Surface Water Station SW056 Outfall,* November.

DOE (U.S. Department of Energy), 2006a. *Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit*, September 29.

DOE (U.S. Department of Energy), 2006b. *Rocky Flats, Colorado, Site Wetland Mitigation Monitoring and Management Plan*, June.

DOE (U.S. Department of Energy), 2006c. *Rocky Flats Site 2006 Integrated Monitoring Plan Background Document*, July.

DOE (U.S. Department of Energy), 2007a. *Rocky Flats Legacy Management Agreement*, March 14. Includes modifications to Attachment 2, dated March 2008.

DOE (U.S. Department of Energy), 2007b. *Erosion Control Plan for the Rocky Flats Property Central Operable Unit*, July.

DOE (U.S. Department of Energy), 2007c. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2006*, DOE-LM/1455-2007, April.

DOE (U.S. Department of Energy), 2008a. *Present Landfill Monitoring and Maintenance Plan and Post-Closure Plan*, *U.S. Department of Energy Rocky Flats Site*, March.

DOE (U.S. Department of Energy), 2008b. *Ecological Monitoring Methods Handbook for the Rocky Flats, Colorado, Site*, September.

DOE (U.S. Department of Energy), 2008c. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2007*, April.

DOE (U.S. Department of Energy), 2009a. *Original Landfill Monitoring and Maintenance Plan, U.S. Department of Energy Rocky Flats Site*, September.

DOE (U.S. Department of Energy), 2009b. *Rocky Flats, Colorado, Site Revegetation Plan*, January.

DOE (U.S. Department of Energy), 2009c. *Rocky Flats, Colorado, Site Vegetation Management Plan*, January.

DOE (U.S. Department of Energy), 2009d. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2008*, April.

DOE (U.S. Department of Energy), 2010a. *Operations and Maintenance Plan for Rocky Flats Surface Water Control Project*, January.

DOE (U.S. Department of Energy), 2010b. *Operations and Maintenance Manual for the Rocky Flats Groundwater Treatment Systems*, January.

DOE (U.S. Department of Energy), 2010c. *Rocky Flats Site Quarterly Report of Site Surveillance and Maintenance Activities, First Quarter Calendar Year 2010*, July.

DOE (U.S. Department of Energy), 2010d. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2009*, April.

DOE (U.S. Department of Energy), 2010e. *Rocky Flats Site Quarterly Report of Site Surveillance and Maintenance Activities, Second Quarter Calendar Year 2010*, October.

DOE (U.S. Department of Energy), 2010f. *Emergency Response Plan for the Rocky Flats Site Dams*, January.

DOE (U.S. Department of Energy), 2010g. *2010 U.S. Fish and Wildlife Biological Opinion Report for the Rocky Flats Site*.

DOE (U.S. Department of Energy), 2011a. *Rocky Flats Site Operations Guide*, January.

DOE (U.S. Department of Energy), 2011b. *Rocky Flats Site Quarterly Report of Site Surveillance and Maintenance Activities, Third Quarter Calendar Year 2010*, January.

DOE (U.S. Department of Energy), 2011c. *Rocky Flats, Colorado, Site, 2010 Annual Wetland Mitigation Monitoring Report.*

EG&G, 1995a. *Hydrogeologic Characterization Report, Volume 2 of the Sitewide Geoscience Characterization Study*, EG&G Rocky Flats, Golden, Colorado, February.

EG&G, 1995b. *Geologic Characterization Report, Volume 1 of the Sitewide Geoscience Characterization Study*, EG&G Rocky Flats, Golden, Colorado, February.

Environmental Procedures Catalog, LMS/PRO/S04325, continually updated. Prepared by S.M. Stoller Corporation, Legacy Management Support contractor for U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

EPA (U.S. Environmental Protection Agency), 1997. *Evaluation of Radiochemical Data Usability*, Office of Environmental Management, ES/ER/MS-5, April.

EPA (U.S. Environmental Protection Agency), 2000. *Engineered Approaches to In Situ Bioremediation of Chlorinated Solvents: Fundamentals and Field Applications*, Office of Solid Waste and Emergency Response, EPA 542-R-00-008, July.

EPA (U.S. Environmental Protection Agency), 2001. *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review*, EPA540-R-00/006, June.

EPA (U.S. Environmental Protection Agency), 2008. *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, USEPA-540-R-08/01, June.

EPA (U.S. Environmental Protection Agency), 2010a. Report of Findings Revegetation Assessment, Rocky Flats Site, Jefferson County, CO. Prepared by ESCO Associates Inc., October.

EPA (U.S. Environmental Protection Agency), 2010b. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA540/R-10/011, January.

Friedlander, G., J.W. Kennedy, E.S. Macias, and J.M. Miller, 1981. *Nuclear and Radiochemistry*, 3rd Edition, John Wiley and Sons.

GPFA (Great Plains Flora Association), 1986. *Flora of the Great Plains*, 2nd printing with 1991 supplement, University Press of Kansas, Lawrence, Kansas.

Jefferson County, 2009. "Re: Plague Confirmed in Jefferson County Prairie-Dog Population," Jefferson County Department of Health and Environment, Jefferson County, Colorado, July 15, 2009. http://www.jeffco.us/news/news_item_T3_R1441.htm (accessed December 2, 2009).

K-H (Kaiser-Hill Company, LLC), 2000a. *Quarterly Report for the Rocky Flats Groundwater Plume Treatment Systems: January through March 2000*, March 30.

K-H (Kaiser-Hill Company, LLC), 2000b. *Quarterly Report for the Rocky Flats Groundwater Plume Treatment Systems: April through June 2000*, June 30.

K-H (Kaiser-Hill Company, LLC), 2000c. *Quarterly Report for the Rocky Flats Groundwater Plume Treatment Systems: July through September 2000*, September 30.

K-H (Kaiser-Hill Company, LLC), 2000d. *Quarterly Report for the Rocky Flats Groundwater Plume Treatment Systems: October through December 2000*, December 31.

K-H (Kaiser-Hill Company, LLC), 2001. *Final PU&D Yard Plume Enhanced Natural Attenuation Treatability Study Report*, September.

K-H (Kaiser-Hill Company, LLC), 2002. *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems: January through December 2001*, March.

K-H (Kaiser-Hill Company, LLC), 2003. *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems: January through December 2002*, May 2.

K-H (Kaiser-Hill Company, LLC), 2004a. *Statistical Methods for Trending Groundwater Quality Data*, 04-RF-01164, November.

K-H (Kaiser-Hill Company, LLC), 2004b. *Final 2002 Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site*, RFETS-2002-RFCA-GWMR, February.

K-H (Kaiser-Hill Company, LLC), 2004c. *Uranium in Surface Soil, Surface Water, and Groundwater at the Rocky Flats Environmental Technology Site*, June.

K-H (Kaiser-Hill Company, LLC), 2004d. *Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats*, March.

K-H (Kaiser-Hill Company, LLC), 2005a. *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems: January through December 2003*, January 31.

K-H (Kaiser-Hill Company, LLC), 2005b. *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Treatment Systems: January 2003 through December 2004*, August.

K-H (Kaiser-Hill Company, LLC), 2005c. *Closeout Report for IHSS Group 900-2 (IHSS 900-153 – Oil Burn Pit No. 2, and IHSS 900-154 – Pallet Burn Site)*, Golden, Colorado, June.

Legacy Management CERCLA Sites Quality Assurance Project Plan, LMS/PLN/S04353, continually updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

Rantz, S.E., 1982a. *Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge,* U.S. Geological Survey Water-Supply Paper 2175, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C.

Rantz, S.E., 1982b. *Measurement and Computation of Streamflow: Volume 2. Computation of Discharge,* U.S. Geological Survey Water-Supply Paper 2175, U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C.

RMRS (Rocky Mountain Remediation Services), 1998. *Procedure for Evaluation of Data for Usability.*

RMRS (Rocky Mountain Remediation Services), 2000a. *Final 1999 Annual RFCA Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site*, 00-RF-03112, November.

RMRS (Rocky Mountain Remediation Services), 2000b. *Quality Assurance Program Plan for the Automated Surface-Water Monitoring Program*, RF/RMRS-2000-013, Revision 0, March.

RMRS (Rocky Mountain Remediation Services), 2001. *Quality Assurance Program Plan for the Groundwater Monitoring Program Rocky Flats Environmental Technology Site*.

Safe Sites, 2001. *Final 2000 Annual RFCA Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site*, November.

Safe Sites, 2002. *Final 2001 Annual RFCA Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site*, 02-RF-01873, November.

Sanitas Technologies, 2009. *Sanitas for Ground Water*, Version 9, Olathe, Kansas.

USFWS (U.S. Fish and Wildlife Service), 2005. *Rocky Flats National Wildlife Refuge Comprehensive Conservation Plan and Environmental Impact Statement,* Rocky Mountain Arsenal, Commerce City, Colorado, June.

USGS (U.S. Geological Survey), 2006. *Description, Properties, and Degradation of Selected Volatile Organic Compounds Detected in Ground Water— A Review of Selected Literature*, Open-File Report 2006-1338; Reston, Virginia.

Weber, W.A., 1976. *Rocky Mountain Flora*, Colorado Associated University Press, Boulder, Colorado.

Weber, W.A., 1990. *Colorado Flora: Eastern Slope*, University Press of Colorado, Niwot, Colorado.

Weber, W.A. and R.C. Wittmann, 1992. Catalog of the Colorado Flora: A Biodiversity Baseline, University Press of Colorado, Niwot, Colorado.

Weber, W.A. and R.C. Wittmann, 2001. Colorado Flora: Western Slope, 3rd edition, University Press of Colorado, Niwot, Colorado.

Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats, Colorado, Site Calendar Year 2010

Appendixes

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Annual Report Appendixes

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