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2016 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee

Data and Evaluations

This document is approved for
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2016 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee

Data and Evaluations

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Prepared by the
Water Resources Restoration Program
URS | CH2M Oak Ridge LLC

Prepared for the
U.S. Department of Energy
Office of Environmental Management

URS | CH2M Oak Ridge LLC
Managing and Safely Delivering the Department of Energy's Vision
for the East Tennessee Technology Park Mission
under contract DE-SC-0004645

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CONTENTS

FIGURES

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TABLES

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ACRONYMS

AM	Action Memorandum
aMSL	above Mean Sea Level
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BCBG	Bear Creek Burial Ground
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BFK	Brushy Fork kilometer
bgs	below ground surface
BMAP	Biological Monitoring and Abatement Program
BORCE	Black Oak Ridge Conservation Easement
BSWTS	Big Spring Water Treatment System
BVBGs	Bethel Valley Burial Grounds
BYBY	Boneyard/Burnyard
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CNS	Consolidated Nuclear Security, LLC
COC	contaminant of concern
CRK	Clinch River kilometer
CRM	Clinch River mile
CWA	Clean Water Act of 1972
CWTS	Chromium Water Treatment System
CY	calendar year
D&D	decontamination and decommissioning
DARA	Disposal Area Remedial Action
DCA	dichloroethane
DCE	dichloroethene
DCS	Derived Concentration Standard
DGT	downgradient trench
DHC	*Dehalococcoides* sp.
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DSWM	Division of Solid Waste Management
DVS	Dynamic Verification Strategy
ECU	Electrocoagulation Unit
EEVOC	East End Volatile Organic Compound
EFK	East Fork Poplar Creek kilometer
ELCR	excess lifetime cancer risk
EM	Environmental Management
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
EPP	excavation/penetration permit
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ETTP	East Tennessee Technology Park
EU	exposure unit
EWQP	ETTP Water Quality Program

FCAP	Filled Coal Ash Pond
FCK	First Creek kilometer
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreement
FFK	Fifth Creek kilometer
FS	feasibility study
FY	fiscal year
FYR	Five-Year Review
GAC	granular activated carbon
GWPP	Groundwater Protection Program
HCK	Hinds Creek kilometer
HI	hazard index
HQ	Hazard Quotient
HRE	Homogeneous Reactor Experiment
IHP	Intermediate Holding Pond
IW	interception well
KHQ	Kerr Hollow Quarry
LEFPC	Lower East Fork Poplar Creek
LLLW	liquid low-level waste
LLW	low-level waste
LTS	long-term stewardship
LUC	land use control
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
LUM	Land Use Manager
LWBR	Lower Watts Bar Reservoir
MBK	Mill Branch kilometer
MBWEIR	Melton Branch Weir
MCK	McCoy Branch kilometer
MCL	maximum contaminant level
MCL-DC	maximum contaminant level derived concentration
MCLG	maximum contaminant level goal
MEK	Melton Branch kilometer
MIK	Mitchell Branch kilometer
MMS	Moment Magnitude Scale
MSRE	Molten Salt Reactor Experiment
MTF	Mercury Treatment Facility
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
NNSS	Nevada National Security Site
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSC	Non-Significant Change
NT	North Tributary
OREIS	Oak Ridge Environmental Information System
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Office
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl

PCCR	Phased Construction Completion Report
PCE	perchloroethene/tetrachloroethene
PCK	Poplar Creek kilometer
PCM	Poplar Creek mile
PCP	Post-Closure Permit
PHK	Pinhook Branch kilometer
PID	photoionization detector
PLFA	phospholipid fatty acids
PNNL	Pacific Northwest National Laboratory
POC	point-of-compliance
PVC	polyvinyl chloride
PWTC	Process Waste Treatment Complex
QAPP	Quality Assurance Project Plan
RA	remedial action
RAIS	Risk Assessment Information System
RAO	remedial action objective
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act of 1976
RDR	Remedial Design Report
RER	Remediation Effectiveness Report
RI	Remedial Investigation
RmAR	Removal Action Report
RmSE	Removal Site Evaluation
ROD	Record of Decision
RSE	Remedial Site Evaluation
S&M	surveillance and maintenance
SAP	sampling and analysis plan
SD	storm drain
SDWA	Safe Drinking Water Act of 1974
SE	standard error
SIOU	Surface Impoundments Operable Unit
SNS	Spallation Neutron Source
STP	Sewage Treatment Plant
SWPP	Storm Water Pollution Prevention
SWSA	Solid Waste Storage Area
TCA	trichloroethane
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TRM	Tennessee River mile
TRU	transuranic
TSS	total suspended solids
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UCOR	URS | CH2M Oak Ridge LLC
UEFPC	Upper East Fork Poplar Creek
UNC	United Nuclear Corporation
UPF	Uranium Processing Facility

UT-B	University of Tennessee-Battelle, LLC
UU/UE	unlimited use/unlimited exposure
VC	vinyl chloride
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	Waste Area Group
WBIWG	Watts Bar Interagency Working Group
WBK	Walker Branch kilometer
WCK	White Oak Creek kilometer
WCWEIR	White Oak Creek Weir
WEMA	West End Mercury Area
WHP	Waste Handling Plan
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOL	White Oak Lake
WRRP	Water Resources Restoration Program
Y-12	Y-12 National Security Complex

ACKNOWLEDGEMENTS

Primary tasks of the U.S. Department of Energy Oak Ridge Office of Environmental Management (DOE OREM) are contracted to various entities. URS | CH2M Oak Ridge LLC (UCOR) conducts environmental cleanup and long-term stewardship (LTS) for DOE OREM at sites on the Oak Ridge Reservation (ORR) with Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as the primary regulatory authority and at impacted sites off the reservation (e.g., Lower East Fork Poplar Creek [LEFPC]). UCOR implements DOE OREM's Water Resources Restoration Program (WRRP), a comprehensive, integrated environmental monitoring program for the ORR, and prepares the annual Remediation Effectiveness Report (RER). Consolidated Nuclear Security, LLC (CNS) operates the Y-12 National Security Complex (Y-12), which manages the production and refurbishment of nuclear weapon components for the DOE and the National Nuclear Security Administration. A partnership between the University of Tennessee and Battelle, LLC (UT-B) manages and operates the Oak Ridge National Laboratory (ORNL) for the DOE.

The UCOR WRRP gratefully acknowledges the contributions and efforts of many organizations and individuals on the ORR for providing support in preparation of the 2016 RER. Particular thanks are due to the Aquatic Ecology Group of the Environmental Sciences Division (UT-B) at ORNL for providing field support, biological data, and technical interpretations included in the biological monitoring sections of this report. Where applicable, ORR monitoring data collected by other programs were used to augment the WRRP sampling results. Considerable thanks are due to UT-B's Environmental Protection and Waste Services Division; the CNS Environmental, Safety and Health Organization and Groundwater Protection programs at Y-12; and UCOR's Environmental Compliance and Protection Organization (East Tennessee Technology Park [ETTP]) for providing National Pollution Discharge Elimination System (NPDES) Clean Water Act data. LTS information used in the RER is collected and compiled in conjunction with the UCOR surveillance and maintenance (S&M) programs, CNS's Liquid Waste Operations at Y-12, and UT-B's Facilities Management Division. The Tennessee Valley Authority (TVA) generously provided historical sampling results that were used to construct some graphs depicting off-site data. A sincere note of thanks is due to UCOR subcontractor Restoration Services, Inc. (RSI) sampling and support personnel for their diligent efforts in completing much of the field work for the WRRP monitoring program.

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EXECUTIVE SUMMARY

Under the requirements of the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014) established between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC), all environmental restoration activities on the Oak Ridge Reservation (ORR) are performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This *2016 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*:

- evaluates the performance of completed and ongoing CERCLA actions on and around the DOE ORR,
- evaluates the effectiveness of and compliance with the long-term stewardship (LTS) requirements for each of the completed actions, and
- summarizes watershed monitoring results.

First issued in 1997, the Remediation Effectiveness Report (RER) has been reissued annually to update the performance of completed actions and to add descriptions of new CERCLA actions. Generally, the data reported in the 2016 RER were collected prior to or in fiscal year (FY) 2015.

Remedial decisions on the ORR have been made at the watershed scale in recognition of surface water being the major pathway for off-site contaminant transport and to ensure that the evaluation considers the cumulative resources needed for cleanup and the resource implications for alternate end uses. While waiting for the watershed decisions to be made with the associated series of remedial actions (RAs), single-project actions were performed primarily to mitigate immediate risks and to reduce further migration of contaminants off-site. The watershed Records of Decision (RODs) contain performance goals to be met and a series of RAs designed to achieve the goals. Since the implementation of these watershed RODs can take many years to complete, evaluation of performance must consider completed actions, actions not yet implemented, and actions which are in progress.

Monitoring information used to assess performance was compiled by the DOE Oak Ridge Office of Environmental Management (OREM) through the Water Resources Restoration Program (WRRP) that was established to implement a comprehensive, integrated environmental monitoring and assessment program for the ORR and to minimize duplication of field, analytical, and reporting efforts. Groundwater, surface water, sediment, and biota are monitored and evaluated as part of this assessment program. In addition to collecting performance assessment data, baseline data also are collected to gauge the effectiveness of future actions once implemented.

Most of the remediation decisions do not allow unrestricted end use, therefore LTS will be required at these sites. LTS is the set of activities necessary to protect human health and the environment from physical hazards, residual contamination, and wastes remaining following remediation. The RER evaluates the performance of LTS activities that are required by CERCLA documents to protect human health and the environment.

A chapter is devoted to each of the watersheds, to Chestnut Ridge, to off-site actions, and to other sites. Rather than forming a single defined hydrologic watershed, Chestnut Ridge and the East Tennessee Technology Park (ETTP) comprise several individual sub-watersheds but are treated as a single unit for decision-making and performance assessment. Each chapter identifies completed single-project actions and completed watershed-scale actions with LTS requirements.

A summary of the effectiveness evaluation follows. Issues and recommendations, including closed out issues and the status of Five-Year Review (FYR) issues, are summarized in Chapter 1 and included in Tables 1.2, 1.3, 1.4, and 1.5. More detailed discussion of the issues and recommendations are in each Chapter. FYR Action Plans are in Appendix C.

Bethel Valley

Following is a summary of the Bethel Valley watershed assessment:

- Strontium-90 and ^{137}Cs concentrations at the Bethel Valley watershed integration point (7500 Bridge) met their risk reduction goals. The Corehole 8 Extraction System met its performance goal based on ^{90}Sr flux reduction at First Creek during FY 2015, which contributed to the risk reduction goal for ^{90}Sr being met downstream at the 7500 Bridge.

- Surface water discharges of ^{90}Sr in Northwest Tributary and Raccoon Creek have decreased significantly as a result of hydrologic isolation of shallow buried waste at Solid Waste Storage Area 3 (SWSA 3) and the Contractor's Landfill. Comparison of SWSA 3 area pre-remediation to FY 2015 groundwater contaminant concentrations shows that levels are decreasing or stable. Although three of nine wells have not yet attained design target groundwater levels, the groundwater level fluctuations within the waste depth zone in the hydrologic isolation area show that direct infiltration of rainwater into buried waste has been controlled.

- Mercury concentrations at the Bethel Valley watershed integration point (7500 Bridge) continue to meet the AWQC of 51 ng/L. CERCLA actions at Building 4501 to re-route and pre-treat mercury contaminated building sump water are shown to be effective at reducing mercury concentrations in the receiving reach of White Oak Creek (WOC). Mercury concentrations measured at WOC-105, located a short distance downstream from the former storm drain (SD) discharge from Building 4501, were less than the ambient water quality criteria (AWQC) level in FY 2015 samples.

- Wells 4645, 4646, and 4647 monitor groundwater in the Raccoon Creek headwater area. These exit pathway wells did not contain contaminants above drinking water criteria in FY 2015. Strontium-90 was detected at low levels in well 4647, the shallowest of these wells, in both semi-annual samples, and in well 4646 in one sample. The maximum detected level was detected in well 4647 and was approximately 25% of the maximum contaminant level derived concentration (MCL-DC) of 8 pCi/L. Well 4647 samples groundwater near the known contaminated seep that discharges into Raccoon Creek. Strontium-90 was not detected in well 4645 during FY 2015.

- The observed improvement in fish mercury concentrations to levels below the EPA-recommended fish-based AWQC for mercury continued in WOC. Biological monitoring of the Bethel Valley watershed indicates moderate ecological recovery since 1987. Invertebrate community monitoring shows there is little evidence of improvement since 2002. Recent introductions of new fish species, however, have been partially successful.

- Land use controls (LUCs) in Bethel Valley were maintained. Signs were maintained to control access and surveillance patrols were conducted as part of routine surveillance and maintenance (S&M) inspections. The Excavation/Penetration Permit (EPP) Program functioned according to established procedures and plans.

Melton Valley

Following is a summary of the Melton Valley watershed assessment:

- Radiological goals for ^{137}Cs, ^{90}Sr, and tritium, which are the principal surface water contaminants in the Melton Valley watershed, were met at the watershed integration point (White Oak Dam). For the principal contaminants in Melton Valley surface water, the average concentrations at tributary and mainstem monitoring locations remained compliant with goals of the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3).

- Groundwater level monitoring of the hydrologic isolation areas in Melton Valley showed that performance criteria were met at 46 of 52 locations. DOE is making recommendations concerning an issue identified in the 2015 RER for five groundwater level performance monitoring wells that have experienced chronic goal exceedances. At one of the wells (4127 in SWSA 6) physical modifications to the well are recommended; at two of the wells (0955 and 0958 in SWSA 4 near the downgradient trench) a cessation of monitoring goal requirements is recommended; and at two wells (well 1071 in SWSA 4 and well 0850 in SWSA 6) the recommendation is to continue water level monitoring for long-term trend evaluation (with no specified water level goal). At SWSA 6, DOE recommends continued monitoring of downgradient groundwater quality in well 0838 as the indicator of cap performance since that well is downgradient of the well 0850 area and has shown significant decreases in contaminant levels post-remediation. These recommendations will be discussed at a Project Team meeting for incorporation into an addendum to the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3). Completion of this process and modification of well 4127 will close the issue. Although operation of the SWSA 4 downgradient groundwater collection trench remains challenging, discharges from the area in surface water met ROD goals. Performance of the SWSA 4 downgradient trench will be evaluated in the 2016 FYR process.

- Although three monitoring wells at the Seepage Pits and Trenches (one well at Trench 7 and two wells at Trench 5) are experiencing increasing contaminant trends, groundwater contaminant concentrations around the shallow land burial sites are generally stable or decreasing compared to concentrations measured before completion of the Melton Valley remedy.

- Groundwater analyses conducted on samples from the on-site exit pathway wells since their construction in 2004 and off-site wells have resulted in a number of radionuclides and VOCs being detected periodically in different monitoring locations. An off-site detection of low concentrations of VOCs occurred early in the sampling history from one sampling event in 2010 at one well. It is suspected to have occurred because of well development pumping stresses in the off-site well during construction that caused low head in a discrete fracture zone connected to the vicinity of an on-site exit pathway well where detection of similar VOCs occurred. Lower detection limits in FY 2015 allowed several detections of very low concentrations of ^{90}Sr, ^{99}Tc, and tritium in the on-site and off-site monitoring wells.

- The biological monitoring results indicate that Melton Branch and lower WOC stream communities are impaired relative to reference sites. Since introduction of new fish species in the watershed, fish communities have improved steadily in both species richness and abundance. However, there is no evidence of improving trends in the benthic macroinvertebrate communities over the last 5 – 10 years, with substantial year to year variation.

- LUCs were implemented in Melton Valley in FY 2015 in accordance with the approved Land Use Control Implementation Plan (LUCIP) for the watershed as certified in Appendix A of this document.

- Signs were maintained to control access and surveillance patrols were conducted. The EPP Program functioned according to established procedures and plans. Inspections of engineering controls were conducted at the Melton Valley hydrologic isolation areas and maintenance was performed as required. Items such as isolation caps, drainage features, monitoring weirs, and leachate collection equipment were inspected as applicable at each site. All caps were mowed a minimum of once during the year.

Bear Creek Valley

Following is a summary of the Bear Creek Valley (BCV) watershed assessment:

- Surface water monitoring at the integration point (Bear Creek kilometer [BCK] 9.2) showed that the *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y 12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) goal of ≤34 kg/yr of uranium was not attained. The measured uranium flux at the integration point in FY 2015 was about 89 kg, which is 2.5 times the ROD goal. The FY 2015, integration point uranium flux decreased by about 8 kg compared to FY 2014 discharge and remained proportional to the total annual rainfall. An estimated one-third of the uranium flux is attributed to surface water discharged from the S-3 Ponds plume, and the remaining two-thirds originated in the Bear Creek Burial Grounds (BCBGs), inclusive of approximately 2.5% that originated from North Tributary 3 (NT-3). The uranium mass balance estimate for the integration point monitoring at BCK 9.2 compared to the sum of upstream contributing stations was within 0.5% during FY 2015, which is considered an excellent mass balance considering the complex nature of surface water and shallow groundwater flow in the area.

- NT-8 near the BCBGs continues to be the largest contributor of uranium to Bear Creek having accounted for 51.2 kg of uranium during FY 2015. Implementation of an NT-8 Surface Water action is a potential project identified in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Investigations and projects during groundwater strategy implementation will be sequenced according to ORR-wide groundwater issues prioritization.

- Nitrate concentrations meet applicable ROD criteria at the watershed integration point (BCK 9.2). Cadmium concentrations exceeded AWQC requirements at NT-1 and at the BCK 12.34 monitoring location near the S-3 Ponds contaminant source.

- The average nitrate concentration measured at BCK 12.34 near the S-3 Pond source area was less than the industrial risk-based concentration.

- In Zone 1, the western half of BCV, groundwater contaminant concentrations continue to remain low. However, there are uncertainties about groundwater contaminant levels and flow paths that have been identified in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Evaluation of potential pathways and installation of additional wells will be included in investigations during groundwater strategy implementation and will be sequenced according to ORR-wide groundwater issues prioritization. Evaluation of uranium isotope ratios in the Zone 1 springs and wells shows that spring SS-6 is unique in the area in that its uranium appears to originate from upstream of NT-8 while all the other Zone 1 locations show uranium isotopic signatures that reflect the influence of NT-8 discharges.

- Mean mercury concentrations in rockbass in lower Bear Creek (BCK 3.3) decreased from FY 2014, however remained elevated and are above human health guidelines, specifically, the EPA-recommended AWQC.

- Cadmium, uranium, and polychlorinated biphenyl (PCB) concentrations in stoneroller minnows in 2015 continued the long-term trend of elevated levels in Bear Creek. For the first time, nickel concentrations in fish at all three Bear Creek sampling sites were below reference stream values.

- LUCs in BCV were maintained. Signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections. Inspections conducted at the Boneyard/Burnyard (BYBY), Spoil Area 1, and SY-200 Yard sites included assessment of the vegetative cover and drainage. Maintenance activities and routine mowing were performed.

The Environmental Management Waste Management Facility (EMWMF) is an operating CERCLA waste disposal facility located in the BCV watershed. Operation of the EMWMF is an ongoing CERCLA action to dispose of waste from CERCLA response actions on the ORR and associated sites. The CERCLA action status of the EMWMF is not reported in this document but is evaluated in the EMWMF annual Phased Construction Completion Report (PCCR).

Chestnut Ridge

Following is a summary of the Chestnut Ridge assessment:

- **United Nuclear Corporation (UNC) –** Gross beta activity continues to be higher in downgradient well GW-205 than in the other UNC monitoring locations; although levels have decreased significantly since the well was redeveloped in 2010. The gross beta activity is attributed predominantly to the presence of potassium containing a natural radioactive ^{40}K component. Strontium-90 has been detected intermittently in the well but was not detected in FY 2015. Lower detection limits in FY 2015 allowed detection of ^{90}Sr at a very low level (<1 pCi/L) in upgradient well 1090. The downgradient spring (UNC SW-1) exhibits data that demonstrate a lack of impact from the UNC site on the nearest groundwater discharge to surface water.

- **Kerr Hollow Quarry (KHQ) –** The July 2015 result for the Resource Conservation and Recovery Act (RCRA) point-of-compliance (POC) well GW-144 shows the carbon tetrachloride concentration just slightly above the detection limit and similar to levels sporadically detected in previous groundwater samples from the well. This continues to represent a long-term decreasing trend of carbon tetrachloride at the KHQ. The changes implemented by the DOE and UCOR, Operator and Co-operator of the KHQ, respectively, to increase monitoring of GW-144 and the downgradient exit pathway surface water location S17 to semiannually will be continued until four consecutive non-detect results are obtained in samples obtained from well GW-144.

- **Filled Coal Ash Pond (FCAP) –** The monitoring results since the RA indicate that the remedy is reducing metals contamination from the coal ash in surface water in McCoy Branch. The ROD for FCAP did not stipulate that the RA would attain AWQC in McCoy Branch but did stipulate that the action would reduce contaminant loading in the stream at least as well as the pre-existing natural wetland. Although concentrations have decreased significantly since implementation of the RA, total arsenic concentrations often exceed the screening criterion (0.01 mg/L) in both the upgradient and downgradient locations at the FCAP wetland. Based on the sampling for the FY 2011 through FY 2015 period, the passive wetland treatment area reduces total arsenic concentrations by about 93% with associated reductions of dissolved arsenic of about 19%. Arsenic levels in Rogers Quarry fish have been near background. However, selenium and mercury concentrations remain higher in fish relative to typical background concentrations for selenium and relative to federal AWQC guidelines for mercury, suggesting continuing low level inputs from either the FCAP or stream and/or quarry ash deposits downstream. Stream community measures show that McCoy Branch remains below, or at the lower end, of values observed in reference streams.

- Inspections were performed at the UNC site, KHQ, and FCAP to assess items such as site security and access controls, proper signage, vegetative cover, drainage features, and condition of wells as applicable at each site. Routine mowing and other maintenance activities were performed in FY 2015.

Upper East Fork Poplar Creek

Following is a summary of the Upper East Fork Poplar Creek (UEFPC) watershed assessment:

- The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) goal for mercury in surface water at Station 17 is 200 ng/L. The average flow-paced composite mercury concentration during FY 2015 was 1,030 ng/L, down from 1,491 ng/L in FY 2014. Total mercury concentrations in one of the weekly composite samples collected at Station 17 during FY 2015 was less than the 200 ng/L ROD goal. Based on comparison of the mercury concentration in filtered and unfiltered sample aliquots from the weekly composite samples, approximately 90% or more of the mercury leaving the site is associated with suspended particulates in the water column.
- The Big Spring Water Treatment System (BSWTS) was fully operational during FY 2015. Although no significant downtime or operational problems occurred, winter and early spring seasonal rainfall caused the influent to BSWTS groundwater collection system to exceed the treatment system's design capacity. This necessitated bypassing the system during 30 weeks. Because of the somewhat sporadic rainfall pattern in FY 2015 with interspersed dry periods and above average rainfall periods, the system bypass occurrences included several periods during December, January, April, May, July, and August. Approximately 4.5 g of mercury were discharged to UEFPC during the year (less than 0.1% of measured flux at Station 17).
- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux at Station 17 in FY 2015 increased relative to levels measured during FY 2014.
- The East End Volatile Organic Compound (EEVOC) plume removal action is measured through two metrics. The first metric is the effectiveness of the groundwater withdrawals at reducing VOC concentrations in the plume off DOE property to the northeast in Union Valley. The second metric is the performance of the air stripper at removing the signature VOCs from the water discharged to UEFPC. FY 2015 data indicate that the groundwater pump and treatment system has effectively withdrawn groundwater and has limited off-site plume migration. Evidence of that performance is the below drinking water limit concentrations of carbon tetrachloride in off-site monitoring wells in Union Valley. During FY 2015, the air stripper system performed well after a mechanical problem noted in November 2014 was corrected. A problem with airflow in the air stripper was identified and corrected, which significantly improved volatile organic compound (VOC) removal efficiency.
- Aquatic biological monitoring shows that mercury concentrations in rock bass at Station 17 generally remain stable, and have not responded to either increases or decreases in aqueous mercury concentrations. However, at upstream locations East Fork Poplar Creek kilometer (EFK) 23.4 and EFK 24.2, mercury concentrations in redbreast appear to have been responsive to water increases and decreases associated with the SD cleanout. No changes in fish mercury concentrations are so far evident in fish sampling results post flow augmentation shutoff.
- LUCs in UEFPC were maintained, including signs to control access, surveillance patrols, and an ongoing EPP program. Institutional controls in Union Valley were maintained.

Off-Site Actions

Following is a summary of the off-site actions assessment:

- **Lower East Fork Poplar Creek (LEFPC)** – Monitoring at Station 17 is conducted to measure the concentration and mass flux of mercury that is discharged from the UEFPC watershed into LEFPC. During FY 2015, the flow-paced continuous monitoring detected an average concentration of 1,030 ng/L, down from 1,491 ng/L in FY 2014, and a mass flux of 8.1 kg mercury, down from 14.4 kg in FY 2014. The levels of mercury in fish tissue in the LEFPC have remained elevated.

  A periodic survey to detect residential use of shallow groundwater was last performed in FY 2012. There were no new wells identified for residential use along LEFPC. Visual inspections in FY 2015 confirmed that land use of the property of the former Dean Stallings Ford automobile dealership has not changed. The area is now leased to Ole Ben Franklin Motors used car dealership which opened for business in January 2014.

- **Clinch River/Poplar Creek and Lower Watts Bar Reservoir (LWBR)** – Performance monitoring of the Clinch River and Poplar Creek continues to indicate an overall downward trend in fish PCB concentrations. The decreasing PCB trends in fish are some of the most dramatic observed by the long-running Oak Ridge biological monitoring programs. However, striped bass are routinely above PCB advisory limits, especially larger fish. Mercury concentrations in fish at monitored sites continue to indicate the influence of mercury sources from East Fork Poplar Creek, with elevated levels in fish in upper Poplar Creek and lower levels with distance downstream. Overall, the performance monitoring has been successful in addressing the ROD goal of evaluating changes in fish contaminant levels and how those levels compare to fish advisory limits. Performance monitoring results from LWBR obtained during FY 2015 continue to indicate that mercury and PCB levels in fish are decreasing from historical levels.

  Fish consumption advisories are maintained by TDEC and were in effect for Clinch River/Poplar Creek and LWBR in FY 2015. The Tennessee Wildlife Resources Agency (TWRA) posts these advisories on their website and includes the advisories in their Tennessee Fishing Guide that is available on-line and where fishing licenses are sold.

  The Watts Bar Interagency Working Group (WBIWG) provided continued controls on sediment-disturbing activity in the deep water channel. In FY 2015, four dredging permit applications were received and approved for Clinch River/Poplar Creek and LWBR.

ETTP

Following is a summary of the ETTP watershed assessment:

- VOC concentrations in wells monitored downgradient of K-1070-C/D show that a broad area is affected by the releases from the G-Pit liquid VOC disposals. While concentrations along one portion of the impacted area continue to decrease, there remains a known area with very high concentrations of the contaminants disposed at the site. The persistent, very high concentrations of these VOCs suggest that a dense non-aqueous phase liquid (DNAPL) source beneath and/or downgradient of the G-Pit continues to release mass into the plume.

- Performance monitoring at the K-1007-P1 Holding Pond began in 2010. The performance monitoring focus has been on tracking PCB accumulation in bluegill fillets (to assess human health concerns) and bluegill whole bodies (to evaluate ecological risk concerns). In FY 2015, the bluegill sunfish PCB

concentrations were lower than the human and ecological risk goals for the pond. Largemouth bass fillets, which were monitored in FY 2015 for the first time since the remedial action, did exceed the human health target but were three times lower than pre-action concentrations. In general, plant, wildlife, and water quality sampling have indicated improving trends toward reaching the desired end state, while the fish population has changed dramatically from one year to the next. It will take some time for environmental conditions in the pond to fully stabilize, allowing a better assessment of whether PCB exposure in the pond has sufficiently decreased.

- During FY 2015, surface water and groundwater monitoring indicates that contaminant levels are generally stable to decreasing in most instances and are consistent with the data from previous years. All surface water radiological data were below the screening level of 4% of the Derived Concentration Standard (DCS). VOC concentrations at the Mitchell Branch K-1700 weir are well below the applicable AWQC and the benchmark values for potential surface water toxicity. Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell Branch. Total chromium and hexavalent chromium in Mitchell Branch are below AWQC.

- In FY 2015, mercury continued periodically to exceed the AWQC in storm water outfalls, surface water locations, and groundwater monitoring wells and exceeds the EPA's recommended criterion in fish tissue. The long-term trend at the K-1700 Mitchell Branch exit pathway location shows a continuing decline from peak levels in FY 2010. Knowledge of historical mercury processes has increased substantially, and these legacy sources of mercury contamination will be addressed under planned CERCLA response actions for D&D and soil remediation.

- VOCs are the most significant groundwater contaminant at ETTP. Trichloroethene (TCE) concentrations in wells BRW-003 and BRW-017 in the K-1064 Peninsula area and from the PC-0 spring in the K-901-A Holding Pond area are continuing to decline. At the K-770 area, the alpha and beta activity levels have reached relatively low levels, although seasonal fluctuations are apparent in the data. Measured alpha and beta activity levels in K-770 area groundwater were below drinking water screening levels in FY 2015. At the K-901-A Holding Pond area, there were increases in detected alpha and beta activity in all four wells. Additional radiological analyses will be performed in FY 2016. Chromium concentrations in UNW-043 in the K-31/K-33 area continued to be much lower than the MCLs. In the K-27/K-29 area, vinyl chloride (VC) continues to slightly exceed the MCL in BRW-058, VOCs in BRW-016 are decreasing and are below MCLs, and TCE in UNW-038 fluctuates between 10 – 20 times the MCL.

- Following demolition of Building K-25, ^{99}Tc was found in storm water and underground utilities associated with Building K-25. During FY 2015, two phases of a subsurface ^{99}Tc investigation were completed. This investigation confirmed the conceptual model that ^{99}Tc percolated from the Building K-25 slab into the backfill around the electrical duct bank. The ^{99}Tc was transported rapidly along this utility corridor to the areas where the high concentrations are currently detected, along the eastern side of the Building K-25 East Wing. The groundwater plume trajectory is to the south/southwest from the duct bank manholes 21 and 22 and to the northeast from the K-1413 area toward Mitchell Branch. In FY 2015, ^{99}Tc sampling of storm water discharges and in the sanitary sewer system shows both in compliance with the DOE Order annual sum-of-fractions requirement.

- Aquatic biological monitoring of Mitchell Branch indicates mercury and PCBs are elevated in fish to concentrations above human health thresholds, and fish and benthic communities remain impaired relative to upstream and reference sites, especially in the lower sections.

- Interim LTS requirements for slabs following building demolition were the subject of two issues that have been resolved. The ETTP D&D and RA Project Teams have reached agreement on the management of potentially contaminated slabs, and the process to manage potentially contaminated slabs is contained in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4).

  General LUCs remained in place at ETTP. Signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections. The EPP Program functioned according to established procedures and plans for the site. Required mowing was performed. Signs and access controls at the K-1070-C/D Burial Ground were inspected.

  The northern section of Zone 1 was identified as a conservation easement, the Black Oak Ridge Conservation Easement (BORCE), on March 14, 2005. The BORCE is utilized for recreational use, e.g., hiking, bicycling, and select controlled deer hunts. However, the end use identified in the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) is unrestricted industrial, i.e., recreational use was not designated. The determination in the Proposed Plan that industrial use goals for Zone 1 are also protective of recreational uses is planned to be included in the Zone 1 Final Soils ROD to address this issue.

CERCLA Actions at Other Sites

Following is a summary of the other sites assessment:

- **White Wing Scrap Yard** – Inspections were performed at the White Wing Scrap Yard to assess items such as access roads and the condition of gates and perimeter fencing. Routine site maintenance was performed.

- **Oak Ridge Associated Universities South Campus Facility** – Concentrations of detected VOCs in wells GW-841 and GW-842 from FY 1994 through FY 2015 have exhibited a long-term decreasing concentration history with mixed behavior between FY 2013 and FY 2015. The FY 2015 results show that TCE in well GW-841 increased slightly and is above the drinking water standard. TCE in well GW-842 decreased slightly in FY 2015 and remains below the drinking water standard. No VOCs were detected in surface water at the site during FY 2015. Groundwater use restrictions at the site were maintained.

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1. INTRODUCTION

1.1 PURPOSE

The purposes of the annual Remediation Effectiveness Report (RER) are to:

- evaluate the performance of completed and ongoing actions performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) on and around the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR),

- evaluate the effectiveness of and compliance with the long-term stewardship (LTS) requirements for each of the completed actions, and

- summarize watershed monitoring results.

With the exception of some ecological sampling data, all data reported in this *2016 Remediation Effectiveness Report* were collected prior to or in fiscal year (FY) 2015.

Additionally, submittal of the annual RER to the Tennessee Department of Environment and Conservation (TDEC) Division of Solid Waste Management (DSWM) is a condition of three Resource Conservation and Recovery Act of 1976 (RCRA) Post-Closure Permits (PCPs) at the Y-12 National Security Complex (Y-12) on the ORR (TNHW-113, TNHW-116, and TNHW-128). Reporting of monitoring for Solid Waste Storage Area 6 (SWSA 6) at the Oak Ridge National Laboratory (ORNL) that was previously performed under RCRA is also now included in the annual RER. This decision was based on the determination that the CERCLA program being implemented at SWSA 6 provides RCRA-equivalent post-closure care of the unit through compliance with RCRA substantive requirements.

1.2 REMEDIATION STRATEGY

In Oak Ridge, DOE and its predecessor agencies have had a mission over the past 60 years of uranium enrichment, weapons production, and energy research. As a result of this mission, there is a legacy of hundreds of contaminated sites on the ORR. The ORR was placed on the CERCLA National Priorities List (NPL) in 1989. The *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014), signed by DOE, the U.S. Environmental Protection Agency (EPA), and TDEC in 1991, describes how remediation under CERCLA will be performed.

The remediation strategy for the contaminated sites on the ORR is based on a watershed management approach. The Clinch River bounds the ORR on three sides, and there are active creeks that flow down the valleys to the Clinch River (Figure 1.1). These surface water systems are fed by runoff from rainfall and by the groundwater that continually discharges to the surface streams. As much as 90% of the water entering the ground flows rapidly through highly porous, shallow soil, where many of the contaminated sites are located, before discharging to nearby surface water. Consequently, the primary pathway for contaminant migration is through shallow groundwater to surface water which then flows off-site. Because of abundant rainfall (an average of 54 in./yr), contaminant transport by shallow subsurface flow to surface waters, and the presence of contaminated sites in defined watersheds, a watershed strategy became the basis for environmental restoration.

Watershed management is an integrated, holistic approach to restore and protect ecosystems and to protect human health by focusing on hydrologically defined drainage basins. Watershed management is applied to the environmental restoration of the ORR by grouping contaminated sites into the following five watersheds (Figure 1.1):

- Bethel Valley,
- Melton Valley,
- Bear Creek Valley (BCV),
- Upper East Fork Poplar Creek (UEFPC), and
- East Tennessee Technology Park (ETTP).

Additionally, decisions have been made and actions taken off-site (Lower East Fork Poplar Creek [LEFPC], Clinch River/Poplar Creek, and Lower Watts Bar Reservoir [LWBR]), on Chestnut Ridge, and at other sites (White Wing Scrap Yard and Oak Ridge Associated Universities South Campus Facility).

The watersheds are used to:

- identify, assess, and prioritize contaminant releases,
- make remediation decisions, and
- evaluate remediation effectiveness.

Contaminants released from the contaminated sites accumulate in floodplain soils and aquatic sediments. Contaminants not retained, or those remobilized, are released to the surface waters and subsequently off-site to the Clinch River. Therefore, the surface water acts as an integrator of contaminant flux, and integration points (Figure 1.1) are identified in each watershed at which contaminant releases can be measured, assessed, tracked, and prioritized. Once the baseline monitoring and characterization are completed and the cleanup objectives are defined, the contribution of each remedial action (RA) toward achieving the objectives can be estimated and assessed at the watershed integration point. Through surface water monitoring, both the specific performance of each action and the cumulative progress toward achieving the cleanup objectives can be assessed. Additionally, implementation of an ORR-wide strategy is underway to prioritize and address groundwater contamination and includes a study of off-site groundwater (Section 1.2.1).

Since its inception in 1989, the following risk-based prioritization has been used for determining the sequence of remediation work:

- mitigate immediate on-site and off-site risks,
- reduce further migration of contaminants off-site,
- address sources of off-site surface water and groundwater contamination,
- address remaining on-site contamination, and
- address demolition of facilities.

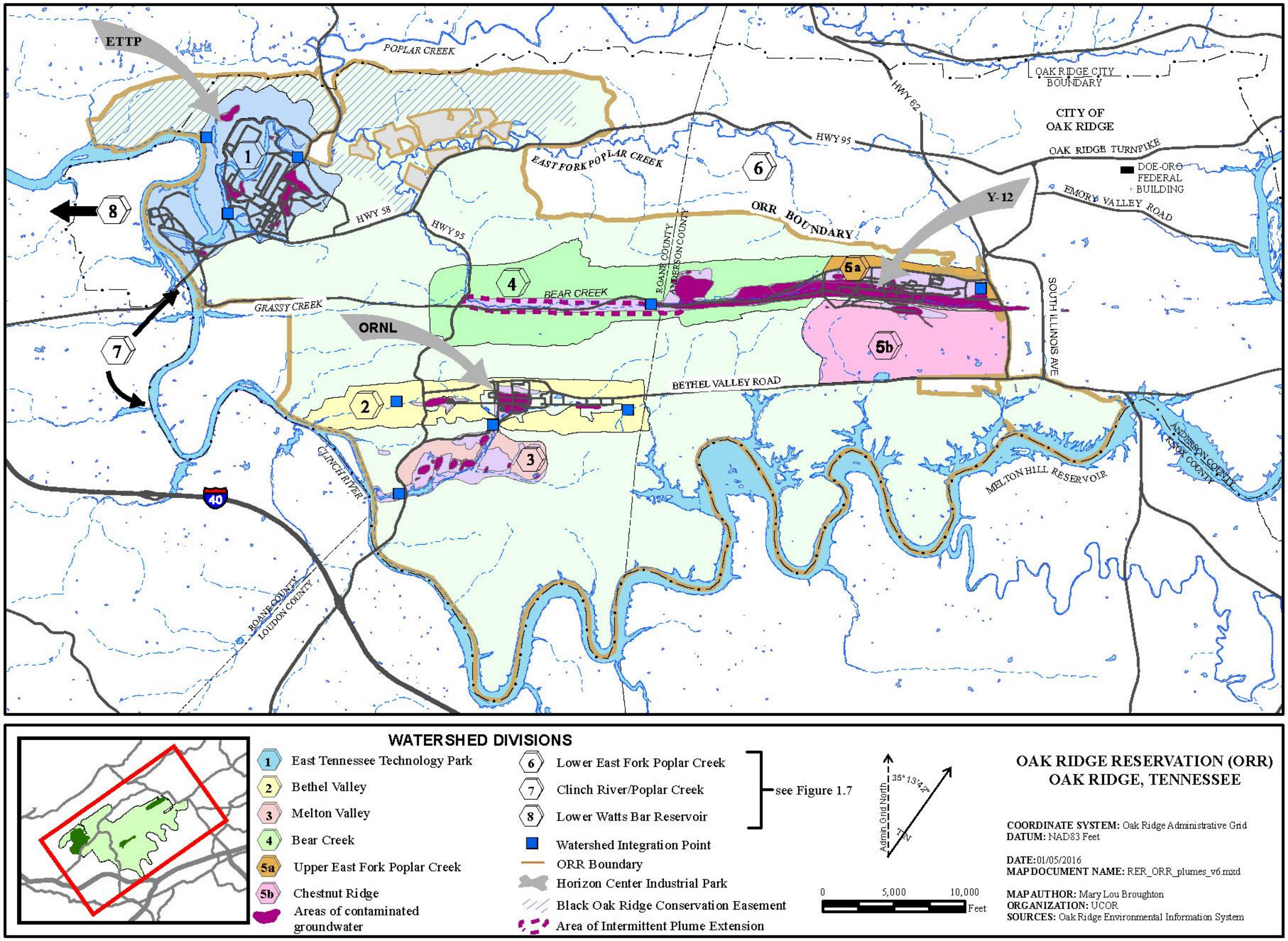

Figure 1.1. Watersheds on the ORR.

Remedial decisions reflect tradeoffs among protection of human health and the environment, compliance with environmental standards, and implementation criteria, primarily cost and implementability. A preferred alternative is selected that represents the optimum solution among these factors. For the ORR, the optimum solution needs to be determined at the watershed scale to ensure that the evaluation considers the cumulative resources needed for cleanup and the resource implications for alternate end uses. The optimum decision for a single contaminated site may not be the same as when other contaminated sites in the same watershed are considered as well. For this reason, the optimum decision for each contaminated site is made in the context of the optimum solution for the entire watershed. By focusing on future end use, the appropriate level of cleanup for a watershed can be established. The watershed Records of Decision (RODs) contain performance goals to be met and a series of RAs designed to achieve them.

While waiting for the watershed decisions to be made with the associated series of RAs, single-project actions were performed primarily to mitigate immediate risks and to reduce further migration of contaminants off-site. In addition, interim RODs have been signed for Bethel Valley (DOE/OR/01-1862&D4), Melton Valley (DOE/OR/01-1826&D3), UEFPC (DOE/OR/01-1951&D3 and DOE/OR/01-2229&D3), BCV (DOE/OR/01-1750&D4) and Zone 1 and Zone 2 at ETTP (DOE/OR/01-1997&D2 and DOE/OR/01-2161&D2, respectively) for sources and soil. This allowed decisions to be made and remediation performed on sources and soil and the more complex decisions on topics such as groundwater, surface water, sediment, ecological protection, and final land use controls (LUCs) to be deferred until the source terms were remediated and a better understanding of the contaminant pathways obtained. These interim RODs also are considered interim for the sources and may be changed in the final RODs.

1.2.1 ORR Groundwater Strategy

Figure 1.1 shows areas of known groundwater contamination in each of the watersheds. No watershed-scale final groundwater decisions have been made on the ORR to date, although several groundwater RAs have been undertaken. Progress toward groundwater remediation has been challenging because of the hydrogeologic complexity of fractured rock and karst systems. During the 1990s, several passive groundwater RAs were implemented using *in situ* media to capture or degrade contaminants. None of these RAs met with long-term success, and all were terminated. RAs that have been successful at prevention of the spread of groundwater contamination have included containment pump-and-treat systems and aggressive hydrologic isolation of wastes left in place by capping and *in situ* stabilization. Containment pump-and-treat systems are successful at mitigation of off-site plume migration at the Y-12 East End Volatile Organic Compound (EEVOC) plume in UEFPC and at the hexavalent chromium plume at the ETTP. Such systems do require periodic maintenance and potential modification, as is the case at the Core Hole 8 plume in Bethel Valley. In Melton Valley, aggressive hydrologic isolation and *in situ* solidification by grouting of wastes left in place is successful in halting formation of contaminated leachate which feeds groundwater contaminant plumes.

Development of an interagency approach for addressing ORR groundwater contamination was completed in FY 2013 and resulted in an ORR Groundwater Strategy (*Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* [DOE/OR/01-2628/V1&V2&D2]) that was agreed to by DOE, EPA, and TDEC in FY 2014. The ORR Groundwater Strategy provides a comprehensive framework for early actions and long-term implementation to support CERCLA decision-making for ORR groundwater.

The ORR Groundwater Strategy identified and ranked plumes across the ORR using a modified EPA Hazard Ranking System approach and available data. The approach takes into account the inherent hazards of a plume, a plume’s ability to migrate, and distance from the plume to potential receptors. Since

groundwater contaminant migration may result in surface water discharges that exceed ecological protection standards, both human and ecological receptors were considered in plume ranking. Plume ranking results guide the prioritization of projects identified to address plumes and data uncertainties. The initial plume ranking and project prioritization results presented in the ORR Groundwater Strategy will be reevaluated as implementation of the strategy proceeds. Findings will be used to identify early groundwater actions that may be necessary for protection of human health and the environment prior to final site cleanup.

Implementation of ORR Groundwater Strategy recommendations began in FY 2014 and continued in FY 2015 as described below.

ORR Groundwater Program. An ongoing ORR Groundwater Program is in place with a senior geohydrologist and other assigned resources. Activities being performed under this program include co-sampling with TDEC and development of a regional scale groundwater flow model. ORR Groundwater Program findings will be integrated with remedy effectiveness and trend monitoring conducted by the Water Resources Restoration Program (WRRP) and will be used to systematically prioritize and investigate groundwater plumes and data gaps.

During FY 2015, in conjunction with the use of lower detection limits by the ORR Groundwater Program (required by the data quality objectives), detection limits were lowered for many WRRP laboratory parameters, which resulted in the detection of low concentrations of some analytes that would not have been identified in previous years. Many of these detections were "J qualified" (e.g., 0.39 J µg/L), meaning that the analyte was determined to be present, although the reported concentration is approximate (J = estimated value). This use of lower detection limits for WRRP monitoring was a temporary change. Data will be evaluated to identify WRRP locations where it may be beneficial to continue use of lower detection limits (e.g., exit pathways).

Off-site Groundwater Assessment. An Off-site Groundwater Assessment project to evaluate off-site groundwater quality and movement is underway. The project is a cooperative DOE, EPA, and TDEC effort. Two sampling events were completed in FY 2015 in accordance with an approved work plan. A confirmatory sampling event and preparation of a Remedial Site Evaluation (RSE) report of results are planned for FY 2016. The RSE report is scheduled to be issued in November 2016.

Regional flow model. The geologic framework for the regional scale flow model was completed in FY 2015. Testing activities on a Test Case model were also completed. Construction of the regional scale flow model is underway. The regional flow model will serve as an underlying framework to support future cleanup decisions and actions.

1.3 LTS

Because most of the remediation decisions for ORR sites do not allow unlimited use/unlimited exposure (UU/UE), LTS will be required at these sites. LTS is the set of activities necessary to protect human health and the environment from physical hazards, residual contamination, and wastes remaining following remediation. The basic elements of LTS are:

- Stewards – Stewards are responsible for developing, implementing, and overseeing LTS activities.

- Operations – Operations are those activities necessary to ensure the integrity of the engineering controls and LUCs.

- *Engineering controls* include actions to stabilize and/or physically contain or isolate waste, contamination, or other residual hazards. Engineering controls include *in situ* stabilization; capping of residual contamination; excavation of residual contamination; groundwater extraction and treatment systems; demolition of buildings; and vaults, repositories, or engineered landfills designed to isolate waste or materials.

- *LUCs* are legal and other non-engineering measures intended to prevent the public from coming into contact with contamination left in place. LUCs include administrative controls such as property record restrictions, property record notices, zoning notices, excavation/penetration permit (EPP) programs and state advisories, as well as physical controls, such as contamination area postings, fences, signs, and surveillance patrols.

Operations include facility operations (e.g., routine operations of a groundwater treatment facility to maintain optimum performance), inspection, verification, surveillance, monitoring (e.g., monitoring of surface water, groundwater, sediment and biota, as reported in RERs), enforcement, maintenance, modification, replacement, and evaluation.

- Information Systems – Information systems maintain records of residual contamination, associated risks, required LTS activities, and performance of the engineering controls and LUCs.

- Research – Research is needed in areas such as the long-term performance of stabilization and containment technologies and long-term migration of contaminants to reduce the cost of LTS and the risk of residual contamination.

- Public Participation – Public participation is required since the public is being protected and should be involved in selecting, implementing, and reviewing the performance of the remedy and LTS activities.

- Public Education – Public education is necessary to ensure that the nature and risk of residual contamination and the resultant types of LUCs are understood.

- Funding – Adequate and sustained funding is necessary to develop and maintain LTS activities.

LTS ensures that the engineering controls and LUCs remain effective for an extended, or possibly indefinite, period of time until residual hazards are reduced sufficiently to permit unrestricted use and unlimited access (McCracken 2004). LTS is designed to ensure that:

- engineering controls prevent the residual hazard from migrating to the receptor, and

- LUCs prevent the receptor from encountering the residual hazard.

Various CERCLA decision documents are used to make remediation decisions on the ORR. Typically, either a ROD for an RA or Action Memorandum (AM) for a removal action defines the selected remedy. These decision documents contain the statutory decision for the response actions and may also specify LTS requirements. However, because most decision documents generally lack specifics on LTS requirements, additional details typically are found in post-ROD documents, such as post-construction reports, remedial action reports (RARs), removal action reports (RmARs), phased construction completion reports (PCCRs), or monitoring plans. Final LTS requirements will be included in comprehensive RARs for each watershed ROD. This will allow source control actions to have been completed or at least identified, the interim RAs to be completed, evaluated, and changed, if necessary,

and the end state of each watershed to be understood so that appropriate LTS requirements can be identified.

The RER evaluates the performance of LTS activities. The definitions encompassing LTS have evolved over time, and earlier decision documents used the term "institutional controls" instead of LUCs and engineering controls. This term "institutional controls" is used throughout this document when using citations directly from these earlier decision documents.

Figure 1.2 illustrates the Environmental Management (EM) lifecycle. As remediation projects are completed, areas with residual contamination transition to LTS. Performance and protectiveness of implemented remedies are reviewed and follow-up actions are taken to address any identified issues to ensure protectiveness. This review may lead to a reevaluation of the approved remedy.

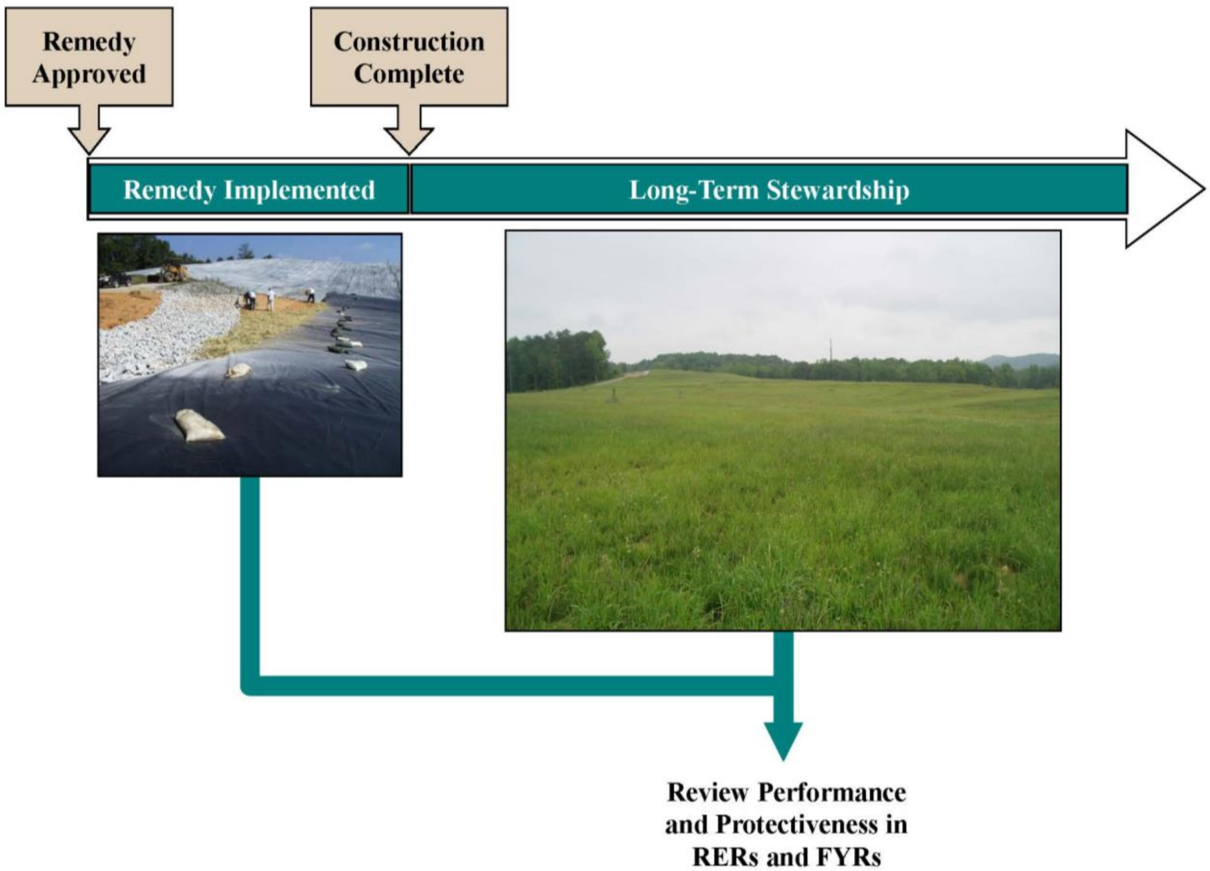

Figure 1.2. EM lifecycle.

The hierarchy of assessing the performance of implemented remedies is illustrated in Figure 1.3. The decision document describes the remedy in terms of engineering controls and LUCs. The completion document describes the completed action and may further define LTS requirements. Under LTS, engineering controls must be operated, maintained, and monitored, and LUCs must be inspected and verified so protectiveness and performance can be evaluated. On the ORR, the DOE Oak Ridge Office of Environmental Management (OREM) uses the WRRP to implement performance monitoring requirements (Section 1.3.1) and to track other LTS requirements (Section 1.3.2). Performance is assessed and reported in the RER and CERCLA Five-Year Review (FYR) which may cause a reevaluation of the remedy. In FY 2015, work began on the 2016 FYR, including sampling and analyses, as well as site tour

visits, used specifically for the FYR (Figure 1.4). Data collected will be evaluated and presented in the *2016 Fourth Reservation-Wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (in preparation).

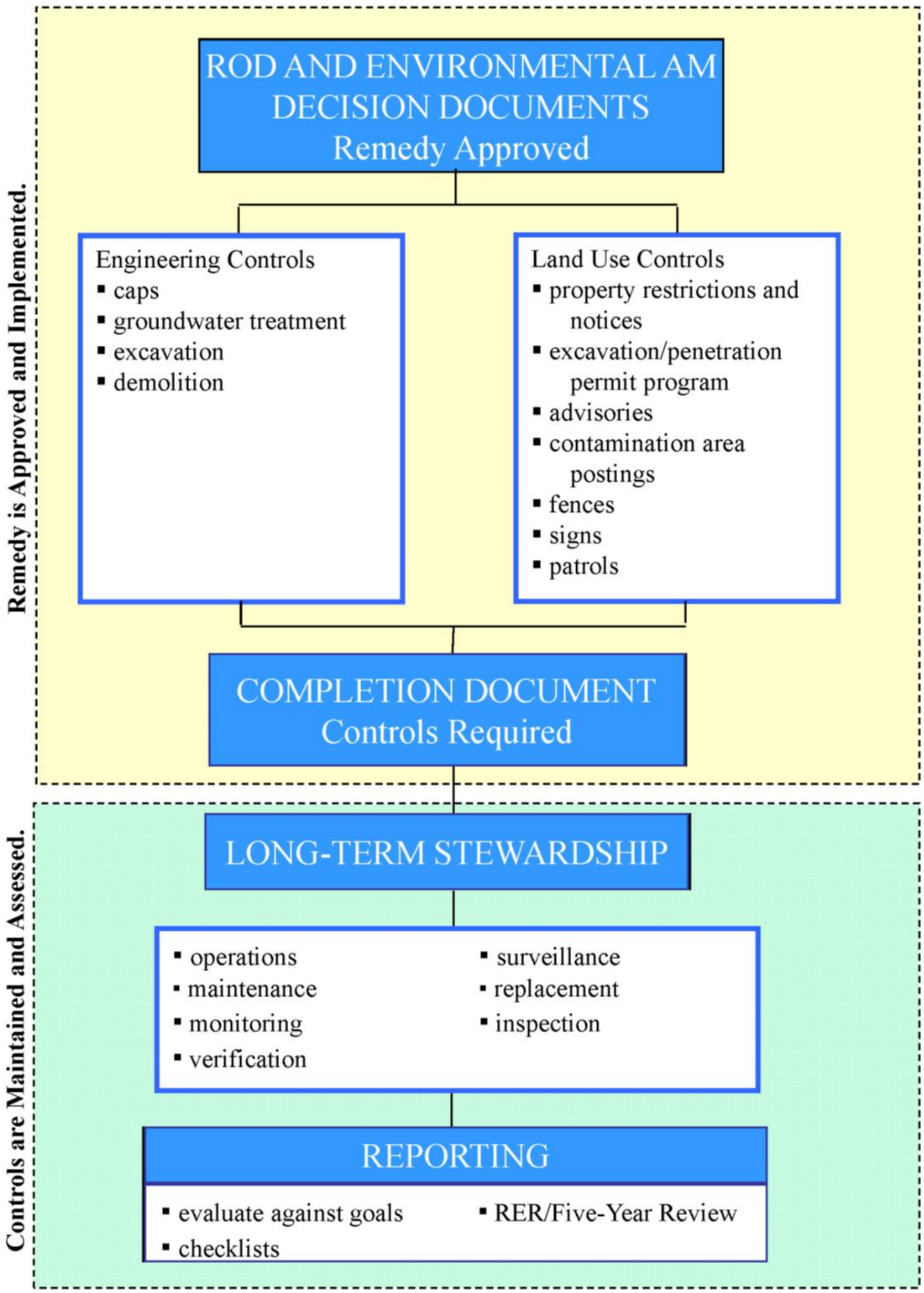

Figure 1.3. Hierarchy for assessing performance.

Figure 1.4. FYR site tour visits in Bethel Valley.

1.3.1 Performance Monitoring

Performance monitoring is an instrumental component of LTS. It is used to assess the performance of completed CERCLA actions where residual contamination is left that does not allow for UU/UE. On the ORR for CERCLA sites, this information is compiled by DOE OREM through the WRRP. The WRRP was established to implement a comprehensive, integrated environmental monitoring and assessment program for the ORR and to minimize duplication of field, analytical, and reporting efforts. Groundwater, surface water, sediment, and biota are monitored and evaluated as part of this assessment program. In addition to collecting performance assessment data, baseline data also is collected to gauge the effectiveness of future actions once implemented. All data used in the RER are collected in accordance with the watershed-specific monitoring plans and the *Quality Assurance Project Plan for the Water Resources Restoration Program* (UCOR-4049), or, for data collected by other programs, in accordance with a quality assurance project plan (QAPP) that meets equivalent standards and requirements.

The *Quality Assurance Project Plan for the Water Resources Restoration Program* (UCOR-4049), referred to as the WRRP QAPP, has been developed to identify and implement quality assurance requirements for use in sample collection, laboratory analysis, and data management of groundwater, surface water, sediment, and biota activities performed under the WRRP. The WRRP QAPP identifies the procedures that will be followed in the collection, custody, and handling of samples, as well as verification and validation of environmental/laboratory data, used in the WRRP. Appendix F of the WRRP QAPP also contains specific sampling and analysis plan (SAP)/QAPP checklists approved by the EPA. The WRRP QAPP meets the requirements of the EPA (EPA/240/B-01/003), *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)*, and integrates with the current *Data Management Implementation Plan for the Water Resources Restoration Program, Oak Ridge, Tennessee* (UCOR-4160).

Performance levels (goals) for CERCLA actions are identified in decision documents and are used for performance monitoring. Some performance levels are risk-based and dependent upon future end uses for environmental media designated in the decision document (e.g., industrial land use). Additionally, ambient water quality criteria (AWQC) and Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) are either identified as applicable or relevant and appropriate requirements (ARARs) or used as screening levels for many CERCLA actions and are therefore also used for comparative purposes but are not performance goals unless explicitly stated in the decision document.

Tennessee has surface water use classifications listed in Rules of the TDEC, Chap. 0400-40-04, and assigns one or more of those uses to each surface water body in the state. Numeric and narrative AWQC are listed in Chap. 0400-40-03-.03 for each of these designated uses. For the designated uses set for streams on the ORR, only Fish and Aquatic Life and Recreational Use have specific numeric AWQC set for particular compounds. Unless stated otherwise, the most stringent of the applicable AWQC for the assigned designated uses for ORR surface waters were used in the RER for comparison to the surface water data.

Cleanup goals for groundwater on the ORR have yet to be determined and will be set under future CERCLA decisions for ORR watershed actions. Tennessee is authorized by EPA to administer the federal Clean Water Act of 1972 (CWA) in the state, and has a classification scheme for groundwater that includes use classifications and specific numeric criteria and risk standards for each use. However, as described in Section 5.3.4 of the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2), the state groundwater rules are not EPA-approved. Absent that approval, the rules are not considered by EPA to be *legally applicable* at EPA CERCLA sites, as that term is applied under the CERCLA ARAR process, so they do not apply to ORR groundwater cleanup. The CERCLA National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that federal SDWA MCLs and non-zero maximum contaminant level goals (MCLGs) be attained for all RAs for

groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCLGs are relevant and appropriate under the circumstances of the release [40 *Code of Federal Regulations* (CFR) 300.430(e)(2)(i)(B)-(C)]. Unless stated otherwise, the most stringent of the state or federal MCLs or non-zero MCLGs for ORR groundwater were used in the RER for comparison to groundwater data. The use of MCLs/non-zero MCLGs is not intended to imply any conclusions regarding the use classification or cleanup goals for ORR groundwaters at this time.

Select biological monitoring data are also collected and used to assess performance. The data provide a usable measure of overall improvements in aquatic conditions. However, unless indicated otherwise, these data are not intended to imply any conclusions regarding the current status of ecological risk. The risk to ecological receptors for most watersheds will be evaluated in future studies such as Remedial Investigations (RIs) and addressed by final decisions for each of the watersheds.

1.3.1.1 Watershed-scale Monitoring Plans

A meeting was held in FY 2013 in which the Federal Facility Agreement (FFA) Project Managers determined that watershed-scale sampling and analysis plans for the Oak Ridge, Tennessee sites would be classified as primary documents tied to an existing type of primary document (i.e., an RAR) under the current FFA. With this decision, the status of the watershed-scale monitoring plans was clarified, providing approval authority to the TDEC, as well as the EPA. Table 1.1 provides the previous title of each of the watershed-scale monitoring plans with its document number and the associated primary document title.

1.3.2 Tracking Other LTS Requirements

Information about other LTS requirements used in this document was collected and/or compiled by DOE OREM through the WRRP in conjunction with surveillance and maintenance (S&M) programs at ETTP, ORNL, and Y-12. Site-specific inspections to assess the condition of engineering controls, as well as physical LUCs, i.e., access controls, signs, and security patrols, are performed by the S&M programs in accordance with site-specific S&M plans. Inspection checklists are completed electronically for each location and linked to any needed maintenance request forms in the Land Use Manager (LUM) web-based application. This documentation is maintained electronically in LUM and hard copies are ultimately filed in the Document Management Center. The WRRP routinely reviews the status of these checklists in LUM to monitor effectiveness and to summarize compliance with the LTS requirements annually in the RER.

Documentation verifying the implementation of administrative LUCs, i.e., property record restrictions, property record notices, zoning notices, and EPP programs, is obtained from many sources, including the County Register of Deeds offices for property record restrictions and property record notices, the City Planning Commission for zoning notices, and project engineers for the EPP program. Copies of this documentation are obtained by the WRRP and maintained with the project files.

The *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation* (DOE/OR/01-1824&D1/A2) requires that the Manager, DOE Oak Ridge Operations (ORO), annually verify in the RER that Land Use Control Implementation Plans (LUCIPs) are being implemented on the ORR. Only select LUCs for Melton Valley require an annual certification, and this annual certification for Melton Valley is in Appendix A. The Manager of the OREM is the designated official for this certification.

1.3.2.1 LUM Tracking System

In 2013, a new electronic data entry and tracking system was implemented in the field to help consolidate the more than 200 data and progress tracking spreadsheets that were being generated each year for LTS. The LUM software streamlines the stewardship tracking process for more than 90 ORR CERCLA and RCRA sites and generates consistent, real-time information. LUM went live in 2014 and serves as the administrative record for site inspection checklists.

Advantages of LUM include centralized data storage; standardized content and reports; easy access in field; paperless or standard inspection template; accountable record of CERCLA/RCRA required inspections; efficient tracking of LTS requirements and compliance (helps ensure nothing is missed); query function; and automatic e-mail reminders and notifications regarding upcoming inspections, outstanding issues, site maintenance requests, and corrective actions. This new tracking process facilitates the monitoring and implementation of LTS activities across the ORR.

1.4 NPL BOUNDARY DEFINITION

The approximately 33,500 acre DOE ORR includes the former K-25 gaseous diffusion plant (ETTP), Y-12, ORNL, BCV waste management areas, the Melton Valley waste management areas, Chestnut Ridge, Scarboro Facilities, and White Wing Scrap Yard historically operational portions of the Reservation, which are surrounded by approximately 19,600 acres of mostly wooded parcels. These wooded, buffer parcels have little to no federal process-related history and most have now been determined to be clean and never part of the Oak Ridge NPL Site. However, the use of the Site title, *Oak Ridge Reservation,* made it appear that the entire Reservation was placed on the NPL in 1989.

The FFA Appendix C list of remediation areas has been modified to better represent only the known contaminated areas, on and off the ORR, constituting the NPL site. The FFA Appendix B Oak Ridge Site Description now contains a new map that reflects the areas on and off the reservation that will be addressed under CERCLA via the FFA.

Figure 1.5 is a map showing in purple the above listed historically operational portions of the Reservation that have been or will be addressed by CERCLA decision documents, in pink the listed FFA Appendix C areas that are outside of the above identified portions, and hatched river/creek sediment contamination areas. DOE operational areas identified in gold, like the Spallation Neutron Source (SNS) facility, are outside the historic operational portions and have not been listed in the FFA as requiring cleanup at this time.

Table 1.1. Revised watershed-scale monitoring plan titles

Document Number	Previous Title	Primary Document Title
DOE/OR/01-1982&D3	Water Resources Restoration Program Sampling and Analysis Plan for the Melton Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee	Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan
DOE/OR/01-2457&D2/A1	Water Resources Restoration Program Sampling and Analysis Plan for the Bear Creek Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee	Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee
DOE/OR/01-2466&D3	Water Resources Restoration Program Sampling and Analysis Plan for the Upper East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds, Oak Ridge Reservation, Oak Ridge, Tennessee	East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee
DOE/OR/01-1820&D3	Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee	Lower Watts Bar Reservoir and Clinch River/ Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee
DOE/OR/01-2477&D1	NA	East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee
DOE/OR/01-2478&D1	NA	Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan for the Oak Ridge Reservation, Oak Ridge, Tennessee

NA = not applicable

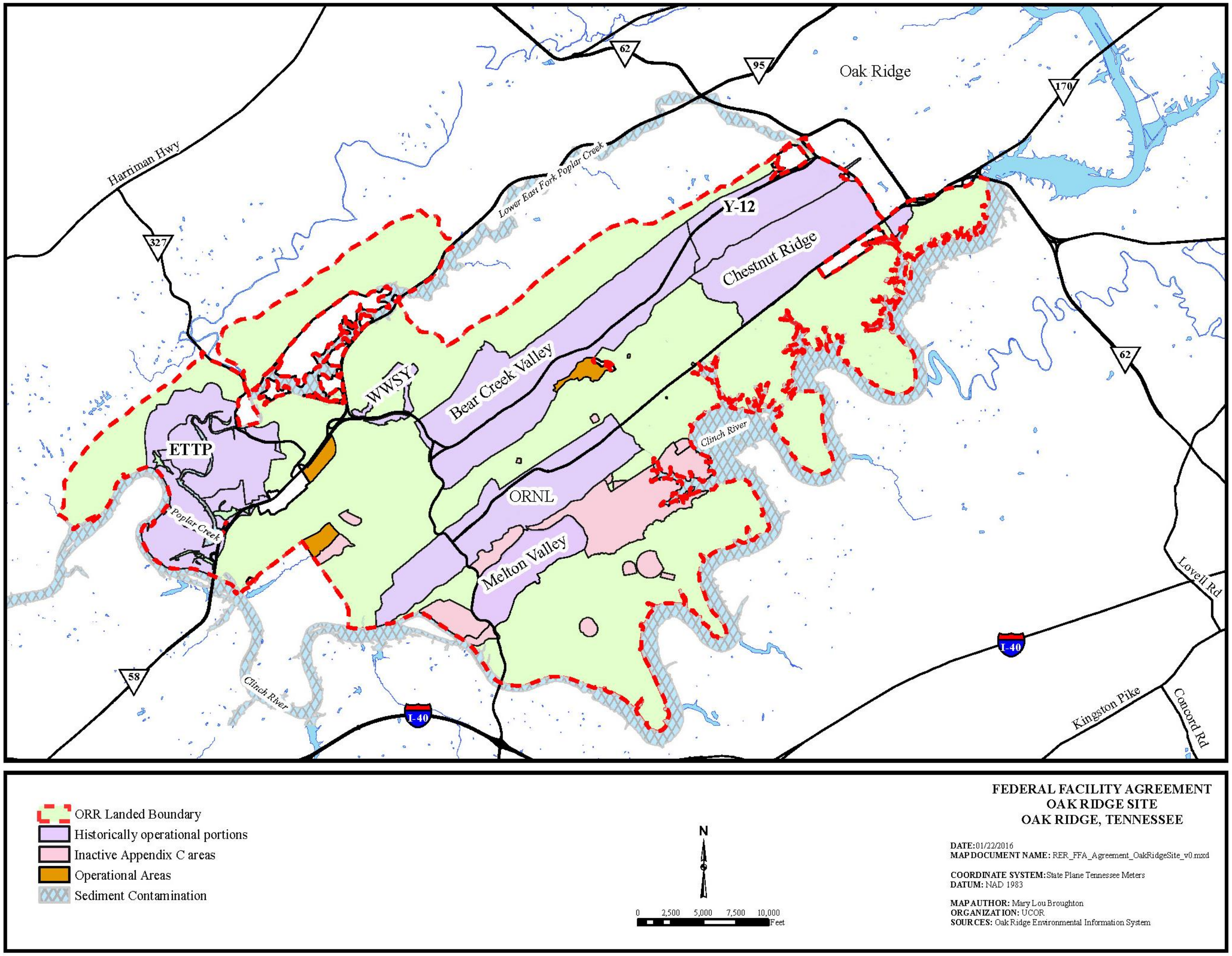

Figure 1.5. FFA Oak Ridge site.

1.5 ORR RAINFALL

The quantity, duration, and intensity of rainfall affect contaminant concentrations in groundwater and surface water across the ORR. Because of this, general rainfall trends for FY 2015 are summarized to provide a general context for the remainder of this document.

Details of rainfall distribution for FY 2015 are illustrated in Figure 1.6. Mean monthly rainfall values for FY 2015 range from approximately 1.5 in./mo. to 8.24 in./mo. During FY 2015, the greatest monthly rainfall occurred in July 2015 during which numerous strong thunderstorm systems dropped more than 8 in. of rainfall across the ORR. The lowest monthly rainfall occurred during May 2015 with only approximately 1.5 in. of rain. During FY 2015, rainfall distribution was somewhat uneven with the months of November and May experiencing below average monthly average levels while October and July experienced above average rainfall. The remainder of the months experienced about average or greater than average rainfall levels.

Total average rainfall on the ORR during FY 2015 (Figure 1.7) was 55.9 in. based on a composite of six rain-gauge stations located throughout the ORR. As shown in Figure 1.8, two of the rain gauges are located at ETTP (K-1208RG and K-1209RG), two of the rain gauges are located at Y-12 (Y-12RGWest and TOWY; TOWE data was used prior to 2006 when TOWY was constructed), one rain gauge is located at ORNL (formerly TOWC which was replaced by newly constructed TOWD at essentially the same location), and the Oak Ridge Townsite raingage (KOQT) located at the Federal Office Building. The total rainfall during FY 2015 was approximately 2 in. more than the long-term mean of 54 in./yr. The higher than average annual rainfall is reflected in somewhat increased contaminant flux values at several monitoring locations.

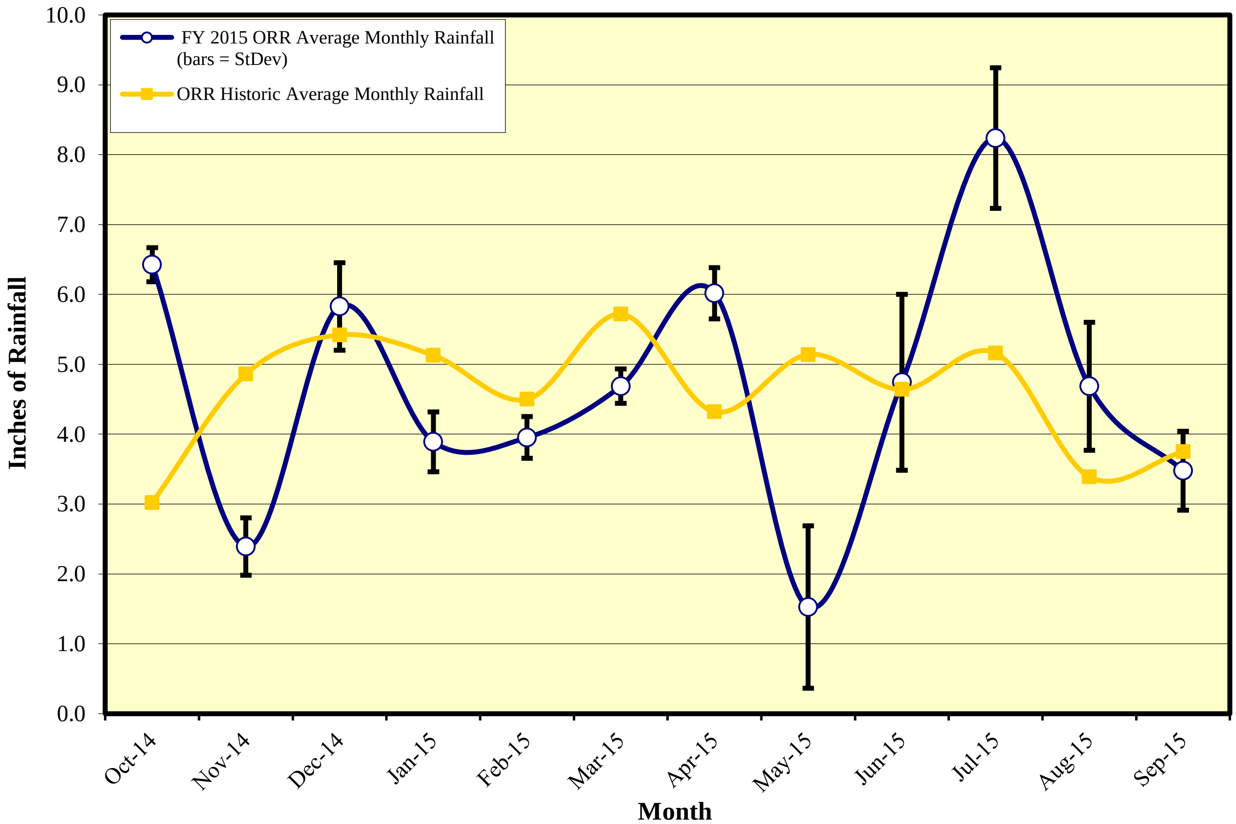

Figure 1.6. FY 2015 monthly average rainfall from six rain gauges on the ORR.

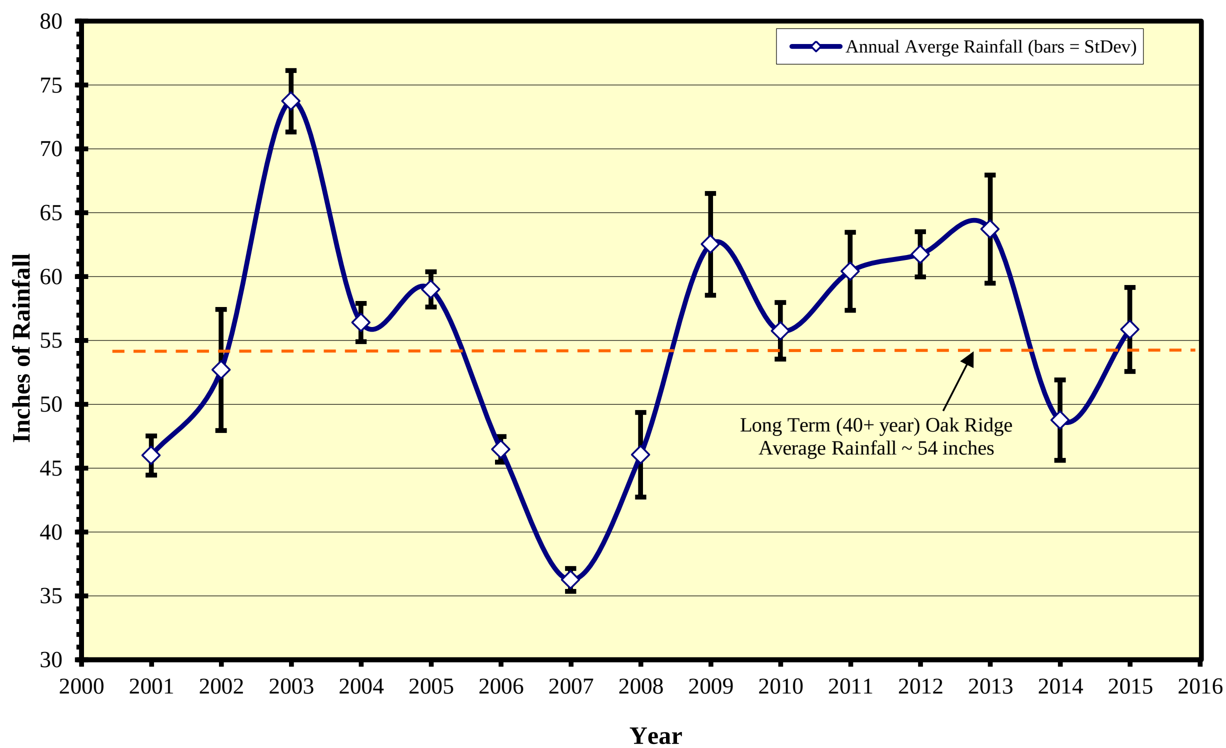

Figure 1.7. Mean annual rainfall from six rain gauges on the ORR, FY 2001 – 2015.

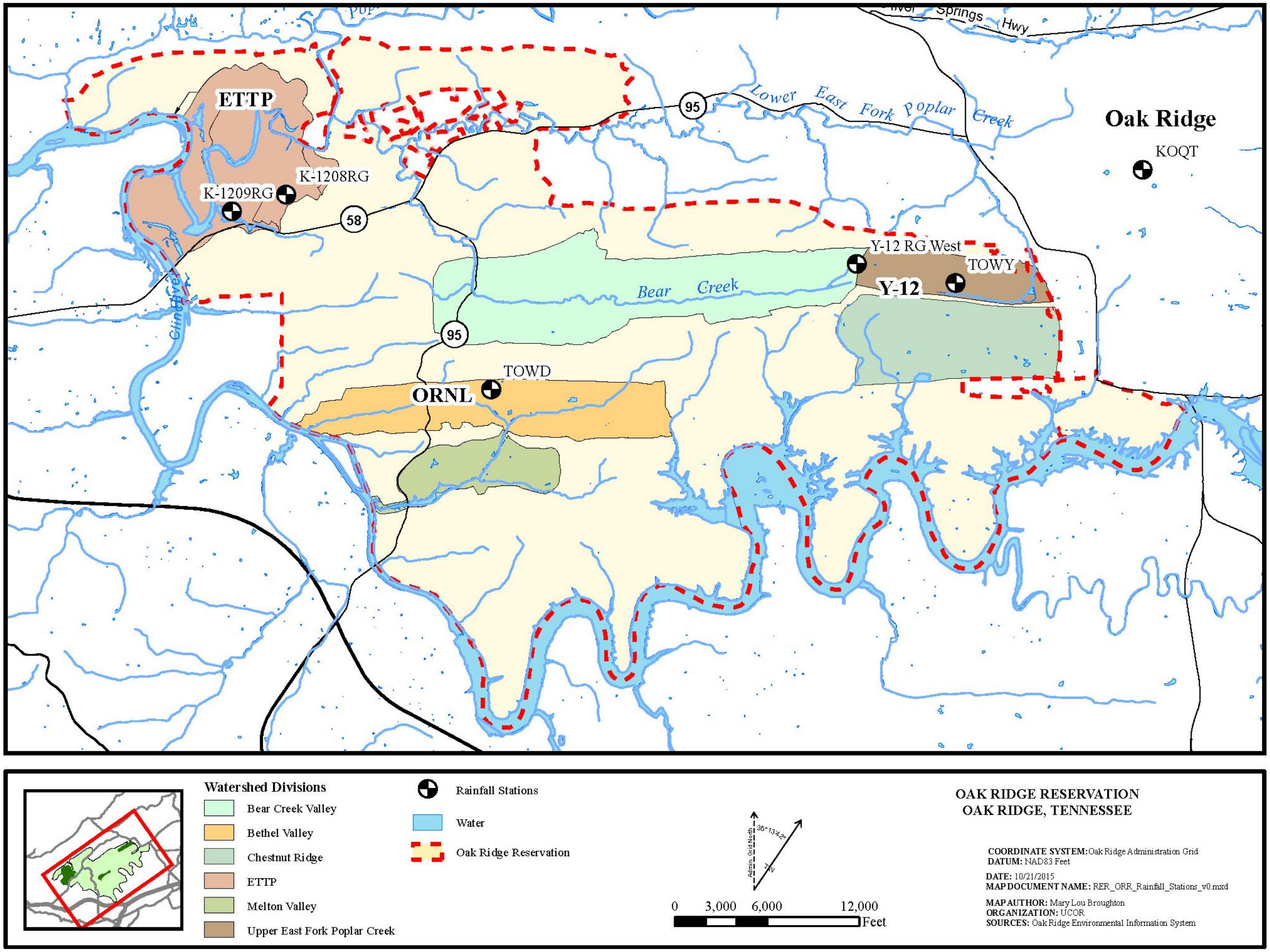

Figure 1.8. Rain-gauge stations across the ORR.

1.6 DOCUMENT ORGANIZATION

The RER contains the following chapters:

- Chapter 1 – Introduction
- Chapter 2 – Bethel Valley Watershed
- Chapter 3 – Melton Valley Watershed
- Chapter 4 – Bear Creek Valley Watershed
- Chapter 5 – Chestnut Ridge
- Chapter 6 – Upper East Fork Poplar Creek Watershed
- Chapter 7 – Off-Site Actions
- Chapter 8 – East Tennessee Technology Park
- Chapter 9 – CERCLA Actions at Other Sites
- Appendix A – Certification of Land Use Control Implementation Fiscal Year 2015
- Appendix B – Selected Oak Ridge National Laboratory Groundwater Data
- Appendix C – Action Plans Identified from 2011 Third Reservation-Wide CERCLA Five-Year Review (DOE/OR/01-2516&D2)

Figure 1.1 shows the watersheds on the ORR and Figure 1.9 shows the off-site CERCLA areas downstream of the ORR. Implementation of the watershed RODs can take many years to complete. Therefore, watershed maps in each chapter use different symbols to identify completed actions and actions in progress.

A chapter is devoted to each of the watersheds (Figure 1.1), to Chestnut Ridge, to off-site actions, and to other sites. Rather than forming a single defined hydrologic watershed, Chestnut Ridge and ETTP comprise several individual sub-watersheds but are treated as a single unit for decision-making and performance assessment purposes. Each chapter identifies completed watershed-scale actions, completed single-project actions, and completed demolition projects (if applicable) with LTS requirements. For each chapter, the following information is provided:

- Description of the completed actions, including engineering controls and LUCs;
- Description of monitoring and other LTS requirements (e.g., inspection and verification of LUCs, facility operations, and site inspection and maintenance) for completed actions;
- Evaluation of compliance with LTS requirements. When insufficient data exist to assess the impact of the completed actions, e.g., when the action was only recently completed or not all actions prescribed

by the watershed ROD have been implemented, a preliminary evaluation is made of early indicators of effectiveness at the watershed scale, such as contaminant trends at surface water integration points;

- Summary and issues and recommendations.

Actions that do not have LTS requirements or have been terminated or superseded by watershed-scale actions are not discussed. The *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2516&D2) includes an up-to-date compendium of all CERCLA decisions.

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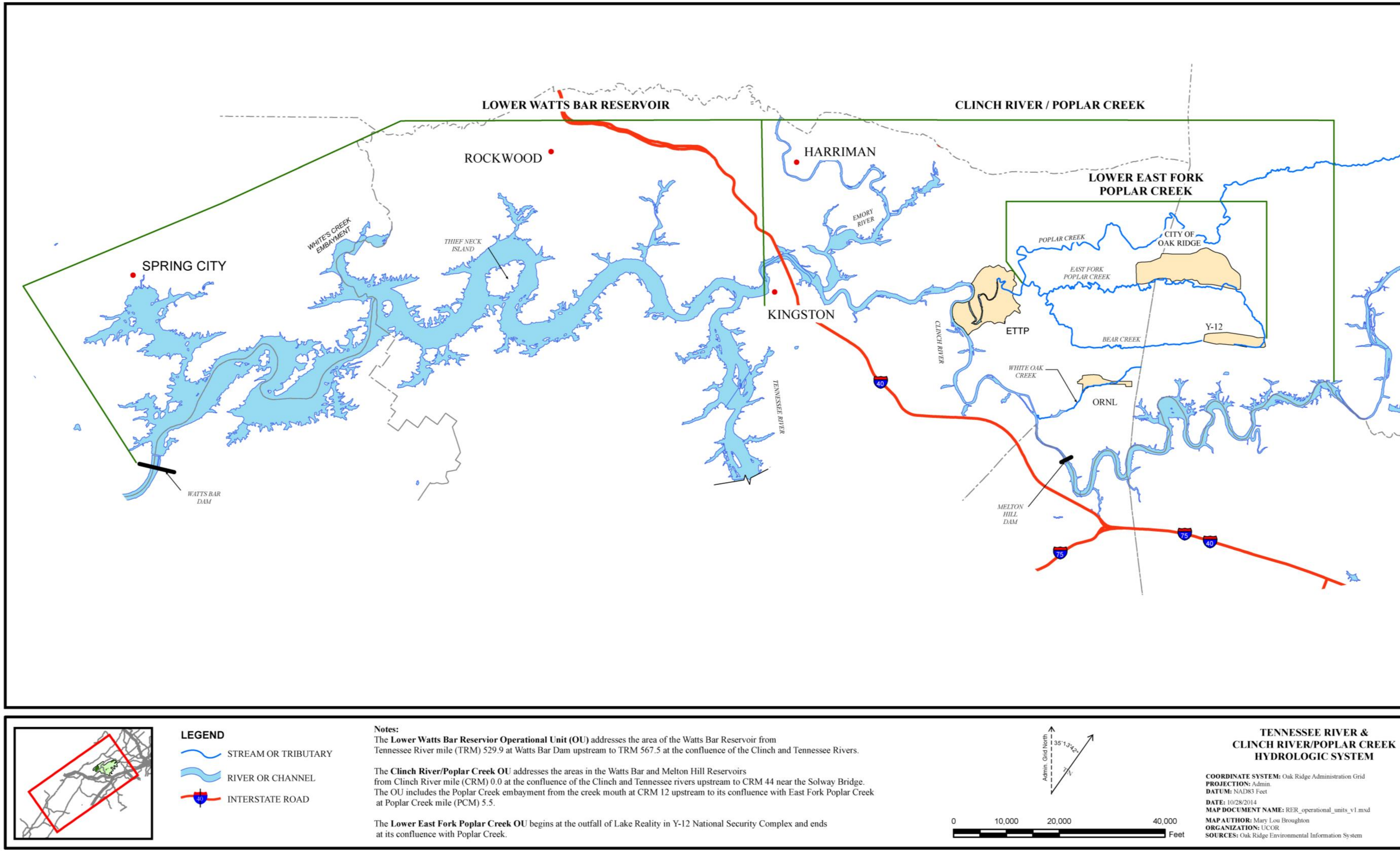

Figure 1.9. Off-site CERCLA areas (Lower Watts Bar, Clinch River/Poplar Creek, and LEFPC Operational Units).

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1.7 ISSUES AND RECOMMENDATIONS

To track issues through their resolution, Table 1.2 is a compilation of the issues and recommendations identified in subsequent chapters of this RER and unresolved issues carried forward from a previous RER. Beginning with the 2015 RER, a trackable RER issue is defined as an item identified in the effectiveness evaluation that:

- is for a completed CERCLA action.
- does not meet a performance standard or goal specified in a ROD or completion document (e.g., RAR, PCCR, etc.). For example, monitoring results exceed a performance level over a period of time or an engineering control or LUC was not performed as specified and a timely repair was not able to be made.
- does not already have an identified path forward through planned remedy maintenance actions or designated future CERCLA actions.

Other factors may be considered when determining if an item is a trackable RER issue (e.g., unusual climatic conditions, intermittent nature of exceedance, etc.). Observations from monitoring data (e.g., trends) and stewardship tracking are highlighted in the Executive Summary of the RER.

Table 1.3 identifies those issues that are closed in this RER and will no longer be tracked in future RERs or FYRs. Table 1.4 is a summary of open issues, recommendations, and follow-up actions from the *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2516&D2) updated through September 2015. Table 1.5 is a summary of closed issues and recommendations from the 2011 FYR.

An issue that is carried forward from a previous year's RER is only discussed in the respective chapter of the text if FY 2015 assessment clarifies, modifies, or otherwise impacts the issue in any way. For example, because issues in Table 1.2 may require completion of future actions, those particular issues will remain in the table for tracking purposes, but generally will not be discussed in any detail in the respective chapter.

Table 1.2. 2016 RER issues and recommendations
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation/Resolution	Responsible parties	Target response date
Melton Valley			
1. Several wells in Melton Valley have chronically not attained the ROD goal for groundwater level within hydrologically isolated areas. (2015 RER)	1. Two wells in SWSA 6 and three wells in SWSA 4 have not attained the ROD goal for groundwater level control inside hydrologically isolated areas. At one well (well 4127 in SWSA 6) physical modifications are recommended; at two wells in SWSA 4 near the downgradient trench a cessation of monitoring goal requirements is recommended; and at two wells (one well in SWSA 4 and one well in SWSA 6) the recommendation is to continue water level monitoring for long-term trend evaluation (with no specified water level goal). At SWSA 6, DOE recommends continued monitoring of downgradient groundwater quality in well 0838 as the indicator of cap performance since that well is downgradient of the well 0850 area and has shown significant decreases in contaminant levels post-remediation. These recommendations will be discussed at a Project Team meeting for incorporation into an addendum to the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan.* Completion of this process and modification of well 4127 will close the issue.	DOE	FY 2017
ETTP			
1. The northern section of ETTP Zone 1 has been identified as a conservation easement (BORCE). The BORCE is utilized for recreational use: hiking, bicycling, and select controlled deer hunts. The end use identified in the ETTP Zone 1 ROD is unrestricted industrial, i.e., recreational use was not designated. (2010 RER)	1. DOE acknowledges the land use differences that exist between the BORCE and that which is designated in the Zone 1 ROD. The *Final Proposed Plan for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D3) addresses anticipated future industrial and recreational land use in Zone 1. The determination in the Proposed Plan that industrial use goals for Zone 1 are also protective of recreational uses is planned to be included in the Zone 1 Final Soils ROD.	DOE/EPA & TDEC	FY 2016 with Zone 1 Final Soils ROD

[a]The year of the RER in which the issue originated is provided in parentheses, e.g., (2013 RER).

BORCE = Black Oak Ridge Conservation Easement
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FY = fiscal year
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation

Table 1.3. RER issues closed in 2015

Issue[a]	Recommendation/Resolution	Responsible parties Primary/Support	Target response date
	ETTP		
1. An asphalt cover has been placed over the K-29 slab since approval of the CERCLA completion document for building demolition. (2014 RER)	1. Agreement has been reached on the management of potentially contaminated slabs, and this agreement has been documented in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D2). The ETTP Project Team has agreed to apply this management approach to the K-29 slab and document it accordingly.	DOE/EPA & TDEC	FY 2015
2. There are several issues associated with the interim management of potentially contaminated slabs at ETTP. Monitoring requirements identified in demolition completion documents have been changed or eliminated following a RA decision for the area without appropriate interaction. The frequency of radiological monitoring by the Radiation Protection Program has changed without notification to the Regulators. Fixatives placed over radiological contamination do not have specified inspection and maintenance requirements. (2013 RER)	2. Agreement has been reached on the management of potentially contaminated slabs, and this agreement has been documented in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D2).	DOE/EPA & TDEC	FY 2015

[a]The year of the RER in which the issue originated is provided in parentheses, e.g., (2013 RER). Only issues that are closed out in this RER (2016) are included. Similarly, prior RERs have identified issues which were closed out in that year.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FY = fiscal year
RA = remedial action
RER = Remediation Effectiveness Report
TDEC = Tennessee Department of Environment and Conservation

Table 1.4. 2011 FYR summary of open issues and recommendations and follow-up actions[a]

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
			Off-ORR Actions				
OF-2 [OUs 28]	New information suggests mobilization of mercury from the UEFPC and LEFPC streambed and stream banks is the primary source of mercury export during high-flow conditions. The current ROD did not address the entire hydrologic system (e.g., upstream sources within Y-12) and did not address creek bank or creek bed sediments.	Assessment of the entire EFPC system from its headwaters within Y-12 (OU 28) to its downstream confluence with Poplar Creek will be documented in the RER. Any potential action on this issue will be addressed as part of the sequencing approach for mercury remediation throughout the system (see Issue UEF-1).	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: Action Plan #1 with a status update is included in this RER in Appendix C. In FY 2015, Action Plan #1 activities included 1) completing field studies of bank soil erosion and shallow groundwater through spring 2015, and 2) generating a model of current mercury flux conditions such that various remedial scenarios can be simulated. A final report summarizing field and laboratory studies and modeling work for the Action Plan #1 project will be published in March 2016.	Y	Y
OF-3 [OU 10]	New mercury bioaccumulation studies show mercury uptake in spiders along EFPC.	Continue studies to complete the conceptual model for mercury bioaccumulation in measurement points (e.g., spiders) and subsequent ecological endpoint receptors in the EFPC RI prior to the Final ROD.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 03/30/13. Status: Action Plan #2 with a status update is included in this RER in Appendix C. In FY 2015, invertebrate samples were collected at selected plots with soil mercury data from FY 2014. Sampling results will be used to determine a site-specific revised bioaccumulation factor that will be used to calculate an ecological remediation level. This will be used for a protectiveness determination in FY 2016.	Deferred	Deferred

Table 1.4. 2011 FYR summary of open issues and recommendations and follow-up actions[a] (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b] Current	Affects Protectiveness? (Y/N)[b] Future
					UEFPC Actions		
UEF-1 [OU 28]	Mercury concentrations at Station 17 are above the 200 ppt performance goal. Mercury concentrations in fish in LEFPC have yet to respond to commensurate reductions of mercury from historical response actions.	Remedial measures have not been completed under the UEFPC Phase I ROD. Implementation of Mercury Mitigation Strategy, including the Mercury Action Strategy Document and a Mercury Water Treatment System (Outfall 163), are initial phased response actions.	DOE	EPA/TDEC	Submit action plan(s) per FFA Section XXXI in the Mercury Mitigation Strategy 3/31/13, including: • RDWP and Conceptual Design (Outfall 200) 6/30/13. Status: An amendment to the UEFPC Phase I ROD to add an Outfall 200 MTF (*Amendment to the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee Water Treatment at Outfall 200* [DOE/OR/01-2697&D1]) was submitted to the regulators in November 2015.	Y	Y
					ETTP		
ETTP-1 [OU 15]	Land use in the northern portion of Zone 1 (Black Oak Ridge) has been changed to a conservation easement (BORCE) and used for recreational use: hiking, bicycling, and select deer hunts. The end use identified in the Zone 1 ROD is unrestricted industrial (i.e., recreational use was not designated).	Designate use as recreational. Address through appropriate documentation agreed upon with the ETTP Core Team. Determine if industrial use goals are protective of recreational uses. The *Final Proposed Plan for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D1) addresses anticipated future industrial and recreational land use in Zone 1. The determination in the Proposed Plan that industrial use goals for Zone 1 are also protective of recreational uses is planned to be included in the Zone 1 Final Soils ROD.	DOE	EPA/TDEC	Zone 1 Final Proposed Plan – 8/9/14. Zone 1 Final ROD – 12/17/15. Status: The *Final Proposed Plan for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D1) was submitted to the regulators on 4/29/14. The Zone 1 Final Soils ROD is scheduled for submittal in FY 2016.	N	Y

[a]Issues and actions are from the 2011 FYR, (DOE/OR/01-2516&D2), status as of September 30, 2015.
[b]Assumes that the proposed recommendation has not been implemented.

BORCE = Black Oak Ridge Conservation Easement
CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System
DOE = U.S. Department of Energy
EFPC = East Fork Poplar Creek
EPA = U.S. Environmental Protection Agency

Table 1.4. 2011 FYR summary of open issues and recommendations and follow-up actions[a] (cont.)

ETTP = East Tennessee Technology Park
FFA = Federal Facility Agreement
FY = fiscal year
FYR = Five-Year Review
LEFPC = Lower East Fork Poplar Creek
MTF = Mercury Treatment Facility
N = No
OU = operable unit
RER = Remediation Effectiveness Report
RDWP = Remedial Design Work Plan
RI = Remedial Investigation
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek
Y = Yes
Y-12 = Y-12 National Security Complex

Table 1.5. 2011 FYR summary of closed issues and recommendations[a]

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
		General Issue – All Watershed ROD Actions with pending long-term actions					
Closed G-1 [OUs 30, 32, 28, 15]	Risk methods, toxicity factors, and COCs have changed over time for actions under watershed RODs that are in progress.	During planning for additional actions not yet started under the BV, BCV, UEFPC, Zone 1, and Zone 2 RODs, remediation levels will be updated prior to implementing additional actions and documented in approved CERCLA work plans. The remediation levels will be included in post-ROD documentation.	DOE	EPA/TDEC	Status: Risk and COC information are being updated as needed in planning and documenting watershed actions. For example: • In recent ETTP Zone 2 PCCRs (e.g., *Phased Construction Completion Report for Exposure Units Z2-04 and Z2-05 in Zone 2, at the East Tennessee Technology Park, Oak Ridge, Tennessee* [DOE/OR/01-2590&D1] approved 02/11/13), characterization data is compared against Zone 2 ROD RLs for ROD-identified COCs; risk screening levels (current chemical RSLs and radionuclide PRGs) for an aggregate risk evaluation; and the Zone 2 ROD soil screening levels for protection of groundwater. • Technetium-99 was not a COC in the ETTP Zone 2 ROD but when increased levels were detected following demolition of the K-25 building, a soil remediation level for ^{99}Tc was developed and incorporated in a revision to the Zone 2 RDR/RAWP. As part of the protectiveness evaluation, a comparison of updated risk and COC information as compared to the ROD-specified criteria will be performed for completed actions as part of the FYR to determine potential impacts to the RAOs established by the applicable ROD.	N	Y

Table 1.5. 2011 FYR summary of closed issues and recommendations (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
Off-ORR Actions							
Closed OF-1 [OU 10]	There is mercury underlying the parking lot corner at the Former Dean Stallings Ford property along LEFPC. This property is for sale and the sale could result in a change in land use.	DOE will monitor any future changes to land use. If changes occur DOE will evaluate the need for additional ICs and other response actions.	DOE	EPA/TDEC	Annually via RER. (note: annual review OK because remedy is protective) Monitoring of the former Dean Stallings Ford property is completed annually and reported on in the RER. Checking on the former Dean Stallings property is a requirement as stated in the RAR on the LEFPC Project (DOE/OR/01-1680&D5). "An annual survey to verify land use in the area of the Dean Stallings Ford automobile dealership parking lot shall be performed to verify that the land use has not changed since the issuance of the *East Fork Poplar Creek—Sewer Line Beltway Remedial Investigation Report* (DOE/OR/02-1119&V1&D2)," therefore this issue is closed.	N	Y
Closed OF-4 [OU 24]	The ^{137}Cs action level used by the WBIWG should be reviewed in light of the various changes in the risk assessment process and cancer slope factors.	The WBIWG will review the ^{137}Cs action level used for dredging permit decisions.	WBIWG	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: The Action Plan identified that the ^{137}Cs action level continues to be protective in the Watts Bar Reservoir and Clinch River/Poplar Creek for reviewing typical residential dredge permit requests. Larger commercial dredge requests will be evaluated to assure protectiveness. This Action Plan is closed out. The closed out Action Plan (#3) is included in this RER, Appendix C.	N	Y

Table 1.5. 2011 FYR summary of closed issues and recommendations (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
			MV Actions				
Closed MV-1 [OU 29]	During FY 2009 and FY 2010, the groundwater level control in the SWSA 4 downgradient trench in MV showed short-term problems following significant rainfall events. This indicates the possibility that contaminated groundwater may be discharged to the IHP for periods of time when water level control in the trench is inadequate.	DOE will evaluate the performance of the downgradient trench extraction wells and will recommend an action to improve system performance.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: A project to redevelop extraction wells in the SWSA 4 downgradient trench and to replace failed pumps is now complete and therefore this Action Plan is closed out. The closed out Action Plan (#4) is included in this RER, Appendix C.	N	N
			BV Actions				
Closed BV-1 [OU 30]	The BV ROD goal for surface water of "achieve at least 45% risk reduction at 7500 Bridge" is difficult to use as a quantitative measure of performance due to (1) uncertainty related to the exact baseline risk values against which to measure this reduction, and (2) lack of clarity in the ROD on sampling and statistical approach for measuring changes.	Modify Interim ROD to clarify criteria.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: The Action Plan clarifies baseline conditions and recommends that the 45% risk reduction goal continue to be evaluated using the current approach; therefore this Action Plan is closed out. The closed out Action Plan (#5) is included in this RER, Appendix C.	N	N
Closed BV-2 [OU 35]	Corehole 8 Plume collection system operation and maintenance issues are preventing it from currently meeting the RmAR performance goals.	Corehole Plume collection system is currently being upgraded. System is scheduled to be back online in FY 2012.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: The Action Plan identified the large scale upgrade of the Corehole 8 plume collection system, i.e., installation of two bedrock plume extraction wells and replacement of all of the system's electrical, mechanical and control components. This upgrade is now complete and therefore this	N	Y

Table 1.5. 2011 FYR summary of closed issues and recommendations (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
					Action Plan is closed out. The closed out Action Plan (#6) with a description of the activities is included in this RER, Appendix C.		
			UEFPC Actions				
Closed UEF-2 [OU 42]	The POC for the AWQC (organisms only) for the EEVOC Plume needs to be revised to an in-stream POC.	DOE will issue a NSC to the EEVOC Plume AM to clarify the POC for monitoring compliance.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: DOE has issued an NSC to the EEVOC Plume AM and an erratum to the RmAR and therefore this Action Plan is closed out. The closed out Action Plan (#7) is included in this RER, Appendix C.	Y	Y
			BCV				
Closed BCV-1 [OU 32]	The BCV ROD does not provide a comprehensive list of COCs and related RLs to evaluate compliance with ROD goals. This was the first "watershed" ROD and did not include these levels.	Identify specific COCs and related RLs to assess remedy performance prior to the BCV final ROD.	DOE	EPA/TDEC	Submit action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: Action Plan #8 clarifies criteria and provides a recommended approach to assess remedy performance; therefore, this Action Plan is closed out. The closed out Action Plan #8 is included in this RER, Appendix C.	N	Y

Table 1.5. 2011 FYR summary of closed issues and recommendations (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b] Current	Affects Protectiveness? (Y/N)[b] Future
Closed BCV-2 [OU 32]	NT-1 currently exceeds AWQC ARAR for cadmium (0.25 µg/L) and the OU is not protective of aquatic life. The S-3 Ponds removal action to address S-3 Ponds Pathways 1 and 2 was ineffective and, therefore, terminated. The S-3 Pond RA for Pathway 3 has not been implemented. Uranium activity at BCK 9.2 remains above acceptable levels for residential and industrial human receptors; however, there is no current unacceptable human exposure. Approximately 51% appears to come from NT-8, which drains the BCV Burial Grounds that are not under an existing ROD. A second significant amount of flux passing BCK 9.2 is measured at BCK 12.34, which drains the S-3 Ponds.	FFA Appendix E milestones for response actions at NT-8 and S-3 Ponds Pathways 1-3 deferred to FFA Appendix J in 2022 per agreement at the April 30, 2012 Supervisory Management Team meeting. Remaining actions for elevated flux passing BCK 9.2 and not meeting the Phase I ROD objectives will be evaluated in subsequent decision documents (e.g., NT-8 early action and BCBGs Final Action) and prioritized/scheduled in accordance with FFA Appendix E and J.	DOE	EPA/TDEC	Submit S-3 Ponds Pathways 1–3 action plan per FFA Section XXXI in 2012 D2 RER 7/30/12; report on action plan completion/status in 2013 RER 3/30/13. Status: Monitoring for uranium and cadmium at BCK 12.34 will continue. Action Plan #9 describes the FFA schedule for response actions at S-3 Ponds Pathways 1-3, NT-8, and BCBGs. This Action Plan is closed out. The closed out Action Plan #9 is included in this RER, Appendix C.	Y	Y
Chestnut Ridge							
Closed CR-1 [OU 26]	Monitoring at FCAP indicates arsenic concentrations in surface water downstream of the FCAP dam are occasionally greater than revised AWQC for "recreation, organisms only." However, arsenic concentrations are less than the AWQC for "fish and aquatic life." The ROD does not specify compliance with either of these numeric criteria; however, they are used as comparative criteria to track reduction in "contaminant migration to surface water" and "risk to ecological receptors."	Continue to monitor water quality downstream of the dam at MCK 2.0 as currently planned per WRRP monitoring.	DOE	EPA/TDEC	Report data and provide AWQC comparison in the annual RER. In the 2013 RER, report specifically on the status of this FYR issue. Status: AWQC comparison is included in the 2013 RER. The use of AWQC as comparative criteria was written into the text of the FCAP performance monitoring goals and objectives section in the 2013 RER (Section 5.4.1.1), therefore this issue is closed.	N	N
ETTP							
Closed ETTP-2 [OU 15]	The DVS process was not designed to address all sources of contamination to groundwater, and although PCCRs have released land for industrial use, some sources remain, e.g., K-1070-F, Contractor's Spoil Area, and others.	Address ongoing sources.	DOE	EPA/TDEC	Status: The DVS process has been approved and implemented in accordance with the Zone 1 Interim ROD as documented in approved PCCRs. Selection of remedies for remaining sources of groundwater contamination has been deferred to the future ETTP Sitewide ROD.	N	Y

Table 1.5. 2011 FYR summary of closed issues and recommendations (cont.)

[a]Issues and actions are from the 2011 FYR, (DOE/OR/01-2516&D2), status as of September 30, 2015.
[b]Assumes that the proposed recommendation has not been implemented.

AM = Action Memorandum
ARAR = applicable or relevant and appropriate requirement
AWQC = Ambient Water Quality Criteria
BCBG = Bear Creek Burial Ground
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
BV = Bethel Valley
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System
COC = contaminant of concern
CR = Clinch River
DOE = U.S. Department of Energy
DVS = Dynamic Verification Strategy
EEVOC = East End Volatile Organic Compound
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FCAP = Filled Coal Ash Pond
FFA = Federal Facility Agreement
FY = fiscal year
FYR = Five-Year Review
IC = institutional control
IHP = Intermediate Holding Pond
LEFPC = Lower East Fork Poplar Creek
MCK = McCoy Branch kilometer
MV = Melton Valley
N = No
NSC = Non-Significant Change
NT = North Tributary
OU = operable unit
PCCR = Phased Construction Completion Report
POC = point-of-compliance
PRG = Preliminary Remediation Goal
RA = remedial action
RAO = remedial action objective
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
RDR = Remedial Design Report
RER = Remediation Effectiveness Report
RL = remediation level
RmAR = Removal Action Report
ROD = Record of Decision
RSL = Regional Screening Level
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek
WBIWG = Watts Bar Interagency Working Group
Y = Yes

1.8 REFERENCES

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DOE/OR/01-1826&D3. *Record of Decision for Interim Actions in the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1862&D4. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5),* 2001, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, D. C.

McCracken, Stephen H., March 18, 2004, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee, Memorandum to Gerald G. Boyd, U.S. Department of Energy Oak Ridge Operations Office Manager, Oak Ridge, Tennessee on the subject Oak Ridge Long-term Stewardship Strategic Plan.

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TNHW-116. *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime*, 2003, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2003, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

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UCOR-4160. *Data Management Implementation Plan for the Water Resources Restoration Program, Oak Ridge, Tennessee*, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

2. BETHEL VALLEY WATERSHED

2.1 INTRODUCTION AND STATUS

2.1.1 Introduction

The Bethel Valley watershed contains most of the active facilities and a considerable fraction of the CERCLA facilities and contaminated sites at ORNL. Table 2.1 lists the CERCLA actions within the watershed and identifies those with monitoring or other LTS requirements. Figure 2.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Only sites that have LTS requirements (Table 2.1) are included in these performance evaluations. End uses of a site form the basis of remedial action objectives (RAOs) and determine access restrictions and allowable activities at the site. Figure 2.2 shows ROD-designated end uses within the watershed and interim controls requiring LTS.

Completed CERCLA actions in the Bethel Valley watershed are gauged against their respective action specific goals. However, CERCLA actions have yet to be fully implemented within the watershed. Therefore, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provide a preliminary evaluation of the early indicators of effectiveness at the watershed scale.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 6 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

2.1.2 Status

<u>Watershed-Scale Actions</u>

The *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4) includes a combination of RAs and decontamination and decommissioning (D&D) projects.

- The *Remedial Design Report/Remedial Action Work Plan for Soils, Sediments, and Dynamic Characterization Strategy for Bethel Valley* (DOE/OR/01-2378&D5) presents a statistically-based soil characterization strategy to verify that the RAOs in the ROD are met following RA. Actions completed to date under this *Remedial Design Report/Remedial Action Work Plan* (RDR/RAWP) include remediation of Northwest Quadrant slabs and soil (DOE/OR/01-2579&D1) and the Building 3550 slab (DOE/OR/01-2627&D1) located in the main plan area of ORNL (see Figure 2.1). No RA activities were completed or initiated under this RDR/RAWP in FY 2015.

- **Building 3042 Reactor Pool Seep**. The Building 3042 Oak Ridge Research Reactor was an isotope production and irradiation facility that operated from 1958 through 1987. During routine S&M activities, a seep was detected in the Building 3042 reactor pool on September 10, 2014, from the bottom flange area located beneath the pool (Figure 2.3) in the sub-pile room (Figure 2.4). An RA project with the primary objective of addressing the reactor pool seep was initiated in FY 2015 and is being performed under the ROD with no changes to the final selected remedy. A component of

addressing the seep is the removal of material from the pool. The project is being implemented in accordance with the *Remedial Action Work Plan/Waste Handling Plan for the Building 3042 Oak Ridge Research Reactor Pool Action, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2689&D2), approved on August 18, 2015.

- The Remedial Design Report/Remedial Action Work Plan for the Decontamination and Decommissioning of Non-Reactor Facilities in Bethel Valley and addenda (DOE/OR/01-2428&D2, DOE/OR/01-2428&D2/A2, DOE/OR/01-2428&D2/A3) address demolition of approximately 180 facilities and the removal of legacy material planned for implementation over a period of more than 20 years. No D&D activities were completed or initiated under this RDR/RAWP in FY 2015.

Single-Project Actions

Buildings 3074 and 3136, and the 3020 Stack Dismantlement. The *Time-Critical Removal Action Memorandum for Buildings 3074 and 3136, and the 3020 Stack at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2407&D1) was prepared in 2009 for the dismantlement of Buildings 3074 and 3136 and the 3020 Stack. Buildings 3074 and 3136 were dismantled in FY 2009, and the waste was disposed in FY 2012. The 3020 Stack was not dismantled. If it is dismantled in the future, the scope will be performed as a separate CERCLA response action. In June 2014, the *Removal Action Report for Buildings 3074 and 3136 and the 3020 Stack at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2641&D1) documenting dismantlement of Buildings 3074 and 3136 was submitted to EPA and TDEC. EPA approved the document and TDEC provided comments. The D2 version of the report was submitted on May 22, 2015, and TDEC provided comments on that version.

Table 2.1. CERCLA actions in Bethel Valley watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Watershed-scale actions			
Bethel Valley Interim Actions	ROD (DOE/OR/01-1862&D4): 05/02/02	**Watershed-scale requirements**	Yes (see Table 2.4)/Yes (see Table 2.13)
	NSC (DOE/OR/01-2152&D1), addition of Hot Storage Garden (3597): 06/25/04	**Actions complete**	
	NSC, delineates area of land transferred for multi-program research facility: 12/03/04	PCCR for Hot Storage Garden (DOE/OR/01-2265&D1) approved 01/10/06	No/No
	NSC, addition of IFDP facilities: 09/10/09	PCCR for the Tanks T-1, T-2, and HFIR (DOE/OR/01-2238&D1) approved 11/16/05	No/No[c]
	NSC, errata to NSC submitted 09/10/09; no approval required: 10/26/09	PCCR for the Bethel Valley Mercury Sumps Groundwater Action (DOE/OR/01-2472&D1) approved 08/27/10	Yes/Yes
	ESD (DOE/OR/01-2446&D2), changes to SWSA 3 remedy: 10/05/10	PCCR for Corehole 8 Extraction System (DOE/OR/01-2534&D1/A1) approved 04/23/12	Yes/Yes
	NSC, clarification of risk reduction goals at 7500 bridge: 11/16/13	PCCR for Northwest Quadrant Slabs and Soils (DOE/OR/01-2579&D1) approved 11/05/12	No/TBD[d]
		PCCR for D&D of General Maintenance Facilities (DOE/OR/01-2552&D2) approved 10/09/12	No/TBD[d]
		PCCR for D&D of Small Facilities and Southeast Contaminated Lab Facilities (DOE/OR/01-2573&D2) approved 10/09/12	No/TBD[d]
		PCCR for Isotopes Row Facilities Legacy Material Removal (DOE/OR/01-2557&D2) approved 09/21/12	No/No
		PCCR for BVBGs (DOE/OR/01-2533&D2) approved 05/11/12	Yes/Yes
		PCCR for 4500 Gaseous Waste Reconfiguration and Stabilization (DOE/OR/01-2614&D1) approved on 11/20/13	No/No
		PCCR for Building 3026 C Hot Cell Demolition (DOE/OR/01-2629&D1) approved on 11/21/13	No/TBD[d]
		PCCR for Building 3038 Legacy Material Removal (DOE/OR/01-2617&D2) approved on 01/27/14	No/No

Table 2.1. CERCLA actions in Bethel Valley watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
		PCCR for 3550 Slab (DOE/OR/01-2627&D1) approved on 11/04/13	No/No
Single-project actions			
		Actions complete	
WAG 1 Corehole 8 (Plume Collection)	AM (DOE/OR/02-1317&D2): 11/10/94 Addendum AM (Letter): 04/22/98 Addendum AM (DOE/OR/01-1831&D2): 09/30/99	RmAR (DOE/OR/01-1380&D1) approved 09/11/95	Superseded by PCCR for Corehole 8 Extraction System (DOE/OR/01-2534&D1/A1)[e]
		Phase I Operations Report (DOE/OR/01-1832&D2) submitted on 11/02/99	
		Phase II Operations Report (DOE/OR/01-1882&D1) approved 06/21/00	
Building 3001 Canal	AM (DOE/OR/02-1533&D2): 11/18/96	RmAR (DOE/OR/01-1599&D2) approved 08/22/97	No/No[f]
Surface Impoundments Operable Unit	ROD (DOE/OR/02-1630&D2): 09/25/97	RAR for Impoundments A and B (DOE/OR/01-2086&D2) approved 05/17/04	No/Yes
		RAR for Impoundments C and D (DOE/OR/01-1784&D2) approved 04/19/99	No/No
Metal Recovery Facility	AM (DOE/OR/01-1843&D2): 03/3/00	RmAR ([DOE/OR/01-2000&D2/R1] approved with the acceptance of the Completion Letter [waste disposition] 06/18/08)	No/Yes
WAG 1 Tank WC-14 (1) Liquid removal	AM (DOE/OR/02-1322&D2): 02/16/95	RmAR (DOE/OR/01-1397&D1) approved 08/21/95	Discontinued/No
WAG 1 Tank WC-14 (2) Sludge removal	AM (DOE/OR/02-1598&D2): 09/3/97	RmAR (DOE/OR/01-1738&D2) approved 12/15/98	No/No
Waste Evaporator Facility	AM (DOE/OR/02-1381&D2): 07/28/95	RmAR (DOE/OR/01-1460&D1) approved 12/12/96	No/No
GAAT Operable Unit	ROD (DOE/OR/02-1591&D3): 09/2/97	RAR (DOE/OR-01-1955&D1) approved 10/2/01	No/No
Inactive Liquid LLW Tanks	AM (DOE/OR/01-1813&D1): 05/26/99 AM Addendum (DOE/OR/01-1833&D2): 09/30/99	RmAR (DOE/OR/01-1953&D2) approved 10/2/01	No/No
		RmAR II Addendum (DOE/OR/01-1953&D2/A2) submitted 09/26/01	No/No
GAAT Shells/Risers	AM (DOE/OR/01-1957&D2): 07/13/01	RmAR (DOE/OR/01-2010&D1) approved 08/21/02	No/No

Table 2.1. CERCLA actions in Bethel Valley watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Corehole 8 Plume Source (Tank W-1A)	AM (DOE/OR/01-1749&D1): 09/17/98 Amended in 1999	RmAR (DOE/OR/01-1969&D3) approved 08/30/12	No/Yes
2000 Complex D&D	AM (DOE/OR/01-2412&D1): 09/03/09	RmAR for 2000 Complex (DOE/OR/01-2501&D1) approved 08/25/11	No/No
3026 C&D D&D Wooden Superstructure	AM (DOE/OR/01-2402&D2) 03/24/09	RmAR (Wooden Superstructure) (DOE/OR/01-2470&D1) submitted 03/22/11 (approval not required)	No/TBD[d]
		Actions in progress	
Buildings 3074, 3136 and 3020 Stack D&D	AM (DOE/OR/01-2407&D1): 04/09/09	RmAR (DOE/OR/01-2641&D2) submitted on 05/22/15	TBD[g]

[a]Information on the enforceable agreement milestones for ongoing actions is in Appendix E of the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]"No/No" indicates no monitoring/other LTS requirements are identified in the CERCLA action completion document beyond those identified in the watershed ROD. Refer to Table 2.4 for watershed-scale monitoring requirements and Figure 2.2 and Table 2.13 for watershed-scale LUCs and other LTS requirements.

[c]The *Phased Construction Completion Report for the Remediation of Tanks T-1, T-2, and HFIR* (DOE/OR/01-2238&D1) states that the above-ground areas of these sites are subject to routine maintenance and radiological surveys. However, this requirement was superseded by the *Remedial Action Report for the Melton Valley Watershed* (DOE/OR/01-2343&D1/A1) which omits any LTS requirements for these sites. The LTS of these sites is no longer reported in the RER. The T-1 and T-2 Tanks are located on the Bethel Valley watershed map (Figure 2.1) and HFIR Tank is located on the Melton Valley watershed map (Figure 3.1).

[d]This completion document includes "Other LTS" requirements for potentially contaminated slabs, e.g., slab monitoring, access controls, inspection, etc. Interim LTS requirements for potentially contaminated slabs following building demolition are the subject of an informal dispute. Until the informal dispute is resolved, the "Other LTS" requirements for potentially contaminated slabs are not known and are TBD.

[e]The "Monitoring/Other LTS" requirements in a completion document have been superseded, or replaced, by the requirements in the subsequent, referenced completion document.

[f]The *Removal Action Report on the Building 3001 Canal* (DOE/OR/01-1599&D2) required monthly inspections of the grout and paint for one year only. The monthly checks were conducted through 2006 and are no longer reported in the annual RER.

[g]The completion document was not approved during the FY 2015 reporting period.

AM = Action Memorandum
BVBGs = Bethel Valley Burial Grounds
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
D&D = decontamination and decommissioning
ESD = Explanation of Significant Difference
FY = fiscal year
GAAT = Gunite and Associated Tanks
HFIR = High Flux Isotope Reactor
IFDP = Integrated Facility Disposition Project
LLW = low-level waste
LTS = long-term stewardship
LUC = land use control
NSC = Non-Significant Change
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RER = Remediation Effectiveness Report
RmAR = Removal Action Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TBD = to be determined
WAG = Waste Area Grouping

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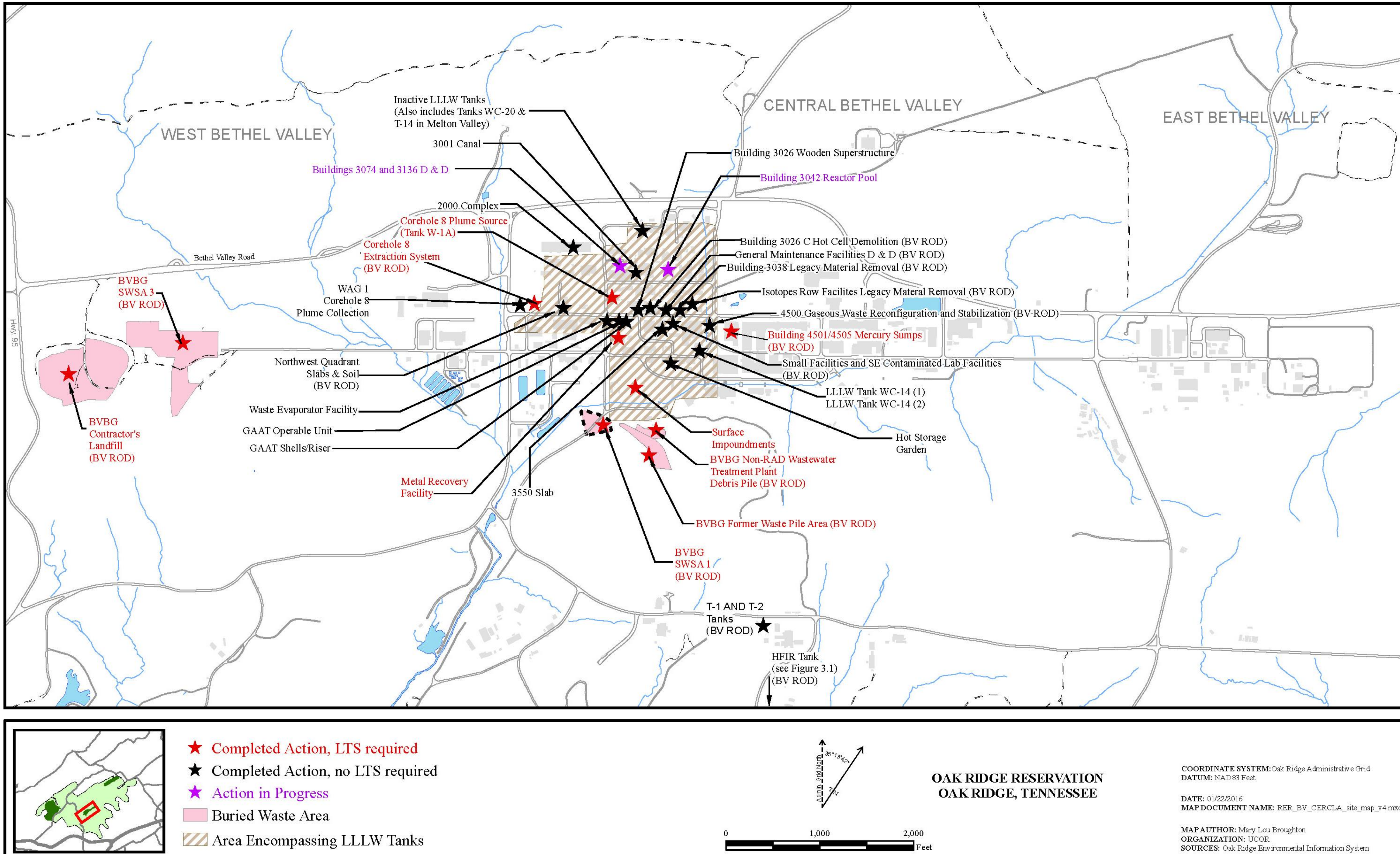

Figure 2.1. Bethel Valley watershed.

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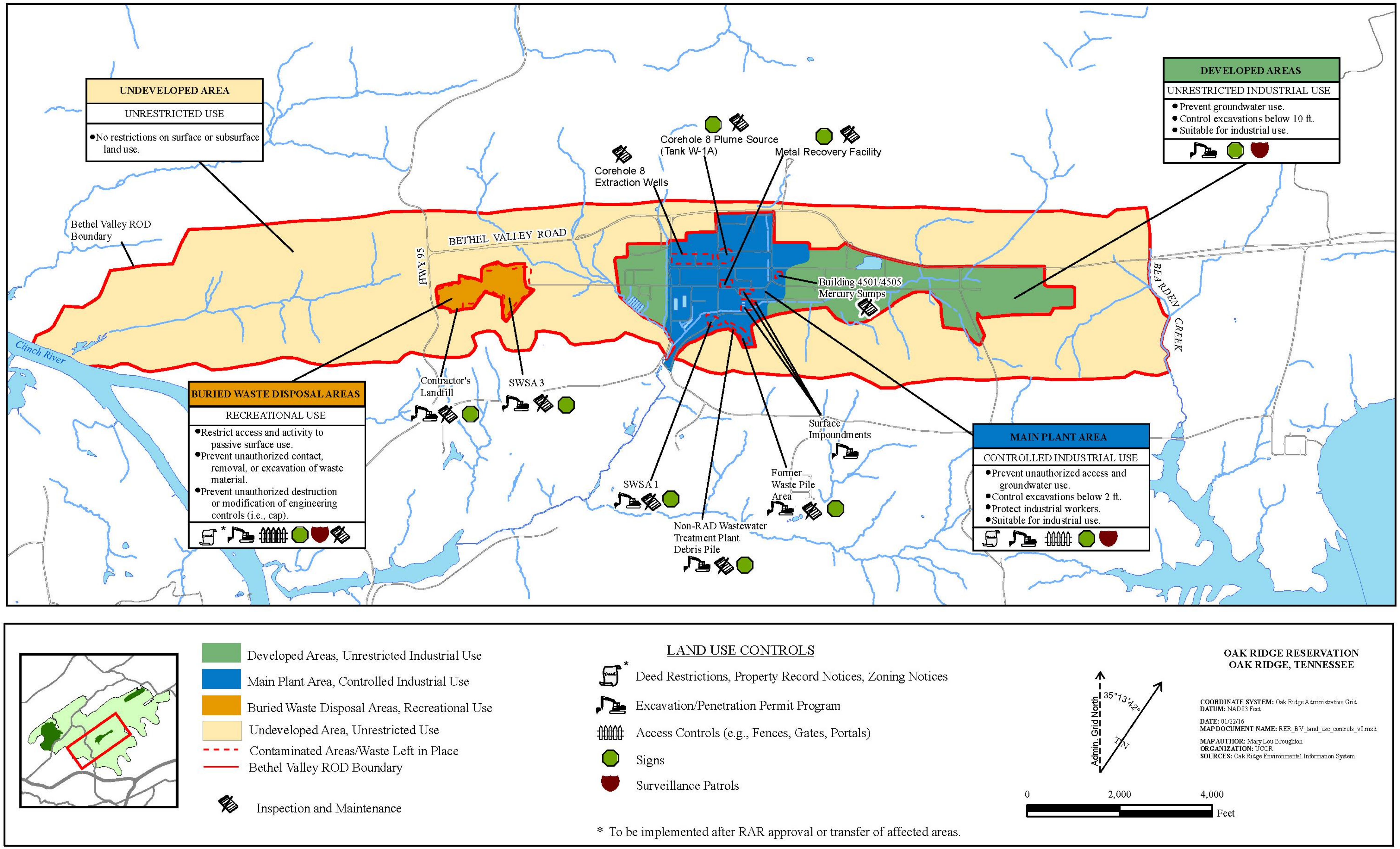

Figure 2.2. Bethel Valley ROD-designated end uses and interim controls requiring LTS.

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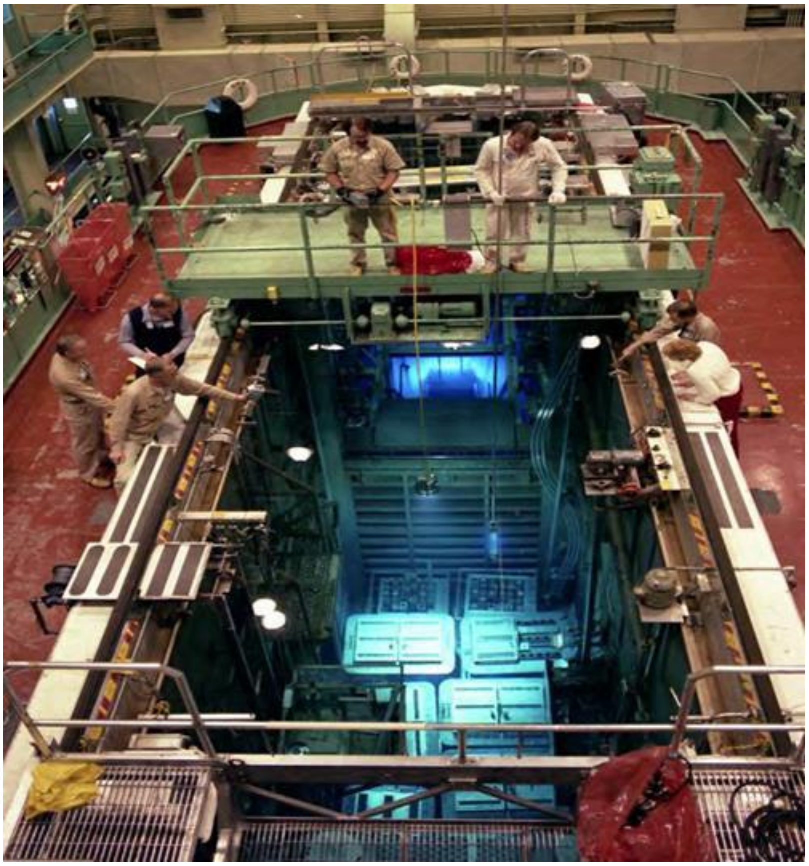

Figure 2.3. Building 3042 reactor pool.

Figure 2.4. Building 3042 sub-pile room.

2.2 ROD FOR INTERIM ACTIONS FOR THE BETHEL VALLEY WATERSHED

2.2.1 Performance Monitoring

2.2.1.1 Performance Monitoring Goals and Objectives

The remedy in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) includes actions to address contaminated buildings and other facilities designated for demolition, buried waste, underground liquid low-level waste (LLLW) tanks, accessible underground process and LLLW transfer pipelines, accessible contaminated surface and subsurface soil, contaminated sediment and surface water, contaminated groundwater, and groundwater monitoring wells and piezometers no longer needed for monitoring. The scope does not include active facilities (e.g., Building 4500N) and infrastructure that have ongoing missions, nor does it include contaminated media and sources that are inaccessible due to the presence of the active facilities and infrastructure. The final groundwater decision will be made after source control actions are complete, their effectiveness is monitored, and limited additional characterization data is collected.

The *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) stipulated RAOs for Bethel Valley based on future end use including controlled industrial use (the main ORNL plant area), unrestricted industrial use (the other currently developed areas), a recreational use area (buried waste disposal areas), and unrestricted use areas (including West Bethel Valley/Raccoon Creek and portions of the Bearden Creek drainage to the east); protection of surface water; protection of groundwater; and protection of ecological receptors (Table 2.2). Figure 2.2 illustrates the future end use areas.

Table 2.2. RAOs for Bethel Valley[a]

Issue	*Protection goals*
Future end use	*Protect human health for: (1) controlled industrial use in ORNL's main plant area, (2) unrestricted industrial use in the remainder of the ORNL developed areas, (3) recreational use of SWSA 3 and the Contractor's Landfill, and (4) unrestricted use in the undeveloped areas, all to a risk level of 1×10^{-4}*
Protection of surface water bodies	*Achieve AWQC for designated stream uses in all waters of the state*
	Achieve at least 45% risk reduction at the 7500 Bridge
	Maintain surface water and achieve sediment recreational risk-based limits to a goal of 1×10^{-4}
Groundwater protection	*Minimize further impacts to groundwater*
	Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	*Maintain protection for area populations of terrestrial organisms; protect reach-level populations of aquatic organisms*

[a]*Record of Decision for Interim Actions at Bethel Valley* (DOE/OR/01-1862&D4).

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective
SWSA = Solid Waste Storage Area

RAOs for surface water include attainment of a 45% risk reduction from baseline levels of 1994 at the 7500 Bridge and attainment of AWQC for designated stream uses. Principal contaminants of concern identified for risk reduction at the 7500 Bridge include ^{90}Sr and ^{137}Cs. In addition, the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) specifies the attainment and maintenance of water quality and sediment contaminant levels of 1×10^{-4} for a hypothetical recreational end use scenario. The RAOs for groundwater are to prevent further degradation of water quality by remediation of soils that contribute to groundwater contamination above a 1×10^{-4} risk level for a hypothetical industrial use

scenario, to protect surface water by continued collection and treatment of groundwater that causes surface water exceedances, and to reduce surface water risk from contaminated groundwater discharge.

The *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) included specific performance objectives and performance measures that form the basis of remediation effectiveness monitoring. These performance objectives provide a quantitative basis to evaluate the effectiveness of remedial activities including the attainment of AWQC numeric and narrative goals related to contaminant discharges to surface water, and the evaluation of hydrologic isolation at limiting contaminant releases from buried waste by monitoring groundwater fluctuation within hydrologic isolation areas. The ROD did not specify ARAR-based groundwater remediation levels and meeting such ARAR-based levels is not a performance objective of the ROD. The ROD includes the requirements to monitor groundwater exit pathway wells and to monitor groundwater in the vicinity of contaminant source control areas to measure effectiveness of contaminant source control actions. Post-remediation monitoring and other LTS requirements will be developed in the PCCR for each element of the remedy. Table 2.3 lists the performance objectives and performance measures for the defined RAs. Figure 2.5 shows watershed scale monitoring locations and Table 2.4 lists CERCLA action performance monitoring in Bethel Valley.

Table 2.3. Performance measures for major actions in Bethel Valley[a]

Waste type	***Unit***	***Remedial actions***	***Performance objective (protection goals)***	***Performance measure (demonstration of effectiveness)***
Facilities D&D (buildings and appurtenances)	*Multiple (53) structures*	*Remove facilities to grade. Remaining structures at or below grade will undergo decontamination and stabilization or removal depending on cost effectiveness and underlying soil contamination*	*Protect human health for industrial use; minimize further impacts to groundwater*	*Contamination removed to protect industrial worker to 0.6 m (2 ft) or 3 m (10 ft). Loose contamination in subsurface removed to the extent practicable*
	Graphite Reactor building	*Stabilize Graphite Reactor core*	*Protect human health for industrial use and visitors*	*Negative pressure in building interior no longer needed*
Buried waste	*SWSA 1*	*Install a cap*	*Protect human health for controlled industrial use; minimize further impacts to groundwater*	*Entire area of buried waste covered by cap; infiltration limited by cap*
	Former Waste Pile Area	*Install and/or maintain soil cover*	*Protect human health for controlled industrial use*	*All debris and contamination above remediation levels covered*
	NRWTP Debris Pile	*Install and/or maintain soil cover*	*Protect human health for controlled industrial use*	*All debris and contamination above remediation levels covered*
	SWSA 3	*Install multilayer cap and upgradient surface water and groundwater diversion trench*	*Protect human health through access controls; minimize further impacts to groundwater*	*Entire area of buried waste covered by cap designed to meet relevant RCRA landfill cover requirements; stable or decreasing surface water concentrations; stable groundwater concentrations*
	Contractor's Landfill	*Install and maintain soil cover*	*Protect human health through access controls*	*All contamination above remediation levels covered*

Table 2.3. Performance measures for major actions in Bethel Valley[a] (cont.)

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
Tank sludge and linings	*Tank contents*	*Remove sludge and liquid from S-424, T-1, T-2, and HFIR*	*Minimize further impact to groundwater*	*Sludge removed to the extent practicable*
	Tank shells	*Fill the four tanks with grout*	*Minimize further impacts to groundwater*	*Tanks filled to the extent practicable*
Inactive LLLW pipelines	*Inside main plant area*	*Stabilize pipelines and add trench barriers*	*Maintain surface water recreational risk-based limits; achieve at least 45% risk reduction at 7500 Bridge; minimize further impacts to groundwater*	*Surface water goals met. Pipelines filled to the extent practicable*
	Outside main plant area	*Remove pipelines and contaminated bedding material [estimated at 1000 lin m (4000 lin ft)]*	*Protect human health for unrestricted industrial use*	*Meet remediation levels to 3 m (10 ft)*
Contaminated soil impacting worker protection	*Main plant area*	*Remove contaminated surface soil [estimated at 9000 m^3 (12,000 yd^3)]. Up to 10% of area may be covered.*	*Protect human health for controlled industrial use*	*Meets remediation levels to 0.6 m (2 ft). Substitutions of covers for removal determined on a case-by-case analysis during design*
	Outside main plant area	*Remove contaminated soil to 3 m (10 ft) [estimated at 500 m^3 (700 yd^3)]*	*Protect human health for unrestricted industrial use*	*Meets remediation levels to 3 m (10 ft)*
	Vicinity of SWSA 3 (multiple contaminated locations)	*Remove soil [estimated at 17,500 m^3 (22,900 yd^3)]*	*Protect human health for unrestricted use*	*Meets remediation levels*
Contaminated soil impacting groundwater	*Bethel Valley*	*Remove contaminated soil [estimated at 1500 m^3 (2000 yd^3)]*	*Minimize further impacts to groundwater*	*No soil above trigger levels and not contributing above 10^{-4} industrial risk from groundwater*
Sediment and floodplain soils	*White Oak Creek, First Creek and Fifth Creek*	*Remove contaminated sediment to depth of deposition and floodplain soils to a maximum depth of 0.6 m (2 ft) [estimated at 13,500 m^3 (17,600 yd^3)]*	*Achieve recreational risk-based limits in sediment, achieve at least 45% risk reduction at 7500 Bridge (primarily ^{137}Cs); protect human health for controlled industrial use; protect reach-level benthic invertebrate populations*	*Meets remediation levels and results in healthy benthic invertebrate populations. Meets surface water goals of at least 45% risk reduction at 7500 Bridge[b]*
Groundwater	*Core Hole 8 Plume*	*Extract groundwater from four wells and from sumps at seven stormwater junction boxes [estimated at combined rate of 380 L/min (100 gal/min)]*	*Prevent groundwater from causing surface water exceedances (at least 45% risk reduction at 7500 Bridge); minimize further impacts to groundwater*	*Controls plume growth; collect highly contaminated groundwater to extent practicable; effluent meets surface water goals and plant NPDES permit*
	^{90}Sr-contaminated sumps	*Pump from 27 existing sumps [estimated at combined rate of 360 L/min (81 gal/min)];*	*Prevent groundwater from causing surface water exceedances (recreational risk-based*	*Streams meet surface water goals (recreational risk and at least 45% risk reduction at 7500*

Table 2.3. Performance measures for major actions in Bethel Valley[a] (cont.)

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
		continue to treat to remove ^{90}Sr	*levels and at least 45% risk reduction at 7500 Bridge)*	*Bridge[b]); effluent meets surface water goals and plant NPDES permit*
	Mercury-contaminated sumps	*Pump from four existing sumps at a combined rate of 34 L/min (9 gal/min); add treatment to remove mercury*	*Prevent groundwater from causing surface water exceedances (meet AWQC)*	*Streams meet AWQC in surface water; effluent meets surface water goals and plant NPDES permit*
	VOC Plume	*Implement enhanced in situ anaerobic bioremediation*	*Minimize further impacts to groundwater*	*Biodegradation occurs and reduces VOC mass and concentration*
	Well P&A	*Grout obsolete or poor quality monitoring wells and piezometers and abandon in place (estimated at 229 wells); in areas designated for unrestricted industrial or unrestricted use, remove to depth of 3 m (10 ft)*	*Protect human health for the specified industrial use; minimize further impacts to groundwater*	*No unacceptable risk to workers. Consistent with TDEC plugging and abandonment standards [1200-4-6-.09(16)[c]]*

[a]Table 2.37 of *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4).

[b]A *Notification of Non-Significant Change to the Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4/R2) clarified the target concentration levels and compliance sampling techniques for measuring the 45% risk reduction.

[c]Previous ARAR citations have referenced TDEC 1200-4-6-.09. Current ARAR citations and current well P&A practice is consistent with substantive requirements of TDEC 0400-45-06-.09.

ARAR = applicable or relevant and appropriate requirement
AWQC = ambient water quality criteria
D&D = decontamination and decommissioning
HFIR = high flux isotope reactor
LLLW = liquid low-level (radioactive) waste
NPDES = National Pollutant Discharge Elimination System
NRWTP = Nonradiological Wastewater Treatment Plant
P & A = plugging and abandonment
RCRA = Resource Conservation and Recovery Act of 1976
Sr = strontium
SWSA = solid waste storage area
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound

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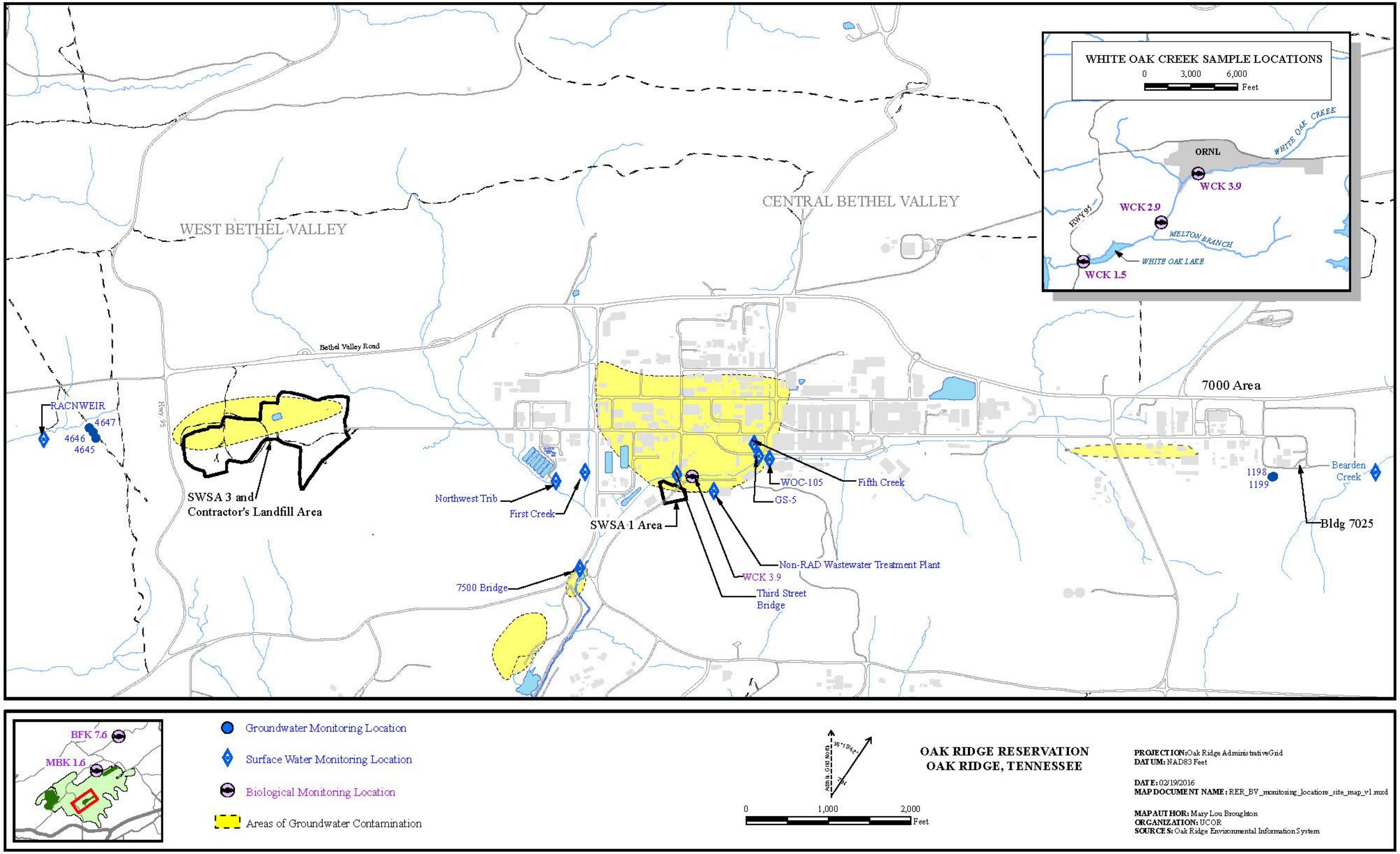

Figure 2.5. Watershed scale monitoring locations in Bethel Valley.

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Table 2.4. CERCLA action performance monitoring in Bethel Valley*[a]

Media	Monitoring Location	Schedule and Type of Sample	Parameters	Performance Standard
		PERFORMANCE MONITORING		
Surface water	7500 Bridge Weir	Continuous flow-proportionate monthly composite sample	^{90}Sr, gamma activity[b]	Achieve (BV Interim Actions ROD): • 45% risk reduction from 1994 levels at 7500 Bridge for ^{90}Sr and ^{137}Cs (i.e., 37 pCi/L of ^{90}Sr and 33 pCi/L of ^{137}Cs) • AWQC for all designated stream uses in all waters of the state (FYR)
	First Creek Weir	Continuous flow-proportionate monthly composite sample	COCs (^{90}Sr, gross alpha, gamma activity [b])	None specified (BV Interim Actions ROD)
	NWT Weir	Continuous flow-proportionate monthly composite sample	COCs (^{90}Sr)	
	Raccoon Creek Weir	Continuous flow-proportionate monthly composite sample	COCs (^{90}Sr)	
	7500 Bridge Weir	Monthly grab sample Semiannual grab sample (Hg snapshot) Annual grab sample (prior to FYR)	Total mercury Total mercury AWQC	51 ppt (ng/L) Hg (BV Mercury Sumps) 51 ppt (ng/L) Hg (BV Mercury Sumps) AWQC (BV Mercury Sumps)
	WOC-105	Semiannual grab sample (Hg snapshot)	Total mercury	51 ppt (ng/L) Hg (BV Mercury Sumps)
	First Creek	Continuous flow-proportionate monthly composite monitoring	^{90}Sr	Document quantity of ^{90}Sr discharging from Corehole 8 plume to First Creek as it contributes to WOC (PCCR for Corehole 8 Extraction System)
	SWSA 3 Sediment Basin (BVBGs BASIN OUT)	Semiannual grab monitoring	Metals, VOCs, ^{90}Sr, and tritium	Basin will access upgradient trench as a potential source of contaminants and can be compared to the recreational goal of 1×10^{-4} risk for swimmers (BVBGs action)

Table 2.4. CERCLA action performance monitoring in Bethel Valley*[a] (cont.)

Media	Monitoring Location	Schedule and Type of Sample	Parameters	Performance Standard
Biota	WCK 6.8 WCK 3.9 FCK 0.1 FCK 0.8 FFK 0.2 FFK 1.0	Fish and benthic macroinvertebrate species surveys	Richness and density survey	Comparison to reference location to evaluate whether aquatic populations are being protected (BV Interim Actions ROD)
Groundwater	4579-01 4579-02 4579-03	Semiannual grab samples[c]	Gross alpha and gross beta activity, ^{90}Sr	Exit pathway (West BV/Raccoon Creek area) monitoring trend to determine if contaminants are leaving known contaminated areas (BVGWES)
	Well 4411	Quarterly grab sample	^{90}Sr	To monitor contaminant concentration trends (PCCR for Corehole 8 Extraction System)
	Well 4570	Semiannual grab sample	^{90}Sr	Sample groundwater down-dip to the southwest of the Corehole 8 Plume source (PCCR for Corehole 8 Extraction System)
	Wells 4571 and 4572	Semiannual grab sample	^{90}Sr	Installed west along geologic strike to detect potential underflow of First Creek (PCCR for Corehole 8 Extraction System)
	Wells:[d] **0482**, **0483**, **0484**, **0491**, **0492**, **0493**, 0692, 0693, **0694**, 0698, 0699, 0700, 0702, 0706, 0790, 0985, 0986, 0987, 0988, 0990, 0991, 0992, 0993, 0994, 0995, **0996**, **0997**, 0998, 1247, 1248, 4579-01, 4579-02, 4579-03, 4645, 4646, 4647, 4670, 4671, 4672, 4673, 4674, 4675	Quarterly synoptic monitoring	Water levels	Intent of the SWSA 3—CSMA cap is to limit the amount of water that encounters buried wastes by reducing or eliminating percolation of precipitation and through-flow of shallow groundwater. Therefore, water table elevations are expected to decline under the cap over time (See Table 7-2 of BVBGs PCCR [DOE/OR/01-2533&D2] for long-term water table elevation goals for SWSA 3).
	Wells 0706, 0995 Well 0985 Wells 4645, 4646, 4647 Wells 0992, 0993, 0994, 0997, 4579-01, 4579-02 , 4579-03	Semiannual grab samples	^{90}Sr, tritium VOCs, ^{90}Sr, tritium Metals, ^{90}Sr, tritium Metals, VOCs, ^{90}Sr, tritium, gross alpha, and gross beta	Downward trend in ^{90}Sr concentration towards 8 pCi/L (BVBGs PCCR)

*Source: *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2478&D1).

Table 2.4. CERCLA action performance monitoring in Bethel Valley*[a] (cont.)

[a]Table presents current requirements for monitoring included in the Interim Actions ROD for the BV, post-decision primary documents, or any subsequent errata that have received concurrence/approval from the EPA and TDEC. Additional monitoring requirements will be developed and approved during the remedial design process for actions yet to be implemented.

[b]Gamma scan provides ^{137}Cs, ^{60}Co, and ^{40}K activity.

[c]Per the BVGWES report (DOE/OR/01-2219&D2), semiannual grab samples in each monitoring zone were recommended for two years (starting in FY 2006), which provided a total of six baseline values. If analytical results are consistent, monitoring will be reduced to high- and low-base sampling every three years. If those results are consistent for a period of nine years (through FY 2016), monitoring will be reduced to high- and low-base sampling every five years. Monitoring at this frequency will continue until a statistically valid decreasing trend is clearly demonstrated. Note that monitoring has not been reduced due to the presence of contamination.

[d]**Bold** values represent wells included in Table 7-2 of the PCCR for BVBGs (DOE/OR/01-2533&D2) and listed in Table 2.11 of this report which specifies long-term water table elevation goals for nine wells.

AWQC = ambient water quality criteria
BV = Bethel Valley
BVBGs = Bethel Valley Burial Grounds
BVGWES = Bethel Valley Groundwater Engineering Study
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC = contaminant(s) of concern
CSMA = Closed Scrap Metal Area
EPA = Environmental Protection Agency
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
FY = fiscal year
FYR = Five-Year Review
NWT = Northwest tributary
PCCR = Phased Construction Completion Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound
WCK = White Oak Creek kilometer
WOC = White Oak Creek

2.2.1.2 Evaluation of Performance Monitoring Data

2.2.1.2.1 Surface Water

2.2.1.2.1.1 Surface Water Quality Goals and Monitoring Requirements

The following excerpts (italicized) from Section 2.12.7.3 of the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) include the specific concentration goals for the principal surface water contaminants of concern.

Remediation levels for surface water

Remediation levels for surface water are established for each of the three surface water protection or remediation goals stated in the RAO (Sect. 2.8.2). These three goals and a brief explanation of their origin are given below.

1. *Achieve AWQC for designated stream uses in all waters of the state. White Oak Creek is classified for Fish and Aquatic Life, Recreation, and Livestock Watering and Wildlife uses, but not for Domestic or Industrial Water Supply or Irrigation*[1]*. All other named and unnamed surface waters in the valley are also classified for Irrigation by default under the Rules of the TDEC Chap. 1200-4-4. Both numeric AWQC and narrative criteria for the protection of human health and aquatic organisms will be met. Numeric AWQC exist for selected compounds under the Recreation and Fish and Aquatic Life use classifications. Consistent with EPA guidance, compliance with numeric AWQC for Recreation and Fish and Aquatic Life classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., Irrigation or Livestock Watering and Wildlife).*

2. *Maintain surface water risk below the recreational risk-based limit of* 1×10^{-4}*. This goal is a more explicit statement on how the narrative criteria portion of the AWQC goal described above will be achieved for Bethel Valley. The CERCLA risk assessment process is used for quantifying remediation levels to address the narrative AWQC for recreational use.*

3. *Achieve at least 45% risk reduction in surface water exiting Bethel Valley. This goal is a direct corollary of a goal in the Melton Valley watershed ROD to protect an off-site resident user of surface water within 10 years from completion of actions in Melton Valley and Bethel Valley. To protect the off-site resident, the Melton Valley watershed ROD established remediation levels at the confluence of White Oak Creek with the Clinch River to achieve an annual average ELCR of* 1×10^{-4} *and an HI of 1 for a residential exposure scenario (i.e., general household use). The Melton Valley watershed FS (DOE 1998c) estimated that the risk at White Oak Dam was* 6.4×10^{-4} *ELCR under a hypothetical residential scenario and 1994 baseline conditions. Of this total risk, Bethel Valley contributed approximately 20% (*1.3×10^{-4} *ELCR), primarily in the form of* ^{90}Sr *and* ^{137}Cs*. Assuming the Melton Valley remedy achieves at least an 82% reduction of the Melton Valley contribution to the risk at White Oak Dam, then Bethel Valley must achieve at least a 45% risk reduction in surface water exiting Bethel Valley to meet the Melton Valley watershed ROD goal of protection of the off-site resident.*

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[1]The use classifications for White Oak Creek (WOC) has changed since the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) was signed. This surface water body is currently classified for Fish and Aquatic Life, Recreation, and Irrigation uses and is no longer classified for Livestock Watering and Wildlife use.

Remediation levels for the three goals are summarized in Table 2.5 (*Table 2.38 in ROD) and explained in more detail in the following three subsections: Numeric AWQC, Narrative Criteria, and Risk Reduction for Off-Site Releases. The surface water remediation levels will be met within 10 years from completion of source actions in Bethel Valley.*

Numeric AWQC*. The Bethel Valley RI/FS noted numeric AWQC exceedances for cadmium, chromium, copper, iron, and mercury in White Oak Creek, First Creek, and Fifth Creek (Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee, DOE/OR/01-1748&D2, Oak Ridge, Tennessee). However, AWQC will be met for all site-related contaminants in all waters of the state. The numeric AWQC for (1) Fish and Aquatic Life and (2) Recreation (organisms only) use classifications are tabulated in Rules of the TDEC Chap. 1200-4-3.03. Compliance will be based on statistically valid data assessments. The initial sampling locations proposed for determining compliance were shown previously in* Figure 2.5 (Figure 2.36 in ROD)*; these sampling locations will be finalized in a post-ROD Sampling Plan. The locations are generally at the downstream end of individual reaches but before any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.*

Narrative Criteria*. The CERCLA risk assessment process is used to address the narrative criteria for waters of the state. A recreational risk scenario considered representative of the surface water use classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or, conversely, to derive allowable concentrations from risk-based limits.*

Based on the human health risk assessment in the Bethel Valley RI/FS, no waters of the state exceeded recreational risk-based limits. Therefore, no surface water risk-based COCs were identified for which allowable concentrations need to be derived at this time. However, if in the course of periodic surface water monitoring, consistently unacceptable recreational risks are found and new significant COCs are identified, then the risk assessment process will be used to derive allowable concentrations for the new surface water COCs.

Waters of the state must achieve an annual average ELCR less than 1×10^{-4} *and an HI less than 1 for a recreational exposure scenario. This goal applies only to surface water and only to those COCs, such as radionuclides, that do not have numeric AWQC. The numeric AWQC for individual contaminants is generally equivalent to risk levels ranging up to* 10^{-5}*. The annual average risk goal of* 1×10^{-4} *meets the intent of the AWQC because, when multiple contaminants are present in the surface water, their individual risk levels would be roughly equivalent to the AWQC-equivalent risk of* 10^{-5}*. A lower risk goal could require individual contaminant risks to be below the AWQC-equivalent risk of* 10^{-5}*.*

Under this ROD, the recreational scenario is defined as a wading scenario in the streams. It does not include fishing because the streams are too small to support fishable fish. The initial sampling locations proposed for determining conformity with these levels are shown in Figure 2.5 (Fig. 2.36 in ROD)*; these sampling locations will be finalized in a post-ROD sampling plan. The locations are at the downstream end of individual reaches (i.e., First Creek, Fifth Creek, NWT, Raccoon Creek, White Oak Creek between 7500 Bridge and First Creek, White Oak Creek between First Creek and Fifth Creek, and White Oak Creek above Fifth Creek) but before any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.*

Risk Reduction for Off-Site Releases*. Surface water exiting Bethel Valley must achieve at least 45% risk reduction from a 1994 baseline. This 45% risk reduction will be based on the combined risk from* ^{90}Sr *and* ^{137}Cs*, the two principal risk contributors, and is in addition to that reduction attributable to radioactive*

decay from 1994. The 45% reduction in total residential ELCR must be achieved within 10 years from completion of source actions selected in this ROD in Bethel Valley.

A *Notification of Non-Significant Change to the Record of Decision for Interim Actions in Bethel Valley (DOE/OR/01-1862&D4/R2)* clarified the target concentration levels and compliance sampling techniques for measuring the 45% risk reduction as follows:

> *. . .DOE is therefore adding to the BV ROD the specific target concentration levels for ^{90}Sr and ^{137}Cs of 37 pCi/L and 33 pCi/L, respectively, to meet the 45% risk reduction goal. . .DOE is issuing this non-significant change to clarify that sampling is done in the following manner based on the following approach:*
>
> *A monthly flow-paced composite sample at the 7500 Bridge will be taken and used for the average concentration parameter in the risk calculation to demonstrate compliance with the 45% risk reduction goal. This sampling approach produces an average (arithmetic mean) annual constituent concentration result that inherently accounts for impacts of flow rate on concentrations over time. This sampling approach is also conservatively reflective of how a surface water intake system for a public water supply would be sampled.*

Surface water remediation levels are outlined in Table 2.5.

Table 2.5. Surface water remediation levels in Bethel Valley[*]

Bethel Valley	*Numeric AWQC*	*Narrative criteria[a]*	*Risk Reduction for off-site releases*
Receptor	*Hypothetical recreational user: fish and aquatic life*	*Hypothetical recreational user*	*Hypothetical off-site resident*
Areas affected	*All waters of the state*	*All waters of the state*	*Confluence of WOC with the Clinch River*
Anticipated compliance locations	*See Fig. 2.36* (Figure 2.5)	*See Fig. 2.36* (Figure 2.5) *(remediation levels are applied to selected reaches[b])*	*7500 Bridge or equivalent integration point*
Remediation level	*Levels established in Rules of the TDEC Chap. 1200-4-3-.03*	*Annual average ELCR <1 x 10^{-4} and HI <1*	*Surface water risk (based on ^{90}Sr and ^{137}Cs only) will be at least 45% less than the 1994 baseline*
Exposure scenarios	*NA (numeric criteria tabulated in regulation; no separate calculation using exposure scenarios needed)*	*Hypothetical recreational wading for waters of the state (the exposure scenario does not include fish ingestion)*	*Hypothetical residential (i.e., general household use) scenario at confluence of WOC with the Clinch River translated to a risk reduction of at least 45 percent in surface water exiting Bethel Valley (i.e., 7500 Bridge) from a 1994 baseline*

[*]Table 2.38 of the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4).

[a]*Unacceptable risks in surface water do not exist in Bethel Valley based on the RI/FS analysis. If unacceptable risks are encountered in the future, then the narrative criteria will be achieved by developing remediation levels based on a hypothetical recreational receptor.*

[b]*Surface water reaches: First Creek, Fifth Creek, Northwest Tributary, Raccoon Creek, WOC between 7500 Bridge and First Creek, WOC between First Creek and Fifth Creek, and WOC above Fifth Creek.*

AWQC = ambient water quality criteria
ELCR = excess lifetime cancer risk
FS = feasibility study
HI = hazard index
NA = not applicable
RI = remedial investigation
TDEC = Tennessee Department of Environment and Conservation
WOC = White Oak Creek

2.2.1.2.1.2 Surface Water Monitoring Results

This section presents the surface water monitoring results of watershed-scale contaminant discharge monitoring and single-project action monitoring results related to completed or ongoing CERCLA projects. Watershed-scale surface water and groundwater monitoring provides an ongoing data record against which to determine the effectiveness of RAs, as well as verifying reduction of off-site releases of contaminants.

The Bethel Valley administrative watershed (Figure 2.5) lies in portions of three topographic basins. The White Oak Creek (WOC) basin encompasses all of the ORNL main campus area as well as most of the SWSA 3 and Contractor's Landfill area, and all but the easternmost portion of facilities at the 7000 Services area. The western portion of SWSA 3 and all of the Contractor's Landfill lie in the headwater of the Raccoon Creek basin which is wholly included in the Bethel Valley administrative watershed which drains directly to the Clinch River. The easternmost portion of the 7000 Services Area lies in the Bearden Creek topographic basin which drains directly into Melton Hill Reservoir.

Surface water monitoring in Bethel Valley includes both continuous, flow-paced monitoring by the EM Program at key instream locations and routine collection of grab samples, as well as ORNL facility discharge monitoring conducted by University of Tennessee-Battelle, LLC (UT-B) for the DOE Office of Science.

The *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) stipulates that AWQC be met in surface water. DOE evaluates the status of AWQC attainment in each CERCLA FYR. The most recent review conducted in the *2011 Third Reservation-Wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2) indicated that for 10 sampled locations including WOC mainstem and tributary locations criterion exceedances were detected for chlordane at two locations, for heptachlor at two locations, and for mercury at one location.

2.2.1.2.1.3 Watershed-Scale Surface Water Monitoring Results

Radiological Discharges to WOC

Historic and ongoing discharges of ^{90}Sr and ^{137}Cs in surface water in the central part of Bethel Valley are principal contaminants of concern that directly impact the condition of the watershed and are performance metrics for the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4). Tritium discharges in WOC originate primarily from sources outside of Bethel Valley:

- groundwater collected in Melton Valley and transferred to the Process Water Treatment Complex (PWTC) via the groundwater collection and treatment system.
- wastewaters generated by Office of Science operating facilities such as the High Flux Isotope Reactor and SNS that are discharged via the PWTC and sanitary sewage systems.

Figure 2.6 shows locations in the ORNL main plant area in Bethel Valley where contaminant concentrations and flows are measured to estimate the discharge fluxes from various contributing areas or outfalls. Strontium-90 is the principal radiological contaminant of concern (COC) in surface water in Bethel Valley because it is a fairly widely distributed contaminant in buried waste, in contaminated soils related to LLLW pipeline leaks, and in groundwater. Three CERCLA actions included in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) were completed during FY 2012 that are reducing ^{90}Sr discharges to surface water – the Bethel Valley Burial Grounds (BVBGs) RA at

SWSAs 1 and 3, installation of additional groundwater extraction wells in the Corehole 8 plume, and completion of the excavation of Tank W-1A and associated contaminated soils.

Cesium-137 is a significant surface water contaminant in WOC, and its sources include discharges from the PWTC and soils on the WOC floodplain contaminated from the former Surface Impoundments Operable Unit area downstream to 7500 Bridge Weir. While actions that will directly address several known source areas of ^{137}Cs have not yet been completed, ongoing measurement of these contaminants is conducted to track baseline discharge conditions.

The 7500 Bridge is the primary exit pathway for surface water to discharge from the upper portion of the WOC watershed in Bethel Valley into the lower WOC watershed area in Melton Valley. Table 2.6 lists the average annual ^{90}Sr and ^{137}Cs activities calculated from the flow-paced monthly composite samples collected at the 7500 Bridge for the baseline year (FY 1994) and for the period FY 2001 through FY 2015. The Bethel Valley ROD goals for ^{90}Sr and ^{137}Cs based on the 45% risk-reduction requirement are included in the table column headers. As shown in Table 2.6 and on Figure 2.7, ^{90}Sr and ^{137}Cs activities were less than the ROD goal levels during FY 2015. The annual average radionuclide activities shown on Figure 2.7 summarize the variable levels measured in the monthly composite samples. To reflect the variability in parameter levels, the graphs include both the annual average activity and the average plus one standard deviation of the mean. For years when the mean plus one standard deviation shows a wider range there was more measured variation than for years when these results show a narrower range.

During FY 2015, the ungauged ^{90}Sr sources contributed about 45% of the total 0.22 Ci measured at the 7500 Bridge Weir. Figure 2.8 shows the contributions of gauged and ungauged sources of ^{90}Sr flux to the 7500 Bridge Weir integration point total for FY 2015. The principal source of this ungauged flux is attributed to discharges that occurred through SD outfalls and from non-point groundwater discharges directly to WOC. During FY 2015, SD outfall monitoring identified ^{90}Sr discharges from OF-304 that exceeded the DOE-Derived Concentration Standard (DCS). The flow volume of OF-304 is normally less than 1 gpm and the flux discharge from this outfall is a very small portion of the ungauged flux that was calculated for the FY. The OF-304 SD network does not receive any building or process discharges. The sources of water to the network are roof drains, paved area runoff, and groundwater infiltration in the former Surface Impoundments Operable Unit (SIOU) area. Sampling conducted in the SD late in the FY indicated that the ^{90}Sr concentrations in the SD are higher than those measured in area groundwater monitoring wells which suggests a waste management infrastructure source. DOE is conducting investigations to identify the point(s) of contaminated groundwater inleakage to the SD and potential source(s) of contamination. The Bethel Valley ROD did not include a final decision for groundwater remediation but did include actions related to residual contamination, principally soils, to prevent further contamination of groundwater.

Tritium concentrations in surface water in the Bethel Valley portion of WOC increased in 2006 as a result of collection and transfer for treatment of former groundwater discharges in Melton Valley and remain at elevated levels. This activity is conducted as a condition of the RA taken in Melton Valley. However, tritium concentrations in surface water throughout WOC are still below the DOE DCS level for tritium (1.9×10^6 pCi/L; DOE-STD-1196-2011).

Table 2.6. 7500 Bridge risk-reduction goal evaluation

Year	Average ^{90}Sr (Goal = 37 pCi/L)[b]	Average ^{137}Cs (Goal = 33 pCi/L)[b]
1994[a]	67	59
2001	37	**219**
2002	37	**116**
2003	37	**41**
2004	**78**	**47**
2005	**70**	**78**
2006	35	33
2007	27	17
2008	27	<6
2009	**40**	12
2010	**42**	10
2011	**54**	<16
2012	33	<15
2013	33	<24
2014	33	<15
2015	35	24

Bold values indicate years during which annual average concentration exceeded the ROD risk-based goal.

[a]*Record of Decision for Interim Actions in Bethel Valley Watershed* (DOE/OR/01-1862&D4) baseline year.
[b]Goal = 45% reduction in average concentrations compared to concentrations during baseline year.

ROD = Record of Decision

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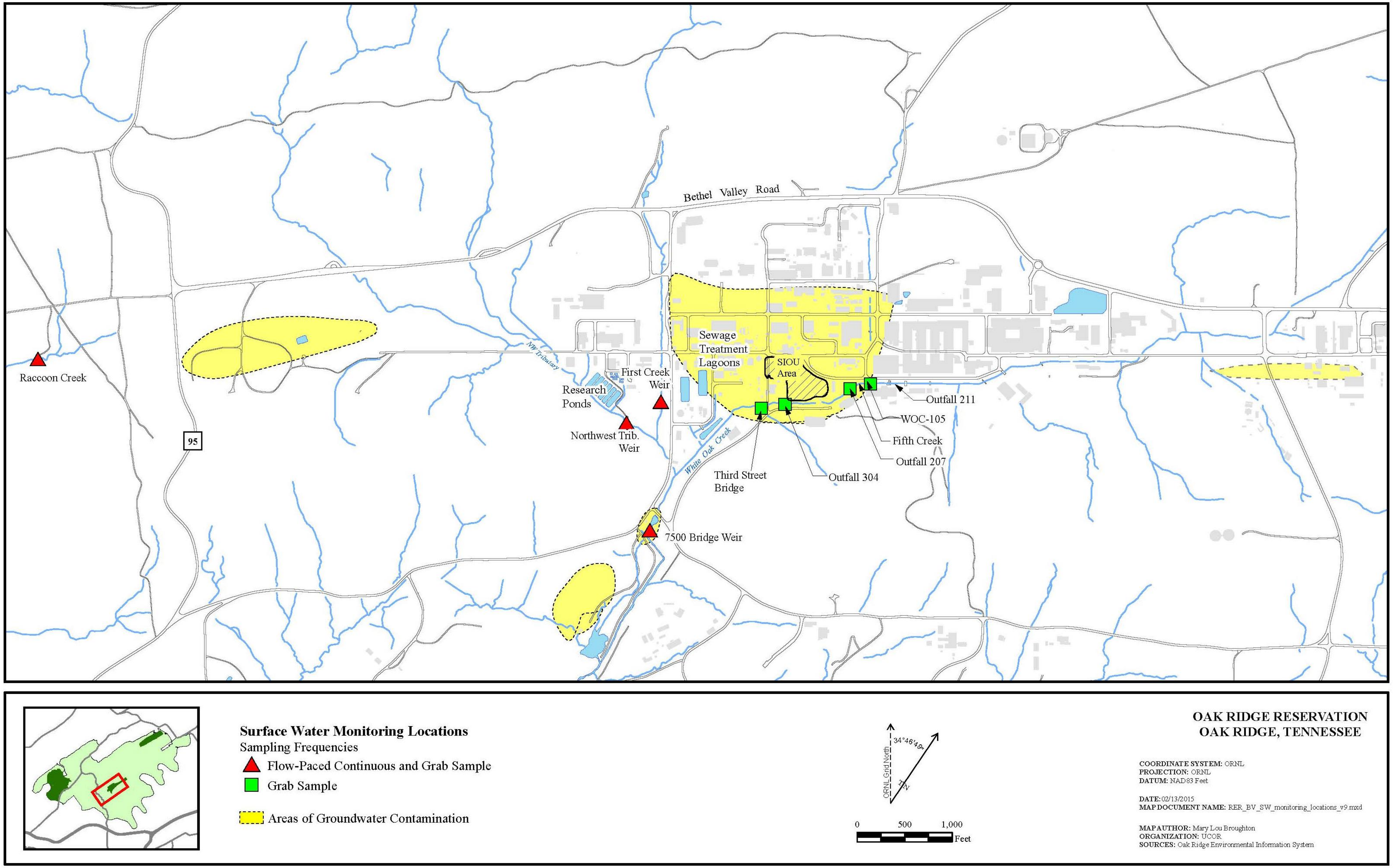

Figure 2.6. CERCLA surface water monitoring locations in ORNL main plant area.

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Radiological Discharges to Raccoon Creek and Bearden Creek

Raccoon Creek and Northwest Tributary (SWSA 3 Area). Surface water in the western end of Bethel Valley is monitored to measure contaminant discharges to Raccoon Creek and the Clinch River via a western exit pathway. Figure 2.5 shows locations where Bethel Valley exit pathway sampling is conducted. Contaminated groundwater originating in SWSA 3 seeps to the headwaters of Raccoon Creek, a short distance to the west of Tennessee Highway 95. The seepage pathway from SWSA 3 to Raccoon Creek was discovered in the early 1980s and monitoring has been conducted at the Raccoon Creek Weir since the 1990s. The principal contaminant detected in the Raccoon Creek headwaters is ^{90}Sr. The annual flux of ^{90}Sr discharging via Raccoon Creek has been measured since 1999 with the exception of FY 2005, 2006, and part of 2007 when problems with flow measurements at the site prevented estimating flux.

Table 2.7 summarizes annual ^{90}Sr detection frequency and maximum value; total annual flow volume for months having detectable ^{90}Sr; average ^{90}Sr activity from continuous flow-paced samples containing detectable levels at the Raccoon Creek Weir; and estimated flux for periods when reliable station flow data were available. The average detected ^{90}Sr activity, the calculated ^{90}Sr flux, and the flow volumes include data only for months in which ^{90}Sr was detected. Since completion of the SWSA 3 hydrologic isolation in 2011, the ^{90}Sr activity levels in the Raccoon Creek headwaters have decreased by 50 – 60% from values measured during the previous several years. This decrease is attributed to the effect of hydrologic isolation of buried waste in SWSA 3 and the Contractor's Landfill.

Surface water monitoring is also conducted in the Northwest Tributary as part of general watershed monitoring as well as for pre- and post-remediation performance evaluation of the BVBGs SWSA 3 action. The surface water sampling in Raccoon Creek and Northwest Tributary are conducted to establish both the activity level and flux of ^{90}Sr, which is the principal COC in surface water in the area. Continuous flow sampling has been conducted at the Northwest Tributary Weir and the Raccoon Creek Weir for many years.

The long-term surface water flux monitoring (Figure 2.9) of Raccoon Creek shows that the Raccoon Creek ^{90}Sr flux is less than 10% of the flux measured at Northwest Tributary (Figure 2.10). Lower detection limits in FY 2015 allowed resolution of lower contaminant discharge levels. During FY 2015, all the Raccoon Creek monthly composite samples had detectable ^{90}Sr, however, none of the results were greater than 50% of the 8 pCi/L drinking water maximum contaminant level derived concentration (MCL-DC)[2].

[2]This maximum contamination level derived concentration (MCL-DC) is listed in 40 *Code of Federal Regulations* (CFR) 141.66(d)(2), Table A, as the "Average Annual Concentration Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr," which is the maximum contaminant level (MCL) for beta particle and photon radioactivity.

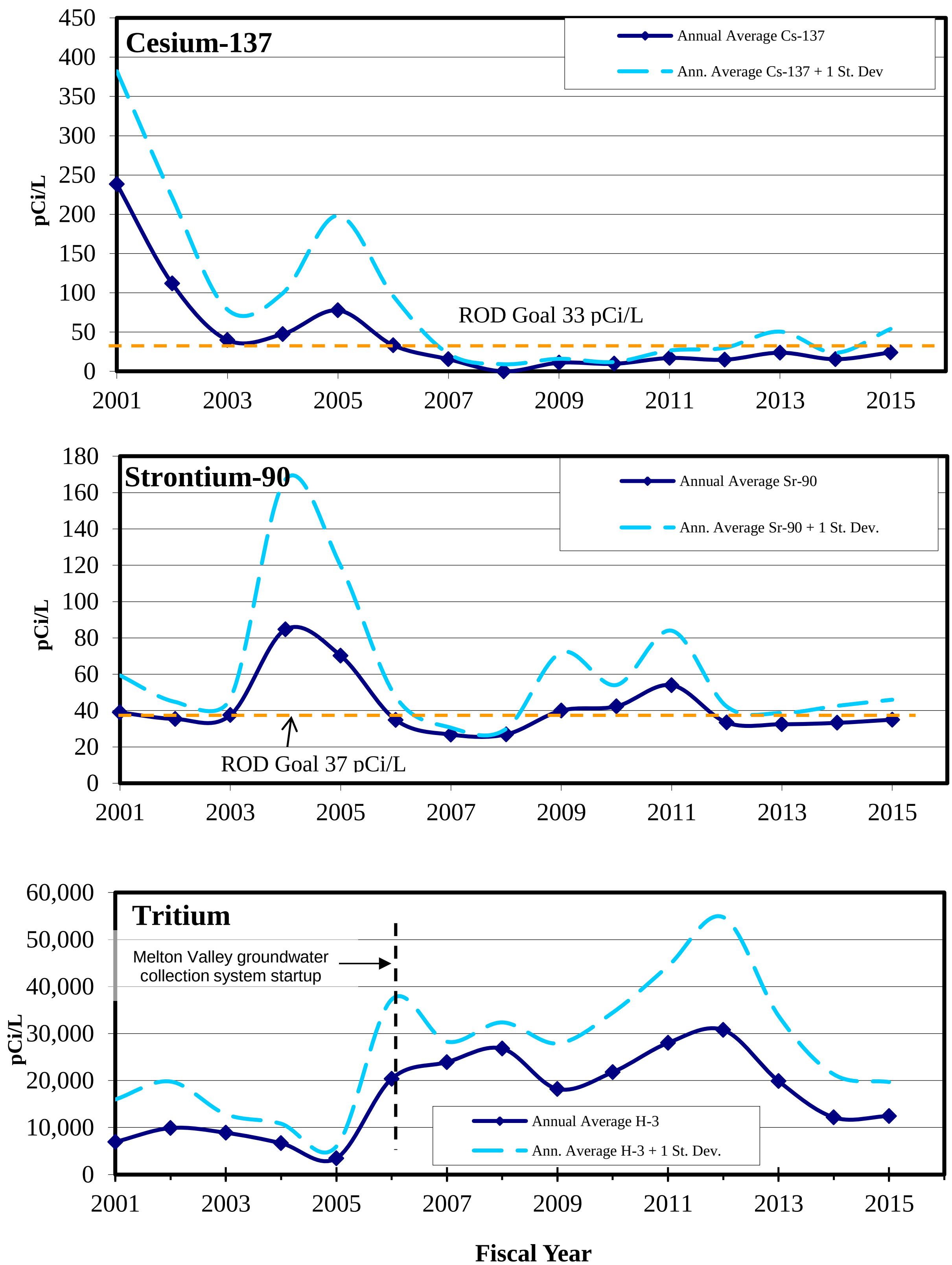

Figure 2.7. Annual average activities of ^{137}Cs, ^{90}Sr, and tritium at 7500 Bridge.

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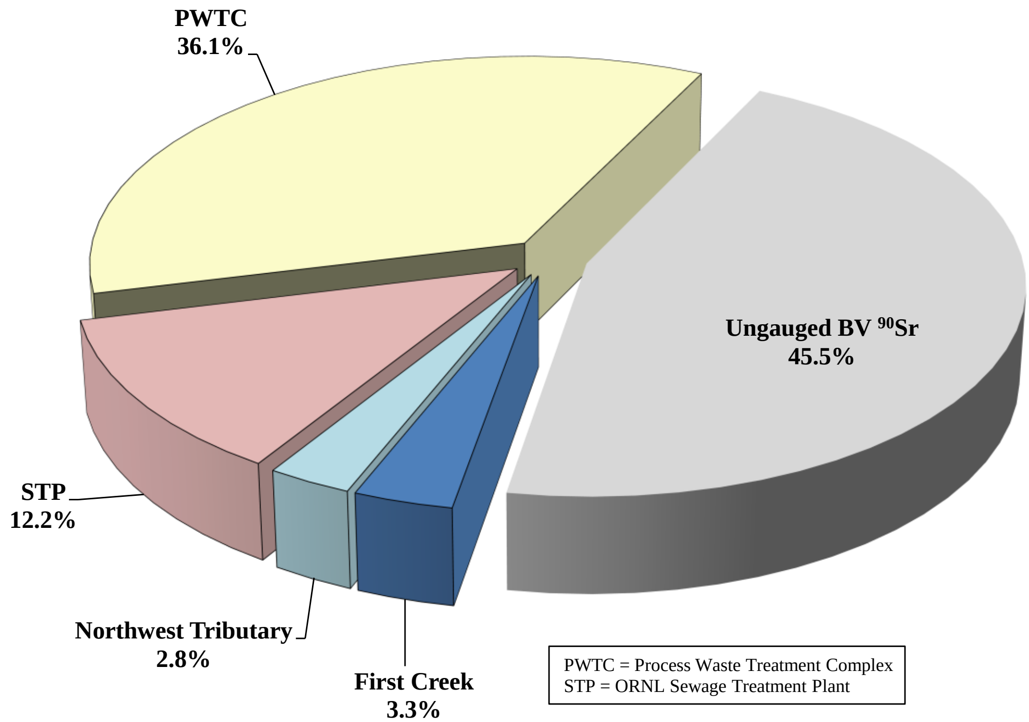

Figure 2.8. Percentage contributions of gauged and ungauged sources flux to the 7500 Bridge watershed FY 2015 total ^{90}Sr discharge.

Table 2.7. ^{90}Sr data from Raccoon Creek Weir

Year	Detection frequency and maximum value (No. detects/No. samples) (Maximum pCi/L)	Flow volume for months with detected ^{90}Sr (L)	Average detected ^{90}Sr (pCi/L)	^{90}Sr Flux (Ci)
FY 1999 Total	8 / 12 55.9	84,336,484	20.9[a]	3.7E-04
FY 2001 (11 months)	7 / 11 8.15	6,6011,324	5.2[a]	3.10E-04
FY 2002	7 / 12 25.1	3,0153,673	13.2[a]	9.35E-04
FY 2003 (11 months)	10 / 12 17.9	241,405,801	6.4[a]	9.8E-04
FY 2004	12 / 12 26.9	254,130,320	9.6[a]	1.68E-03
FY 2005	12 / 12 64.8	--[b]	16.8[a]	--
FY 2006	12 / 12 77.2	--[b]	29.3[a]	--
FY 2007 (February – September)	6 / 8 32.4	86,992,200[c]	12.7[a]	1.1E-03
FY 2008	12 / 12 59.6	117,209,419	15.5[a]	6.4E-04
FY 2009	8 / 12 35.6	150,003,288	10.7[a]	6.2E-04
FY 2010	5 / 12 18.4	20,509,344	11.5[a]	1.9E-04
FY 2011[d]	11 / 12 18.3	277,034,731	5.2	6.4E-04
FY 2012	8 / 12 9.05	146,306,405	4.0	4.3E-04
FY 2013	6 / 12 12.0	383,686,704	5.5	5.9E-04
FY 2014	9 / 12 12.9	182,522,116	4.9	3.7E-4
FY 2015	12 / 12 3.46	224,091,518	2.2	3.5E-4

. **Table 2.7. ^{90}Sr data from Raccoon Creek Weir (cont.)**

[a]Activity value represents average activity for all monthly flow composite samples with detected ^{90}Sr.
[b]The FY 2005 and 2006 flow and flux data are not reported as the data have been deemed unusable due to problems associated with the weir.
[c]Station was returned to full operation at end of January 2007. Reported flows and fluxes are calculated for the months when flow was present after station maintenance.
[d]The SWSA 3 hydrologic isolation was completed during FY 2011.

FY = fiscal year
SWSA = Solid Waste Storage Area

Northwest Tributary (SWSA 3 RA)

The Northwest Tributary of WOC surface water basin receives surface runoff from the area generally west of First Creek and east of the WOC/Raccoon Creek watershed divide and from the northern slope of Haw Ridge to the south and the southern slope of Chestnut Ridge to the north. Dry season baseflow discharge in the Northwest Tributary comes from groundwater and from discharges from the constructed ponds associated with the ORNL 1500 complex. The eastern karst discharge pathway from beneath SWSA 3 contributes flow to the Northwest Tributary and is a groundwater transport pathway for ^{90}Sr from SWSA 3 to the stream. Surface water monitoring has been conducted for many years at the Northwest Tributary Weir. The principal COC in surface water related to SWSA 3 is ^{90}Sr. Continuous flow-paced surface water composite sampling is conducted with a monthly composite period to measure average ^{90}Sr activity level and discharge flux. Figure 2.10 shows the monthly ^{90}Sr activity levels and discharge fluxes for FYs 2005 through 2015. The period during which SWSA 3 remediation occurred is also shown. The Northwest Tributary surface water monitoring location is shown in Figure 2.11.

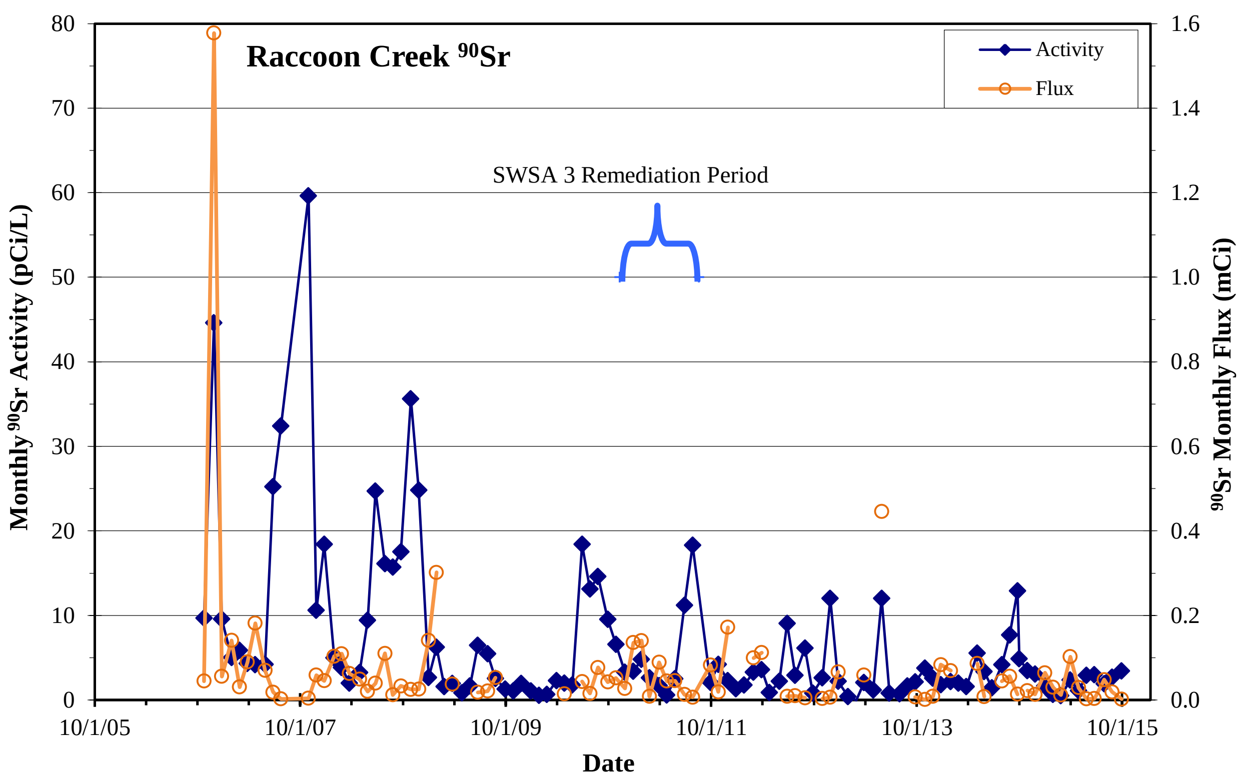

Figure 2.9. Raccoon Creek ^{90}Sr monitoring results FY 2006 – FY 2015.

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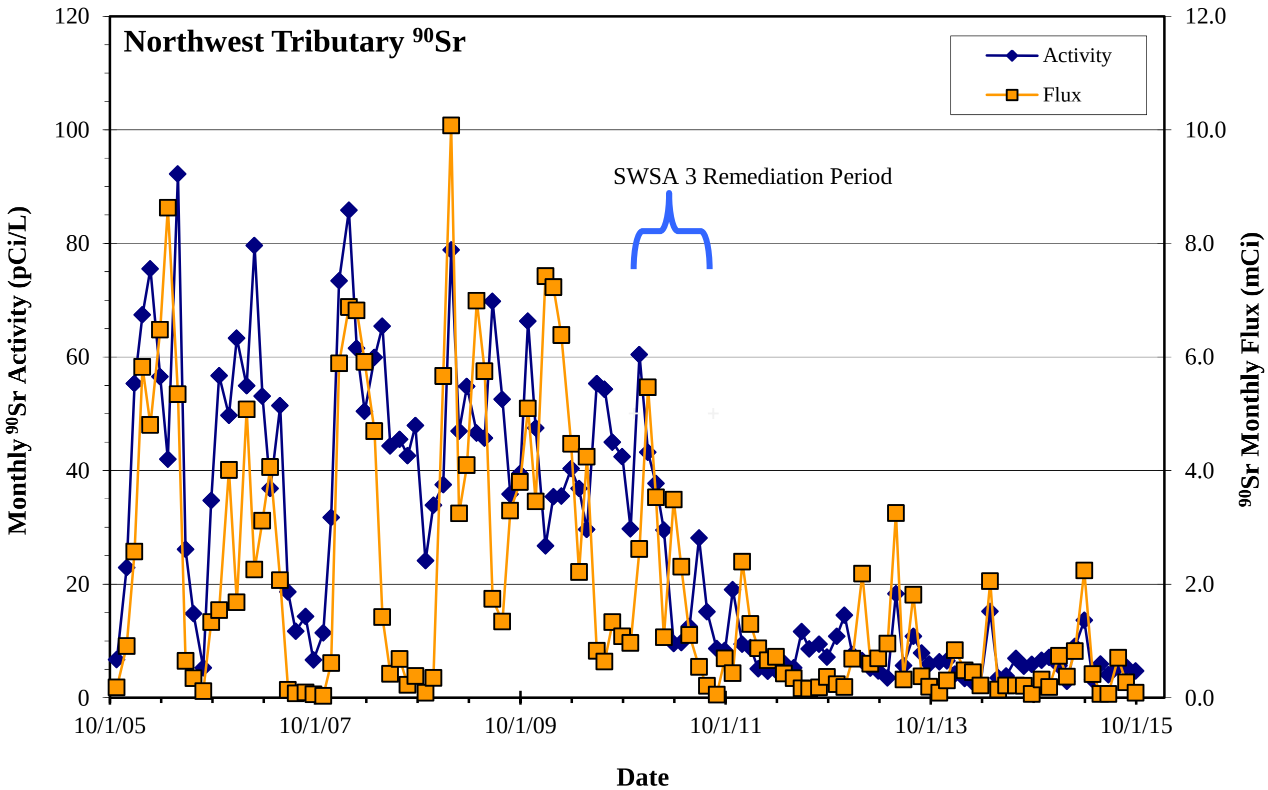

Figure 2.10. Northwest Tributary ^{90}Sr monitoring results FY 2005 – FY 2015.

Activity levels and discharge fluxes of ^{90}Sr decreased during the construction period and have reached a new, lower level with an associated lower fluctuation range subsequent to completion of the RA. Comparison of Northwest Tributary average ^{90}Sr activity levels and fluxes between the pre-remediation period (December 2008 through December 2010) and the remediation and post-remediation period (March 2011 through September 2015) shows a 75% reduction. Average ^{90}Sr activity before remediation was 46 pCi/L (standard deviation 13 pCi/L) while during- and post-remediation average ^{90}Sr activity has been 7.9 pCi/L (standard deviation 4.7 pCi/L). The pre-remediation average monthly ^{90}Sr discharge flux was 3.98 mCi/mo. (standard deviation 2.48 mCi/mo.) while during- and post-remediation average monthly flux has been 0.72 mCi/mo. (standard deviation 0.8 mCi/mo.). The post-remediation long-term average monthly ^{90}Sr activities and fluxes and their respective standard deviations are decreasing with time which reflects progressive water quality improvement since the primary contaminant source was hydrologically isolated.

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Figure 2.11. Northwest Tributary surface water monitoring location.

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Bearden Creek (7000 area). The eastern surface water exit pathway near the ORNL site is in Bearden Creek which lies to the east of the ORNL 7000 Services Area (Figure 2.5). Surface water is sampled in a tributary of Bearden Creek at the eastern end of the ORNL area in Bethel Valley to evaluate contaminant discharges to surface water east of the 7000 Services Area. The principal contaminant source that affects this area is the former tritium handling facility at Building 7025 (Figure 2.5). Tritium has been detected in groundwater and surface water in the area, as described below. The 7000 Services Area is also the site of a volatile organic compound (VOC) plume in groundwater that migrates westward from its source toward WOC.

Surface water monitoring has been conducted in the Bearden Creek tributary near the 7000 Services Area since the mid-1990s. Parameters included in analytical suites have varied over the monitoring history and have included metals, VOCs, and radionuclides. Metals, VOCs, and gross alpha and beta activity have not exceeded drinking water criteria with the exception of aluminum, which may be related to suspended solids as indicated by elevated turbidity levels in field measurements. Of 23 results obtained since the mid-1990s, 12 contained detectable activities of tritium. During 1998 and 1999, two samples were reported to contain tritium at activities greater than the drinking water MCL-DC (20,000 pCi/L)[3]; however these results are considered suspect because of possible laboratory problems. During the period 2000 through 2005, seven of 10 samples contained detectable tritium at activities ranging from 417 pCi/L to 949 pCi/L. A hiatus in sampling at the Bearden Creek location occurred between 2005 and 2009. Of nine semiannual samples collected since 2009, only one detection of tritium has occurred at an activity of 511 pCi/L in July 2010. The Bethel Valley ROD is an interim decision that addresses sources contributing to groundwater contamination and the contaminated groundwater's contribution to surface water contamination. Groundwater cleanup levels have not yet been established in a groundwater decision document. Drinking water MCLs are used here only as reference or screening levels when discussing detected groundwater contaminants. All of the sample results, excluding the suspect 1998 – 1999 results, have been either non-detect values or were less than 10% of the drinking water tritium MCL-DC.

Surface Water Mercury Monitoring

Mercury is a COC in surface water because of its strong bioaccumulation tendency in fish. Mercury sampling has been conducted for many years at the 7500 Bridge. Since the winter of 2008, semiannual sampling of mercury has been conducted at First Creek, Northwest Tributary, Raccoon Creek, Fifth Creek, in WOC at the Third Street Bridge, and at WOC-105 upstream of the Fifth Creek confluence. Monitoring results for Raccoon Creek, Northwest Tributary, and First Creek indicate that they are not significant contributors of mercury, as each of these sites has routinely contained less than 5 ng/L of total mercury. Mercury discharges to WOC in Bethel Valley originate predominantly from discharges directly to WOC upstream of Fifth Creek, from sources to Fifth Creek, and from treated wastewater effluent discharged from the ORNL PWTC. The most stringent applicable AWQC concentration for mercury is 51 ng/L.

Fifth Creek contains mercury at concentrations that have ranged from <10 ng/L to >100 ng/L. During the past several years, there have been a few mercury detections at levels several times the 51 ng/L AWQC value. ORNL and EM staffs have worked collaboratively to locate the sources of mercury discharge into Fifth Creek. During FY 2015, the CERCLA monitoring program collected two samples from Fifth Creek for mercury analysis. The sample collected in November 2014 contained 15.1 ng/L total mercury, while the sample collected in May contained 13.8 ng/L total mercury. These concentrations indicate a decrease in mercury contamination entering Fifth Creek from SDs following utility system repairs that occurred in September 2014 that were reported in the 2015 RER.

[3]This MCL-DC is listed in 40 CFR 141.66(d)(2), Table A, as the "Average Annual Concentration Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr," which is the MCL for beta particle and photon radioactivity.

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The ORNL PWTC treats both radiologically and chemically contaminated wastewater that originates from numerous sources from the Office of Science activities at ORNL and a wide range of EM related sources including collected groundwater from the ORNL site and leachate from the Environmental Management Waste Management Facility (EMWMF). Effluent from the facility is regulated and monitored under the facility National Pollutant Discharge Elimination System (NPDES) permit and there is an associated radiological monitoring plan. Effluent monitoring and permit reporting is the responsibility of the Office of Science and is implemented by UT-B. NPDES effluent monitoring over the past few years has shown mercury concentrations in the facility effluent several times greater than the AWQC level. The treatment process includes several stages of processing including clarification, ion exchange and chemical processes before the final step, which is passage through two columns containing granular activated carbon (GAC) to remove organic compounds and mercury. During FY 2014, DOE proactively conducted sampling and analyses to evaluate the effectiveness the GAC columns for mercury removal. Those tests indicated that mercury removal efficiency was less than optimal. During the summer of 2014, DOE replaced the conventional GAC in one column with a sulfur impregnated GAC to provide a treatment media that may be more effective at mercury removal prior to discharge. Recent FY 2015 effluent monitoring has demonstrated that the GAC replacement has reduced mercury concentrations in the PWTC effluent.

Additional mercury monitoring results related to the RA for mercury discharges from Building 4501 are discussed below. DOE has completed actions stipulated by the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) for treatment of basement sump groundwater at Building 4501. Other sources of mercury contamination in soil throughout the site will be addressed in future actions under the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4). Monitoring of mercury in surface water in Fifth Creek and other locations in Bethel Valley will continue.

Building 4501 Mercury Contaminated Sump Discharges

In December 2007, the first RA specified in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) was partially completed by re-routing mercury-contaminated basement sump water at Building 4501 to treatment at the PWTC. In October 2009, the Building 4501 sump system was completed with the installation of an ion exchange system for the collected sump water to remove particle-associated mercury and dissolved mercury from the wastewater stream prior to its final treatment and discharge at the PWTC. This system installation includes a pre-filter and ion exchange located in the basement of Building 4501 that serves to pre-treat the sump water which is then routed to the PWTC.

Mercury monitoring is conducted at several surface water sampling locations in Bethel Valley, and two locations are key to measuring the effectiveness of the Building 4501 sump water re-route. These locations include the watershed integration point surface water sampling location at the 7500 Bridge and an in-stream sampling location (WOC-105) that is located approximately 250 ft downstream of the Outfall 211 SD (Figure 2.6). Prior to the 2007 RA in the Building 4501 basement, some of the mercury contaminated basement sump discharges were routed to the SD that discharges at Outfall 211. Residual mercury contamination, including elemental mercury, remains in sediment accumulations in the upper portion of the SD. This residual mercury contamination is the source of ongoing mercury discharges to WOC at Outfall 211.

Figure 2.12 shows the mercury concentration history for the WOC-105 and 7500 Bridge locations. As shown on Figure 2.12, after 4501 basement sump water was routed to the PWTC the frequency of AWQC exceedances for total mercury at 7500 Bridge decreased, with infrequent spikes that exceed the AWQC level. At the WOC-105 location, a similar dramatic decrease in mercury concentrations followed the removal of Building 4501 basement sump water discharges from Outfall 211.

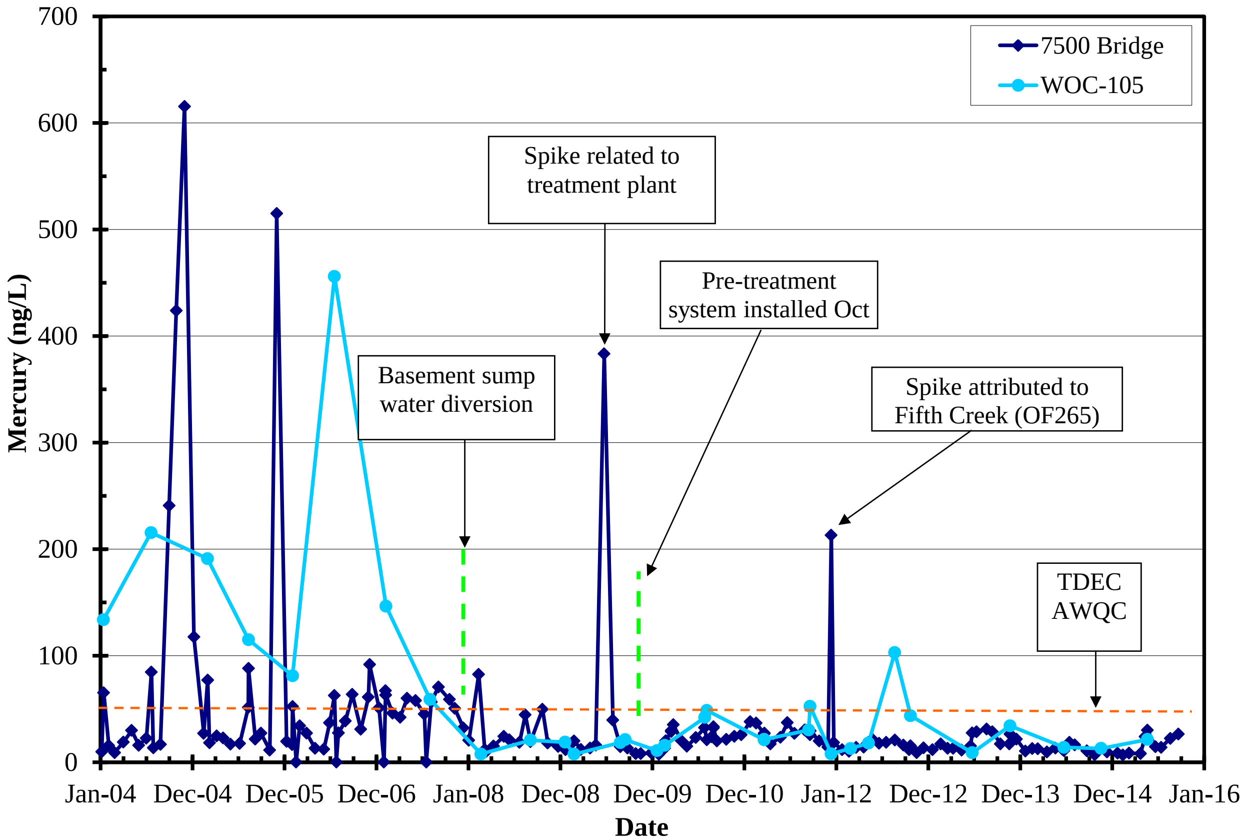

Figure 2.12. Mercury concentration history at 7500 Bridge and WOC-105 monitoring locations.

During FY 2015, mercury concentrations were less than the AWQC limit in both of the semiannual samples collected at WOC-105. During FY 2015, all of the mercury sample concentrations at 7500 Bridge were below the AWQC value of 51 ng/L.

Corehole 8 Extraction System

In 1991, CERCLA characterization efforts identified a plume of ^{90}Sr contaminated groundwater in the western portion of the ORNL Main Plant Area, referred to as the Corehole 8 plume (Figure 2.13). Note that the Corehole 8 plume source (Tank W-1A) is addressed as a separate action in Section 2.3.1. A removal site evaluation performed in 1994 concluded that contaminated groundwater seeping into the SD system was being discharged into First Creek. First Creek is a tributary to WOC and ultimately to the Clinch River. Further investigation showed that contaminated groundwater entered the storm water collection system by in-leakage to three catch basins in the western part of ORNL.

Since the time that seepage into First Creek was discovered, the Corehole 8 Plume has been addressed through a series of actions beginning with the initial Corehole 8 (Plume Collection) removal action completed in 1994. Performance monitoring and other LTS requirements for that removal action have been superseded by the *Phased Construction Completion Report for the Bethel Valley (Corehole 8) Extraction System* (DOE/OR/01-2534&D1) approved April 23, 2012. This action was completed under the Bethel Valley ROD.

Figure 2.14 is a simplified conceptual block diagram of the Corehole 8 plume that shows the plume confined within a dipping limestone bed that is approximately 10 ft thick. Contaminants seep into the

weathered limestone bed beneath the North Tank Farm near Tank W-1A. Groundwater seepage within the dipping bed carries contamination downward and westward, as shown by the flowlines in Figure 2.14. A portion of the flow rises to discharge into the base of the soil profile near the western edge of the ORNL central campus near First Street, where the plume collection system was installed during implementation of the removal action. Contaminant concentrations are attenuated along the seepage pathway with approximately 100-fold reduction in concentration measured between well 4411 (near the source area) and at well 0812 and in the collection system at the western end of the plume. The full vertical and lateral extent of the Corehole 8 Plume has not been confirmed but will be determined by investigations leading to a final groundwater decision for Bethel Valley.

Evaluation of Plume Collection Performance Monitoring Data

During FY 2015, the Corehole 8 plume interceptor system did achieve the performance goal for reduction of ^{90}Sr discharge to First Creek, as discussed below. During FY 2009 – FY 2011 the electrical control systems on the original groundwater collection sumps became increasingly unreliable and numerous operational outages occurred. In 2010 DOE issued the *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory, Oak Ridge Tennessee* (DOE/OR/01-2469&D2) that included design details for extraction system expansion including the addition of bedrock plume extraction wells, testing and repair of existing delivery piping, and replacement of the existing pumps and the entire system controls. In mid-March of FY 2012, the refurbished collection system was placed in operation. Upon completion of the refurbishment, the *Phased Construction Completion Report for the Bethel Valley Corehole 8 Extraction System at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2534&D1) was approved that documents the work performed and the system configuration upon completion.

First Creek is the receiving surface water body for discharge of contaminated groundwater in the Corehole 8 plume. Continuous flow-paced monitoring of First Creek has been ongoing since before the Corehole 8 plume removal action was conducted. Table 2.8 includes the FY 2015 monthly flow volumes, ^{90}Sr activities, and ^{90}Sr fluxes, as well as similar data from 1994 prior to the removal action. The flux of ^{90}Sr measured in First Creek in FY 2015 was approximately 5% of the flux measured during calendar year 1994 prior to startup of the Corehole 8 groundwater collection system. Table 2.9 shows the history of ^{90}Sr fluxes and flux reduction factors in First Creek from calendar year 1993 through FY 2015.

Performance evaluation data summarized in Table 2.9 show that the Corehole 8 plume collection system effectively reduced contaminant discharge to First Creek through FY 2008, but that performance deteriorated in FY 2009 and remained poor through FY 2011. The system performance goal was not met during FY 2009 through FY 2011. Despite the system being out of service for half the FY 2012 due to construction, the remedy goal of ^{90}Sr reduction in First Creek was met during FY 2012. During FY 2015, the Corehole 8 plume collection system experienced minimal operational problems; pump failure in one of the shallow groundwater sump lift stations was corrected as part of normal operation and the system was returned to service.

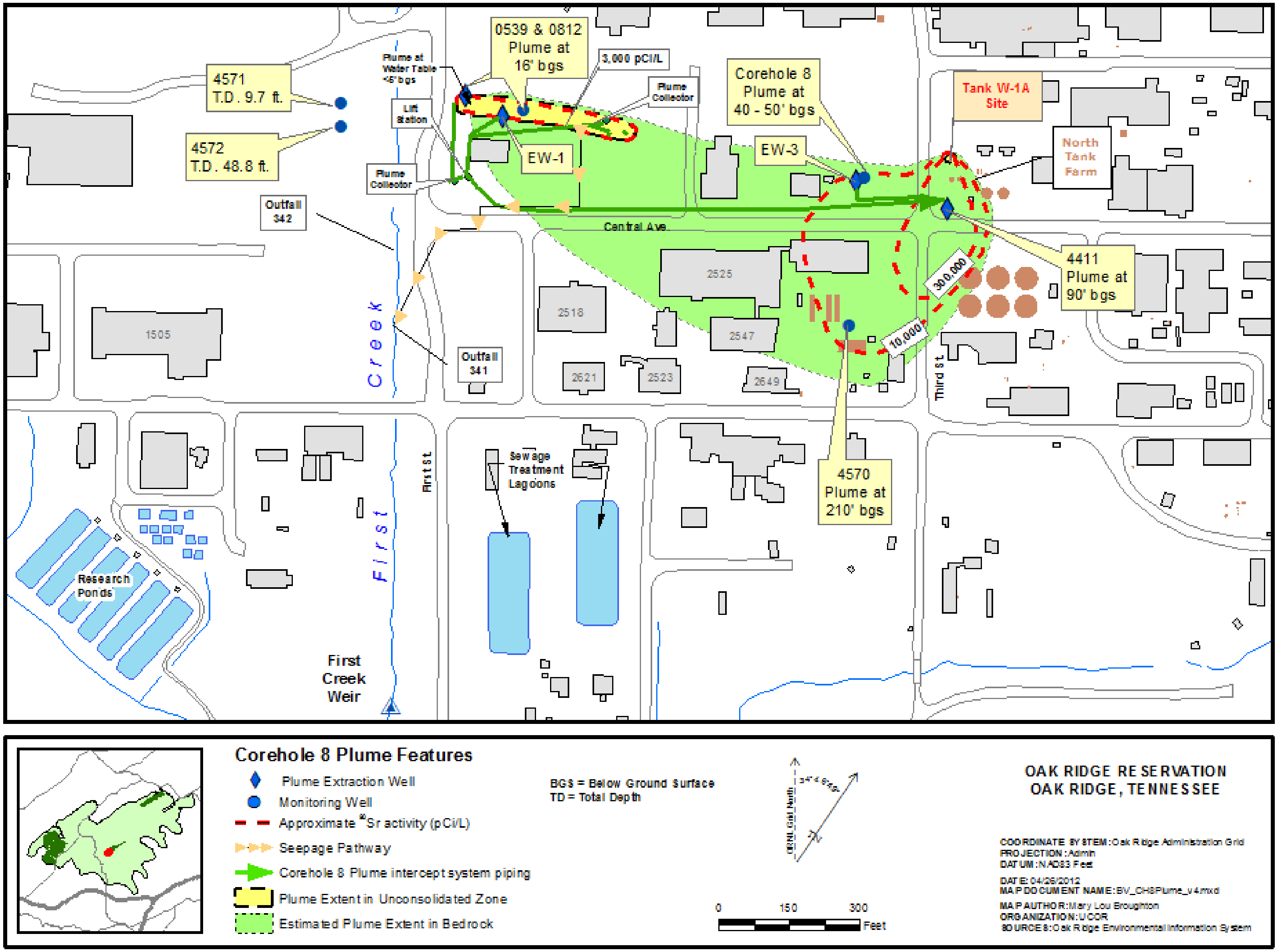

Figure 2.13. Location and features of the Corehole 8 Plume.

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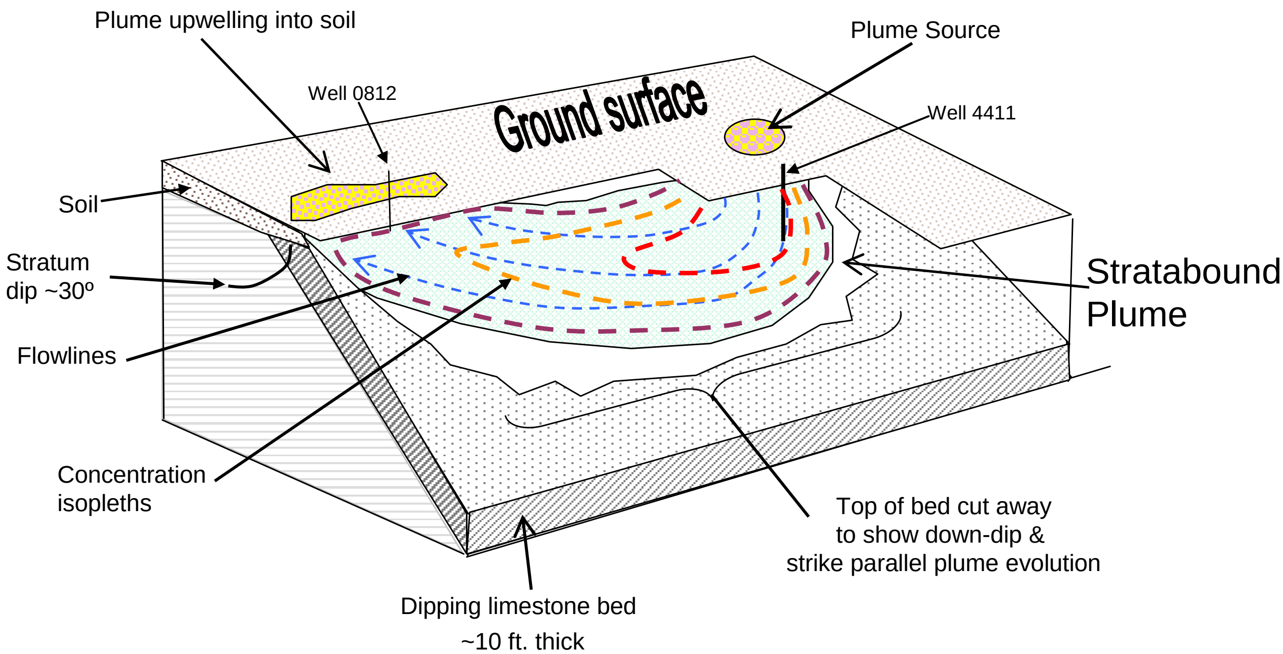

Figure 2.14. Conceptual block diagram of the Corehole 8 Plume.

Table 2.8. First Creek ^{90}Sr fluxes pre-action and in FY 2015

Month	CY 1994 (pre-action)			Month	FY 2015		
	^{90}Sr (pCi/L)	Flow volume (L)	^{90}Sr flux (Ci)		^{90}Sr (pCi/L)	Flow volume (L)	^{90}Sr flux (Ci)
January 1994	124.4	102,893,891	0.0128	October 2014	7.55	49,927,507	0.0004
February 1994	95.6	126,569,038	0.0121	November 2014	1.71	23,472,677	0.00004
March 1994	89.2	228,699,552	0.0204	December 2014	10.4	110,767,306	0.0012
April 1994	105.4	166,982,922	0.0176	January 2015	9.26	115,811,021	0.0011
May 1994	236.5	41,437,632	0.0098	February 2015	1.84	79,591,954	0.0001
June 1994	297.3	32,963,337	0.0098	March 2015	14.1	154,328,256	0.0022
July 1994	324.4	25,585,697	0.0083	April 2015	5.21	111,985,229	0.0006
August 1994	378.4	30,919,662	0.0117	May 2015	1.33	24,425,467	0.00003
September 1994	364.9	26,586,673	0.0097	June 2015	1.71	27,125,294	0.00005
October 1994	133.6	24,700,599	0.0033	July 2015	11	105,211,800	0.0012
November 1994	260.9	37,178,996	0.0097	August 2015	8.23	49,971,686	0.0004
December 1994	179.8	66,740,823	0.012	September 2015	4.37	36,155,232	0.00016
Total		911,258,822	0.137	Total		888,773,429	0.0074

CY = calendar year
FY = fiscal year

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Table 2.9. ^{90}Sr flux changes at First Creek Weir, 1993 – 2015

Year	^{90}Sr flux (Ci)	Percent reduction from CY 1994[a]
CY 1993	0.13	
CY 1994	0.137	
CY 1995	0.067	51.1
FY 1996	NA	NA
FY 1997	0.036[b]	73.7
FY 1998	0.044[c]	67.9
FY 1999	0.044[c]	67.9
FY 2000	0.026	81.0
FY 2001	0.035	74.8
FY 2002	0.034	75.0
FY 2003	0.016	88.0
FY 2004	0.016	88.5
FY 2005	0.019	86.2
FY 2006	0.011	92.0
FY 2007	0.014	89.2
FY 2008	0.022	84.0
FY 2009	**0.119**	12.9
FY 2010	**0.131**	5.0
FY 2011	**0.116**	8.5
FY 2012	0.059	43.1
FY 2013	0.042	69.5
FY 2014	0.013	90.8
FY 2015	0.0074	94.6

[a]Remedy effectiveness (20 – 50% reduction from 1994 flux).
[b]Represents 10 months of data.
[c]Represents 11 months of data.

Bold table entries indicate years when the remedy has not achieved the performance goal.

CY = calendar year
FY = fiscal year
NA = not applicable

Figure 2.15 shows the historical ^{90}Sr and $^{233/234}$U activities measured in groundwater at well 4411 and Corehole 8 Zone 2. Well 4411 is a plume extraction well that intersects the plume at a depth of approximately 90 ft below ground surface (bgs) in a location approximately 120 ft south of the former Tank W-1A location, where leakage from a broken LLLW pipeline created the plume source. Samples from well 4411 are taken at the wellhead and represent contaminant concentrations in extracted groundwater that is being pumped to the PWTC for treatment. Corehole 8 is a 50 ft deep well in which a Westbay® multizone sampling system was installed to allow sampling of discrete intervals in the well. Zone 2 is the second zone from the bottom of the well, and its sampling interval spans the depth of 41.2 – 43.2 ft bgs. During well installation and initial sampling, this zone was found to produce the

highest activities of contaminants in the well and for that reason it has become the focal point for ongoing monitoring at that location. Data presented in Figure 2.15 show that during FY 2015 at Corehole 8, ^{90}Sr and $^{233/234}$U activities continued the decreasing trend that started in 2012 coincident with completion of Tank W-1A and associated contaminated soil removal. Similar to Corehole 8, ^{90}Sr and $^{233/234}$U activities in well 4411 continued to gradually decline during FY 2015.

Figure 2.16 shows the Corehole 8 groundwater collection sump ^{90}Sr and alpha activity data from system startup in 1995 through FY 2015. Notations on the figure show approximate dates when extraction of contaminated groundwater via well 4411 started, as well as the approximate dates during which contaminated soil was excavated from the North Tank Farm. The data demonstrate that both actions had visible benefits in reducing contaminant activities in the plume collection system that is located in the western end of the plume. Table 2.10 includes Corehole 8 collection system monthly and year-end total flow volumes collected and strontium flux captured and sent to the PWTC for FY 1997 and FY 2015. Figure 2.17 shows the annual flux of ^{90}Sr collected by the Corehole 8 groundwater collection system along with total annual rainfall. The long-term average annual rainfall for Oak Ridge is approximately 54 in./yr. As shown on Figure 2.17, FY 2003 – FY 2005 and FY 2009 – 2013 were years of above average rainfall. FY 2003 was an especially unusual year in that the annual rainfall was approximately 35% above the long-term average.

Figure 2.18 shows ^{90}Sr and $^{233/234}$U activities measured at well 4570 (Figure 2.13) since its installation as recommended in the *Engineering Study Report for Groundwater Actions in Bethel Valley* (DOE/OR/01-2219&D2). Well 4570 was drilled to evaluate down-dip extent of the plume in the stratabound limestone unit. During construction of the well, samples of the drilling return water were collected periodically and screened for beta activity as an indicator of the presence of ^{90}Sr. Beta activity levels increased at approximately 200 ft bgs, which was the projected depth of the limestone bed at that location. Contaminant activities have declined overall since the beginning of monitoring this well although both contaminants exhibited an increasing behavior during FY 2014 and FY 2015. The cause of the increase is uncertain; however, the sample collected during summer of 2015 showed that the increasing trend has moderated. Wells 4571 and 4572 (Figure 2.13) are monitored semiannually to evaluate the potential extension of the plume west of First Creek. Well 4571 samples groundwater from the top of bedrock at a depth of 9.7 ft, while well 4572 samples shallow bedrock groundwater at a depth of 48.8 ft bgs. Strontium-90 was detected in the shallower well (4571) in both samples collected during FY 2015. In January, ^{90}Sr was measured at 5.23 pCi/L and in July the result was 0.468 pCi/L. Lower detection limits in FY 2015 allowed detection of a low concentration of ^{90}Sr in July that would not have been identified in previous years. In the sampling history of these two wells, ^{90}Sr has been detected in five of 21 samples and the FY 2015 result of 5.23 pCi/L is the maximum detected result. At well 4572, ^{90}Sr has been detected only one time in 2011 at a concentration of 2.47 pCi/L. No detection was noted in the sample from well 4571 during that event. All of the detected ^{90}Sr results in these wells are below the 8 pCi/L MCL-DC.

Plume Collection Performance Summary. The Corehole 8 plume collection system met its performance goal during FY 2015 based on ^{90}Sr flux reduction in First Creek (Table 2.9) which contributed to the average measured ^{90}Sr activity at 7500 Bridge meeting its ROD goal (Table 2.6). Contaminant activity levels in the plume rose to high levels in the 2009 – 2010 period and have decreased significantly as shown on graphs for well 4411, Corehole 8 Zone 2, and in the collected groundwater in the Corehole 8 collection system. This decrease in plume contaminant levels is an indication that the plume mass is gradually decreasing. The monthly ^{90}Sr concentration and estimated monthly and annual flux of ^{90}Sr captured during FY 2015 are summarized in Table 2.10.

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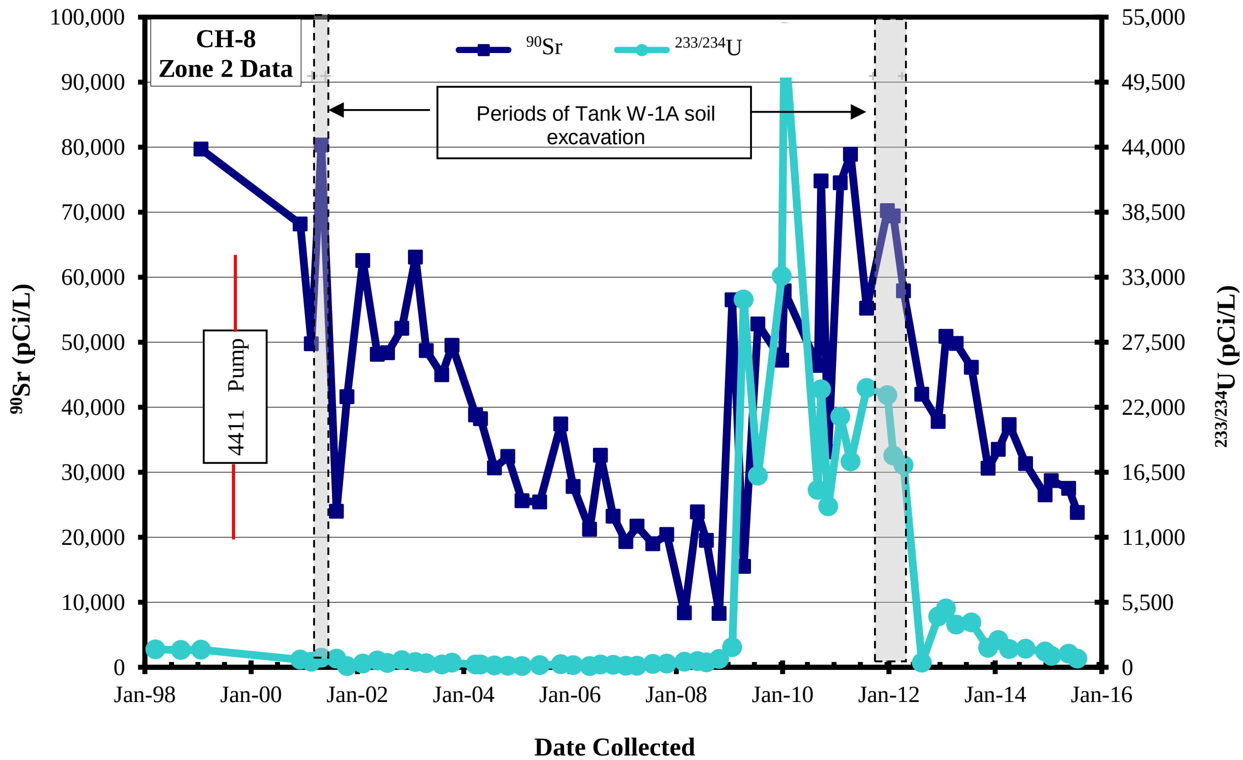

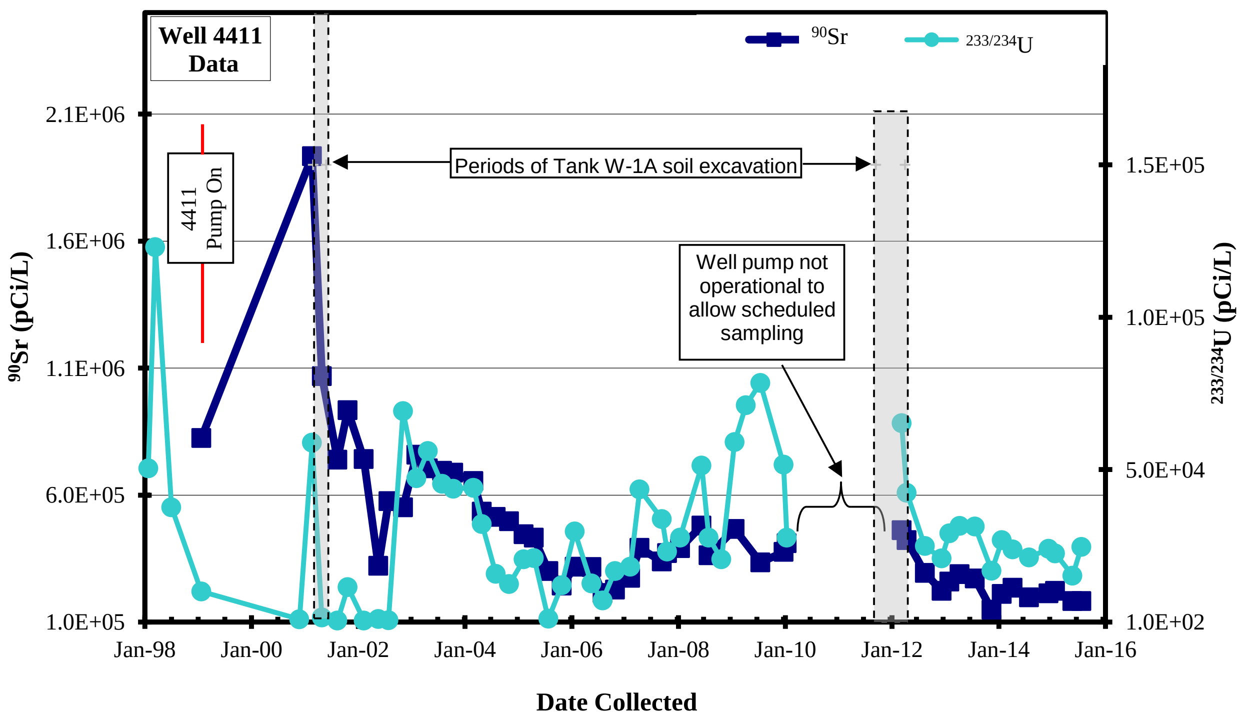

Figure 2.15. Contaminant activities in well 4411 and Corehole 8 Zone 2.

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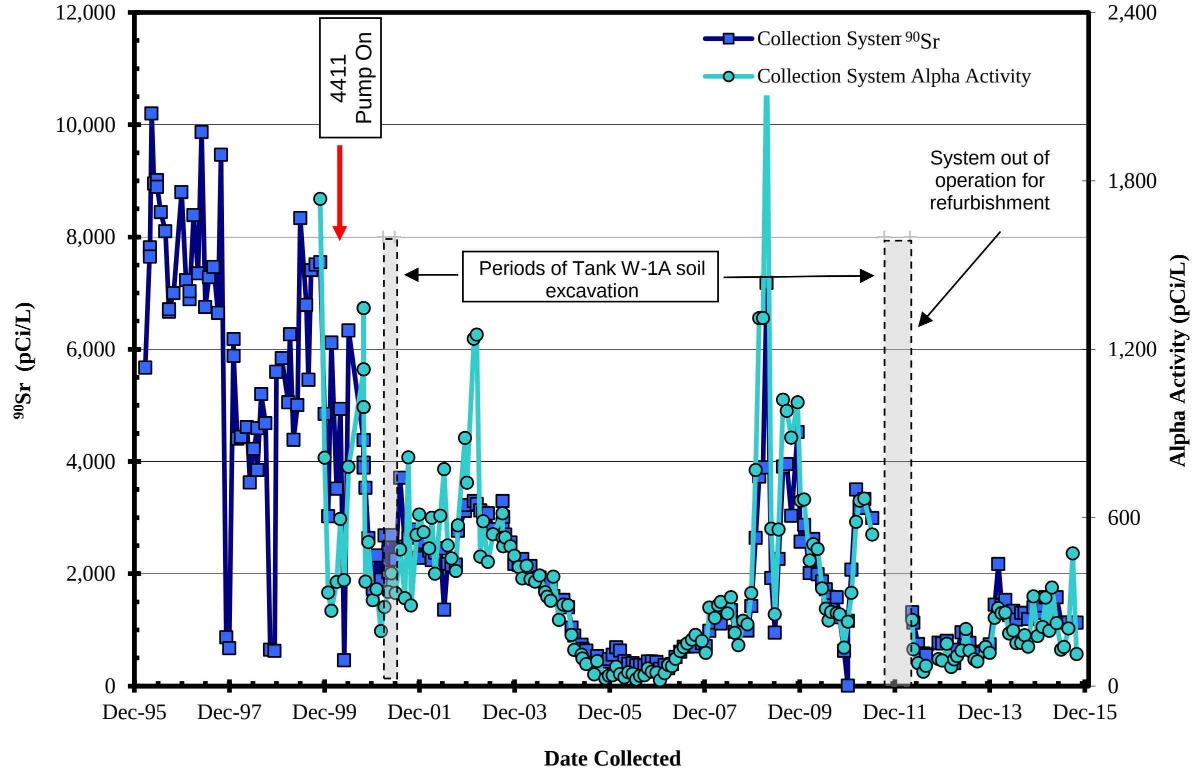

Figure 2.16. ^{90}Sr and alpha activity in collected Corehole 8 Plume groundwater.

Table 2.10. Corehole 8 groundwater collection system ^{90}Sr flux

Month	FY 1997			Month	FY 2015		
	^{90}Sr (pCi/L)	Flow volume (L)	^{90}Sr flux (Ci)		^{90}Sr (pCi/L)	Flow volume (L)[a]	^{90}Sr flux (Ci)
October 1996	8,700	933,000	0.0081	October 2014	1,400	648,504	0.0009
November 1996	8,800	1,845,000	0.0162	November 2014	1,300	550,973	0.0007
December 1996	7,230	2,595,000	0.0188	December 2014	1,430	998,539	0.0014
January 1997	6,890	1,711,000	0.0118	January 2015	1,580	927,144	0.0015
February 1997	8,390	1,858,000	0.0156	February 2015	1,330	791,914	0.0011
March 1997	7,350	2,162,000	0.0159	March 2015	1,530	1,032,912	0.0016
April 1997	9,870	1,946,000	0.0192	April 2015	1,580	890,482	0.0014
May 1997	6,750	1,697,000	0.0115	May 2015	1,130	405,461	0.0005
June 1997	7,280	2,631,000	0.0192	June 2015	1,180	565,862	0.0007
July 1997	7,463	1,705,000	0.0127	July 2015	1,240	919,858	0.0011
August 1997	6,647	1,131,000	0.0075	August 2015	2,040	518,342	0.0011
September 1997	9,465	953,000	0.009	September 2015	1,400	410,990	0.0004
	Total	21,167,000	0.1655		Total	8,660,981	0.012

[a]A 2012 change in the flow monitoring equipment and sampling system triggering mechanism caused a non-systematic reduction of the apparent collection system flow total volumes compared to prior results.

FY = fiscal year

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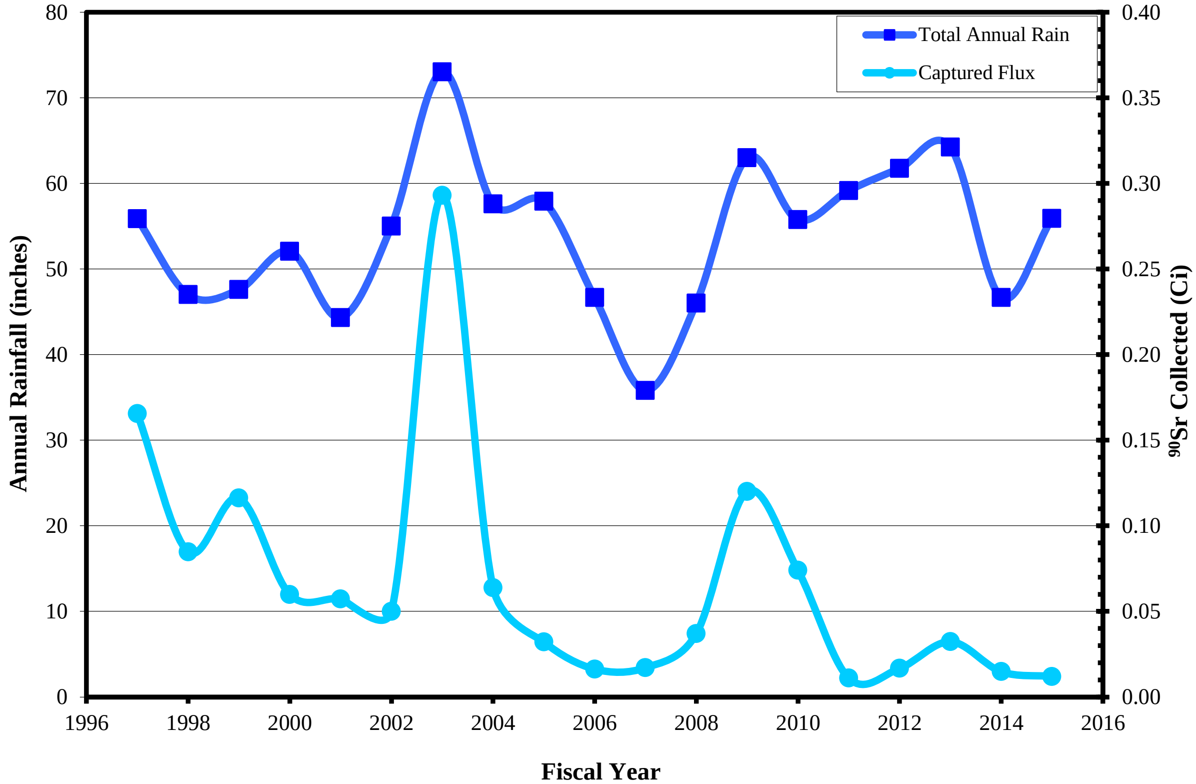


Figure 2.17. Corehole 8 Plume groundwater collector annual intercepted ^{90}Sr flux and rainfall.

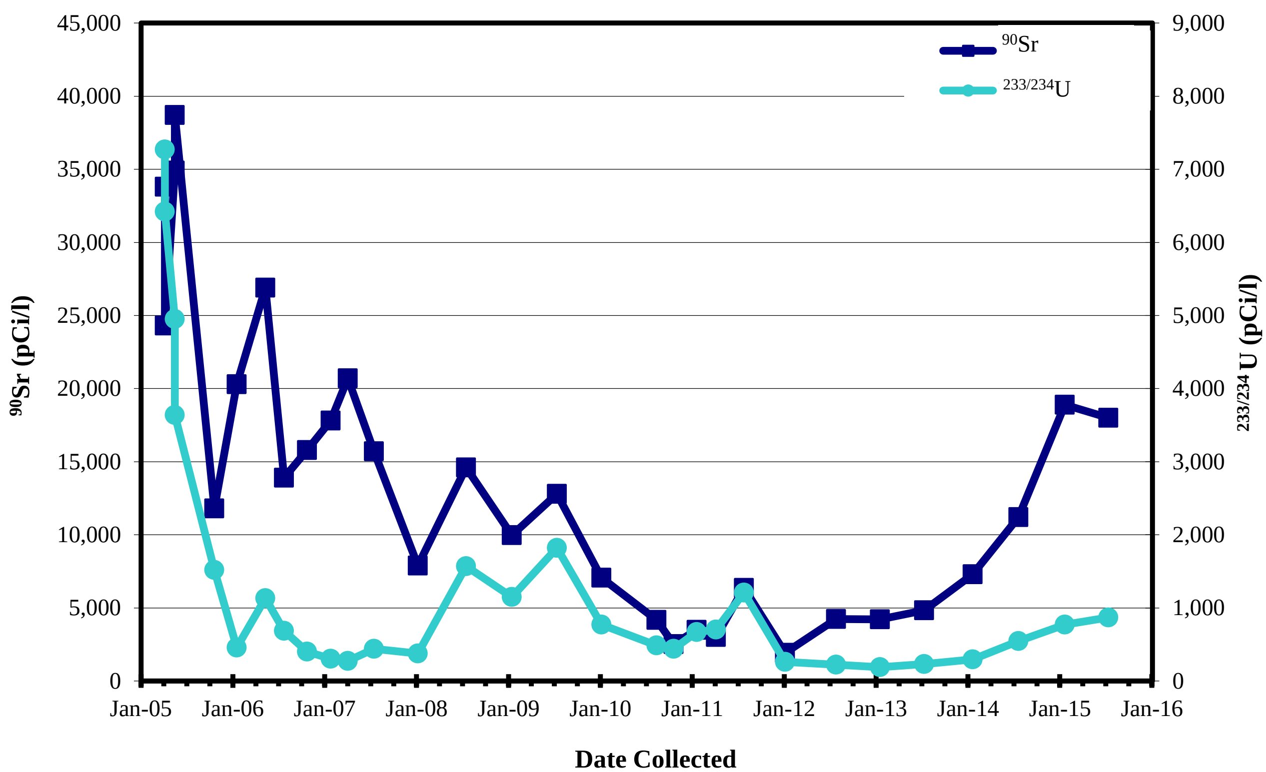


Figure 2.18. ^{90}Sr and $^{233/234}$U activities in well 4570.

2.2.1.2.2 Groundwater

CERCLA groundwater monitoring in Bethel Valley for actions under the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) includes exit pathway well monitoring, ongoing monitoring related to the 7000 Area VOC Plume Treatability Study that was conducted in 2011, and monitoring related to the SWSA 3 RA. Exit pathway wells in the western and eastern ends of the ORNL area in Bethel Valley are monitored to determine if contaminants discharge to Raccoon Creek and Bearden Creek, respectively. Results of surface water monitoring in these two subwatersheds were discussed in Section 2.2.1.2.1.3. Figure 2.5 shows locations where Bethel Valley exit pathway sampling is conducted. Bearden Creek Exit Pathway groundwater monitoring well results (wells 1198 and 1199) are discussed later in this section. Wells 4579, 4645, 4646, and 4647 in the Raccoon Creek headwaters are discussed along with the SWSA 3 monitoring results.

ORNL 7000 Area VOC Plume Treatability Study

The 7000 area VOC plume is predominantly a trichloroethene (TCE) plume, with several transformation products that are formed by microbial degradation of the TCE. Principal degradation products include cis-1,2-dichloroethene (DCE), 1,1-DCE, and vinyl chloride (VC). The plume occurs essentially totally in fractured, karst bedrock of the Ordovician age Witten formation. The Witten formation is comprised of interbedded argillaceous limestone (containing a high clay/silt fraction) and relatively pure limestone beds. In the 7000 area, the lower half of the Witten formation contains two relatively distinct pure limestone members locally referred to as the “Little Lime” and the “Big Lime” (which is not correlative with the Mississipian age Big Lime that is a prominent petroleum producing formation beneath the Cumberland Plateau and Mountains). The core portion of the plume occurs in the “Little Lime” which is also suspected to be a key groundwater contaminant pathway for radionuclides at SWSA 3. The source of the TCE is suspected to have been released from a small parts cleaning facility that was dismantled prior to CERCLA site investigations. The principal known discharge location for groundwater affected by the plume is a small spring that forms the head water of a small tributary of WOC.

The report for the *Treatability Study for the Bethel Valley 7000 Area Groundwater Plume, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2566&D1) was issued in May 2012. The report presented the results of field and laboratory tests that were used to design a field scale biostimulation pilot test. The report also summarized monitoring results for a one year period following the injection of materials that allowed native dehalogenating microbes and other native microbes to increase their population numbers with resulting degradation of TCE and its transformation products.

Sampling and analysis are ongoing at seven monitoring wells (752, 1201, 4576, 4577, 4581, 4582, and 4583) and one spring (SP-200) in the study area to document the sustainability of the treatment and measure ongoing trends in VOC concentrations and microbial populations. In addition, sampling is periodically conducted for VOCs at additional wells in the vicinity of the study area. These include three zones in the multi-port well 4575 and at well 754.

Figure 2.19 provides the plume map, projected to the surface, prior to injection of the biostimulant materials, and includes a cross-section showing the TCE plume (with VC concentrations also indicated on the cross-section) based on the December 2010 groundwater data. Figure 2.20 represents the plume, in both plan view and cross-sections, as depicted based on the July 2015 groundwater data.

Following injection of the emulsified vegetable oil and hydrogen releasing compound into 4 wells in the study area, the endemic community of microbes, including the native *Dehalococcoides* sp (DHC), grew rapidly producing strongly anaerobic groundwater conditions in the vicinity. TCE concentrations declined fairly rapidly and the daughter products increased in proportion in the area where the biostimulant altered

the groundwater chemistry and the microbial community flourished. Figures 2.21, 2.22, and 2.23 show the monitored trends of VOC compounds and DHC pre-biostimulation through FY 2015.

At injection wells 0752 and 4583 near the upgradient end of the test area, TCE concentrations decreased by well over two orders of magnitude (very rapidly at 4583 and more gradually at 0752) before beginning to rebound through inflow of dissolved phase plume water from upgradient of the wells. As of the end of FY 2015, TCE concentrations at both wells are an order of magnitude lower than initial concentrations. DHC levels are rather low in both wells and TCE daughter products are similar to pre-biostimulation levels.

At injection wells 1201 and 4582, located near the middle of the test area, TCE concentrations continue a downward trend with a dramatic decrease from 10,000 µg/L to about 1 µg/L at well 4582 and a more modest decrease from about 1,000 µg/L to about 10 µg/L at well 1201. At well 1201, the DHC abundance remains high (around 10^6 cells/mL) and TCE daughter products remain rather constant, with cis-1,2-DCE and VC concentrations >100 µg/L and >1,000 µg/L, respectively. Ethylene, a final stage degradation product in the TCE degradation chain, remains present at several hundred µg/L which indicates the biodegradation process is continuing in the area. At well 4582, cis-1,2-DCE and VC concentrations have continued to decrease along with the decrease in TCE and, although the DHC abundance has declined, ethylene is still present at the 100 – 1,000 µg/L level.

As reported in the 2015 RER, the post-injection data indicate the longevity of the carbon amendment appears to be 12 to 18 mo. for shallow or upgradient wells, and at least 30 mo. for deeper and downgradient wells. The change from anaerobic to aerobic conditions in groundwater also resulted in a decrease in the dechlorinating bacteria (DHC), which is not surprising given that these bacteria are strict anaerobes.

In summary, the monitoring data collected to date indicate significant TCE degradation has occurred at six of the seven wells as a result of the in situ treatment pilot study, and daughter product appearance and degradation has also occurred at the same six wells. Additionally, the molar sum of chlorinated ethenes indicates a strong decline at three of the seven wells, and a minimal to moderate decline at the four remaining wells. A molar sum analysis is helpful in assessing overall contaminant destruction for a contaminant that is degraded through sequential daughter products. Finally, the low detected concentrations of TCE and cis-1,2-DCE at the SP-200 spring (located approximately 1200 ft downgradient of the injection wells) do not appear to have been affected whatsoever by the pilot study amendment injections. The long-term responses observed at each well are somewhat distinctive but overall the site response is showing a return to pre-test conditions in the wells at the upgradient end of the test area and continuing evidence of biodegradation and drift of degradation products in the mid-section and downgradient end of the test area.

General conclusions can be made from the ongoing monitoring results:

- After 4.5 years of TCE biodegradation from the single biostimulant injection, VOC concentrations within and downgradient of the treatment zone remain significantly lower than pre-injection concentrations.

- Positive contaminant degradation effects from the amendment injection were observed in monitoring wells approximately 120 and 350 ft downgradient of the injection wells.

- Increases in contaminant levels at the same points in time appear to correlate with periods of heavy precipitation suggesting that a slug of contaminants is periodically pulsed through the aquifer at times of higher infiltration.

- Rapid influxes of fresh, oxygenated groundwater appeared to reduce the lifespan of the injected carbon amendment and decrease the anaerobic dechlorinating bacteria (DHC) population.

- The post-injection data suggest that carbon donor material has persisted in the injection wells for up to 4.5 years; however, anaerobic conditions abated at three of the four injection wells at roughly 18 mo. after the amendment injection.

The post-injection monitoring results of the field-scale amendment injections in the 7000 Area of ORNL have indicated that anaerobic reductive dechlorination can be successfully implemented at full scale for treating TCE in groundwater in the 7000 Area.

The *Treatability Study Work Plan for 7000 Area in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-2475&D2) stipulated monitoring of VOCs, field parameters, biodegradation parameters, and genetic indicators for one year post-injection of the biostimulants. Thus, the treatability study ended in January of 2012 which was one full year post-injection. The report (*Treatability Study for the Bethel Valley 7000 Area Groundwater Plume Oak Ridge National Laboratory Oak Ridge, Tennessee* [DOE/OR/01-2566&D1]) issued in 2012 recommended continued monitoring without stipulating a duration. DOE continued that full scale monitoring through FY 2014 to obtain a more robust dataset to document the microbial processes. In FY 2015, DOE discontinued analysis of phospholipid fatty acids (PLFA) and hydrogen gas because the numbers of DHC had shown significant declines. DOE continues to monitor field parameters, VOCs (including ethane, ethylene, and methane), total and ferrous iron, anions (including alkalinity, chloride, fluoride, sulfate, nitrate-nitrite, and sulfide), total organic carbon (TOC), and abundance of DHC which is the functional microbial genera responsible for degradation of TCE and its transformation compounds. Starting in FY 2016, DOE will analyze groundwater at the ORNL 7000 Area for VOCs including chlorinated organics and their transformation products as well as methane/ethylene/ethane to track ongoing degradation and rebound in the plume. Additional RAs on the ORNL 7000 TCE plume will be conducted as a matter of prioritization in the ORR Groundwater Program and in accordance with the agreed FFA schedule.

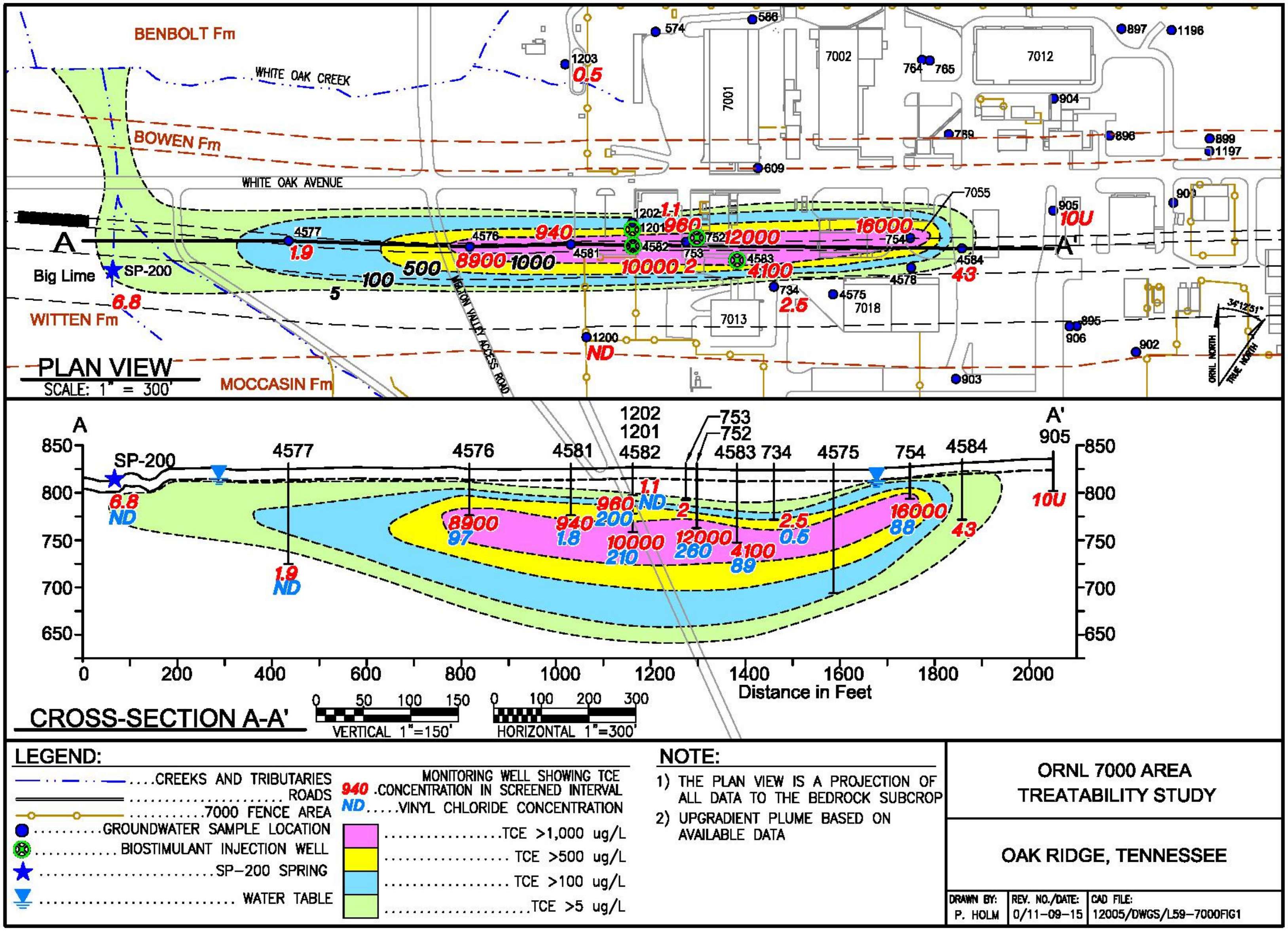


Figure 2.19. ORNL 7000 Area pre-treatability study VOC plume plan and section views.

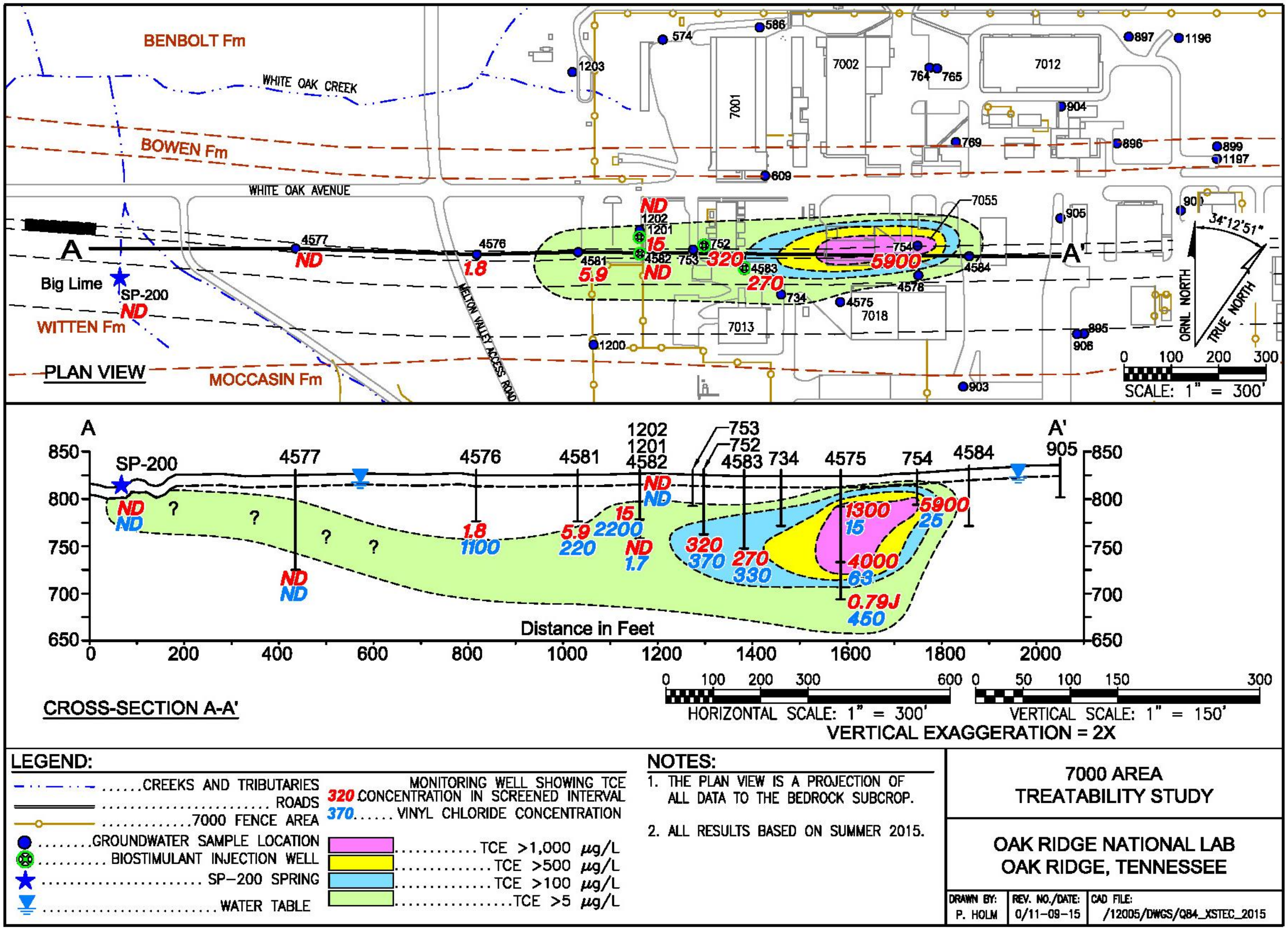


Figure 2.20. ORNL 7000 Area treatability test VOC plume plan and section views 4.5 years after biostimulation in July 2015.

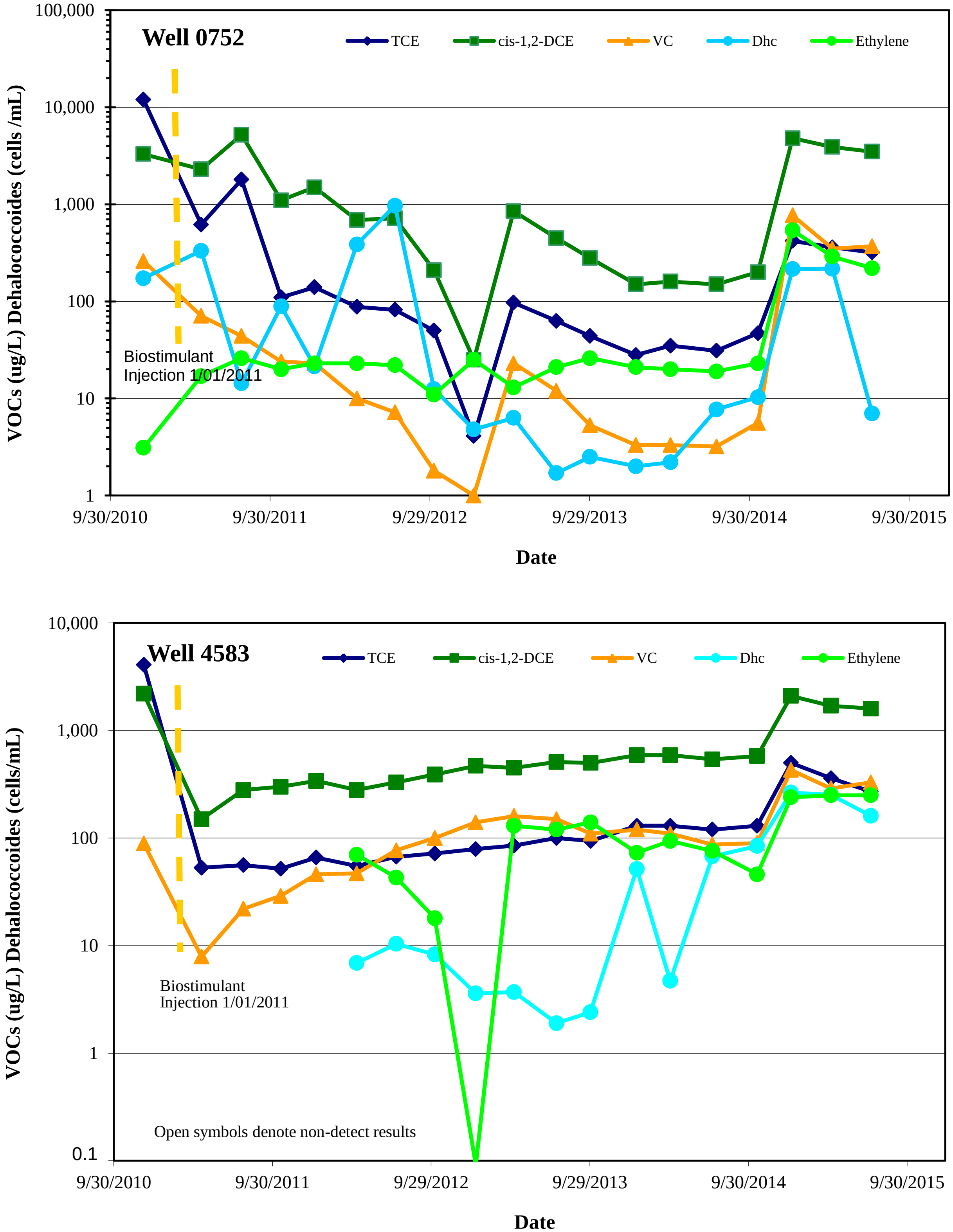


Figure 2.21. Well 0752 and 4583 trends for VOCs and DHC.

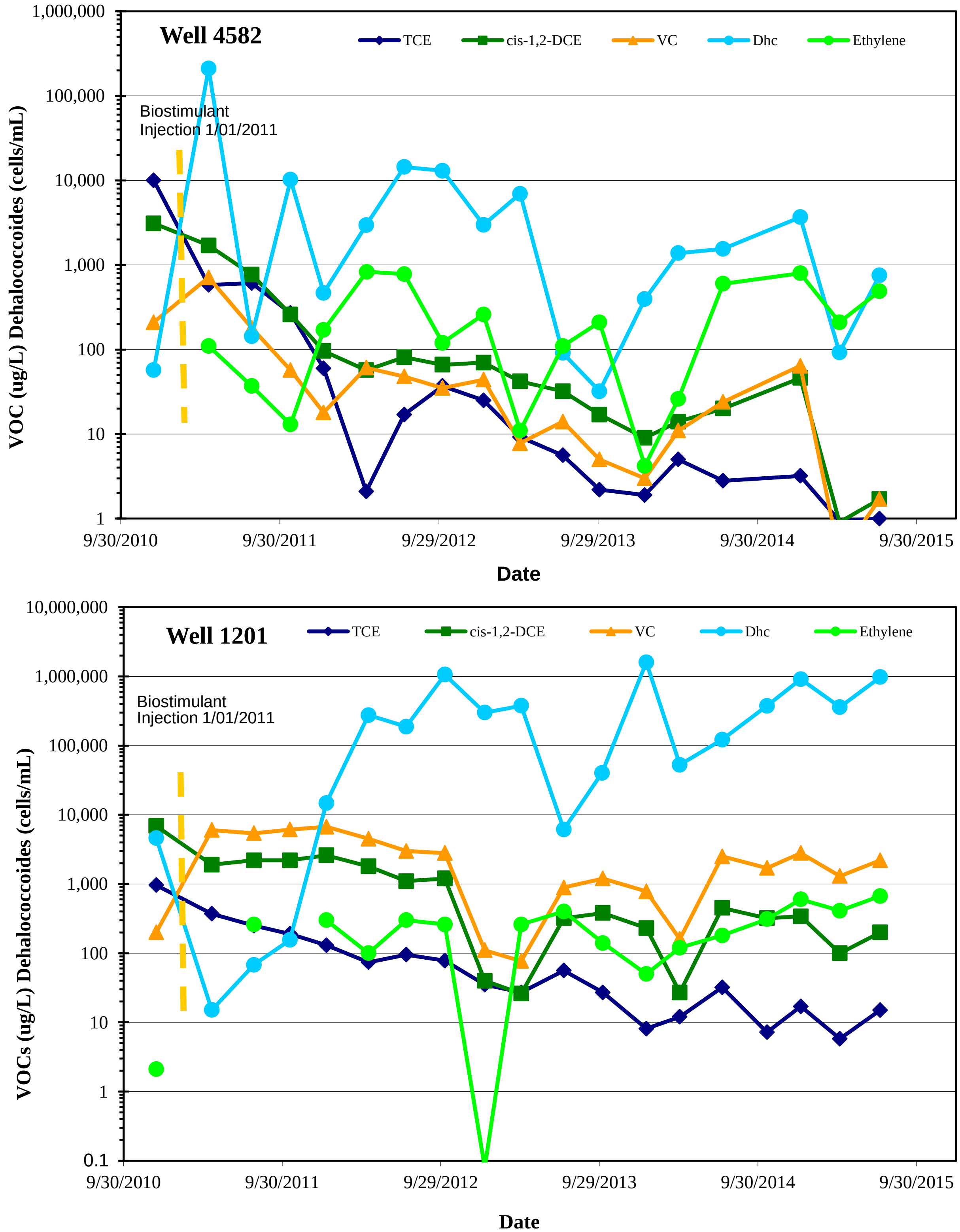
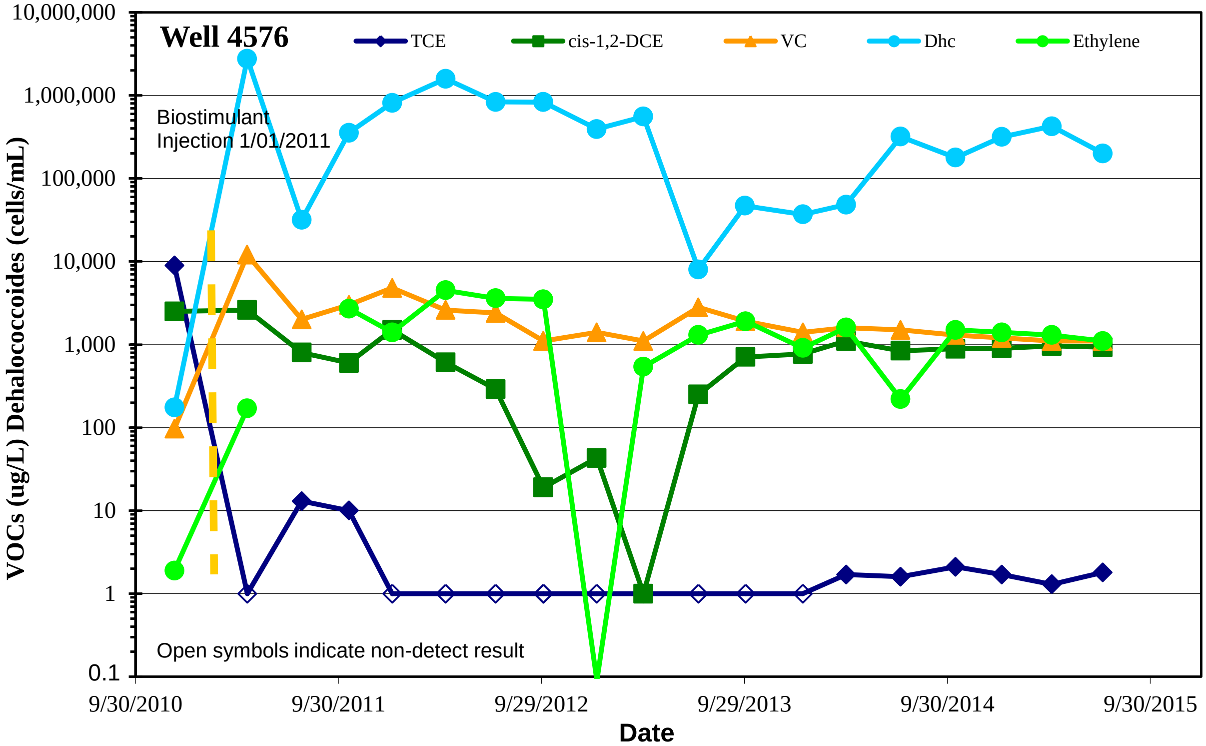


Figure 2.22. Well 1201 and 4582 trends for VOCs and DHC.



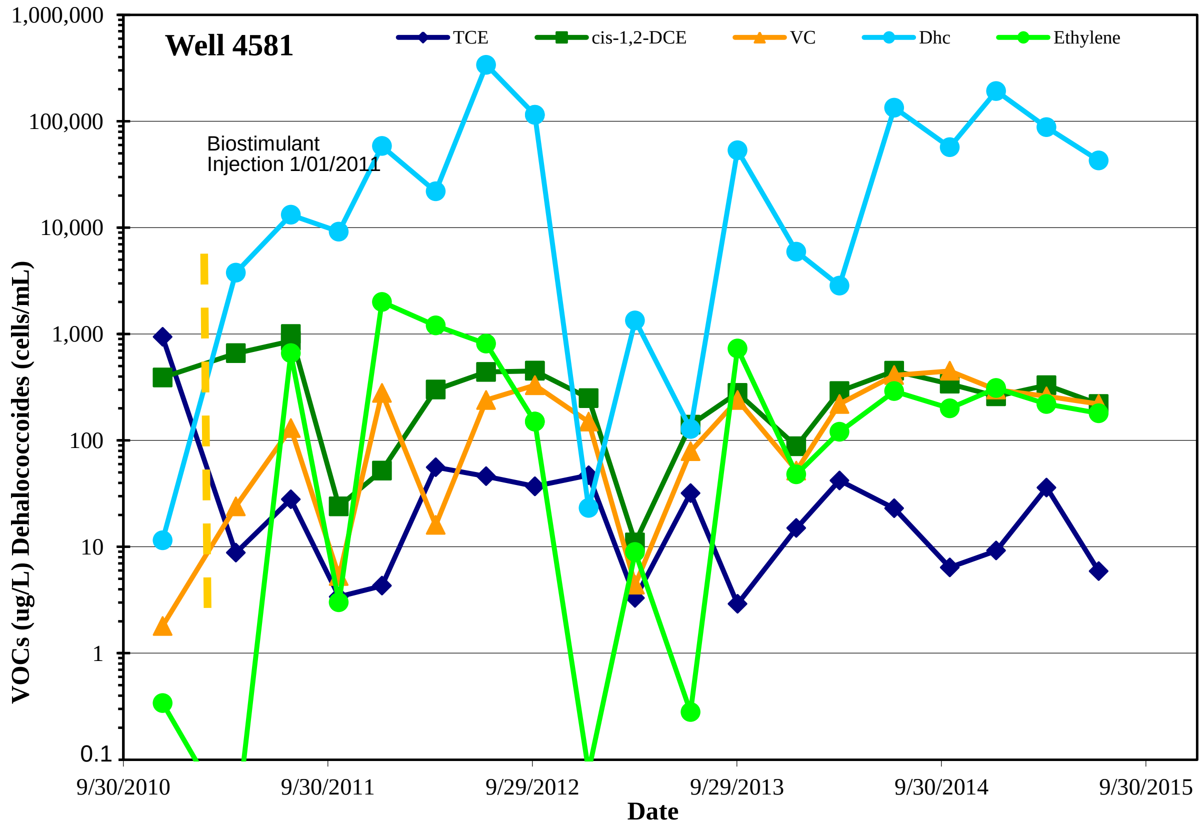


Figure 2.23. Well 4576 and 4581 trends for VOCs and DHC.

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SWSA 3 and Raccoon Creek Exit Pathway

SWSA 3 was the third area used for mixed radioactive and hazardous waste disposal at ORNL. The site also received waste materials from Y-12, ETTP (the former K-25 Gaseous Diffusion Plant), and off-site sources since it was designated as a regional disposal site for radioactive waste by the Atomic Energy Commission. The 6.1 acre mixed waste disposal area received wastes for below-grade disposal between 1946 and 1951; however, the area was used as an above ground contaminated equipment storage area until 1979. Other waste management units in the vicinity of SWSA 3 included a 4 acre scrap metal disposal area and a 7 acre Contractor's Landfill. The BVBGs RA conducted between 2010 and 2012 constructed upgradient shallow groundwater/stormflow diversion trenches along the upslope (southern) edge of the scrap metal storage area and SWSA 3 with a multi-layer hydrologic isolation cap over both units. A soil cover was constructed over the Contractor's Landfill. The SWSA 3 and scrap metal area cap and the Contractor's Landfill soil cover are contiguous features and the two areas are demarcated by a narrow gravel roadway corridor.

The three disposal units were constructed in clay-rich residual soils derived from weathering of the underlying Witten formation argillaceous (containing significant amount of clay and silt) limestone. Waste disposal trenches in SWSA 3 were excavated into the clay-rich soil and it is not known how much soil buffer was left between the base of disposed waste and the top of the limestone bedrock. Emplacement of contaminated waste on a fractured or karst bedrock surface creates an immediate pathway for contamination to enter the groundwater. Local areas consist of colluvial soils derived from residuum of the Rome and Moccassin formations that underlie the northern slope of Haw Ridge to the south of the disposal units. Bedrock to the north of the disposal units is the Bowen formation—a thin (~ 30 ft thick) siliceous shale with a thin limestone zone in its mid-section and the Benbolt formation which is another mixed argillaceous and pure limestone formation. Because of its siliceous nature, the Bowen formation is somewhat less susceptible to chemical weathering and thus may act as an aquitard between the overlying and underlying limestone-rich bedrock formations. The bedrock beneath the disposal areas is the Witten formation which contains interbeds of argillaceous limestone and relatively pure limestone. Site investigations at SWSA 3 conducted in the late 1970s and early 1980s documented the existence of karst conditions at SWSA 3 as evidenced by cavities encountered in bedrock boreholes and rapid movement of groundwater. Three groundwater tracing activities were conducted at SWSA 3 and groundwater seepage velocities in karst pathways were documented to range from about 120 ft/d to over 43,000 ft/d. The tracer tests documented shallow groundwater movement at rapid velocities emerging at springs and seeps in the headwaters of both the Northwest Tributary to the east and Raccoon Creek to the west. A tracer injected in well 0493 in the western portion of SWSA 3 was observed in both streams with a migration velocity of about 240 ft/d to the east into the Northwest Tributary and a velocity of about 120 ft/d to the west into the Raccoon Creek headwater. Tracer migration both east and west from the injection point suggests the existence of the groundwater divide for shallow groundwater in the vicinity of the injection point location. The strength of the shallow groundwater divide at greater depths beneath the SWSA 3 area has not been verified.

The *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge Tennessee* (DOE/OR/01-2533&D2) specifies groundwater level measurement locations and frequencies, as well as sampling locations for analysis of site related contaminants. Figure 2.24 shows the monitoring locations and indicates the types and frequencies of monitoring required. The synoptic groundwater level measurements are useful to prepare piezometric surface maps and to evaluate local vertical head gradients between shallow wells constructed in the soil or near top of bedrock zone compared to deeper wells constructed in bedrock. Groundwater elevations measured in the synoptic surveys are tabulated in Table 2.11. Figure 2.25 shows a piezometric surface map drawn based on average 2015 groundwater elevation data from water table wells. The map shows the major groundwater elevation contours as well as locations where groundwater tracing studies were

conducted in the early 1980s. The inferred tracer trajectories (Figure 2.25) for the tracer injected at well 0493 to the points of emergence in the adjacent stream heads suggests that the "Little Lime" member of the Witten Formation may be a conductive pathway for both the tracer and the co-located ^{90}Sr discharges. There is an apparent area of low groundwater level beneath the northeastern portion of the SWSA 3 cap. This area appears to be co-located with the inferred subcrop of the "Little Lime" member of the Witten formation. Groundwater elevations in the wells within the closed 810 ft piezometric contour are the lowest in the area but are slightly higher than the elevation in Northwest Tributary where the ^{90}Sr and tracer entered the stream. The piezometric contours show gradients from both the north side (Bowen/Benbolt formations) and south (upper Witten and Moccasin formations) toward a low water level trend in the lowermost Witten formation. This is a result of the karst drainage network in that area. A groundwater divide having an elevation between 810 and 815 ft above Mean Sea Level (aMSL) is shown on Figure 2.25 beneath the western end of the SWSA 3 cap based on the combination of groundwater elevation data obtained during post-remediation monitoring and the historic tracer behavior.

The *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2533&D2) states *"…the goal for SWSA 3 is a declining trend in the average water elevations to approximately the elevation of bedrock…"* Table 7-2 of the PCCR specified average groundwater elevation goals for nine wells at SWSA 3. The long-term water table elevation goals and progress toward their attainment are included in Table 2.11. Since installation of the cap and upgradient stormflow diversion trench in 2011, three of the nine wells assigned target groundwater elevations have not attained the elevation goal to date. The three wells are located in the eastern portion of SWSA 3. Hydrographs for the wells with continuous groundwater level monitoring are included in Appendix B.1. The hydrographs show that there are gradual groundwater elevation declines in progress in the three wells that have not yet met the PCCR goals.

Table 2.11. SWSA 3 groundwater target elevation attainment summary

Well	Elevation Goal (ft aMSL)	FY 2015 Average Groundwater Elevation (ft aMSL)
0482	823	**826.93**
0483	835	827.88
0484	824	816.15
0491	816	**824.55**
0492	818.5	**823.79**
0493	829	820.99
0694	838.33	836.93
0996	814.31	808.04
0997	818.64	811.83

Bold table entries indicate wells that have not attained their groundwater elevation goal.

aMSL = above mean sea level
FY = fiscal year
SWSA = Solid Waste Storage Area

As indicated in Figure 2.24, sampling and analysis for contaminants of interest are required for groundwater wells and surface water at the SWSA 3 sediment basin. The sediment basin surface water is sampled because discharges from the upgradient shallow groundwater/stormflow diversion trench drain into the basin. Contaminants specified for analysis in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds* (DOE/OR/01-2533&D2) include ^{90}Sr and tritium, VOCs, and metals.

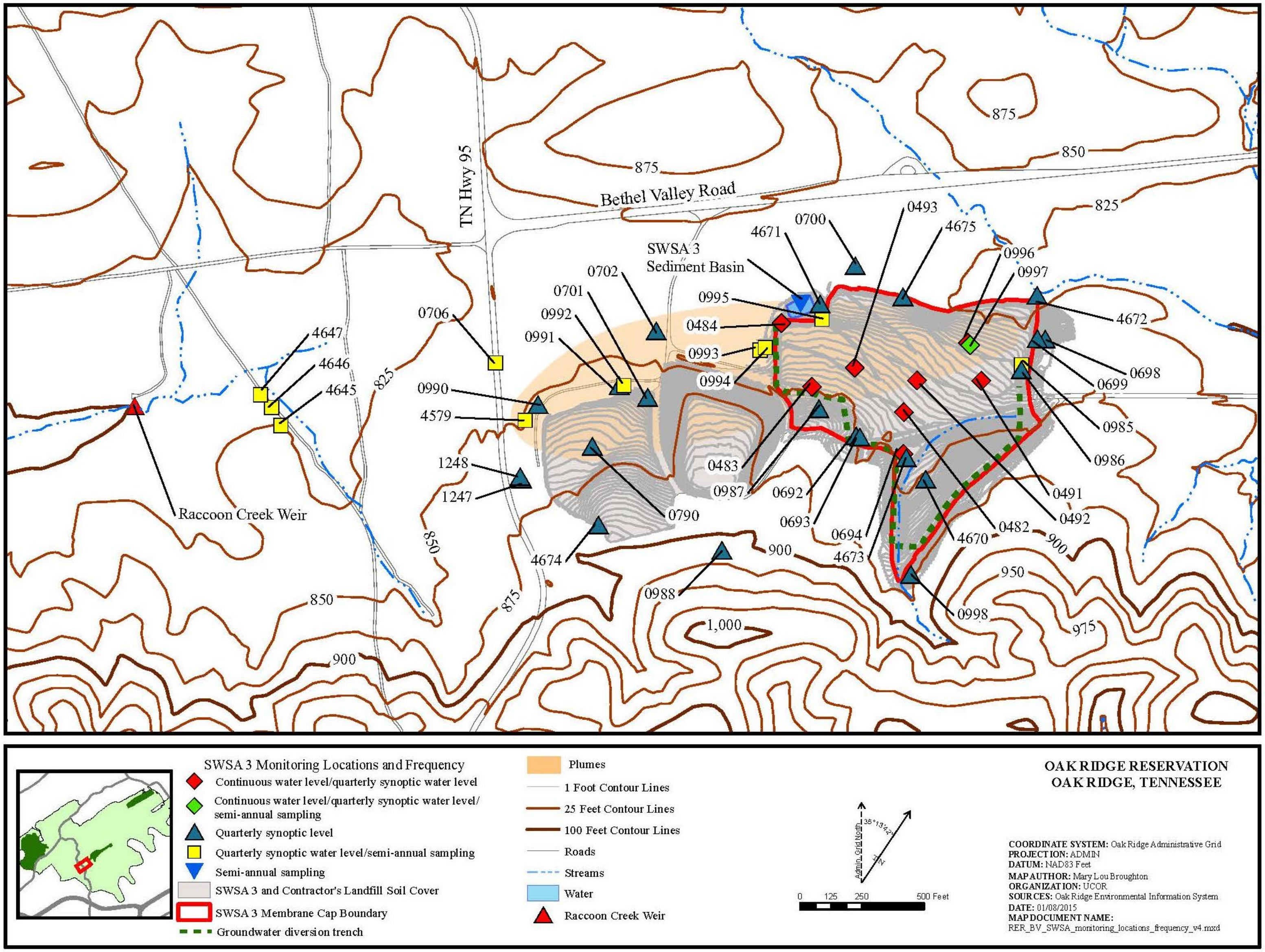

Figure 2.24. SWSA 3 monitoring locations.

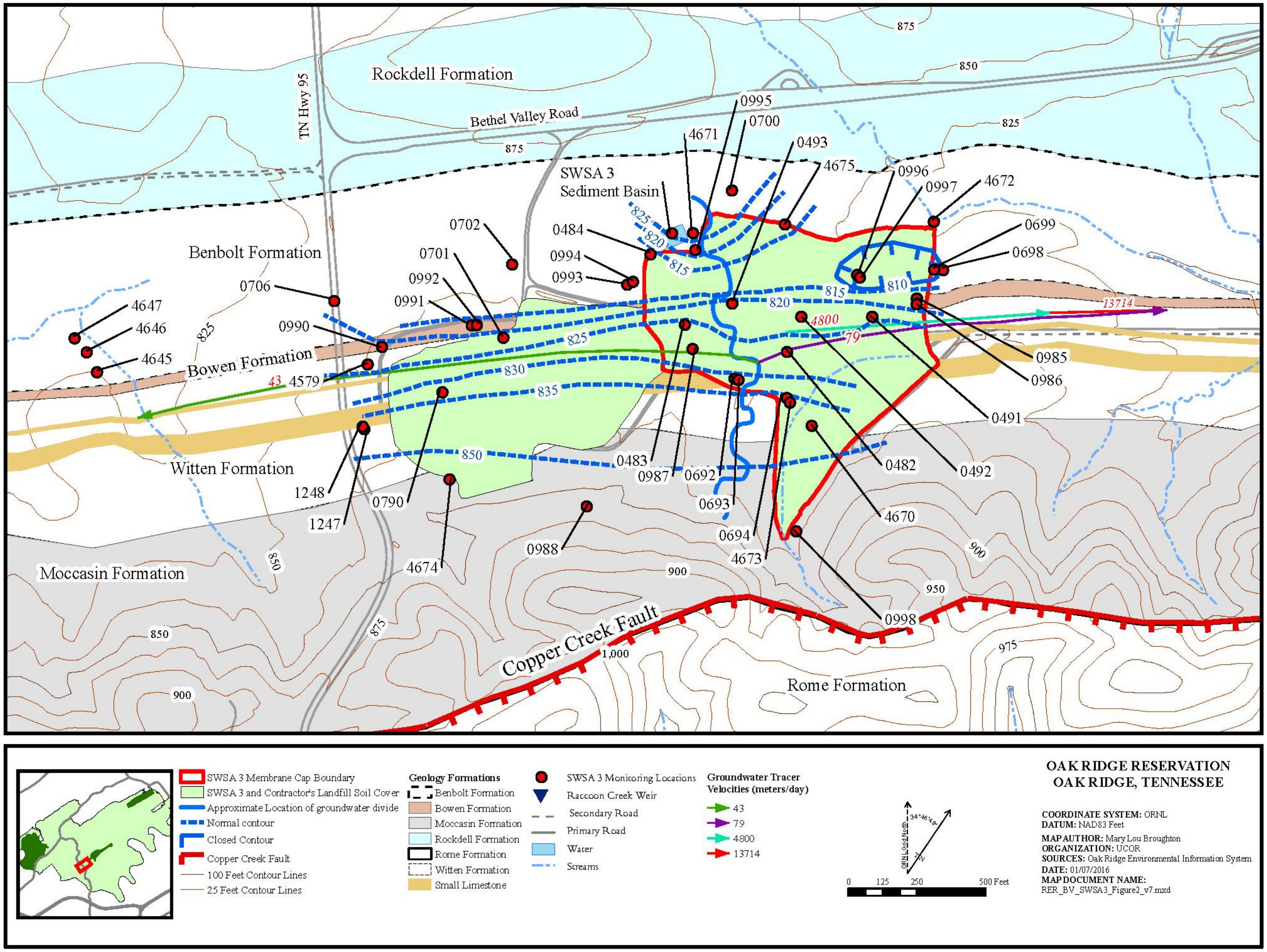

Figure 2.25. SWSA 3 area geology and piezometric surface map.

Groundwater analytical results from sampling rounds conducted during FY 2015 were screened against MCLs to determine locations where the criteria are exceeded. Figure 2.24 shows the approximate extent of groundwater contamination above MCLs in the vicinity of SWSA 3 and the Contractors Landfill (the light brown plume area) based on FY 2015 groundwater sampling and analysis. Table 2.12 lists contaminants detected in groundwater during FY 2015 at levels greater than MCLs. The table also includes trend evaluations for the contaminants based on the Mann-Kendall trend evaluation method. Based on the available data ^{90}Sr, which is the principal groundwater contaminant at SWSA 3, shows decreasing to stable or no trend activity behavior where it is detected at levels greater than the MCL-DC. The data show that an area of groundwater contaminated with ^{90}Sr occurs near the western edge of the SWSA 3 cap at well 0994. During FY 2015 the maximum ^{90}Sr activity in well 0994 was 126 pCi/L, which is about one-fifth the value of pre-remediation levels. Well 0994 is an 80.5 ft deep bedrock well with open-hole construction in the 59.1 – 80.5 ft interval below original ground surface. The open hole portion of this well intersects the lowermost Witten formation and the upper half of the Bowen Formation. This interval was found to be prone to conduit formation along the bedding contacts between the contrasting limestone and siliceous siltstones during investigations conducted in the 1980's (Steuber et al., 1981). These conduits provide preferential groundwater flow pathways predominantly along geologic strike. Well 0993, which is a shallower (45 ft deep) well adjacent to well 0994, had ^{90}Sr activities of 16.3 and 28.9 pCi/L in samples collected in November 2014 and May 2015. The overall trend in this well remains decreasing. Benzene is detected in groundwater samples from multi-zone well 4579 zones 1 and 2 (depth 152 and 80 ft bgs, respectively). Toluene and xylene are also detected in these samples, which suggests the compounds are likely related to petroleum hydrocarbons rather than chemical solvents. Whether these are related to naturally occurring petroleum compounds in the area bedrock or represent fuel type contamination is not known. In Table 2.12, an increasing trend is shown for benzene in well 4579-02. This trend is indicated when the initial post-remediation result is included, however, if that result is excluded from the trend evaluation, the benzene trend is stable.

Wells 4645, 4646, and 4647 that were installed in 2010 to monitor groundwater in the Raccoon Creek headwater did not contain contaminants above drinking water criteria in 2015. Lower detection limits in FY 2015 allowed detection of very low concentrations of ^{90}Sr in groundwater and surface water. In past years, ^{90}Sr has been consistently detected in well 4647, the shallowest of the Raccoon Creek headwater area exit pathway wells, at levels less than the 8 pCi/L drinking water MCL-DC. That well samples groundwater near the known contaminated seep that discharges into Raccoon Creek. During FY 2015, ^{90}Sr was detected at 2.16 pCi/L in December and 1.04 pCi/L in June. During June 2015, ^{90}Sr was detected in well 4646 at 0.527 pCi/L. Strontium-90 was not detected in well 4645 during FY 2015.

Bearden Creek Exit Pathway

Groundwater monitoring data from wells 1198 and 1199 that are located southwest of Building 7025 (the former Tritium Target Facility) have exhibited detectable tritium concentrations since 1991 (Figure 2.5). Both wells monitor groundwater in bedrock, with well 1198 being a shallower well, screened from about 28 – 43 ft bgs, and well 1199 being a deeper well, screened from about 53 to 73 ft bgs. Tritium concentrations in these wells have decreased steadily since the inception of monitoring when peak tritium activities of about 8,000 pCi/L were measured in well 1199 and about 15,000 pCi/L in well 1198. During FY 2015, tritium was detected in well 1198 at levels less than 300 pCi/L in samples collected in January and July. In well 1199, tritium activity was measured at 1,090 pCi/L in January and 1,100 pCi/L in July. Analyses for VOCs have been conducted throughout the monitoring history at both wells. VOCs have occasionally been detected in well 1199. No VOC compounds were detected in either well in the two FY 2015 sampling events.

Table 2.12. Summary of FY 2015 SWSA 3 groundwater MCL exceedances and related contaminant trends

Well	Anal. Type	Analyte	All Data			MCL	Units	Pre-Remediation FY 09 – 11		Post-remediation FY 12 – 15		FY 15 Max	M-K Trend Analysis	Notes
			No. of analyses	No. of detects	Results >MCL			No. of detects	Average	No. of detects	Average			
0992	RAD	Beta Activity[a]	17	17	11	50	pCi/L	10	**142**	5	**52.1**	44.6	Stable	
0992	RAD	^{90}Sr[b]	17	17	17	8	pCi/L	10	**66.9**	5	**24.96**	**19.8**	Stable	
0993	RAD	Beta Activity	17	17	9	50	pCi/L	10	**365.3**	7	**41.9**	**61.3**		
0993	RAD	^{90}Sr	17	17	17	8	pCi/L	10	**167**	7	**19.9**	**28.9**	Decreasing	
0994	RAD	Beta Activity	22	22	21	50	pCi/L	15	**1,330**	7	**404**	**354**	Decreasing	
0994	RAD	^{90}Sr	20	20	20	8	pCi/L	13	**655**	5	**186**	**150**	Decreasing	
0995	RAD	^{90}Sr	15	8	1	8	pCi/L	6	2.6	2	**102.8**	**200**	No Trend	
0997	RAD	^{90}Sr	18	18	15	8	pCi/L	11	**40.1**	7	**8.53**	**10.3**	Decreasing	
4579-01	VOA	Benzene	18	18	18	5	µg/L	7	**9.49**	11	**7.69**	**9.1**	Decreasing	
4579-01	RAD	Beta Activity	27	13	3	50	pCi/L	9	**60.74**	4	32.39	42.2	Stable	Only first result >MCL
4579-01	RAD	^{90}Sr	28	10	4	8	pCi/L	6	**34.3**	4	**9.89**	**13.2**	Decreasing	Former Stable trend
4579-02	VOA	Benzene	18	17	11	5	µg/L	6	**5.53**	11	**6.0**	**6.5**	**Increasing**/ Stable	Increase caused by very low initial value. Trend stable if initial result is excluded
4579-02	RAD	^{90}Sr	28	9	2	8	pCi/L	6	**14.75**	3	**11.55**	1.61	Decreasing	Mostly <MDA; first result >MDA
4579-03	RAD	Alpha Activity	27	5	1	15	pCi/L	4	4.83	1	**16.2**	**16.2**	Stable	All <MDA except for one outlier
4579-03	RAD	^{90}Sr	28	26	9	8	pCi/L	16	**8.71**	10	7.47	6.91	Stable	
RACNW EIR[c]	RAD	^{90}Sr	85	14	6	8	pCi/L	22	**9.0**	36	**3.94**	3.46	Stable	

Notes: Average concentration calculated using only detected results.
Bold table entries indicate results that exceed MCL values.

Table 2.12. Summary of FY 2015 SWSA 3 groundwater MCL exceedances and related contaminant trends (cont.)

Quantitative trend analysis based on M-K Test of time-series sampling/analysis results for a maximum of ten sampling events (counting backward from the most recent sampling date). Based on the methodology described in Gilbert (1987) and Wiedemeier et al., 1999, non-detect analytical results, which were reported for wells 4579-01 (beta and ^{90}Sr) and 4579-02 (benzene and ^{90}Sr), were replaced with the appropriate detection limit or MDA as surrogate values for M-K Test purposes. The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. The time series data define a *Stable* trend if the S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, whereas *No Trend* is evident if the CV is >1.

[a]50 pCi/L is the value used to trigger analyses to determine beta emitting radionuclides present in public water supplies (65 FR 76708 – 76753).
[b]8 pCi/L is the MCL-DC listed in 40 CFR 141.66(d)(2), Table A, as the "Average Annual Concentration Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr," which is the MCL for beta particle and photon radioactivity.
[c]RACNWEIR data based on monthly flow-paced composite samples.

CFR = *Code of Federal Regulations*
CV = coefficient of variation
FR = Federal Register
FY = fiscal year
Max = maximum value
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
MDA = minimum detectable activity
M-K = Mann-Kendall
RACNWEIR = Raccoon Creek Weir
RAD = radionuclide
SWSA = Solid Waste Storage Area
VOA = volatile organic analyses

2.2.1.2.3 Aquatic Biological Monitoring in WOC

Biological monitoring data are available for several locations in Bethel Valley, including a location in WOC near the watershed's exit point (Figure 2.26). This information is useful in evaluating watershed trends and the effectiveness of watershed-scale decisions defined in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4). Biological monitoring data for the WOC watershed includes contaminant accumulation in fish, fish community surveys, and benthic macroinvertebrate surveys.

Mercury concentrations in fish collected from all stream sections of WOC decreased in 2015, remaining below the EPA recommended fish-based mercury AWQC of 0.3 µg/g (Figure 2.27). The overall downward trend in mercury concentrations in fish in this stream from 2007 – 2015 is likely due to the decreases in aqueous mercury concentrations seen as a result of the *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion at the Oak Ridge National Laboratory* (DOE/OR/01-2472&D1) in 2008. Mercury concentrations in fish collected from White Oak Lake (WOL), however, have fluctuated significantly during the same time period. From 2008 – 2012, average concentrations in both bluegill and largemouth bass increased, reaching their highest mean concentrations on record in 2012. Since 2012, however, concentrations in bass and bluegill collected in WOL have been decreasing, averaging 0.36 µg/g and 0.08 µg/g, respectively, in 2015 (Figure 2.27).

The ORNL's Water Quality Protection Program continues to investigate the sources of polychlorinated biphenyls (PCBs) to WOC. Studies conducted in 2009 – 2010 identified First Creek as a major source of PCBs to WOC, and follow up work from 2011 – 2015 has pinpointed specific pipes and outfalls leading to First Creek (e.g., Outfall 341, Outfall 250) as significant contributors of PCBs to the WOC watershed. Mean total PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in redbreast sunfish from the WOC watershed remained within historical ranges, with mean concentrations of 0.27 $\pm$ 0.02 µg/g at White Oak Creek kilometer (WCK) 3.9, 0.43 $\pm$ 0.04 µg/g at WCK 2.9, and 0.26 $\pm$ 0.04 µg/g at WCK 2.3 (compared to 0.46 µg/g at WCK 3.9, 0.19 µg/g at WCK 2.9, and 0.37 µg/g in 2014) (Figure 2.28). Mean PCB concentrations in largemouth bass collected from WCK 1.5 (1.31 µg/g) increased slightly in 2015, but remained comparable to those seen in 2014 (1.13 µg/g; Figure 2.28), and mean concentrations in bluegill remained comparable to those seen in previous years (0.53 µg/g; Figure 2.28).

Evaluations of PCB concentrations in fish must carefully consider the species of fish sampled and the assumptions used in any risk analyses. PCBs in sunfish, for example, provide a meaningful evaluation of spatial and temporal trends, but may not represent the maximum PCB concentrations relevant to human or wildlife risk (largemouth bass and catfish for example are typically larger, older, and fattier). Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused Total Maximum Daily Loads (TMDLs), including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the state of Tennessee, assessments of impairment for water body segments, as well as public fishing advisories, are based on fish tissue concentrations. Historically, the Food and Drug Administration (FDA) threshold limit of 2 µg/g in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. Most recently, the water quality criterion (0.00064 µg/L for total PCBs) has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2007) under its TMDL Program, and this concentration is 0.02 mg/kg in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in the WOC watershed are still well above the calculated TMDL concentration.

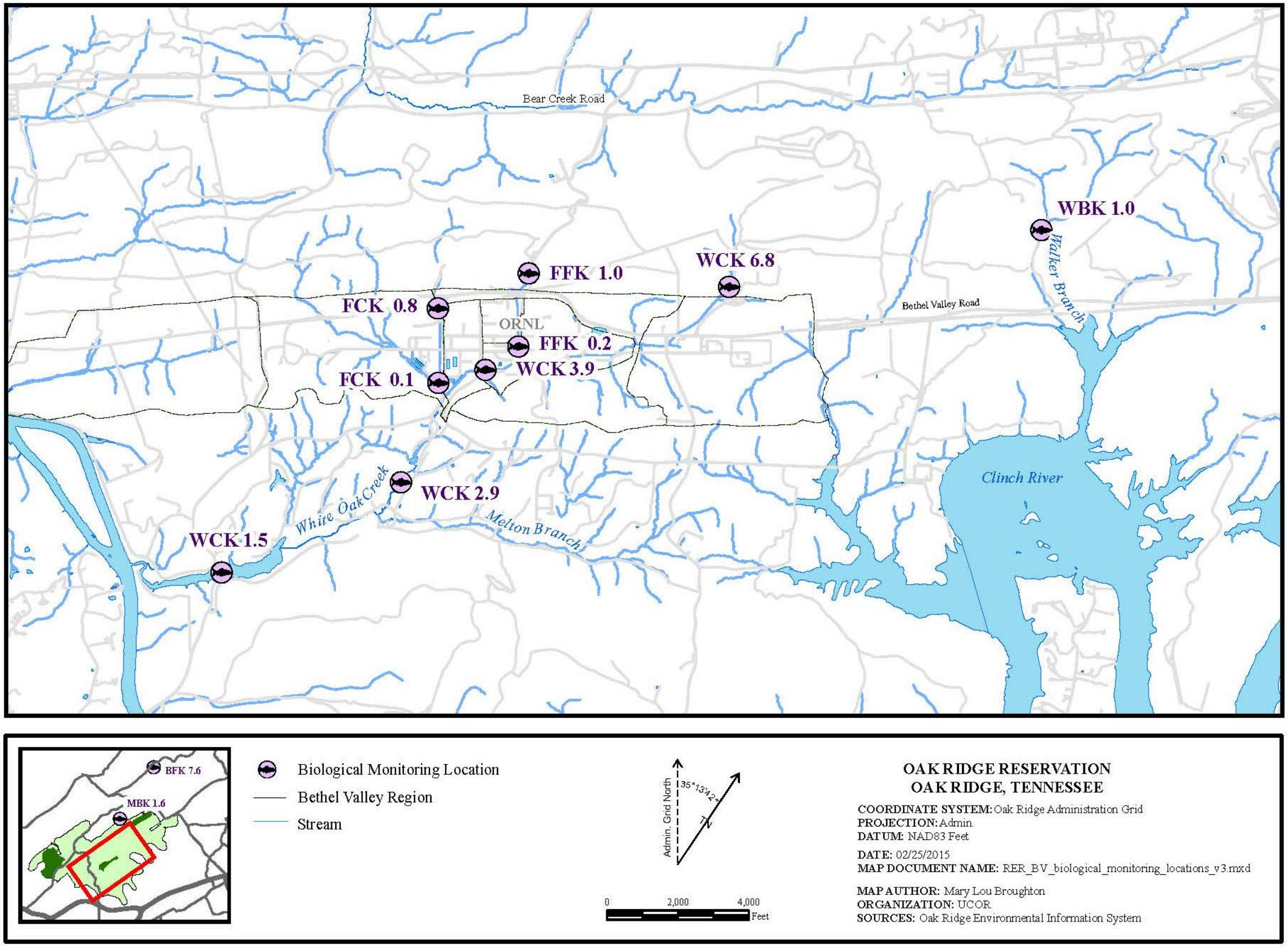

Figure 2.26. Biological monitoring locations at the ORNL.

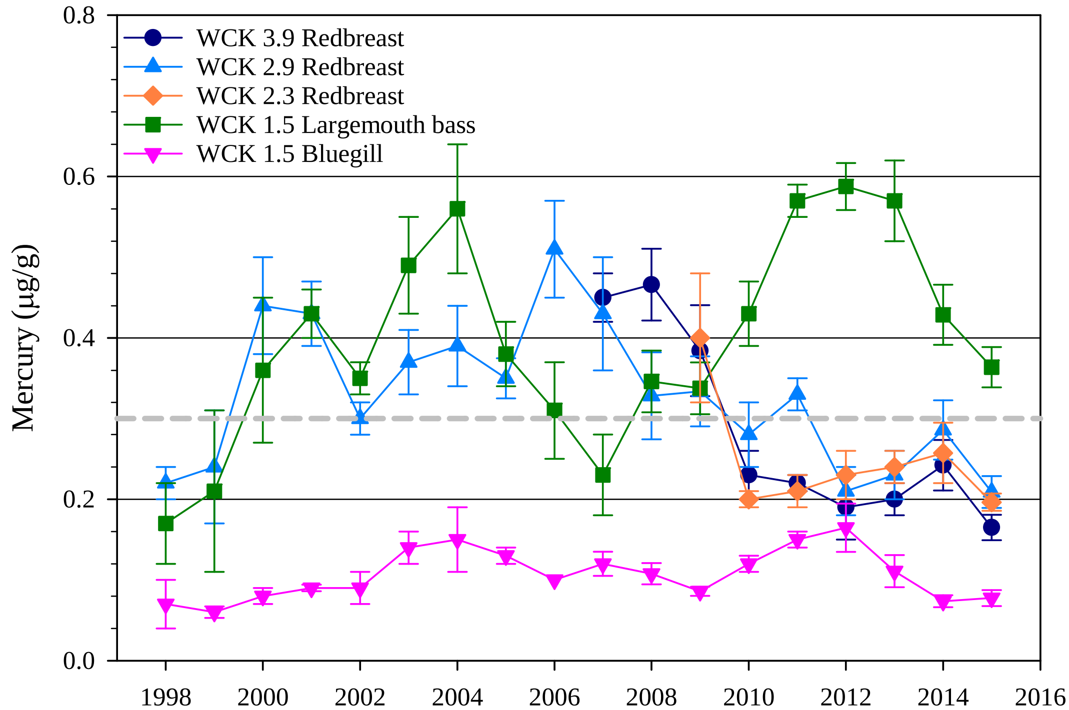

Figure 2.27. Mean concentrations of mercury (µg/g, ± SE, N = 6) in muscle tissue of sunfish and bass from WOC (WCK 2.9 and WCK 3.9) and WOL (WCK 1.5), 1998 – 2015.

Dashed gray line indicates EPA's recommended AWQC (0.3 µg/g mercury in fish fillet).

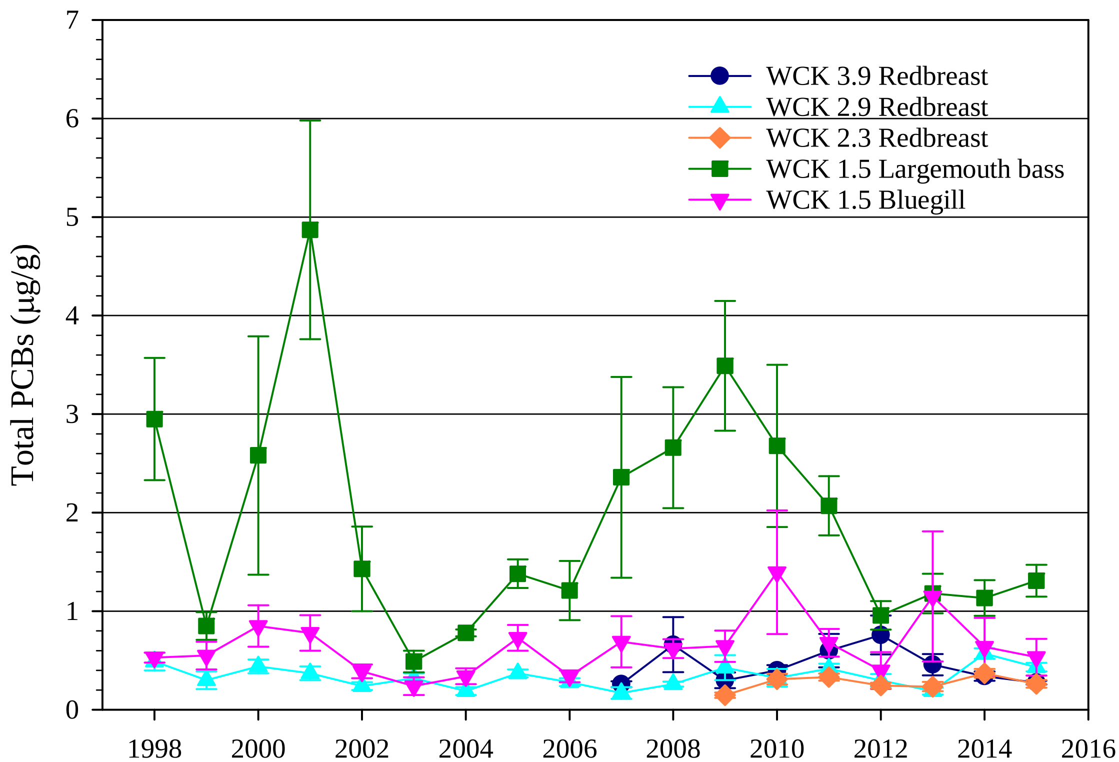

Figure 2.28. PCB concentrations (µg/g, ± SE, N = 6) in fish fillet collected from the WOC watershed, 1998 – 2015.

Fish and benthic communities in WOC are negatively impacted relative to local reference sites, although improvements have occurred since the mid-1980s. The fish communities in WOC have been fairly stable in terms of overall numbers of species in recent samples, with numbers of fish species being well below the larger Brushy Fork reference site (Brushy Fork kilometer [BFK] 7.6). The number of species at WCK 3.9 tends to be similar to or greater than the number of fish species found at the smaller Mill Branch reference site (Mill Branch kilometer [MBK] 1.6), while species numbers at the most upstream WOC site (WCK 6.8) still remain fairly low (Figure 2.29). Nutrient availability in smaller headwater systems can be a limiting factor for both species richness and also density. Additionally, these sites have had developmental and industrial impacts which, coupled with numerous fish passage barriers in the watershed, are likely causes contributing to low diversity. Recent introductions of native fish species into WOC watershed have been successful with continuing reproduction observed in five of the six introduced species and expanded distributions for three species. These expansions have included lower tributary sites such as First Creek and even above potential fish passage barriers into upper WOC. The introduced species fill in missing groups of fish, including sensitive species such as darters and suckers, and are helping the overall richness of the fish fauna in WOC become more comparable with area reference streams. Samples collected in 2015 at WCK 3.9 included two darter species and high densities of striped shiners, all of which are introduced species. The fish introductions are a management tool to compensate for the isolation of WOC watershed by dams and weirs that prevent natural upstream fish passage, with fish being placed in the WOC watershed beginning in 2008 – 2012, and 2014.

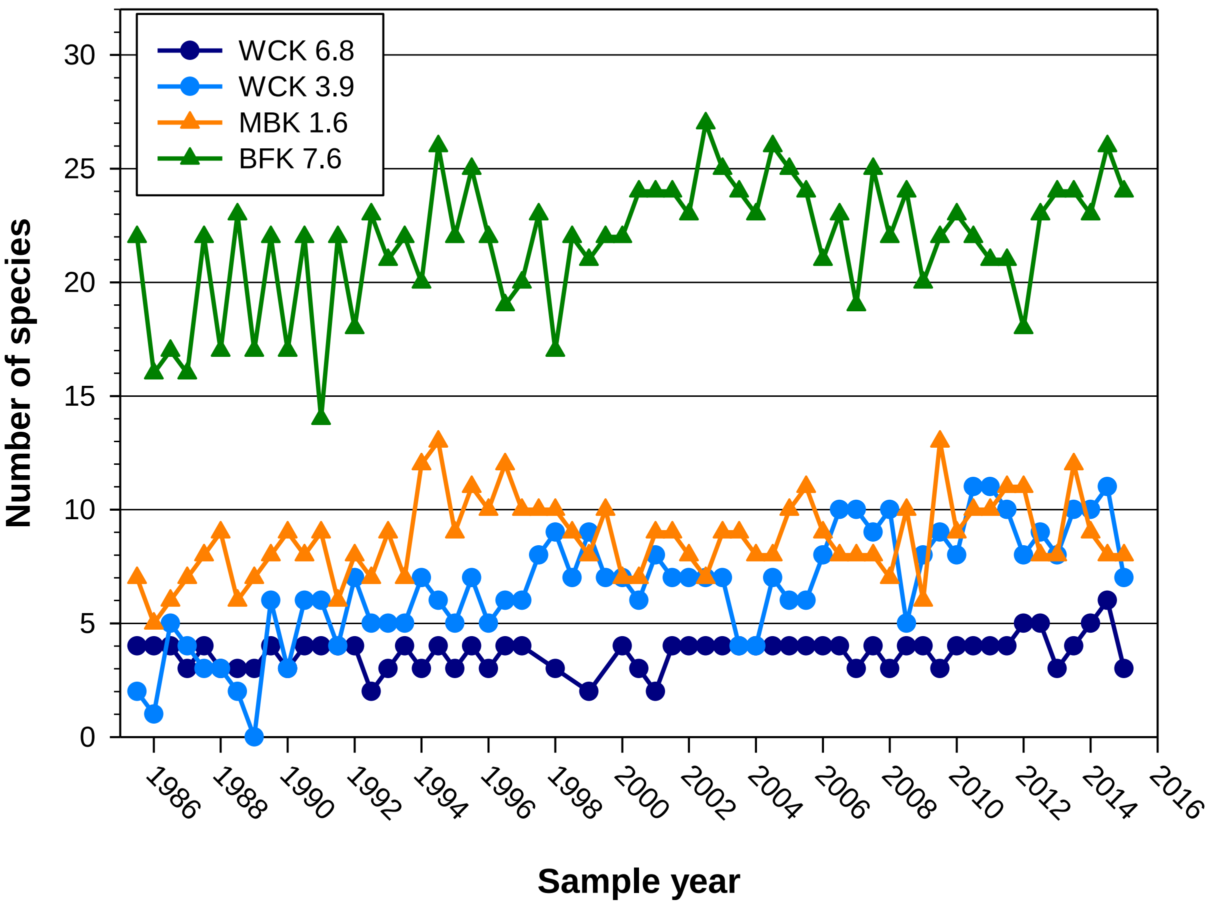

Figure 2.29. Species richness (number of species) in samples of the fish community in upper WOC and reference streams, BFK and MBK, 1985 – 2015.

Fish density is often a better indicator of stream impacts in small tributaries which generally lack species diversity. The two small second order tributaries that flow through the main ORNL facility into WOC (First Creek and Fifth Creek) have improved since 1985. First Creek has had historical impacts associated with development activities but has stabilized in recent years (Figure 2.30). Moderate increases in density at the lower site since 2011 are correlated with increased diversity associated with fish introduction efforts mentioned above. Fish densities in Fifth Creek are much more variable and reflect a stream that has likely been stressed by chronic chlorine inputs which exacerbated seasonal impacts such as drought or flooding (Figure 2.31).

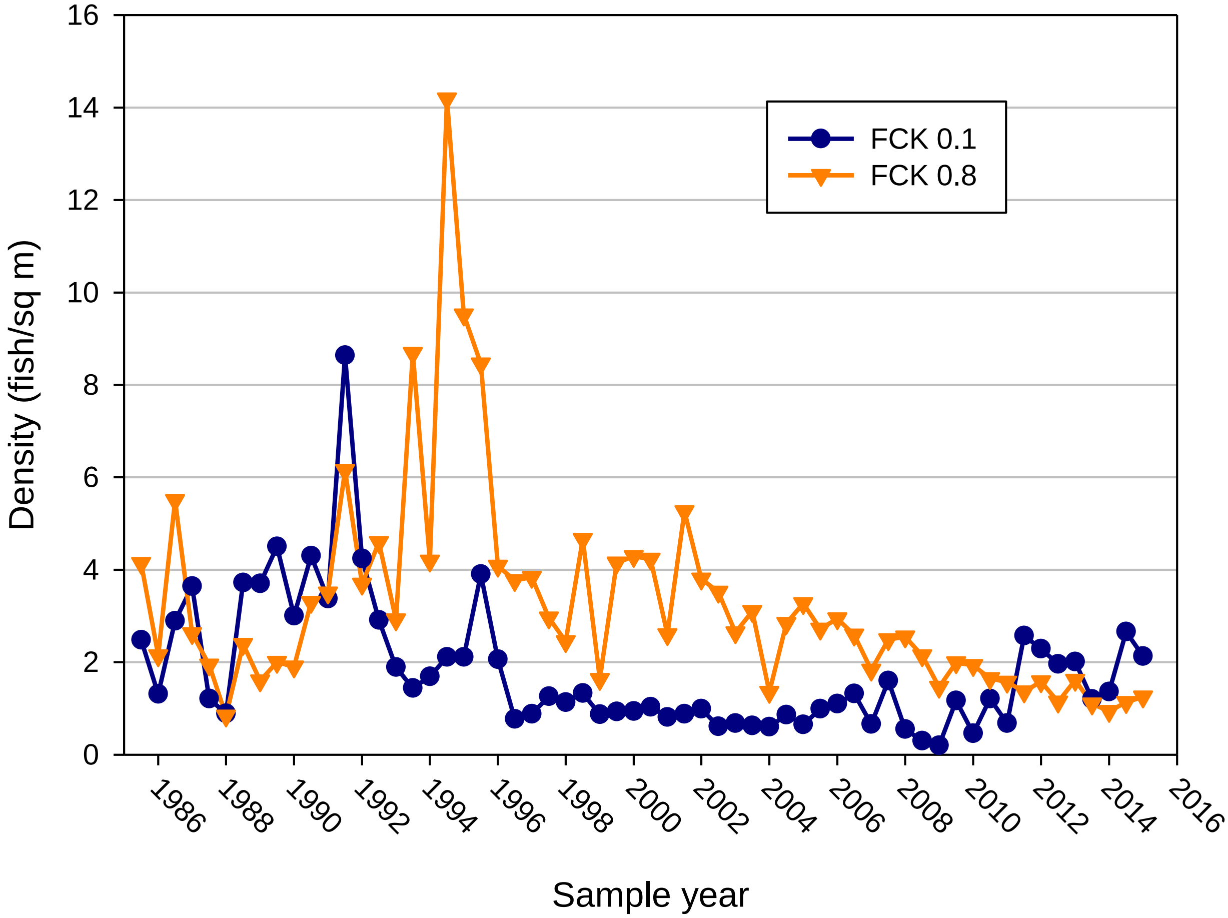

Figure 2.30. Fish density (fish/m^2) in samples of the fish community in First Creek, 1985 – 2015.

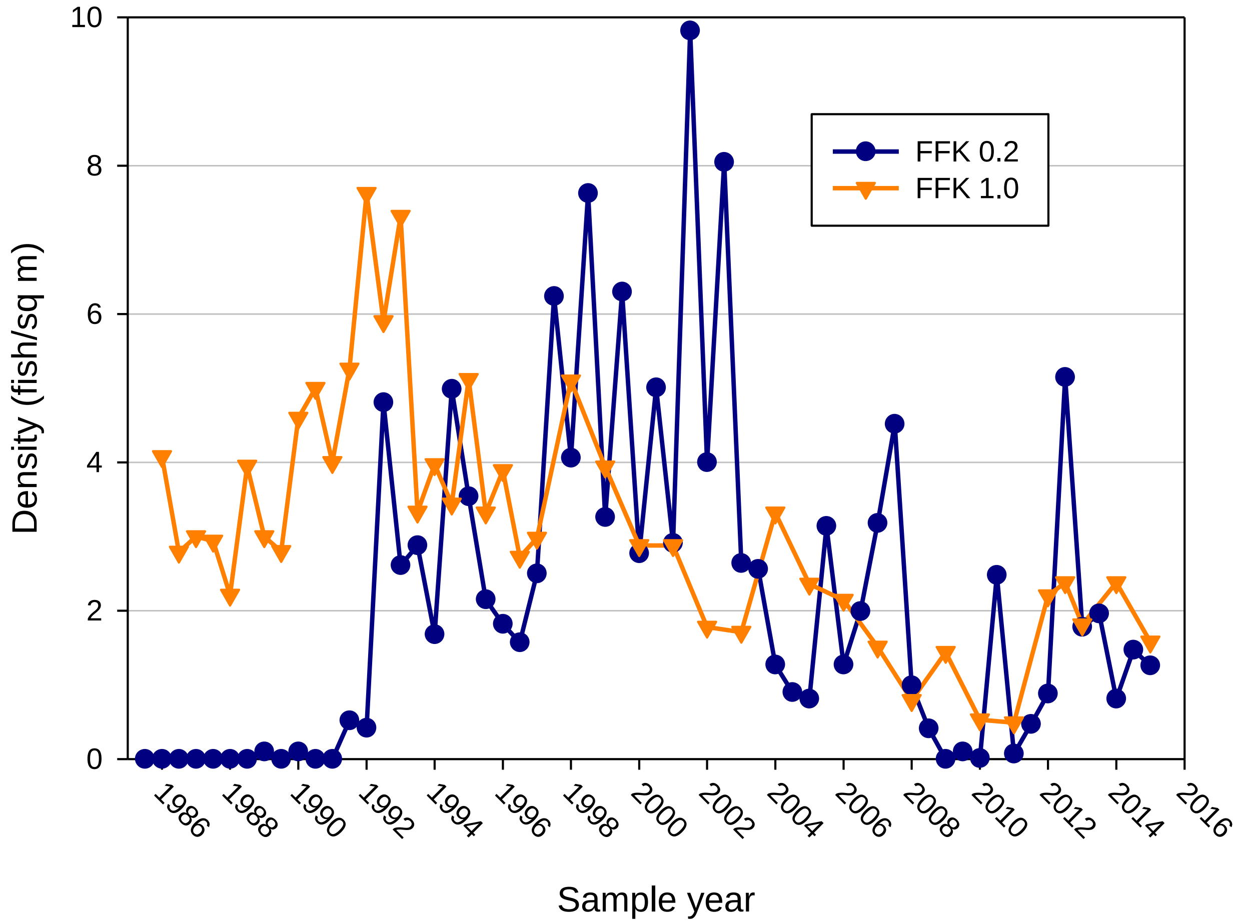

Figure 2.31. Fish density (fish/m²) in samples of the fish community in Fifth Creek, 1985 – 2015.

The species richness of the pollution intolerant benthic macroinvertebrate taxa (Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa) at WCK 3.9 in WOC has improved substantially since 1987 (Figure 2.32). However, the overall trend in EPT taxa richness since 2002 continues to suggest that the community at that site has stabilized and no further recovery has occurred. Results for WCK 6.8 in 2014, downstream of most SNS outfalls to WOC, continued to indicate that conditions at that site are comparable to those at the Walker Branch kilometer 1.0 reference site (Figure 2.32). Like WCK 3.9, the condition of the benthic macroinvertebrate community in lower Fifth Creek at Fifth Creek kilometer (FFK) 0.2 has improved considerably since 1987, but unlike WCK 3.9, the number of pollution intolerant EPT taxa at FFK 0.2 remains much lower relative to its reference site (Figure 2.33). In contrast to WCK 3.9 and FFK 0.2, the number of pollution intolerant taxa at First Creek kilometer (FCK) 0.1 has decreased annually since 2012 (Figure 2.34). Whereas the EPT richness estimates for FCK 0.1 in 2012 and 2013 were within the range observed from 1995 through 2001, the number of pollution intolerant taxa in 2014 was below that range. It was noted in WOC watershed in 2014 that the substrate in riffles had shifted considerably at all but reference sites due to heavy rains in late winter and early spring; these shifts may have had a temporary negative effect on the invertebrate community at some sites.

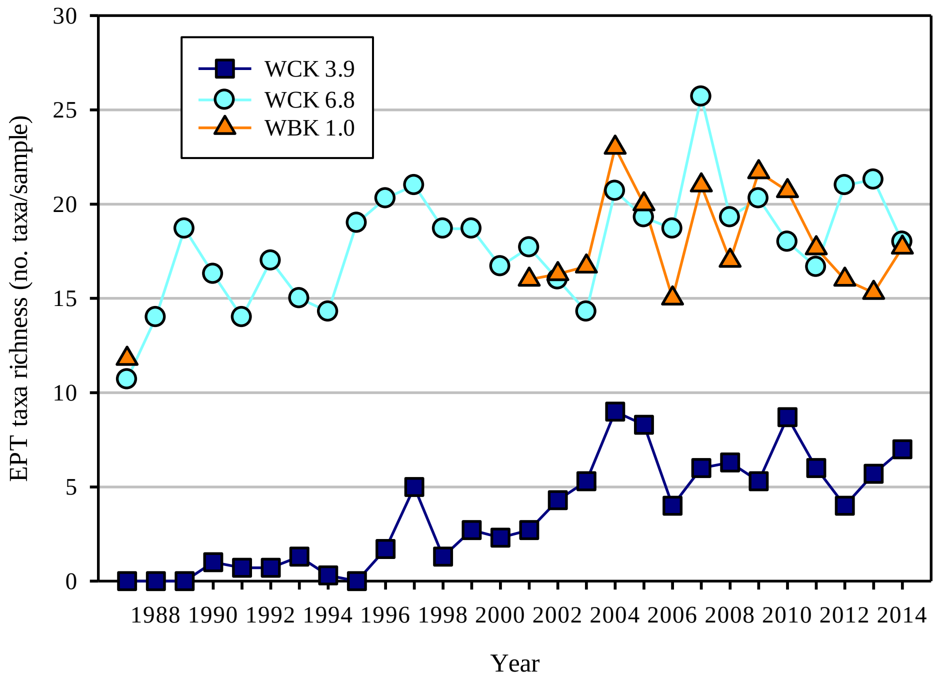

Figure 2.32. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in upper WOC and Walker Branch, April sampling periods, 1987 – 2014.[a,b]

[a]WBK = Walker Branch kilometer. WCK = White Oak Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.
[b]Samples collected in 2015 have not yet been processed. Data were not available for Walker Branch from 1988 – 2000.

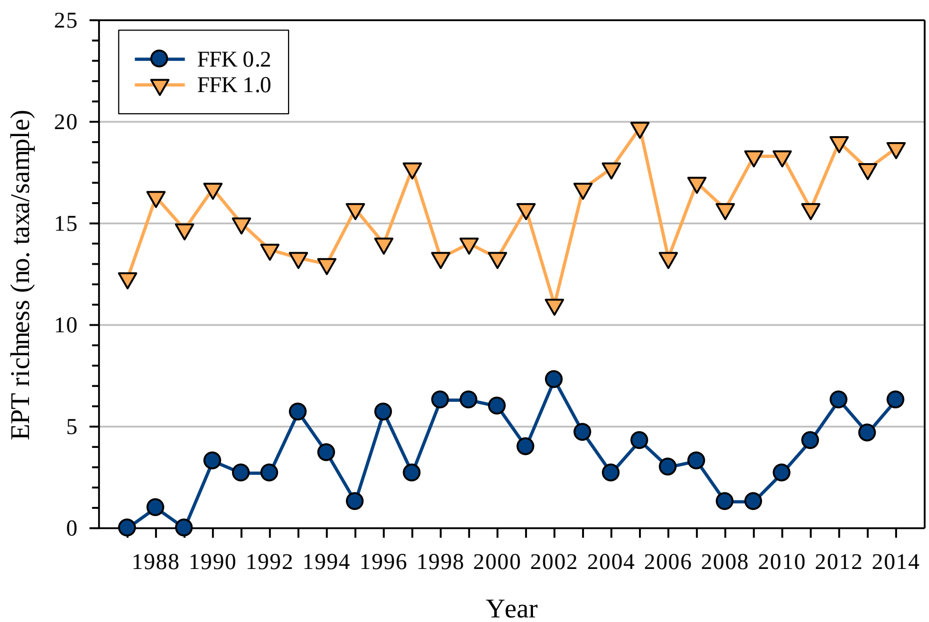

Figure 2.33. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in Fifth Creek, April sampling periods, 1987 – 2014.[a,b]

[a]FFK = Fifth Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.
[b]Samples collected in 2015 have not yet been processed.

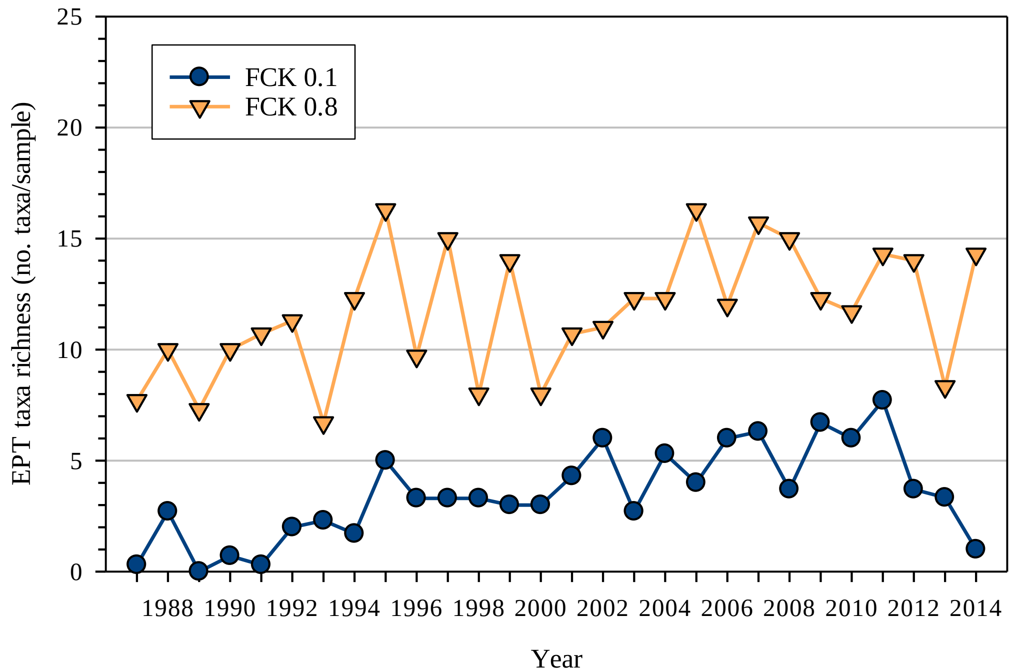

Figure 2.34. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in First Creek, April sampling periods, 1987 – 2014.[a,b]

[a]FCK = First Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.
[b]Samples collected in 2015 have not yet been processed.

2.2.1.3 Performance Summary

Following is a summary of the FY 2015 Bethel Valley watershed performance monitoring:

- Strontium-90 and ^{137}Cs concentrations at the Bethel Valley watershed integration point (7500 Bridge) met their risk reduction goals. The Corehole 8 Extraction System met its performance goal based on ^{90}Sr flux reduction at First Creek during FY 2015, which contributed to the risk reduction goal for ^{90}Sr being met downstream at the 7500 Bridge.

- Surface water discharges of ^{90}Sr in Northwest Tributary and Raccoon Creek have decreased significantly as a result of hydrologic isolation of shallow buried waste at SWSA 3 and the Contractor's Landfill. Comparison of SWSA 3 area pre-remediation to FY 2015 groundwater contaminant concentrations shows that levels are decreasing or stable. Although three of nine wells have not yet attained design target groundwater levels, the groundwater level fluctuations within the waste depth zone in the hydrologic isolation area show that direct infiltration of rainwater into buried waste has been controlled.

- Mercury concentrations at the Bethel Valley watershed integration point (7500 Bridge) continue to meet the AWQC of 51 ng/L. CERCLA actions at Building 4501 to re-route and pre-treat mercury contaminated building sump water are shown to be effective at reducing mercury concentrations in the receiving reach of WOC. Mercury concentrations measured at WOC-105, located a short distance downstream from the former storm drain (SD) discharge from Building 4501, were less than the AWQC level in FY 2015 samples.

- Wells 4645, 4646, and 4647 monitor groundwater in the Raccoon Creek headwater area. These exit pathway wells did not contain contaminants above drinking water criteria in FY 2015. Strontium-90 was detected at low levels in well 4647, the shallowest of these wells, in both semi-annual samples, and in well 4646 in one sample. The maximum detected level was detected in well 4647 and was approximately 25% of the MCL-DC of 8 pCi/L. Well 4647 samples groundwater near the known contaminated seep that discharges into Raccoon Creek. Strontium-90 was not detected in well 4645 during FY 2015.

- The observed improvement in fish mercury concentrations to levels below the EPA-recommended fish-based AWQC for mercury continued in WOC. Biological monitoring of the Bethel Valley watershed indicates moderate ecological recovery since 1987. Invertebrate community monitoring shows there is little evidence of improvement since 2002. Recent introductions of new fish species, however, have been partially successful.

2.2.2 Other LTS Requirements

Other LTS requirements for Bethel Valley watershed actions are listed in Table 2.13 and described below.

2.2.2.1 Requirements

Watershed-scale Requirements

The *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) includes interim LUCs to protect against unacceptable exposures to contamination during and after remediation. These interim LUCs will remain in effect until permanent LUCs are established in a future, final remedial decision. Objectives of the interim LUCs are below and shown in Figure 2.2:

- Groundwater use. Until a final groundwater decision is made, groundwater use restrictions are required in contaminated areas.

- Controlled industrial area. Restrict excavations or penetrations deeper than 0.6 m (2 ft) and prevent uses of the land more intrusive than industrial above 0.6 m (2 ft).

- Unrestricted industrial area. No restrictions on excavations or penetrations shallower than 3 m (10 ft) and prevent uses of the land more intrusive than industrial deeper than 3 m (10 ft).

- Recreational area (as applied to the SWSA 3 Burial Ground and the Contractor's Landfill). Restrict recreational activity to passive surface use of disposal areas; prevent unauthorized contact, removal, or excavation of waste material; prevent unauthorized destruction or modification of engineered controls; and preclude use of the areas for additional future waste disposals or alternate uses inconsistent with the management of currently disposed waste.

- Unrestricted areas. None required.

Building 4501 Mercury Treatment System Requirements

The LTS requirement specified in the *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion* (DOE/OR/01-2472&D1) is maintenance of the mercury pretreatment system in Building 4501, which began operation on October 23, 2009. Specifically, this requires maintenance of the pump, replacement of the cartridge prefilter, as needed, replacement of the ion exchange resin annually, and collection of system performance and operational data.

Corehole 8 Plume Extraction System Requirements

The *Phased Construction Completion Report for the Bethel Valley (Corehole 8) Extraction System* (DOE/OR/01-2534&D1) includes the following LTS requirements−operations and maintenance of the extraction system, routine walkdowns of the system to determine if the indicator lights are in the correct position, annual pressure testing of the line, and visual inspections of the indicator lights on the arrestors following severe thunderstorms. Operational reliability is tracked through monthly status reporting by the facility manager. Significant system outages will be reported to DOE for concurrence on implementation of actions deemed necessary to restore reliable operation.

LUC requirements at the Corehole 8 plume extraction system site are consistent with the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) designated land use of "Controlled Industrial." The LUC objective for this area is to prevent unauthorized access to restricted areas or any use of groundwater (except for the purpose of monitoring, testing, or treatment of groundwater); control excavation or penetrations below 2 ft or depths below the groundwater table; prevent unauthorized access; protect industrial workers; and preclude uses of the area that are inconsistent with the current industrial uses.

Table 2.13. Other LTS requirements for the Bethel Valley watershed

Type of control	Affected areas	Purposes of control	Duration	Implementation	Frequency/ Implementation
Other LTS requirements for LUCs[a] – Watershed-scale requirements					
***Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4)**					
1. Property Record Restrictions[b] *A. Land use* *B. Groundwater*	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions*	*Restrict use of property by imposing limitations* *Prohibit uses of groundwater*	*Indefinitely*	*Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office*	*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)*
2. Property Record Notices[c]	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions*	*Provide notice to anyone searching records about the existence and location of contaminated areas*	*Indefinitely*	*Notice recorded by DOE in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD; 2) upon transfer of affected areas; 3) upon completion of all remedial actions*	*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)*
3. Zoning Notices[d]	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions*	*Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes*	*Indefinitely*	*Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after signing of the ROD; final Zoning Notice and survey plat filed with City Planning Commission upon completion of all remedial actions*	*DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission*
4. Excavation/Penetration Permit Program[e]	*Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions*	*Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity*	*As long as property remains under DOE control*	• *Implemented by DOE and its contractors* • *Initiated by permit request*	*DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedures*

Table 2.13. Other LTS requirements for the Bethel Valley watershed (cont.)

Type of control	Affected areas	Purposes of control	Duration	Implementation	Frequency/ Implementation
Other LTS requirements for LUCs[a] – Watershed-scale requirements					
5. Access Controls[f] (e.g., fences, gates, and portals)	*Specific locations will, if necessary, be determined by each remediation project*	*Control and restrict access to workers and the public to prevent unauthorized uses*	*Indefinitely*	*Controls maintained by DOE*	*DOE official (or its contractors) will conduct field survey no less than annually of all controls to assess condition (i.e., remain erect, intact, and functioning)*
6. Signs[g]	*At select locations throughout Bethel Valley*	*Provide notice or warning to prevent unauthorized access*	*Indefinitely*	*Signage maintained by DOE*	*DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)*
7. Surveillance Patrols	*Patrol of selected areas throughout Bethel Valley, as necessary*	*Control and monitor access by workers/public*	*Indefinitely*	• *Established and maintained by DOE* • *Necessity of patrols evaluated upon completion of remedial actions*	*DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted*

Other LTS requirements for Specific Areas

Areas	Project Documents	Other LTS Requirements	Frequency/ Implementation
***Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4)**			
Bethel Valley Mercury Sumps	Bethel Valley Mercury Sumps PCCR (DOE/OR/01-2472&D1)	• The ORNL Building 4501 Facility Manager will be responsible for operation and maintenance of the system, including pump maintenance and replacement of the cartridge prefilter as needed. • Anticipated that the ion exchange resin will require annual replacement.	Monitor annually to ensure it is functioning properly
Corehole 8 Extraction System	Corehole 8 Extraction Wells PCCR (DOE/OR/01-2534&D1)	• DOE and its contractor will maintain continual operation of the Corehole 8 extraction system. • When a warning light that a pump has stopped functioning is illuminated in the Waste	Annual monitoring for each LUC following

Table 2.13. Other LTS requirements for the Bethel Valley watershed (cont.)

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/ Implementation**
		Operations Control Center, maintenance workers will go to the source of the problem/failure and evaluate the nature of the problem. • Mandatory that annual pressure tests be conducted on each pipeline in this plume collection system. • In the event a line fails its annual pressure test, that portion of the collection system will be taken out of service pending leak diagnostics and repair. • A second routine service requirement is the servicing of lightning arrestors at electrical power poles 7 and 18. Following severe thunderstorm activities the indicator lights on the arrestors require visual inspection to determine when replacement becomes necessary. • Additionally, the maintenance subcontractor will perform routine walkdowns of the system to determine if the indicator lights are in the correct position in the field. If there is a failure of a component in the system, the operator will contact the UCOR facility manager to report the problem. • The LUC objectives for Corehole 8 designated “controlled industrial” established by Bethel Valley ROD are: – prevent unauthorized access to restricted areas or any use of groundwater (except for the purpose of monitoring, testing, or treatment of groundwater); – control excavation or penetrations below 2 ft or depths below the groundwater table; – protect industrial workers; and – preclude uses of the area that are inconsistent with the current industrial uses	implementation Annual verification that each LUC continues to be effectively implemented
BVBGs: • SWSA 1 • Former Waste Pile Area • Nonradioactive Wastewater Treatment Plant Debris Pile • SWSA 3 • Contractor’s Landfill	BVBGs PCCR (DOE/OR/01-2533&D2)	Long-term S&M actions will be conducted to control erosion, cap or cover settlement, run-on and run-off control system, trench drains, prevent rodent infestation, and control vegetative covers to prevent tree growth • Long-term S&M will also include maintenance of monitoring wells and survey benchmarks • If cap or cover damage is observed, the RDR/RAWP Appendix D should be consulted for detailed methods of determining the extent of damage to geosynthetic layers in the cap, and should be used to plan and implement repairs or maintenance at these sites • Vegetation is to be mowed (e.g., with a bush-hog) once per year to prevent growth of deep-rooted woody species • Semiannual inspections of: – Erosion damage and run-on/run-off drainage systems (and inspect following any rainfall of 25 yr, 24 hr intensity or equivalent) – Vegetative cover – Cover settlement, subsidence (and inspect after seismic events greater than 4.0 on the	Site visits for inspections and physical controls will be no less than annually Annual RER to describe any necessary maintenance performed during the year, identify any breaches of the LUC objectives, and evaluate the status of the LUC objectives and

Table 2.13. Other LTS requirements for the Bethel Valley watershed (cont.)

Areas	Project Documents	Other LTS Requirements	Frequency/ Implementation
Other LTS requirements for Specific Areas			
		Richter scale) – Rodent control – Gas vents – Exterior condition of monitoring wells and piezometers – Survey benchmarks • Annual inspections of: – Interior condition of monitoring wells and piezometers – Cap and soil cover maintenance, road and signs maintenance • Inspection of weirs at surface water monitoring locations for clogging at each sampling event LUC objectives for the BVBGs are to prevent unauthorized access to restricted areas or use of groundwater; prevent unauthorized contact, removal, or excavation of waste left in place; protect maintenance workers; and preclude unauthorized uses of the area • Precluded uses include any additional material storage or waste disposal within the closed burial areas and any development or use of the property for residential, uncontrolled commercial/industrial, elementary and secondary schools, child care facilities and playgrounds • All seven Bethel Valley controls listed at the beginning of this table apply to the burial grounds	describe how any deficiencies have been addressed Every fifth year, reporting of information necessary to satisfy the requirements of the CERCLA FYR for the Reservation
Record of Decision for the Surface Impoundments Operable Unit, Oak Ridge National Laboratory, Oak Ridge, Tennessee **(DOE/OR/02-1630&D2)**			
Surface Impoundments Operable Units A and B	RAR for Impoundments A and B (DOE/OR/01-2086&D2)	• Excavation institutional controls will remain in place for potential residual subsurface contamination around the site	Monitor annually to ensure the permit program is functioning properly
Action Memorandum for the Demolition of the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee **(DOE/OR/01-1843&D2)**			
Metal Recovery Facility, Building 3505	RmAR for Metal Recovery Facility, Building 3505 (DOE/OR/01-2000&D2/R1)	• Though the surface areas have no radiological restrictions, the area is posted as an underground contamination area • The gravel area has no special maintenance needs beyond ensuring that the gravel cover is not grossly disturbed. In the event that the gravel cover is disturbed in a manner that might expose subsurface contamination, it will be repaired so as to restore the minimum 2 in. gravel protective cover over the epoxy barrier coating. • The site footprint has been included in the site database for periodic inspection to ensure that the residual subsurface contamination is not disturbed without proper evaluation	Verify annually that controls are being implemented

Table 2.13. Other LTS requirements for the Bethel Valley watershed (cont.)

Areas	Project Documents	Other LTS Requirements	Frequency/ Implementation
Other LTS requirements for Specific Areas			
***Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1749&D1)**			
Corehole 8 Plume Source (Tank W-1A)	RmAR for Corehole 8 Plume Source (Tank W-1A) (DOE/OR/01-1969&D3)	• No excavation can be performed at the site unless an EPP is obtained.	Verify annually that controls are being implemented

[a] Source for LUCs # 1-7: *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

[b] *Property Record Restrictions—Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.*

[c] *Property Record Notices—Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.*

[d] *Zoning Notices—Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.*

[e] *Excavation/Penetration Permit Program—Refers to the internal DOE/DOE contractor administrative program(s) that requires permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.*

[f] *Access Controls—Physical barriers or restrictions to entry.*

[g] *Signs—Posted command, warning, or direction.*

BVBGs = Bethel Valley Burial Grounds
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE = U.S. Department of Energy
EPP = excavation/penetration permit
FYR = Five-Year Review
LTS = long-term stewardship
LUC = land use control
ORNL = Oak Ridge National Laboratory
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
RDR = Remedial Design Report
RER = Remediation Effectiveness Report
RmAR = Removal Action Report
ROD = Record of Decision
S&M = surveillance and maintenance
SWSA = Solid Waste Storage Area
UCOR = URS | CH2M Oak Ridge LLC

BVBGs Requirements

Under the *Explanation of Significant Differences from the Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-2446&D2) the SWSA 3 cap was extended to cover Contaminated Soil Area Number 2 and Contaminated Soil Area Number 3, as well as buried waste in the Closed Scrap Metal Area. These areas were designated as unrestricted end use in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) (after excavation). Now that they are under the SWSA 3 cap, the end use for these areas is recreational. This project was completed in FY 2011, and the PCCR was approved by the regulators on May 11, 2012 (DOE/OR/01-2533&D2).

The LTS requirements for the BVBGs areas (SWSA 1, Former Waste Pile Area, Nonradioactive Wastewater Treatment Plant Debris Pile, SWSA 3, and Contractor's Landfill) are specified in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds* (DOE/OR/01-2533&D2) and include long-term S&M of the caps and covers. Specifically, S&M actions are to control erosion, to cap or cover settlement, to maintain run-on and run-off control system, to maintain trench drains, to prevent rodent infestation, to control vegetative covers to prevent tree growth, and to maintain monitoring wells and survey benchmarks. The *Phased Construction Completion Report for the Bethel Valley Burial Grounds* (DOE/OR/01-2533&D2) provides details on the inspection schedules, procedures, and corrective actions. LUCs for the BVBGs are the same as those specified in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4), with the exception of SWSA 3 expanding the area classified for recreational use (see discussion in section above). LUCs required by the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4) include property record restrictions; property record notices; zoning notices; internal permits programs (including excavation permit requirements); access controls; signs; and surveillance patrols. The primary controls used to limit unauthorized activities in the remediated areas include appropriate signage and administration of an EPP program.

2.2.2.2 Status of Requirements

Status of Watershed-scale Requirements

LUCs were maintained for the specified end use areas identified in the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4). Signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections. The EPP Program functioned according to established procedures and plans.

Status of Building 4501 Mercury Treatments System Requirements

Inspections of the Building 4501 pretreatment system were conducted weekly in FY 2015 by the UT-B Facility Manager in accordance with the operating manual. Monthly system status updates were submitted to the WRRP documenting system operations, monthly pumped/treated volume, and influent/effluent concentrations. In FY 2015 routine maintenance included inlet filter changes and replacing resin. The old resin, which was replaced on January 15, 2015, had lasted for 18.5 mos., had treated 30.5 M gal of water, and had removed 269 g of mercury. On July 29, 2015 the flow meter started reading higher than the actual flow. The system flow meter was replaced on September 23, 2015.

Status of Corehole 8 Plume Extraction System Requirements

Routine inspections were conducted in FY 2015 of the Corehole 8 plume extraction system and documented on monthly status reports. Maintenance of the system included replacing a defective solenoid valve on Extraction Well #1 that was preventing flow from the well. Operational issues noted on

inspection sheets included continued low value readings on Lift Station #1 flow meter compared to actual pump outflow; and Lift Station #2 pump was discovered inoperable on September 23, 2014 and restored on October 2, 2014. See Section 2.2.1.2.1.3 for performance of the extraction system in FY 2015.

The primary controls used to limit unauthorized activities at the Corehole 8 plume extraction system site include appropriate signage and administration of an EPP program. Access by the general public is restricted by the portal guard stations at the east and west ends of Bethel Valley Road. The Corehole 8 extraction system is not individually fenced and gated. While there are no physical controls to preclude access to the Corehole 8 extraction system by ORNL workers and visitors, appropriate signage and procedural controls are in place to warn of potential hazards.

Status of BVBG Requirements

Inspections of the BVBGs were conducted semiannually in FY 2015 in accordance with the *Phased Construction Completion Report for the Bethel Valley Burial Grounds* (DOE/OR/01-2533&D2). Inspection items included cover system, gas vents, access roads and culverts, survey benchmarks, drainage system, facility signs, and presence of unauthorized materials. No maintenance was required in FY 2015 beyond routine mowing.

Per the *Phased Construction Completion Report for the Bethel Valley Burial Grounds* (DOE/OR/01-2533&D2), a survey plat documenting use restrictions and information about residual contamination and waste management areas was prepared. It will be submitted by DOE to the County Register of Deeds office upon completion of RAs (i.e., approval of the Bethel Valley RAR). Access by the general public is restricted by portal guard stations at the east and west ends of Bethel Valley Road. The BVBGs sites are not individually fenced and gated. While there are no physical controls to preclude access to the BVBGs sites by ORNL workers and visitors, appropriate signage and procedural controls are in place to warn of potential hazards.

2.3 SINGLE-PROJECT ACTIONS IN BETHEL VALLEY WATERSHED

2.3.1 Tank W-1A

The location of the former Tank W-1A site (the Corehole 8 plume source) is shown on Figure 2.1. The *Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at the Oak Ridge National Laboratory* (DOE/OR/01-1969&D3), approved in November 2012, documents completion of the non-time critical removal action to address the source of contaminants being released to groundwater. This action removed Tank W-1A, contaminated soils surrounding the tank, tank saddles along with associated piping, valve pits and appurtenances in the area of the excavation. This report documents the actions taken toward removal of the Core Hole 8 plume source (Tank W-1A) as prescribed in the *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A)* (DOE/OR/01-1749&D1). The removal action objective of reducing off-site releases of contaminants at White Oak Dam by addressing the source area was met.

2.3.1.1 Other LTS Requirements

The Tank W-1A (Corehole 8 plume source) site has only LUC requirements. No surface water or groundwater monitoring is required to verify the effectiveness of the removal action; however, the Corehole 8 Plume groundwater recovery and monitoring continue at well 4411 and the Corehole 8 sump.

The only LUC specified in the *Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at the Oak Ridge National Laboratory* (DOE/OR/01-1969&D3) includes the requirement that no excavation can be performed at the site unless an EPP is obtained.

2.3.1.2 Status of Requirements

Excavation at all areas at ORNL, including the former Tank W-1A site, remained controlled in FY 2015 through the EPP Program.

2.3.2 Surface Impoundments

The location of the Surface Impoundments is provided on Figure 2.1. This action removed contaminated water, sediment, and the upper 0.1 to 0.2 ft of subimpoundment soil (clay). The action was implemented in two phases. The first phase removed contaminated water and sediment and backfilled impoundments C and D, which were small, lined impoundments. The second phase removed and treated discrete batches of contaminated sediment and backfilled impoundments A and B, which were larger, unlined impoundments. Upon completion, all four impoundments were covered with gravel and asphalt and are currently used as parking areas.

2.3.2.1 Other LTS Requirements

The *Remedial Action Report on the Surface Impoundments Operable Unit* (DOE/OR/01-2086&D2) states that no institutional controls are needed at the site; however, the report requires that institutional controls that limit excavation remain in place for potential residual subsurface contamination around the site.

2.3.2.2 Status of Requirements

The site underwent an annual inspection in FY 2015 by the ORNL S&M Program to check for evidence of unauthorized excavation/penetration without a valid permit. No unacceptable activity was noted. In addition, an EPP Program with procedures is in place that does not allow unauthorized excavations/penetrations in this area.

2.3.3 Metal Recovery Facility

2.3.3.1 Other LTS Requirements

The location of the Metal Recovery Facility is shown on Figure 2.1. This action removed surface structures to slab, leaving in place the concrete floor slab, foundation, and other subsurface structures. The floor slab was sealed, and the slab and surrounding yard were covered with a minimum 2 in. of gravel. Final disposition of the slab and subsurface structures has been deferred to the *Record of Decision for Interim Actions in Bethel Valley* (DOE/OR/01-1862&D4).

The *Removal Action Report for the Metal Recovery Facility, Building 3505* (DOE/OR/01-2000&D2/R1) requires S&M and posting as an underground contamination area. S&M is required to ensure that the gravel cover is not grossly disturbed in a manner that might expose subsurface contamination. In the event that the gravel cover is disturbed, the minimum 2 in. gravel protective cover over the epoxy barrier coating must be restored.

2.3.3.2 Status of Requirements

The site underwent an annual inspection in FY 2015 performed by the ORNL S&M Program to monitor the condition of the gravel cover and ensure that the signs denoting underground contamination are visible and firmly in place. No maintenance was required.

2.4 BETHEL VALLEY WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Bethel Valley watershed are in Table 2.14.

Table 2.14. Bethel Valley watershed issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issue Carried Forward			
None			
Completed/Resolved Issues[b]			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

2.5 REFERENCES

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DOE/OR/01-2086&D2. *Remedial Action Report on the Surface Impoundments Operable Unit at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2004, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2533&D2. *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2534&D1. *Phased Construction Completion Report for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2566&D1. *Treatability Study for the Bethel Valley 7000 Area Groundwater Plume, Oak Ridge National Laboratory*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

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3. MELTON VALLEY WATERSHED

3.1 INTRODUCTION AND STATUS

3.1.1 Introduction

The Melton Valley watershed contains former burial grounds, tanks, facilities, disposal pits and trenches, and underground injection wells. Table 3.1 lists CERCLA actions within the watershed and identifies those with monitoring or other LTS requirements. Figure 3.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Only sites that have LTS requirements (Table 3.1) are included in these performance evaluations. End uses of a site form the basis of RAOs and determine access restrictions and allowable activities at the site. Figure 3.2 shows ROD-designated end uses within the watershed and interim controls requiring LTS.

Completed CERCLA actions in the Melton Valley watershed are gauged against their respective action specific goals. The collected data provides an evaluation of the indicators of effectiveness at the watershed scale.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 5 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). The information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

3.1.2 Status Update

<u>Watershed-Scale Actions</u>

The interim RAs in the *Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3) (Melton Valley ROD) have been completed and documented in the *Remedial Action Report for the Melton Valley Watershed, Oak Ridge, Tennessee* (DOE/OR/01-2343&D1) and RAR errata and addendum (Table 3.1). These interim RAs included a wide range of activities to reduce contaminant releases from the site, demolish unneeded facilities, plug and abandon unneeded wells, and remediate contaminated soils to prescribed risk levels. Selected remedies for sediments, floodplain soil exhibiting radiation <2500 µR/hr, and groundwater are not included in the Melton Valley ROD. A future remedial decision will select the remedy for these areas and will finalize or modify the interim RAs addressed under the Melton Valley ROD. Currently, contaminated sediments prevent WOC from meeting its stream use classifications (e.g., recreation). Performance monitoring of completed Melton Valley ROD actions continued in FY 2015.

Sampling the off-site wells to evaluate potential groundwater communication beneath the Clinch River between the ORR and an area of off-site groundwater use continued in accordance with the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3).

Single-Project Actions

Molten Salt Reactor Experiment

- Defueling of the salt in the three fuel and flush drain tanks was completed under the *Record of Decision for Interim Action to Remove Fuel and Flush Salts from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1671&D2) and *Explanation of Significant Differences for the Record of Decision for Interim Action to Remove Fuel and Flush Salts from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2088&D2) and documented in the *Phased Construction Completion Report for the Removal and Transfer of the Uranium from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2256&D1) approved in 2008.

  The *Waste Handling Plan for the Molten Salt Reactor Experiment Remediation of Secondary Low-Level Waste under the Melton Valley Closure Project at Oak Ridge, National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2200&D1) provided the execution plan for managing and disposing of waste from the defueling activities, as well as previously generated CERCLA waste. According to the Waste Handling Plan (WHP), all radioactive low-level waste (LLW) was expected to go to the EMWMF. All mixed or hazardous waste (mainly due to lead) was to be shipped for off-site treatment and disposal. Approximately 120 yd^3 of LLW was sent to EMWMF under an approved profile, as documented in the PCCR.

  In 2013, EPA and TDEC (Crane, J. L. January 24, 2013 and Petrie, R. January 9, 2013, respectively) requested an inventory of waste remaining at Molten Salt Reactor Experiment (MSRE) and a schedule for disposal. DOE provided an inventory of waste items (McMillian, W. G. and Japp, J. M. March 27, 2013), and the disposition plan (McMillian, W. G. and Japp, J. M. July 24, 2013). The *Addendum to the Waste Handling Plan for the Molten Salt Reactor Experiment Remediation of Secondary Low-Level Waste under the Melton Valley Closure Project at Oak Ridge, National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2200&D1/A1) (WHP Addendum) was prepared and approved in FY 2014 to:

  - Update activities and agreements since the WHP was approved.
  - Provide a clear description of waste remaining to be disposed under the WHP and waste that is not included in the WHP.
  - Detail the plan for characterizing the waste that is expected to be eligible for disposal in EMWMF, including documentation to justify disposal of some waste items and containers without sampling.
  - Provide information concerning future submittals of PCCRs to document the disposal of MSRE waste included in the WHP.

  As required by the WHP Addendum, preparation of a PCCR was initiated in FY 2015 that documents the MSRE waste characterized and disposed in FY 2014 and FY 2015 (Figure 3.3).

Table 3.1. CERCLA actions in Melton Valley watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
		Watershed-scale actions	
Melton Valley Interim Actions	ROD (DOE/OR/01-1826&D3): 09/21/00	**Watershed-scale requirements**	Yes (see Table 3.3)/ Yes (see Table 3.10)
	ROD Amendment (DOE/OR/01-2170&D1): 09/07/04 Changes remediation approach for Trenches 5 & 7 to *in situ* grouting ESD (DOE/OR/01-2040&D2): 03/12/04 Adds Tumulus 1 and 2 and the Intermediate Waste Management Facility to the scope of the Interim ROD ESD (DOE/OR/01-2165&D1): 09/07/04 Modifies requirements for 11 waste units ESD (DOE/OR/01-2249&D1): 09/13/05 Removes seven facilities from MSRE D&D ESD (DOE/OR/01-2333&D1): 12/27/06 Removes five shielded transfer tanks from D&D scope LUCIP (DOE/OR/01-1977&D6): 05/24/06	**Actions complete**	
		RAR (DOE/OR/01-2343&D1) 09/05/07	Yes/Yes
		– (DOE/OR/01-2343&D1/A1) erratum approved 06/25/09	No/Yes
		– (DOE/OR/01-2343&D1/A2) erratum submitted 10/19/09 (no approval required)	No/Yes
		– (DOE/OR/01-2343&D1/A3/R1) addendum approved 08/22/14	No/No
		– Melton Valley Watershed RAR CMP (DOE/OR/01-1982&D3) approved 09/05/13	Yes/No
		• PCCR for Hydrofracture Well Plugging & Abandonment (DOE/OR/01-2138&D1) approved 07/14/06	Superseded by RAR (DOE/OR/01-2343&D1)
		• PCCR for New Hydrofracture Facility D&D (DOE/OR/01-2306&D1) approved 07/31/06	
		• PCCR for Trenches 5 and 7 and HRE Fuel Wells In Situ Grouting (DOE/OR/01-2302&D1) approved 08/14/06	
		• PCCR for Hydrologic Isolation at SWSA 6 (DOE/OR/01-2285&D1) approved 09/06/06	
		• PCCR for SWSA 4 and IHP (DOE/OR/01-2300&D1) approved 09/11/06	
		• PCCR for Old Hydrofracture Facility D&D (DOE/OR/01-2014&D2) approved 09/26/06	
		• PCCR for Hydrologic Isolation at Seepage Pits and Trenches (DOE/OR/01-2310&D1) approved 10/02/06	
		• PCCR for Soils and Sediments (DOE/OR/01-2315&D1) approved 10/02/06	

Table 3.1. CERCLA actions in Melton Valley watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
		• PCCR for HRE Ancillary Facilities D&D (DOE/OR/01-2307&D1) approved 10/04/06	
		• 7841 Equipment Storage Area and 7802F Storage Shed D&D (DOE/OR/01-2323&D1) approved 10/05/06	
		• Hydrologic Isolation at SWSA 5 (DOE/OR/01-2286&D1) approved 11/06/06	
		Single-project actions	
		Actions complete	
WOCE	AM (Letter): 11/9/90	RmAR (ORNL/ER/Sub/91-KA931/4) approved 09/30/92	No/Yes
WAG 13 Cesium Plots	IROD (DOE/OR1059&D4): 10/06/92	RAR Postconstruction report (DOE/OR/01-1218&D2) approved 08/25/94	No/Yes
WAG 5 Seep C	AM (DOE/OR/02-1235&D2): 03/30/94	RmAR Postconstruction Report (DOE/OR/01-1334&D2) approved 06/22/95 – System shutdown prior to capping	Superseded by Melton Valley ROD (DOE/OR/01-1826&D3)
WAG 5 Seep D	AM (DOE/OR/02-1283&D2): 07/26/94	RmAR Postconstruction Report (DOE/OR/01-1334&D2) approved 06/22/95 – Collection of contaminated groundwater ongoing	Superseded by Melton Valley ROD (DOE/OR/01-1826&D3)
WAG 4 Seep Control	AM (DOE/OR/02-1440&D2): 02/12//96	RmAR (DOE/OR/01-1544&D2) approved 03/05/98	Superseded by Melton Valley ROD (DOE/OR/01-1826&D3)
MSRE D&D Reactive Gas	AM (Letter): 06/12/95	RmAR (DOE/OR/01-1623&D2) approved 02/12/98	No/No
MSRE D&D Uranium Deposit Removal	AM (DOE/OR/02-1488&D2): 08/6/96	RmAR (DOE/OR/01-1918&D2) approved 12/18/01	No/Yes
Old Hydrofracture Tank Sludges	AM (DOE/OR/02-1487&D2): 09/12/96	RmAR (DOE/OR/01-1759&D1) approved 12/15/98	No/No

Table 3.1. CERCLA actions in Melton Valley watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Old Hydrofracture Tanks and Impoundment	AM (DOE/OR/01-1751&D3): 05/14/99 AM Addendum (DOE/OR/01-1866&D2): 03/31/00	RmAR (DOE/OR/01-1908&D2) approved 05/11/01	Superseded by Melton Valley ROD (DOE/OR/01-1826&D3)
White Oak Dam	AM (Time Critical) for Corrective Actions at White Oak Dam (DOE/OR/01-2460&D1): 7/23/10	RmAR (DOE/OR/01-2509&D1) approved 11/08/11	Yes/Yes
		– (DOE/OR/01-2509&D1) erratum submitted 10/23/12 (no approval required)	No/Yes
		Actions in progress	
MSRE D&D Fuel Salt Removal	ROD (DOE/OR/02-1671&D2): 07/07/98 ESD (DOE/OR/01-2088&D2) approved: 01/19/07 Deletes requirement to convert ^{233}U to an oxide	PCCR (DOE/OR/01-2256&D1 [removal and transfer of uranium from the MSRE Facility]) approved 10/10/08	No/No
		PCCR for waste characterized and disposed in FY 2014 and FY 2015 in progress	TBD[c]
TRU Waste Processing Complex Sludge Test Area Buildout	AM (DOE/OR/01-2621&D1) 08/02/13	RmAR (DOE/OR/01-2672&D1) approved 03/20/15	No/No

[a]Information on the enforceable agreement milestones for ongoing actions is in Appendix E of the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]"No/No" indicates no monitoring/other LTS requirements are identified in the CERCLA action completion document beyond those identified in the watershed ROD. Refer to Table 3.3 for watershed-scale monitoring requirements and Figure 3.2 and Table 3.10 for watershed-scale LUCs and other LTS requirements.

[c]The completion document was not approved during the FY 2015 reporting period.

AM = Action Memorandum
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
D&D = decontamination and decommissioning
ESD = Explanation of Significant Difference
FY = fiscal year
HRE = Homogeneous Reactor Experiment
IHP = Intermediate Holding Pond
IROD = Interim Record of Decision
LTS = long-term stewardship
LUC = land use control
LUCIP = Land Use Control Implementation Plan
MSRE = Molten Salt Reactor Experiment
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RmAR = Removal Action Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TBD = to be determined
TRU = transuranic
WAG = Waste Area Grouping
WOCE = White Oak Creek Embayment

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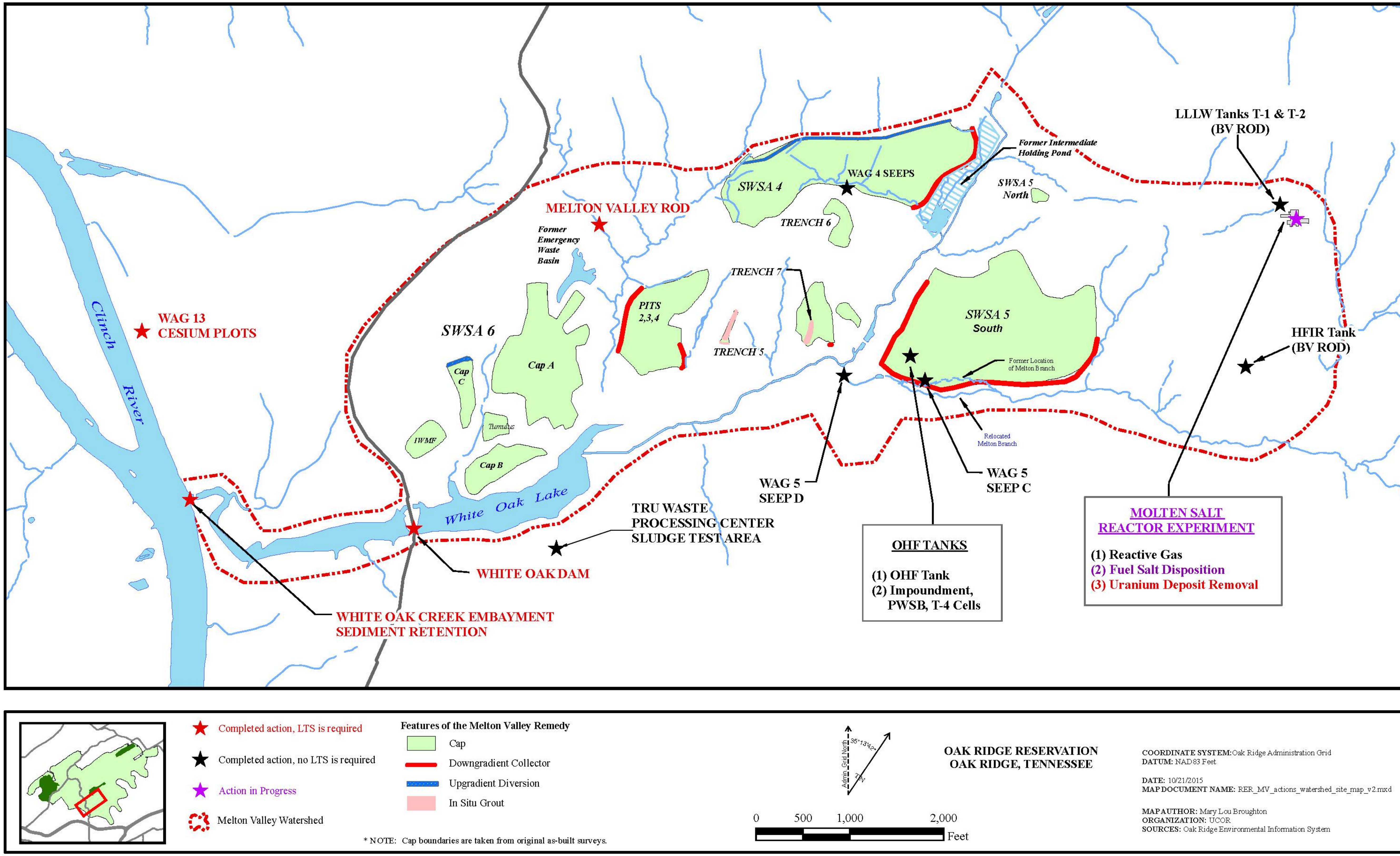

Figure 3.1. Melton Valley watershed.

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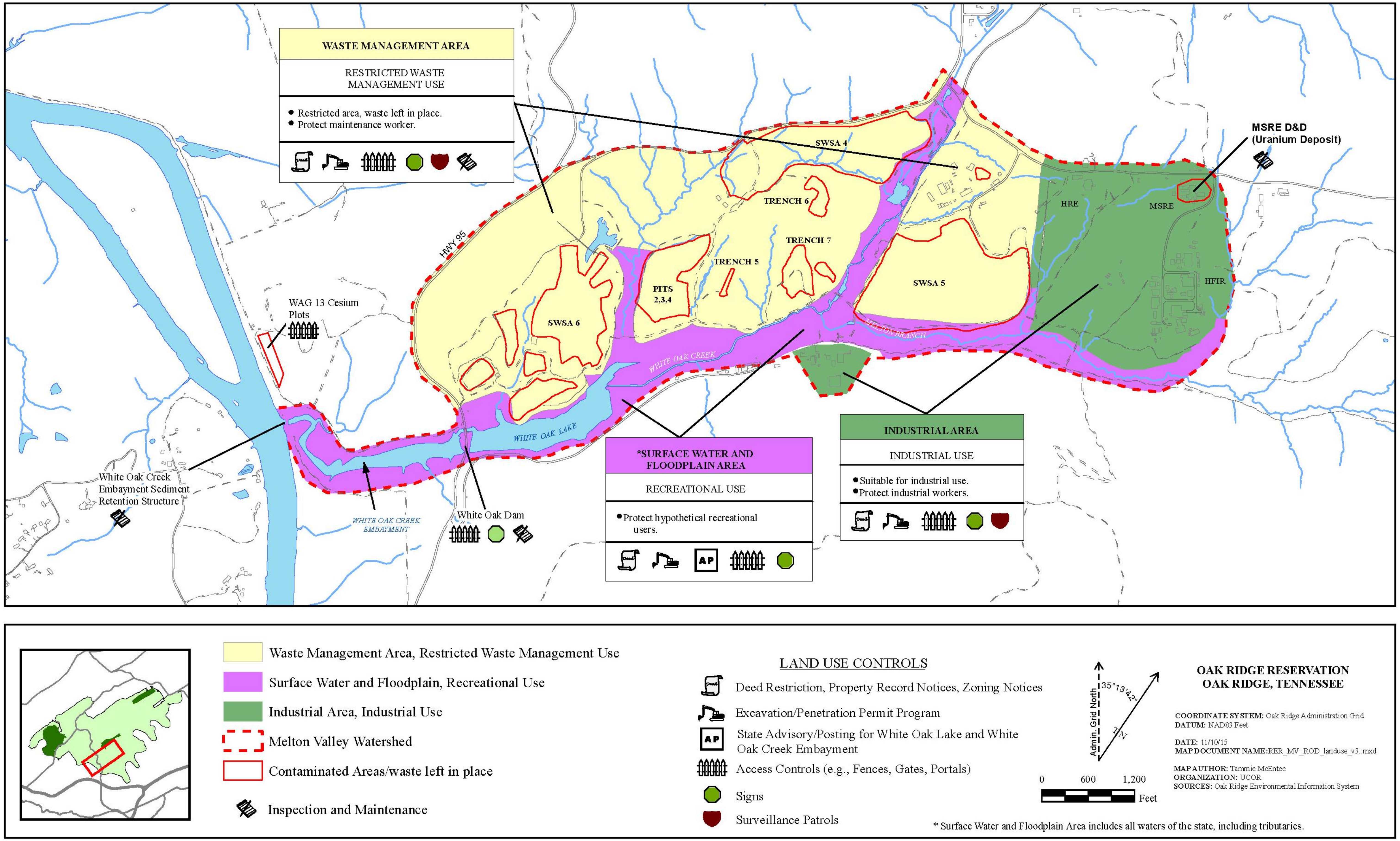

Figure 3.2. Melton Valley ROD-designated end use and interim controls requiring LTS.

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Figure 3.3. MSRE waste disposal activities.

S&M

- The *Waste Handling Plan for Surveillance & Maintenance Activities at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2565&D2; DOE/OR-01-2565&D2/A1) was approved in January 2013 to define the manner in which waste will be managed from S&M activities conducted at contaminated sites and facilities awaiting and following response actions under CERCLA at ORNL. This WHP requires periodic PCCRs to document the waste disposed. In FY 2015 a PCCR to document the waste disposed in FY 2014 and FY 2015 was initiated.

Transuranic Waste Processing Center

- The Transuranic Waste Processing Center processes transuranic and alpha LLW that is stored at ORNL for permanent disposal. The Sludge Processing Facilities Buildout project includes the construction of a prototypical test facility to conduct technology maturation in support of the design and construction of the future sludge processing facilities. Site preparation activities began in April 2013, including clearing and grubbing of vegetation, removal of organic material and topsoil layers, and build-up and leveling of the site with suitable material followed by mechanical compaction supportive of future construction. During excavation of test pits in May 2013, various anomalous materials, including Tyvek, wood debris, trash, stainless steel and polyvinyl chloride (PVC) well casing materials, and concrete, were discovered. Some of this material was contaminated. Work was paused, and an *Action Memorandum for Time-Critical Removal Action for the Sludge Test Area Buildout at the Transuranic Waste Processing Center, Oak Ridge National Laboratory, Oak Ridge,*

Tennessee (DOE/OR/01-2621&D1) was prepared to remove and dispose of the contaminated soil and debris. The work under this time-critical removal action was completed in FY 2014 (Figure 3.4) and the *Removal Action Report for Sludge Test Area Soil and Debris at the TRU Waste Processing Center*, *Oak Ridge*, *Tennessee* (DOE/OR/01-2672&D1) was approved in March 2015. No monitoring or other LTS requirements are specified in the report.

Figure 3.4. Backfill and compaction of the Sludge Test Area excavation at TWPC.

3.2 ROD FOR INTERIM ACTIONS FOR MELTON VALLEY WATERSHED

3.2.1 Performance Monitoring

3.2.1.1 Performance Goals and Monitoring Objectives

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) includes actions for the hydrologic isolation of burial grounds, removal of impoundments, grouting of Homogeneous Reactor Experiment (HRE) fuel wells, remediation of inactive waste pipelines, *in situ* grouting of Seepage Trenches 5 and 7, removal of contaminated soil and sediment, demolition of buildings, plugging and abandonment of wells, monitoring, and LUCs. It also stipulates RAOs for Melton Valley based on the industrial use area (east of SWSA 5), the Waste Management Area, the Surface Water and Floodplain Area, and for human receptors and ecological populations (Table 3.2). Table 3.3 includes the performance objectives and performance measures in the ROD for those elements of the

remedy that specified post-remediation monitoring. These performance objectives provide a quantitative basis to evaluate the effectiveness of hydrologic isolation at limiting contaminant releases from buried waste by monitoring groundwater fluctuation within hydrologic isolation areas. Additionally, the performance measure for surface water quality is to achieve the AWQC numeric and narrative goals related to contaminant discharges originating from Melton Valley within two years after completion of remediation. Also included in Table 3.3 are goal attainment dates and references to sections in this RER where the annual status of performance for each metric is discussed.

During the design process for *in situ* grouting of Liquid Waste Seepage Trenches 5 and 7, a groundwater quality monitoring plan was prepared and implemented to monitor wells in the vicinity of those two units for water quality evaluation. Results of that sampling and analyses are included in Section 3.2.1.2.2.

Most of the laterally-flowing shallow groundwater (<10 ft) emanating from capped waste areas is collected by downgradient interceptor trenches at SWSA 5; along the eastern edge of SWSA 4; southeast of Trench 7; along the eastern and western sides of Pits 2, 3, and 4; and at Seep D. The system includes over 30 pumps that are operated based on automated level controls in the groundwater collection areas. The collected groundwater is all routed to an equalization tank located at SWSA 4 before transfer to the PWTC in Bethel Valley. Water at the equalization tank is sampled to verify that the wastewater meets the facility's waste acceptance criteria (WAC).

3.2.1.2 Evaluation of Performance Monitoring Data

This section evaluates the monitoring data in terms of meeting the goals of the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3). Performance monitoring includes surface water monitoring, groundwater monitoring, and biological monitoring. Figure 3.5 shows the watershed scale monitoring locations.

3.2.1.2.1 Surface Water

This section presents the results of remedy effectiveness evaluation of surface water monitoring in the Melton Valley watershed. Section 3.2.1.2.1.1 summarizes the remediation goals for surface water; Section 3.2.1.2.1.2 presents information concerning major radionuclide concentrations and fluxes at the surface water integration point monitoring stations; and Section 3.2.1.2.1.3 presents data obtained at the tributary sampling locations.

Table 3.2. RAOs for the Melton Valley watershed selected remedy[a]

Area/receptor	***Goal***
Waste management area (includes SWSA 4, 5, and 6 and Seepage Pits and Trenches)	• *Manage waste disposal sites as a restricted waste management area* • *Protect maintenance workers* • *Meet AWQC in surface water in a reasonable amount of time* • *Mitigate further impact to groundwater*
Industrial use area (generally the area east of SWSA 5)	• *Manage areas generally east of SWSA 5 as an industrial area* • *Protect industrial workers* • *Meet AWQC in surface water in a reasonable amount of time* • *Mitigate further impact to groundwater*
Surface water and floodplain area	• *Achieve numeric and narrative AWQC for waters of the state in a reasonable*

Table 3.2. RAOs for the Melton Valley watershed selected remedy[a] (cont.)

Area/receptor	*Goal*
	amount of time • *Remediate contaminated floodplain soils to 2500 µR/hour[b]* • *Protect an off-site resident user of surface water at the confluence of White Oak Creek with the Clinch River from contaminant sources in Melton Valley* • *Make progress toward meeting Clinch River's stream use classification as a drinking water source at confluence of White Oak Creek with the Clinch River*
Human receptors	• *Protect maintenance workers, industrial workers, and off-site resident users of surface water (at the confluence of White Oak Creek with the Clinch River) to a 10^{-4} to 10^{-6} excess lifetime cancer risk and a HI of 1* • *Protect hypothetical recreational users of waters of the state[c]*
Ecological receptors	• *Protect ecological populations[d]*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), Table 1.1.
[b]A future CERCLA decision will be prepared to determine whether additional actions are required for floodplain soil <2500 µR/h.
[c]This remedy addresses water quality but does not fully address fish consumption or sediment/floodplain soil contact or exposure under the recreational scenario. This remedy protects the hypothetical recreational user through a combination of RAs including LUCs. A future CERCLA decision will be prepared to assess whether any additional actions are required. Additional data collection and evaluation will be conducted as part of this remedy to further assess the status of ecological receptors in these areas. Results of this ecological monitoring and any additional actions, as necessary, will be included in a future remedial decision.
[d]The selected remedy enhances overall protection of valley-wide ecological populations and subbasin-level populations over a majority of the valley. However, portions of the valley that are not addressed by the selected remedy may pose potential unacceptable risks to ecological receptors.

AWQC = ambient water quality criteria
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
HI = hazard index
LUC = land use control
RA = remedial action
RAO = remedial action objective
SWSA = Solid Waste Storage Area

Table 3.3. Performance measures for major actions in the Melton Valley watershed[a]

Unit type/unit names project scope	***Performance objectives***	***Performance measure[b]*** **(Attainment schedule) [RER section]**
SWSA 4 *SWSA 4* *Liquid Seepage Pit 1 & Secondary Media* *Inactive Waste Transfer Lines @ Lagoon Road* *Pilot Pits Area* *Shallow Well P&A*	*Contain disposed & contaminated materials* *Meet RAO for the waste management use area* [soil]	*Prevent releases from SWSA 4 from causing AWQC exceedances in waters of the state within 2 years after SWSA 4 construction is complete* (Fall 2008).[c] [See Section 3.2.1.2.1.3] *Reduce SWSA 4 contaminant releases to surface water by approximately 80% to meet computed 1 X 10^{-4} total residential risk at the confluence of White Oak Creek with Clinch River in ~10 years after all ROD actions are complete* (2016).[c] [See Section 3.2.1.2.1.3] *Reduce groundwater through flow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area* [See Section 3.2.1.2.2]

Table 3.3. Performance measures for major actions in the Melton Valley watershed[a] (cont.)

Unit type/unit names project scope	*Performance objectives*	*Performance measure[b]* (Attainment schedule) [RER section]
SWSA 5 South *SWSA 5 South* *Stabilized OHF Pond and Tanks* *Stabilized subsurface OHF facilities* *Contaminated soils at OHF site* *Shallow Well P&A*	*Contain disposed materials* *Meet RAO for the waste management use area* [soil]	*Prevent releases from SW 5 South from causing AWQC exceedances in waters of the state in Melton Branch, Lower HRE Tributary, and SWSA 5 D1 within 2 years after SWSA 5 South construction is complete* (Fall 2008).[c] [See Section 3.2.1.2.1.3] *Reduce SWSA 5 contaminant releases to surface water by approximately 80% to meet computed 1 X 10^{-4} total residential risk at the confluence of White Oak Creek with Clinch River in ~10 years after all ROD actions are complete (2016).*[c] *[See Section 3.2.1.2.1.3]* *Reduce groundwater throughflow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.2.1.2.2]
SWSA 5 North 4 trenches	*Contain disposed materials* *Meet RAO for the waste management use area* [soil]	*Verify that groundwater does not contact the buried waste through water level monitoring in and adjacent to the trenches after capping.* [See Section 3.2.1.2.2.2]
SWSA 6 *SWSA 6* *Shallow Well P&A*	*Contain disposed materials* *Meet RAO for the waste management area* [soil]	*Prevent releases from SWSA 6 from causing AWQC exceedances in waters of the state within 2 years after SWSA 6 construction is complete* (Fall 2008).[c] [See Section 3.2.1.2.1.3] *Comply with RCRA postclosure requirements for designated RCRA areas (Ongoing).* [See Section 3.2.2] *Reduce groundwater throughflow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.2.1.2.2]
Pits 2, 3, and 4 and Trench 6 *Liquid seepage pits* *Inactive waste pipelines* *Shallow well P&A*	*Contain disposed materials* *Meet RAO for the waste management use area* [soil]	*Prevent releases from Liquid Waste Seepage Pits 2, 3, and 4, and Trench 6 from causing AWQC exceedances in waters of the state within 2 years after construction is complete* (Fall 2008).[c] [See Section 3.2.1.2.1.3] *Reduce groundwater throughflow in the contained area by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.2.1.2.2]
Trenches 5 and 7 *Liquid seepage trenches* *Inactive waste pipelines* *Shallow well P&A*	*Immobilize disposed materials.* *Meet RAO for the waste management use area* [soil]	*Prevent releases from Seepage Trenches 5 and 7 from causing AWQC exceedances in waters of the state within 2 years after ISV is complete* (Fall 2008).[c] [See Section 3.2.1.2.1.3] *Vitrify any additional contaminated soils that cause contamination of groundwater leading to surface water exceedances.*
Surface water quality	*Meet TDEC numeric AWQC and narrative (risk-based) water quality criteria in all waters of the state for specified uses.* *Meet risk levels for hypothetical recreational water use (contact and consumption under the recreational exposure scenario)*	*Achieve numeric AWQC and narrative (risk-based) water quality criteria in waters of the state within 2 years after completion of all actions that are part of the selected remedy. Meet recreation use criteria for water contact and consumption, excluding fish consumption* (Fall 2008).[c] [See Section 3.2.1.2.1.2]

Table 3.3. Performance measures for major actions in the Melton Valley watershed[a] (cont.)

Unit type/unit names project scope	*Performance objectives*	***Performance measure[b]*** **(Attainment schedule) [RER section]**
		Reduce contaminant releases to meet water quality conditions that would allow hypothetical residential use (risk level of 1 X 10^{-4} for water only – no fish consumption or sediment contact scenarios) at confluence with the Clinch River in ~10 years after completion of all ROD actions. Reductions in ^{90}Sr and tritium of 75-80% are required. [See Section 3.2.1.2.1.3]

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), Table 2.17.

[b]*To meet a target post-remediation risk level of 1 X 10-4 for surface water under the residential scenario at the mouth of White Oak Creek an 80% reduction of risk from the sum of individual contaminants from combined sources in Melton Valley is required. This calculation includes anticipated reductions in surface water contaminant risk that originate in Bethel Valley. Reduction of releases from individual source areas in Melton Valley as a result of remedial actions may vary somewhat. For all remediated areas, post-construction surveillance and maintenance monitoring will be implemented, which includes inspection of cap integrity, proper functioning and maintenance of surface water and groundwater flow control features, and conformance with land use control requirements.*

[c]Indicates date by which goal is to be attained.

Note: Non-italicized text within table references sections in the current document.

AWQC = ambient water quality criteria
HRE = Homogeneous Reactor Experiment
ISV = *in situ* vitrification
OHF = Old Hydrofracture Facility
P&A = plugging and abandonment
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation

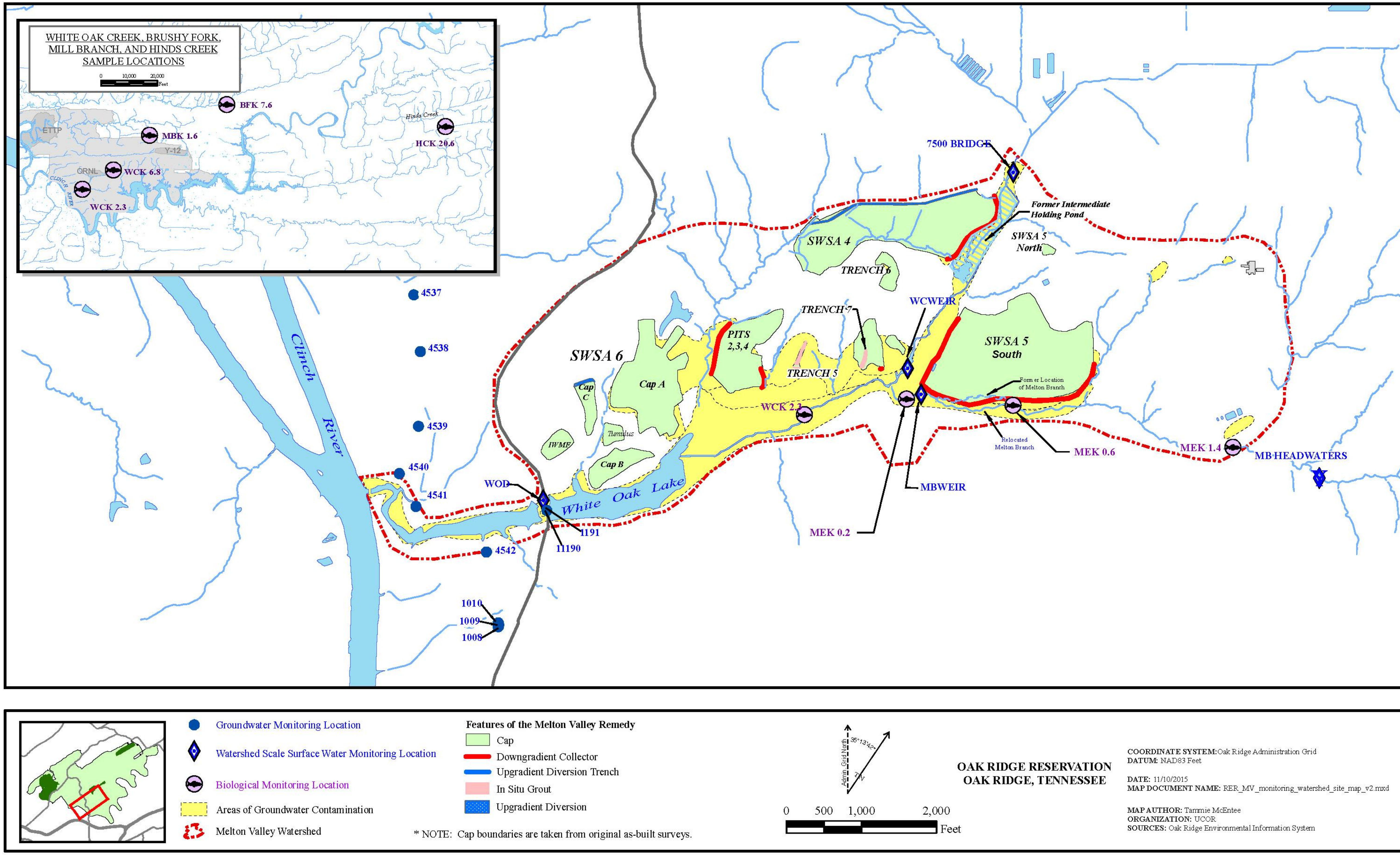

Figure 3.5. Melton Valley watershed scale monitoring locations.

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3.2.1.2.1.1 Surface Water Quality Goals and Monitoring Requirements

Surface water goals include protection of the Clinch River to meet its stream use classification (e.g., such as a domestic water supply) and to achieve AWQC in waters of the state. The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) includes specific surface water remediation levels (Table 3.4). Locations where surface water monitoring occurs to evaluate the remedy performance are shown on Figure 3.6. The following excerpts from the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) include the specific concentration goals for the principal surface water contaminants of concern in Melton Valley.

Table 3.4. Surface water remediation levels for the Melton Valley watershed[a]

Melton Valley watershed	***Goal: AWQC in waters of the state***		***Residential risk***
	Numeric AWQC	***Narrative AWQC/ recreational risk***	
Receptor	*Hypothetical recreational user; fish and aquatic life*	*Hypothetical recreational user*	*Hypothetical off-site resident*
Areas affected	*All waters of the state*	*All waters of the state*	*Confluence of White Oak Creek with Clinch River*
Anticipated compliance locations	See Figure 3.5 of RER	See Figure 3.5 of RER	*Confluence of White Oak Creek with Clinch River*
Remediation level	*Levels established in Rules of the TDEC Chapter 1200-4-3-.03*	See Table 3.6 of RER	See Table 3.5 of RER
Exposure scenarios	*N/A (numeric criteria tabulated in regulation; no separate calculation using exposure scenarios needed)*	*Hypothetical recreational swimming for White Oak Lake and White Oak Creek Embayment; recreational wading for White Oak Creek, Melton Branch, and other waters of the state. The exposure scenarios do not take into account fish ingestion and sediment contact*	*Hypothetical residential (i.e., general household use)*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), Table 2.18.

Note: Non-italicized text within table is referencing figures and tables in the current document.

AWQC = ambient water quality criteria
N/A = not applicable
RER = Remediation Effectiveness Report
TDEC = Tennessee Department of Environment and Conservation

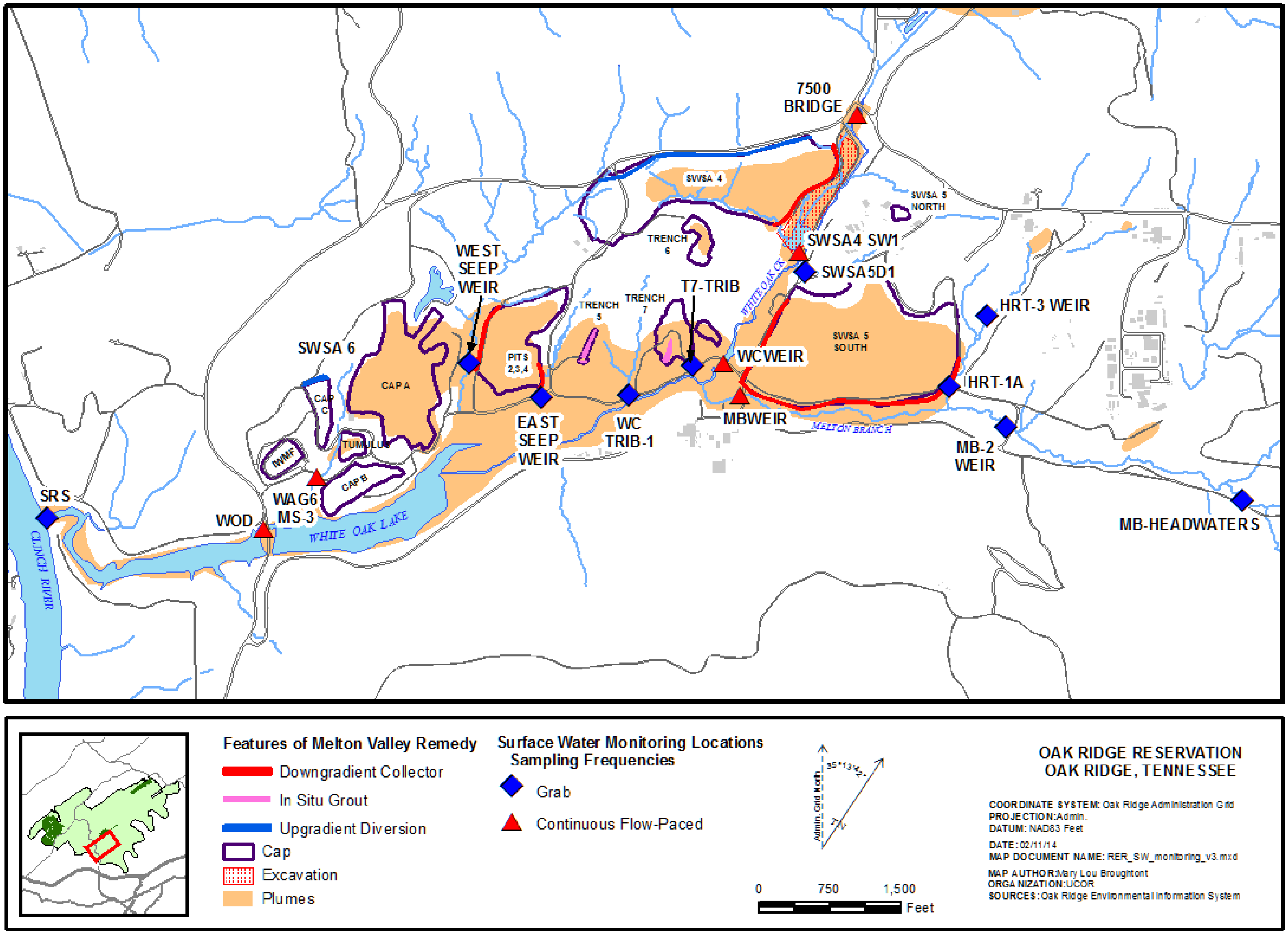

Figure 3.6. Melton Valley surface water monitoring locations.

Protect Clinch River to meet its stream use classification

This goal protects the Clinch River as a domestic water supply (e.g., meets SDWA MCLs), which is the most stringent of the use classifications assigned to the Clinch River, from contaminated surface water coming from Melton Valley. This goal provides residential risk-based limits for surface water at the confluence of WOC with the Clinch River. This goal will be met within 10 years from completion of actions in Melton Valley and Bethel Valley. Remediation levels at the confluence of WOC with Clinch River will achieve an annual average excess lifetime cancer risk (ELCR) less than 1×10^{-4} and a hazard index (HI) less than one for a residential exposure scenario (i.e., general household use). Samples to demonstrate compliance with these remediation levels may be taken from the White Oak Creek Embayment (WOCE) and/or White Oak Dam. Table 3.5 lists the remediation levels for the contaminants contributing to residential risk at White Oak Dam.

Table 3.5. Residential risk-based surface water remediation concentrations for the Melton Valley watershed[a]

Contaminants at White Oak Dam[b]	*Units*	*Reference concentration[c]*	*Minimum detection limit[d]*	*Concentrations based on a residential scenario[e] (for WOCE and/or White Oak Dam)*
Arsenic	*mg/L*	*ND*	*0.003*	*0.0056*
Chloroform	*mg/L*	*ND*	*0.001*	*0.021*
1,2-dichloroethane	*mg/L*	*ND*	*0.001*	*0.016*
PCBs	*mg/L*	*ND*	*0.001*	*0.011*
Cesium-137+D	*pCi/L*	*40*	*10.0*	*150*
Cobalt-60	*pCi/L*	*ND*	*10.0*	*250*
Strontium-90+D	*pCi/L*	*ND*	*2.0*	*85*
Tritium	*pCi/L*	*1626*	*300*	*58,000*

Note: The remediation levels are calculated at 1×10^{-4} or excess lifetime cancer risk or hazard index of 1 using standard risk assessment protocols for a general household use scenario. These values apply to single contaminants only. To account for the total risk from multiple contaminants, sum of ratios calculations may be applied to all contaminants that are present above background. Actual remediation concentrations when multiple contaminants are present will therefore likely be lower than the single contaminant concentrations listed in the table. Concentrations for other contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above.

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), Table 2.20.

[b]*Beryllium was identified as a contaminant of concern in the Feasibility Study but was not included here because the Environmental Protection Agency has since revised its position on the carcinogenicity of beryllium [see Record of Decision for Interim Actions for the Melton Valley Watershed (DOE/OR/01-1826&D3) Table 2.5]. Also, some of these contaminants have Safe Drinking Water Act maximum contaminant levels. The selected remedy will make progress toward protecting Clinch River as a drinking water source (i.e., meet Safe Drinking Water Act maximum contaminant levels).*

[c]*Reference concentrations equal twice the arithmetic mean of the background; these concentrations were used for surface water analyte screening in the Melton Valley watershed risk assessment.*

[d]*The minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities.*

[e]*The residential scenario assumes a 70-kg adult receptor, an exposure frequency of 350 days/year, an exposure duration of 30 years, an ingestion rate of 2 L/day, and a skin surface area (for dermal exposure) of 1.94 m^2.*

D = daughter products
ND = not detected or analyzed
PCB = polychlorinated biphenyl
WOCE = White Oak Creek Embayment

Achieve AWQC in waters of the state

White Oak Creek and Melton Branch (MB) are classified for Fish and Aquatic Life, Recreation, and Livestock Watering and Wildlife uses, but not for Domestic or Industrial Water Supply or Irrigation[1]. All other named and unnamed surface waters in the watershed are also classified for Irrigation by default under the Rules of the TDEC Chapter 1200-4-4. Numeric AWQC and narrative criteria for the protection of human health (based on ELCR of 1 X 10^{-4} and HI less than 1 for recreational exposure scenario) and aquatic organisms will be met for site-related contaminants in all waters of the state in MV in ~10 years from completion of source actions in MV. Numeric AWQC exist for selected compounds under the Recreation and Fish and Aquatic Life Classifications. Consistent with EPA guidance, compliance with numeric AWQC for Recreation and Fish and Aquatic Life Classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., Irrigation or Livestock Watering and Wildlife). A recreational risk scenario considered representative of the surface water classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or conversely to derive allowable concentrations from risk-based limits.

AWQC in Waters of the State—Numeric AWQC

The numeric AWQC for (1) Fish and Aquatic life and (2) Recreation (organisms only) apply to waters of the state in MV and are tabulated in Rules of the TDEC Chapter 1200-4-3-.03 for most of the COCs. Compliance will be based on statistically valid data assessments, and take into account frequency of detection and data trends. The sampling locations for the selected remedy will be finalized in a post-ROD sampling plan. The locations are generally at the downstream end of individual reaches but upstream of any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.

AWQC in Waters of the State—Narrative Criteria

In accordance with EPA guidance, the CERCLA risk assessment process is used to address the narrative criteria for waters of the state. A recreational risk scenario considered representative of the surface water classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or conversely to derive allowable concentrations from risk-based limits. However, DOE does not reasonably foresee actual recreational use of MV surface water in the future.

Waters of the state containing COCs that do not have numeric AWQC will achieve an annual average ELCR less than 1 X 10^{-4} and an HI less than 1 for a recreational exposure scenario. This goal applies only to surface water and only to those contaminants of concern that do not have numeric AWQC, such as radionuclides. The numeric AWQC for individual contaminants is generally equivalent to risk levels ranging up to 10^{-5}. The annual average risk goal of 1 X 10^{-4} meets the intent of the AWQC because when multiple contaminants are present in the surface water, as is likely, their individual risk levels would be roughly equivalent to the AWQC-equivalent risk of 10^{-5}. A lower risk goal could routinely require individual contaminant risks to be below the AWQC-equivalent risk of 10^{-5}.

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[1]The use classifications for WOC and Melton Branch have changed since the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) was signed. These surface water bodies are currently classified for Fish and Aquatic Life, Recreation, and Irrigation uses and are no longer classified for Livestock Watering and Wildlife use. Under the new regulations, all other surface waters unnamed in the Clinch River Basin section of the regulations, with the exception of wet weather conveyances, are classified as Fish and Aquatic Life, Recreation, Irrigation, and Livestock Watering and Wildlife use.

Under this ROD, the recreational scenario is defined as a swimming scenario for the impounded water bodies, such as White Oak Lake and the WOCE, and a wading scenario for streams such as WOC and MB. Since contaminated sediments are left in place under the remedy in this ROD, the swimming or wading scenarios do not include external exposure to or contact with sediment. Also, the scenarios do not include fish consumption because some contaminants in fish may be linked to contaminated sediments. Table 3.6 *[sic] lists the remediation levels for the recreational surface water COCs identified in the FS. The sampling locations for the selected remedy will be finalized in a post-ROD sampling plan.*

Table 3.6. Recreational risk-based surface water remediation concentrations for the Melton Valley watershed[a]

COCs identified in the FS[b]	*Units*	*Reference Concentration[c]*	*Minimum Detection Limit[d]*	*Concentrations based on a recreational swimming scenario[e] (for White Oak Lake and WOCE)*	*Concentrations based on a recreational wading scenario[f] (for White Oak Creek, Melton Branch, and other waters of the state)*
Arsenic	*mg/L*	*ND*	*0.003*	*NA[g]*	*NA[g]*
Tetrachloroethylene	*mg/L*	*ND*	*0.001*	*NA[g]*	*NA[g]*
Vinyl chloride	*mg/L*	*ND*	*0.001*	*NA[g]*	*NA[g]*
Cesium-137+D	*pCi/L*	*40*	*10.0*	*4.69E+04*	*2.37E+05*
Cobalt-60	*pCi/L*	*ND*	*10.0*	*7.84E+04*	*3.92E+05*
Radium-228+D	*pCi/L*	*ND*	*0.5*	*5.97E+03*	*2.99E+04*
Strontium-90+D	*pCi/L*	*ND*	*2.0*	*2.65E+04*	*1.33E+05*
Tritium	*pCi/L*	*1,626*	*300*	*2.07E+07*	*1.04E+08*
Uranium-234	*pCi/L*	*ND*	*0.5*	*3.34E+04*	*1.67E+05*

***Note**: The remediation levels are calculated at 1 X 10^{-4} excess lifetime cancer risk or hazard index of 1 using standard risk assessment protocols for a swimming or wading scenario. These values apply to single contaminants only. To account for the total risk from multiple contaminants, sum of ratios calculations may be applied to all contaminants that are present above background. Actual remediation concentrations when multiple contaminants are present will therefore likely be lower than the single contaminant concentrations listed in the table. Concentrations for other site-related contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above.*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), Table 2.19.

[b]*Beryllium was identified as a contaminant of concern in the Feasibility Study but was not included here because Environmental Protection Agency has since revised its position on the carcinogenicity of beryllium [see Record of Decision for Interim Actions for the Melton Valley Watershed (DOE/OR/01-1826&D3) Table 2.5].*

[c]*Reference concentrations equal twice the arithmetic mean of the background; these concentrations were used for surface water analyte screening in the Melton Valley watershed risk assessment.*

[d]*The minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities.*

[e]*The recreational swimming scenario assumes a 70-kg adult receptor, an exposure frequency of 45 hours/year, an exposure duration of 30 years, an ingestion rate of 0.05 L/hour, and a skin surface area (for dermal exposure) of 1.94 m^2.*

[f]*The recreational wading scenario assumes a 70-kg adult receptor, an exposure frequency of 45 hrs/yr, an exposure duration of 30 years, an ingestion rate of 0.01 L/hour, and a skin surface area (for dermal exposure) of 0.632 m^2.*

[g]*Risk-based concentrations to meet the narrative criteria were not derived for these contaminants of concern since numeric ambient water quality criteria exist for them.*

COC = contaminant on concern
D = daughter products
FS = feasibility study
NA = not applicable
ND = not detected or analyzed
WOCE = White Oak Creek Embayment

3.2.1.2.1.2 Integration Point Monitoring Results

This section provides an evaluation of the surface water quality data collected at surface water integration points on WOC and Melton Branch during FY 2015 compared to the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goals and performance metrics. Surface water monitoring locations are shown on Figure 3.6.

The principal surface water integration point monitoring station in Melton Valley is at White Oak Dam where WOC discharges from WOL. Continuous, flow-paced sampling is conducted at White Oak Dam to provide an ongoing record of radiological discharges from the watershed. The monitoring integrates measurements of radionuclide activities on samples collected during each month and the flow volume passing through the monitoring station to derive a flux value. Similar monitoring is conducted at three upstream integration point surface water monitoring stations – the White Oak Creek Weir (WCWEIR), the Melton Branch Weir (MBWEIR), and the 7500 Bridge. Table 3.7 displays the activities of ^{137}Cs, ^{90}Sr, and tritium from the monthly flow-paced composite samples obtained at these main stem integration points.

Comparison of ^{137}Cs, ^{90}Sr, and tritium activities measured at White Oak Dam (Table 3.7) with the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goal (Table 3.5) is the basis for remedy effectiveness evaluation for protection of the Clinch River.

Figure 3.7 shows the annual average and average-plus-one standard deviation activities of ^{137}Cs, ^{90}Sr, and tritium at White Oak Dam for FY 2001 through FY 2015. Total annual rainfall at the ORNL is provided to enable long-term comparison of contaminant response to rainfall. *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goals for these three contaminants for protection of the Clinch River as a public water supply are also shown. The monthly flow-paced sampling provides continuous sampling of surface water at each sample station to ensure the best available measure of the time- and flow-weighted average contaminant activity.

Comparison of ^{137}Cs, ^{90}Sr, and tritium activities (Table 3.7) measured at 7500 Bridge, WCWEIR, and MBWEIR, which are upstream integration monitoring locations, with the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goal for a recreational scenario (Table 3.6) indicates that all average concentrations for FY 2015 are below the risk-based goals for these constituents. Comparison of the monitoring results from White Oak Dam (Table 3.7) with the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goals for discharges to the Clinch River (Table 3.5) shows that the goals were met throughout FY 2015. Additional information concerning CERCLA contaminant monitoring at the 7500 Bridge is presented in Chapter 2, as applicable to goals of the *Record of Decision for Interim Actions at Bethel Valley Watershed* (DOE/OR/01-1862&D4).

Figure 3.8 shows the annual radionuclide flux for ^{137}Cs, ^{90}Sr, and tritium measured at White Oak Dam and the ORNL site total annual rainfall from FY 2001 through FY 2015. During FY 2015, rainfall was slightly greater than the long-term average of 54 in. The total fluxes of ^{137}Cs, ^{90}Sr, and tritium measured during FY 2015 remained low and comparable to the FY 2007 through FY 2014 values.

The Melton Valley ROD stipulates that AWQC be met in surface water in a reasonable amount of time. The most recent review conducted in the *2011 Third Reservation-Wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2) that included WOC mainstem and tributary sample locations indicated that for 13 sampled locations the only instance of a ROD COC exceeding the AWQC was a single mercury measurement at one location.

3.2.1.2.1.3 Tributary Surface Water Monitoring Results

Tributary monitoring locations (Figure 3.6) are sampled to evaluate the effect of remediation on water quality in tributaries to WOC and Melton Branch. Samples are obtained by the grab method, except at Waste Area Group 6 (WAG 6) MS-3 and SWSA 4 SW1 where flow-paced composite sampling is performed. Radiological remediation level goals for surface water in the Melton Valley tributaries are in Table 3.6. All results are well below the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) recreational goals for surface water. Graphs showing average annual concentrations of the major radionuclides over time at key tributary monitoring locations are in Figures 3.9 and 3.10. Examination of these figures indicates that in most areas radiological contaminant levels are either continuing to decrease compared to pre-2006 Melton Valley remedy completion data or have reached essentially stable levels. As shown in the middle panel of Figure 3.9, ^{90}Sr levels in the HRE Tributary downstream of the HRE facility (HRT-3 WEIR) showed an increasing trend for FY 2012 and continue to fluctuate through FY 2015. The cause of this increasing trend was investigated during FY 2014. Surface water grab samples were collected from the HRE tributary upstream and downstream of the HRE facility and from the small tributary on the east side of the facility. The results indicated that contamination enters the tributary east of the HRE from secondary contaminants associated with the abandoned LLLW transfer piping on the north side of Melton Valley Drive. Contaminant concentrations in the HRE tributary continue to remain below ROD risk-based goals for surface water upstream of White Oak Dam (Table 3.6).

Table 3.7. Summary of FY 2015 radiological contaminant levels at surface water integration points in Melton Valley

	7500 Bridge			WCWEIR			MBWEIR			White Oak Dam		
Monthly composite date	^{90}Sr	Tritium	^{137}Cs	^{90}Sr	Tritium	^{137}Cs	^{90}Sr	Tritium	^{137}Cs	^{90}Sr	Tritium	^{137}Cs
29-Oct-14	29.2	13100	16.6	26	14,000	120	53	7,900	<4.6	54	15,000	130
26-Nov-14	28.6	18800	106	23	20,000	23	41	13,000	<4.3	50	18,000	17
31-Dec-14	28.8	8500	9.41	21	10,000	10	36	6,200	<4.7	51	11,000	12
28-Jan-15	20.2	9290	8.83	19	5,200	22	29	2,900	<4.2	28	4,900	25
25-Feb-15	29.4	6250	13.9	44	12,000	17	45	4,300	<5.1	57	7,400	5.4
25-Mar-15	29.1	7960	7.9	41	6,000	13	28	2,600	<4.4	60	6,200	12
29-Apr-15	36.1	4330	10.6	33	4,700	21	29	2,800	<3.3	51	5,100	11
27-May-15	34.8	6280	12.7	30	3,900	13	32	7,600	<4.3	54	4,200	75
24-Jun-15	**40.1**	12300	11.6	42	8,600	37	29	4,100	<4.4	59	6,400	61
29-Jul-15	33.6	15700	7.13	44	7,400	8.3	52	4,800	<4.3	67	5,600	11
26-Aug-15	**50**	16600	63.6	53	23,000	9.8	38	10,000	<4.2	67	16,000	19
30-Sep-15	**59.1**	30300	20.5	52	28,000	91	37	12,000	<4.2	74	25,000	51
Average activity (pCi/L)	34.9	12,500	30.0	35.7	11,900	32	37.4	6,500	<4.3	56	10,400	36
ROD Goal[a]	*37*[b]	*1.04E+8*	*33*[b]	*1.33E+5*	*1.04E+8*	*2.37E+5*	*1.33E+5*	*1.04E+8*	*2.37E+5*	85	58,000	150

[a]Melton Valley ROD goals per Tables 3.5 and 3.6.
[b]Bethel Valley ROD goals.

Bold value indicates sample concentration exceeds *Melton Valley or Bethel Valley ROD goal.*
Activity values are pCi/L.

FY = fiscal year
MBWEIR = Melton Branch Weir
ROD = Record of Decision
WCWEIR = White Oak Creek Weir

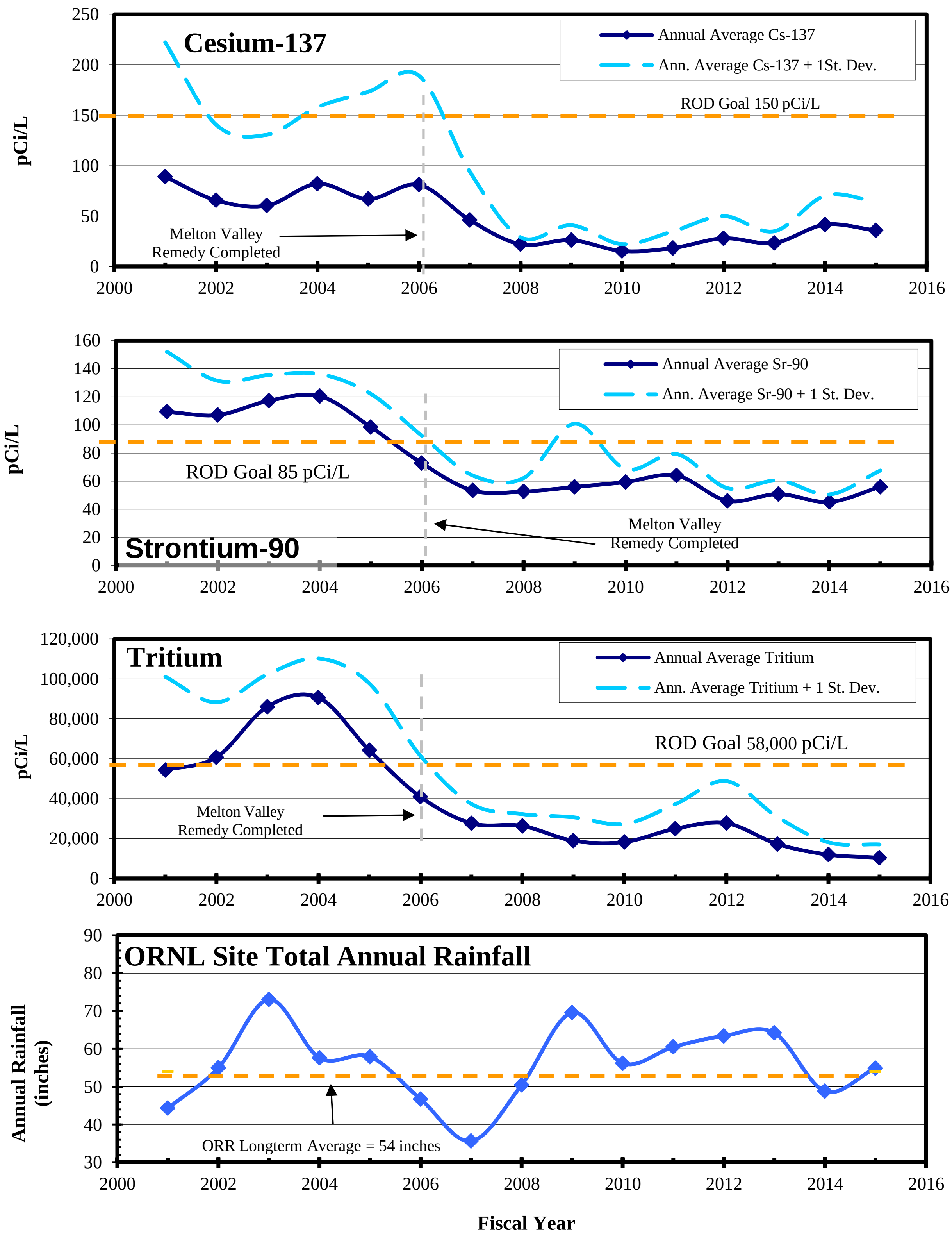


Figure 3.7. Annual average surface water activities of ^{137}Cs, ^{90}Sr, and tritium at White Oak Dam.

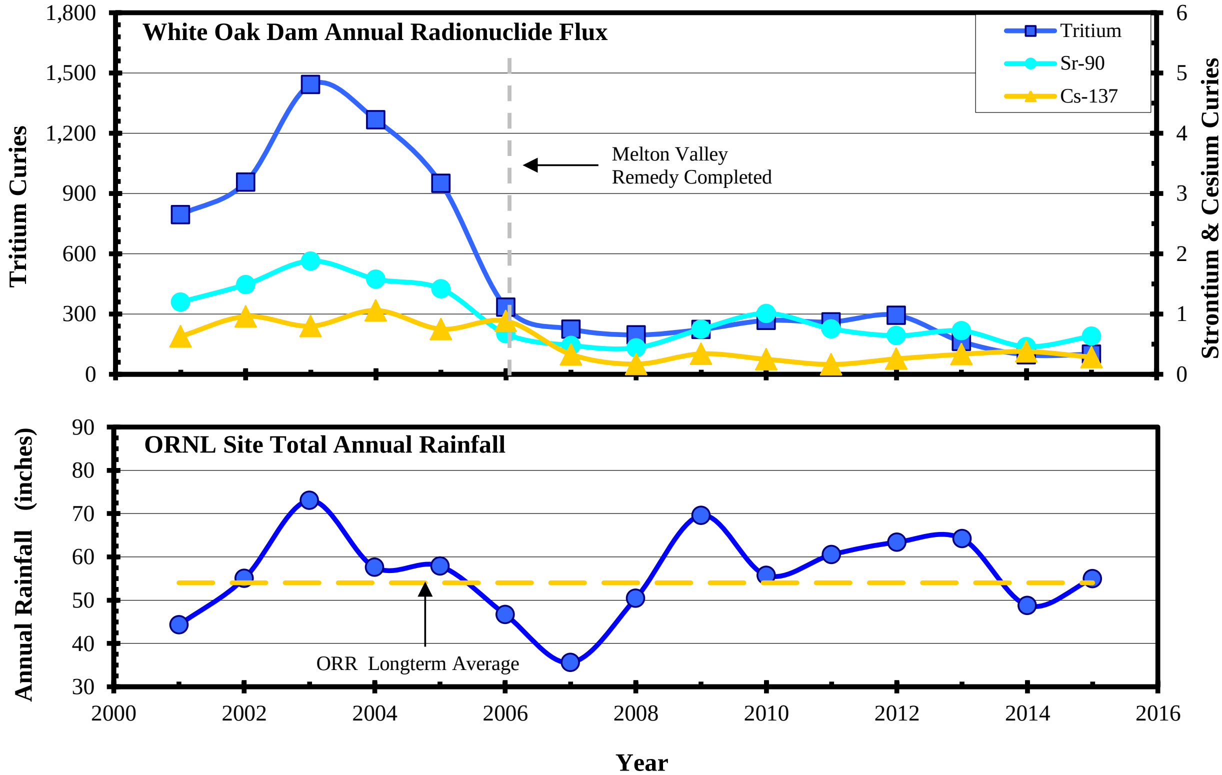


Figure 3.8. Annual radionuclide fluxes at White Oak Dam and annual rainfall at the ORNL.

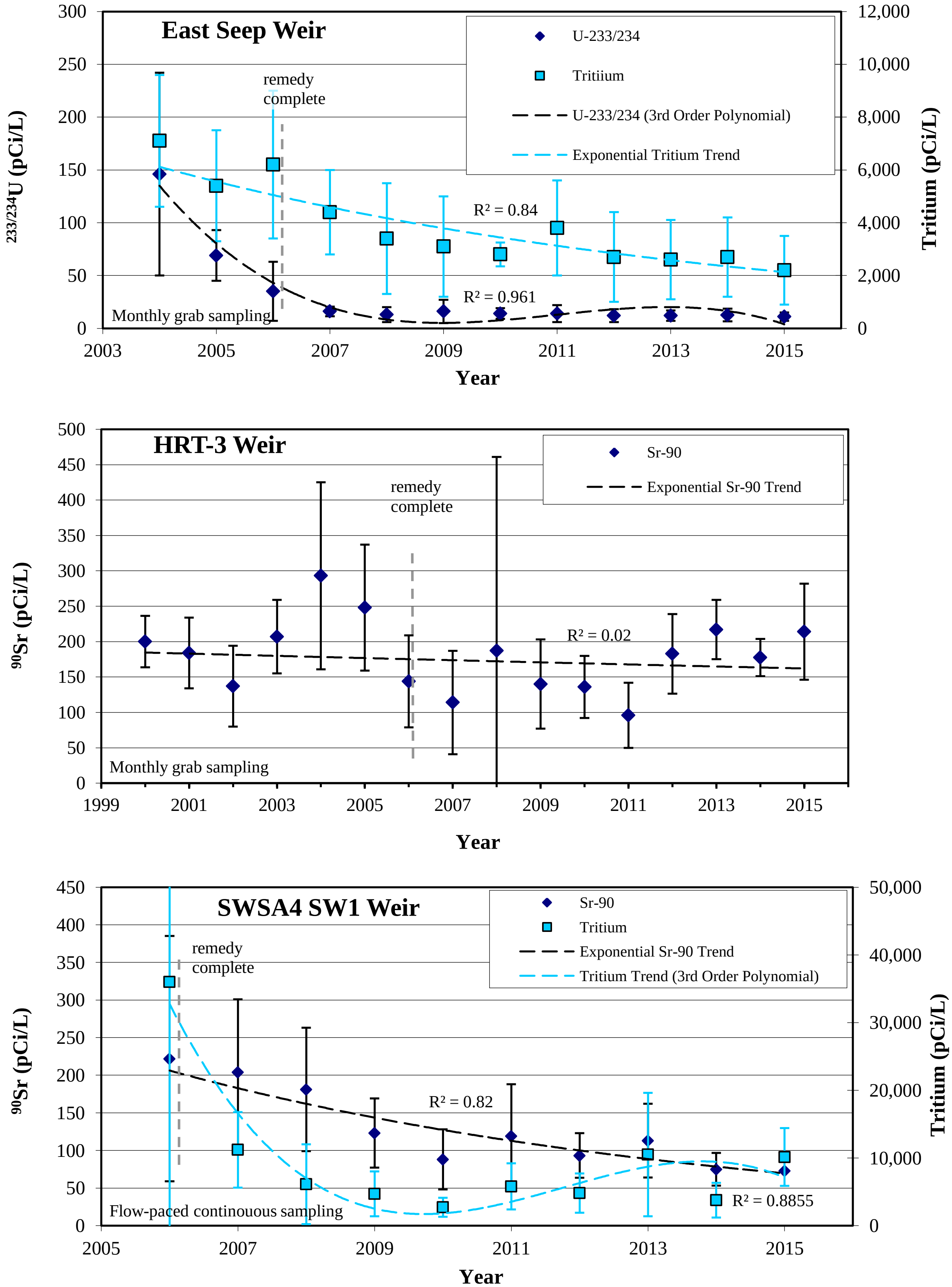


Figure 3.9. Tributary surface water average annual radionuclide activities at East Seep Weir, HRT-3 Weir, and SWSA 4 SW1 Weir.

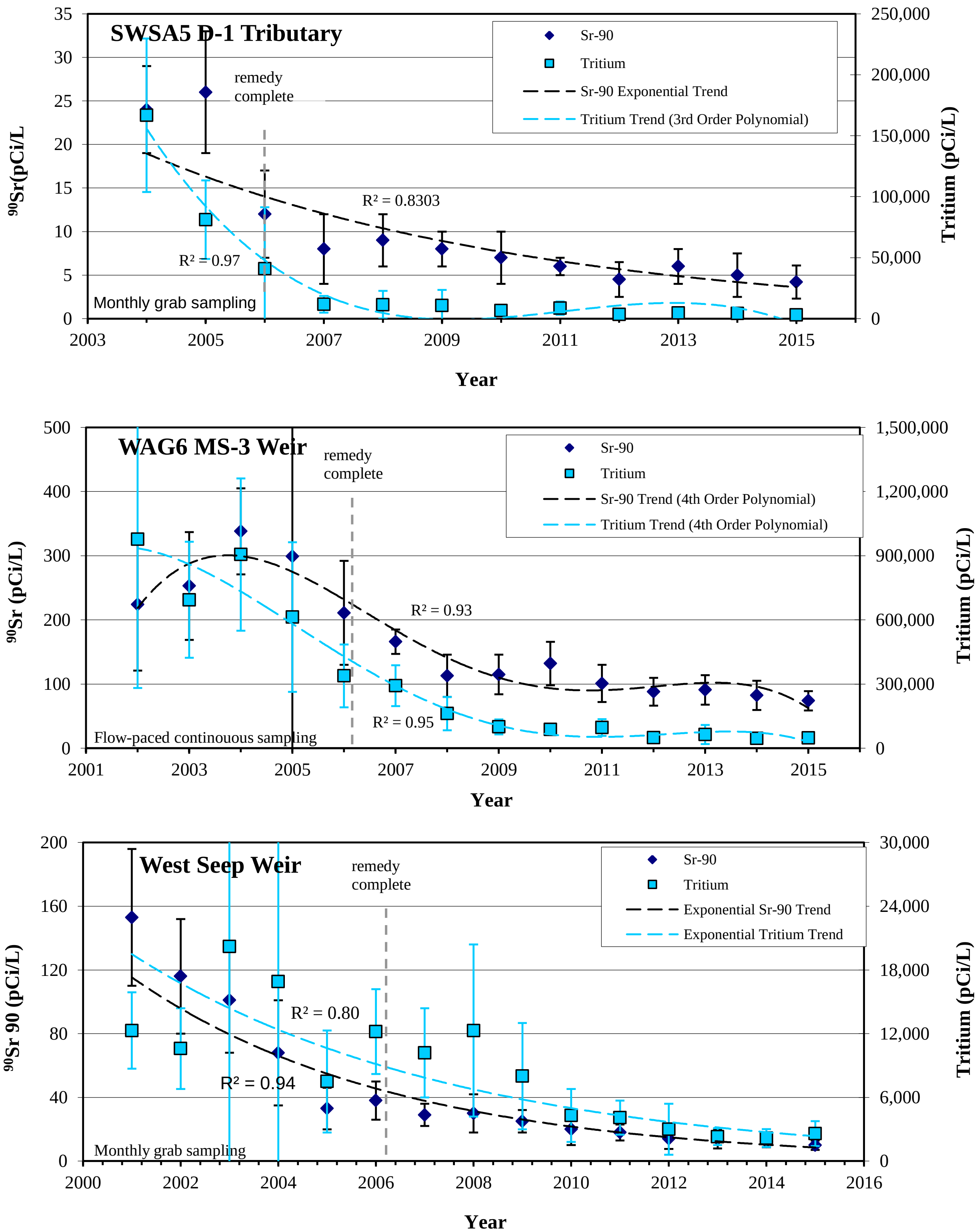


Figure 3.10. Tributary surface water average annual radionuclide activities at SWSA 5 D1-Tributary, WAG 6 MS-3 Weir, and West Seep Weir.

3.2.1.2.2 Groundwater Monitoring

3.2.1.2.2.1 Groundwater Quality Goals and Monitoring Requirements

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) RAO for groundwater is to mitigate further impact to groundwater in the waste management and industrial land use areas (Table 3.2). The ROD did not specify ARAR-based groundwater remediation levels and meeting such ARAR-based levels is not a performance objective of the ROD. Mitigation of further groundwater impacts from the Melton Valley CERCLA units was a goal of hydrologic isolation of buried waste, *in situ* grouting of Liquid Waste Seepage Trenches 5 and 7, and excavation of contaminated soils and pond sediment per the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3). The performance metric for hydrologic isolation effectiveness is based on reduction of groundwater contact with principal threat source materials in shallow land waste burial units (Table 3.3). Groundwater level control in hydrologic isolation areas is discussed in Section 3.2.1.2.2.2.

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3). stipulates that groundwater be monitored in the exit pathway along the western edge of the valley, in the vicinity of the hydrofracture waste injection sites, and in the vicinity of contaminant source control areas. Monitoring results obtained to date in these areas, including SWSA 6, are discussed in Section 3.2.1.2.2.3.

3.2.1.2.2.2 Groundwater-Level Control in Hydrologic Isolation Units

Minimization of surface water infiltration and groundwater inflows into buried waste to reduce contaminant releases is key to the concept of hydrologic isolation. Prior to remediation, groundwater levels were observed to rise into waste burial trenches in many areas of Melton Valley. In some areas waste trenches were known to completely fill with water during winter months allowing contaminated water to run overland to adjacent streams. Contact of rainfall percolation water with buried waste materials was the source of contaminated leachate that subsequently seeped downward into the groundwater and laterally to adjacent seeps, springs, and streams.

The Melton Valley remedy utilizes multilayer caps to prevent vertical infiltration of rainwater into buried waste and upgradient storm flow interceptor trenches, where necessary, to prevent shallow subsurface seepage from entering the areas laterally. Downgradient seepage collection trenches were constructed in several locations along downgradient perimeters of buried waste units. Seepage that is pumped from these trenches is piped to the ORNL PWTC for treatment prior to discharge to WOC in Bethel Valley. Since an impermeable cutoff wall was not part of the design of the SWSA 4 downgradient trench, continuous pumping from the trench is required to maintain a groundwater capture gradient in the three-section trench to prevent contaminant discharge to the former Intermediate Holding Pond (IHP) area. At the other Melton Valley downgradient trench locations, bentonite slurry walls were constructed adjacent to the groundwater capture trenches to eliminate inflows from outside the contained area.

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) includes the performance goal of reducing groundwater-level fluctuations within hydrologically isolated areas by >75% from preconstruction fluctuation ranges (Table 3.3). The performance goal of attaining a >75% reduction in groundwater-level fluctuations created a design requirement to minimize, as much as possible, the contact of groundwater with buried waste to reduce the contaminated leachate formation process. As such, the fluctuation range is most relevant in cases where groundwater levels rise into the waste burial elevation zone. Groundwater-level fluctuations at elevations below the contaminant sources have less importance to the overall remedy effectiveness. During the remedial design of each hydrologic isolation area, wells were selected for monitoring the post-remediation groundwater-level fluctuations.

Pre-remediation baseline fluctuation ranges were evaluated for the wells and target post-remediation groundwater elevations were determined to indicate that groundwater levels had dropped to below the 75% fluctuation range elevation.

Figure 3.11 shows the locations where groundwater-level monitoring is conducted to evaluate hydrologic isolation performance. Wells shown within capped areas (52 wells) and along the northern edge of SWSA 4 where the upgradient stormflow diversion trench is located (three wells within or upgradient of the trench) are used to evaluate hydrologic isolation effectiveness. Six wells (in addition to the other 55 wells used to monitor caps) were specified in Melton Valley closure documentation to monitor groundwater levels at the SWSA 4 downgradient groundwater collection trench. Since remedy operation started in 2006, DOE has increased the number of wells used to monitor the SWSA 4 downgradient to a total of 14 wells to provide thorough data coverage of the area. As shown on the inset in Figure 3.11, groundwater elevation monitoring of six wells along the SWSA 4 downgradient trench (DGT) was required in the Melton Valley RAR. DOE also monitors water level in eight additional wells along the DGT on a discretionary basis to better understand and manage the groundwater collection at that site. Symbol shape and color on Figure 3.11 indicate locations where the maximum observed groundwater elevation attains (is lower than) or exceeds (is greater than) the target groundwater-level specified in the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3).

During FY 2015, 46 of the 52 wells located beneath caps and used to monitor hydrologic isolation effectiveness met their target groundwater elevations while six wells did not meet the goal – wells 0850 and 4127 in SWSA 6, and wells 0955, 0958, and 1071 in SWSA 4. Well 2018 in SWSA 5 North also had two measurements during FY 2015 that exceeded the target groundwater elevation, however the remaining 10 measurements indicated that the well was dry. Well 2018 is at the edge of the small cap that covers four transuranic (TRU) waste disposal trenches. Being at the edge of the cap, the well can be influenced by rainfall percolation from outside the capped area. The other two nearby wells (2019 and 2020) were dry on all 12 monthly measurement dates. Since monitoring at well 2018 started in 2007, 19 of 96 monthly measurements have indicated that there was water in the well. Eleven of the 19 observations have exceeded the target groundwater elevation. The highest frequency of target water level exceedances and observations of water present in the well occurred in FY 2010 which was a nearly average year for rainfall. The two observations of water in well 2018 show the ephemeral nature of water percolation at the cap edge and are interpreted as not indicating a problem with the adjacent cap because of the low frequency of occurrence.

Since monitoring for the Melton Valley ROD goals was initiated, five of the wells have typically had some exceedance of their target elevations each year. For the five locations that have chronically not attained the ROD goal, an issue was identified in the 2015 RER to review conditions, including potential modifications to monitoring and applicable CERCLA documentation. The following discussions related to the conditions that cause the wells to exceed ROD goals and recommendations are intended to fulfill closure of the 2015 issue related to the Melton Valley groundwater goal attainment.

Figure 3.12 shows well hydrographs and target groundwater elevations for SWSA 6 wells 0850 and 4127. Well 0850 is located in a low valley area which tends to retain groundwater beneath the cap. Groundwater levels fluctuate seasonally and to a lesser degree in response to storm events. In order to understand the effect of the cap on contaminant levels in groundwater discharging beneath the downgradient cap edge, DOE has sampled and analyzed groundwater from well 0838 (shown on Figure 3.11) which is located approximately 300 ft downgradient of well 0850. The monitoring data show that contaminant levels in well 0838 are low and tritium activity in the well has decreased from over 200,000 pCi/L in 2004 to approximately 2,800 pCi/L in 2015. This decrease in contaminant concentrations downgradient of the area monitored by well 0850 indicates that although the groundwater levels remain somewhat elevated compared to the ROD goal, the hydrologic isolation remedy is performing quite satisfactorily. DOE

recommends that groundwater levels in well 0850 continue to be monitored for the purpose of trending the annual groundwater levels with no further target elevation criterion. The purpose of continued water level monitoring for trending purposes could identify groundwater level increases if cap deterioration allows inleakage of rainwater upgradient of the well.

Well 4127 in SWSA 6 is a 44 ft deep bedrock that shows an elevated groundwater level in bedrock beneath the local waste burial trench floors. DOE recommends modifying this well by plugging the portion of the borehole deeper than the bedrock surface at a depth of 23 ft and enabling monitoring of groundwater level fluctuations above the bedrock surface. Buried solid waste in the vicinity was all placed shallower than the top of bedrock.

Well 1071 located in the western portion of SWSA 4 is a 25 ft deep (measured from original ground surface) bedrock well and is approximately 20 ft inside the capped area from the upgradient stormflow diversion trench. The bedrock surface lies approximately 10.5 ft below the original ground surface (elevation 799.5) and the top of screen in the well is 9.25 ft (elevation 800.7) from the original ground surface. The as-built invert elevation of the upgradient trench near well 1071 is approximately 808 ft aMSL which is several feet higher than the top of the well screen and maximum measured water levels in the well. Based on this construction geometry the upgradient trench would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. The fluctuation range measured at well 1071 based on the continuous water levels indicates that the target fluctuation range (2.25 ft) was met during FY 2015 although the water level measured was higher than the target goal. The well hydrograph shown in Figure 3.13 shows that since continuous water level monitoring was initiated in the spring of 2012, the annual low groundwater levels have been approximately at the target groundwater level with seasonal fluctuations that have risen to approximately 1 ft above the target level. Since well 1071 is measuring groundwater in a zone deeper than the head-controlling upgradient trench, DOE recommends that the monitoring objective for this well be modified to observe long-term head trends with discontinuation of the target elevation concept. The purpose for long-term monitoring would be to use well 1071 data to observe whether progressive increases in groundwater level occur in the area.

Wells 0955 and 0958 are located in eastern SWSA 4 beneath the hydrologic isolation cap on the burial ground side of the downgradient groundwater interceptor trench (Figure 3.11). The design intention of the downgradient trench is to maintain a lower groundwater level in the trench than beneath the former IHP area to the east. The reason wells 0955 and 0958 at SWSA 4 typically do not meet target groundwater levels is because groundwater levels in these wells are directly tied to the groundwater levels in the downgradient collection trench. Water levels in the trench cycle up and down based on the cycling of the extraction pumps. Seasonal fluctuations in groundwater influx combined with occasional surface inflows from high water levels in the IHP cause water levels to rise in the collection trench which overwhelms the pumping capacity of the extraction wells in the trench. During FY 2015, 10 of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation and at well 0958 two of the required quarterly groundwater level measurements exceeded the groundwater elevation goal. Both of these wells are constructed at levels much lower than the buried waste in SWSA 4 and their water level fluctuations are not indicative of water fluctuating in buried waste. As shown on Figure 3.14, these wells have experienced target elevation exceedances for most of the years they have been monitored. In terms of SWSA 4 downgradient trench performance evaluation, data from these wells is not essential because DOE has a total of 14 continuously monitored wells that are used to evaluate the groundwater gradient between the collection trench and the IHP area. DOE recommends that groundwater level monitoring in wells 0955 and 0958 be discontinued as a performance requirement.

By design, the operation of the SWSA 4 downgradient trench relies upon maintaining lower groundwater levels within the trench compared to levels beneath the former IHP area to the east and beneath the

hydrologic isolation cap to the west. If the groundwater extraction pumps installed in the gravel backfilled trench cannot pump enough water, some groundwater can escape into the surface water in the IHP area. Figure 3.15 shows hydrographs for FY 2015 from wells constructed in the downgradient trench and in the IHP area. During the winter months, groundwater recharge is much greater than during the growing season and all the groundwater collection systems produce much more flow. Groundwater levels in the SWSA 4 downgradient trench rose to levels essentially the same as levels in the IHP area. During FY 2015, downgradient trench extraction pump problems occurred in downgradient trench segments A and B, which allowed groundwater levels in the trench to rise above design levels for prolonged periods. Figure 3.15 shows that for the A segment there were elevated in-trench water levels from April until mid-September. In the B trench segment there were apparent groundwater extraction problems between mid-July and mid-September. Similar problems have occurred with the SWSA 4 downgradient trench previously and during FY 2013 a project was implemented to redevelop all the groundwater extraction wells in the SWSA 4 downgradient trench and replace failed pumps to improve the remedy performance.

A secondary measure of the SWSA 4 downgradient trench performance is the contaminant discharge from the IHP area as measured at SWSA 4 SW1, which is the location where surface water from the IHP area flows into WOC (data presented in previous section). As shown in Figure 3.9, during FY 2013 there was a slight increase in measured ^{90}Sr and tritium levels in the surface water at SWSA 4 SW1 during the period when downgradient trench extraction well refurbishment was ongoing. During FY 2014 ^{90}Sr and tritium levels at SWSA 4 SW1 decreased somewhat and during FY 2015 the average tritium concentration rose again while the ^{90}Sr level remained nearly constant. Monitoring data from FY 2014 and 2015 show that the groundwater level control in the downgradient collection trench remains challenged during winter months and that problems with pumping system reliability continue. Performance of the SWSA 4 downgradient trench will be evaluated in the 2016 FYR process.

Appendix B.2 contains a tabular summary of groundwater level monitoring results compared to target groundwater elevations. Well hydrographs showing groundwater level responses during FY 2007 through FY 2015 are also included in Appendix B.2.

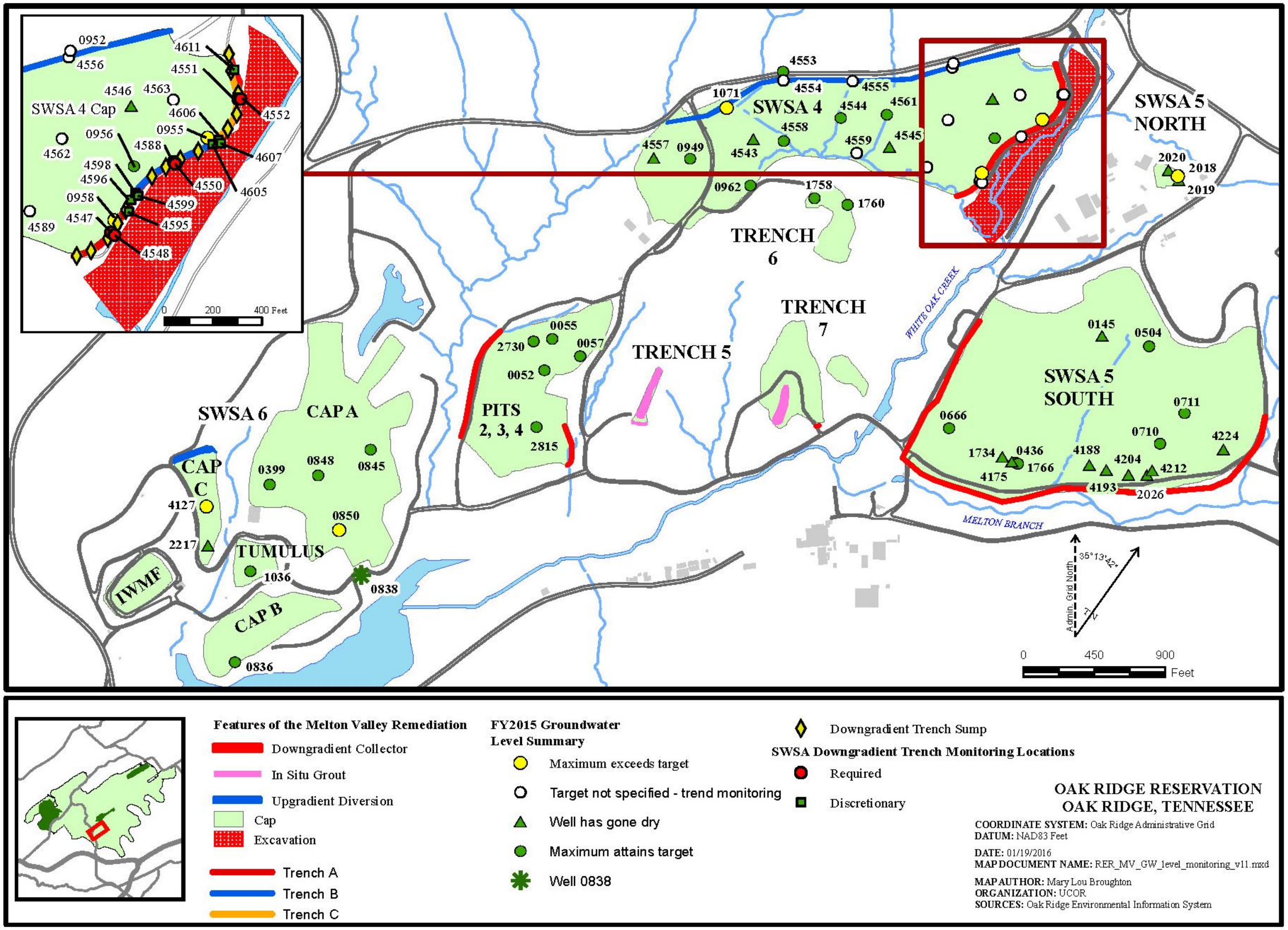
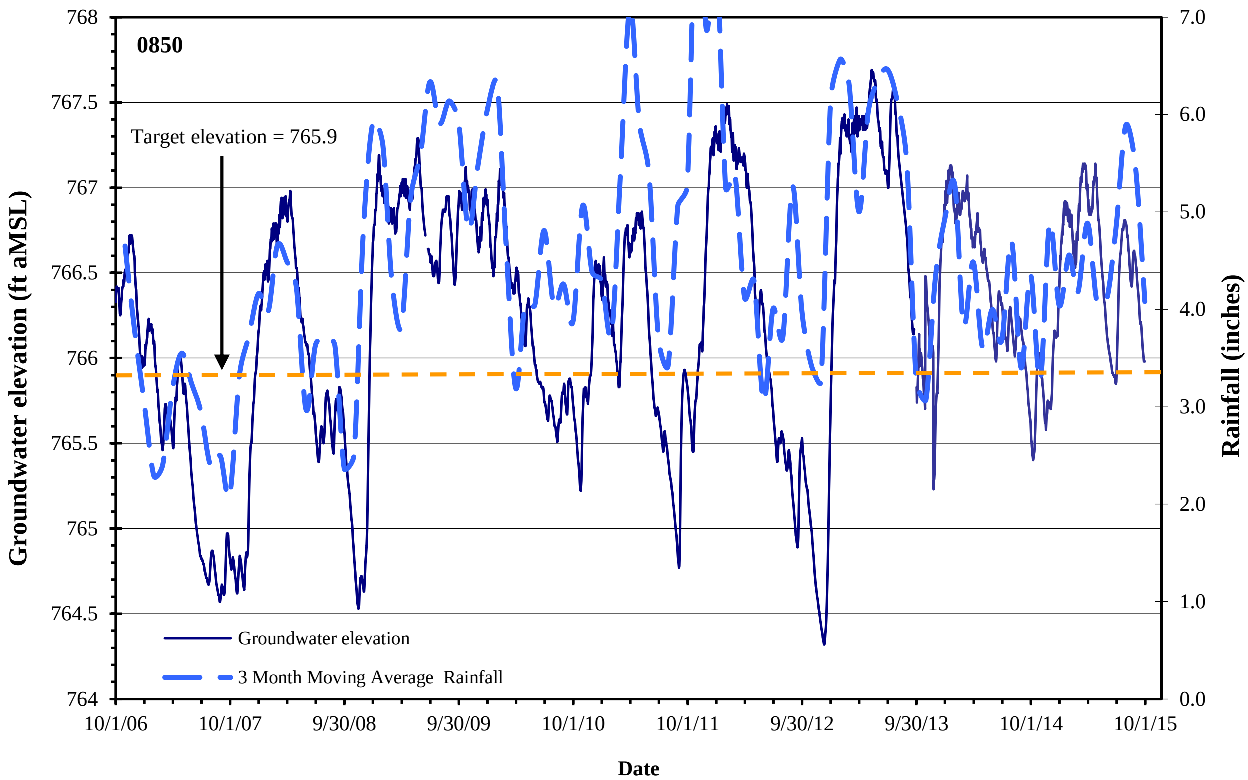


Figure 3.11. Summary of groundwater-level monitoring results for FY 2015.



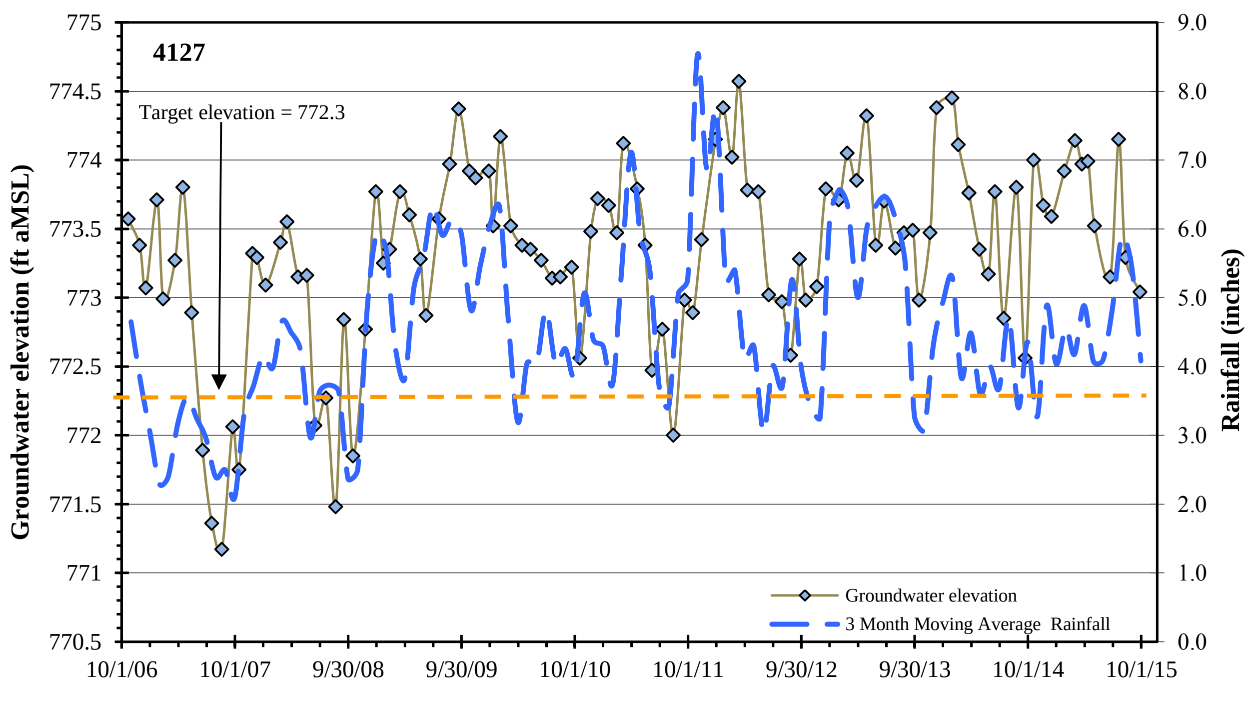


Figure 3.12. Hydrographs for wells 4127 and 0850 for FY 2007 – FY 2015.

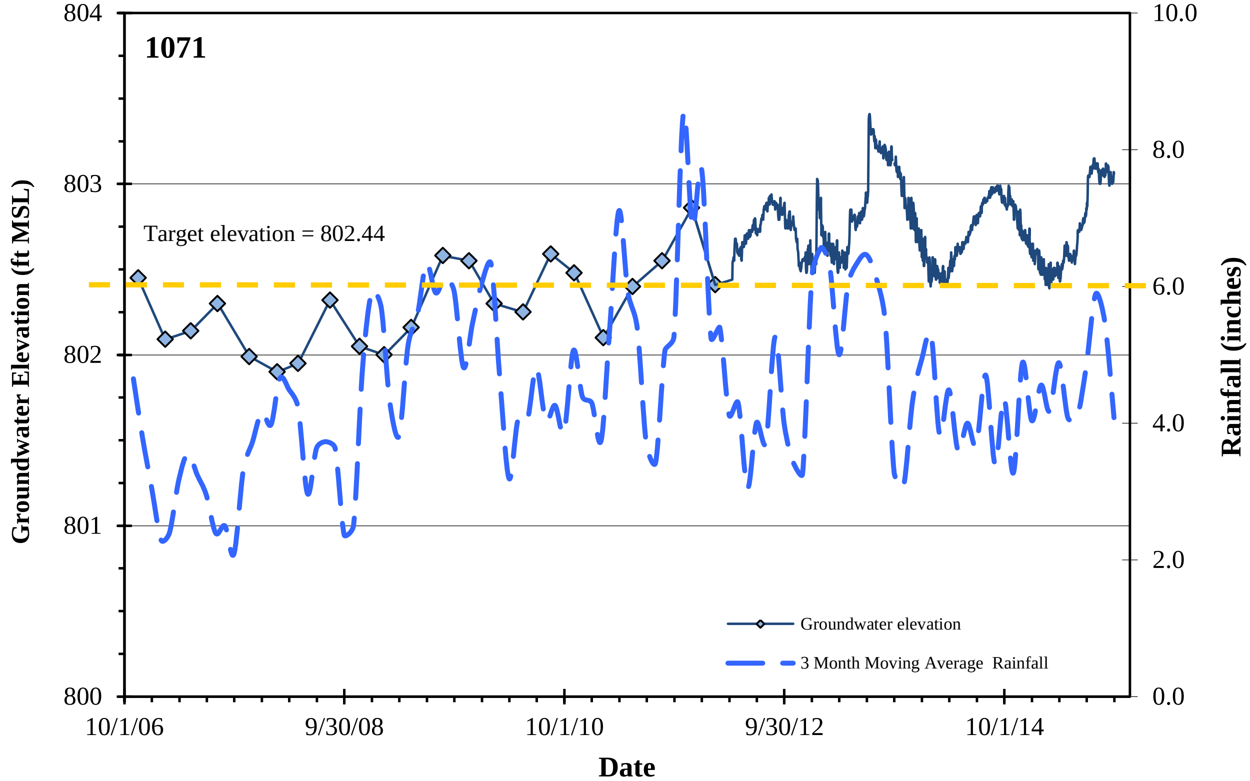
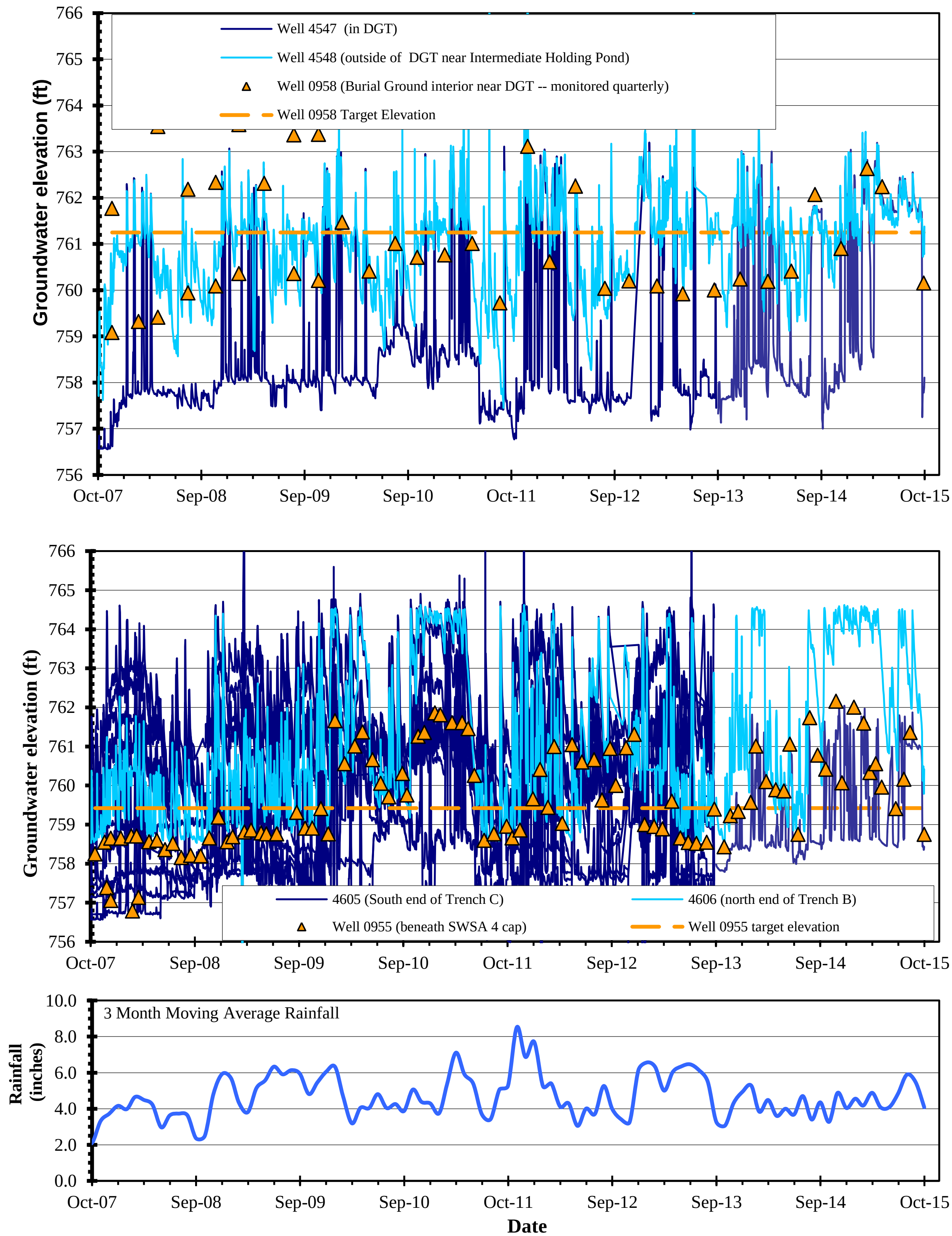


Figure 3.13. Hydrograph for well 1071.



DGT - downgradient trench IHP = Intermediate Holding Pond SWSA = solid waste storage area

Figure 3.14. Hydrographs of wells in SWSA 4, the downgradient trench, in the former IHP area.

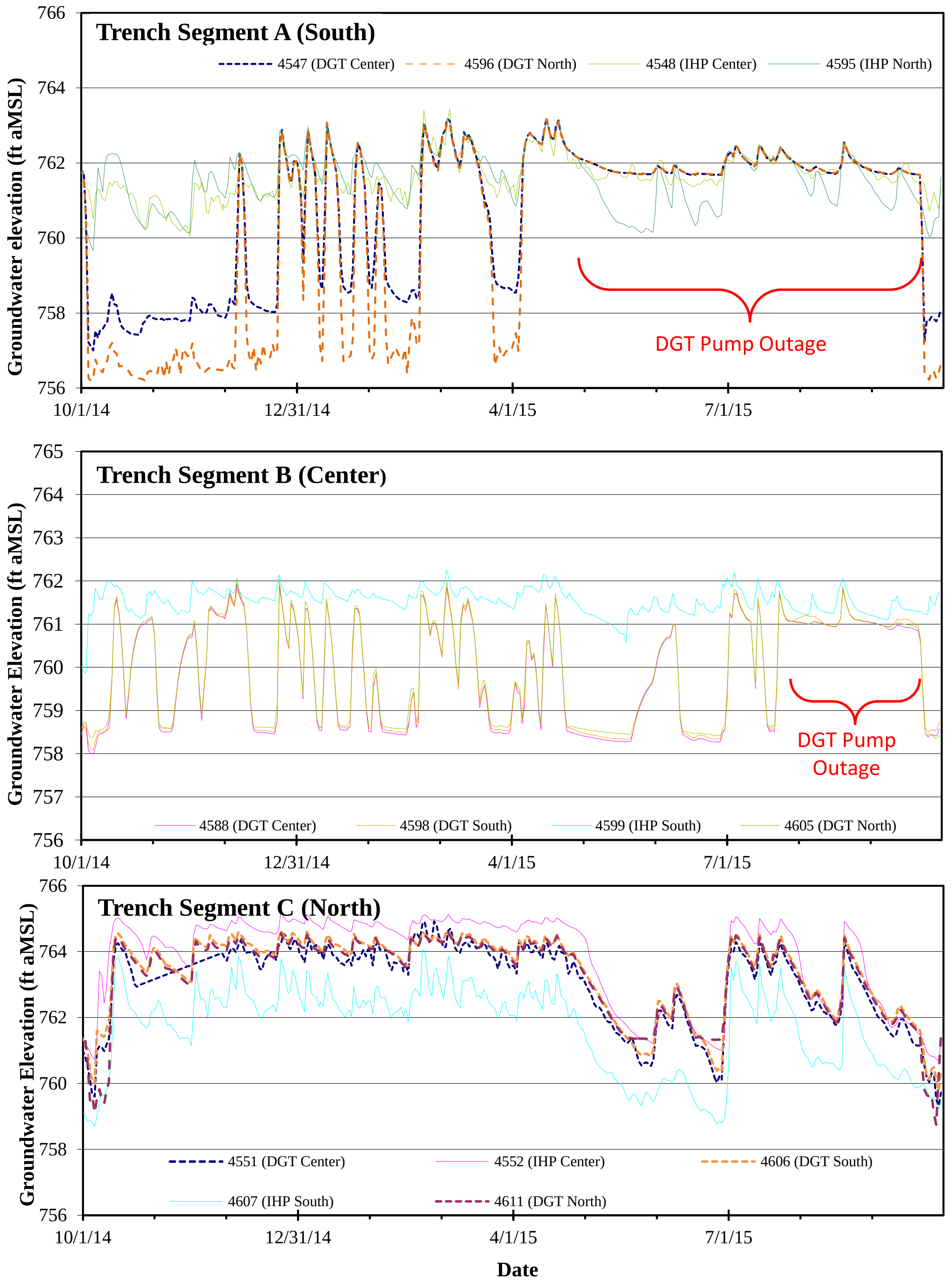


Figure 3.15. Hydrographs from piezometers monitoring the SWSA 4 downgradient trench performance.

3.2.1.2.2.3 Groundwater Quality

Groundwater monitoring is conducted for CERCLA remediation effectiveness evaluation in Melton Valley exit pathway wells, near the Seepage Pits and Trenches, and around the Tumulus low-level solid waste disposal facility in SWSA 6. Additionally, groundwater monitoring is conducted at SWSA 6 under CERCLA. As discussed in Section 1.1, the CERCLA program provides RCRA-equivalent post-closure care of the unit through compliance with RCRA substantive requirements.

Seepage Pits and Trenches Area Groundwater Quality

Groundwater monitoring is conducted in wells located around the perimeter of the Seepage Pits and Trenches area (formerly referred to as WAG 7), as well as in the immediate proximity of LLLW Seepage Trenches 5 and 7.

Figure 3.16 shows the locations of wells that are monitored at the Pits and Trenches area. Monitoring of these wells was started prior to conducting the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) RAs. At Pits 2, 3, and 4, the remedy consisted of constructing a multi-layer hydraulic isolation cap over the three large seepage basins and constructing groundwater collection trenches along the western and eastern cap edges to collect contaminated groundwater. At Trenches 5 and 7, in situ grouting was used to fill voids in the gravel-filled trenches and reduce permeability of the surrounding soil. After grouting was complete, hydrologic isolation caps were constructed over the trench area at Trench 5 and over the trench and adjacent contaminated soil areas at Trench 7. A small groundwater seepage collections trench was constructed at the mouth of a valley on the east side of Trench 7 where a radiologically contaminated seep had previously existed.

Groundwater contaminants of concern at the Seepage Pits and Trenches are primarily radionuclides. Principal radionuclides detected at the Seepage Pits and Trenches include ^{14}C, ^{60}Co, ^{90}Sr, ^{99}Tc, tritium, ^{232}U, $^{233/234}U$, and ^{238}U. Carbon-14 was a constituent of the LLLW disposed in the seepage trenches, and because the chemical treatment used to immobilize strontium and cesium had little effect on carbon, this contaminant is detected in many wells near the Pits and Trenches. The highest levels of groundwater contamination in the Seepage Pits and Trenches area occur in the immediate vicinity of Trenches 5 and 7. Table 3.8 includes a summary of radiological contaminants for 14 wells in the Pits and Trenches area where radiological contaminants exceed risk-based screening criteria. Included in the table are the location of the well with respect to its contaminant source, the well number, principal radiological contaminants in the well, the average pre-remediation (February 2004 – September 2006) activity level, the average FY 2015 activity level, and the ratio of FY 2015 activity to pre-remediation activity (which indicates the factor by which contaminant levels have changed since remediation). Table 3.8 identifies the trend of radionuclide activity levels based on the 10 most recent analytical results per analyte per well during the post-remediation time period (January 2008 through September 2015) based on the Mann-Kendall non-parametric trend evaluation approach. This approach to trend evaluation analyzes the cumulative direction (increasing, decreasing, or stable) of concentration change of an analyte through time. The Mann-Kendall method requires at least four results for a parameter to conduct the trend evaluation. Sufficient data for trend analysis were available for all applicable contaminants. The method provides a 90% confidence level that the trend is significant. It is noted that the post-remediation trend is not related to the ratio of FY 2015/pre-remedy activity levels for the well. The trend is restricted to the post-remediation behavior of radiological contamination.

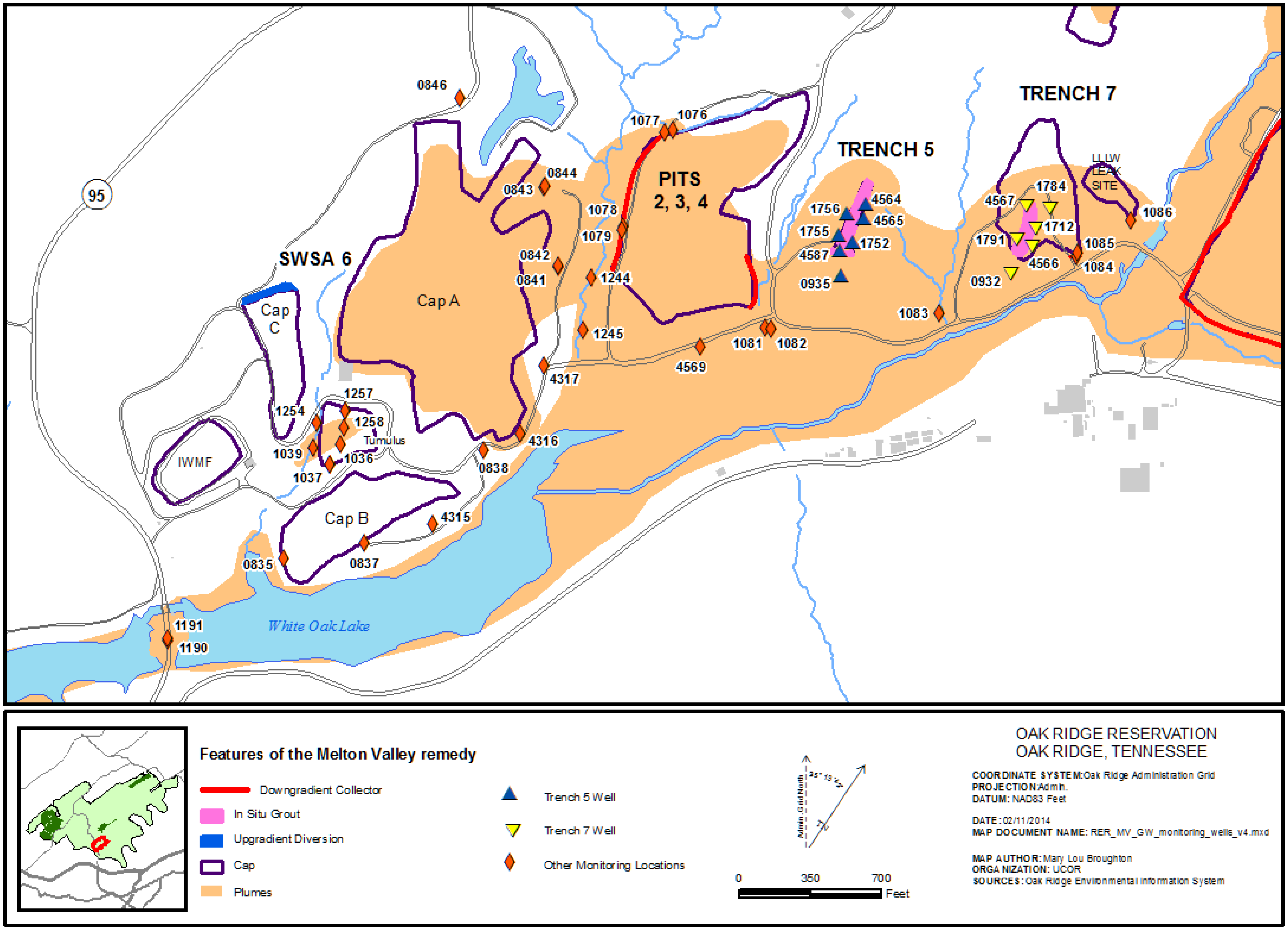


Figure 3.16. Locations of wells monitored in the vicinity of the Seepage Pits and Trenches and SWSA 6.

Table 3.8. Summary of radiological groundwater contaminants detected at Seepage Pits and Trenches

Area	Well	Contaminant	Average Activity (pCi/L) Pre-Remedy	Average Activity (pCi/L) FY 2015	Ratio (FY 2015/Pre-Remedy)	Exceeds Screening Level	M-K Post-Remedy Trend
Pits 2, 3, 4	1079	Alpha activity	478	207	0.4	MCL	Stable
		Tritium	130,333	75,117	0.6	MCL-DC	Decreasing
		Uranium-233/234	264	215	0.8	Residential	Decreasing
Trench 5	0935	Tritium	38,000	23,167	0.6	MCL-DC	Decreasing
	1752	Alpha activity	932	1,262	1.4	MCL	Increasing
		Carbon-14	246,667	78,017	0.3	Industrial	Stable
		Technetium-99	28,100	5,262	0.2	MCL-DC	Stable
		Uranium-232	66.7	192	2.9	Industrial	Increasing
		Uranium-233/234	593	963	1.6	Industrial	Increasing
		Uranium-238	74.1	90.6	1.2	Residential	Increasing
	1755	Alpha activity	1,687	1,410	0.8	MCL	Stable
		Carbon-14	109,700	30,367	0.3	Industrial	Stable
		Technetium-99	4,177	1,363	0.3	MCL-DC	Decreasing
		Uranium-232	150	233	1.5	Industrial	Stable
		Uranium-233/234	884	1,312	1.5	Industrial	Stable
		Uranium-238	111	110	1	Residential	Stable
	1756	Alpha activity	2,464	364	0.1	MCL	Stable
		Carbon-14	59,700	10,890	0.2	Industrial	Stable
		Technetium-99	4,403	1,098	0.2	MCL-DC	Stable
		Uranium-232	189	52	0.3	Residential	Stable
		Uranium-233/234	1,416	343	0.2	Industrial	Stable
	4564	Alpha activity	73.5	28.5	0.4	MCL	Decreasing
		Carbon-14	33,467	9,645	0.3	Residential	Stable
	4565	Carbon-14	57,600	13,372	0.2	Industrial	Stable
	4587	Alpha activity	55	111	2	MCL	Stable
		Carbon-14	34,700	26,167	0.8	Industrial	Decreasing
		Technetium-99	8,150	1,770	0.2	MCL-DC	Decreasing
		Uranium-233/234	22.3	88.2	4	Residential	Stable
Trench 7	1084	Carbon-14	38,400	5,932	0.2	Residential	Decreasing
	1086	Strontium-90	14	8.0	0.6	MCL-DC	Stable
	1712	Alpha activity	290	380	1.3	MCL	Stable
		Carbon-14	59,500	29,350	0.5	Industrial	Stable
		Tritium	2,650	20,583	7.8	MCL-DC	Increasing
		Uranium-232	34.7	133	3.8	Industrial	Increasing
		Uranium-233/234	215	270	1.3	Industrial	Stable

Table 3.8. Summary of radiological groundwater contaminants detected at Seepage Pits and Trenches (cont.)

Area	Well	Contaminant	Average Activity (pCi/L)		Ratio (FY 2015/Pre-Remedy)	Exceeds Screening Level	M-K Post-Remedy Trend
			Pre-Remedy	FY 2015			
	1784	Alpha activity	54	21	0.4	MCL	Stable
		Carbon-14	16,400	7,148	0.4	Residential	Stable
	1791	Alpha activity	7	46	7	MCL	Stable
		Carbon-14	27,300	14,100	0.5	Industrial	Decreasing
		Technetium-99	898	15,000	16.7	MCL-DC	Increasing
	4566	Alpha activity	51	18.1	0.4	MCL	Stable
		Carbon-14	148,467	43,067	0.3	Industrial	Stable
		Cobalt-60	2,743	691	0.3	Residential	Decreasing
		Technetium-99	1,250	1,475	1.2	MCL-DC	Stable

Quantitative trend analysis based on M-K Test of time-series sampling/analysis results for a maximum of ten sampling events (counting backward from the most recent sampling date) of post-remedy data (after January 2008). Based on the methodology described in Gilbert (1987) and Wiedemeier et al., 1999, non-detect alpha activity results reported for wells 1791 and 4566 were replaced with the MDA as a surrogate value for M-K Test purposes. The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots within the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. The time series data define a *Stable* trend if the S statistic does not plot within the equivalent 90% confidence interval and the associated CV is <1, whereas *No Trend* is evident if the CV is >1.

CV = coefficient of variation
FY = fiscal year
Industrial = industrial scenario 1 x 10-4 risk-based activity
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration (tritium MCL-DC = 20,000 pCi/L, technetium-99 MCL-DC = 900 pCi/L, and strontium-90 MCL-DC = 8 pCi/L).
MDA = maximum detectable activity
M-K = Mann-Kendall
Residential = residential scenario 1 x 10-4 risk-based activity

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) did not specify target groundwater contaminant levels or ARAR-based performance goals but stated that the remedy should “Mitigate further impact to groundwater” (Table 3.2). To provide a sense of risk levels associated with the detected radionuclides, FY 2015 contaminant levels are compared to four screening criteria: SDWA MCLs and MCL-DCs **(**8 pCi/L for ^{90}Sr, 900 pCi/L for ^{99}Tc[2], and 20,000 pCi/L for tritium), 1E-4 risk equivalent activities for industrial (based on Risk Assessment Information System [RAIS] risk calculator) or residential (based on EPA regional screening levels) water use scenarios. Risk-based criteria of the residential scenario are lower than for the industrial scenario, so if a radionuclide exceeds the industrial screen it also exceeds the residential screen. Conversely, in Table 3.8, those radionuclides that are identified as exceeding the residential screen do not exceed the corresponding industrial screen level. The analytical suite for all the wells at the Seepage Pits and Trenches is uniform. For wells and/or analytes not included in Table 3.8, analytical results may be either not detected or do not exceed any of the listed screening criteria.

Significant radionuclide reductions have occurred at most of the wells where screening criteria are exceeded. The median ratio of FY 2015 to pre-remediation levels was 0.55, which is consistent with previous levels since FY 2011, indicating an overall reduction of groundwater contaminant levels in the area of a factor of approximately two. Forty-four combinations of locations and constituents are included in trend evaluation at the end of FY 2015. Of those 44 trends, 27 are stable (increased from 26 in FY 2014), 10 are decreasing (down from 12 in FY 2014), and seven are increasing compared to six that

[2]This maximum contaminant level derived concentration (MCL-DC) is the average annual concentration assumed to produce a total body or organ dose of 4 mrem/yr (which is the maximum contaminant level (MCL) for beta particle and photon radioactivity), as calculated using the 168 hr data list in the National Bureau of Standards Handbook 69, as amended August, 1963, Department of Commerce, which is incorporated by reference into 40 *Code of Federal Regulations* (CFR) 141.66(d)(2).

were increasing in FY 2014, five at the end of FY 2013, and 10 that were increasing as of the end of FY 2012. The reduction of increasing trends noted at the end of FY 2015 compared to the end of FY 2012 and the stable ratio of pre-remedy to current year contaminant ratios indicates that groundwater contaminant levels in the Seepage Pits and Trenches area are fairly stable. The seven increasing contaminant trends identified in Table 3.8 included increases in one well at Seepage Trench 5 and two wells at Seepage Trench 7. At Seepage Trench 5 well 1752 post-remedy concentrations are increasing for alpha activity and ^{232}U, $^{233/234}$U, and ^{238}U. At Seepage Trench 7 well 1712 post-remedy concentrations are increasing for tritium and ^{232}U and at well 1791 ^{99}Tc concentrations are increasing. At Seepage Trench 5, groundwater from the vicinity of well 1752, on the eastern side of the seepage trench, is expected to migrate toward the adjacent surface water tributary (WCTRIB-1) and then to WOC. Monitoring data from WCTRIB-1 show that alpha activity has been detected in one of four samples collected during FY 2014 and FY 2015 at approximately 25% of the MCL, ^{232}U is not detected, and $^{233/234}$U and ^{238}U were each detected at less than 0.5 pCi/L in one of two samples collected on different dates during FY 2015. There is no discernable increasing impact to surface water from the increasing groundwater trends observed in well 1752. At Seepage Trench 7 the two wells that exhibit increasing contaminant trends lie on both the east and west side of the seepage trench and ridgecrest. Since the wells lie on opposing sides of the topographic high area it is suspected that groundwater seepage moves in opposite directions for the two wells. Well 1712 lies on the eastern side of Seepage Trench 7 and it is suspected that contaminated groundwater near that well seeps eastward beneath the capped area and discharges into the nearby downgradient groundwater collection trench with no discharge to surface water. Well 1791, which lies on the western side of the Seepage Trench, has an increasing trend for ^{99}Tc and its presumed discharge pathway also heads toward WCTRIB-1. Monitoring data from WCTRIB-1 shows that ^{99}Tc is present at concentrations ranging from about 107 to 119 pCi/L based on semi-annual sampling during FY 2014 and FY 2015. Six wells at the Seepage Pits and Trenches (four at Trench 5 and two at Trench 7) have ^{99}Tc present at concentrations greater than the 900 pCi/L MCL-DC which indicates that WCTRIB-1 may be affected by contamination from either source. Monitoring of these wells will continue consistent with the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3).

Three tributaries to WOC originate in, or receive water from the Seepage Pits and Trenches, as shown on Figure 3.6. Review of the surface water tributary monitoring (Section 3.2.1.2.1.3, Figures 3.9 and 3.10) shows that levels of radiological contamination have decreased at the West Seep Creek and East Seep sampling locations. The location shown as T7-TRIB on Figure 3.6 (also known as SW7-5) is the location of a former seep that formerly contained ^{60}Co and was the subject of investigations in the 1980s. During Melton Valley closure, a groundwater collection system was installed to capture residual groundwater seepage in the area, and the entire area was capped. Thus, no more seepage occurs to WOC. The WOC TRIB-1 location is sampled during the year prior to each CERCLA FYR. The most recent FYR showed that contaminant levels there have also diminished since site closure.

SWSA 6 Groundwater Monitoring Results

SWSA 6, located at the DOE ORNL facility, is a closed shallow land burial site for LLW and other waste types. SWSA 6 was included in the EPA NPL for cleanup under CERCLA. Portions of SWSA 6 were determined to have received hazardous waste after November 1980 and, therefore, those portions of the site have been regulated under RCRA since 1986, when the determination was made that hazardous materials had been disposed.

The site was placed in interim status under RCRA awaiting final closure in a comprehensive action (the Melton Valley CERCLA Closure Project) that addressed both the RCRA and CERCLA waste units in SWSA 6. To reduce contaminant releases from the RCRA units during the interim status period, in 1988 – 1989 the areas were capped with synthetic membrane caps to prevent rainwater percolation into the buried waste.

Final site closure was accomplished in 2006 when CERCLA RAs specified for Melton Valley, including closure of SWSA 6, were completed. The Melton Valley CERCLA RAs at SWSA 6 included construction of permanent caps over all the RCRA waste disposal units, as well as most other buried waste units within the waste disposal area. The cap design and construction are RCRA compliant. SWSA 6 closure design and as-built constructed features are documented in the *Phased Construction Completion Report for Hydrologic Isolation at Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2285&D1).

As discussed in Section 1.1, annual reporting for SWSA 6 has been discontinued under RCRA but will be included in the annual RER. Former RCRA groundwater monitoring requirements for SWSA 6 have been incorporated into the CERCLA watershed-scale monitoring plan (*Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* [DOE/OR/01-1982&D3]). Annual reporting of the groundwater monitoring results for SWSA 6 will focus on monitoring results where constituents of concern are detected.

Groundwater monitoring at SWSA 6 conducted by the WRRP is a continuation of the monitoring previously prescribed for the site by RCRA requirements. The SWSA 6 groundwater monitoring program consists of sampling 10 wells formerly used for RCRA monitoring (Figure 3.16) around the perimeter of SWSA 6 with analysis for VOCs and lead that were designated as hazardous constituents regulated under RCRA. Well 0838 on the SWSA 6 perimeter is sampled to monitor groundwater quality at the mouth of a small valley near the location of a now inactive former surface water monitoring station and was not included in former RCRA monitoring. In addition, radiological constituents and other constituents are analyzed in selected wells at the site to monitor site discharges. Well 0846 is the designated upgradient well for SWSA 6 monitoring. The principal detected contaminants are VOCs, carbon tetrachloride and its degradation product chloroform, and TCE and its degradation products cis-1,2-DCE and 1,2-dichloroethane (DCA). VOCs were disposed in a number of areas in SWSA 6. One area in the eastern portion of the site is the likely source of VOCs detected since site perimeter groundwater monitoring started in the late 1980s. These constituents are detected regularly in wells 0841 and 0842, located on the eastern boundary of SWSA 6. Wells 0841 and 0842 comprise a well pair that includes a bedrock well and a shallower well that monitors groundwater at and above the soil/bedrock interface. Well 0841 monitors groundwater in bedrock at the depth of 36.5 to 56.5 ft bgs, while well 0842 is shallower with a screened interval between 8 and 28 ft bgs.

Figure 3.17 includes monitoring results of VOCs in well 0841 as well as the TCE monitoring history from well 0842. TCE, 1,2-DCA, and carbon tetrachloride are the three chlorinated VOCs in well 0841 that have exceeded their MCLs. In the early monitoring history of well 0841 none of these VOCs were detected. In the late 1990's TCE became detectable followed by 1,2-DCA and carbon tetrachloride. TCE concentrations increased rapidly in 2000 and 2001 and have decreased somewhat to levels that vary seasonally within a range of about 50 µg/L to 130 µg/L. The 1,2-DCA and carbon tetrachloride fluctuate at concentrations 1 – 2 times their 5 µg/L MCL. Other VOCs that are detected in well 0841 at concentrations less than their MCLs include chloroform, tetrachloroethene (PCE), and cis-1,2-DCE.

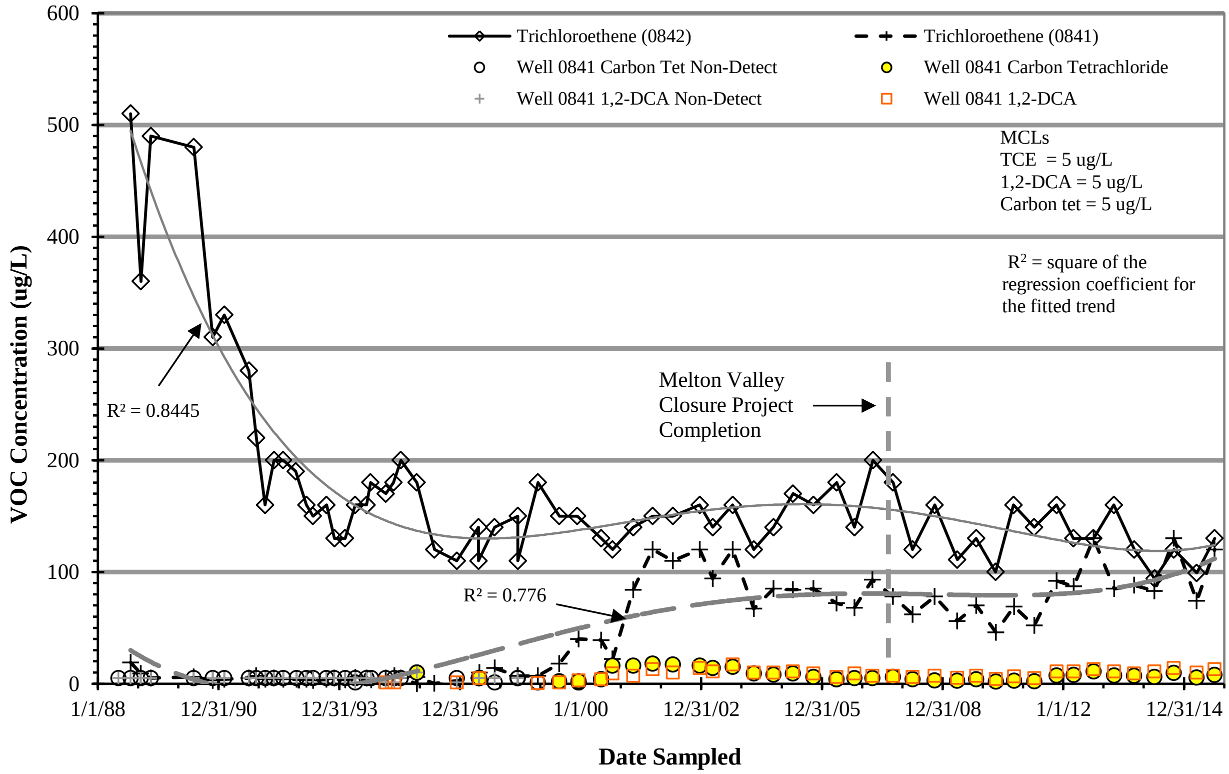


Figure 3.17. Long-term monitoring results for VOCs in SWSA 6 well 0841 and TCE in well 0842.

Figure 3.18 shows the results of long-term monitoring of TCE, carbon tetrachloride, and 1,2-DCA in well 0842. Concentrations of these three VOCs have decreased since the early monitoring period although the concentrations appear to have stabilized within fluctuation ranges of about factors of two times since the site closure was completed in 2006. Concentrations of carbon tetrachloride and 1,2-DCA are at approximately twice their MCLs while the TCE concentrations remain more than 20 times the MCL. Well 0842 has had consistently higher TCE concentrations than well 0841 and TCE concentrations in well 0842 have decreased from levels near 500 µg/L in the late 1980s to levels between 100 – 200 µg/L since about 1992. Measured TCE concentrations fluctuate seasonally with higher TCE concentrations typically measured in dry season samples and lower concentrations measured in wet season samples. This fluctuation pattern suggests that recharge of groundwater during the wet season creates a dilutional effect in the groundwater system monitored in these two wells. Following completion of hydrologic isolation of the SWSA 6 waste burial areas, the TCE concentration measured in well 0842 began to decrease somewhat.

The only other well monitored at the perimeter of SWSA 6 that contains measureable chlorinated VOCs is well 0843. During FY 2015, detected VOCs in well 0843 included cis-1,2-DCE, which was present at concentrations less than 3 µg/L, and TCE was present at concentrations of 0.53 J and 0.47 J µg/L in April and October, respectively. The MCLs for cis-1,2-DCE and TCE are 70 µg/L and 5 µg/L, respectively.

Lead is also a contaminant of concern in SWSA 6 because of disposal of lead (not lead used as a shielding material). Lead has been detected in groundwater at low concentrations occasionally along the southern edge of SWSA 6. Samples from the SWSA 6 perimeter wells were analyzed for lead and it was detected in the October sample from well 4315 at concentrations of 5.9 µg/L. The action level for lead in drinking water is 15 µg/L.

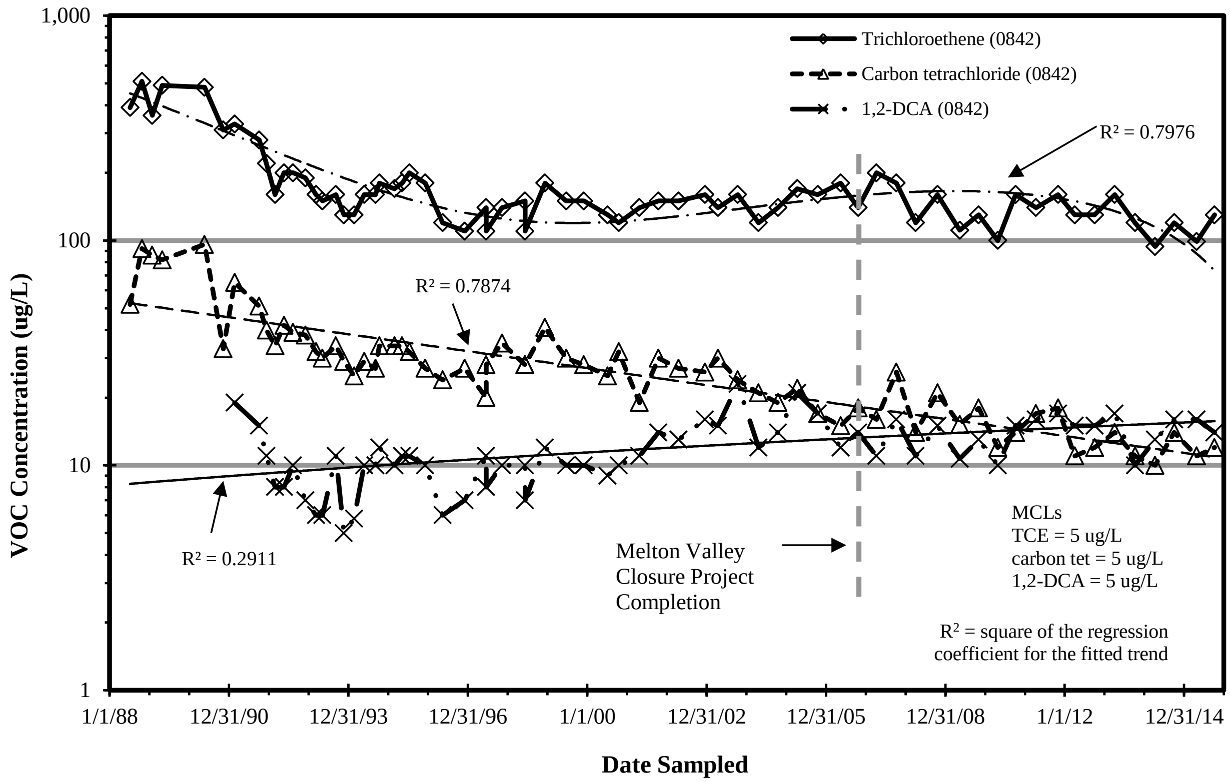


Figure 3.18. Long-term monitoring results for VOCs in SWSA 6 well 0842.

CERCLA radiological monitoring of groundwater is also conducted in these wells. The principal and most mobile radionuclide detected in groundwater is tritium. The highest tritium activities in the RCRA well network are measured in wells 0841, 0842, 0843, 0844, and 4316 along the eastern site boundary. Tritium activity trends exhibit long-term decreases in wells 0841, 0842, and 0843 and in wells 0841 and 0842 levels have decreased to below the MCL-DC of 20,000 pCi/L. Tritium in well 0844 exhibited a long-term increasing trend from 1995 through the spring of 2011 but has decreased through FY 2015. Tritium activity in well 4316 doubled in the period between 1994 and 2008 and has decreased nearly 50% from levels measured in 2008. The groundwater contaminant trends along the eastern edge of SWSA 6 suggest that contamination in bedrock wells is susceptible to trends that started long before Melton Valley closure and those trends are slowly responding to the burial ground capping.

Tritium is also monitored in groundwater around the Tumulus low-level solid waste disposal facility where historic discharges from containerized waste created a groundwater tritium plume. Six wells (Figure 3.16) at the Tumulus are sampled to measure the groundwater tritium trends. Graphs of the tumulus area groundwater tritium monitoring data are included in Appendix B.3. Tritium levels in wells 1037, 1254, and 1257 have been less than the MCL-DC (20,000 pCi/L) since the end of FY 2011. Wells 1036 and 1258 continue to exhibit the highest tritium levels in the area. The trend observed at well 1036 appears to have stabilized between 2010 and 2015 at levels around 200,000 pCi/L, while tritium levels in well 1258 have decreased since the fall of 2010 and appear to have stabilized at slightly less than 80,000 pCi/L. The tritium level in Well 1039 have fluctuated at levels less than, to over twice the MCL-DC for tritium since Melton Valley remedy completion. During FY 2015 both semi-annual sample results from well 1039 were less than the MCL-DC of 20,000 pCi/L. The overall behavior of tritium in groundwater beneath and adjacent to the Tumulus cap indicates that tritium levels stabilized beneath the capped area and levels are decreasing near and outside the cap.

The reduction in tritium discharges from the Tumulus is a significant component of the decrease in tritium measured in surface water at WAG 6 MS3 which is located nearby (Figure 3.6). The reader is referred back to Section 3.2.1.2.1 for the surface water data presentation.

Melton Valley On-site Exit Pathway and Off-site Wells

On-site exit pathway and off-site groundwater monitoring includes monitoring of wells 1190 and 1191 that are located on White Oak Dam, monitoring of six deep on-site exit pathway wells plus a cluster of three wells between the Clinch River and the western edge of SWSA 6, and monitoring of off-site wells located southwest of the Clinch River (Figure 3.20).

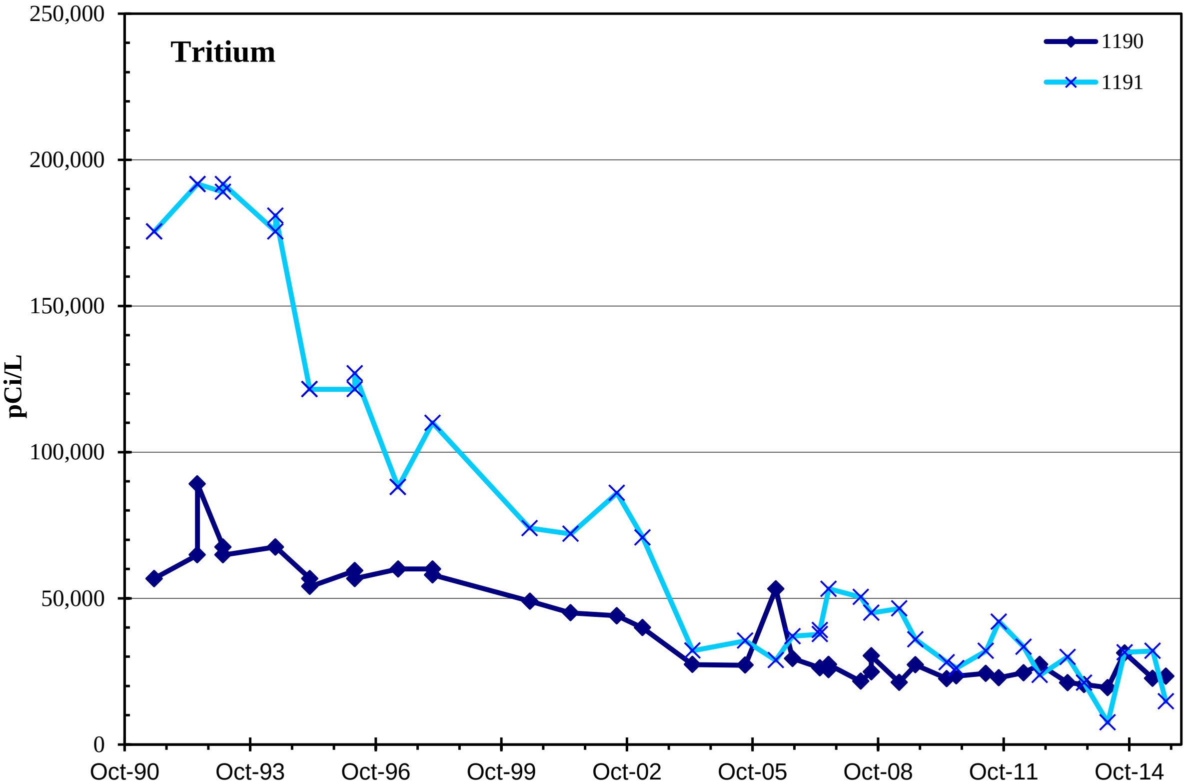
- Wells 1190 and 1191 are about 47 and 26 ft deep, respectively, and are located near the centerline of White Oak Dam. Well 1190 is constructed to monitor groundwater in bedrock at elevation 708 – 718 ft above mean sea level (aMSL), the upper limit of which is approximately equivalent to the bed of the Clinch River located about 2,500 ft to the west. Well 1191 samples water from the interface between the bedrock surface and the sediment/soil fill zone beneath the dam at elevations from 724 – 743 ft aMSL, which is approximately equivalent to elevations of the WOCE and the channel of the Clinch River. Tritium and ^{90}Sr are the principal contaminants detected in these wells. Figure 3.19 shows the activity histories from about 1990 through FY 2015 and Figures 3.16 and 3.20 show the location of the wells. In the past, tritium levels in well 1191 were higher than those in well 1190, although levels have been decreasing in both wells. Since 2012, the tritium concentrations in both wells have been very similar at levels about 1.5 times the 20,000 pCi/L MCL-DC, with higher variability in well 1191. This convergence of tritium concentrations between the shallower well and the deeper well is a reflection of the overall, long-term reduction of tritium that is present in the WOC aquatic system. The well 1191 tritium data show a nearly 10-fold decrease in levels since the early 1990s. Strontium-90 is not detected in well 1190, which is the deeper, bedrock well. In well 1191, ^{90}Sr has attained near steady-state concentrations since about 2004 at an average of about 150 pCi/L with a standard deviation of about 25 pCi/L.

- As part of the *ROD for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3), in 2004 six groundwater monitoring wells were installed in the western end of Melton Valley to serve as on-site exit pathway wells to detect site-related contaminants that may seep toward the Clinch River. These six deep, multizone monitoring wells were constructed in a line extending from the toe of Haw Ridge southward to the south side of the WOCE near White Oak Dam. Locations of these wells are shown on Figure 3.20. Three wells (1008, 1009, and 1010) in a previously constructed well cluster near the southern end of the line of on-site exit pathway wells are also shown. On-site exit pathway wells near the Clinch River on the ORR side were drilled to bottom elevations of about 250 ft aMSL and completed in the transition zone above the brine interface. Based on test results, a total of 36 sampling zones were created by installation of Westbay® multizone sampling systems. Subsequent to installation, each zone was purged in preparation for sampling. Over FY 2005 and FY 2006, baseline samples were collected and analyzed to evaluate the stabilization of groundwater quality in the sampled zones.

- In FY 2010, off-site groundwater monitoring was initiated west of the Clinch River across from the Melton Valley waste management areas. This action was taken in response to detection of site-related contaminants in some of the on-site exit pathway well monitoring zones in FY 2007 through FY 2009, and because of concern that increasing groundwater withdrawals on the western side of the Clinch River could potentially pull groundwater that has been affected by DOE's waste disposal activities beneath the river. As a precaution, DOE has provided water to residents in the area and provided funding for extension of utility water supplies through the residential area along Jones Road to minimize groundwater withdrawals near the Clinch River.

- The off-site groundwater monitoring project included installation and sampling of two well clusters (OMW-1 and OMW-2) containing five wells each on a ridgecrest west of the river, modification and sampling of two existing wells (OMW-3 and OMW-4) near the river to create three sampling intervals within each borehole, and sampling of seven existing wells in the vicinity. Locations of the off-site wells are shown on Figure 3.20. Goals of this continued monitoring effort are: 1) to allow measurement of groundwater levels to determine the potential flow directions on the west side of the river in comparison to those on the DOE side of the river and, 2) to allow groundwater sampling from discrete elevation ranges that match elevations where samples are collected from multizone wells on the DOE side of the river. In addition to constructing the off-site wells to sample groundwater from elevations correlative to those on the DOE side of the river, to the extent feasible, the off-site wells were constructed in locations where sample intervals would be in approximately correlative hydrostratigraphic zones on both sides of the river. For example, well 4539 on the DOE side of the river and off-site well cluster OMW-1 intersect the upper portion of the Maryville Limestone stratigraphic unit. Similarly, wells 4540 and 4541 intersect strata also sampled in off-site well cluster OMW-2. In the off-site monitoring network, the deepest wells in the two ridgecrest clusters were drilled to allow sampling in the elevation range between 200 – 300 ft aMSL, comparable to the base of multizone wells on the DOE side of the river. Shallower target monitoring elevations are within the 400 – 500, 500 – 600, and 700 – 750 ft aMSL ranges. Modified off-site wells near the Clinch River that were converted to three-zone nested sampling wells were constructed to allow additional head monitoring and groundwater sampling in the nominal 400 – 500, 550 – 600, 600 – 650, 650 – 700, and 700 – 750 ft aMSL ranges. The seven existing off-site wells that are monitored are typical open borehole water wells and groundwater from long bedrock intervals is included in the monitoring.

The deep groundwater monitoring data are discussed in terms of sample zone elevation because the local area has surface topographic relief of 200 – 300 ft between Clinch River elevation and the crests of ridges. Therefore, depth references related to different monitoring locations are not directly comparable. Beneath Melton Valley, relatively fresh groundwater extends from the water table downward to an elevation of approximately 350 – 400 ft aMSL. In the freshwater interval, bicarbonate is the dominant anion and calcium and sodium are the dominant cations, with sodium concentrations increasing with increasing depth. Beneath the fresh water zone, groundwater contains rapidly increasing concentrations of dissolved solids that include residual components of the naturally occurring ancient brine contained in the bedrock. This deep groundwater is non-potable because of natural salinity and wells constructed in the bedrock at these elevations produce very little water. At elevations ranging from about 250 – 300 ft aMSL beneath Melton Valley (450 – 500 ft below the level of the Clinch River), the groundwater is saline brine that contains extremely high dissolved solids concentrations dominated by sodium and chloride, but also containing calcium, magnesium, potassium, barium, lithium, strontium, and other metal ions. Monitoring data show that there is a transition zone of rapidly increasing chloride concentrations from about 1,000 mg/L at about the 300 ft elevation to 100,000 mg/L or more at about the 200 ft elevation. The brine has a high density (1.2 – 1.3 g/cc compared to densities near 1.0 g/cc for the overlying groundwater) because of the high concentrations of dissolved ions. This strong density contrast between the brines at depth and the overlying fresher groundwater and reduced permeability with depth inhibit the mixing of constituents between the two zones. The on-site exit pathway wells and off-site wells were designed and installed to sample groundwater above the non-potable brine zone.



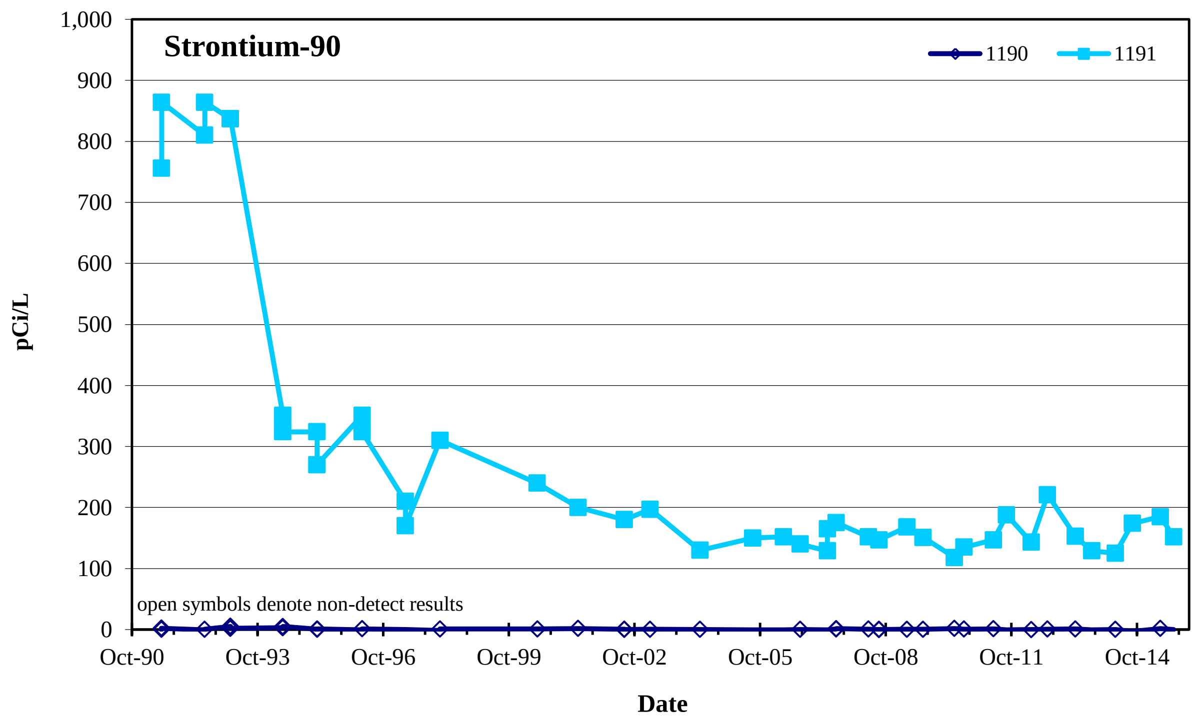


Figure 3.19. White Oak Dam groundwater tritium and ^{90}Sr activity histories.

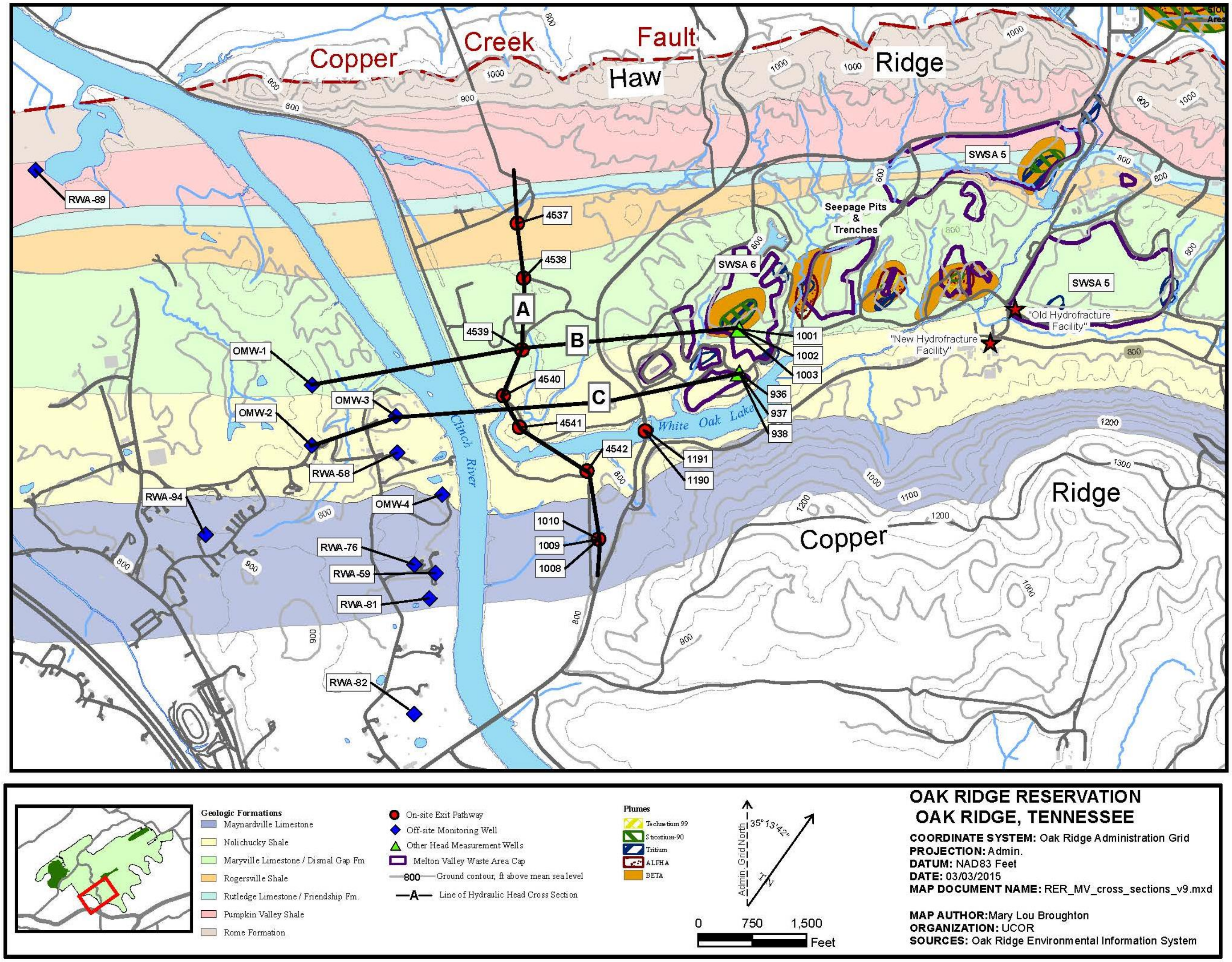


Figure 3.20. Locations of Melton Valley on-site exit pathway and off-site wells.

Melton Valley On-site Exit Pathway and Off-site Wells Groundwater Level Monitoring Results

Groundwater level monitoring is conducted continuously in the two installed off-site well clusters and two modified existing off-site wells. The purpose of making detailed groundwater level measurements is to provide head data over the range of elevations monitored. The head data are used to develop hydraulic head cross sections that indicate potential directions of groundwater movement based on the relative head differences along the section lines. Groundwater seepage occurs between areas of higher hydraulic head to those of lower hydraulic head. In porous media such as sand and gravel aquifers, groundwater seepage normally occurs in the direction of maximum observed gradient. However, in geologically complex bedrock, with folds, fractures, and faults such as that observed at Oak Ridge, lines of maximum apparent gradient can indicate barriers to flow because of a lower density of interconnected fractures along that direction compared to another direction where geologic conditions predispose flow to occur. Most plumes in this area tend to follow flow pathways parallel to geologic strike and many occur in confined to semiconfined bedrock zones that have either preferential fracturing (including bedding plane partings), preferential weathering because of bedrock type, or both.

The location of three hydraulic head cross sections (A, B, and C) are shown on Figure 3.20. Figure 3.21 shows the average FY 2015 hydraulic head (and total dissolved solids) in the Melton Valley on-site exit pathway wells along Cross Section A which is parallel to the Clinch River. Areas of relatively low hydraulic head occur in the Rutledge Limestone (Friendship Formation) at the northern end of the cross section and in the Nolichucky Shale beneath the mouth of WOC in the southern part of the section. The low head area in the Rutledge Limestone contains fairly fresh water and is thought to discharge to the Clinch River through openings in the carbonate bedrock. The relatively low head observed near the mouth of WOC aligns with the lowest part of Melton Valley where WOC and WOL are located. Areas of relatively higher head occur near the center of the section in the Maryville Limestone (Dismal Gap Formation) and at the southern end of the section at the toe of Copper Ridge. The area of higher head in the Maryville Limestone zone aligns with the knobs in the middle of Melton Valley where most of the ORNL shallow land burial grounds and the liquid waste seepage pits and trenches are located. Groundwater recharge on the knobs maintains groundwater head in the bedrock in the Maryville Limestone outcrop belt. Although the head gradients indicated on Cross Section A suggest the potential for groundwater flow in the plane of the page, most of the groundwater in bedrock flows through interconnected fractures that are essentially perpendicular to this cross section and groundwater flow is toward the Clinch River (toward the viewer of this figure).

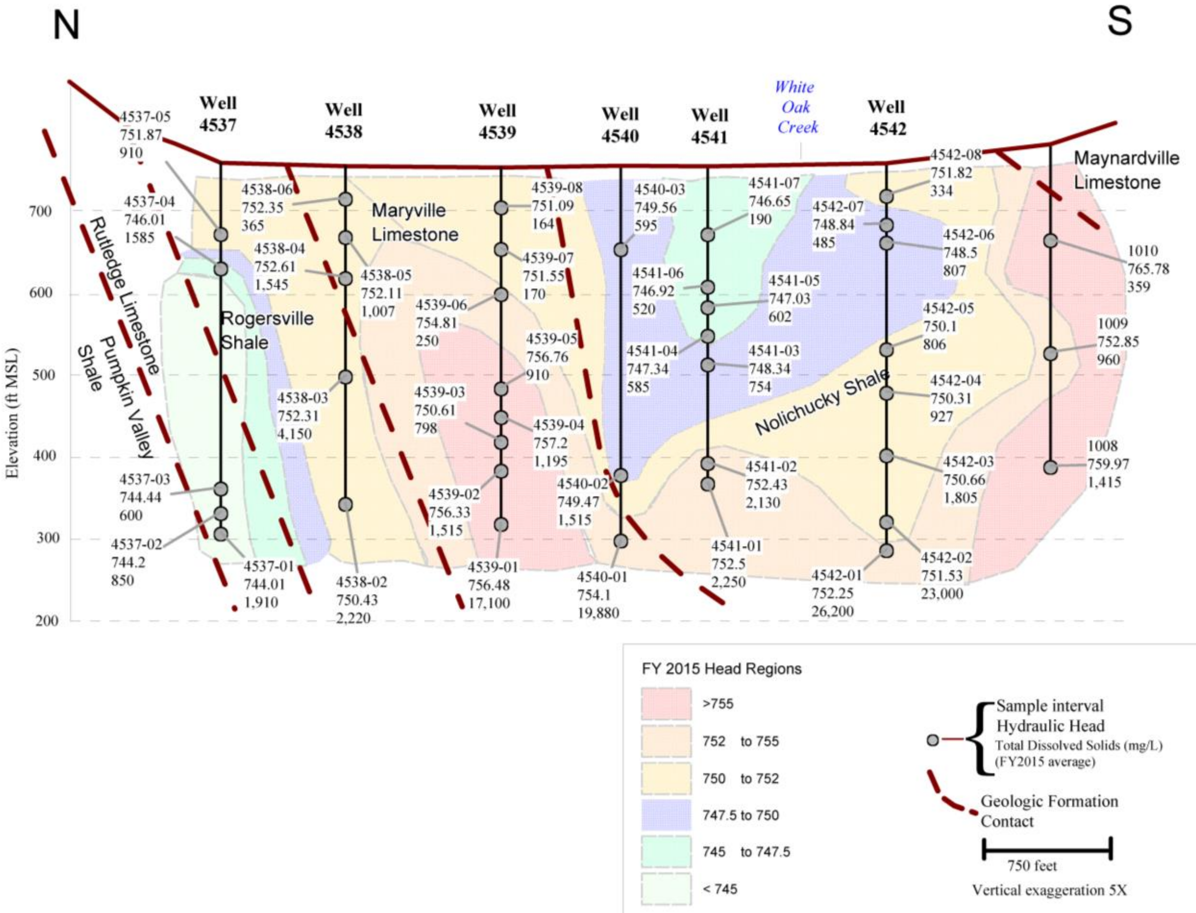


Figure 3.21. Hydraulic head cross section A.

Figure 3.22 shows the hydraulic head and total dissolved solids in the wells along Cross Section B that has its western end on the ridgecrest at OMW-1 and its eastern end near the center of SWSA 6. This section is drawn essentially parallel to geologic strike in the Maryville Limestone as shown on Figure 3.20. The hydraulic head variations along Cross Section B show that a region of head ranging from 775 to >800 ft aMSL exists beneath the ridgecrest on the western side of the Clinch River. The downward head gradient beneath the ridge indicates that this is a recharge area for groundwater and the gradient, and flow direction, is toward the Clinch River, which has a winter pool elevation of about 737 ft aMSL. The lowest head region on Cross Section B occurs beneath the Clinch River, suggesting discharge to the river. On the eastern side of the Clinch River, the hydraulic head profile shows increasing head levels in the limestone beneath the SWSA 6 area where the profile terminates. Head levels measured at the eastern end of Cross Section B are lower than those beneath the off-site ridgecrest at the western terminus. The general head variations along this profile indicate that groundwater recharge occurs on the upland areas both east and west of the Clinch River where rainfall percolation to the groundwater table maintains the water table head. This head pressure, and associated groundwater movement, translates through interconnected fractures mostly parallel to geologic strike in the bedrock and head pressure is relieved in the discharge area at the Clinch River. The zone beneath the Clinch River acts as a hydraulic sink, as depicted by the 750 ft hydraulic head contour which has higher head areas on both east and west sides.

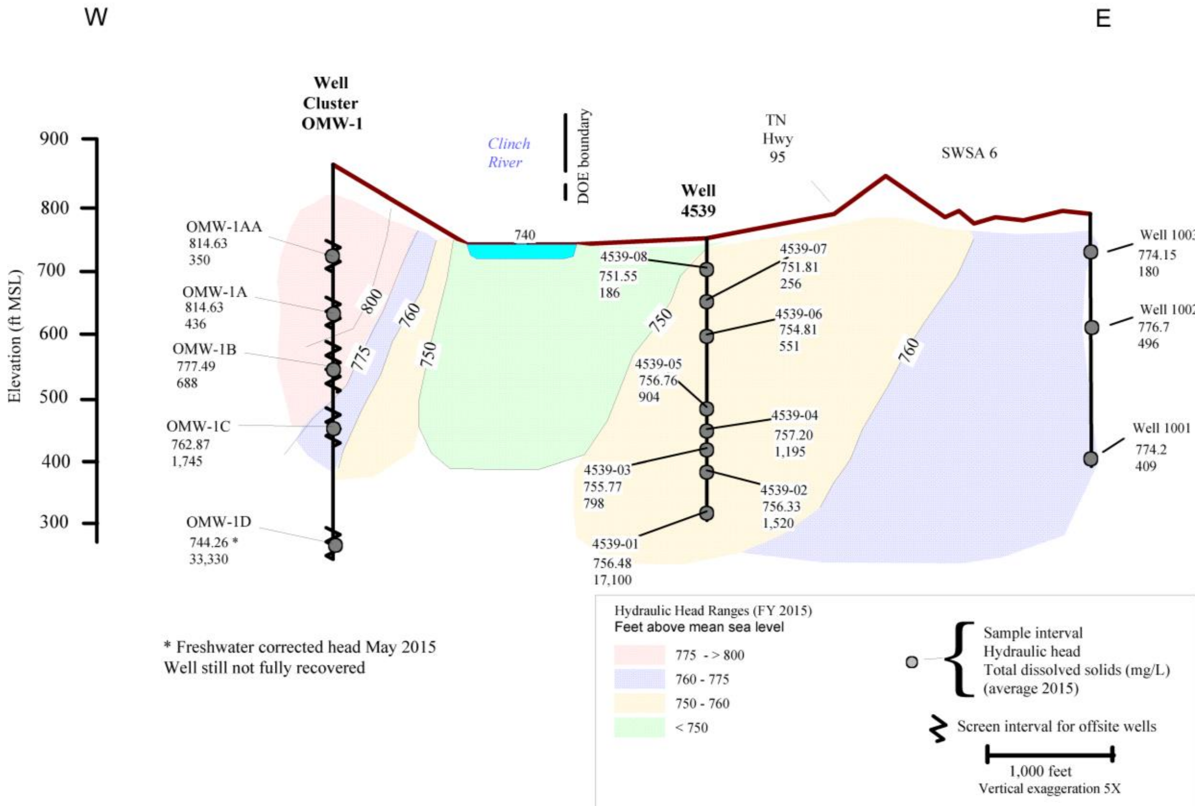


Figure 3.22. Hydraulic head cross section B.

The deepest well in off-site cluster OMW-1 (OMW-1D) is constructed in a very low-yield bedrock zone and, although the screened interval is about 100 ft in length, the well has not fully recovered in 63 mo. since the well development was completed. Because of the slow recovery, weekly water level measurements were conducted prior to early August 2014 when a continuous monitoring device was installed. The groundwater level continues to rise steadily with a recovery rate of about 1 ft/mo. The well has recovered from an initial water level of about 510 ft aMSL after construction and development in July 2010 to freshwater corrected head of approximately 744 ft aMSL as of the end of May 2015. This head level in well OMW-1D at the end of FY 2015 was higher than the Clinch River surface water elevation with continuing recovery. The well is expected to achieve a stabilized head level above the elevation of the Clinch River. However, many more months will be required for full recovery since the rate of recovery gradually diminishes over time. A number of deep investigative wells in the Melton Valley waste disposal areas exhibited similar extremely slow recovery, which is indicative of the low hydraulic conductivity of much of the bedrock at depth.

Figure 3.23 shows the hydraulic head and total dissolved solids profile along Cross Section C (Figure 3.20), which has its western terminus at off-site well cluster OMW-2 and its eastern terminus at wells on a knoll in the southern part of SWSA 6 at well 0938. This section is aligned approximately along geologic strike in the Nolichucky Shale. Similar to Cross Section B, the hydraulic head measured beneath the ridgecrest on the west side of the Clinch River ranges from 775 to >800 ft aMSL in the upper part of the groundwater system. Also similar to Cross Section B, there is a downward gradient measured between the individual wells within the OMW-2 well cluster. Similar to the behavior of well OMW-1D, the water level measured in the deepest OMW-2 cluster (well OMW-2D) has not recovered to a stable head condition. Although head in well OMW-2D is not fully recovered, the heads at the end of FY 2015 were

more than 20 ft higher than the Clinch River water level, which indicates underflow of the ridgecrest in that area is very unlikely.

The overall head distribution in Cross Section C is similar to that in Cross Section B with the lowest observed hydraulic head lying beneath the Clinch River. This section is drawn to coincide with the low groundwater region that underlies WOC and WOL in the Nolichucky Shale outcrop band. Heading east from the Clinch River, the hydraulic head elevation increases gradually but does not reach the levels observed in Cross Section B at a similar distance east of the river. This more gradual gradient is attributed to the more subdued topography along the section line and the observation that groundwater enters bedrock fractures along this profile at lower head elevations than at the eastern end of Cross Section B. Similar to Cross Section B, that area beneath the Clinch River has lower hydraulic head than areas to the east and west, indicating groundwater discharges into the Clinch River from both sides.

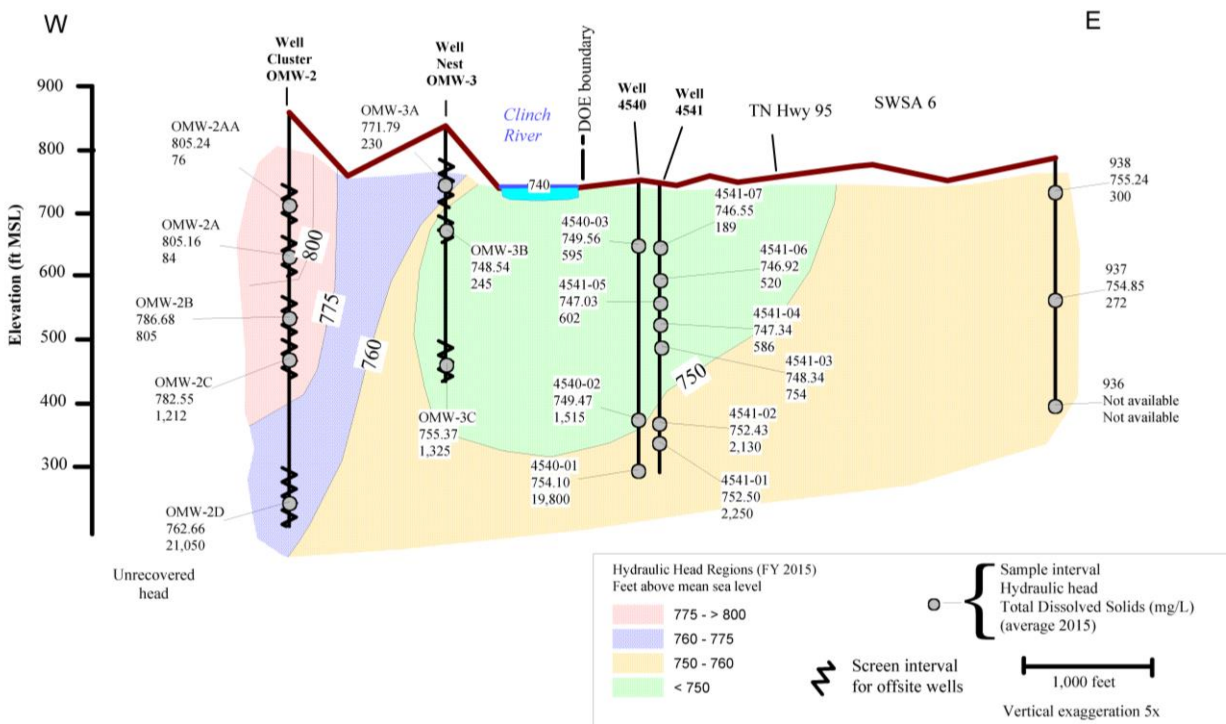


Figure 3.23. Hydraulic head cross section C.

The head data profiles summarized in Figures 3.22 and 3.23 combined with lower topography further to the west suggest that a groundwater seepage boundary occurs beneath the ridgecrest on the western side of the Clinch River near well clusters OMW-1 and OMW-2. The zone of elevated head beneath the ridgeline that extends downward, apparently to the deepest levels monitored, provides a natural barrier to groundwater seepage from east to west. Well hydrographs for the off-site wells are included in Appendix B.4.

Melton Valley On-Site Exit Pathway and Off-site Wells Groundwater Quality Monitoring Results

Groundwater quality monitoring has been conducted in the Melton Valley on-site exit pathway wells since 2006 and four rounds of samples were collected in the off-site wells between July 2010 and the end of FY 2011. Sampling of the off-site wells occurred semiannually during FY 2012 through FY 2015. Revised sampling frequency and parameters were agreed upon in FY 2013 by DOE, EPA, and TDEC and

are documented in the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3).

The analytical results for unfiltered samples from all the wells, both the Melton Valley on-site exit pathway wells and the off-site wells, have been compared to the EPA SDWA primary MCLs. The MCLs are used only as screening criteria; the ROD did not specify MCLs as ARAR-based performance goals for groundwater. Table 3.9 is a summary of the data screening results for primary MCLs and summarizes Mann-Kendall trend evaluations for constituents exceeding MCLs where a sufficient number of detections have occurred.

- The Mann-Kendall approach to trend evaluation analyzes the cumulative direction (increasing, decreasing, or stable) of concentration change of an analyte through time. The criterion used to begin the Mann-Kendall trend analysis on this dataset was that a minimum of four detected results for the analyte of interest had to be available and either at least two results exceeded the MCL or a result during FY 2015 exceeded the MCL. Analytes with fewer than four detected results were excluded from trend analysis although they are identified in Table 3.9 by the number of detections and an entry of "NA" in the trend evaluation column. The most recent 10 results per analyte per well were used in the Mann-Kendall trend evaluation. In cases where wells have less than 10 total sampling events per well, all available data were included. The method provides a 90% confidence level that the trend is significant.

- The raw data for on-site exit pathway wells were conditioned prior to trend analysis by removal of early-time data points when wells were still equilibrating chemically. Outliers (high or low values, selected based on the coefficient of variation) were removed for the purpose of trend evaluation. Data from all of the available off-site sampling episodes during FY 2011 through FY 2015 for the off-site wells were included in trend evaluation. When both filtered and unfiltered metal results were available, both types of results were used for trend evaluation and are reported separately for each sample location. Comparison of filtered to unfiltered results for metals has shown that for some constituents, the unfiltered results are higher than those for filtered samples. This indicates some of the metals are strongly associated with turbidity or suspended solids rather than the dissolved phase.

Well construction activities in the off-site well clusters at OMW-1 and OMW-2 introduced a large amount of cement grout into the boreholes to seal the well casings into the bedrock. This grout has created a pH effect that shows itself as very high pH in the groundwater samples from most of the wells in those two well clusters. Similar effects are not observed at the OMW-3 and OMW-4 wells or in the other monitored off-site wells.

Fluoride is widespread in the area and many samples exceed the 4 mg/L MCL. Although fluoride is a common constituent in solid waste leachate and may have been a component of liquid wastes disposed in Melton Valley, fluoride is also a common naturally-occurring element and a component of clay minerals common in shales. Review of shallow groundwater monitoring data near the Melton Valley waste disposal areas does not show fluoride plumes emanating from buried waste. Among the several metals that have shown some exceedances of MCLs, barium and thallium are common constituents of geologic brines. A brine sample from a deep monitoring well in a similar hydrostratigraphic setting approximately six mi. away in BCV contained higher concentrations of these two elements than the levels reported in Table 3.9. Analysis of field-filtered aliquots for metals has demonstrated that much of the metal concentration for constituents such as cadmium, chromium, and lead is associated with particulates since concentrations in the field-filtered portion were much lower (sometimes non-detectable) than in the unfiltered portion.

Alpha activity is a radiological indicator analysis and may indicate the presence of radium, uranium, thorium, or transuranic radionuclides. However, alpha activity measurement is susceptible to falsely elevated results in water samples containing high dissolved solids, as do many of the Melton Valley groundwater samples. Detailed analysis of alpha-emitting radionuclides frequently does not detect combinations of nuclides that quantitatively match the alpha activity measurement. Analysis for alpha-emitting radionuclides in the Melton Valley and off-site groundwater has detected low levels of radium and uranium.

Beta activity analysis is also an indicator analysis that may indicate the presence of beta-emitting radionuclides and is prone to falsely elevated results when high levels of dissolved solids are present. The most common beta-emitting radionuclide in groundwater at ORNL is ^{90}Sr. Strontium-90 has been detected frequently (in six of 12 samples) in one of the Melton Valley on-site exit pathway wells (4537-02) and has exceeded the 8 pCi/L MCL-DC at that well on two occasions. Lower detection limits in FY 2015 for many analytes, including ^{90}Sr, ^{99}Tc, and tritium, allowed detection of analytes at lower levels than in previous years. During FY 2015, ^{90}Sr was detected in 11 samples collected from nine sample zones in the on-site exit pathway transect wells. All the detected results were J qualified (J = estimated value). The maximum detected concentration was 2.45 J pCi/L, which was detected in well 4542-04 in a field duplicate sample collected in December 2014. All the other detected ^{90}Sr results from the on-site wells were less than 1 pCi/L. During FY 2015, ^{90}Sr was detected in six samples collected in off-site wells. All the detected results were J qualified at levels of 0.742 pCi/L or less. All of the ^{90}Sr detections in the Melton Valley exit pathway and off-site wells during FY 2015 were well below the MCL-DC concentration of 8 pCi/L. The occurrence of ^{90}Sr in the on-site exit pathway wells was identified as one of the high priority issues in development of the ORR Groundwater Strategy and will be investigated further based on prioritization of activities in the Groundwater Program.

Although much less widespread than ^{90}Sr, ^{99}Tc is present in groundwater in the Seepage Pits and Trenches area. During FY 2015, ^{99}Tc was detected in four on-site samples at concentrations in the 4.4 – 5.3 pCi/L range and concentrations of 4.32 J and 4.93 J pCi/L were measured in two off-site wells. These J qualified detections are at concentrations approximately 0.5% of the 900 pCi/L MCL-DC for ^{99}Tc. A single previous off-site detection (25 pCi/L) of ^{99}Tc occurred in a sample from one of these off-site wells in 2010.

During FY 2015, tritium was detected at J qualified concentrations of 169 pCi/L or less in four on-site exit pathway groundwater samples and at concentrations of 220 J pCi/L or less in six off-site samples. The highest on-site tritium result occurred in an April sample from monitoring zone 4537-02 located at the northern end of the on-site transect of wells. All of the detected tritium concentrations are in the range of about 10% or less of the MCL-DC concentration of 20,000 pCi/L.

Table 3.9. Results of data screen for Melton Valley On-site Exit Pathway and Off-Site Wells compared to EPA Primary National Drinking Water Criteria and constituent trend evaluation

Analyte	MCL[a]	Units	Station[b]	No. analyses[c]	No. detects[d]	No. >MCL[e]	Results			M-K Trend[f]
							Mean	Max	Max Date	
Fluoride	4	mg/L	1008	8	8	**8**	6.97	7.69	06/18/14	Stable
			1009	9	9	**9**	9.58	9.89	09/22/10	Decreasing
			1010	9	4	1	1.64	6.2	06/11/96	NA
			4537-04	15	15	**3**	2.78	4.19	04/14/14	Increasing
			4537-05	16	16	**13**	4.53	5.58	10/17/12	Stable
			4538-03	18	18	1	3.27	19.7	12/01/04	NA
			4538-04	16	16	**11**	4.31	5.06	10/23/13	Increasing
			4538-05	15	15	**9**	4.01	5	**10/22/14**	Increasing
			4539-02	21	21	**19**	4.84	5.6	05/03/06	Increasing
			4539-03	17	17	**15**	4.90	6	05/03/06	Stable
			4539-04	20	20	**19**	5.24	5.9	02/24/05	Stable
			4539-05	18	18	**17**	10.95	21.3	08/02/07	Stable
			4539-06	18	18	**17**	5.48	6.6	07/26/06	Stable
			4540-02	18	18	**16**	4.85	5.76	11/19/13	Stable
			4540-03	18	18	**16**	5.93	6.9	02/15/06	Stable
			4541-01	16	16	**14**	4.40	5	03/01/05	Stable
			4541-02	19	19	**13**	4.14	4.73	**05/14/15**	Increasing
			4541-03	18	18	**16**	5.39	6.26	05/30/12	Stable
			4542-01	17	11	1	1.36	5.67	06/18/12	NA
			4542-03	16	16	**15**	5.71	9.4	06/06/05	Decreasing
			4542-04	20	20	**20**	8.38	9.96	12/11/13	Stable
			4542-05	18	18	**14**	6.40	9.7	08/09/07	Stable
			4542-07	16	16	1	1.11	9.76	08/30/11	NA
			OMW-1B	12	12	**12**	6.09	6.58	10/24/13	Stable
			OMW-1C	12	12	2	3.70	4.24	04/16/14	Stable
			OMW-2B	12	12	**12**	7.01	7.99	04/17/14	Increasing
			OMW-2C	12	12	**6**	3.87	4.8	04/16/14	Increasing
Antimony	0.006	mg/L	OMW-1D	11	9	5	0.0068	0.0159	07/13/10	Decreasing
			OMW-1D-F	9	7	2	0.0054	0.00689	02/17/11	Decreasing
			OMW-3C	12	6	**4**	0.0086	0.0129	04/30/14	Stable
			OMW-3C-F	10	6	**5**	0.0095	0.0122	10/30/13	Stable
Arsenic	0.01	mg/L	1009	7	1	1	0.011	0.011	06/09/14	NA
			4537-02	11	11	3	0.009	0.015	01/30/08	Decreasing
			4537-02-F	9	8	2	0.0081	0.012	01/30/08	Decreasing
			4541-01	10	2	1	0.0094	0.0112	12/03/13	NA
			OMW-1A	8	8	1	0.0068	0.0105	04/18/12	NA
			OMW-1A-F	8	5	1	0.0081	0.0113	09/29/11	NA
			OMW-1B	8	8	**8**	0.0205	0.023	10/24/13	Stable
			OMW-1B-F	8	7	**7**	0.0195	0.0229	10/25/12	Stable
			OMW-2C	8	8	3	0.0105	0.0147	10/30/12	Stable
			OMW-2C-F	8	7	2	0.0089	0.0149	10/30/12	Stable
Barium	2	mg/L	4539-01	8	8	**8**	13.8	17.6	**04/27/15**	Increasing
			4539-01-F	8	8	**8**	13.8	17.3	**04/27/15**	Increasing
			4539-02	16	16	**1**	0.56	3.27	**04/29/15**	No Trend
			4540-01	15	15	**15**	21.9	30.9	**11/11/14**	Increasing

Table 3.9. Results of data screen for Melton Valley On-site Exit Pathway and Off-Site Wells compared to EPA Primary National Drinking Water Criteria and constituent trend evaluation (cont.)

Analyte	MCL[a]	Units	Station[b]	No. analyses[c]	No. detects[d]	No. >MCL[e]	Results			M-K Trend[f]
							Mean	Max	Max Date	
			4540-01-F	14	14	**14**	23.9	30.7	11/18/13	Increasing
			4542-01	13	13	**13**	17.4	41.7	08/25/10	Increasing
			4542-01-F	12	12	**12**	15.6	23.3	**05/26/15**	Increasing
			4542-02	13	13	**13**	15.7	19.2	12/05/13	Increasing
			4542-02-F	13	13	13	16.1	19.3	12/05/13	Increasing
			OMW-1D	11	11	**7**	11.3	27.4	**05/07/15**	Increasing
			OMW-1D-F	9	9	**7**	14.3	24.6	**05/07/15**	Increasing
			OMW-2D	11	11	**8**	11.6	28.7	**05/26/15**	Increasing
			OMW-2D-F	9	9	**8**	14.6	29.6	**05/26/15**	Increasing
Beryllium	0.004	mg/L	OMW-1C	12	1	1	0.0042	0.00416	07/13/10	NA
			OMW-1D	11	1	1	0.0152	0.0152	07/13/10	NA
Cadmium	0.005	mg/L	OMW-1D	11	3	1	0.0057	0.0158	07/13/10	NA
Chromium	0.1	mg/L	4538-02	12	12	1	0.047	0.125	09/02/09	NA
			4538-03	13	11	1	0.021	0.108	07/31/07	NA
			4539-02	16	15	**1**	0.036	0.252	**04/29/15**	No Trend
			4540-02	15	15	1	0.035	0.128	02/12/07	NA
Lead[g]	0.015	mg/L	4538-02	12	12	1	0.0067	0.0175	09/02/09	NA
			4538-03	13	9	1	0.0028	0.0153	07/31/07	NA
			4539-02	16	13	**1**	0.0064	0.0435	**04/29/15**	Increasing
			4540-02	15	12	1	0.0074	0.0234	02/12/07	NA
			OMW-1C	12	2	1	0.0119	0.0231	07/13/10	NA
			OMW-1D	11	4	1	0.026	0.1	07/13/10	NA
Nickel	0.1	mg/L	4539-02	16	16	**1**	0.0215	0.157	**04/29/15**	No Trend
Thallium	0.002	mg/L	4538-02	12	6	1	0.001	0.00253	09/02/09	NA
			4542-03	11	1	1	0.011	0.011	03/15/10	NA
			OMW-1C	12	1	1	0.0028	0.0028	07/13/10	NA
			OMW-1D	11	1	1	0.0104	0.0104	07/13/10	NA
Uranium	0.03	mg/L	OMW-1D	11	3	1	0.0667	0.2	07/13/10	NA
Alpha activity	15	pCi/L	4537-01	16	9	1	8.96	25.5	04/11/12	NA
			4538-02	16	8	5	20.7	45.5	08/01/06	Stable
			4538-03	18	7	3	16.1	41.7	02/15/05	NA
			4539-01	8	1	1	56.6	56.6	09/11/14	NA
			4539-02	21	15	**6**	39.0	221	02/17/05	Increasing
			4539-04	20	8	2	15.9	61.7	05/16/05	NA
			4539-05	18	4	1	12.3	37.1	05/16/05	NA
			4540-01	20	3	3	41.0	53.5	02/28/05	NA
			4540-02	20	6	2	41.0	171	05/08/06	NA
			4541-01	16	3	1	12.7	25.7	12/21/04	NA
			4541-02	19	2	1	19.0	28.8	08/07/07	NA
			4541-04	20	6	2	177	1010	05/19/05	NA
			4541-05	20	7	3	13.9	22.4	05/10/06	NA
			4541-06	20	7	2	11.0	24.4	07/27/06	NA
			4542-01	18	3	3	31.5	53.7	06/18/12	NA
			4542-04	20	6	3	11.3	19.1	02/22/06	NA
Beta activity	50	pCi/L	4537-01	16	12	1	20.3	116	04/11/12	NA
			4537-02	18	13	1	13.1	63.5	02/16/11	NA
			4538-02	16	11	2	55.7	275	08/01/06	NA

Table 3.9. Results of data screen for Melton Valley On-site Exit Pathway and Off-Site Wells compared to EPA Primary National Drinking Water Criteria and constituent trend evaluation (cont.)

Analyte	MCL[a]	Units	Station[b]	No. analyses[c]	No. detects[d]	No. >MCL[e]	Results			M-K Trend[f]
							Mean	Max	Max Date	
			4538-03	18	8	6	242	1330	07/31/07	NA
			4539-01	8	5	2	56.5	103	09/11/14	Increasing
			4539-02	21	17	7	96.6	534	02/17/05	NA
			4539-04	20	15	2	18.4	75	05/16/05	NA
			4540-01	20	10	4	68.0	166	02/15/06	NA
			4540-02	20	15	2	41.0	355	05/08/06	NA
			4541-02	19	5	2	212	982	08/07/07	NA
			4541-04	20	10	5	117	873	05/19/05	NA
			4541-05	20	14	5	32.8	95.6	05/19/05	NA
			4541-06	20	13	4	29.5	81.2	05/10/06	NA
			4542-01	18	4	3	114	169	06/05/13	NA
			4542-02	18	5	3	69.7	154	06/06/13	Increasing
			4542-04	20	11	2	25.8	87.4	05/15/06	NA
			OMW-1D	11	9	**8**	79.0	125	**05/07/15**	Stable
Total Radium Alpha	5	pCi/L	4538-04	9	2	1	32.9	65.2	03/02/10	NA
			4539-01	8	7	**2**	3.4	9.13	**12/10/14**	Stable
			4540-01	13	13	**9**	6.0	10.2	05/22/12	Increasing
			4540-02	13	10	1	1.6	5.02	08/18/10	NA
			4541-01	9	8	**1**	2.1	5.65	**05/13/15**	Stable
			4542-01	12	12	**7**	6.3	15.9	11/26/12	Increasing
			4542-02	12	12	**6**	4.8	15.3	11/27/12	Stable
			OMW-1D	11	10	**5**	4.4	9.01	**11/11/14**	Increasing
Strontium-90[h]	8	pCi/L	4537-01	9	1	1	27.9	27.9	04/11/12	NA
			4537-02	14	6	2	18.6	83.2	11/01/05	NA
			4540-02	16	4	1	5.66	16.5	05/08/06	NA
Benzene	5	µg/L	OMW-2D	11	9	**5**	4.24	6.14	11/06/12	Stable
Methylene chloride	5	µg/L	4538-02	15	3	2	9.47	15	09/27/10	NA
			4539-08	18	2	1	3.52	5.04	08/01/06	NA
			4542-04	20	2	1	4.1	8	05/09/13	NA
			4542-05	18	1	1	8	8	05/15/06	NA
Trichloroethene	5	µg/L	4537-03	15	1	1	113	113	05/15/06	NA
			4539-02	20	2	1	3.95	7.02	09/14/10	NA
			4539-08	18	1	1	30.9	30.9	08/06/10	NA
			4541-02	19	2	1	21.1	40.2	08/13/10	NA
			OMW-1B	12	1	1	81.1	81.1	08/23/10	NA
Vinyl chloride	2	µg/L	4537-03	15	1	1	7.49	7.49	09/27/10	NA
			4541-02	19	3	1	1.29	2.92	09/14/10	NA
			OMW-1B	12	1	1	2.63	2.63	08/23/10	NA
cis-1,2-Dichloroethene	70	µg/L	OMW-1B	12	1	1	80.8	80.8	09/27/10	NA

Bold type face in No. >MCL column indicates at least one result exceeded the MCL during FY 2015 and **bold** type face in Max Date column indicates max detected results exceeding MCL occurred in FY 2015.

[a]SLs are EPA Primary National Drinking Water Standards (SDWA MCLs) except beta activity, for which the screening level of 50 pCi/L was used and ^{90}Sr (see footnote h).
[b]See Figures 3.21 through 3.23 for zone locations. An "-F" designation at the end of the station name indicates results are for filtered samples.
[c]No. of Analyses = total number of analyses for analyte from each location.
[d]No. Detected = number of analyses in which analyte was detectable.
[e]No. >MCL = number of results that were greater than the SDWA MCL.

Table 3.9. Results of data screen for Melton Valley On-site Exit Pathway and Off-Site Wells compared to EPA Primary National Drinking Water Criteria and constituent trend evaluation (cont.)

[f]Quantitative trend analysis based on M-K Test of time-series sampling/analysis results for a maximum of ten sampling events (counting backward from the most recent sampling date). Evaluation is performed if No. Det. >3 and No. above MCL>=2, or a result >MCL is during FY 2015. Based on the methodology described in Gilbert (1987) and Wiedemeier et al., 1999, non-detect analytical results were replaced with the appropriate detection limit or MDA as surrogate values for M-K Test purposes. The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. The time series data define a *Stable* trend if the S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, whereas *No Trend* is evident if the CV is >1. NA (not applicable) indicates that the number of constituent detections available do not fulfill the basic criteria to conduct the trend evaluation as of the end of FY 2015.

[g]There is not a drinking water MCL for lead. The lead concentration of 0.015 mg/L is an EPA action level for water utilities to pursue actions to reduce lead concentrations in their distribution system.

[h]8 pCi/L is the MCL-DC listed in 40 CFR 141.66(d)(2), Table A, as the "Average Annual Concentration Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr," which is the MCL for beta particle and photon radioactivity.

CFR = Code of Federal Regulations
CV = coefficient of variation
EPA = U.S. Environmental Protection Agency
FY = fiscal year
M-K = Mann-Kendall
Max = maximum
MCL = maximum contaminant level
MDA = minimum detectable activity
NA = not applicable
SDWA = Safe Drinking Water Act
SL = screening level

During FY 2015, very low concentrations (maximum of 1.25 µg/L) of chloroform were detected in two on-site multizone sampling locations 4539-02 and 4542-05. VC was detected at a concentration of 0.39 J µg/L in well 1008 which is located at the south end of the on-site exit pathway groundwater monitoring transect. Methylene chloride was detected in six on-site samples and in seven off-site samples during FY 2015. The maximum measured methylene chloride concentration during FY 2015 was 5.76 µg/L from well 4542-06 in June. All the methylene chloride detections were in samples collected during the FY 2015 third quarter sampling event. In addition to being a degradation product of carbon tetrachloride under chemically reducing conditions, methylene chloride (dichloromethane) is also a common laboratory chemical in analytical labs and this compound is commonly detected at low levels because of lab atmosphere affects. Methylene chloride can further degrade to methyl chloride and subsequently to methane which can enter subsurface microbial metabolic processes. In the late 1990s, methylene chloride was detected in some wells in SWSA 6 at concentrations as high as 120 µg/L, however, since 2002, the highest concentration measured in wells sampled at SWSA 6 was 11 µg/L measured in the RCRA monitoring well 0837 in April 2007. Methylene chloride was not detected in any of the SWSA 6 groundwater samples during FY 2015.

As shown in Table 3.9, the large majority (99 of 131 combinations of sample locations and MCL parameters exceeded) of the on-site exit pathway and off-site wells which have had drinking water standard exceedances show either too few elevated concentrations to conduct the exceedance values trend, exhibit stable trends, or show no trend. Six decreasing trends are identified, two for fluoride in on-site wells 1009 and 4542-03, two for antimony (in off-site well OMW-1D for both filtered and unfiltered samples), and two for arsenic in both filtered and unfiltered results from well 4537-02.

Table 3.9 identifies 26 increasing MCL parameter exceedance trends. Seven of the increasing trends are for fluoride. Five of the locations are in on-site wells and two are in off-site wells. In the off-site wells, the maximum observed concentrations to date occurred in FY 2014. In the on-site wells, two of the five maximum fluoride concentrations occurred in FY 2015 and the remainder occurred in FY 2006 and FY 2014. Twelve increasing trends were identified for barium. The trend evaluation for metals includes both trends for total metals and filtered (dissolved) aliquots. In all instances the increasing barium trends are indicated in both filtered and unfiltered data. All the increasing barium trends occur in the deepest sampling zones where the wells sample groundwater from the transition zone between shallower fresh water and deeper highly saline water. The connate brines at depth contain extremely high concentration of many dissolved metals including barium. This deep groundwater also contains high concentrations of

chloride and sodium. These deep sampling zones monitor conditions in the transition zone between relative fresh actively circulating groundwater and deeper connate brines.

An increasing trend for lead is present at on-site well 4539-02 in the total metals (unfiltered) aliquot but this trend is not occurring in the filtered metals aliquot. Unfiltered samples from Westbay well zone 4539-02 produce high suspended solids (FY 2015 values ranged from 21 – 116 mg/L) which apparently have associated lead.

Increasing trends are indicated for alpha activity in one on-site monitoring location and for beta activity in two on-site monitoring locations. An increasing alpha activity trend is indicated at well 4539-02 where six of 15 detected alpha activity results have exceeded the 15 pCi/L MCL with maximum detection in 2005. Increasing trends for beta activity are indicated at sample locations 4539-01 and 4542-02. The maximum measured beta activity levels for these locations occurred in FY 2014 and FY 2013, respectively.

Total radium alpha activity MCL exceedances have been measured in eight wells (seven on-site and one off-site). Similar to the case for barium, the wells with elevated radium alpha activity levels are all among the deepest sampling zones which encounter the saline groundwater in the transition zone between relatively shallow groundwater and the underlying connate brines. Increasing trends for total radium alpha activity are present in two on-site wells and one off-site well.

A comparison of FY 2015 groundwater analytical results to EPA MCL screening levels for the Melton Valley on-site exit pathway and off-site wells follows:

- During FY 2015, drinking water MCLs were exceeded for alpha activity (15 pCi/L MCL) in six on-site exit pathway well sampling zones and two off-site wells, both of which produce highly saline groundwater samples and high dissolved solids samples are known to cause high bias in the analytical result. The MCL for total radium alpha activity (5 pCi/L) was exceeded in five deep monitoring zones in on-site exit pathway wells and in one deep off-site well. Radium is a naturally occurring daughter product of radionuclides in the uranium/thorium decay series. Radium is a known natural constituent of deep saline groundwaters which also affects the chemistry of the monitoring locations where the measured radium MCL exceedances are found. Beta activity exceeded the 50 pCi/L screening level during FY 2015 in three of the deepest sampling zones in on-site exit pathway wells (4539-02, 4540-01, and 4542-01) and in one deep off-site well. Similar to the alpha activity, the high dissolved solids content in the saline zone naturally contributes to elevated beta activity in the analyses.

- Lower detection limits for ^{90}Sr during FY 2015 allowed a resultant increase in the detection frequency. Although ^{90}Sr was detected in samples from nine on-site exit pathway sampling zones and was detected in six off-site wells during FY 2015, the maximum detected concentration on-site was less than half the MCL-DC of 8 pCi/L and the detections of ^{90}Sr in off-site wells were approximately 10% or less of the MCL-DC. In the on-site exit pathway wells, sample zone 4537-02 has the most consistent history of ^{90}Sr detection although during FY 2015 the maximum detected ^{90}Sr (2.45 J pCi/L) occurred at sample location 4542-04. Samples from zone 4537-02 have been analyzed for radiostrontium on 14 dates with six detected results. The maximum detected concentration (83.2 pCi/L) was from sample zone 4537-02 in November 2005, early in the monitoring history of the on-site exit pathway wells. Two of the detected results from zone 4537-02 have exceeded the ^{90}Sr MCL-DC of 8 pCi/L and the most recent radiostrontium detection from this zone occurred in April 2012. Beyond the results in that sample zone, detections of radiostrontium have tended to be sporadic, both temporally and spatially. Besides the results discussed for zone 4537-02, the remaining 23 radiostrontium detections have been distributed among 13 separate sampling zones.

- The MCL for antimony was exceeded in the deepest sampling interval of one off-site well and in none of the on-site exit pathway wells. The arsenic MCL was exceeded in two off-site wells and in none of the on-site exit pathway wells. MCLs were exceeded for barium in five on-site deep exit pathway monitoring zones and in two deep off-site monitoring zones, for benzene in one deep off-site well, and for fluoride in 19 on-site exit pathway sample zones and three off-site sample zones in two wells. The barium and benzene MCL exceedances occur in deep groundwater samples collected from the transition zone between the fresher groundwater at shallower depths and the underlying connate brines, which are known to contain these substances derived from natural sources. In addition to being a common indicator of man-made waste sources, fluoride is a common minor groundwater constituent that originates from natural bedrock sources. Areas with natural fluoride concentrations greater than 4 mg/L are known to exist but are uncommon.

3.2.1.2.2.4 PWTC WAC Compliance for Collected Groundwater

Groundwater collected in the downgradient seepage interceptor systems at Seepage Pits and Trenches, SWSA 4, and SWSA 5 is pumped to the equalization tank located at SWSA 4 prior to being pumped via pipeline to the PWTC in Bethel Valley for treatment. Samples of the collected groundwater are obtained monthly at the equalization tank and analyses include metals, radionuclides, and VOCs. WAC for the PWTC have been developed for radionuclides and metals. The only constituent detected near the PWTC WAC was tritium. The DOE DCS for tritium is 1.9×10^6 pCi/L (DOE-STD-1196-2011) and the average and maximum tritium concentrations measured in FY 2015 in the collected groundwater were about 5.6×10^5 and 2.0×10^6, respectively, which are somewhat higher than the values measured during FY 2014. During FY 2015, only one of the monthly samples contained tritium at concentrations greater than the WAC. The PWTC discharge was compliant with the required discharge limit for tritium in all of the continuous, flow-paced samples collected and analyzed by UT-B at the point of discharge.

3.2.1.2.3 Aquatic Biological Monitoring

The monitoring of fish and benthic macroinvertebrate communities provides a useful measure of watershed trends and whether *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) goals of achieving narrative AWQC and protecting ecological populations are met. Aquatic biological monitoring locations used to gauge the conditions of the Melton Valley watershed, as well as their reference sites, are shown on Figure 3.5. As is the case for most watershed units, biological monitoring data in Melton Branch include contaminant accumulation in fish, fish community surveys, and benthic macroinvertebrate surveys. In addition to Melton Branch, fish and benthic macroinvertebrate monitoring results include a site in WOC just downstream of the Melton Branch confluence (WCK 2.3).

Redbreast sunfish were collected in 2015 from lower Melton Branch kilometer (MEK) 0.2 and fillets analyzed for mercury, PCBs, metals, and ^{137}Cs. Mean (± standard error [SE]) mercury concentrations in these fish remained similar to those seen in 2014 (average 0.14 ± 0.01 µg/g), below the EPA-recommended AWQC (0.3 µg/g mercury in fish) but higher than typical of reference site concentrations in this species. PCB concentrations were near background levels and in most cases below detection limits, averaging <0.05 µg/g in the six redbreast sunfish analyzed. As expected, most metals (As, Be, Cd, Cr, Cu, Pb, Ni, Ag, and Tl) were below detection limits or at levels similar to those in fish from the Hinds Creek reference site. Cesium-137 was not detected in sunfish samples from MEK 0.2.

The monitoring results for WOC below the Melton Branch confluence continue to indicate slight to moderate impacts to fish communities relative to uncontaminated sites, but most stream sites are much improved relative to their ecological status in the mid-1980s (Figures 3.24 and 3.25). After a period of mostly stable numbers of fish species, some improvement in diversity has occurred at the downstream

sites as a result of a fish introduction program in 2008 – 2012 and 2014. Two darter species and an additional minnow species are now routinely found in Melton Branch contributing to historically high species richness values at both sites. In addition, four or five of the introduced fish species are regularly found in most samples at the lowest WOC site, WCK 2.3. In recent collections an increased number of juvenile fish from our introduced species has been observed, indicating their continued colonization of the watershed. The apparent success of these introduced sensitive species is additional evidence that water quality in Melton Valley has improved since the 1980s.

The benthic macroinvertebrate community in lower WOC (WCK 2.3), as measured by the number of pollution-intolerant taxa (i.e., EPT taxa richness), remains moderately degraded relative to a comparable reference site and the headwater site in WOC (MBK 1.6 and WCK 6.8, respectively), while the macroinvertebrate community in lower Melton Branch (MEK 0.6) continues to show characteristics that indicate conditions are nearly comparable to slightly degraded relative to reference conditions (Figure 3.26). Wide fluctuations in the number of pollution-intolerant taxa at WCK 2.3 in recent years may reflect, in part, changes related to an increase in the frequency of above normal flows caused by increased precipitation. The substrate at this site is dominated by gravels that are more easily dislodged (i.e., they provide less habitat stability) and covered by smaller sediment particles (i.e., increased embeddedness) during modest increases in flow. Disturbances of the substrate caused by rapid increases in discharge during heavy rain can have negative consequences on many species of benthic macroinvertebrates through either increased mortality (e.g., crushing by shifting substrate particles) or loss of usable habitat (e.g., loss of habitable space used by sprawling species). This contrasts upper WOC and the reference site where larger cobbles dominate the substrate and are less likely to be disturbed during brief periods of high flows; thus, minimizing negative effects to macroinvertebrates.

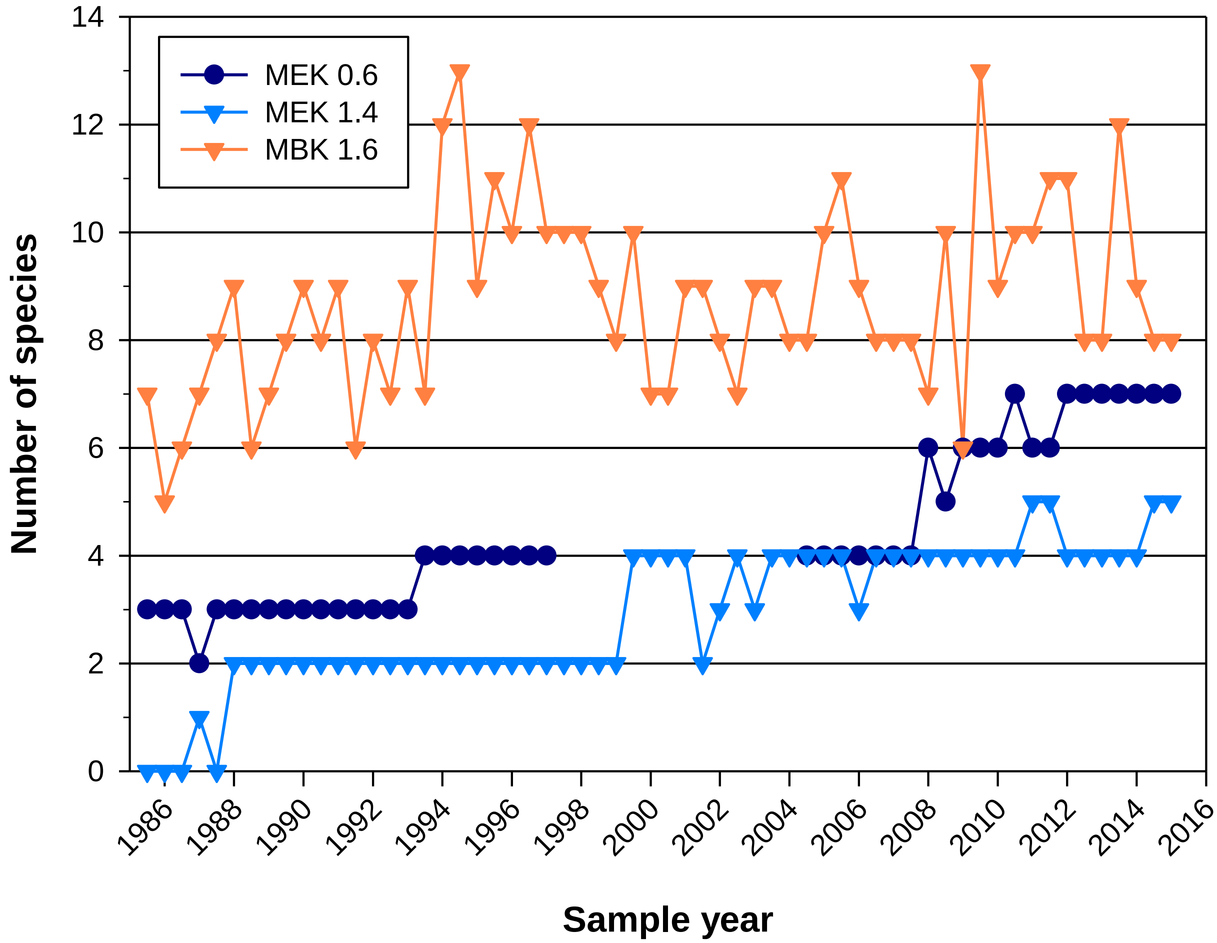


Figure 3.24. Species richness (number of species) in samples of the fish community in Melton Branch (MEK) and a reference stream, Mill Branch (MBK), 1985 – 2015.[a]

[a]Symbols not joined by lines show periods when samples were not collected.

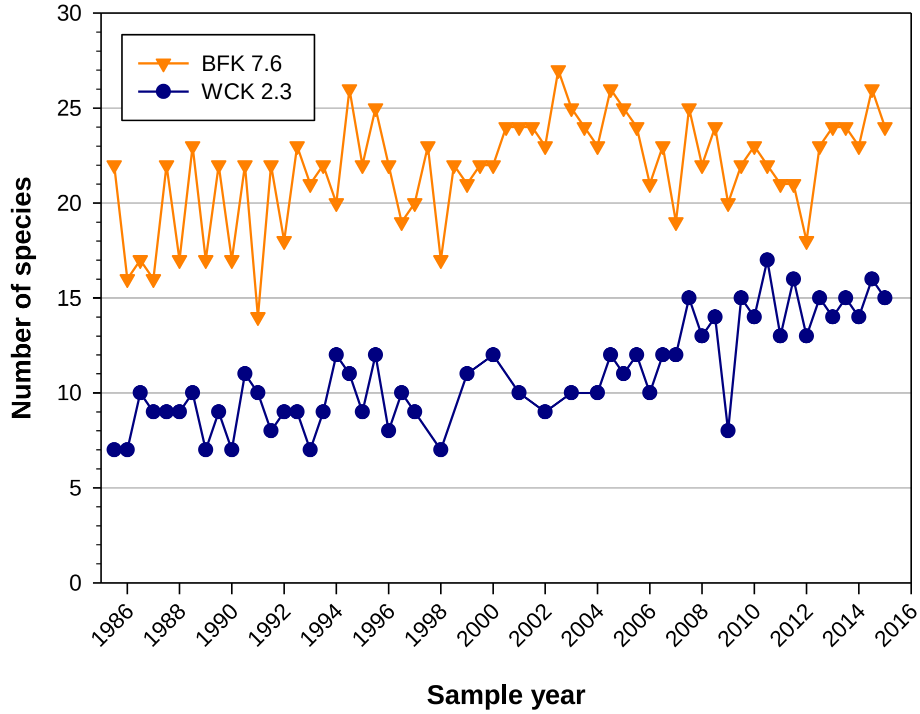


Figure 3.25. Species richness (number of species) in samples of the fish community in lower WOC (WCK 2.3) and a reference stream, Brushy Fork (BFK), 1985 – 2015.

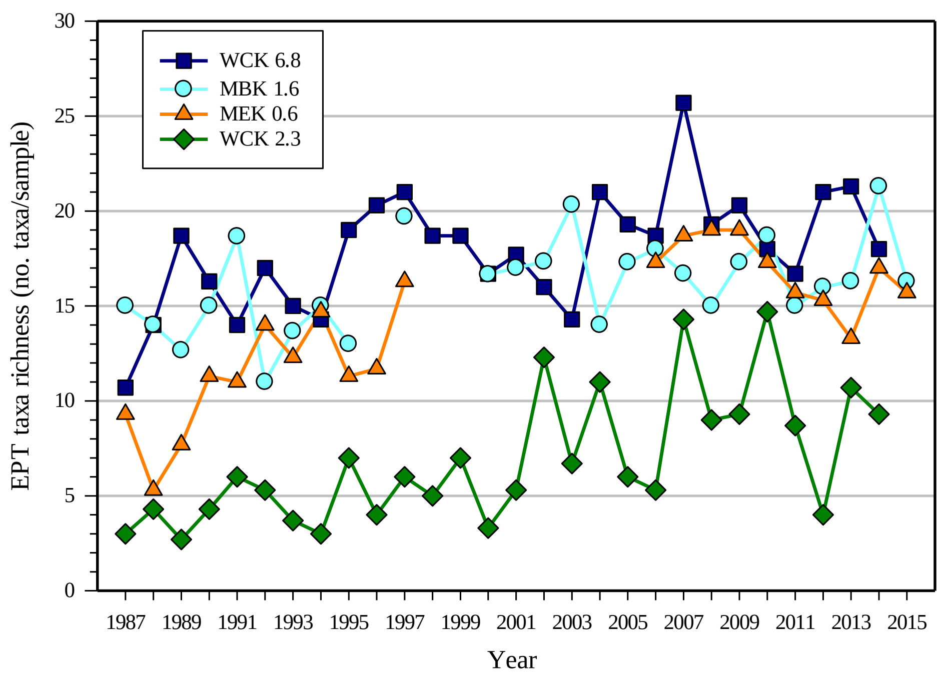


Figure 3.26. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate communities in lower WOC (WCK 2.3), lower Melton Branch (MEK 0.6), and reference sites in upper WOC (WCK 6.8) and Mill Branch (MBK 1.6), April sampling periods, 1987 – 2014.[a,b]

[a]WOC watershed invertebrates are processed in the FY following collection thus samples collected in spring of 2015 have not yet been processed.

[b]Symbols not joined by lines show periods when samples were not collected.

3.2.1.3 Performance Summary

Following is a summary of the FY 2015 Melton Valley watershed performance monitoring:

- Radiological goals for ^{137}Cs, ^{90}Sr, and tritium, which are the principal surface water contaminants in the Melton Valley watershed, were met at the watershed integration point (White Oak Dam). For the principal contaminants in Melton Valley surface water, the average concentrations at tributary and mainstem monitoring locations remained compliant with goals of the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3).

- Groundwater level monitoring of the hydrologic isolation areas in Melton Valley showed that performance criteria were met at 46 of 52 locations. DOE is making recommendations concerning an issue identified in the 2015 RER for five groundwater level performance monitoring wells that have experienced chronic goal exceedances. At one of the wells (4127 in SWSA 6) physical modifications to the well are recommended; at two of the wells (0955 and 0958 in SWSA 4 near the downgradient trench) a cessation of monitoring goal requirements is recommended; and at two wells (well 1071 in SWSA 4 and well 0850 in SWSA 6) the recommendation is to continue water level monitoring for long-term trend evaluation (with no specified water level goal). At SWSA 6, DOE recommends continued monitoring of downgradient groundwater quality in well 0838 as the indicator of cap performance since that well is downgradient of the well 0850 area and has shown significant decreases in contaminant levels post-remediation. These recommendations will be discussed at a Project Team meeting for incorporation into an addendum to the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3). Completion of this process and modification of well 4127 will close the issue. Although operation of the SWSA 4 downgradient groundwater collection trench remains challenging, discharges from the area in surface water met ROD goals. Performance of the SWSA 4 downgradient trench will be evaluated in the 2016 FYR process.

- Although three monitoring wells at the Seepage Pits and Trenches (one well at Trench 7 and two wells at Trench 5) are experiencing increasing contaminant trends, groundwater contaminant concentrations around the shallow land burial sites are generally stable or decreasing compared to concentrations measured before completion of the Melton Valley remedy.

- Groundwater analyses conducted on samples from the on-site exit pathway wells since their construction in 2004 and off-site wells have resulted in a number of radionuclides and VOCs being detected periodically in different monitoring locations. An off-site detection of low concentrations of VOCs occurred early in the sampling history from one sampling event in 2010 at one well. It is suspected to have occurred because of well development pumping stresses in the off-site well during construction that caused low head in a discrete fracture zone connected to the vicinity of an on-site exit pathway well where detection of similar VOCs occurred. Lower detection limits in FY 2015 allowed several detections of very low concentrations of ^{90}Sr, ^{99}Tc, and tritium in the on-site and off-site monitoring wells.

- The biological monitoring results indicate that Melton Branch and lower WOC stream communities are impaired relative to reference sites. Since introduction of new fish species in the watershed, fish communities have improved steadily in both species richness and abundance. However, there is no evidence of improving trends in the benthic macroinvertebrate communities over the last 5 – 10 years, with substantial year to year variation.

3.2.2 Other LTS Requirements

Other LTS requirements for Melton Valley watershed actions are listed in Table 3.10 and described below.

3.2.2.1 Requirements

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) requires interim LUCs to protect against unacceptable exposures to contamination during and after remediation (Table 3.10). During remediation, interim LUCs were imposed that will remain in effect until final LUCs are established in future, final remedial decisions. The LUC objectives (DOE/OR/01-1826&D3) follow:

- ***Industrial area*** – prevent unauthorized access to or use of groundwater; control excavations or penetrations below prescribed contamination cleanup depths; prevent unauthorized access; and preclude uses of the area that are inconsistent with the LUCs.

- ***Waste management area*** – prevent unauthorized access to or use of groundwater; prevent unauthorized contact, removal, or excavation of source material; prevent unauthorized access; and preclude alternate uses of the area, e.g., additional waste disposal or development.

- ***Surface water and floodplain area*** – prevent unauthorized access to surface water, sediment, floodplain soils, or underlying groundwater; prevent fish consumption; and preclude uses of the media that are inconsistent with LUCs.

Table 3.10. Other LTS Requirements for the Melton Valley watershed

Other LTS requirements for LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ Implementation**
Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee **(DOE/OR/01-1826&D3)**					
1. DOE land notation (property record restrictions)[b] *A. Land use* *B. Groundwater*	*Restrict use of property by imposing limitations. Prohibit uses of groundwater. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. It was recorded by DOE in accordance with state law at the County Register of Deeds office.*	*DOE land notation will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP.*	*DOE land notation, including boundary survey plats, will be generated for SWSA 4, SWSA 5 (North and South), SWSA 6 (Caps A - E), and Pits and Trenches (Seepage Pits, Trenches 5 through 7, and 7A Leak Site). No additional unit-specific requirements.*	*DOE land notation will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP.*	*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s).*
2. Property record notices[c]	*Provide notice to anyone searching records about the existence and location of a hazardous waste landfill(s) and contaminated areas, and limitations on their use. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Notice will be provided by DOE Environmental Management to the public. This notice will be supplemented with the DOE land notation after completion of remediation (see above).*	*DOE property record notices will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP and documented in the RAR. No additional unit-specific requirements.*			*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s).*

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

Other LTS requirements for LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ Implementation**
3. Zoning notices[d]	*Provide notice to City Planning Commission about the existence and location of hazardous waste landfill(s) and/or PTSM contamination areas and providing use limitations information for zoning/planning purposes if/when MV areas are transferred out of DOE federal control.*	*The ORR including Melton Valley wide area is currently zoned as a federal controlled industrial/research (FIR) area with the City Planning Commission. Zoning notices, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*RCRA Subtitle C hazardous waste landfill(s) Property Record notice(s) will be filed according to TDEC Chapter 1200-1-11.05 and/or 1200-1-11.06 with the City Planning Commission. Zoning notice, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*The ORR including the Melton Valley floodplain area is currently zoned as a federal controlled industrial/research (FIR) area with the City Planning Commission. Zoning notices, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission.*
4. EPP program[e]	*Provide notice to worker/developer on the extent of contamination and prohibit or limit excavation/penetration activity. As long as the property remains under DOE control, including transferred property, it remains subject to the EPP program. Implemented by DOE and its contractors; initiated by permit request.*	*Existing DOE/Contractor EPP program remains in effect to provide worker protection*			*DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedure*
5. State advisories postings[f] *(e.g., no fishing or contact advisory)*	*Provide notice to resource users of contamination and risks associated with uses. Duration is indefinite, or until use conditions change as determined by the state. Although not a requirement, advisories and postings may be established by TDEC in the future.*	*Not applicable to controlled industrial areas or waste management areas*		*Applicable to White Oak Lake and the White Oak Creek Embayment*	*DOE official (or its contractors) will conduct field survey no less than annually and assess signs condition (i.e., remain intact, erect, and legible)* *DOE official (or its contractors) will verify no less than annually information with Tennessee Wildlife Resources Agency official*

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

Other LTS requirements for LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ Implementation**
6. Access controls[g] *(e.g., fences, gates, and portals)*	*Control and restrict access to workers and the public to prevent unauthorized uses. Control will last until concentrations of hazardous substances in the environmental media are at levels to allow for unrestricted use and exposure. Maintained by DOE.*	*Access controls are in place in Melton Valley and maintained by DOE*			*DOE official (or its contractors) will conduct field survey no less than annually of all controls to assess condition (i.e., remain erect, intact, and functioning)*
7. Signs[h]	*Provide notice or warning to prevent unauthorized access. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Signage maintained by DOE at 20 locations throughout the Melton Valley Watershed near major access points.*	*Signs have been posted on a Melton Valley-wide basis at 20 locations throughout the Melton Valley Watershed near major access points in accordance with the final approved LUCIP. No additional unit-specific requirements.*			*DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)*
	Provide notice to resource users of contamination and prohibit fishing/contact. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Signage maintained by DOE at 6 locations around the White Oak Lake and White Oak Creek Embayment at major access points.	*Not applicable to controlled industrial areas or waste management areas*		*Signs have been posted at 6 of the 20 access locations around White Oak Lake and the White Oak Creek Embayment*	*DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)*
8. Surveillance patrols	*Control and monitor access by workers/ public. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Established and maintained by DOE*	*Surveillance patrols will be implemented on a Melton Valley-wide basis in accordance with the final approved LUCIP. No additional unit-specific requirements.*			*DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted*

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

Areas	Project Documents	Other LTS Requirements	Frequency/Implementation
Other LTS requirements for Specific Areas			
***Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3)**			
SWSA 4	RAR (DOE/OR/01-2343&D1)[i,j]	• Inspection and maintenance of the landfill cover system includes the vegetative cover, erosion control, settlement and subsidence control, maintenance of the gas vent system, fence and roadways • Access controls and signs will be inspected and repaired as needed • Primary maintenance activity is mowing • Groundwater collection system monitoring and maintenance	• Semiannually and after seismic events greater than 4.0 on the Richter scale inspect the cover, compacted fill, or isolation cap outslopes • Semiannually and following any rainfall of 25 yr, 24 h intensity or greater (>5.5 in. in a 24 h period) inspect the surface drainage network • Semiannually inspect the rock buttress outslopes and gas vents • Annually inspect the cap maintenance roads, fences, gates, and signs • Frequency of the site visits for inspections of physical controls will be no less than annually
SWSA 5	RAR (DOE/OR/01-2343&D1)[i,j]	• Inspection and maintenance of the landfill cover system includes the vegetative cover, erosion control, settlement and subsidence control, maintenance of the gas vent system, fence and roadways • Access controls and signs will be inspected and repaired as needed • Primary maintenance activity is mowing • Groundwater collection system monitoring and maintenance	• Semiannually and after seismic events greater than 4.0 on the Richter scale inspect the cover, compacted fill, or isolation cap outslopes • Semiannually and following any rainfall of 25 yr, 24 h intensity or greater (>5.5 in. in a 24 h period) inspect the surface drainage network • Semiannually inspect the rock buttress outslopes and gas vents • Annually inspect the cap maintenance roads, fences, gates, and signs • Frequency of the site visits for inspections of physical controls will be no less than annually

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

Areas	Project Documents	Other LTS Requirements	Frequency/Implementation
Other LTS requirements for Specific Areas			
SWSA 6	RAR (DOE/OR/01-2343&D1)[i,j]	• Inspection and maintenance of the landfill cover system includes the vegetative cover, erosion control, settlement and subsidence control, maintenance of the gas vent system, fence, and roadway • Access controls and signs will be inspected and repaired as needed	• Semiannually and after seismic events greater than 4.0 on the Richter scale inspect the cover, compacted fill, or isolation cap outslopes • Semiannually and following any rainfall of 25 yr, 24 h intensity or greater (>5.5 in. in a 24 h period) inspect the surface drainage network • Semiannually inspect the rock buttress outslopes and gas vents • Annually inspect the cap maintenance roads, fences, gates, and signs • Frequency of site visits for inspections of physical controls will be no less than annually
Seepage Pits and Trenches Area	RAR (DOE/OR/01-2343&D1)[i,j]	• Inspection and maintenance of the landfill cover system includes the vegetative cover, erosion control, settlement and subsidence control, maintenance of the gas vent system, fence and roadways • Access controls and signs will be inspected and repaired as needed • Primary maintenance activity is mowing • Groundwater collection system monitoring and maintenance	• Semiannually and after seismic events greater than 4.0 on the Richter scale inspect the cover, compacted fill, or isolation cap outslopes • Semiannually and following any rainfall of 25 yr, 24 h intensity or greater (>5.5 in. in a 24 h period) inspect the surface drainage network • Semiannually inspect the rock buttress outslopes and gas vents • Annually inspect the cap maintenance roads, fences, gates, and signs • Frequency of site visits for inspections of physical controls will be no less than annually
Action Memorandum* letter dated November 9, 1990 on subject *White Oak Creek Embayment Interim Containment Action			
WOCE	RmAR (ORNL/ER/Sub/91-KA931/4)	• Sediment-retention structure included in regular site inspection program	• Not specified
***Interim Record of Decision for Oak Ridge National Laboratory Waste Area Grouping 13 Cesium Plots, Oak Ridge, Tennessee* (DOE/OR-1059&D4)**			
WAG 13 Cesium Plots	RAR Postconstruction report (DOE/OR/01-1218&D2)	• The fence enclosure will remain in place	• Perform long-term operations and maintenance as necessary

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
***Action Memorandum for Uranium Deposit Removal at the Molten Salt Reactor Experiment, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1488&D2)**			
MSRE D&D Uranium Deposit Removal	RmAR (DOE/OR/01-1918&D2)	• S&M activities for the interim storage of the collector canister holding the uranium-laden charcoal removed from the ACB • Venting of the canister as necessary to maintain a pressure of less than 50 psig • If interim storage is required beyond two years, it will be necessary to denature the collector canister • S&M activities for the ACB performed pursuant to facility authorization basis documents and approved procedures • O&M of the ventilation system to maintain a negative air pressure	• Periodic measurements (daily checks of the pressure gauge and hourly recorder data) • Monthly checks of the CBC for water accumulation and presence of a pump for removing water from the CBC • Annual tests of the pump
***Action Memorandum for Time-Critical Removal Action for Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2460&D1)**			
White Oak Dam	RmAR (DOE/OR/01-2509&D1)	• Routine maintenance includes: repairs to fences and gates; maintenance of signage and postings; maintenance of pole-mounted overhead lights at the site; testing, lubrication and maintenance of the lift gates; vegetation control; and any needed repair of any observed subsidence, erosion damage, animal holes, or other damage to the dam surface (except for the roadway pavement which is the responsibility of state of Tennessee) • Final land use controls will be defined in a future CERCLA decision for ORNL, as necessary • Access to WOL and WOCE will continue to be restricted in accordance with existing ROD and LUCIP requirements	• Periodic inspections in accordance with FEMA guidelines for dam safety

[a]Source for LUCs # 1-8: *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2343&D1) and 2009 errata. Source of Frequency/Implementation for LUCs # 1-8: *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1977&D6).

[b]DOE land notation (property record restriction) – includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with the original property acquisition records of DOE and its predecessor agencies. This DOE land notation may be referred to as property record restrictions in some ORR RODs.

[c]Property Record Notices – includes conditions that inform, restrict, or prohibit certain uses of real property. They serve also to alert anyone searching for property information about residual contamination/waste disposal areas on the property.

[d]Zoning notices – includes information on the location of hazardous waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., the City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.

Table 3.10. Other LTS Requirements for the Melton Valley watershed (cont.)

[e]EPP program – refers to the internal DOE/DOE contractor administrative program(s) that requires the permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or, in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.

[f]State advisories/postings – refers to health advisory information provided by the TDEC Division of Water Pollution Control related to use or restrictions thereon of surface waters that currently do not meet the designated uses established in Rules of the TDEC Chapter 1200-4-4. Although not required, TDEC may provide advisories and postings in the future. Currently such information is included on signs maintained by DOE that are placed along WOL and WOCE to provide notice to potential users of contamination and prohibit fishing/water contact.

[g]Access controls – physical barriers or restrictions to entry.

[h]Signs – DOE posted command, warning, or direction.

[i]This includes errata DOE/OR/01-2343&D1/A1 and DOE/OR/01-2343&D1/A2 and addendum DOE/OR/01-2343&D1/A3/R1.

[j]LTS requirements are detailed in the *Melton Valley Surveillance and Maintenance Plan* (DOE/OR/01-2342&D1) attached to the RAR (DOE/OR/01-2343&D1) as Appendix E.

ACB = auxiliary charcoal bed
CBC = charcoal bed cell
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
D&D = decontamination and decommissioning
DOE = U.S. Department of Energy
EPP = excavation/penetration permit
FEMA = Federal Emergency Management Agency
FIR = federal controlled industrial/research
LTS = long-term stewardship
LUC = land use control
LUCIP = Land Use Controls Implementation Plan
MSRE = Molten Salt Reactor Experiment
MV = Melton Valley
O&M = operations and maintenance
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
psig = pounds per square inch gauge
PTSM = principal threat source material
RAR = Remedial Action Report.
RCRA = Resource Conservation and Recovery Act of 1976
RmAR = Removal Action Report
ROD = Record of Decision
S&M = surveillance and maintenance
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
WAG = Waste Area Grouping
WOCE = White Oak Creek Embayment
WOL = White Oak Lake

The LUCs (property record restrictions [deeds], property record notices, zoning notices, EPP program, state advisories/postings, access controls, signs, and surveillance patrols) are listed in Table 3.10. The implementation and maintenance of these LUCs are specified in the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE/OR/01-1977&D6). Because of the similarity in interim LUC objectives among the three remediation areas, most of the LUCs apply throughout the watershed.

The requirements of the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE/OR/01-1977&D6) are in Appendix A, along with the required certification. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE/OR/01-1977&D6) requires individual remediation projects within the Melton Valley watershed to identify applicable additional LUCs in the project completion document. None of the Melton Valley completion documents contain additional project-specific LUCs.

While the completion documents do not require additional LUCs, the hydrologic isolation projects include engineering controls that are to be maintained at the 14 separate waste caps. Table 3.10 lists these LTS requirements from the Melton Valley completion documents. Maintenance of the engineering controls at the caps is addressed in the *Melton Valley Surveillance and Maintenance Plan* (DOE/OR/01-2342&D1) that is attached to the *Remedial Action Report for the Melton Valley Watershed* (DOE/OR/01-2343&D1). This plan covers the S&M required for all remediation completed in Melton Valley. Inspections and maintenance of the engineering controls began immediately upon completion and are implemented in accordance with the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC/OR-2288).

3.2.2.2 Status of Requirements

Appendix A contains the Certification of LUCs for FY 2015. The LUCAP attached to the *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation* (DOE/OR/01-1824&D1/A2) requires that the Manager, DOE OREM, annually verify in the RER that LUCIPs are being implemented on the ORR. A summary of the implementation verification and status of the Melton Valley watershed LUCs follows:

Property Record Restrictions (Deeds)

- The DOE filed the Melton Valley Land Notation with the Roane County Register’s of Deeds office on August 21, 2008. It is titled, “Notation on Ownership Record for Notification of Closure of Melton Valley Burial Grounds,” and was filed as an Environmental Notation in Book 1290, pages 727 – 748. The Land Notation includes the principal contaminants left in place and restrictions on the property. Survey plats for each of the waste units were attached to the Land Notation that delineated property that will be restricted in its future use. For FY 2015, this information was verified to be properly filed electronically at the Roane County Register’s of Deeds office.

Property Record Notices

- It was verified in FY 2015 that the 2007 DOE Melton Valley Property Record notice remains properly recorded at the Roane County Register’s of Deeds office.

Zoning Notices

- For FY 2015, the areas remain under federal control and no Zoning Notice has been filed to date.

EPP Program

- The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE/OR/01-1826&D3) requires that an EPP program be in place throughout Melton Valley to provide notice to the worker/developer, i.e., permit requestor, on the extent of contamination and to prohibit or limit unauthorized excavation/penetration activity, as appropriate. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE/OR/01-1977&D6) requires a DOE official (or its contractor) to verify no less than annually the functioning of the permit program against existing procedures.

- In FY 2015, there were no excavation permits requested for Melton Valley remediation areas.

State Advisories/Postings

- For FY 2015, a field survey was conducted by the WRRP and the S&M Program to verify signs maintained by DOE to provide notice to potential users of contamination and prohibit fishing/water contact, were in place, in good condition, and legible.

Access Controls

- All major access points remain guarded or locked at all times, and interior gates are selectively locked. Specifically, access is restricted by security portals at the east and west ends of Bethel Valley Road. There also is a locked gate at the junction of the Melton Valley haul road and the Melton Valley Access Road. Perimeter roads around Melton Valley have gates that allow access for maintenance activities. Conditions at two locations have changed, but adequate controls are in place.

Signs

- Signs in place around the Melton Valley watershed and at the WOL and WOCE to provide notice of contamination or warning to prevent unauthorized access remain in good condition and are legible. Additional signs have been posted at locations around WOL and WOCE and on the Sediment Retention Structure to provide notice to potential resource users of contamination and to prohibit fishing/swimming.

Surveillance Patrols

- Patrols may be performed as part of the required, routine S&M site inspections to ensure that incompatible uses have not occurred for units/areas requiring land use restrictions. In FY 2015, surveillance patrols were performed by the ORNL S&M Program as part of routine site inspections and inspections of the capped areas within Melton Valley were performed on a semiannual basis. In addition, routine patrols of various areas within Melton Valley are performed no less than quarterly.

In addition to implementing the physical LUCs, i.e., access controls, signs, and surveillance patrols, as detailed above, the S&M Program also performed inspections of the Melton Valley hydrologic isolation areas to inspect each of the engineering controls listed below as applicable at each site:

- Vegetative cover on compacted fill or isolation cap,

- Compacted fill cover or isolation cap outslopes,

- Rock buttress outslopes,

- Surface drainage features,
- Monitoring wells (including well interior conditions),
- Weirs at surface water monitoring locations,
- Groundwater (leachate) collection equipment,
- Gas vents,
- Wetlands,
- Melton Branch relocation area, and
- Cover/cap maintenance roads, gates, and signs.

In FY 2015, engineering controls were inspected semiannually by the S&M Program according to the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC/OR-2288) at the following sites:

- SWSA 4,
- SWSA 5 North 4 – Trench Area,
- SWSA 5 South,
- SWSA 6 Capped Area – CAP A,
- SWSA 6 Capped Area – CAP B,
- SWSA 6 Capped Area – CAP C,
- SWSA 6 Capped Area – CAP D,
- SWSA 6 Capped Area – CAP E,
- SWSA 6 Capped Area – Hill Cut Test Facility,
- Pits 2, 3, and 4,
- Trench 5,
- Trench 6 and Trench 6 Leak Sites,
- Trench 7 and Trench 7 Leak Sites Cap, and
- Trench 7 East Leak Site.

Maintenance during FY 2015 included rehanging signs that may have fallen off from the weather and repairing three gas vents that became unattached. All caps received vegetation control (spraying with herbicides), and were mowed a minimum of once during the year.

3.3 SINGLE-PROJECT ACTIONS

3.3.1 WOCE Sediment Retention Structure

Location of the WOC Sediment Retention Structure is shown on Figure 3.1. The scope of this action was the construction of a sediment retention structure at the mouth of WOC to contain the sediments in lower WOCE and minimize contaminant transport off-site to the Clinch River and Watts Bar Reservoir. The Sediment Retention Structure uses rip-rap-filled wire gabions to slow water movement, preventing scour of sediment out of the embayment during changes in WOC flow and fluctuation of Watts Bar Reservoir levels.

3.3.1.1 Other LTS Requirements

Other LTS requirements are listed in Table 3.10 and shown on Figure 3.2 and include only inspection and maintenance of the sediment retention structure.

3.3.1.2 Status of Requirements

The site was inspected monthly in FY 2015 by the S&M Program to check the fence and gate to ensure they were preventing access, inspect the condition of the warning signs, determine if excessive debris or vegetation had built up on the Sediment Retention Structure, and identify any evidence that there had been any movement or shift of the embayment structure. Minor maintenance during FY 2015 included adding some new signs to replace those that were starting to fade.

3.3.2 WAG 13 Cesium Plots

The location of the WAG 13 Cesium Plots is shown on Figure 3.1. The scope of this action involved excavation of contaminated soil from the plots, placement of a permeable liner in each excavated plot and backfill with clean, compacted fill material and topsoil layer.

3.3.2.1 Other LTS Requirements

Other LTS requirements are listed in Table 3.10 and shown on Figure 3.2 and include only long-term S&M of the fenced enclosure.

3.3.2.2 Status

The site underwent quarterly inspections in FY 2015 conducted by the S&M Program to verify that all gates to the site were closed and locked, the fence was not damaged, vegetation within the fenced area was cut, vegetation growth along fence line was acceptable, radiological postings were in place, point-of-compliance (POC) signs were in place, and the site was clear of unauthorized materials. Minor maintenance included repairing minor damage to a portion of the fence caused by limbs or sections of trees. No additional maintenance was required, and routine mowing was performed.

3.3.3 MSRE Uranium Deposit Removal

The location of the MSRE is shown on Figure 3.1. The scope of this action involved the break up and removal of nongranular uranium-laden charcoal and vacuuming of the remaining loose charcoal and chips from the auxiliary charcoal bed to ensure that less than a critical mass remains.

3.3.3.1 Other LTS Requirements

Other LTS requirements listed in Table 3.10 and shown on Figure 3.2 are specified in the *Removal Action Report for Uranium Deposit Removal at the Molten Salt Reactor Experiment* (DOE/OR/01-1918&D2) and include S&M for the interim storage of the collector canister holding the uranium-laden charcoal removed from the auxiliary charcoal bed. Specifically, requirements include periodic pressure measurements (daily checks of the pressure gauge and hourly recorder data) and venting of the canister, as necessary, to maintain a pressure of less than 50 psig.

3.3.3.2 Status of Requirements

Inspections were conducted daily of the uranium-laden charcoal canister, in accordance with MSRE procedures. These inspections included periodic pressure measurements and periodic venting of the canister to reduce pressure when needed. No maintenance was performed on the charcoal canister in FY 2015.

3.3.4 White Oak Dam

The location of the White Oak Dam is shown on Figure 3.1. The goal of this time-critical removal action was to maintain the containment of contaminated sediment in WOL and improve the stability of the highway embankment that makes up part of White Oak Dam.

3.3.4.1 Other LTS Requirements

The other LTS requirements associated with the *Removal Action Report for Corrective Actions at White Oak Dam* (DOE/OR/01-2509&D1) are listed in Table 3.10 and shown on Figure 3.2 and include periodic inspections. The modifications to White Oak Dam completed under this removal action require no active operation or maintenance. The improved armoring of the upstream and downstream slopes of the dam uses stone and large rip-rap that has been designed to perform this function without active maintenance; similarly, the grouted box culvert requires no active operation or maintenance. Periodic inspections will be performed in accordance with Federal Emergency Management Agency (FEMA) guidelines for dam safety. Dams located on federal property are self-regulated by the federal agency managing that property. DOE regulates all dams on DOE property from DOE Headquarters Office of Corporate Safety Programs. URS | CH2M Oak Ridge LLC (UCOR) and its subcontractors have overall responsibility for operating and maintaining the White Oak Dam and contiguous property on behalf of DOE OREM, including routine inspections of the White Oak Dam to ensure dam safety. The UT-B has responsibilities at the dam for monitoring the water flow and water level, environmental sampling, and for responding to abnormal incidents. The Tennessee Department of Transportation (TDOT) controls road closure and inspection, operation, and maintenance of the bridge and highway.

The *Management Plan for White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (UCOR-4178) delineates responsibilities for the operation, maintenance, routine inspections, and response to abnormal conditions for the White Oak Dam and associated facilities, and provides the schedule and content of routine and post-event dam inspections. Routine inspections and maintenance of the White Oak Dam include: repairs to fences; maintenance of signage and postings; maintenance of pole-mounted overhead lights at the site; testing, lubrication and maintenance of the lift gates; vegetation control; and any needed repair of any observed subsidence, erosion damage, animal holes, or other damage to the dam surface (except for the roadway pavement which is the responsibility of the state of Tennessee). Special events that require inspections include: overtopping or an event such as an earthquake that exceeds 4.0 on the Moment Magnitude Scale (MMS), a serious vehicle accident on the

dam that goes beyond the roadway, and aircraft crash into the dam, a tornado that could have damaged the dam, or high water going onto the roadway (754.8 ft aMSL).

3.3.4.2 Status of Requirements

In FY 2015, the site underwent required quarterly inspections by S&M Program craft personnel and annual inspections by the facility manager in accordance with the *Management Plan for White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (UCOR-4178). The gates were tested monthly, and there were no special events requiring inspections.

3.4 MELTON VALLEY WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Melton Valley watershed are in Table 3.11.

Table 3.11. Melton Valley watershed issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issue Carried Forward			
1. Several wells in Melton Valley have chronically not attained the ROD goal for groundwater level within hydrologically isolated areas. (2015 RER)	1. Two wells in SWSA 6 and three wells in SWSA 4 have not attained the ROD goal for groundwater level control inside hydrologically isolated areas. At one well (well 4127 in SWSA 6) physical modifications are recommended; at two wells in SWSA 4 near the downgradient trench a cessation of monitoring goal requirements is recommended; and at two wells (one well in SWSA 4 and one well in SWSA 6) the recommendation is to continue water level monitoring for long-term trend evaluation (with no specified water level goal). At SWSA 6, DOE recommends continued monitoring of downgradient groundwater quality in well 0838 as the indicator of cap performance since that well is downgradient of the well 0850 area and has shown significant decreases in contaminant levels post-remediation. These recommendations will be discussed at a Project Team meeting for incorporation into an addendum to the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1982&D3). Completion of this process and modification of well 4127 will close the issue.	DOE	FY 2017
Completed/Resolved Issues[b]			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the *2016 Remediation Effectiveness Report*. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g., (2013 RER).

DOE = U.S. Department of Energy
FY = fiscal year
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area

3.5 REFERENCES

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DOE/OR/01-1826&D3. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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DOE/OR/01-1918&D2. *Removal Action Report for Uranium Deposit Removal at the Molten Salt Reactor Experiment at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2001, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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4. BEAR CREEK VALLEY WATERSHED

4.1 INTRODUCTION AND STATUS

4.1.1 Introduction

The BCV watershed contains closed and active waste disposal facilities. Table 4.1 lists the CERCLA actions within the watershed and identifies those with monitoring or other LTS requirements. Figure 4.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Only sites that have LTS requirements (Table 4.1) are included in these performance evaluations. End uses of a site form the basis of RAOs and determine access restrictions and allowable activities at the site. Figure 4.2 shows ROD-designated end uses within the watershed and interim controls requiring LTS.

Completed CERCLA actions in the BCV watershed are gauged against their respective action specific goals. However, CERCLA actions have yet to be fully implemented within the watershed. Therefore, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provides a preliminary evaluation of the early indicators of effectiveness at the watershed scale.

The EMWMF is an operating CERCLA waste disposal facility located in the BCV watershed. Operation of the EMWMF is an ongoing CERCLA action to dispose waste from CERCLA response actions on the ORR and associated sites. The CERCLA action status of the EMWMF is not reported in this document but is evaluated in the EMWMF annual PCCR.

For a complete discussion on background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 8 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

4.1.2 Status Update

During FY 2015, no additional CERCLA actions were implemented or completed, nor were any associated FFA documents submitted or approved for CERCLA actions located in BCV. Monitoring in support of performance assessments and evaluations continued.

4.2 BCV PHASE I ROD

4.2.1 Performance Monitoring

4.2.1.1 Performance Goals and Monitoring Objectives

The remedy in the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) includes source control and migration control strategies that reduce contaminant

migration in shallow groundwater and surface water. These actions are expected to result in a reduction of contamination levels in groundwater and surface water downstream of the waste areas over time.

Several single-project decisions within BCV watershed predate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4). These earlier actions do not contain specific performance criteria for reduction of contaminant flux or risk reduction at the watershed scale. The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4), a watershed-scale decision, incorporates the preceding single-project actions and sets specific performance standards for contaminant flux and risk reduction for the entire watershed. The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) also includes expected outcomes for the selected remedy against which effectiveness of individual actions is measured. The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) addresses groundwater and surface water by dividing the valley into three zones and establishing performance standards for each zone in terms of resource uses and risks.

This section presents the remediation goals, performance metrics, and progress toward achieving the goals in the BCV watershed. Annual performance measurements obtained during FY 2015 are presented along with historic monitoring results.

The RAOs for the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) are to:

- *protect future residential users of the valley in Zone 1 from risks from exposure to groundwater, surface water, soil, sediment, and waste sources;*

- *Protect a passive recreational user in Zone 2 from unacceptable risks from exposure to surface water and sediment;*

- *And protect industrial workers and maintenance workers in Zone 3 from unacceptable risks from exposure to soil and waste.*

The three land use zones in the BCV watershed are identified on Figure 4.2. Consistent with the RAOs, water quality goals are also established for each zone as stated in Table 4.2, although chemical-specific ARAR-based performance criteria are not included for groundwater. In addition to the watershed-wide water quality goals, the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) provides site-specific water quality goals for the S-3 Site Pathway 3 and the Boneyard/Burnyard (BYBY) actions (Table 4.3).

Table 4.1. CERCLA actions in BCV watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Watershed-scale actions			
BCV Phase I ROD	ROD (DOE/OR/01-1750&D4): 06/16/00	**Watershed-scale requirements**	Yes (see Table 4.5)/Yes (see Table 4.12)
	LUCIP (DOE/OR/01-2320&D1) submitted 09/29/06	**Actions complete**	
		• BYBY PCCR (DOE/OR/01-2077&D2) approved 01/12/04	Yes/Yes
		• Oil Landfarm Soils Containment Pad RAR (DOE/OR/01-1937&D2) approved 07/16/01	No/No
Single-project actions			
BCV OU 2 (Spoil Area 1, SY-200 Yard)	ROD (DOE/OR/02-1435&D2): 01/23/97	No additional actions required; institutional control and S&M ongoing	No/Yes
S-3 Site Tributary Interception (Pathways 1 and 2)	AM (DOE/OR/01-1739&D1): 06/25/98	RmAR (DOE/OR/01-1945&D2): approved 02/11/02	Terminated
	AM Addendum (DOE/OR/01-1739&D1/A1): 10/20/00	RmAR Addendum (DOE/OR/01-1836&D1/A1): approved 06/20/07 (shutdown Pathways 1 and 2 system)	Terminated
BCBGs Unit D-East	AM (DOE/OR/01-2036&D1): 08/12/02	RmAR (DOE/OR/01-2048&D2): approved 05/09/03	No/No
EMWMF Haul Road Construction	ROD (DOE/OR/01-1791&D3: 11/02/99 ESD (DOE/OR/01-2194&D2): 01/11/05	PCCR (DOE/OR/01-2296&D1): approved 04/02/06 (Haul Road)	No/No[c]

[a]Detailed information of the status of actions is from Appendix E of the FFA and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]"No/No" indicates no monitoring/other LTS requirements are identified in the CERCLA action completion document beyond those identified in the watershed ROD. Refer to Table 4.5 for watershed-scale monitoring requirements and Figure 4.2 and Table 4.12 for watershed-scale LUCs and other LTS requirements.

[c]The EMWMF Haul Road Construction is a completed action under the EMWMF ROD. Operation of the EMWMF is an ongoing CERCLA action to dispose waste from CERCLA response actions on the ORR. The CERCLA action status of the EMWMF is evaluated in a separate report.

AM = Action Memorandum
BCBGs = Bear Creek Burial Grounds
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
ESD = Explanation of Significant Differences
EMWMF = Environmental Management Waste Management Facility
FFA = Federal Facility Agreement
LTS = long-term stewardship
LUC = land use control
LUCIP = Land Use Control Implementation Plan
ORR = Oak Ridge Reservation
OU = operable unit
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RmAR = Removal Action Report
ROD = Record of Decision
S&M = surveillance and maintenance

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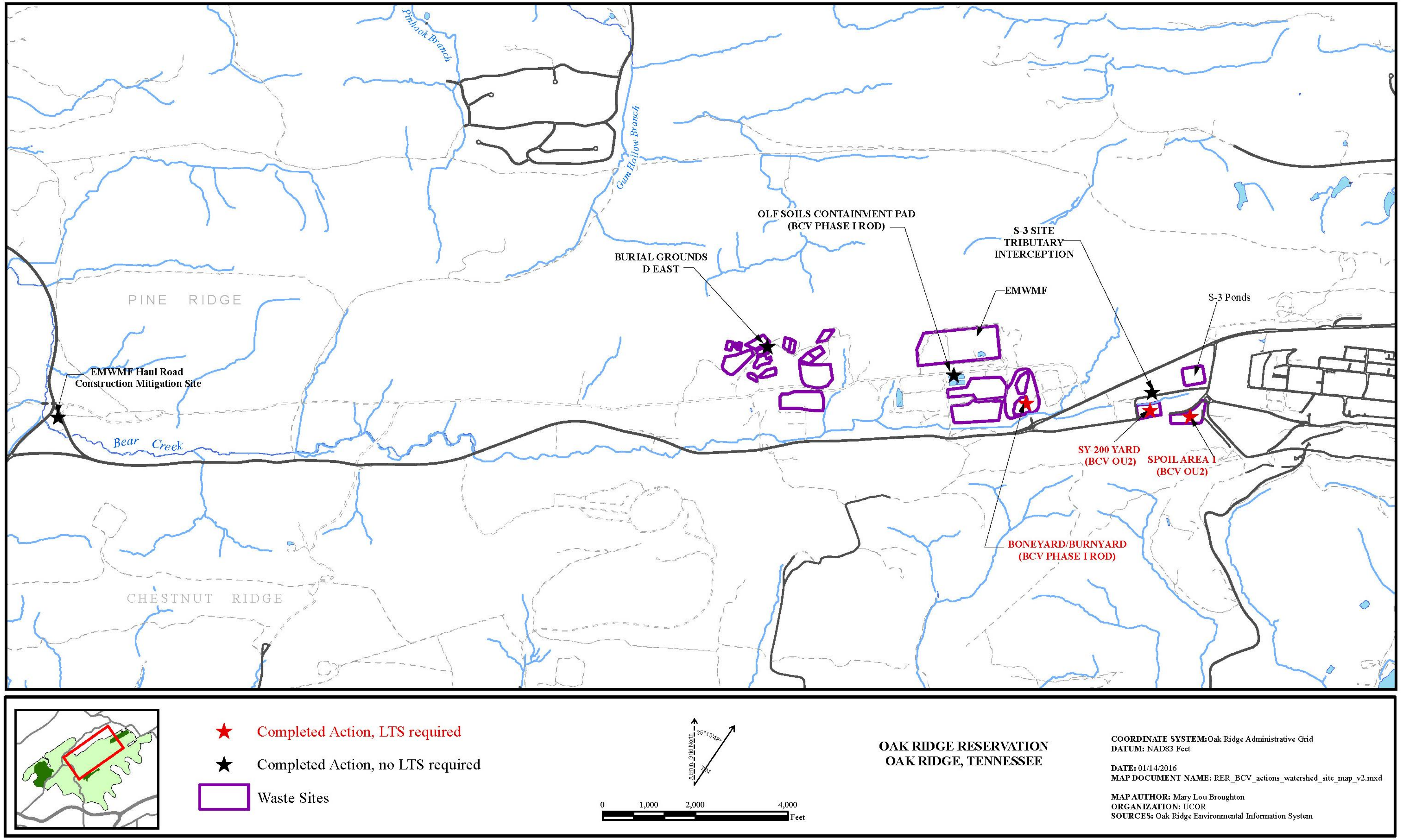

Figure 4.1. BCV watershed.

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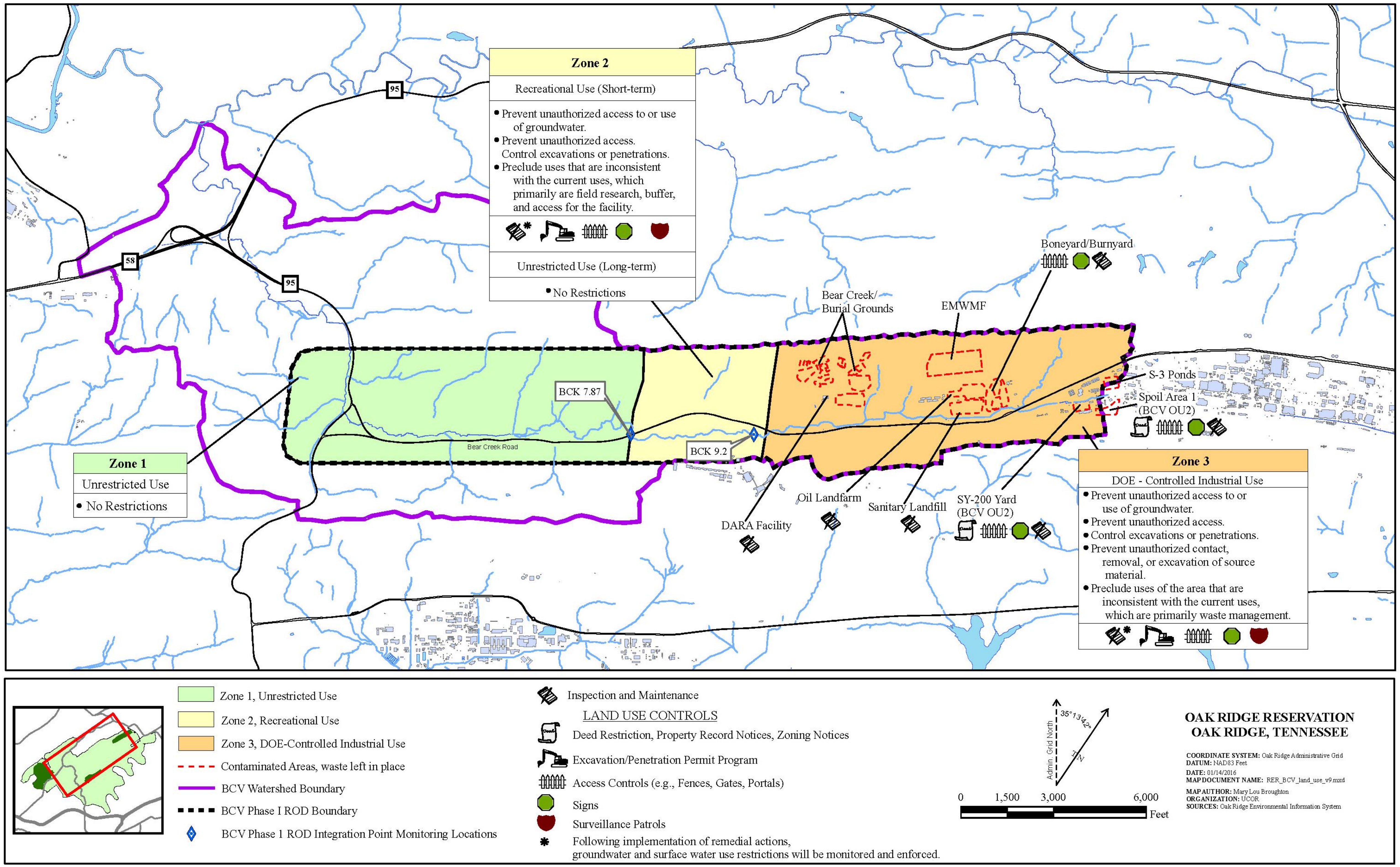

Figure 4.2. BCV Phase I ROD-designated end use and interim controls requiring LTS.

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Table 4.2. Groundwater and surface water goals, BCV watershed[a]

Area of the valley (see Figure 4.2)	*Current situation*	*Goal*
Zone 1 – western half of Bear Creek Valley	*No unacceptable risk posed to a resident or a recreational user. AWQC and groundwater MCLs are not exceeded.*	*Maintain clean groundwater and surface water so that this area continues to be acceptable for unrestricted use* *Land use: Unrestricted*
Zone 2 – a 1-mile-wide buffer zone between zones 1 and 3	*No unacceptable risk posed to a recreational user. Risk to a resident is within the acceptable risk range except for a small area of groundwater contamination. Groundwater MCLs are exceeded, but AWQC are not.*	*Improve groundwater and surface water quality in this zone consistent with eventually achieving conditions compatible with unrestricted use* *Land use: recreational (short-term); unrestricted (long-term)*
Zone 3 – eastern half of Bear Creek Valley	*Contains all the disposal areas that pose considerable risk.* *Groundwater MCLs and AWQC are exceeded.*	*Conduct source control actions to (1) achieve AWQC in all surface water, (2) improve conditions in groundwater to allow Zones 1 and 2 to achieve the intended goals, and (3) reduce risk from direct contact to create conditions compatible with future industrial use* *Land use: controlled industrial*

[a]Source: Table 2.1 of *Record of Decision for the Phase 1 Activities in Bear Creek Valley* ([DOE/OR/01-1750&D4] page 2-13).

AWQC = ambient water quality criteria
BCV = Bear Creek Valley
MCL = maximum contaminant level

Table 4.3. Site-specific goals for RAs at the S-3 Site Pathway 3 and the BYBY[a]

Remedial action goals for S-3 Site Pathway 3	*Remedial action goals for BY/BY*
• *Prevent expansion of the nitrate plume into Zone 1* • *Reduce concentration of cadmium in NT-1 and upper Bear Creek to meet AWQC[b]* • *Prevent future increase in release of uranium to Bear Creek to maintain annual flux below 27.2 kg total Uranium at BCK 12.34* • *Reduce seasonal nitrate flux at NT-1/Bear Creek confluence by 40%. The seasonal nitrate flux benchmark will be defined by the FFA parties in remedial design.*	• *Reduce flux of uranium in NT-3 at confluence with Bear Creek to 4.3 kg/yr* • *Reduce concentration of mercury in NT-3 to meet AWQC (12 ng/L at the time – now 51 ng/L)*

[a]Source: Table 2.2 of *Record of Decision for the Phase 1 Activities in Bear Creek Valley* ([DOE/OR/01-1750&D4] page 2-14).
[b]The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) originally established the cadmium concentration performance standard as 3.9 µg/L. This standard changed to 0.25 µg/L due to a change in the promulgated AWQC.

AWQC = ambient water quality criteria
BYBY = Boneyard/Burnyard
BCK = Bear Creek kilometer
FFA = Federal Facility Agreement
NT = North Tributary
RA = remedial action

The source removal actions related to principal threat source materials and groundwater control actions specified in the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) were intended to attain the stated water quality goals. The following components of the selected remedy are listed in the ROD:

- **S-3 Site.** Install trench at Pathway 3 for passive in situ treatment of shallow groundwater.
- **Oil Landfarm Area.** Actions in the Oil Landfarm Area include:
  - Remove waste stored in Oil Landfarm Soil Containment Pad for commercial off-site disposal and dismantle structure.
  - Excavate source areas in BYBY and contaminated floodplain soils and sediments. Excavated materials meeting the EMWMF WAC will be disposed on-site; materials exceeding EMWMF WAC will be disposed off-site. Install clay cap over uncapped disposal areas at BYBY, and maintain existing caps.
  - Implement hydraulic isolation measures at BYBY, including reconstruction of North Tributary (NT)-3, elimination of stagnation points, and installation of drains or well points.
- **Other Sites**. Remove waste stored in the Disposal Area Remedial Action (DARA) Facility for off-site disposal, and dismantle structure.

Field implementation of actions under the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) was initiated in FY 2000. RAs in the Oil Landfarm Area are complete (BYBY and Oil Landfarm Soil Containment Pad). Other key components of the remedy (S-3 Pathway 3 and DARA facility) have not yet been implemented. An early action addressing S-3 Pathways 1 and 2 was terminated. Response actions for all three components (i.e., Pathways 1, 2 and 3) will be included in the future design considerations for Pathway 3 or in the final groundwater decision for BCV.

The ROD included expected outcomes, target risk levels, and timeframes for attainment of goals for each of the BCV watershed end uses (Table 4.4).

4.2.1.2 Evaluation of Performance Monitoring Data

This section presents the monitoring data that evaluates progress toward meeting the goals of the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4). Performance monitoring includes surface water monitoring, groundwater monitoring, and biological monitoring. The performance metrics and monitoring parameters for each location are outlined in Table 4.5. Performance monitoring outlined in Table 4.5 as well as other baseline and trend monitoring are shown in Figure 4.3 and discussed below.

4.2.1.2.1 Surface Water

4.2.1.2.1.1 Surface Water Quality Goals and Monitoring Requirements

The goals of the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) include AWQC compliance and annual mass (flux) reductions for nitrate and uranium at several locations throughout the watershed. AWQC sampling is conducted in the year prior to each CERCLA FYR. The most recent evaluation of progress toward meeting AWQC in BCV was reported in the *2011 Third Reservation-Wide CERCLA Five-Year Review for the U.S. Department of*

Energy Oak Ridge Reservation, Oak Ridge, Tennessee (DOE/OR/01-2516&D2). Monitoring is keyed to the boundaries between the three zones defined in the ROD. Key surface water monitoring locations include Bear Creek kilometer (BCK) 9.2, BCK 12.34, NT-3, and NT-8 (Figure 4.3). BCK 9.2 is the integration point near the border of Zones 2 and 3. BCK 12.34 is located near the Bear Creek headwater and serves as an integration point for surface water contaminant discharges from the S-3 Ponds area. NT-3 was historically heavily impacted by contaminant discharges from BYBY which has been remediated. NT-8 carries runoff and contaminants from the western end of the BCBGs to Bear Creek just a short distance from the western end of Zone 3 and above the integration point at BCK 9.2.

Zone 1

Zone 1 of BCV watershed constitutes the valley area west of BCK 7.87 (Figure 4.3). Surface water quality is monitored at BCK 7.87. The surface water quality goal for Zone 1 is to meet risk levels consistent with unrestricted use (residential) and to meet AWQC (Table 4.4). Zone 1 surface water monitoring results are compared to AWQC and risk-based concentrations for residential exposure in each CERCLA FYR. The AWQC comparison includes quarterly grab samples for metals and anions during the year prior to each FYR.

Zone 2

Zone 2 of BCV watershed constitutes the section of the valley located between BCK 7.87 and BCK 9.2 (Figure 4.3) and functions as a buffer zone between Zones 1 and 3. The long-term goal for Zone 2 is to improve surface water quality consistent with eventually achieving unrestricted use in 50 years. At BCK 9.2, the monitoring location for Zone 2 surface water, weekly flow-proportional samples are collected for isotopic uranium analysis and monthly grab samples are collected for nitrate analysis. Uranium and nitrate monitoring at BCK 9.2 represents the contribution in surface water from all sources within the Bear Creek watershed migrating from Zone 3 into Zone 2. In addition, quarterly samples for metals and VOCs are collected in the year prior to each CERCLA FYR. Zone 2 surface water results at BCK 9.2 are compared to the uranium flux goal of ≤34 kg/yr from the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) annually and to AWQC during the FYR (Table 4.5). In addition, results for uranium and nitrate at BCK 9.2 are compared to risk-based concentrations for residential exposure.

Table 4.4. Expected outcome of the selected remedy, BCV watershed[a]

	Zone 1	Zone 2	Zone 3		
			S-3 Site/Pathway 3	BYBY/OLF Area	BCBGs
Available land use and time frame	*Unrestricted use (compatible with residential use), available immediately*[b]	*Presently restricted use (compatible with recreational use); compatible with unrestricted use in 50 years*	*Restricted use, long-term waste management area/controlled industrial use*	*Restricted use; long-term waste management area/controlled industrial use*	*N/A*
Available groundwater use and time frame	*Unrestricted use (compatible with residential use) available immediately (MCLs met)*	*Presently restricted use (MCLs not met for nitrates, compatible with recreational use); with unrestricted use in 50 years*	*Restricted use*	*Restricted use*	*N/A*
Available surface water use and time frame	*Unrestricted use (compatible with residential use) available immediately (AWQC met)*	*Unrestricted use(compatible with recreational use); available immediately (AWQC met)*	*Recreational use, AWQC met in 5 years following implementation*	*Recreational use, AWQC met in 5 years following implementation*	*N/A*
Cleanup levels, residual risk	- *MCLs in groundwater* - *AWQC in surface water* - *risk to residential receptor below RAO of* 1×10^{-5}	- *TBD for groundwater* - *AWQC in surface water* - *risk to residential receptor below RAO of* 1×10^{-5}	- *TBD for groundwater* - *AWQC in surface water* - *direct exposure risk to industrial/terrestrial receptors eliminated* - *risk to industrial receptor below RAO of* 1×10^{-5} - *Reduce seasonal nitrate flux at the NT-1/Bear Creek confluence by 40%*	- *TBD for groundwater* - *AWQC in surface water* - *risk to industrial receptor below RAO of* 1×10^{-5}	*N/A*
Anticipated socioeconomic and community revitalization impacts	*Property will meet conditions for residential/recreational/ industrial use*	*Property will meet conditions compatible with recreational/industrial use*	*Waste area is capped and used as a parking lot to support Y-12 activities; surrounding area available for additional controlled industrial use*	*Area devoted to waste management; proposed on site disposal facility provides potential to create new jobs*	*N/A*
Anticipated environmental and ecological benefits	*Media not impacted*	*Slightly impacted groundwater will be restored*	*Impacted surface water will be restored*	*Impacted surface water will be restored, capping will protect terrestrial species*	*N/A*

[a]Source: *Record of Decision for the Phase 1 Activities in Bear Creek Valley* ([DOE/OR/01-1750&D4] Table 2.22).
[b]*Although the selected remedy will allow unrestricted land use for this zone, there are no plans to transfer ownership of this property.*

AWQC = ambient water quality criteria
BCBGs = Bear Creek Burial Grounds
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
MCL = maximum contaminant level
N/A = not applicable
NT = North Tributary
OLF = Oil Landfarm
RAO = remedial action objective
TBD = to be determined
Y-12 = Y-12 National Security Complex

Zone 3

Zone 3 of Bear Creek watershed is the section of the valley located east of BCK 9.2 (Figure 4.3) that contains a currently operating CERCLA waste disposal facility (EMWMF) and former waste disposal sites. The remedial goals for Zone 3 are to attain AWQC in all surface water (short-term), and reduce risks from direct contact to achieve conditions compatible with a long-term, controlled industrial end use. Surface water is monitored at a number of locations within Zone 3, including monitoring required specifically for the S-3 Ponds Pathway 3 and the BYBY (Figure 4.3, Table 4.5).

Monitoring for the S-3 Ponds Pathway 3 is conducted at surface water locations BCK 12.34, NT-1, and NT-2. BCK 12.34 has continuous flow monitoring, and weekly flow-proportional composite samples are analyzed for nitrate, ^{234}U, ^{235}U, and ^{238}U. In addition, monthly grab samples are collected at BCK 12.34 for metals, including cadmium. Quarterly grab samples for metals, including cadmium, are collected at NT-1. NT-2 has continuous flow monitoring and weekly flow-proportional composite samples are analyzed for nitrate.

Effectiveness of remediation at the BYBY is measured by water quality in the NT-3 stream. NT-3 has continuous flow measurements and weekly flow-proportional composite samples are analyzed for ^{234}U, ^{235}U, and ^{238}U. The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) requires surface water at NT-3 to meet AWQC and be below risk-based concentrations for an industrial receptor exposure to surface water (1E-5 ELCR).

The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) includes the following uranium flux goals:

- ≤34 kg/yr at the BCK 9.2 integration point,
- ≤27.2 kg/yr for S-3 Ponds discharge at BCK 12.34, and
- ≤4.3 kg/yr at the mouth of NT-3.

Other uranium flux monitoring locations include BCK 11.54 and NT-8, which both have continuous flow monitoring and weekly flow-proportional composite samples that are analyzed for ^{234}U, ^{235}U, and ^{238}U. BCK 11.54, a Bear Creek main stream station, is located downstream of NT-3 (Table 4.5 and Figure 4.3), and functions as an upstream integration point for the BCBGs. Monitoring at NT-8 is instrumental in determining relative contribution of the BCBGs to uranium flux at BCK 9.2. Further monitoring is conducted in Zone 3 for the FYR and is detailed in Table 4.5.

Table 4.5. BCV watershed CERCLA performance monitoring[a]

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
Zone 1	Biota	BCK 3.3	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; bioaccumulation of mercury, metals (including uranium), and PCBs in stoneroller minnows; bioaccumulation of mercury and PCBs in rockbass	Measure changes in quality of aquatic habitat as compared to reference sites
	Surface water	BCK 4.55	Quarterly grab sample (in year prior to FYR)	Metals, including total and isotopic uranium, and mercury; VOCs; and nitrate[f]	AWQC, risk-based[e]
Zone 1/Zone 2 Boundary (Performance measurement for Zone 1)	Surface water	BCK 7.87	Quarterly grab samples (in year prior to FYR)	Metals, including total and isotopic uranium, and mercury; VOCs; and nitrate[f]	AWQC, risk-based[e]
	Groundwater	GW-712, GW-713, GW-714 (Picket W)	Semiannual grab samples	Nitrate; metals, including uranium; and VOCs	MCLs
Zone 2/Zone 3 Boundary (Performance measurement for Zone 2)	Surface water	IP (BCK 9.2)	Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; VOCs[f]	AWQC, risk-based[e]
			Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux ≤ 34 kg/yr
			Monthly grab samples	Nitrate	Trend, risk-based
		SS-5	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend
	Groundwater	GW-683, GW-684 (Picket A)	Semiannual grab samples	Metals (including mercury, cadmium, and total uranium); VOCs, nitrate, isotopic uranium, and gross alpha and beta activity	TBD[b] trend monitoring
		GW-077, GW-078, GW-079, GW-080 (Exit pathway along strike from BCBGs)	Semiannual grab samples	Metals, VOCs, and isotopic uranium	MCLs for screening only, risk-based
Zone 3	Biota	BCK 9.9	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; Bioaccumulation of mercury, metals (including uranium), and PCBs in stoneroller minnows (whole body)	Measure changes in quality of aquatic habitat as compared to reference sites
			Annual (third quarter bioaccumulation monitoring (in year prior to FYR)	Bioaccumulation of metals, including mercury, and PCBs in invertebrates (preferably caddisflies, and metals and PCBs only in rock bass (fillets)	Measure changes in quality of aquatic habitat as compared to references sites
		BCK 12.4	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; Bioaccumulation of mercury, metals (including uranium) in stoneroller minnows (whole body)	Measure changes in quality of aquatic habitat as compared to references sites

Table 4.5. BCV watershed CERCLA performance monitoring (cont.)

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
	Groundwater	GW-704, GW-706 (Picket B)	Semiannual grab samples	Metals, nitrates, VOCs, gross alpha and beta activity, and isotopic uranium	MCLs for screening only, risk-based
	Surface water	B4CK 12.34	Quarterly grab samples (in year prior to FYR)	Mercury and VOCs[f] (See S-3 Ponds Pathway monitoring in this table for monthly grab for metals, including total uranium and cadmium, and weekly flow-proportionate monitoring for nitrate and isotopic uranium)	AWQC, risk-based[e] – within five years, Uranium ≤ 27.2 kg/yr, Cadmium ≤ 0.25µg/L, Nitrates – 40% seasonal reduction, Nitrate trend
		NT-1	Quarterly grab samples (in year prior to FYR)	Isotopic uranium; VOCs, and nitrate[f]	AWQC, risk-based[e]
		NT-3	Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; and nitrate[f]	AWQC, risk-based[e] – within five years; mercury ≤ 51 ng/L
		NT-5	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend
		BCK 10.15	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend
		BCK 11.54	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium trend
		NT-7	Monthly grab samples	Uranium (isotopic)	Uranium flux trend
		NT-8	Weekly flow-proportional composite samples	Uranium (isotopic)	Determine relative contribution of the BCBGs to uranium flux at BCK 9.2
			Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; nitrate; and VOCs	AWQC, risk-based[e]
BYBY	Surface water	NT-3	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux ≤ 4.3 kg/yr
	Biota	NT-3	Semiannual survey (until recovery complete)	Fish and benthic macroinvertebrate species richness and density	Aquatic community data compared to data available for similar reference streams on the ORR
			Riparian vegetation recovery complete. Annual survey discontinued in FY 2012.	Riparian vegetation recovery monitoring – Percent plant recovery, species diversity, stream vegetation overhang, percent shading, growth and survival of planted species	Compared to results of networks of similar riparian restoration sites monitored

Table 4.5. BCV watershed CERCLA performance monitoring (cont.)

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
Mercury Concentrations – Longitudinal Transect	Surface Water	BCK 9.2, NT-8, SS-5, SS-4, BCK 11.54, BCK 12.34	Semiannual grab samples	Mercury and methylmercury	Trend
S-3 Ponds Pathway 3[c]	Surface water	BCK 12.34	Weekly flow-proportional composite samples	Isotopic uranium and nitrate	Uranium flux ≤ 27.2 kg/yr; Nitrate – 40% seasonal reduction
			Monthly grab sample	Metals, including cadmium	Cadmium ≤ 0.25 µg/L; AWQC – within five years
		NT-1	Quarterly grab samples	Metals, including cadmium	Cadmium ≤ 0.25 µg/L
		NT-2	Weekly flow-proportional composite samples	Nitrate (flux)	Nitrate – 40% seasonal reduction in flux
S-3 Pathways 1 and 2[d]	Monitoring to evaluate the effectiveness of the S-3 Pathways 1 & 2 treatment system is discontinued[g]				

[a]This table summarizes requirements for monitoring included in the *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2457&D2/A1).

[b]Cleanup levels for groundwater are to be determined under future decisions for the BCV Watershed.

[c]RAs for the S-3 Pathway 3 have not been implemented; data are collected to establish a baseline against which performance of the action will be gauged.

[d]Correspondence from regulators (DOE/OR/01-1836&D1/A1) granting permission to shut down treatment system at S-3 Pathways 1 & 2 inadvertently included uranium as the parameter analyzed for the biota; however, the correct parameters should have included mercury and PCBs. The correct parameters were approved in the *Water Resources Restoration Program Sampling and Analysis Plan for the Bear Creek Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2457&D2/A1).

[e]Risk-based concentrations of 1E-5 residential receptor for Zones 1 and 2 and industrial for Zone 3.

[f]Sampling will be conducted for contaminants of concern identified from the BCV RI for risk-based comparisons.

[g]Correspondence from regulators (DOE/OR/01-1836&D1/A1) granting permission to shut down treatment system at S-3 Pathways 1 & 2 requires continuation of monitoring at BCK 12.34, BCK 9.2, BCK 3.3, BCK 9.9, BCK 12.4, as indicated.

AWQC = ambient water quality criteria
BCBGs = Bear Creek Burial Grounds
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
FY = fiscal year
FYR = Five-Year Review
GW = groundwater
IP = integration point
MCL = maximum contaminant level
MDL = minimum detection limit
NT = North Tributary
ORR = Oak Ridge Reservation
PCB = polychlorinated biphenyls
RA = remedial action
RI = Remedial Investigation
TBD = to be determined
VOC = volatile organic compound

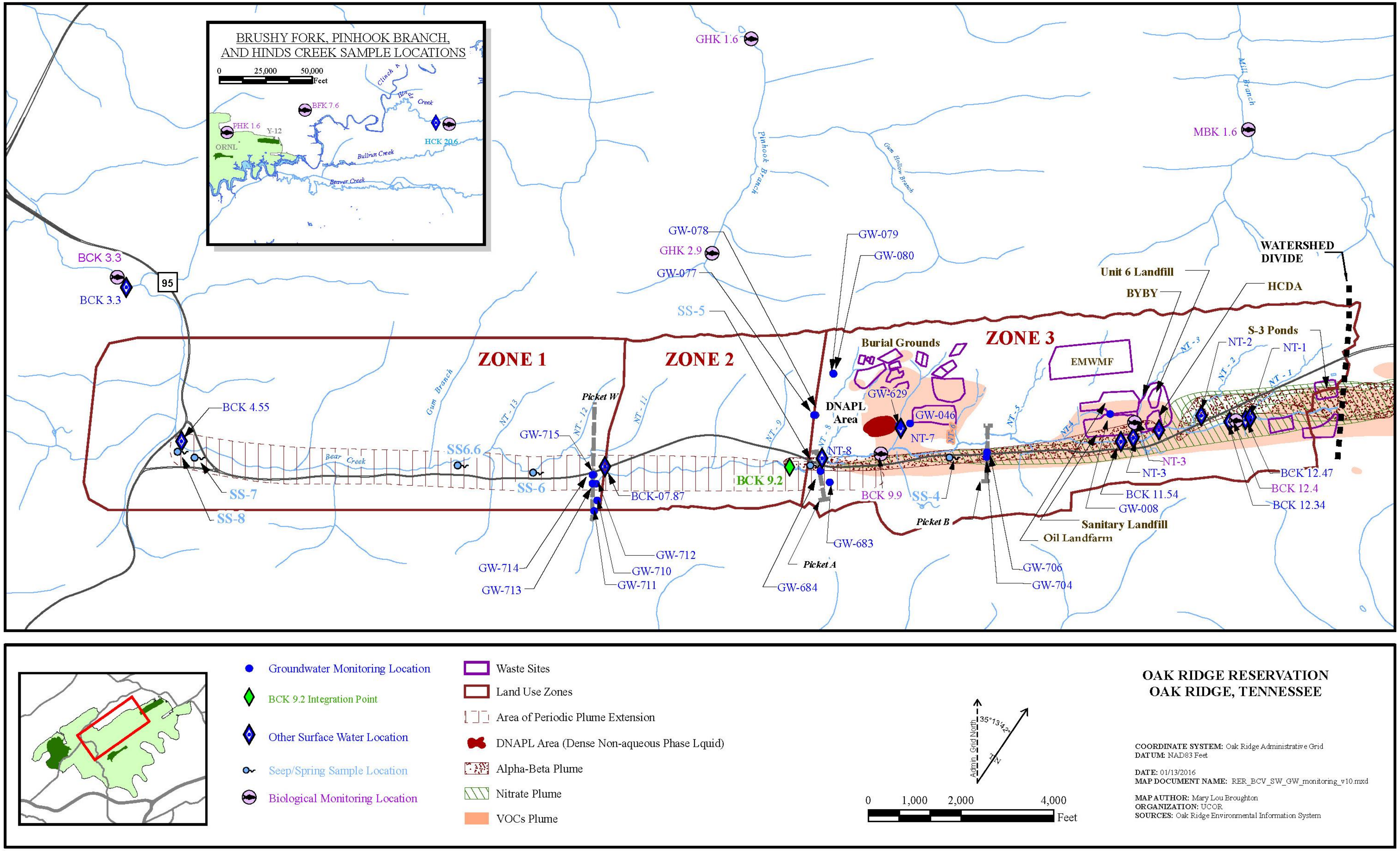

Figure 4.3. Monitoring locations in BCV watershed.

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4.2.1.2.1.2 Surface Water Monitoring Results

The discussion of surface water results is presented in this section in sequence of end use zone. The monitoring emphasis is on measuring remediation related reductions of contaminants of concern that are indicative of potential exposure risk for future land users. The status of BCV watershed-scale long-term CERCLA decision making is provided in Figure 3.6 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, Volume 1 – Main Text* (DOE/OR/01-2516&D2).

Zone 1

Surface water monitoring results are compared to AWQC, and evaluated against the risk-based concentrations for residential exposure to surface water (1E-5) consistent with the unrestricted land use goals. The *2011 Third Reservation-Wide CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2) presented the most recent results and determined that, although detectable, uranium concentrations were less than the MCL and ^{99}TC was present in Bear Creek at BCK 7.87 at levels of approximately 3% or less of the MCL-DC (900 pCi/L). (Note: MCLs are used for screening purposes. They are not ARARs for surface water).

Zone 2

Surface water monitoring was conducted at BCK 9.2, where upstream flow from Zone 3 source areas enters Zone 2. The BCK 9.2 sample location serves a dual function. It is used to assess both the water quality in Zone 2 because this location measures water quality of the inflowing stream, and it serves as the integration point for surface water being discharged from sources in Zone 3.

Uranium isotopes are measured at BCK 9.2 to enable comparison with the 1E-5 risk-based residential exposure concentrations. The uranium isotopic data is also used to calculate the mass of uranium present in terms of the total annual uranium mass discharge (flux) from Zone 3 into Zone 2. Risk based activities for each uranium isotope (1E-5 risk level) are shown in the top row of Table 4.6. These risk-based values are updated annually based on current risk assessment criteria. The FY 2015 average activities of ^{234}U, ^{235}U, and ^{238}U were 7.0, 0.7, and 16.8 pCi/L, respectively. The value for ^{238}U exceeded the risk-based activity of 6.10 pCi/L. These risk-based goals are equivalent to the hypothetical residential exposure goal of a 1E-5 ELCR attributable to the uranium isotopes in the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4). Table 4.6 and Figure 4.4 present the historic average activity of isotopes of uranium and concentration of nitrate and annual average rainfall since the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) was implemented. Over the period of monitoring, ^{235}U has been less than the 7.35 pCi/L risk-based activity in Zone 2. During FY 2012 through FY 2015 the annual average ^{234}U activity levels have attained the watershed risk-based goal. Additional discussion of contaminant transport from Zone 3 into Zone 2 is presented below.

Table 4.6. Historic average activity of uranium isotopes and concentration of nitrate at the integration point (BCK 9.2)

FY	^{234}U pCi/L	^{235}U pCi/L	^{238}U pCi/L	Nitrate mg/L	Average ORR rainfall[a]
Risk-based concentration[b]	7.46	7.35	6.10	46	-
2001	**13.7**	0.7	**28.5**	9.9	45.9
2002	**12.4**	0.8	**24.8**	12.9	52.7
2003	**9.4**	1.2	**18.4**	11.1	73.7
2004	**8.5**	1.1	**17.7**	8.4	56.4
2005	7.3	0.7	**15.9**	6.6	58.9
2006	**9.9**	0.9	**21.3**	9.8	46.4
2007	**8.8**	0.9	**18.8**	-	36.8
2008	**9.1**	0.9	**21.0**	-	49.3
2009	**8.8**	0.8	**21.6**	4.8	62.5
2010	**7.9**	0.8	**17.0**	5.9	55.8
2011	**7.6**	0.7	**17.6**	6.1	59.2
2012	6.3	0.6	**16.1**	4.8	61.8
2013	7.4	0.7	**17.0**	5.7	63.7
2014	7.0	0.7	**17.5**	4.6	48.8
2015	7.0	0.7	**16.8**	3.9	55.9

Bold values indicate the risk-based concentration is exceeded.

[a]Average rainfall in in. for rain gauges at Y-12, ETTP, ORNL, and DOE town site.
[b]Risk-based concentrations (1E-5 for radionuclides and HQ=1 for nitrate) from EPA, regional screening tables accessed November 2015 <**http://www.epa.gov/risk/risk-based-screening-table-generic-tables**>, and <**http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search**>.

BCK = Bear Creek kilometer
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FY = fiscal year
HQ = Hazard Quotient
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
Y-12 = Y-12 National Security Complex

Nitrate concentrations measured at BCK 9.2 since approval of the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) are compared to the risk-based concentrations. Since FY 2000, the average annual nitrate concentrations in surface water at the integration point (BCK 9.47 prior to FY 2006 and BCK 9.2 thereafter) have not exceeded the risk-based (Hazard Quotient [HQ] of 1) residential exposure concentration. During FY 2004 – 2015, the average nitrate concentrations measured at BCK 9.2 have been below the 10 mg/L MCL. The principal source of nitrate contamination is legacy disposal of nitric acid liquids in the S-3 Ponds in the headwaters of Bear Creek. Nitrate has been monitored historically at a number of locations in BCV. Concentrations are highest near the S-3 source and decrease with distance downstream to the west. BCK 9.2 flux measurements are discussed below for comparative purposes to Zone 3 sampling locations.

Zone 3

During FY 2015, surface water monitoring in Zone 3 included the ongoing monitoring of uranium flux at several locations, and nitrate concentration monitoring near the S-3 Ponds area and at the BCK 9.2 integration point.

Surface water monitoring includes sampling at the integration point (BCK 9.2) and intermediate monitoring stations, including tributary monitoring of specific RA areas. Two key metrics were identified in the ROD for effectiveness of remediation in Zone 3—reduction of risk levels and uranium flux at the integration point (BCK 9.2) to 34 kg/yr, and reduction of the uranium flux at BCK 12.34 to 27.2 kg/yr. As previously discussed, ^{238}U activities at BCK 9.2 consistently exceed the risk-based concentration and, in all years prior to FY 2012 except FY 2005, ^{234}U activities exceeded the risk-based concentration.

The post-*Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) history of measured uranium fluxes at BCK 9.2 and BCK 12.34, along with annual rainfall, are summarized in Table 4.7 and Figure 4.5. The watershed flux goal (≤ 34 kg/yr) for the Zone 3 integration point was not met in FY 2015 based on the approximately 89 kg of uranium discharge measured at BCK 9.2. The FY 2015 uranium flux at BCK 12.34 was approximately 26.0 kg which is less than the flux goal of 27.2 kg/yr. Continuous, flow-paced sampling to measure the uranium flux at NT-3 was resumed in FY 2010 in response to the observation of increasing uranium concentrations. During FY 2015, a uranium flux of approximately 2.3 kg was measured at the mouth of NT-3. This uranium discharge achieved the 4.3 kg/yr flux goal for the stream following remediation of the BYBY. Additional discussion of the NT-3 uranium discharge is provided in discussion of the BYBY remedy effectiveness evaluation later in this section.

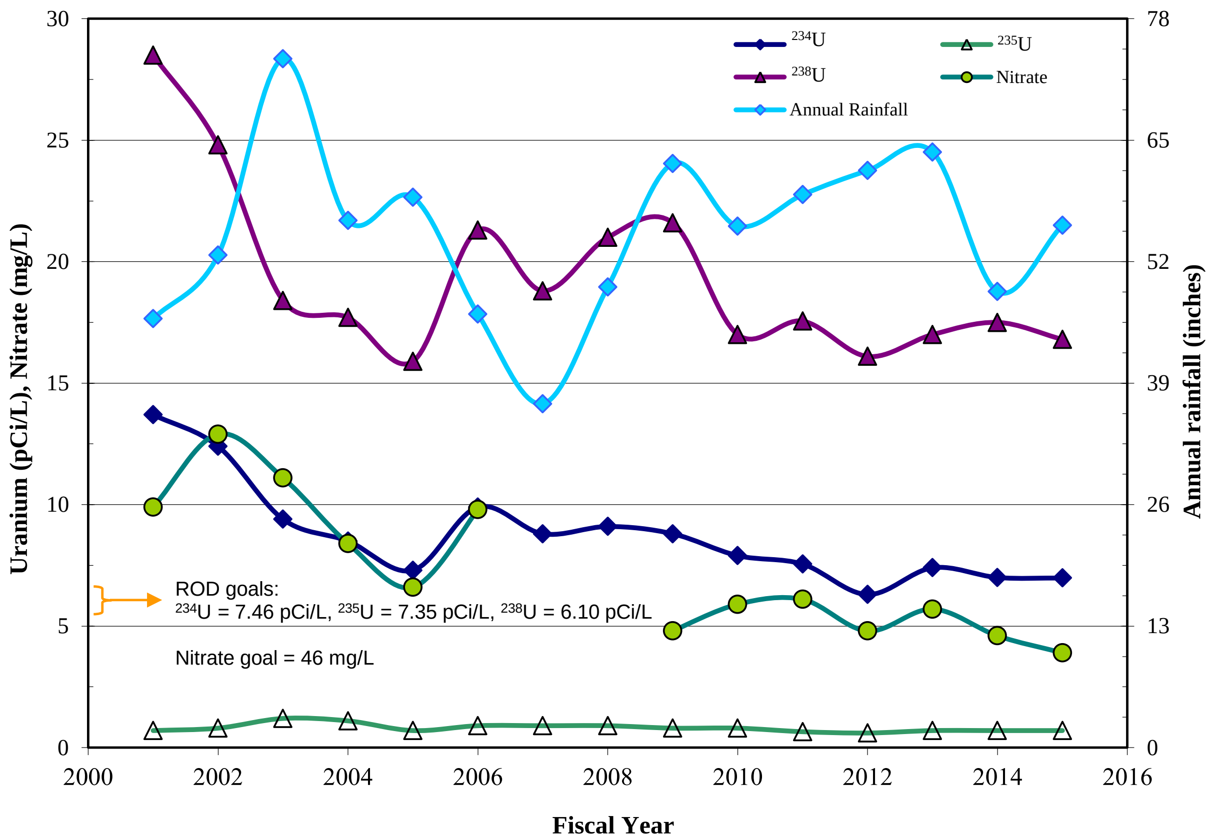


Figure 4.4. Average annual uranium isotope activity, nitrate concentration at BCK 9.2, and annual rainfall.

Table 4.7. Uranium flux[a] at flow-paced monitoring locations in BCV watershed

FY	BCK 9.2	SS-5	NT-8	BCK 11.54	NT-3	BCK 12.34	Average rainfall[b]
ROD Goal	**34**	--	--	--	**4.3**	**27.2**	--
2001	**88.7**	17.2	--	--	**79.9**	24.5	45.9
2002	**120.2**	13.1	--	158.2	**62.8**	25.4	52.7
2003	**165.4**	12.3	--	87.0	**4.6**	**44.3**	73.7
2004	**115.0**	9.5	--	45.8	1.2	**27.3**	56.4
2005	**115.4**	11.1	--	39.8	4.1	**40.3**	58.9
2006	**68.5**	--	--	25.2	1.7	21.3	46.4
2007	**59.5**	--	--	12.6	--[c]	15.8	36.8
2008	**73.2**	--	27.9	15.9	--[c]	23.0	49.3
2009	**147.7**	11.6	43.3[d]	27.2	--[c]	**32.9**	62.5
2010	**118.9**	9.9	61.0	32.5	**14.5**	**33.9**	55.8
2011	**108.7**	9.1	40	36.7	**16.3**	**37.8**	59.2
2012	**114.9**	9.2	43.3	45.4	**13.6**	**32.9**	61.75
2013	**122.3**	9.5	64.0	47.6	**22.3**	**40.3**	63.73
2014	**95.6**	7.7	72.4	38.6	1.87	24.0	48.8
2015	**88.8**	7.3	51.2	45.1	2.3	26.0	55.9

Bold values indicate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) goal for uranium flux has not been met**.**

[a]All flux values are kg of uranium/yr.
[b]Average rainfall in in. for rain gauges at Y-12, ETTP, ORNL, and DOE town site.
[c]Goal attained; flux monitoring discontinued FY 2007. Reinstituted in FY 2010.
[d]Uranium isotope mass balancing at BCK 9.2 suggests NT-8 contributed about 60 kg in FY 2009. Approximately 17 kg infiltrated into karst seepage pathways upstream of the NT-8 flume.

BCK = Bear Creek kilometer
BCV = Bear Creek Valley
DOE = U.S. Department of Energy
ETTP = East Tennessee Technology Park
FY = fiscal year
NT = North Tributary
ORNL = Oak Ridge National Laboratory
ROD = Record of Decision
SS = surface spring
Y-12 = Y-12 National Security Complex

Review of Figure 4.5 shows the relationship between annual total rainfall and total uranium flux at BCK 9.2 and BCK 12.34. The amount of uranium that is mobilized from buried waste sources and residual groundwater contamination in the S-3 Pond area depends on the amount of rainfall that occurs. Increased rainfall causes increased groundwater recharge, more leachate formation, higher groundwater levels, and more contaminant transport from incompletely contained buried/below-grade contaminant sources to the streams. The relationship between annual rainfall and annual uranium fluxes measured at BCK 9.2 and BCK 12.34 is strongly linear during the post-*Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) monitoring period, as demonstrated by the relatively high correlations between rainfall and uranium discharge flux shown in Figure 4.6. The higher mass flux and the greater positive slope of the trend at BCK 9.2 than at BCK 12.34 reflect the presence of a significant uranium source that enters Bear Creek between the two stations. During FY 2007, data collection indicated that NT-8 was a significant contributor of uranium to Bear Creek and continuous flow-paced

monitoring of NT-8 started in FY 2008. During FY 2015, monitoring of NT-8 documented that approximately 51 kg of uranium (approximately 60% of the total BCV uranium discharge) was discharged directly to Bear Creek (Table 4.7). Implementation of an NT-8 Surface Water action is a potential project identified in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Investigations and projects during groundwater strategy implementation will be sequenced according to ORR-wide groundwater issues prioritization.

Estimates were made of the uranium contributions from NT-5 and NT-7. These estimates suggest that NT-5 contributed approximately 0.27 kg of uranium and NT-7 may have contributed approximately 2.0 kg of uranium during FY 2015.

Including all directly measured and estimated uranium sources contributing to the stream (BCK 12.34, NT-3, NT-5, NT-7, NT-8, and SS-5), the mass balance of uranium in the Bear Creek system during FY 2015 shows that about 89.2 kg of uranium were measured or estimated to enter Bear Creek from gauged stream locations in Zone 3 and 88.8 kg of uranium were measured discharging from Zone 3 at BCK 9.2. This mass balance attributes the SS-5 uranium discharge to S-3 Ponds plume groundwater flow in the Maynardville Limestone karst pathway, and does not include the BCK 11.54 data since that location is an intermediate monitoring site that measures uranium fluxes previously measured at BCK 12.34 and NT-3. These data indicate a uranium mass balance difference of less than 1 kg (<0.5% error) for the BCV monitoring system which is extremely good.

Within Zone 3, industrial exposure scenario comparisons are applicable since the ROD remediation goal for that area is controlled industrial use. At BCK 12.34, near the S-3 Ponds, the average ^{234}U, ^{235}U, and ^{238}U activities in FY 2015 were about 19.5, 1.9, and 41.4 pCi/L, respectively. These results are based on analysis of weekly frequency continuous, flow-paced composite samples. The average activity level for ^{234}U met the industrial risk-based activity goal of about 23 pCi/L. The activity level for ^{238}U exceeded the industrial risk-based activity of about 18 pCi/L, using the exposure frequency of 250 d/y, exposure duration of 25 years and one L/d ingestion rate. The ^{235}U has been less than the 22 pCi/L industrial exposure goal since the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) was implemented.

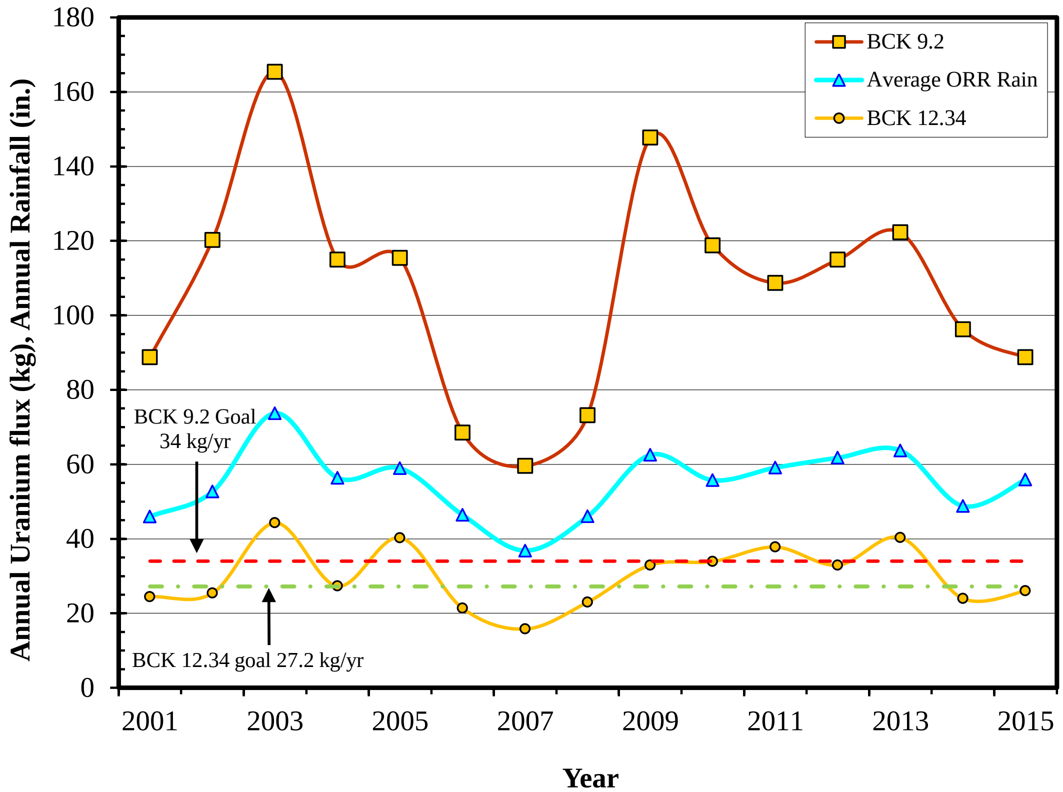


Figure 4.5. Post-ROD uranium flux at BCK 9.2 and BCK 12.34 and annual rainfall.

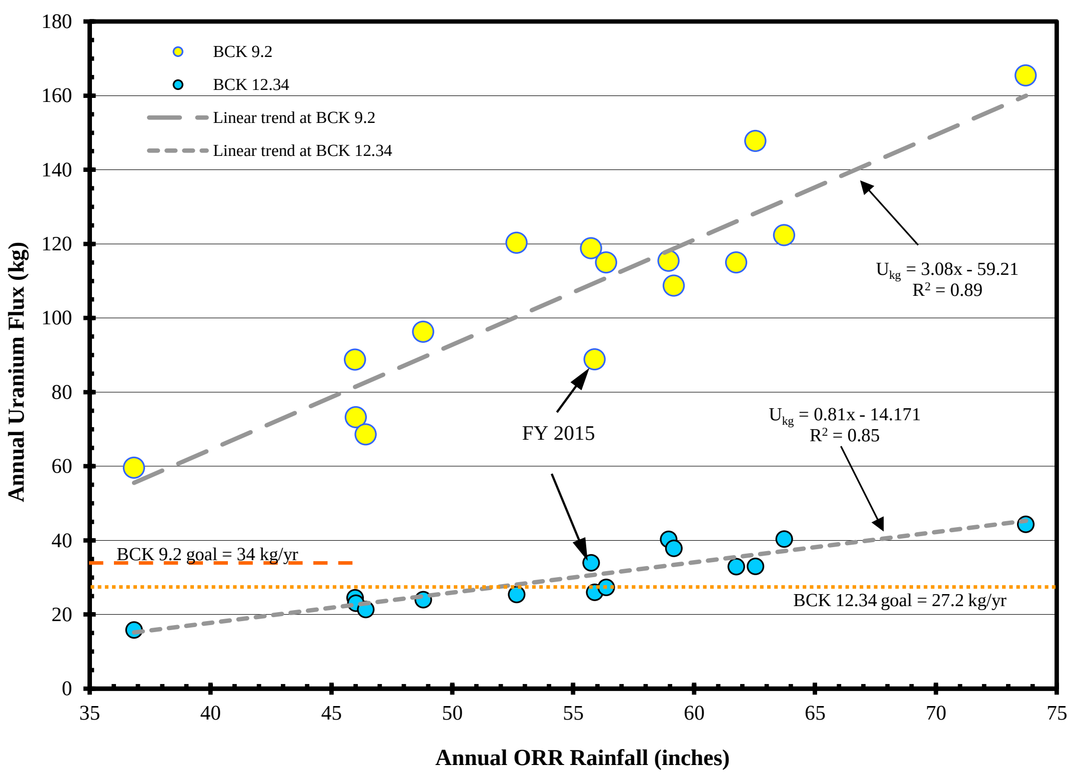


Figure 4.6. Average annual rainfall vs. annual uranium flux at BCK 9.2 and BCK 12.34.

Nitrate and cadmium are also key contaminants of concern in surface water in BCV. The principal source of nitrate contamination is legacy disposal of nitric acid liquids in the S-3 Ponds, which created nitrate plumes in groundwater that discharge in the headwaters of Bear Creek. Nitrate has been monitored historically at a number of locations in BCV. Concentrations are highest near the S-3 source and decrease with distance to the west and downstream. As stated previously, Zone 3 is designated for industrial land use. The preliminary remediation goal for nitrate in an industrial end use scenario is 184 mg/L. Figure 4.7 shows the average nitrate concentration in surface water at BCK 12.34, along with the annual average rainfall. The tendency for dilution of the nitrate concentrations during years of elevated rainfall is apparent in the graph with the mirror relationship between increased rainfall and decreased nitrate concentration. During FY 2015, the average nitrate concentration was 31.2 mg/L based on 52 weekly grab sample results. None of the grab samples collected during FY 2015 exceeded the preliminary remediation goal for nitrate. During the below average rainfall conditions of FY 2007 and 2008, the nitrate preliminary remediation goal was occasionally exceeded because of the absence of upstream runoff that dilutes groundwater seepage into NT-1 near the S-3 Ponds site.

The principal source of cadmium is also disposed liquids from the S-3 ponds. Figure 4.8 shows the cadmium concentrations over time since FY 2000 at NT-01 and BCK 12.34. Cadmium concentrations in the Bear Creek headwaters continuously exceed the 0.25 μg/L AWQC in samples from the NT-01 and BCK 12.34 sampling locations. Samples obtained at BCK 12.34 during FY 2015 contained an average of 1.97 μg/L cadmium with a maximum measured concentration of 3.9 μg/L. In monthly samples collected at the Zone 3 integration point (BCK 9.2) during FY 2015, cadmium was detected in a single sample collected in July at a concentration of 0.65 μg/L, which exceeds the AWQC level of 0.25 μg/L. During July, the ORR experienced above normal rainfall, which is thought to have caused the downstream excursion of detectable cadmium in surface water. In the other 11 regular samples, cadmium was not detected at a detection limit of 0.13 μg/L, which is well below the AWQC level. Overall, these results indicate that cadmium from the S-3 Ponds source is strongly attenuated before the stream enters Zone 2.

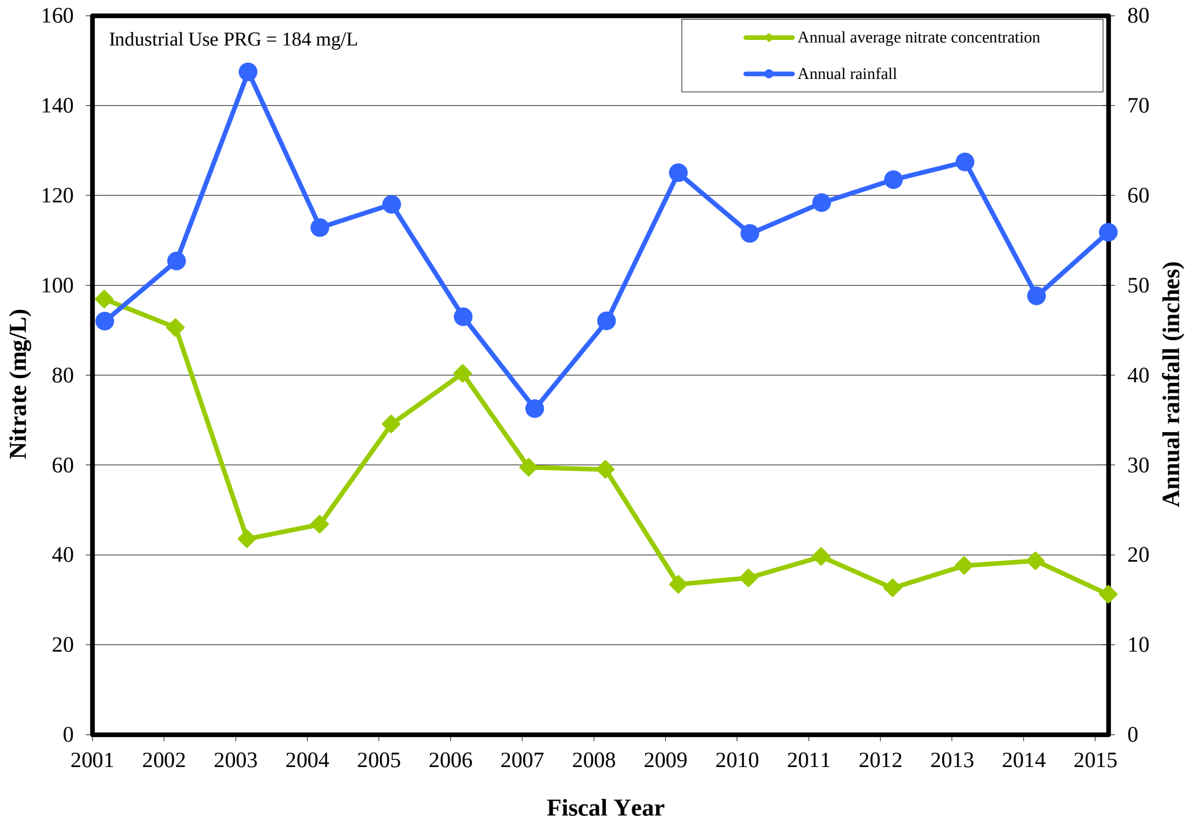


Figure 4.7. BCK 12.34 annual average nitrate concentration and annual rainfall.

BYBY

Effectiveness of remediation at the BYBY is measured by water quality in the NT-3 stream (Figure 4.3). In addition to surface water monitoring at the BYBY, the *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard* (DOE/OR/01-2077&D2) specifies monitoring of benthic macroinvertebrate and fish communities in NT-3. Benthic macroinvertebrate and fish community monitoring are presented in Section 4.2.1.2.3.

The remediation goal for the BYBY excavation was to attain a flux of less than 4.3 kg/yr uranium from NT-3. The flux reduction goal was met and confirmed with sustained flux reduction in post-remediation years until FY 2010. Regulatory approval to discontinue flow paced composite sampling at NT-3 and to replace it with monthly grab samples for uranium was granted in April 2007. Collection of grab samples on a monthly frequency continued except during prolonged dry weather when the stream is dry at the sampling station. Uranium activity levels gradually increased in FY 2007 through FY 2009 and flow-paced sampling was restarted at the beginning of FY 2010 to obtain reliable uranium flux data.

Immediately following BYBY remediation, uranium activities in NT-3 decreased significantly and uranium isotope ratios also changed. Table 4.8 is a tabulation of annual average activities of ^{238}U and ^{234}U measured in NT-3. BYBY remediation was completed in summer of 2002 and the FY 2002 and 2003 uranium activities show the rapid decrease following remediation. Subsequent to the initial post-remediation decrease in both uranium activities and fluxes, increases in uranium activities and fluxes have been measured.

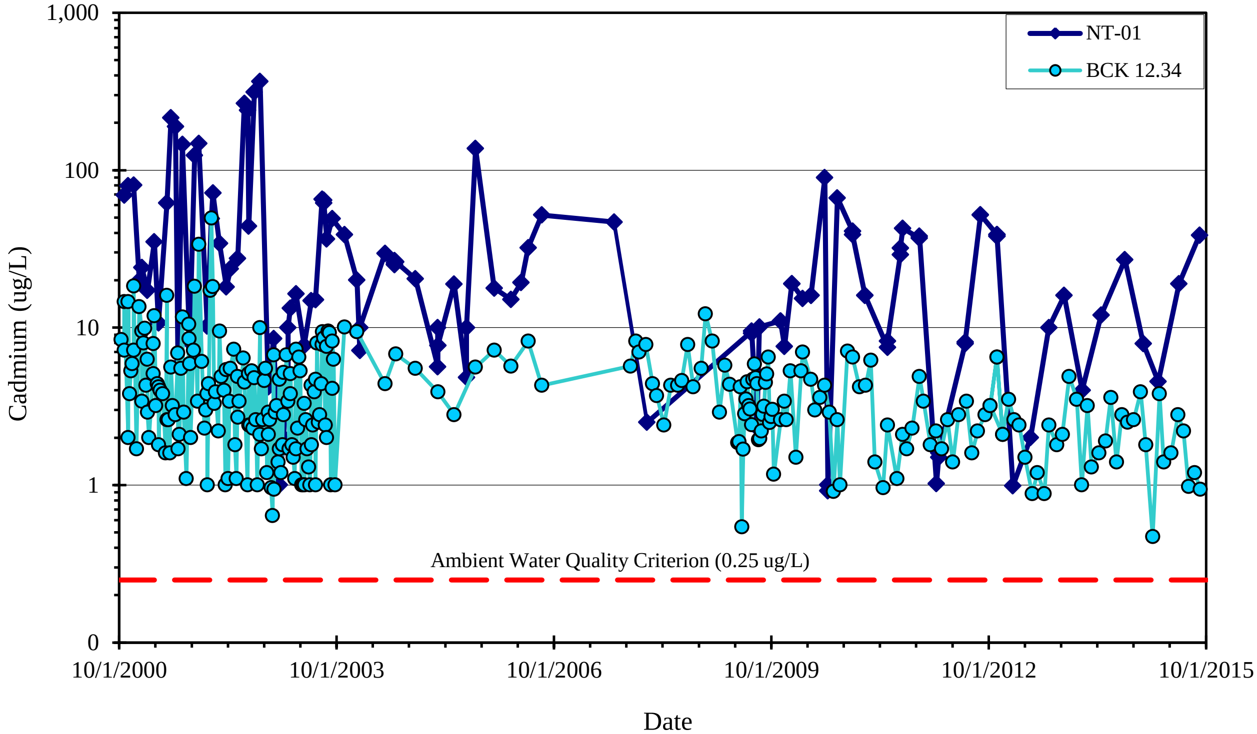


Figure 4.8. Cadmium concentrations at NT-1 and BCK 12.34.

Table 4.8. Annual average ^{234}U and ^{238}U activities at NT-3

FY	Average ^{234}U (pCi/L)	Average ^{238}U (pCi/L)	Average $^{238}U/^{234}U$ ratio	Comments
1999	208	450	2.16	
2000	230	514	2.24	
2001	196	476	2.43	
2002	135	292	2.15	BYBY remediation completed
2003	14	14	1.02	Continuous sampling
2004	7	6	0.85	Continuous sampling
2005	13	14	1.06	Continuous sampling
2006	17	16	0.93	Continuous sampling
2007	46	42	0.91	Continuous sampling
2008	41	39	0.94	Monthly grab sampling
2009	42	40	0.94	Monthly grab sampling
2010	24	22	0.96	Continuous sampling resumed
2011	32	30	0.94	Continuous sampling
2012	20	19	0.93	Continuous sampling
2013	16	15	0.95	Continuous sampling
2014	7.2	7.1	0.99	Continuous sampling
2015	11.6	10.6	0.90	Continuous sampling

BYBY = Boneyard/Burnyard
FY = fiscal year
NT = North Tributary

NT-3 surface water uranium isotope ratios were examined to evaluate the significance of this increase with regard to the BYBY remedy. The data summary in Table 4.8 shows that along with the reduction in total uranium activity in NT-3 following remediation, there was also a shift in the $^{238}U/^{234}U$ ratio. The $^{238}U/^{234}U$ decreased from average values of two to three (indicative of a depleted uranium source having a high fraction of ^{238}U) downward to average values near one. The $^{238}U/^{234}U$ ratios observed since 2007 suggest that the recurrent uranium discharge originates from a depleted uranium source having a different isotopic signature than the remediated BYBY source. These isotopic shifts in the NT-3 surface water suggest that the BYBY source contained isotopically depleted uranium and the increases in uranium activity observed starting in FY 2007 are related to a different contaminant source. As shown on Figure 4.9, two other waste disposal units remain in the NT-3 watershed – the Hazardous Chemical Disposal Area and the Unit 6 Landfill. The 2011 RER (DOE/OR/01-2505&D2) contained a summary of sampling results from grab samples collected at several locations in NT-3. Those results showed that uranium was entering the NT-3 stream downslope from the western side of the Unit 6 Landfill. Those samples did not contain nitrate or ^{99}Tc which would be indicators of breakthrough of the S-3 Ponds contaminant plume into NT-3. An investigation of soil and groundwater contaminant distributions in the vicinity of the Unit 6 Landfill and NT-3 would be required to better understand the source of uranium entering NT-3. Such an investigation is one of the future potential projects listed in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2628/V1&V2&D2).

In addition to being a significant source of uranium to Bear Creek, the BYBY was also a source of mercury contamination. Surface water samples collected from the NT-3 monitoring station prior to the BYBY RA contained high concentrations of total mercury with concentrations in the 200 – 500 ng/L range in 1994 to 1999. In 2001 a value of nearly 660 ng/L was measured. Following completion of the BYBY RA in 2002, the mercury concentrations decreased rapidly with several detected spikes which have subsided to concentrations that are generally less than the AWQC level of 51 ng/L. The most recent criterion exceedance recorded in available data was measured in December 2006. Samples from NT-3 were analyzed for mercury in October 2014 (8.57 ng/L) and May 2015 (18.6 ng/L) and both results were less than the AWQC level, which met the ROD goal.

Methylmercury data are available for NT-3 from samples collected since winter 2010. The methylmercury concentrations measured in NT-3 are relatively high as a fraction of the total mercury and in an absolute sense when compared to those measured elsewhere on the ORR. During FY 2015, two samples were analyzed for methylmercury with concentrations of 0.11 ng/L in October 2014 and 0.19 ng/L measured in May 2015.

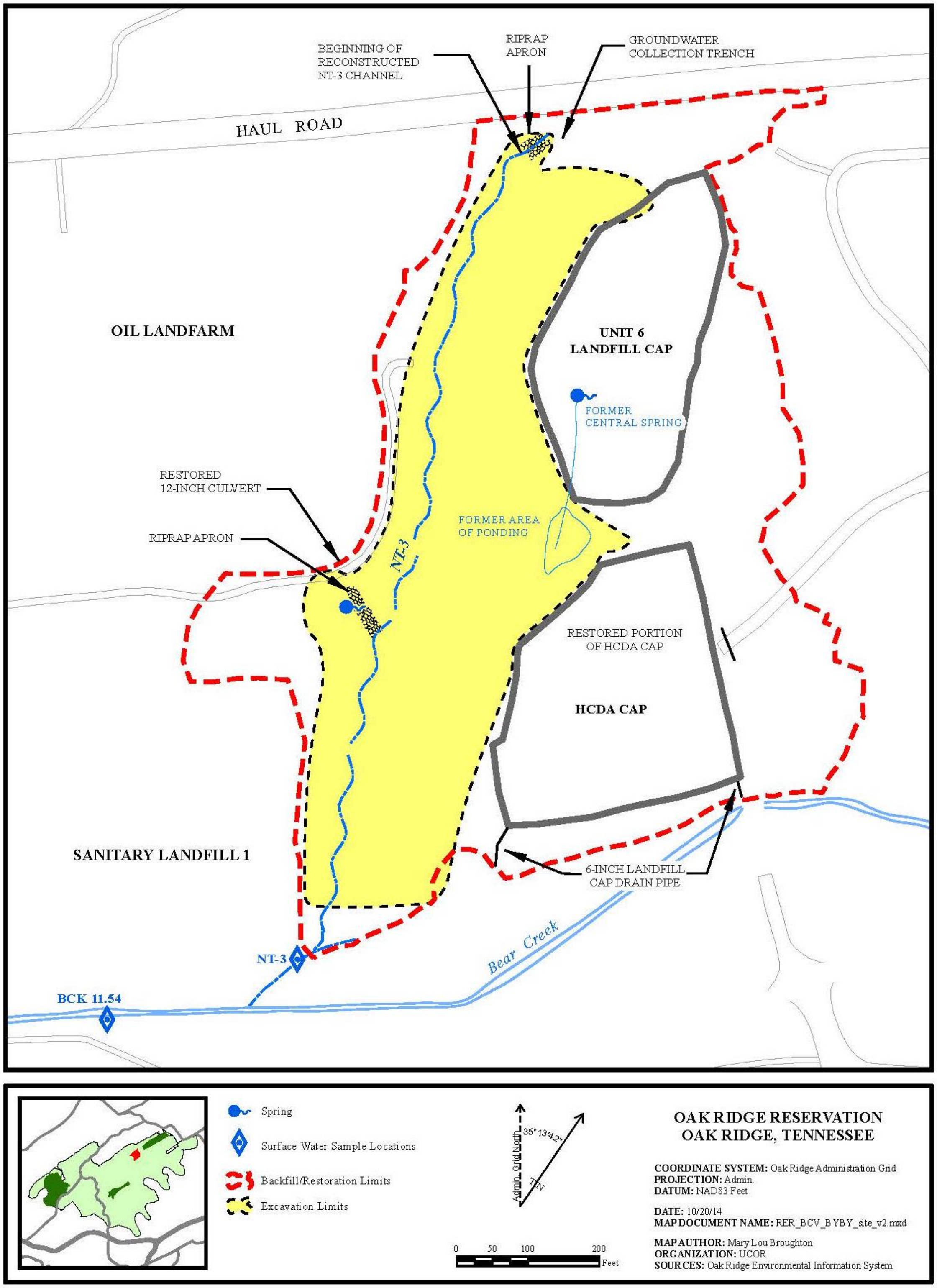


Figure 4.9. Location of BYBY site and monitoring locations.

4.2.1.2.2 Groundwater

The most significant impacts to groundwater in BCV occur within Zone 3 beneath and downgradient from the liquid and solid waste disposal areas. Some groundwater contamination is known to extend from Zone 3 westward into Zones 1 and 2 in the Maynardville Limestone. Geologic and hydrogeologic conditions in BCV are complex. The bedrock formations that underlie the principal contaminant source areas include about 1,200 ft of stratigraphic thickness of thin- to medium-bedded, mixed clastic and carbonate rock types (from oldest to youngest by depositional age consisting of the Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, and Nolichucky Shale). Some of the limestone beds within these predominantly clastic bedrock units are important to groundwater contaminant transport through fractures and larger openings caused by chemical weathering.

The youngest depositional geologic unit in the Conasauga Group is the Maynardville Limestone that is comprised of about 400 ft (stratigraphic thickness) of relatively pure carbonate bedrock. The Maynardville Limestone has been informally subdivided into as many as six distinct lithostratigraphic facies. These lithofacies represent slightly different depositional settings and/or zones that have experienced different post-depositional changes to their primary porosity. These differences in primary bedrock porosity make the zones susceptible to differential chemical weathering and formation of cavities and connected conduits that conduct groundwater flow. Of note is that the lithostratigraphic zone at the top of the Maynardville Limestone has the highest primary porosity and is coincident with a prominent zone of karst development that is a primary contaminant plume pathway. The Maynardville Limestone occupies the lowest topographic position and lies beneath Bear Creek. These lithostratigraphic facies tend to be laterally discontinuous and vary in thickness along geologic strike. In addition to the bedrock depositional heterogeneities, geologic structural features such as joints and fractures, intraformational thrust faulting, and cross-strike faulting further complicate groundwater migration through bedrock.

The role of local faults on groundwater transport may vary by the bedrock lithologies involved. For instance, cross faults that offset the thin- to medium-bedded clastic dominated formations may actually interrupt strike-parallel groundwater movement by abutting clastic beds against carbonate beds effectively forming local barriers to strike-parallel flow. On the other hand, cross faults in massive carbonate bedrock may facilitate flow through the associated fractures with enhancement by chemical weathering processes, thus increasing cross-strike flow. The karst conditions in the Maynardville Limestone facilitate contaminant movement via conduit flow. Such contaminant transport has both continuous and episodic aspects. Interconnections in conduit systems can produce conditions under which flow paths can shift both spatially and vertically depending on groundwater levels and total surface water and groundwater system flow volumes.

The following sections present summary data evaluations of the principal groundwater contaminants in BCV. ROD-based groundwater quality goals for each zone are listed in Table 4.2. Table 4.5 includes the BCV watershed CERCLA performance monitoring requirements that are used to evaluate attainment of these goals. The groundwater goals in the ROD do not include meeting chemical-specific ARAR-based remediation levels. Groundwater sampling locations are shown on Figure 4.3.

Zone 1

As noted in Table 4.2, the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) goal is to “maintain clean groundwater and surface water so that the area continues to be acceptable for unrestricted use.” MCLs are used in Zone 1 as the screening criteria and concentration trends are used elsewhere to evaluate performance. With this goal in mind, during FY 2015 groundwater monitoring in Zone 1 included sampling of three springs (SS-6, SS-7, and SS-8) and six monitoring wells (GW-710 through GW-715) that sample groundwater from the Maynardville Limestone

near the Zone 1/Zone 2 boundary. This line of wells is referred to as Picket W. Well construction information for the wells in Picket W wells is summarized in Table 4.9. The wells are completed at a wide range of depths and elevations and open or screened intervals provide broad coverage of the several locally defined stratigraphic members of the Maynardville Limestone. Currently the wells are monitored semiannually for nitrate; metals, including uranium; VOCs, and radiological constituents.

Table 4.9. Well construction information for wells in Zone 1, Picket W

Well ID	Well type	Ground surface elevation	Sample zone top depth	Sample zone bottom depth	Sample zone top elevation	Sample zone mid-point elevation	Sample zone bottom elevation
GW-710	Open	906.83	539.7	744.5	367.13	264.73	162.33
GW-711	Open	901.96	616	666.2	285.96	260.86	235.76
GW-712	Open	873.61	441.5	457.5	432.11	424.11	416.11
GW-713	Open	877.83	305	315.2	572.83	567.73	562.63
GW-714	Open	872.3	115.1	145	757.2	742.25	727.3
GW-715	Screen	872.17	33.1	43.1	839.07	834.07	829.07

Depth data are ft bgs and elevation data are in ft aMSL.

aMSL = above Mean Sea Level
bgs = below ground surface
GW = groundwater
ID = identification

Wells GW-710 and GW-711 are very deep wells (about 745 ft and 666 ft, respectively) and their water chemistry is dominated by sulfate, chloride, calcium, and sodium. Drilling records indicate that bedrock penetrated in well GW-710 between depths of 350 ft and 699.5 ft bgs contained no water producing fractures. The well depth was extended an additional 45 ft at which point a yield of 5 to 10 gal/hr was obtained. In GW-711, groundwater bearing zones were not present in the depth range of 421 to 650 ft bgs, but sufficient water to provide samples was encountered between 650 and 666 ft depth. Development water from both wells GW-710 and GW-711 were described as greenish in color attributed to dissolved ferrous iron that became an orange precipitate after contact with the air. The development water from both wells had a petroliferous odor that was attributed to naturally occurring organic compounds in the bedrock. As shown in Table 4.9, the open interval in GW-710 is about 205 ft in vertical length and its top elevation is approximately 80 ft higher than the top of the open zone in GW-711. The groundwater at the sampled depths contains approximately 4,000 mg/L total dissolved solids. Specific conductance values in GW-710 fluctuate in the range of about 3,000 to 5,000 µmho/cm while those in GW-711 tend to lie in the range 4,500 – 5,000. The somewhat lower specific conductance levels in GW-710 may be caused by somewhat lower dissolved solids groundwater from the 80 ft higher elevation sampling zone entering the open interval during periods of greater groundwater recharge. Dissolved oxygen is low (<2.5 ppm in GW-710 and less than 1 ppm in GW-711) in this deep groundwater and redox values are fairly strongly reducing at levels below -100 mV. These are indications that the groundwater in these zones has limited interaction with fresh recharging waters at the top of the aquifer.

The only VOCs detected in wells in Picket W in FY 2013 and FY 2014 were low (<5 µg/L) concentrations of petroleum hydrocarbons detected in samples from well GW-710. The source of these hydrocarbons is suspected to be naturally occurring petroleum hydrocarbons that slowly leach from bedrock into deep groundwater as previously mentioned in relation to well development observations. Lower detection limits in FY 2015 allowed detection of low concentrations of VOCs. As a result of this

change, in addition to the detection of benzene in samples from well GW-710, toluene was detected at 0.39 J µg/L (J = estimated value) in a sample collected in March 2015. Samples collected from well GW-711 in March and August 2015 contained low concentrations of benzene (<1 µg/L J qualified results), M+P Xylene (0.4 J µg/L) in August, and toluene was detected at 1 µg/L in August. Very low concentrations of common petroleum hydrocarbon constituents such as these are not uncommon in deep groundwater at the ORR.

Table 4.10 lists available nitrate concentrations in wells GW-710 through GW-715 from FY 2000 to FY 2015. Nitrate is detected in wells GW-710 and GW-711 at concentrations of approximately 0.03 mg/L and is sometimes not detectable at the 0.01 mg/L level. Technetium-99 is not detected in wells GW-710 and GW-711 at detection limits in the 9 – 11 pCi/L range. Lower detection limits in FY 2015 allowed detection of very low levels of uranium isotopes. In the August sample from well GW-710, ^{234}U and ^{238}U were detected at <0.2 pCi/L. At such low levels and with intermittent detectability it is not clear that the detected uranium isotopes in well GW-710 originates from man-made sources. Site related contaminants do not exceed the Bear Creek ROD goal for Zone 1 in wells GW-710 and GW-711.

Well GW-712 is nearly 460 ft deep and has a 16 ft long open interval in bedrock from which groundwater samples are obtained. Well GW-712 samples fresher groundwater than the deeper wells with specific conductance in the 300 – 450 µmho/cm range. Dissolved oxygen levels hover near 1 ppm or slightly less and the redox fluctuates from higher levels near 50 mV to low levels <-200 mV. These fluctuations are considered to be indicative of episodic interactions of fresher recharge water with more sluggishly moving groundwater. The maximum nitrate concentration detected in well GW-712 in FY 2013 through FY 2015 was 0.25 mg/L in July 2015. Technetium-99 has not been detected in well GW-712 during sampling in FY 2013 through FY 2015. During FY 2015, ^{234}U and ^{235}U were detected in the March 2015 sample at activities of 0.223 and 0.118 pCi/L, respectively, while ^{238}U was not detected. In the July sample from well GW-712 ^{234}U was detected at 0.399 pCi/L. Site related contaminants do not exceed the Bear Creek ROD goal for Zone 1 in wells GW-712.

Well GW-713 is about 315 ft deep and samples groundwater from a 10 ft long open interval in bedrock. Specific conductance of the groundwater in this well fluctuates in the range of about 300 – 500 µmho/cm, although in the early 2000s, levels were in the 700 – 1,000 µmho/cm range. Dissolved oxygen tends to fluctuate in the range of about 1 – 2 ppm, although a number of higher values have been observed. Redox fluctuates in the range of about -50 to -200 mV. Well GW-713 has experienced periodic trace-to-low (maximum 14 µg/L) concentrations of PCE, TCE, 1,1,1-trichloroethane (TCA), and 1,2-DCE. VOCs have not been detected in well GW-713 since January 2008. In the mid-1990s and in FY 2000, GW-713 experienced nitrate concentrations of about 1.3 mg/L. Nitrate has been detected intermittently at concentrations less than 1 mg/L subsequently and was detected at 0.037 and 0.18 mg/L in samples collected in January and July 2015, respectively. Technetium-99 has not been detected in samples from well GW-713. Uranium isotopes have been intermittently detected in well GW-713 at low activities (<1.7 pCi/L), however uranium isotopes were not detected in either of the two samples collected during FY 2015 despite the lower detection limits used. Overall, the effects of upstream contaminant sources on well GW-713 have diminished over time. Site related contaminants do not exceed the Bear Creek ROD goal for Zone 1 in wells GW-713.

Well GW-714 is about 145 ft deep and has a 30 ft long open interval in bedrock from which samples are drawn. Specific conductance in recent years has fluctuated in the 400 – 600 µmho/cm range although in the early 2000s levels fluctuated in the 400 – 800 or higher µmho/cm range. Dissolved oxygen typically fluctuates in the 0.2 – 2 ppm range although several higher values were reported in past years. Redox typically fluctuates in the range of about 50 – 200 mV. Site related VOCs have not been detected in well GW-714. Nitrate has been detected throughout the monitoring history of GW-714 and exhibits a decreasing trend. In the early 1990s, nitrate was detected at almost 5 mg/L. In FY 2000, the nitrate

concentration was about 4 mg/L and a steadily decreasing trend was observed with concentrations decreasing to about 1 mg/L in FY 2004. Nitrate was detected in GW-714 at concentrations of 0.43 and 1.2 mg/L in January and July 2015, respectively. The nitrate monitoring results are shown graphically on Figure 4.10 along with results from Zone 1 springs. Technetium-99 is not detected in well GW-714. Uranium-234 and ^{238}U isotopes are regularly detected in well GW-714. During FY 2015, ^{234}U was detected at 0.959 and 0.962 pCi/L and ^{238}U was detected at 11 and 1.15 pCi/L, respectively, in January and July. Uranium-235 is not routinely detected in well GW-714 and was not detected in either January or July 2015. The ^{238}U activities measured in well GW-714 during FY 2015 were similar to those that were seen during the 2003 and 2004 above average rainfall period. Site related contaminants do not exceed the Bear Creek ROD goal for Zone 1 in wells GW-714.

Well GW-715 is about 43 ft deep and has a 10 ft long screen in the monitoring interval. This well has not been actively monitored since its removal from the required RCRA groundwater monitoring regime in BCV. Sampling of well GW-715 was resumed in FY 2014 to provide a more complete understanding of groundwater conditions in this portion of Zone 1 and to support DOE’s ORR Groundwater Program. FY 2015 specific conductance values were in the range of approximately 300 – 350 µmhos/cm which is typical of shallow groundwater on the ORR. In the early 2000s, conductivity values ranged from a low of <200 µmhos/cm to several values in the 500 – 700 µmhos/cm range. Dissolved oxygen levels in GW-715 are typical of the very shallow groundwater zone it samples with levels fluctuating in the range of about 6.3 – 7.8 ppm. This well samples the most oxygen-rich groundwater of all the wells in Picket W. Redox levels in GW-715 have only been measured in FY 2014 and FY 2015 and recorded values lie in the range of 100 – 200 mV. During FY 2015 nitrate was detected at 0.39 and 0.3 mg/L in March and July, respectively. The GW-715 nitrate results are shown graphically on Figure 4.10 along with results from the Zone 1 springs. Technetium-99 was not detected in this well in FY 2015 although it was detected at a low level in FY 2014. Uranium 234 and ^{238}U were detected in both samples from well GW-715 during FY 2015 but $^{235/236}$U was detected only in the July sample. The ^{234}U activities were 0.752 and 0.332 pCi/L for March and July samples, respectively, while the ^{238}U activities were 1.43 and 0.553 pCi/L for the same sample periods. The ^{238}U/^{234}U ratio observed in well GW-715 is similar to the ratios observed in Bear Creek surface water sampled at BCK 9.2. This observation indicates that the groundwater sampled by well GW-715 is in fairly direct communication with the stream as is typical in shallow wells in karst settings. In the GW-715 metals analyses, uranium was detected at 4.3 µg/L in the March sample with a lower estimated concentration of 2.5 µg/L in the July sample. The MCL for uranium as a metal is 30 µg/L. Well GW-715 samples for metals analyses are field filtered prior to acid preservation to allow determination of dissolved vs particle associated metals. Cadmium was not detected in either aliquot in the March sampling event. In the July sample, cadmium was detected at 0.16 µg/L in the unfiltered aliquot but was not detected in the filtered aliquot. As was discussed previously, the S-3 Ponds groundwater contaminant plume contains cadmium which causes AWQC exceedances in the Bear Creek headwaters and was detected in the July surface water sample at BCK 9.2. The presence of cadmium in well GW-715 and surface water along with uranium at a similar uranium isotopic ratio in both media supports the interpretation of a surface water to groundwater connection. Although site related contaminants are present in groundwater in well GW-715, their concentrations are less than the MCL screening levels.

Collectively, the data from groundwater monitoring in Picket W wells indicates that the impacts to Zone 1 groundwater in this well transect are observed predominantly in the shallow groundwater which is most interactive with epikarst groundwater contaminant transport which is spatially and temporally interactive with the surface water contaminant transport in Bear Creek.

Table 4.10. Nitrate concentrations measured in wells GW-710, GW-711, GW-712, GW-713, GW-714, and GW-715[a]

GW-710 (744 ft deep)			GW-711 (666 ft deep)			GW-712 (458 ft deep)			GW-713 (314 ft deep)			GW-714 (145 ft deep)		GW-715 (43.1 ft deep)	
Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)[b]	Date	Nitrate (mg/L)[b]
						1/10/2000	0.02		1/6/2000	0.67		1/5/2000	0.46	1/5/2000	3.4
						7/10/2000	1.4		7/10/2000	1.3		7/11/2000	4	7/11/2000	2.9
						1/2/2001	0.03		1/3/2001	0.33		1/2/2001	3.7	1/2/2001	3.3
						7/2/2001	0.02	U	7/10/2001	0.061		7/2/2001	1.8	7/9/2001	1.4
						1/3/2002	0.02	U	1/3/2002	0.02	U	1/2/2002	1.6	1/2/2002	1.3
						7/1/2002	0.034		7/1/2002	0.02	U	7/1/2002	1.7	7/1/2002	4.2
1/15/2003	0.56	U	1/15/2003	0.56	U	1/6/2003	0.13		1/6/2003	0.16		1/6/2003	1.6	1/7/2003	1.4
7/14/2003	0.28	U	7/14/2003	0.28	U	7/7/2003	0.22		7/7/2003	0.2		7/7/2003	1.3	7/7/2003	0.91
						1/6/2004	0.02	U	1/5/2004	0.02	U	1/5/2004	1.1	1/5/2004	0.67
						7/7/2004	0.02	U	7/7/2004	0.02	U	7/7/2004	0.78		
						1/10/2005	0.094		1/10/2005	0.02	U	1/10/2005	0.67		
						7/6/2005	0.021		7/7/2005	0.02	U	7/6/2005	0.56		
						1/3/2006	0.02	U	1/3/2006	0.02	U	1/3/2006	0.52		
						7/5/2006	0.02	U	7/5/2006	0.02	U	7/5/2006	0.42		
						1/2/2007	0.02	U	1/2/2007	0.02	U	1/2/2007	0.36		
						7/2/2007	0.02	U	7/3/2007	0.02	U	7/2/2007	0.24		
						1/2/2008	0.02	U	1/2/2008	0.02	U	1/2/2008	0.19		
						7/1/2008	0.02	U	7/7/2008	0.02	U	7/1/2008	0.22		
						1/7/2009	0.052		1/7/2009	0.028		1/6/2009	0.24		
						7/6/2009	0.01	U	7/7/2009	0.01		7/6/2009	0.34		
						1/5/2010	0.018		1/4/2010	0.015		1/5/2010	0.55		
						7/21/2010	0.01	U	7/19/2010	0.01	U	7/19/2010	0.36		
						1/5/2011	0.051		1/13/2011	0.01	U	1/5/2011	0.61		
						7/7/2011	0.01	U	7/7/2011	0.01	U	7/6/2011	0.16		
						1/4/2012	0.01	U	1/9/2012	0.057		3/22/2012	0.43		
						7/11/2012	0.01	U	7/16/2012	0.01	U	7/2/2012	0.33		
2/25/2013	0.019		2/25/2013	0.019		1/2/2013	0.013		1/3/2013	0.01	U	1/2/2013	0.44		

Table 4.10. Nitrate concentrations measured in wells GW-712, GW-713, GW-714, and GW-715[a] (cont.)

GW-710 (744 ft deep)			GW-711 (666 ft deep)			GW-712 (458 ft deep)			GW-713 (314 ft deep)			GW-714 (145 ft deep)		GW-715 (43.1 ft deep)	
Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)[b]	Date	Nitrate (mg/L)[b]
9/9/2013	0.026		9/9/2013	0.014		7/1/2013	0.011		7/2/2013	0.012		7/1/2013	0.51		
2/25/2014	0.01	U	2/25/2014	0.01	U	1/2/2014	0.02	J	1/6/2014	0.039	J	1/2/2014	0.55	2/26/2014	0.46
7/31/2014	0.03		7/31/2014	0.025		7/7/2014	0.021		7/7/2014	0.053		7/7/2014	0.45	7/30/2014	2.1
3/12/2015	0.025		3/11//2015	0.0055	J	1/13/2015	0.17		1/14/2015	0.037		1/5/2015	0.43	3/12/2015	0.39
8/4/2015	0.013		8/4/2015	0.0052	J	7/7/2015	0.25		7/8/2015	0.18		7/6/2015	1.2	7/21/2015	0.3

[a]EPA drinking water MCL is 10 mg/L.
[b]Note nitrate detected at specified levels at all dates in this well.

EPA = U.S. Environmental Protection Agency
GW = groundwater well
J = estimated value
MCL = maximum contaminant level
U = not detected

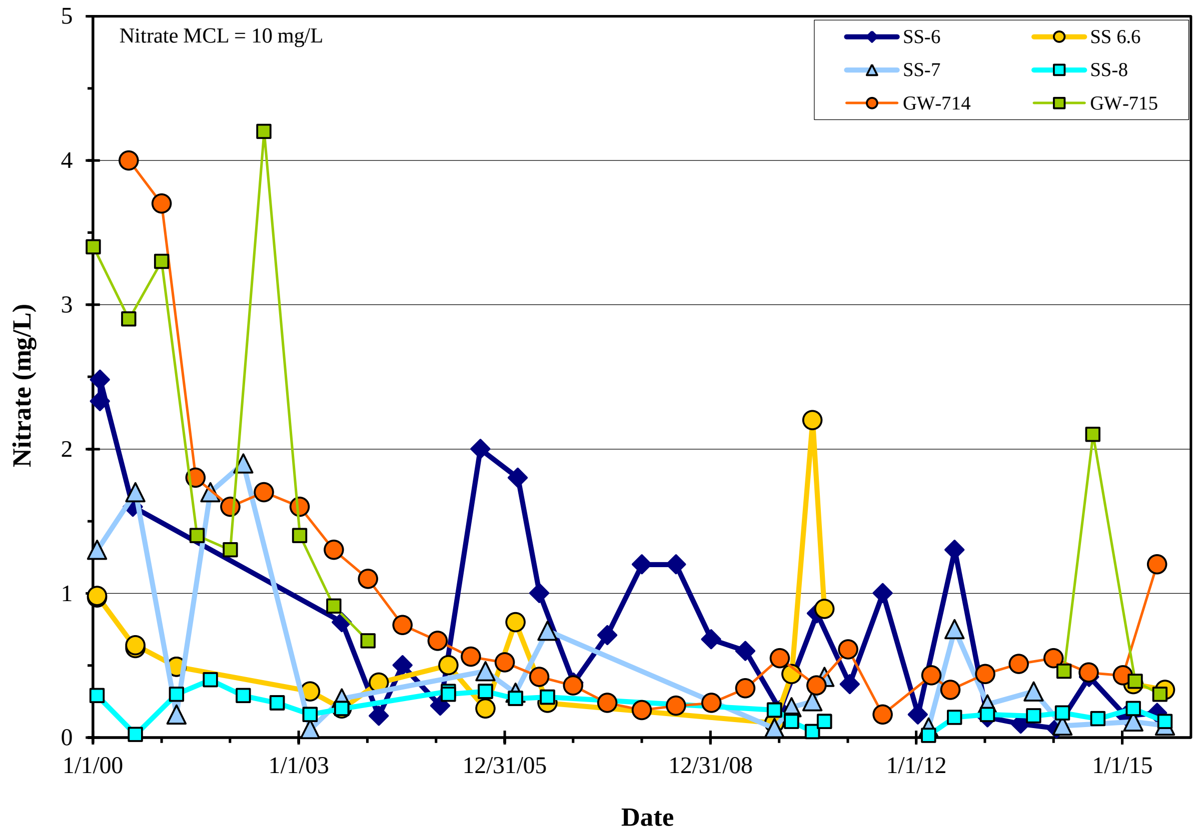


Figure 4.10. Nitrate concentrations in Zone 1 springs and wells GW-714 and GW-715.

Four springs (SS-6, SS-6.6, SS-7, and SS-8) were monitored in Zone 1 in FY 2015 (Figure 4.3). Sampling of these springs was conducted semiannually during the high-flow wet season (typically during winter) and during the low-flow dry season (during summer months). Figure 4.10 shows nitrate concentrations in the Zone 1 springs and wells where consistently detectable from 2000 through FY 2015. Nitrate is commonly detected at BCV Zone 1 springs and in wells GW-714 and GW-715 at concentrations less than 50% of the MCL (10 mg/L).

Springs in BCV discharge groundwater from bedrock flow pathways and all discharge into Bear Creek. The springs act as integration points for groundwater in the karst groundwater flow system in the Maynardville Limestone. This bedrock flow system is very complex. The system contains both components of deep, long-distance flow originating at the S-3 Ponds area in the Bear Creek headwaters as well as shallow components where Bear Creek surface water and groundwater commingle. This commingling occurs as seasonal flow volume and groundwater level variation allow surface water to sink into the bedrock karst with resurgences to the surface via springs further downgradient. The Zone 1 springs are resurgence points for groundwater originating from within BCV and groundwater inputs from the northern slopes of Chestnut Ridge. Analyses are performed for a broad suite of parameters, such as metals (including uranium as a metal), VOCs, anions (including nitrate), and radionuclides (including uranium isotopes and ^{99}Tc). Nitrate, uranium isotopes, and ^{99}Tc are signature contaminants that originate in the S-3 Ponds plume and are focal points in the following discussion.

Table 4.11 contains the results of uranium isotope analyses conducted on Zone 1 spring samples from FY 2000 through FY 2015. The FY 2015 levels detected in Spring SS-6 are consistent with those of previous years. Also included in Table 4.11 is the total uranium concentration calculated from the results of detected (unqualified) isotopic activities.

Uranium isotopic ratios in the spring water discharges have been compared to those from other key source areas in BCV including the S-3 Ponds, discharge at BCK 12.34, NT-3 water, NT-8 water, and the combined discharge monitored at BCK 9.2. The $^{238}U/^{234}U$ ratios indicate that within Zone 1 there is evidence that groundwater in a conduit that originates from upstream of NT-8 discharges intermittently at Spring SS-6 (at times SS-6 has no visible flow although standing water is present in the spring orifice). The uranium isotope ratios for other springs in Zone 1 all indicate that they are resurgence points for groundwater that entered the system from sinking groundwater downstream of the NT-8 sinking reach.

Analyses conducted since FY 2000 show the occasional presence of very low levels of ^{99}Tc in the springs. Like nitrate, ^{99}Tc is a signature contaminant that originates from the S-3 Ponds releases. The levels of ^{99}Tc measured in the Zone 1 springs are in the range of 10 – 30 pCi/L, which are approximately 1% of the MCL-DC activity of 900 pCi/L. The majority of ^{99}Tc results are non-detect and nearly all the results that suggest the presence of ^{99}Tc are J qualified (J = estimated value). Technetium-99 was not detected in springs SS-6, SS-6.6, SS-7, or SS-8 samples in FY 2015.

During the 1990s, low to trace concentrations of PCE, TCE, and 1,2-DCE were detected in SS-6 springwater. Chlorinated VOCs have not been detected at SS-6 since FY 1998. VOCs were not detected in any of the other three springs (SS-6.6, SS-7, and SS-8) sampled in Zone 1 during FY 2015.

Because of the intermittent nature of contaminant detection at low levels in the Zone 1 groundwater, an area of intermittent plume extension in the Maynardville Limestone is shown on Figure 4.3. Contaminant concentrations continue to remain low, and per the approved *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2457&D2/A1), will continue to be monitored and reported annually in the RER. The uncertainties about groundwater contaminant levels and flow paths in BCV Zones 1 and 2 have been identified as issues in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Evaluation of potential pathways and installation of additional wells will be included in investigations during groundwater strategy implementation and will be sequenced according to ORR-wide groundwater issues prioritization.

Table 4.11. Uranium isotope activities in Zone 1 Spring samples, 2000 – 2015

Uranium isotopic data for SS-6

Date	^{234}U (pCi/L)	^{235}U (pCi/L)	^{238}U (pCi/L)	Total U[a] µg/L
2/9/2000	5.87±2.94	0.94±1.25 U	8.32±3.53	25.2
8/3/2000	2.11±0.89	0.07±0.17 U	3.24±1.17	9.8
7/10/2002	1.57±0.82	0.11±0.22 U	3.28±1.23	9.9
8/19/2003	1.47±0.56	0.18±0.22 U	1.89±0.64	5.7
7/7/2004	1.21±0.56	0.33±0.31 J	1.72±0.68	5.2
1/24/2005	0.33±0.31 J	0.04±0.16 U	0.63±0.42 J	--[b]
8/25/2005	2.12±0.73	0.15±0.22 U	3.72±1.02	11.3
3/13/2006	2.1±0.77	0.43±0.36 J	4.2±1.17	12.7
7/5/2006	2.88±0.91	0.18±0.24 U	4.07±1.12	12.3
1/3/2007	0.564±0.307	0.0482±0.168 U	0.932±0.393	2.8
7/2/2007	0.743±0.532	0.137±0.293 U	0.0617±0.293 U	1.20E-04
1/2/2008	2.23±0.876	0.153±0.296 U	2.85±0.982	8.6
7/1/2008	2.68±0.892	0.361±0.323	4.61±1.16	14.1
1/5/2009	2.23±0.842	0.247±0.329 U	2.42±0.888	7.3
7/6/2009	1.53±0.636	0.183±0.228 U	2±0.722	6.1
1/6/2010	0.57±0.442 U	-0.0675±.22 U	0.911±0.504	2.8
7/22/2010	1.47±0.492	0.266±0.226 U	2.64±0.653	8
1/12/2011	1.01±0.42	0.119±0.159 U	1.3±0.45	3.9
7/7/2011	2.05±0.607	0.283±0.237	3.02±0.735	9.3
1/10/2012	0.606±0.405	0.104±0.202 U	0.677±0.4	2.1
7/24/2012	1.76±0.62	0.13±0.218 U	2.57±0.651	7.8
1/14/2013	0.149±0.264 U	-0.132±0.132 U	0.259±0.223 U	4 U
7/11/2013	0.267±0.269 U	-0.00874±0.149 U	0.448±0.265	4 U
1/16/2014	0.33±0.176	0.0745±0.104 U	0.357±0.205	4 U
7/10/2014	0.862±0.279	0.0965±0.0959 U	1.03±0.303	4 U
1/20/2015	0.416±0.223	0.0467±0.0895 U	0.582±0.245	4 U
7/7/2015	0.548±0.247	0.00663±0.0872 U	0.48±0.218	4 U

Uranium isotopic Data for SS-6.6

Date	^{234}U (pCi/L)	^{235}U (pCi/L)	^{238}U (pCi/L)	Total U[a] µg/L
1/25/2000	1.91±0.73	0.09±0.18 U	2.57±0.89	7.8
1/25/2000	1.8±0.66	0.44±0.33 J	3.23±0.96	9.8
8/16/2000	3.13±1.82	0.6±0.81 U	1.99±1.42 J	5.00E-04
8/16/2000	2.25±1.4 J	0.12±0.56 U	0.14±0.34 U	--
3/22/2001	0.68±0.37 J	0.04±0.1 U	1.33±0.53	4
3/22/2001	0.93±0.43	0.09±0.13 U	1.45±0.55	4.4
3/4/2003	0.91±0.52 J	0.3±0.32 U	0.8±0.48 J	--
3/2/2004	2.42±1.79 J	0.48±0.93 U	0.9±1.2 U	--
3/8/2005	0.96±0.46	0.06±0.12 U	2.93±0.86	8.9
9/21/2005	1.18±0.58	0.23±0.27 U	1.56±0.67	4.7
2/28/2006	2.08±0.87	0.29±0.33 U	1.82±0.81	5.5
8/17/2006	1.93±0.83	0.33±0.38 U	1.25±0.67 J	3.10E-04
3/2/2015	0.522±0.238	0.0631±0.0879	0.587±0.246	1.8
8/18/2015	1.18±0.38	0.0599±0.11	1.71±0.463	4.4

Table 4.11. Uranium isotope activities in Zone 1 Spring samples, 2000 – 2015 (cont.)

Uranium isotopic data for SS-7					*Uranium isotopic data for SS-8*				
Date	**^{234}U (pCi/L)**	**^{235}U (pCi/L)**	**^{238}U (pCi/L)**	**Total U[a] µg/L**	**Date**	**^{234}U (pCi/L)**	**^{235}U (pCi/L)**	**^{238}U (pCi/L)**	**Total U[a] µg/L**
1/25/2000	2.89±0.91	0.5±0.36 J	5.25±1.37	15.9	1/25/2000	0.15±0.23 U	0.04±0.11 U	0.2±0.23 U	--
8/16/2000	3.68±1.24	0.41±0.39 J	5.58±1.67	16.9	8/16/2000	0.7±0.47 J	0.12±0.21 U	0.45±0.37 J	--
3/22/2001	0.34±0.23 J	-0.01±0.01 J	0.64±0.33	1.9	3/22/2001	0.27±0.35 U	-0.12±0.09	0.06±0.06 U	--
9/18/2001	2.26±0.56	0.19±0.14 J	3.75±0.82	11.4[c]	9/18/2001	0.18±0.19 J	0.18±0.19 U	0.25±0.22 J	--
3/12/2002	1.59±0.54	-0.01±0.01 U	3.77±0.97	11.4	3/12/2002	0.52±0.27	0 J	0.02±0.06 U	8.40E-05
					9/9/2002	0.27±0.24 J	0.1±0.17 U	0 J	--
					9/9/2002	0.35±0.29 J	0.14±0.2 U	0.14±0.17 U	--
3/4/2003	1.07±0.53	0.4±0.34 J	0.37±0.3 J	1.70E-04	3/4/2003	1.05±0.55	0.14±0.22 U	0.09±0.18 U	1.70E-04
					3/4/2003	1.01±0.55	0.17±0.24 U	0.13±0.24 U	1.60E-04
8/19/2003	0.72±0.4	0.13±0.18 U	1.59±0.63	4.8	8/19/2003	0.1±0.25 U	-0.04±0.04 U	0.03±0.09 U	--
					8/19/2003	0.18±0.2 U	0 J	0.25±0.22 J	--
					3/8/2005	1.25±0.73 J	0.42±0.47 U	1.71±0.86	5.2
					3/8/2005	1.64±0.77	0.57±0.48 J	3.74±1.23	0.11
9/21/2005	2.69±0.83	0.16±0.22 U	3.4±0.96	10.3	9/21/2005	1.26±0.59	0.29±0.3 U	0.28±0.3 U	2.00E-04
					9/21/2005	0.26±0.24 J	-0.02±0.03 U	0.08±0.14 U	--
2/28/2006	0.74±0.41	0.2±0.23 U	1.21±0.54	3.7	2/28/2006	0.52±0.38 J	0.15±0.23 U	0.33±0.3 J	--
					2/28/2006	0.39±0.3 J	0.13±0.2 U	0.16±0.19 U	--
8/17/2006	2.76±0.98	0.07±0.17 U	6.13±1.6	18.6	8/17/2006	0.98±0.53	0.34±0.36 U	0.17±0.22 U	1.60E-04
					8/17/2006	0.56±0.4 J	0.1±0.22 U	0.23±0.28 U	--
12/7/2009	0.724±0.461	0.252±0.279 U	0.24±0.28 U	1.20E-04	12/7/2009	0.55±0.367	0±0.215 U	0.183±0.215	5.50E-01
					12/7/2009	0.248±0.275 U	0.124±0.24 U	0.112±0.24 U	--
3/9/2010	0.791±0.49	0.19±0.237 U	0.785±0.469	2.4	3/9/2010	0.343±0.363 U	0.0802±0.282 U	0.197±0.282 U	--
					3/9/2010	0.37±0.347 U	0.217±0.286 U	0.109±0.253 U	--
6/28/2010	1.06±0.428	0.0723±0.147 U	1.34±0.47	4.1	6/28/2010	0.581±0.313	0.03±0.136 U	0.367±0.253	0.11
					6/28/2010	0.7±0.377	0.0361±0.163 U	0.339±0.278 U	1.10E-04
8/30/2010	1.16±0.47	0.346±0.255	1.81±0.576	5.6	8/30/2010	0.0598±0.211 U	-0.0598±0.154 U	0.218±0.214 U	--
					8/30/2010	0.566±0.328	0.192±0.189 U	0.136±0.196 U	9.10E-05
3/7/2012	0.184±0.208 U	-0.0369±0.148 U	0.143±0.191 U		3/7/2012	0.165±0.197 U	0.0824±0.139 U	-0.0363±0.119 U	--
7/24/2012	1.47±0.504	0.0946±0.143 U	2.6±0.647	7.9	7/24/2012	0.279±0.251 U	0.0364±0.154 U	0.0971±0.146 U	--
1/14/2013	0.443±0.255	0.0175±0.111 U	1.16±0.38	4 U	1/14/2013	0.172±0.169 U	-0.0136±0.114 U	0.163±0.154 U	4 U
9/17/2013	1.2±0.408	0.181±0.184 U	2.23±0.528	7.5	9/17/2013	0.359±0.234	0.0572±0.128 U	0.0768±0.151 U	4 U
2/18/2014	1.6±0.442	0.156±0.154 U	4.29±0.698	4 U	2/18/2014	0.19±0.198 U	-0.0208±0.108 U	0.0833±0.124 U	4 U
8/25/2014	0.887±0.309	0.0511±0.096 U	1.26±0.362	5.1	8/25/2014	0.314±0.173	0.0337±0.0801 U	0.113±0.118 U	4 U

Table 4.11. Uranium isotope activities in Zone 1 Spring samples, 2000 – 2015 (cont.)

Uranium isotopic data for SS-7					***Uranium isotopic data for SS-8***				
Date	**^{234}U (pCi/L)**	**^{235}U (pCi/L)**	**^{238}U (pCi/L)**	**Total U[a] µg/L**	**Date**	**^{234}U (pCi/L)**	**^{235}U (pCi/L)**	**^{238}U (pCi/L)**	**Total U[a] µg/L**
3/2/2015	0.278±0.23	0.104±0.131	0.199±0.171	0.6 J	3/2/2015	0.109±0.106	-0.0103±0.0865 U	0.139±0.128	0.11 J
8/18/2015	0.621±0.252	0.123±0.11	0.44±0.216	2 J	8/18/2015	0.178±0.154	0.0247±0.0911 U	0.0158±0.0911 U	0.33 J

[a]Total uranium mass calculated from detected individual isotope.
[b]Uranium concentrations are not calculated from isotopic results for estimated or non-detect results.
[c]Total uranium metal analysis indicated 27.6 µg/L.

Bold value indicates sample concentration exceeds 30 µg/L MCL for uranium.

J = estimated value
MCL = maximum contaminant level
SS = surface spring
U = not detected

Zone 2

Groundwater monitoring used to evaluate conditions in the eastern end of Zone 2 consists of sampling six wells along the boundary with Zone 3 near the western end of the BCBGs. Well locations are shown on Figure 4.3. Four of these wells (GW-077 through GW-080) are located west of NT-8 and north of Bear Creek Road in the Conasauga Group clastic bedrock formations and the other two wells are constructed in the Maynardville Limestone to the south of Bear Creek Road along the transect designated as Picket A (Figure 4.3).

The groundwater quality goal for Zone 2 is to eventually achieve unrestricted use and, therefore, MCLs and residential risk-based concentrations are used as screening comparison levels.

Wells GW-077 (100 ft deep, screened between 814.4 and 827.3 ft aMSL), and GW-078 (21 ft deep, screened between 893.4 and 902.8 ft aMSL) sample groundwater in the Nolichucky Shale. Wells GW-079 (65 ft deep, screened between 912.3 and 927.3 ft aMSL) and GW-080 (30 ft deep, screened between 947.4 and 956.3 ft aMSL) sample groundwater from the Rogersville Shale Formation. All four of these wells are sampled for uranium and VOCs. No VOCs were detected in any of these four wells during FY 2015. Lower detection limits in FY 2015 allowed detection of low concentrations of uranium metal and uranium isotopes. All of the uranium metal results were lower than 0.25 µg/L. These are the only wells available to sample along the Zone 2/Zone 3 boundary at the western edge of the BCBGs. The possibility of deeper groundwater contamination migration from the dense non-aqueous phase liquid (DNAPL) area beneath the BCBGs cannot be evaluated with the existing well network. This scarcity of groundwater monitoring opportunities in this area west of the BCBGs was identified as an issue in previous RERs and in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2).

Wells GW-683 and GW-684 sample bedrock groundwater from the Maynardville Limestone upgradient of spring SS-5 and are monitored semiannually for metals, including uranium, nitrate, VOCs, and radiological constituents. Well GW-683 is 197.5 ft deep (screened interval elevation 772.65 to 835.55 ft aMSL) and well GW-684 is 129.6 ft deep (screened interval elevation 765.93 to 789.13 ft aMSL). The principal contaminants detected in these wells that presently or have historically exceeded the screening criteria are nitrate and uranium isotopes (Figure 4.11). Nitrate is compared to the MCL of 10 mg/L. Nitrate has been detected in wells GW-683 and GW-684 at concentrations less than half of the MCL since 2002. Since 2009, measured ^{238}U concentrations have been less than the risk-based criterion in wells GW-683 and GW-684. Similar to the contaminant behavior of S-3 Ponds contamination further upgradient in Bear Creek, there appears to be an inverse relationship between rainfall amounts and contaminant concentrations in GW-683 and GW-684. During periods of elevated rainfall there is dilution of contaminants in Maynardville Limestone transport pathways. Technetium-99 was not detected in well GW-683 during FY 2015 semiannual sampling but was detected at 9.24 and 11.7 pCi/L, respectively, in the March and July 2015 samples from well GW-684. Very low (<2 ng/L) concentrations of mercury were detected in both wells during FY 2015. Alpha activity was about 3 pCi/L in well GW-683 during FY 2015 and was 8.46 and 5.67 pCi/L in the March and July samples collected from GW-684. Beta activity levels were 6.3 and 4.26 pCi/L in well GW-683 and were 11.5 and 15.3 pCi/L in GW-684. No VOCs were detected in either of these wells during FY 2015.

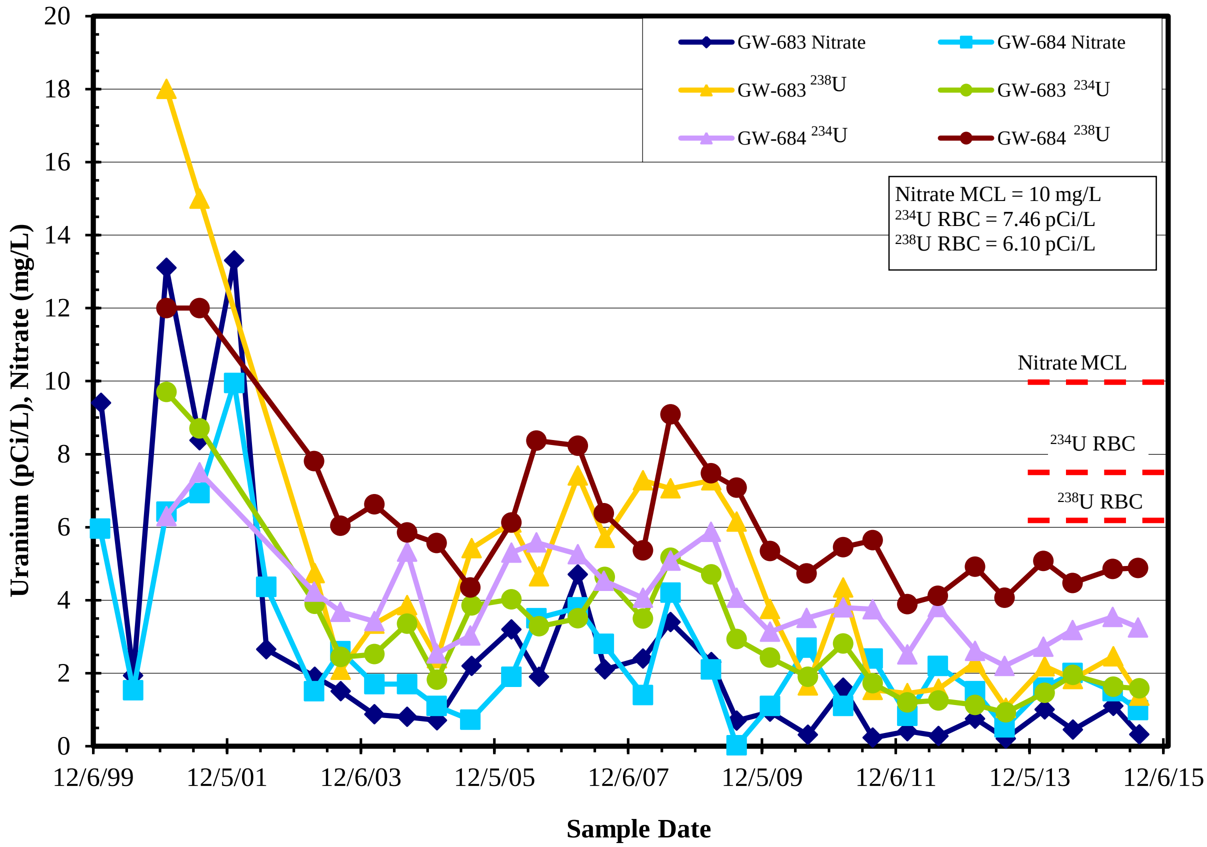


Figure 4.11. Constituents detected above risk-based concentration or MCL at wells GW-683 and GW-684.

Wells GW-683 and GW-684 sample groundwater contamination that originates from upgradient sources, including the S-3 Ponds and portions of the BCBGs, and flows through karst conduits in the Maynardville Limestone prior to rising to discharge into Bear Creek at spring SS-5 (Figure 4.3). Although a portion of the groundwater contaminant plume shown on Figure 4.3 terminates at the known plume discharge point at SS-5, detection of contaminants linked to the S-3 Ponds plume from upstream of the BCBGs in Spring SS-6 further downgradient in Zone 1 indicates the presence of some discrete conduit flow connecting Zones 1 and 3. Wells do not exist in the Maynardville Limestone in Zone 2 that could help delineate the contaminant transport characteristics in that area. Groundwater sampling further to the west at the Picket W wells (Figure 4.3) shows the presence of nitrate and uranium as discussed previously in the Zone 1 groundwater section. Transient episodes of groundwater contaminant migration occur through bedrock groundwater flow pathways through Zone 2 and into Zone 1. A scarcity of groundwater monitoring wells in appropriate locations and depths in Zone 2 makes it impossible to precisely map and track groundwater contaminant transport pathways that may emanate from DNAPL at depth beneath the BCBGs. This scarcity of wells in Zone 2 near the Zone 3 boundary capable of detecting contaminant migration in key geologic positions was identified as an issue in previous RERs and in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2).

Zone 3

Existing CERCLA decision documents pertinent to BCV do not stipulate groundwater actions or remediation levels to be attained within Zone 3. The ROD indicates source area RAs are intended to improve conditions in groundwater for protection of water quality in Zones 1 and 2. Groundwater monitoring in Zone 3 includes monitoring of wells GW-704 and GW-706, which sample groundwater in

the S-3 plume, and RCRA PCP sampling of wells GW-008 near the Oil Landfarm and GW-046 in the BCBGs (Figure 4.3). Contaminant plumes in BCV, as interpreted by the Y-12 Groundwater Protection Program (GWPP), are shown in Figure 4.3.

Wells GW-704 and GW-706 are in Picket B and sample groundwater from bedrock in the Maynardville Limestone exit pathway downgradient from the former S-3 Ponds and other source areas. Well GW-704 samples groundwater from a depth of 256 ft (screened between 685.99 and 697.49 ft aMSL) and well GW-706 samples groundwater from a depth of 182 ft (screened between 743.28 and 769.68 ft aMSL). The wells are located midway between BCK 11.54 and SS-5. Samples from these wells contain uranium, VOCs, nitrate, and ^{99}Tc. Contaminant levels in both wells have exhibited decreasing or stable contaminant signatures over the past several years. Principal contaminant concentration graphs for wells GW-704 and GW-706 are shown in Figure 4.12. During FY 2015, contaminant levels continued their seasonal fluctuations and were consistent with previous years with gradual long-term decreasing trends over the past 15 years of monitoring.

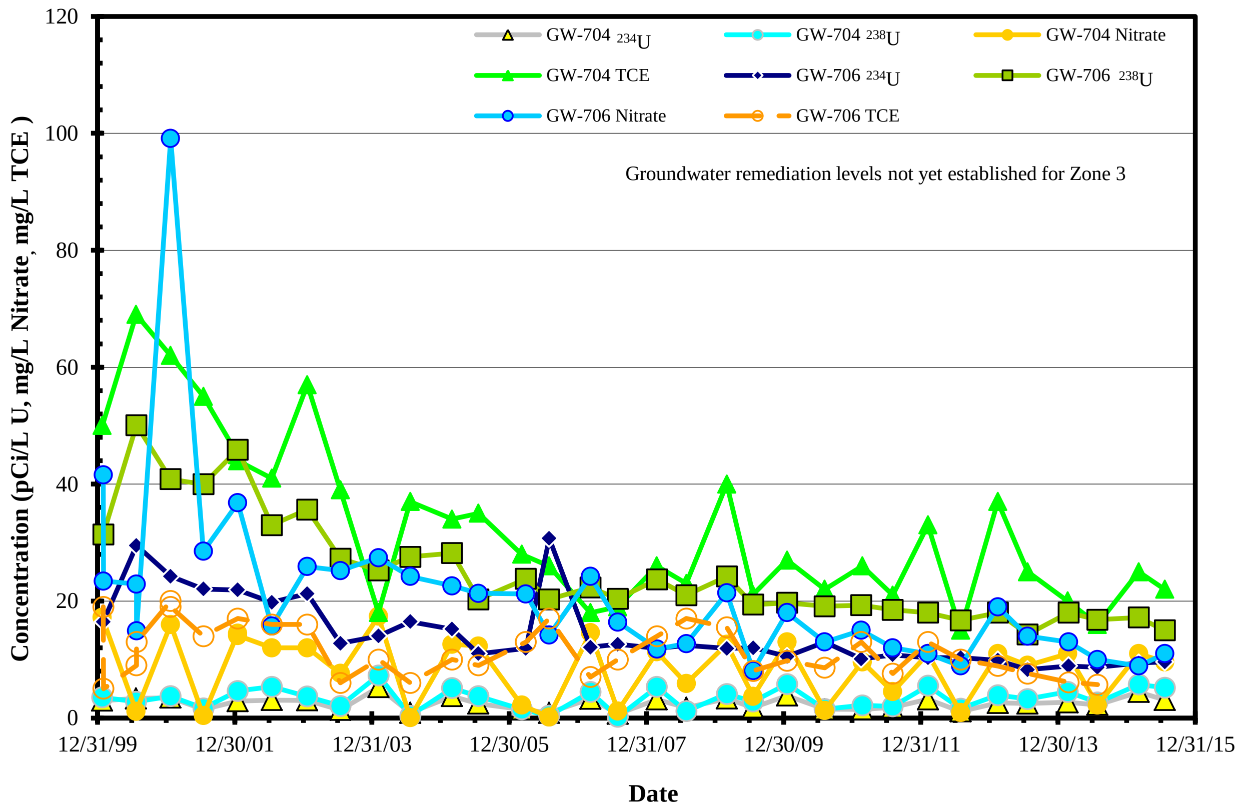
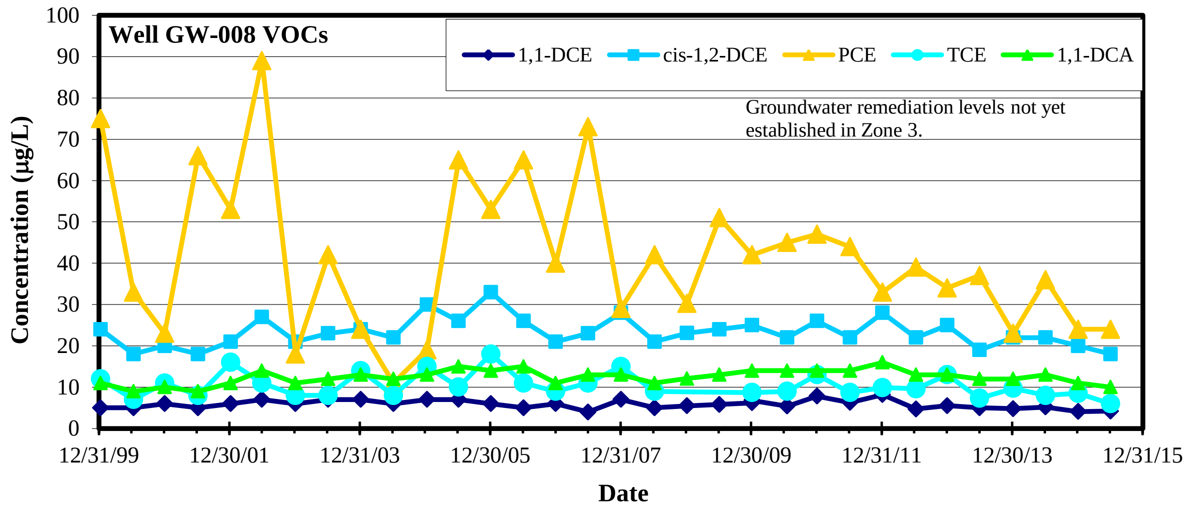


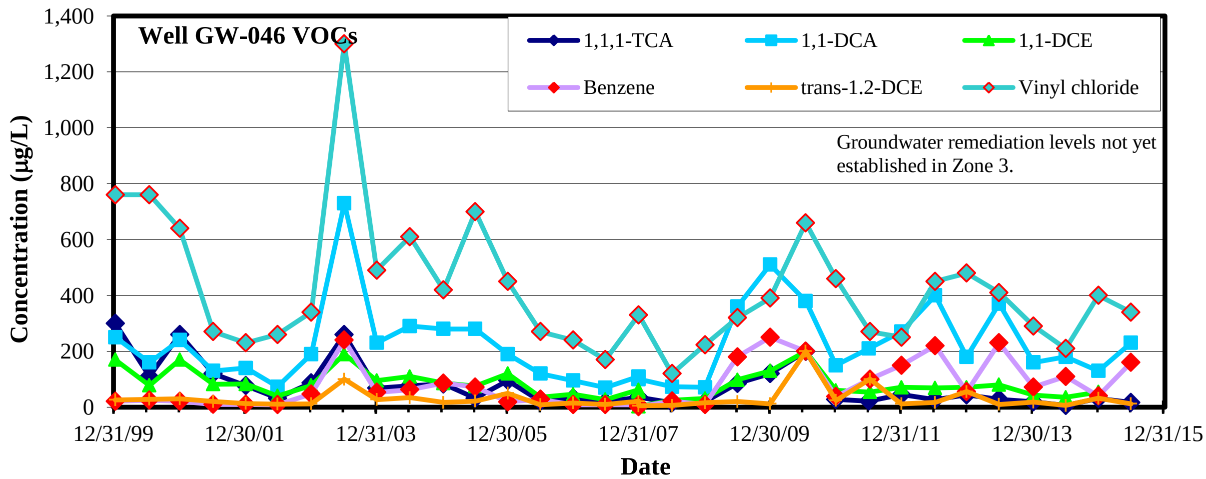
Figure 4.12. Principal contaminant trends in wells GW-704 and GW-706.

Both shallow and deep sources of VOC contamination are present at the BCBGs. VOC liquids were disposed in some shallow waste burial trenches in Burial Ground A-South with resultant shallow and deep contamination. As shown on Figure 4.3, wells GW-008 is located near the Oil Landfarm and GW-046 is located to the east of NT-7 near the southwest corner of Burial Ground A-South. Both of these relatively shallow wells are in areas that are impacted by past disposal of VOC compounds. Well GW-008 samples groundwater from a depth of about 25 ft (screened between 936.61 and 949.11 ft aMSL) and GW-046 samples groundwater from a depth of about 20 ft (screened between 897.83 and 913.13 ft aMSL). Concentration trends for the principal contaminants of concern in these wells are shown in Figure 4.13. The relatively low VOC concentrations in GW-008 did not change greatly during FY 2015. Well GW-046, which is located downgradient from an area where large quantities of

liquid wastes were disposed by percolation into shallow waste burial trenches, contains much higher VOC concentrations. During 2015, VOC concentrations measured in GW-046 exhibited a mixed fluctuation behavior. Trichloroethene and two of the PCE/TCE degradation products, cis-1,2-DCE and VC showed increasing concentrations in March with decreases in July, while the other VOCs showed decreases in March with subsequent increases in July. Short-term VOC concentration fluctuations notwithstanding, the data from these two wells indicate that the VOC contaminant source terms in both of these areas are essentially constant.

Groundwater surveillance monitoring of the BCBGs conducted by the Y-12 GWPP documents increasing VOC concentrations in the noncarbonate, fractured bedrock underlying the area. In a sample collected at a depth of 270 ft in well GW-629 (shown in Figure 4.3) by the Y-12 GWPP in 2009, PCE, TCE, and 1,1-DCA were measured at concentrations of 180 ppm, 24 ppm, and 11 ppm, respectively. These contaminants are not detected to date in wells GW-077 (100.5 ft deep) and GW-078 (21.1 ft deep) that lie farther west of the burial grounds and Bear Creek Tributary NT-8. However, PCE, TCE, and cis-1,2-DCE are detected in surface water in NT-8.





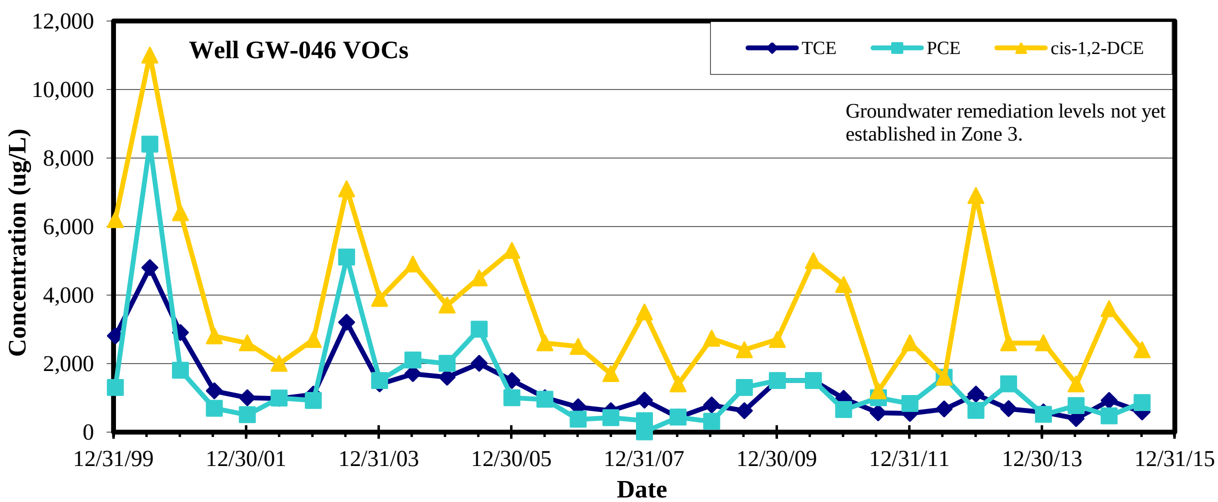


Figure 4.13. VOC concentration trends in wells GW-008 and GW-046.

4.2.1.2.3 Aquatic Biological Monitoring

4.2.1.2.3.1 Watershed Biological Monitoring

Aquatic biological monitoring of stream sites in BCV watershed (Figure 4.3) is used to measure the effectiveness of watershed-scale RAs. Biological monitoring data for streams in BCV include results on (1) contaminant accumulation in fish, (2) fish community surveys, and (3) benthic macroinvertebrate community surveys.

To evaluate instream contaminant exposure and potential human and ecological risks in the BCV watershed, fish are collected twice a year and analyzed for a suite of metals and PCBs at sampling locations BCK 3.3, BCK 9.9, and BCK 12.4 (Figure 4.3). An evaluation of overall ecological health of the streams is conducted by monitoring fish and benthic macroinvertebrate communities at BCK 3.3, BCK 9.9, BCK 12.4, and NT-3 (a tributary to Bear Creek).

Mean mercury concentrations in rock bass from lower Bear Creek (BCK 3.3) again decreased in FY 2015, averaging 0.60 µg/g in fall 2014 and 0.49 µg/g in spring 2015 (Figure 4.14). Though these concentrations are above the EPA-recommended fish-based AWQC of 0.3 µg/g, and remain elevated with respect to concentrations in fish collected from the reference site (Hinds Creek kilometer [HCK] 20.6; Figure 4.3), the concentrations seen in 2015 were lower than those measured for the past six years (Figure 4.14). The overall temporal pattern of mercury concentrations in BCK 3.3 fish suggests seasonally variable levels in the general range of approximately 0.5 – 0.6 ppm, with a temporary increase in fish mercury concentrations over the 2011 – 2013 time period (during which time fish concentrations ranged from approximately 0.8 – 1 ppm on multiple occasions).

Mercury concentrations in fish collected in upper Bear Creek (BCK 9.9) continue to be lower than those in fish collected at the lower site, partly due to differences in species monitored between the two sites. While the lower stretches of Bear Creek are often impounded due to beaver dams which create the deeper pools suitable for rock bass habitat, the upper stretches of Bear Creek are less suitable for rock bass, and the sunfish species most often encountered in the stretch of Bear Creek between BCK 4.6 and BCK 9.9 is the redbreast sunfish, which feed on lower trophic level prey and typically have between 15 – 40% lower mercury concentrations than rock bass collected from the same site. When monitoring began in this stretch of the creek in 2009, average mercury concentrations in redbreast sunfish were slightly below the AWQC, but have been slowly increasing over the past six years such that concentrations in FY 2015 were above the AWQC (0.43 µg/g in fall 2014 and 0.37 µg/g in spring 2015; Figure 4.14).

As seen at many other monitoring sites, mean PCB concentrations in sunfish collected from Bear Creek have fluctuated significantly over time, but with concentrations averaging between 0.1 – 1.2 µg/g in 2015 (Figure 4.15). Fish PCB concentrations remain elevated with respect to the Hinds Creek reference site. Concentrations in fish collected from BCK 9.9 have generally been higher than in fish collected further downstream at BCK 3.3, but there is significant inter-annual variability.

While regulatory guidance and human health risk levels have varied widely for PCBs over the years, in recent years in the state of Tennessee, the water quality criterion (0.00064 µg/L for total PCBs) under the recreation designated use classification has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2007) under its TMDL Program, and this concentration is 0.02 µg/g in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in Bear Creek are still well above the calculated TMDL concentration.

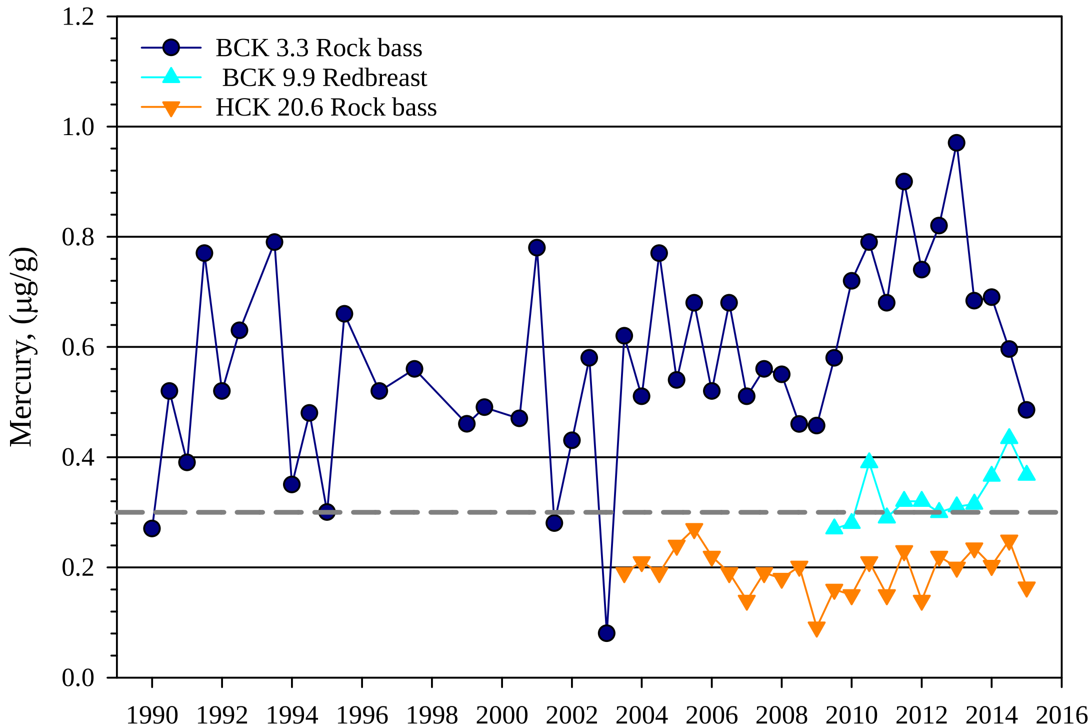


Figure 4.14. Mean concentrations of mercury in rockbass from BCK 3.3, redbreast sunfish from BCK 9.9, and rockbass from the Hinds Creek reference site (HCK 20.6) 1990 – 2015.

Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

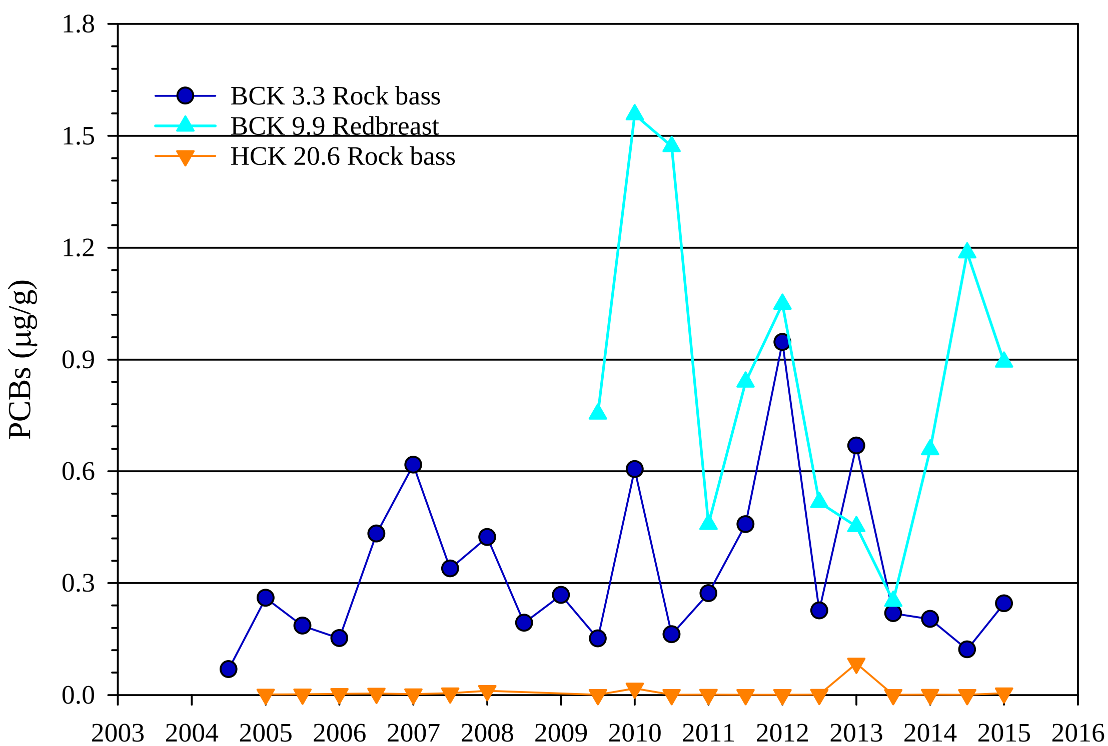


Figure 4.15. Mean concentrations of PCBs in rockbass from BCK 3.3, redbreast sunfish from BCK 9.9, and rockbass from the Hinds Creek reference site (HCK 20.6) 2004 – 2015.

Though there has been much variability over the years, concentrations of nickel, cadmium, and uranium in large-scale stonerollers have historically been highest in upper Bear Creek and have decreased with distance downstream (Figure 4.16, Figure 4.17, and Figure 4.18, respectively). In 2015, stonerollers were not found at the uppermost sampling site, and creek chub were collected instead. While creek chub are similarly sized and have similar life spans to stonerollers, the two species have different feeding habits, with creek chubs feeding on insects and stonerollers feeding on algae and detritus. The difference in feeding habits of these fish could explain the lower nickel and uranium concentrations seen at BCK 12.4 in 2015. Metal concentrations at the two downstream locations in Bear Creek were similar to those seen in recent years. For cadmium, uranium, and PCBs, concentrations in fish were substantially higher at sites in Bear Creek than at the reference site (Figure 4.17, Figure 4.18, and Figure 4.19).

PCB concentrations in large-scale stonerollers in FY 2015 averaged between 1.5 – 4.5 µg/g, continuing the long-term trend of elevated levels in fish (Figure 4.19). PCB levels in minnows collected from the uppermost site in Bear Creek (BCK 12.4) were historically measured, but since concentrations were relatively low, and the primary source of PCBs to the watershed was thought to originate from NT-7 near BCK 9.9, this sampling was discontinued in 2003. PCB concentrations in minnows collected from upper Bear Creek (BCK 9.9) have historically been higher than at the downstream site (BCK 3.3). While levels at BCK 9.9 have fluctuated considerably from year to year, long-term trends suggest that PCBs in fish from this site have been decreasing since a big spike in the 2004 timeframe. At BCK 3.3, fish concentrations similarly spiked in 2004, after which concentrations stabilized in the range of 2 µg/g PCBs.

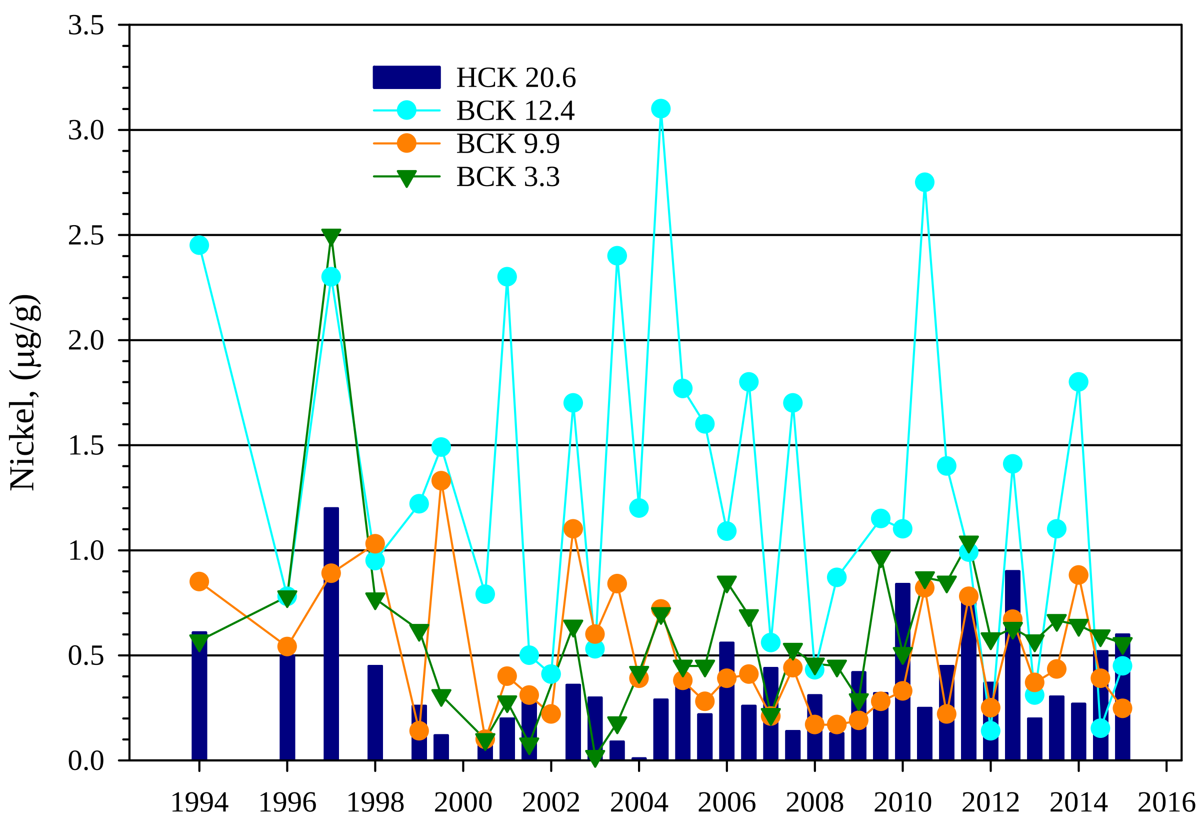


Figure 4.16. Mean nickel concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2015.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

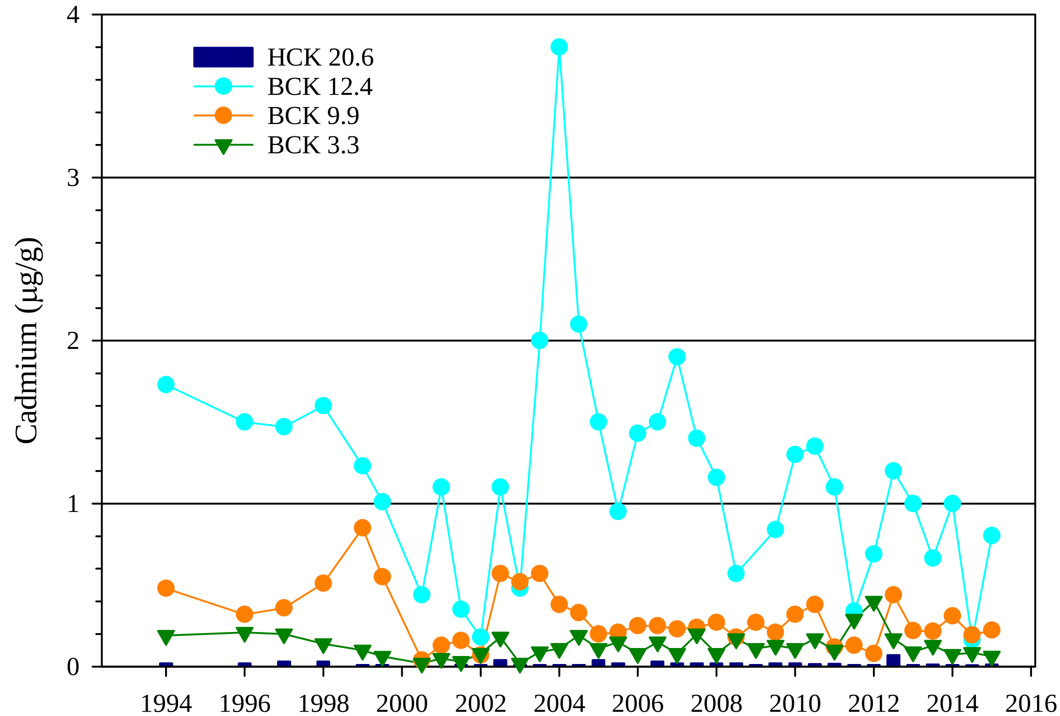


Figure 4.17. Mean cadmium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2015.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

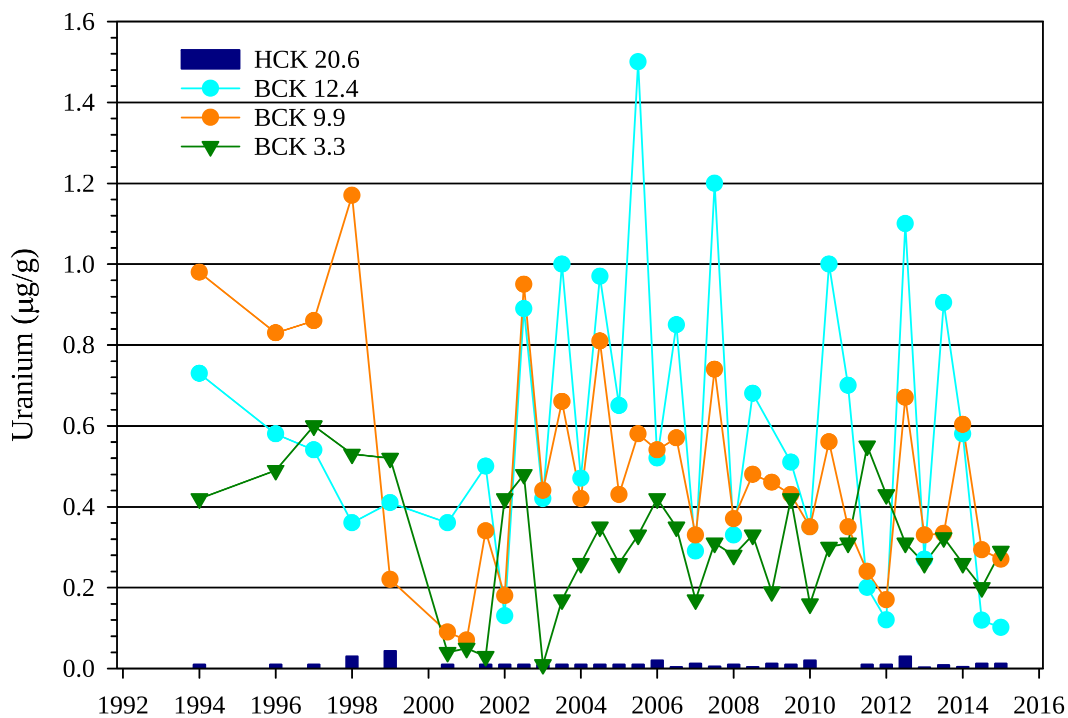


Figure 4.18. Mean uranium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2015.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

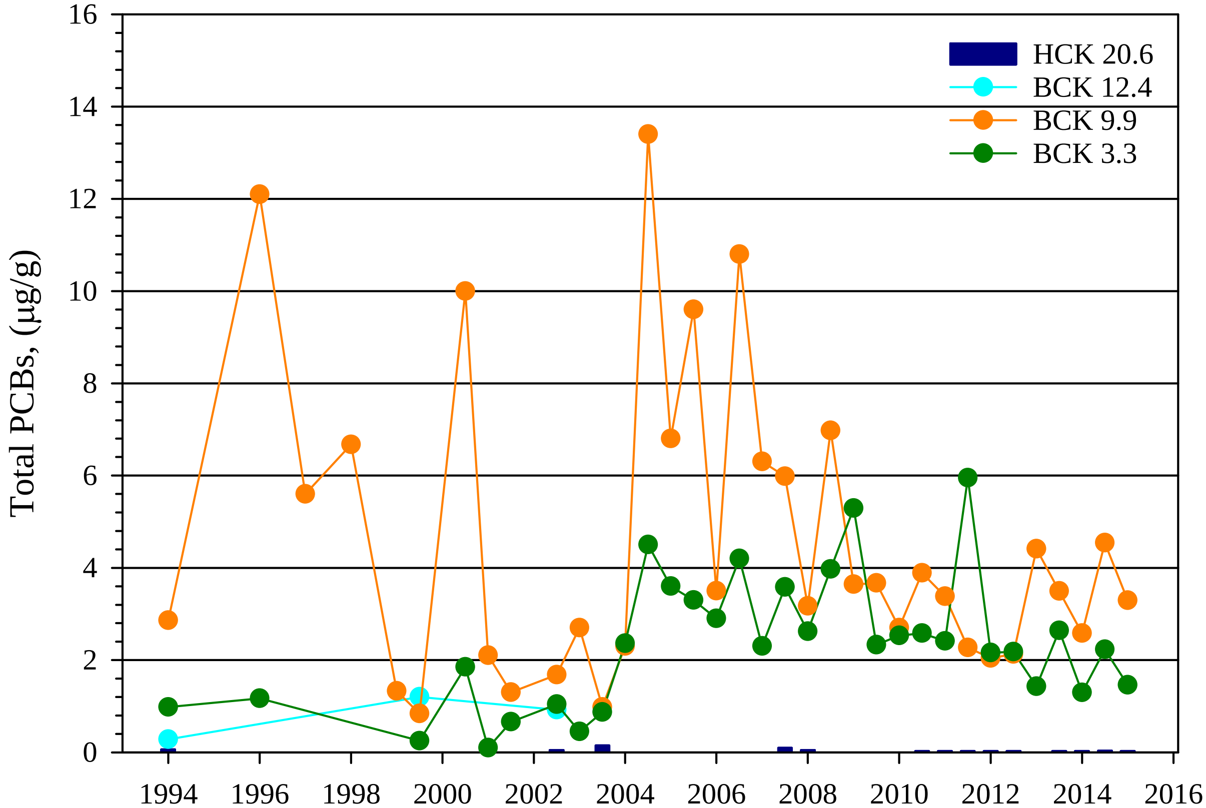


Figure 4.19. Mean PCB concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2015.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

The fish communities in Bear Creek have generally been stable with some annual variation in terms of species richness, including in 2011 and 2012 when species richness was several points higher than the historical average at the lowermost site (BCK 3.3). The downstream sites (BCK 3.3 and BCK 9.9) continue to have a lower number of species relative to a larger reference stream (BFK 7.6), but are similar to or higher than a smaller reference stream (MBK 1.6) (Figure 4.20). However, both lower Bear Creek sites were somewhat limited in sensitive species abundance in 2015 samples and continue to be dominated by more tolerant fish species. BCK 12.4 and NT-3 fish communities also continue to be below total richness values of comparable reference streams (MBK 1.6 and Pinhook Branch kilometer [PHK] 1.6), especially in terms of sensitive species, suggesting that they are more susceptible to stress (Figure 4.21). Previous studies have shown that during low rainfall months in late summer and fall, the upper Bear Creek sites receive a greater percentage of stream flow from contaminated groundwater, which likely contributes to measured stream toxicity (Peterson et al., 2000) and biota impairment. Both sites may also be affected by habitat limitations, especially a lack of pool depth during low flow periods. Once completed, recent stream mitigation efforts at BCK 12.4 have the potential to enhance these habitat limitations by creating a more balanced pool to riffle ratio and increasing the amount of available habitat by means of narrowing a previously channelized section of stream and restoring it to its original channel.

Upper Bear Creek (BCK 12.4) and NT-3 continue to support notably fewer pollution-intolerant benthic macroinvertebrate taxa than nearby reference streams, with the differences between these and the reference sites generally most pronounced during October sampling periods (Figure 4.22). However, a trend of moderate increase in the number of pollution intolerant taxa at NT-3 noted from 2012 through April 2014 appeared to persist through April 2015. Likewise, results for BCK 9.9 continue to suggest a

modest increase in the number of pollution intolerant taxa at that site as well. More favorable flows over longer periods from higher amounts of precipitation after 2007 may, in part, be contributing to apparent improvements at these sites. The condition of the macroinvertebrate community at the most downstream site on Bear Creek (BCK 3.3) continues to be comparable to reference conditions.

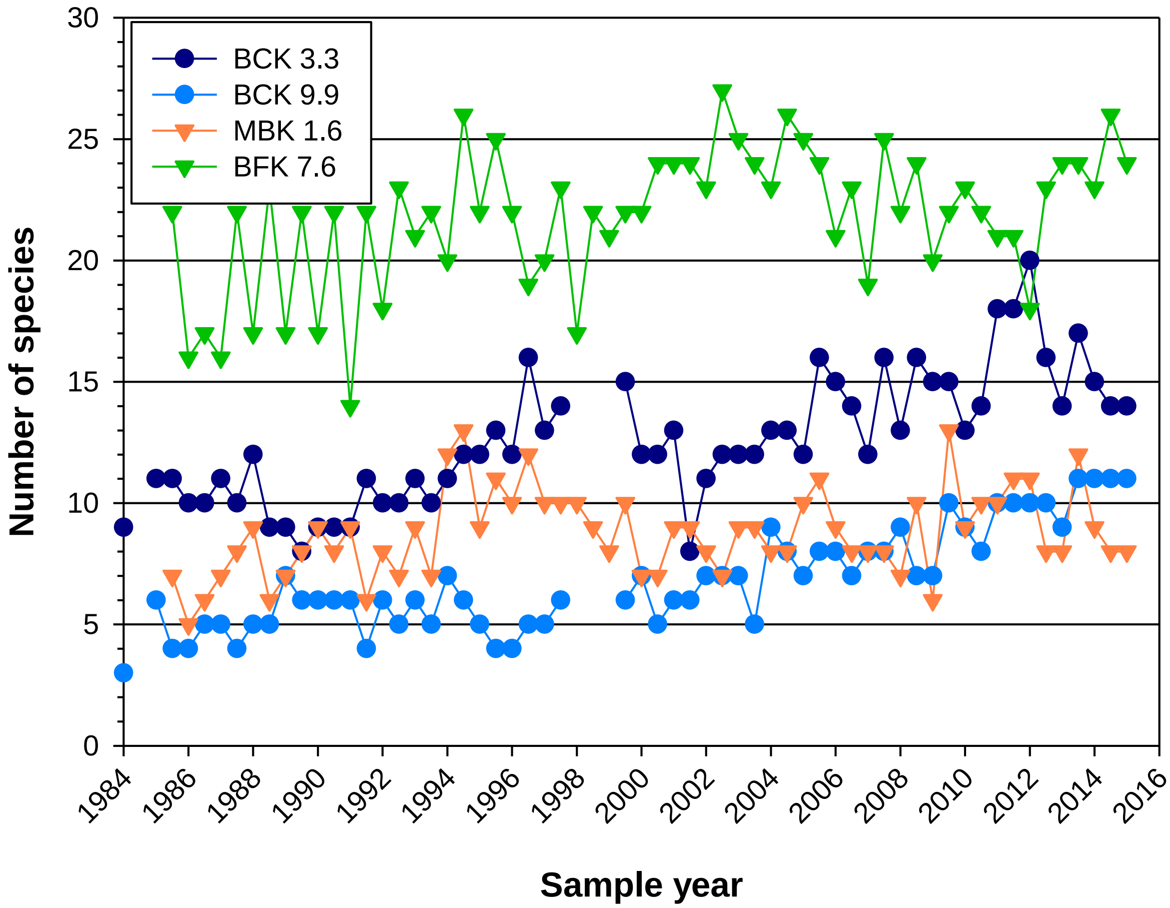


Figure 4.20. Species richness (number of species) in samples of the fish community in lower Bear Creek (BCK), and reference streams, Brushy Fork (BFK) and Mill Branch (MBK), 1984 – 2015.[a]

[a]Interruptions in data lines for BCK sites indicate no results available for those periods.

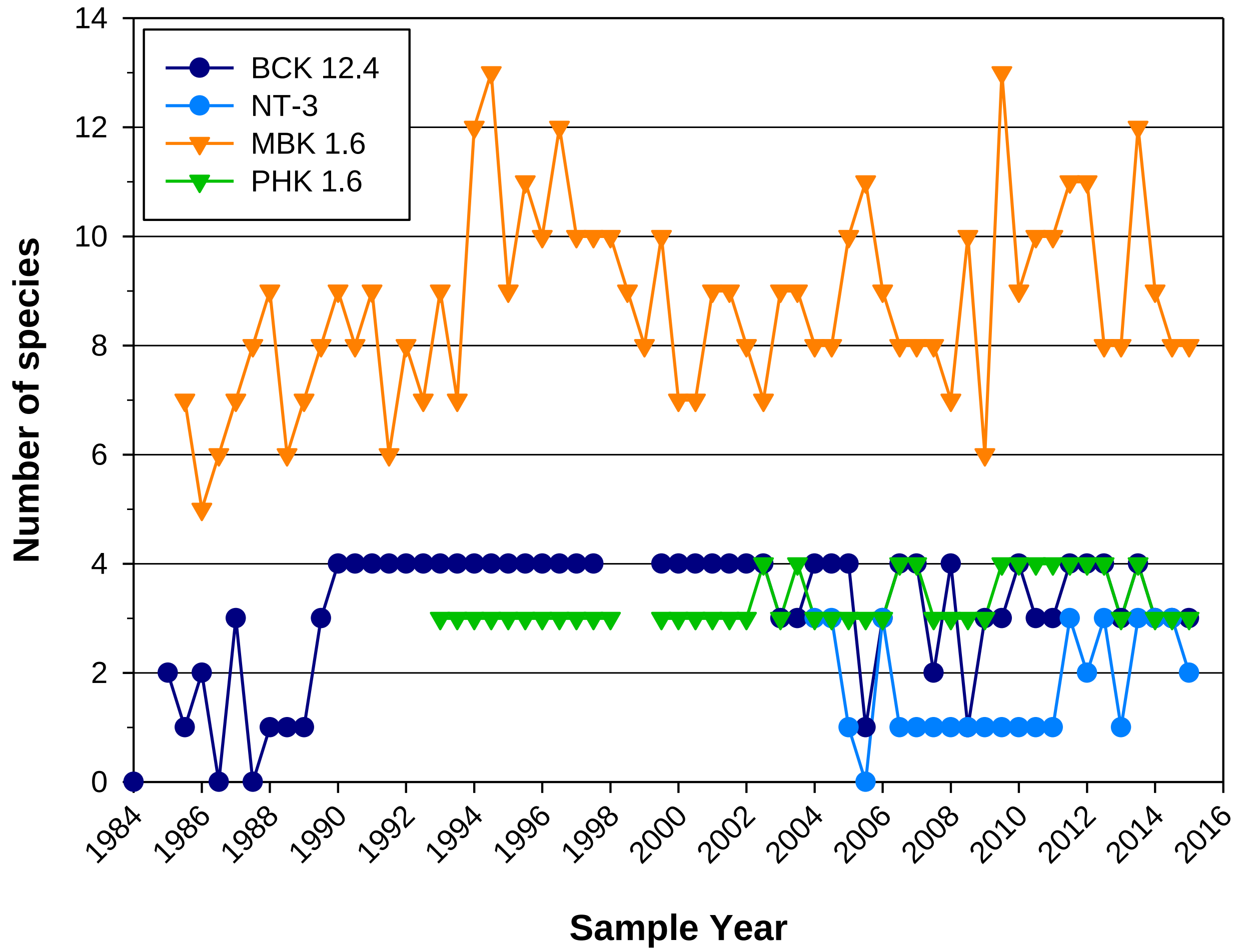


Figure 4.21. Species richness (number of species) in samples of the fish community in upper Bear Creek (BCK), NT-3, and two reference streams, Mill Branch (MBK) and Pinhook Branch (PHK), 1984 – 2015.[a]

[a]Interruptions in data lines for BCK sites indicate no results available for those periods.

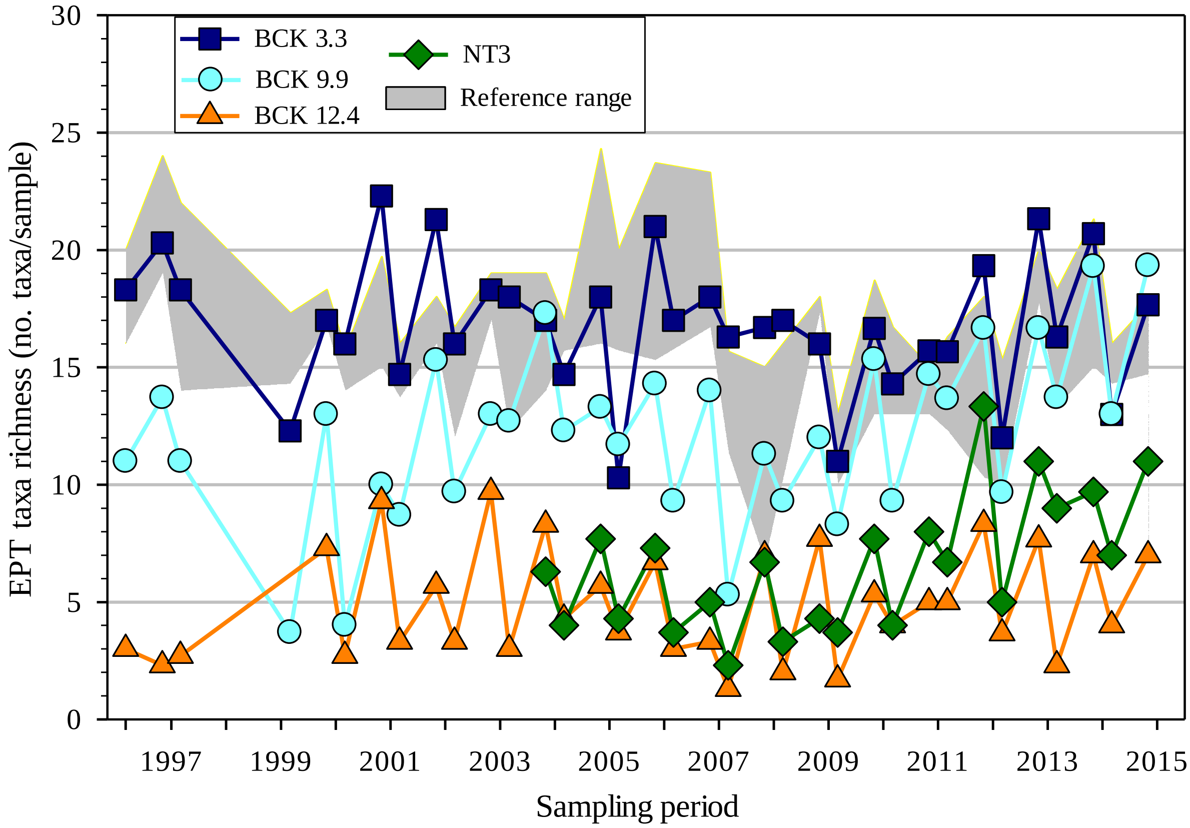


Figure 4.22. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in Bear Creek, NT-3, and range of mean values among reference streams (two sites in Gum Hollow Branch and one site in Mill Branch), for October and April sampling periods from 1996 – 2015 (FY 2015) beginning with October 1996.

Tick marks centered between April and October sampling periods for years after 1996.
NT-3 = North Tributary #3 to Bear Creek
EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

4.2.1.3 Performance Summary

Following is a summary of the FY 2015 BCV watershed performance monitoring:

- Surface water monitoring at the integration point (BCK 9.2) showed that the *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) goal of ≤34 kg/yr of uranium was not attained. The measured uranium flux at the integration point in FY 2015 was about 89 kg, which is 2.5 times the ROD goal. The FY 2015 integration point uranium flux decreased by about 8 kg compared to FY 2014 discharge and remained proportional to the total annual rainfall. An estimated one-third of the uranium flux is attributed to surface water discharged from the S-3 Ponds plume, and the remaining two-thirds originated in the BCBGs, inclusive of approximately 2.5% that originated from NT-3. The uranium mass balance estimate for the integration point monitoring at BCK 9.2 compared to the sum of upstream contributing stations was within 0.5% during FY 2015, which is considered an excellent mass balance considering the complex nature of surface water and shallow groundwater flow in the area.

- NT-8 near the BCBGs continues to be the largest contributor of uranium to Bear Creek having accounted for 51.2 kg of uranium during FY 2015. Implementation of an NT-8 Surface Water action

is a potential project identified in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Investigations and projects during groundwater strategy implementation will be sequenced according to ORR-wide groundwater issues prioritization.

- Nitrate concentrations meet applicable ROD criteria at the watershed integration point (BCK 9.2). Cadmium concentrations exceeded AWQC requirements at NT-1 and at the BCK 12.34 monitoring location near the S-3 Ponds contaminant source.

- The average nitrate concentration measured at BCK 12.34 near the S-3 Pond source area was less than the industrial risk-based concentration.

- In Zone 1, the western half of BCV, groundwater contaminant concentrations continue to remain low. However, there are uncertainties about groundwater contaminant levels and flow paths that have been identified in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2628/V1&V2&D2). Evaluation of potential pathways and installation of additional wells will be included in investigations during groundwater strategy implementation and will be sequenced according to ORR-wide groundwater issues prioritization. Evaluation of uranium isotope ratios in the Zone 1 springs and wells shows that spring SS-6 is unique in the area in that its uranium appears to originate from upstream of NT-8 while all the other Zone 1 locations show uranium isotopic signatures that reflect the influence of NT-8 discharges.

- Mean mercury concentrations in rockbass in lower Bear Creek (BCK 3.3) decreased from FY 2014, however remain elevated and are above human health guidelines, specifically, the EPA-recommended AWQC.

- Cadmium, uranium, and PCB concentrations in stoneroller minnows in 2015 continued the long-term trend of elevated levels in Bear Creek. For the first time, nickel concentrations in fish at all three Bear Creek sampling sites were below reference stream values.

4.2.2 Other LTS Requirements

Other LTS requirements for BCV watershed actions are listed in Table 4.12 and described below.

4.2.2.1 Requirements

Watershed-scale Requirements

LTS requirements outlined in the *Record of Decision for the Phase I Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) include LUCs to restrict groundwater and surface water use consistent with designated end use for each zone (Figure 4.2). Objectives of these LUCs include preventing unauthorized contact, removal, or excavation of buried waste in the BCV watershed; precluding residential or recreational use of Zone 3; and preventing unauthorized access to contaminated groundwater in the BCV watershed. The *Record of Decision for the Phase I Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) also states that DOE will maintain the BCV Phase I sites as controlled industrial areas and limit public access by posting signs and conducting security patrols. Table 4.12 lists the other LTS requirements for the BCV watershed as they are written in the *Record of Decision for the Phase I Activities in Bear Creek Valley* (DOE/OR/01-1750&D4).

- BYBY—The site will be inspected by the Y-12 S&M Program quarterly until the site is stabilized, then on a semiannual basis. Surveillance activities include inspection of capped areas for unwanted vegetation and erosion, and inspection of access controls to the site. Routine maintenance includes

mowing of the capped areas. Non-routine maintenance will be performed as necessary. There are no stewardship requirements specified for the Oil Landfarm Soil Containment Pad.

- S-3 Ponds Pathway 3—Access will be controlled and restricted. Once action is complete, inspection and maintenance of the passive *in situ* treatment system will be required.

- DARA—Access will be controlled and restricted.

Single-Project Scale Requirements

- BCV Operable Unit 2—Maintain the vegetative soil cover.

4.2.2.2 Status of Requirements

Status of Watershed-scale Requirements

LUCs in place in the BCV watershed were maintained throughout FY 2015 as part of the Y-12 S&M Program and in conjunction with Consolidated Nuclear Solutions, LLC (CNS).

Individual RAs under the *Record of Decision for the Phase I Activities in Bear Creek Valley* (DOE/OR/01-1750&D4) underwent routine site inspections conducted by the Y-12 S&M Program as follows:

- BYBY—All components of the site were inspected semiannually in FY 2015, including assessing the vegetative covers for erosion or subsidence; checking for blockage or erosion of the drainage control system; ensuring there are no construction activities and unauthorized materials within the area; evaluating that signs are not missing or damaged and contain correct contact information; ensuring access controls are in place and gates are locked; and ensuring the stability of the channel and banks of NT-3 from the Haul Road to the confluence with Bear Creek. No maintenance was required in FY 2015.

- S-3 Ponds Pathway 3 and DARA Solids Storage Facility—These RAs have not yet been implemented. Access control requirements were maintained in FY 2015 as part of general Y-12 plant controls and will be maintained until the actions are complete. These sites are not accessible to the public. Signs restricting access are in place and the areas are routinely patrolled by Y-12 security personnel.

Status of Single-Project Scale Requirements

Spoil Area 1 and the SY-200 Yard sites of the BCV Operable Unit 2 were inspected quarterly by the Y-12 S&M Program in FY 2015 for erosion of the cover, integrity of surface drainage, evidence of rodent damage, property signs, unlocked gates, and presence of unauthorized material in the area. Maintenance included replacing a broken sign at the SY-200 Yard. Both sites received routine mowing. For FY 2015, the deed restrictions for both areas were verified to be properly filed electronically at the Anderson County Register's of Deeds office via http://www.andersondeeds.com.

4.3 BCV ISSUES AND RECOMMENDATIONS

The issues and recommendations for the BCV watershed are in Table 4.13.

Table 4.12. Other LTS requirements for the BCV watershed

Other LTS requirements for the BCV Watershed and Specific Areas – Watershed-scale requirements			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/01-1750&D4)**			
BCV Watershed	Phase I ROD (DOE/OR/01-1750&D4)	• Surveillance and maintenance activities in BCV will be continued • Controlled industrial land use in Zone 3 and access restrictions in Zones 1 and 2 will be maintained • Prevent unauthorized contact, removal, or excavation of buried waste in the BCV • Preclude residential use in Zones 2 and 3 • Prevent unauthorized access to contaminated groundwater in BCV • Continue access restrictions for the S-3 disposal area • Maintain existing cap (BYBY and Hazardous Chemicals Disposal Area, Oil Landfarm, Sanitary Landfill-1) • Continued S&M of access controls and surface cover (Spoil Area 1 landfill, SY-200 Yard • Posted signs and security patrols of the areas outside the fenced Y-12 Plant boundaries (most areas under the ROD except S-3 site) • DOE will limit public access • Institutional controls in place at the BCBGs will be maintained until remediation decisions for the BCBGs are addressed in future CERCLA decisions • Continue compliant storage of DARA mixed waste until it can be disposed	• Following implementation of RAs, S&M of the site will be conducted under the Y-12 Plant sitewide S&M program • Monitoring and enforcement of use restrictions on groundwater and surface water will be conducted as part of the Y-12 Plant sitewide S&M and water quality programs pending the completion of future CERCLA decisions • A review will be conducted within five years after initiation of the RA to ensure that the remedy continues to provide adequate protection of human health and the environment
Other LTS requirements for Specific Areas			
Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/01-1750&D4)**			
BYBY	PCCR (DOE/OR/01-2077&D2)	• Surveillance activities include inspection of capped areas for unwanted vegetation and erosion and inspection of access controls to site • Routine maintenance includes mowing of capped areas • Non-routine maintenance performed as necessary • After vegetation has been established and the site has been stabilized, the metal cap will be removed from the culvert north of the Haul Road	• Inspect site quarterly until site is stabilized • Inspect site on semiannual basis once stabilized

Table 4.12. Other LTS requirements for the BCV watershed (cont.)

Other LTS requirements for the BCV Watershed and Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
***Record of Decision for Bear Creek Valley Operable Unit 2 (Spoil Area 1 and SY-200 Yard) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/02-1435&D2)**			
Spoil Area 1 and SY-200 Yard	BCV OU 2 ROD (DOE/OR/02-1435&D2)	• Institutional controls must be maintained indefinitely • Physical barriers (fences, gates, and signs) to limit access to the site • Deed restrictions to restrict construction at the sites and prohibit waste intrusion to mitigate direct exposure (primarily external exposure and inhalation of ^{226}Ra) • Restrictions will also require the incorporation of indoor radon mitigation measures in accordance with EPA guidelines for any future structure built on site	• Periodic physical surveillance of the soil cover and other features of the site and maintenance or repair, as required • A FYR will be conducted after completion of RA to ensure remedy continues to protect human health and the environment

BCBGs = Bear Creek Burial Grounds
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DARA = Disposal Area Remedial Action
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
FYR = Five-Year Review
LTS = long-term stewardship
OU = operable unit
PCCR = Phased Construction Completion Report
RA = remedial action
ROD = Record of Decision
S&M = surveillance and maintenance
Y-12 = Y-12 National Security Complex

Table 4.13. BCV watershed issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issue Carried Forward			
None			
Completed/Resolved Issues[b]			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

BCV = Bear Creek Valley
FY = fiscal year
RER = Remediation Effectiveness Report

4.4 REFERENCES

DOE/OR/01-1750&D4. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1836&D1/A1. *Removal Action Report for the Bear Creek Valley Interception Trenches for the S-3 Uranium Plume, Pathways 1 and 2 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1993, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2077&D2. *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2003, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2457&D2/A1. *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2505&D2. *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2628/V1&V2&D2. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, Volumes 1 and Volume 2,* 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Peterson, M. J., J. M. Loar, L. A., Kszos, M. G. Ryon, J. G. Smith. 2000. *Biomonitoring for environmental compliance at select DOE facilities: fifteen years of the Biomonitoring and Abatement Program*. Proceedings of the 25th Annual Conference of the National Association of Environmental Professionals. Overcoming Barriers to Environmental Improvement. National Association of Environmental Professionals publication.

TDEC 2007. State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 2007. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Approved March 2008.

TDEC 2010a. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

5. CHESTNUT RIDGE

5.1 INTRODUCTION AND STATUS

5.1.1 Introduction

Chestnut Ridge is not physically situated within one of the five established watersheds but is located south of Y-12 (Figure 5.1). An integrated Remedial Investigation/Feasibility Study (RI/FS) has not been conducted on Chestnut Ridge and decision processes for the several CERCLA units in the area to date have been single-action project decisions. Table 5.1 lists CERCLA actions on Chestnut Ridge and identifies those with monitoring or other LTS requirements. Figure 5.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Figure 5.2 shows interim controls requiring LTS.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions on Chestnut Ridge is provided in Chapter 9 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

5.1.2 Status Update

During FY 2015, no additional CERCLA actions were implemented or completed, nor were any associated FFA documents submitted or approved for CERCLA actions located on Chestnut Ridge. Monitoring in support of performance assessments and evaluations continued.

5.2 UNITED NUCLEAR CORPORATION DISPOSAL SITE

5.2.1 Performance Monitoring

5.2.1.1 Performance Monitoring Goals and Objectives

The United Nuclear Corporation (UNC) Disposal Site is a 1.3 acre landfill located near the crest of Chestnut Ridge south of Y-12 (Figure 5.1 and Figure 5.3). The *Record of Decision United Nuclear Corporation Disposal Site Declaration* (DOE 1991) was approved in June 1991. Field activities began in May 1992 and were completed in August 1992. Remedial activities included a multilayer cover system, access controls, and groundwater monitoring using existing wells.

This waste disposal facility utilized an unlined excavation in the thick soils near the crest of Chestnut Ridge for retention of approximately 11,000 55 gal drums of cement-fixed sludge, 18,000 drums of contaminated soil, and 288 wooden boxes of contaminated building and process equipment demolition debris from the UNC Disposal Site uranium recovery facility in Wood River Junction, Rhode Island. In addition, Formerly Utilized Sites RA Program waste from the Elza Gate site in Oak Ridge was placed in the site before the final multilayer cap was constructed to limit percolation of rainwater into the waste.

Table 5.1. CERCLA actions in Chestnut Ridge

CERCLA action	Decision document and date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required
Single-project actions			
UNC Disposal Site	ROD: 06/28/91	PCR (DOE/OR/01-1128&D1) approved 09/06/94	Yes/Yes
KHQ	NFA ROD[b] (DOE/OR/02-1398&D2): 09/29/95	RA completed under approved RCRA closure plan	Yes/Yes
FCAP/Upper McCoy Branch	ROD (DOE/OR/02-1410&D3): 02/21/96	RAR (DOE/OR/01-1596&D1) approved 06/03/97	Yes/Yes

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]*Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant* (DOE/OR/02-1398&D2) defers all LTS requirements to the RCRA post-closure permits.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
FCAP = Filled Coal Ash Pond
KHQ = Kerr Hollow Quarry
LTS = long-term stewardship
NFA = No Further Action
PCR = Post-Completion Report
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
UNC = United Nuclear Corporation

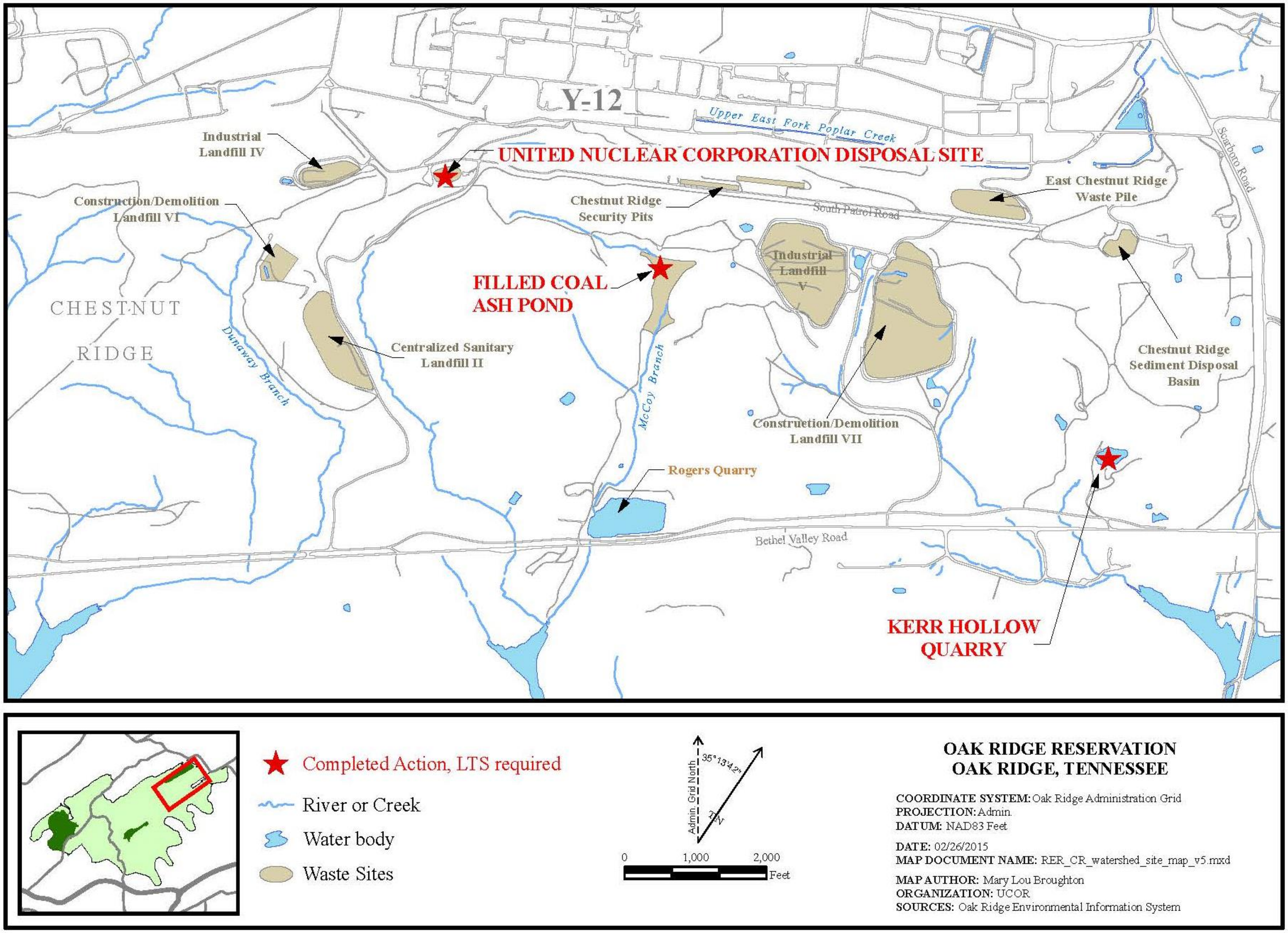


Figure 5.1. CERCLA actions on Chestnut Ridge.

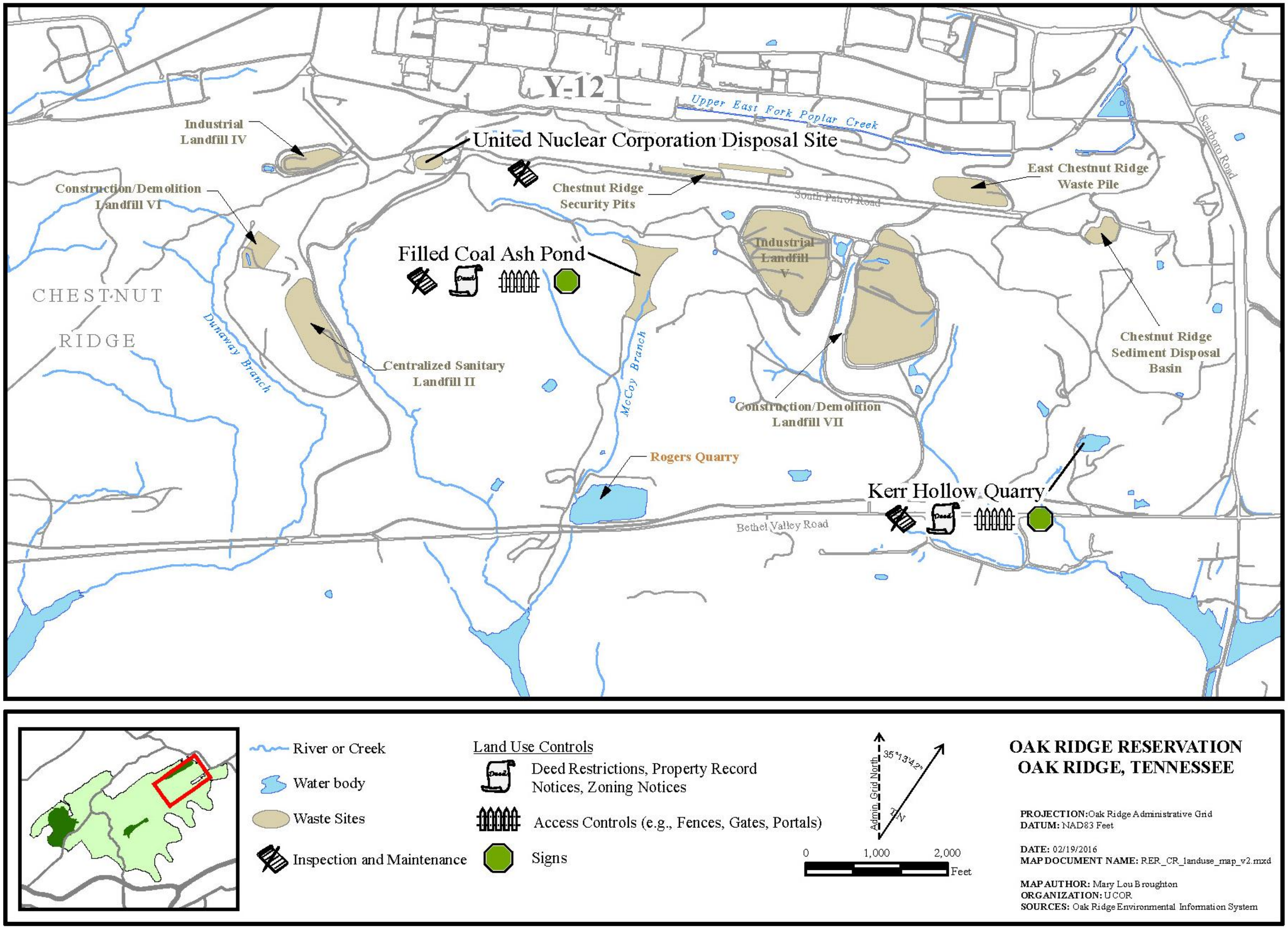


Figure 5.2. Chestnut Ridge interim controls requiring LTS.

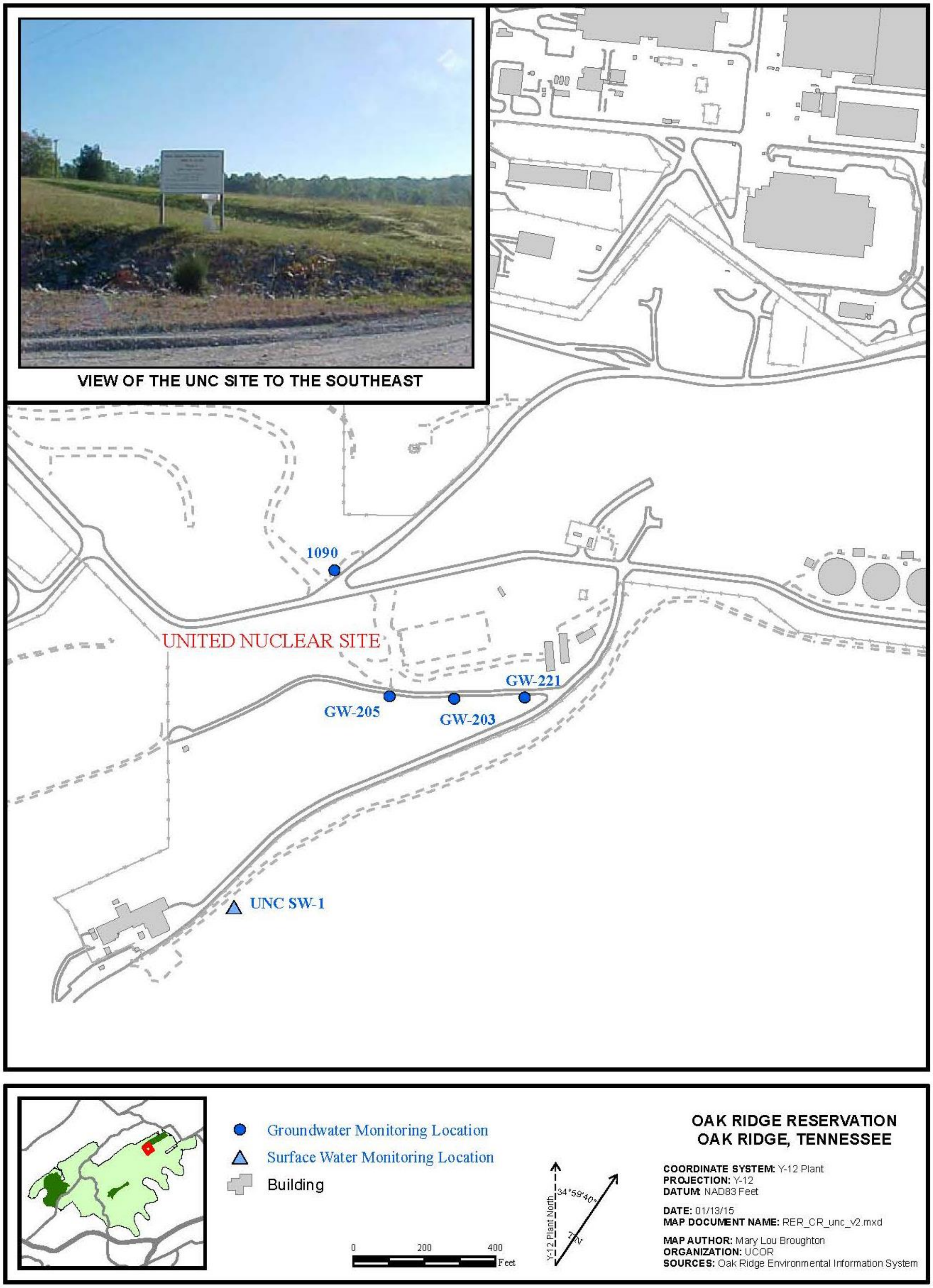


Figure 5.3. UNC Disposal Site.

The major goal of the UNC Disposal Site RA (DOE 1991) is to "ensure that mobile contaminants in the UNC waste, principally nitrate and ^{90}Sr, are not leached to groundwater at a rate that would result in concentrations of these contaminants above safe drinking water standards." The *Feasibility Study for the United Nuclear Corporation Disposal Site* (ES/ER-15&D1) included results of contaminant transport modeling that indicated possible impacts to groundwater including potential nitrate concentrations of as much as 193 mg/L and ^{90}Sr concentrations as great as about 50 pCi/L. The expected performance of the remedy in the *Record of Decision United Nuclear Corporation Disposal Site Declaration* (DOE 1991) is to control contaminant migration so that nitrate is less than the MCL of 10 mg/L and no more than 2 pCi/L of ^{90}Sr will occur in groundwater, which is within the CERCLA ELCR risk range of 10^{-4} to 10^{-6}. Further, the groundwater concentration "is not expected to exceed 8 mg/L for nitrate." The *Post-Construction Report for the United Nuclear Corporation Disposal Site* (DOE/OR/01-1128&D1) specifies implementation of a groundwater monitoring program. Although specific frequencies, locations, and analytes are not mandated by the *Post-Construction Report for the United Nuclear Corporation Disposal Site* (DOE/OR/01-1128&D1), groundwater is monitored for contaminants of concern (nitrate and ^{90}Sr) on which performance assessment is based.

5.2.1.2 Evaluation of Performance Monitoring Data

Monitoring at the UNC site consists of semiannual sampling at one upgradient well (well 1090) and three downgradient wells (GW-203, GW-205, and GW-221) and one downgradient surface water location (UNC SW-1) shown on Figure 5.3 Samples were analyzed for metals, nitrate, gross alpha and beta activity, and ^{90}Sr. Additional isotopic analyses were conducted on samples collected from well GW-205 as noted below. Data for nitrate, gross alpha and beta activity, and ^{90}Sr analyses for all wells are provided in Table 5.2. Potassium-40 was analyzed in well GW-205 and the UNC SW-1 (Table 5.2).

In FY 2015, nitrate concentrations downgradient of the site have remained well below the 10 mg/L SDWA MCL and the "not expected to exceed range" of 8 mg/L. Nitrate concentrations in well GW-203 were comparable to those measured in the upgradient well during the July sampling event but were lower in the March sampling event. Nitrate concentrations in the other downgradient wells were below the concentrations in the upgradient well. In FY 2015, ^{90}Sr was detected in well 1090, the designated upgradient well, in the July sampling event.

Gross alpha activity was detected in wells 1090, GW-203, and GW-205 at levels less than 2 pCi/L in the March 2015 sampling event and in well GW-205 only during the September 2015 sampling event. All of the FY 2015 alpha activity detections were well below the MCL of 15 pCi/L. Gross beta activity was measureable in all three downgradient monitoring wells at some time during FY 2015. The highest measured beta activity levels were observed in well GW-205 which has historically shown the highest beta emitting radiological contaminant levels. The beta activity levels measured in well GW-205 were less than 8 pCi/L, which remains well below the 50 pCi/L screening level.

The history of monitoring at well GW-205 started in 1987. In 1998 the well purge method was changed from a standard three-well-volume method to low-flow purging. Contemporaneous with that change, pH, conductivity, beta activity and potassium concentrations increased, possibly an indication of grout or other alkaline material influence on local groundwater. Prior to the sampling method change, the pH ranged between 7.5 and 8.5 and, following the method change, the pH ranged between 9.5 and 10.5. The well was aggressively redeveloped in autumn 2010, after which pH levels in the well decreased. During FY 2015, the pH at well GW-205 was 8.31 in March (Quarter 2) and 9.33 in July (Quarter 4), which is within the observed range of fluctuation since well redevelopment.

Table 5.2. Analytical results for performance indicator constituents at the UNC Disposal Site, FY 2015

Date	Upgradient well	Downgradient wells			Downgradient spring
	1090	GW-203	GW-205	GW-221	UNC SW-1
			Nitrate (mg/L)		
Q2-15	0.84	0.59	0.28	0.56	0.21
Q4-15	0.84	0.93	0.27	0.5	0.074
			Gross alpha (pCi/L)		
Q2-15	1.35	1.66	1.8	<1.65 U	<2.11 U
Q4-15	<2.88 U	<2.57 U	1.84	<2.26 U	<2.77 U
			Gross beta (pCi/L)		
Q2-15	<4.14 U	<2.58 U	4.19±1.4	2.21	1.54
Q4-15	<2.48 U	1.78	7.65±1.78	1.81	<3.04 U
			^{90}Sr (pCi/L)		
Q2-15	<0.572 U	<0.617 U	<0.731 U	<0.641 U	<0.731 U
Q4-15	0.741	<0.642 U	<0.632 U	0.459 J	<0.683 U
			^{40}K (pCi/L)		
Q2-15	-	-	<203 U	-	<176 U
Q4-15	-	-	-	-	<166 U

Bold value indicates gross alpha above the SDWA MCL (15 pCi/L) or gross beta above the 50 pCi/L screening level used to trigger analyses to determine beta emitting radionuclides present in public water supplies (65 FR 76708 – 76753).

FR = Federal Register
FY = fiscal year
GW = groundwater well
J = estimated value
MCL = maximum contaminant level
SDWA = Safe Drinking Water Act
U = not detected or result less than minimum detectable activity
UNC = United Nuclear Corporation

Table 5.3 presents the ^{90}Sr analytical results for the four monitoring wells at the UNC Disposal Site. Strontium-90 has been detected sporadically at low concentrations in groundwater adjacent to the UNC Disposal Site. The FY 2006 17.8 pCi/L result from well GW-205 exceeded the SDWA MCL-DC of 8 pCi/L but was below the *Feasibility Study for the United Nuclear Corporation Disposal Site* (ES/ER-15&D1) estimate of a maximum groundwater ^{90}Sr concentration of 50 pCi/L. Lower detection limits in FY 2015 allowed a single, low level detection (<1 pCi/L) of ^{90}Sr at upgradient well 1090.

During FY 2015, surface water was sampled at the nearest downgradient spring location (UNC SW-1) to determine if site related contaminants affect surface water. Analytical results indicate that nitrate levels are below drinking water criteria and are lower than results from site monitoring wells. The only radiological parameter detected at UNC SW-1 was a low level of beta activity (1.54 pCi/L) which was detected in the March 2015 sample.

5.2.1.3 Performance Summary

Gross beta activity continues to be higher in downgradient well GW-205 than in the other UNC monitoring locations, although levels have decreased significantly since the well was redeveloped in 2010. The gross beta activity is attributed predominantly to the presence of potassium containing a natural radioactive ^{40}K component. Strontium-90 has been detected intermittently in the well but was not detected in FY 2015. Lower detection limits in FY 2015 allowed detection of ^{90}Sr at a very low level (<1 pCi/L) in

upgradient well 1090. The downgradient spring (UNC SW-1) exhibits data that demonstrate a lack of impact from the UNC site on the nearest groundwater discharge to surface water.

Table 5.3. UNC Disposal Site groundwater ^{90}Sr results[a]

Sample date	1090	GW-203	GW-205	GW-221
Feb-99	<1.4 U	0.82 J	<1.54 U	1.16 J
Aug-99	<1.48 U	<1.67 U	<1.47 U	<1.68 U
Feb-00	<3.15 U	<3.14 U	<3.34 U	<3.25 U
Aug-00	2.22 J	<1.73 U	<4.33 U	<2.08 U
Jan-01	<1.7 U	<1.8 U	0.53 J	0.15 J
Jul-01	0.5 J	<2.39 U	<1.47 U	0.23 J
Jan-02	0.16 J	<1.56 U	0.51 J	0.6 J
Jul-02	<1.92 U	1.28 J	<1.91 U	<1.46 U
Feb-03	<1.57 U	<1.39 U	<1.64 U	<1.59 U
Aug-03	1.39 J	<1.37 U	<1.44 U	1.3 J
Feb-04	0.73 J	<0.99 U	<0.97 U	<1.04 U
Aug-04	<1.06 U	0.65 J	<0.96 U	0.73 J
Feb-05	0.61 J	<1.05 U	<1.18 U	<1.04 U
Jul-05	<1 U	<0.96 U	<1.76 U	<1 U
Mar-06	<1.03 U	<1.36 U	<1.41 U	<1.13 U
Jul-06	1.21 J	1.34 J	**17.8**	2.83
Jan-07	<0.407 U	<0.437 U	<0.433 U	<0.443 U
Jul-07	<0.617 U	<0.613 U	<0.184 U	<0.518 U
Mar-08	<1.72 U	<2.11 U	<1.84 U	2.49 ± 1.11
Aug-08	<-1.89 U	<2.04 U	<2.12 U	<2.08 U
Mar-09	<1.54 U	<1.92 U	<1.61 U	<1.61 U
Jul/Aug-09	<-1.84 U	<1.93 U	<2.3 U	<2.16 U
Jan/Feb-10	<1.19 U	<1.75 U	<1.93 U	<1.97 U
Aug-10	<1.84 U	<2.45 U	<2.42 U	<2.36 U
Mar-11	<2.3 U	<1.92 U	<1.88 U	<1.99 U
Aug-11	<1.88 U	<1.89 U	3.06 ±0.941	2.34 ± 0.872
Feb-12	<2.17 U	<2.05 U	<2.02 U	<2.13 U
Aug-12	<2.16 U	<2.26 U	7.1	<2.39 U
Feb/Mar-13	<1.92 U	<2.05 U	<1.98 U	<2.15 U
Jul-13	<2.12 U	<2.33 U	<2.16 U	<2.13 U
Feb/Mar-14	<2.24 U	<2.38 U	<2.12 U	<1.83 U
Aug/Sep-14	<1.58 U	<2.14 U	<2.14 U	<2.05 U
Mar-15	<0.572 U	<0.617 U	<0.731 U	<0.641 U
Jul-15	0.741±0.34	<0.642 U	<0.642 U	0.459 J

[a]All values pCi/L.

Bold value ^{90}Sr exceeds the 8 pCi/L MCL-DC.

GW = groundwater well
J = estimated value
MCL-DC = maximum contaminant level derived concentration
U = reported concentration was below the minimum detectable activity
UNC = United Nuclear Corporation

5.2.2 Other LTS Requirements

Other LTS requirements for Chestnut Ridge are listed in Table 5.4 and described below.

5.2.2.1 Requirements

The *Post-Construction Report for the United Nuclear Corporation Disposal Site* (DOE/OR/01-1128&D1) requires that surveillance activities continue for 30 years from completion of remediation to ensure that the cap adequately contains the waste in the site. Specific requirements include a visual inspection of the cap be conducted quarterly for the first two years after construction, and semiannually thereafter. If necessary, restorative measures will be implemented. Minor deficiencies such as damaged drains or signs will be noted on the inspection forms and corrected. However, major deficiencies such as the collapse of the cap or major erosion problems will be reported. Required routine maintenance includes mowing and replacement of any topsoil and vegetation, as required.

5.2.2.2 Status of Requirements

All components of the UNC Disposal Site were inspected semiannually in FY 2015 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. No maintenance of the site was required in FY 2015 except routine mowing. Additionally, the UNC Disposal Site is located within the Y-12 property protection area and, as such, is not accessible to the public. The area is routinely patrolled by Y-12 security personnel.

5.2.3 UNC Site Issues and Recommendations

There are no issues or recommendations.

Table 5.4. Other LTS Requirements for Chestnut Ridge

Other LTS requirements for Completed Actions in Chestnut Ridge[a]			
Specific Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
UNC Disposal Site	PCR (DOE/OR/01-1128&D1)	• Site inspections will continue for a period of 30 years following this RA to ensure that the cap is adequately containing the wastes in the site • Routine maintenance will include mowing of the site and the replacement of any topsoil and vegetation that may have been washed from the site	• Inspect site quarterly during the first two years • Inspect site on semiannual basis after first two years
KHQ	ROD (DOE/OR/02-1398&D2)[b] PCP (TNHW-128)[c]	• Regular inspection and maintenance include the site-security fence, survey benchmarks, and the groundwater monitoring wells • Submit notice to local zoning authority with record of the type, location, and quantity of hazardous wastes disposed • Record a notice in the deed/survey plat	• Inspect site quarterly throughout the post-closure care period • The status of the site under CERCLA will be reviewed every five years • The status of the site will be reviewed as part of the RCRA post-closure permit process at least every 10 years
FCAP	RAR (DOE/OR/01-1596&D1)	• Routine inspections will verify the establishment and health of the wetland plants • Deed restrictions per the ROD filed at the Anderson County courthouse • Ash pond and dam are isolated from the public through ORR institutional controls. The site is restricted by fencing and bar gates. • Site is located in the "No Hunting Safety/Security Zone" between the Y-12 Plant and Bethel Valley Road • Signs placed at bar gate and around pond indicate that this area is restricted and that permission is required before beginning any excavation or construction activities at the site • Adequate inspections and maintenance of the dam, spillway channel, adjacent slopes, settling basin, and wetlands • Inspector will look for evidence of erosion, such as rill or gully development, and slope instability at the dam and adjacent areas. Also check general condition of the vegetative cover on the dam, looking for dead spots, excessive weed growth, or invasion of unwanted species. • The emergency spillway and any drainage control structures will be inspected as part of the general facility inspection. The spillway inlet and outlet, as well as the main channel, will be inspected for blockage, settlement, ponding, unwanted vegetation, erosion, damage to the revetment mattress, and other visible factors that could affect performance. The underdrain and settling basin located at the toe of the dam will be inspected for any blockage or impediment to flow. In addition, the settling basin will	• Inspections conducted quarterly throughout post-remediation care period • Dam and spillway will also be inspected following any rainfall event equivalent to a 25 y, 24 h intensity

Table 5.4. Other LTS Requirements for Chestnut Ridge (cont.)

Other LTS requirements for Completed Actions in Chestnut Ridge[a]			
Specific Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
		be inspected for excessive sediment accumulation. The wetlands located down gradient of the settling basin will be monitored for viability of vegetation, and plants will be checked for stability and growth. • The permanent benchmarks will be inspected to determine if they have been damaged. Also, to prevent unauthorized access to the site, the inspector will ensure that the gate at the entrance to the facility is locked and in good condition and that signs restricting unauthorized access are legible and in good condition. During each quarterly inspection, the inspector will also note any evidence of unauthorized access and the need for additional security measures. • Following each inspection, the inspector will complete an inspection checklist, noting any items that require maintenance or repair. Inspection records will be maintained for a minimum of three years from the date of inspection. • Site maintenance will include repair of any damage observed during the site inspection. Any erosion damage will be repaired by restoring the area to its original grade and replacing cover material. Excessive sediment accumulation in the settling basin will be removed, characterized for potential contaminants of concern, and disposed of accordingly. Any blockage or impediment to proper drainage will be removed or repaired. Wetland vegetation will be replaced or replenished, and, if feasible, hydraulic characteristics will be adjusted as necessary to maintain the viability of the wetlands.	

[a] LTS for specific areas is determined by each remediation project and listed in the project specific completion report.
[b] *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant* (DOE/OR/02-1398&D2) defers all LTS requirements to the RCRA post-closure permits.
[c] *Post-Closure Permit Chestnut Ridge Hydrogeologic Regime U.S. Department of Energy, Y-12 National Security Complex Oak Ridge, Tennessee* (TNHW-128).

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980
FCAP = Filled Coal Ash Pond
KHQ = Kerr Hollow Quarry
LTS = long-term stewardship
ORR = Oak Ridge Reservation
PCP = Post-Closure Permit
PCR = Post-Completion Report
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
ROD = Record of Decision
UNC = United Nuclear Corporation
Y-12 = Y-12 National Security Complex

5.3 KERR HOLLOW QUARRY

5.3.1 Performance Monitoring

5.3.1.1 Performance Monitoring Goals and Objectives

The *Record of Decision for Kerr Hollow Quarry* (DOE/OR/02-1398&D2) (Figure 5.1 and Figure 5.4) presents the decision for No Further Action (NFA) at the site, deferring all monitoring, reporting, and maintenance requirements to the *Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime* (TNHW-088), as modified. Because the RCRA closure left contaminated material in place, the permit requires monitoring of groundwater. RCRA-required monitoring is described in this section. The *Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TNHW-088) was reissued in September 2006 (TNHW-128), changing monitoring requirements from semiannual to annual beginning in January 2007.

The objective of the RCRA closure was to prevent physical exposure to contaminants within the quarry and mitigate migration of contaminants to groundwater or surface water runoff. The RCRA closure was deemed protective of human health and the environment under CERCLA, resulting in the NFA *Record of Decision for Kerr Hollow Quarry* (DOE/OR/02-1398&D2). The *RCRA Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TNHW-128) specifies annual detection monitoring, alternating between seasonally high and low flow conditions, to identify any potential future releases to groundwater. Statistical analysis for groundwater target list compounds is conducted for each annual sampling event. The statistical procedure included in the RCRA PCP involves three steps: (1) comparison to a background value (e.g., a calculated upper tolerance limit), (2) trend analysis (Kendall-Tau method or equivalent) if the background value is exceeded, and (3) verification sampling if the results fail the trend analysis. If statistically significant contamination is detected in groundwater while conducting monitoring in accordance with the permit, notification is provided in accordance with the terms of the permit and any necessary remediation will be addressed under CERCLA.

The *Record of Decision for Kerr Hollow Quarry* (DOE/OR/02-1398&D2) states that monitoring of the surface water discharge point (Outfall 301) from the quarry will be performed as a best management practice. Because the outfall was typically dry, the DOE obtained approval to discontinue monitoring of Outfall 301 at the quarry in 2002.

5.3.1.2 Evaluation of Performance Monitoring Data

During calendar year (CY) 2014, annual groundwater monitoring conducted in upgradient/background well GW-231 and in downgradient/POC wells GW-143, GW-144, and GW-145 (Figure 5.4) for metals, VOCs, gross alpha, and gross beta, resulted in a confirmed detection of carbon tetrachloride in POC well GW-144 (1.3 µg/L). Verification sampling in the following month yielded a slightly higher concentration of carbon tetrachloride (3.6 µg/L) than evident in July. After allowing sufficient time for full recovery of the water level in well GW-144, confirmation sampling and analysis in accordance with the Chestnut Ridge PCP was conducted in September. Results showed detection of carbon tetrachloride at a concentration of 1.18 µg/L. Validation of the official laboratory report was completed in October and the required seven day notification was sent to the Division of Solid Waste Management of the TDEC. In November 2014, TDEC accepted the proposed additional monitoring at Kerr Hollow Quarry (KHQ) to address the detection of carbon tetrachloride in POC well GW-144 during the previous July, August, and September. The additional monitoring includes increasing the sampling frequency to semiannually for well GW-144 and adding semiannual sampling for downgradient surface-water exit pathway location

S17. This additional monitoring will continue until four consecutive non-detect samples are obtained from well GW-144.

Groundwater sampling for CY 2015 annual RCRA post-closure detection monitoring at KHQ was performed in January 2015. The analytical results for the groundwater samples show concentrations of RCRA target list constituents below site-specific background levels for all of the designated downgradient wells at the site. Annual sampling/analysis of surface water from an established monitoring station (S17) located downstream of the overflow outlet for KHQ was also initiated in January in response to the RCRA post-closure detection monitoring results from CY 2014 that confirmed detection of carbon tetrachloride in the groundwater from POC well GW-144. Carbon tetrachloride was not detected in either the surface water sample collected at station S17 or the groundwater sample collected from well GW-144.

Semiannual RCRA post-closure detection monitoring at KHQ was performed during July 2015 and involved sampling the groundwater from POC well GW-144 and surface water from station S17 located downstream of the overflow outlet for KHQ. Laboratory analysis of the samples was for the target list of VOCs included in the Chestnut Ridge PCP. No VOCs were detected in samples collected from these locations in January 2015; however, as shown below in Table 5.5, a trace of carbon tetrachloride was detected in the July 2015 sample from POC well GW-144.

Table 5.5. Results of July 2015 detection monitoring at KHQ

Monitoring Location	Sampling Date	Target Compound Concentration (µg/L)		
		Carbon Tetrachloride	Chloroform	Tetrachloroethene
GW-144	07/07/15	1.1	1 U	1 U
S17	07/07/15	1 U	1 U	1 U

KHQ = Kerr Hollow Quarry
GW = groundwater well
U = Not detected at the concentration shown

Semiannual monitoring for VOCs at each location will continue until four consecutive RCRA sampling/analysis events show non-detected results for carbon tetrachloride in POC well GW-144.

Previous groundwater sampling and analysis results from nearly 30 years of uninterrupted RCRA interim status detection monitoring and RCRA post-closure detection monitoring at KHQ show that carbon tetrachloride was detected in 23 of the groundwater samples collected from well GW-144 before July 2015. Sixteen of the detected carbon tetrachloride results, including the historical maximum concentration (6 µg/L in September 1990), were reported for groundwater samples collected during the early and mid-1990s. Sporadic detection of carbon tetrachloride in the groundwater collected from well GW-144 over such an extended period suggests a continued low-level source at KHQ, presumably the dissolution of carbon tetrachloride present in the wastes that remain in the quarry and/or residual in the fractured bedrock or sediment on the quarry floor. The persistent long-term presence of carbon tetrachloride suggests minimal biodegradation in the groundwater and reflects the very slow advective groundwater transport possible under the nearly flat horizontal hydraulic gradient indicated by static water-level elevations in the wells at KHQ.

5.3.1.3 Performance Summary

The July 2015 result for RCRA POC well GW-144 shows the carbon tetrachloride concentration just slightly above the detection limit and similar to levels sporadically detected in previous groundwater

samples from the well. This continues to represent a long-term decreasing trend of carbon tetrachloride at the KHQ. The changes implemented by the DOE and UCOR, Operator and Co-operator of the KHQ, respectively, to increase monitoring of GW-144 and the downgradient exit pathway surface water location S17 to semiannually will be continued until four consecutive non-detect results are obtained in samples obtained from well GW-144.

5.3.2 Other LTS Requirements

5.3.2.1 Requirements

The *Record of Decision for Kerr Hollow Quarry* (DOE/OR/02-1398&D2) does not specify any requirements; however, the *RCRA Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TNHW-128) requires that all security components, signage, survey benchmarks, and monitoring systems at KHQ be inspected quarterly throughout the post-closure care period of 30 years. Final closure certification for the site was February 22, 1995. As a RCRA closure, deed restrictions were required to be filed at the County Register of Deeds Office.

5.3.2.2 Status of Requirements

KHQ was inspected quarterly in FY 2015 by the Y-12 S&M Program for proper signage, integrity of benchmarks and monitoring wells including downhole condition, condition of the fences, gates, and locks, and condition of the access road. Maintenance in FY 2015 included routine mowing, and removing a downed tree across the upper road.

Additionally, the KHQ is located outside the Y-12 property protection area; therefore, separate security fencing and signs exist at the site. The KHQ deed restrictions were filed on April 28, 1994, at the Anderson County Register of Deeds Office and remain in place.

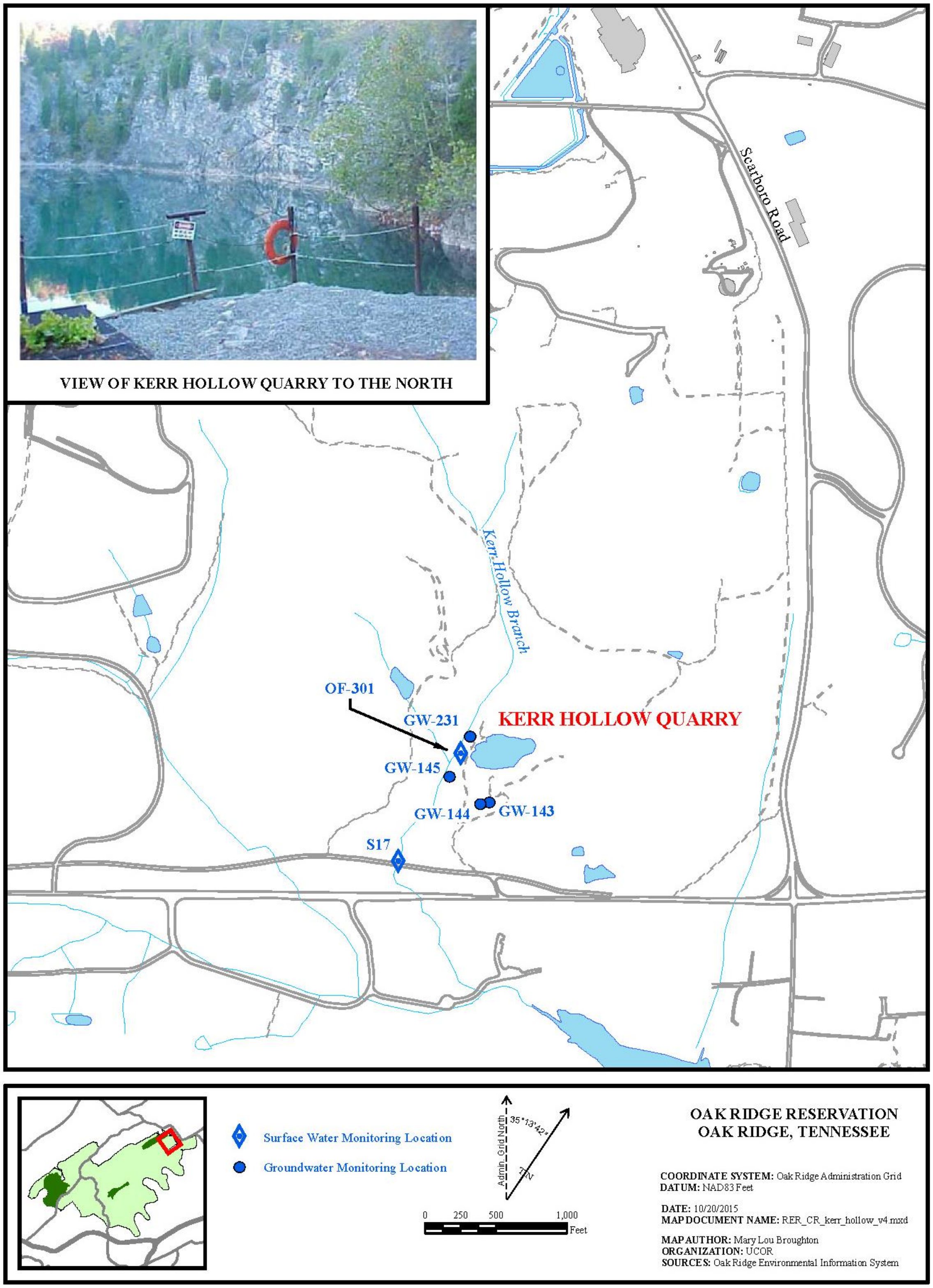


Figure 5.4. KHQ.

5.3.3 KHQ Issues and Recommendations

There are no issues or recommendations.

5.4 FILLED COAL ASH POND/UPPER MCCOY BRANCH

5.4.1 Performance Monitoring

5.4.1.1 Performance Monitoring Goals and Objectives

The Filled Coal Ash Pond (FCAP) is situated south of Y-12 along the southern slope of Chestnut Ridge (Figure 5.1 and Figure 5.5). The scope of the *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (DOE/OR/02-1410&D3) was to remediate the FCAP and vicinity. The *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (DOE/OR/01-1596&D1) documents the following actions: the crest of the dam was raised, the face of the dam was reinforced, a subsurface drain was installed, large trees were removed from the face of the dam, the emergency spillway was repaired (including removal of the steep slope to the east of the spillway), a settling basin and oxygenation weir were constructed at the foot of the dam, and a small wetland was replaced downstream of the settling basin. The RA also includes long-term monitoring of the dam and controls to limit access.

The goal of the RA specified in the ROD (DOE/OR/02-1410&D3) is to reduce risk posed by the site to "plants, animals and humans by: (1) upgrading containment of the coal ash with dam improvements and stabilization, (2) reducing contaminant migration into Upper McCoy Branch with a passive treatment system (existing wetland), and (3) restricting human access to the contamination by implementing institutional controls." The functional goals (DOE/OR/02-1410&D3) are to:

- *minimize the migration of contaminants into surface water,*
- *minimize direct contact of humans and animals with the ash,*
- *reduce the potential for future failure of the dam, and*
- *preserve the local habitat in the long term.*

The *Record of Decision for Chestnut Ridge Operable Unit 2* (DOE/OR/02-1410&D3) requires that surface water be periodically sampled "and analyzed to verify that the passive treatment system reduces contaminant levels in water entering Upper McCoy Branch at least as well as the existing wetland and to evaluate whether the passive treatment system requires maintenance." The *Remedial Action Report on Chestnut Ridge Operable Unit 2* (DOE/OR/01-1596&D1) specifies that surface water samples "be collected and analyzed for the primary contaminants of concern (aluminum, arsenic, iron, manganese, and zinc) and other constituents of relevance to evaluating wetland performance at the site." Two locations, one at the influent to the wetland (McCoy Brank kilometer [MCK] 2.05) and one below the wetland (MCK 2.0), are monitored for metals, anions, radionuclides, and other water quality parameters on a semiannual basis. Both monitoring locations are downstream of the contaminant source.

Monitoring of biological communities is conducted to evaluate protection of the ecosystem in the FCAP vicinity in accordance with ARARs for protection of aquatic resources specified in the *Record of Decision for Chestnut Ridge Operable Unit 2* (DOE/OR/02-1410&D3). The *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2) identified that the ROD does not specify compliance with AWQC; however, they are used as comparative criteria to track reduction in "contaminant migration to surface water" and "risk to ecological receptors." Biological communities are monitored near the wetland

(MCK 1.9) and also below the Rogers Quarry dam (MCK 1.4 and MCK 1.6). Fish are collected from Rogers Quarry for contaminant analysis on an annual basis.

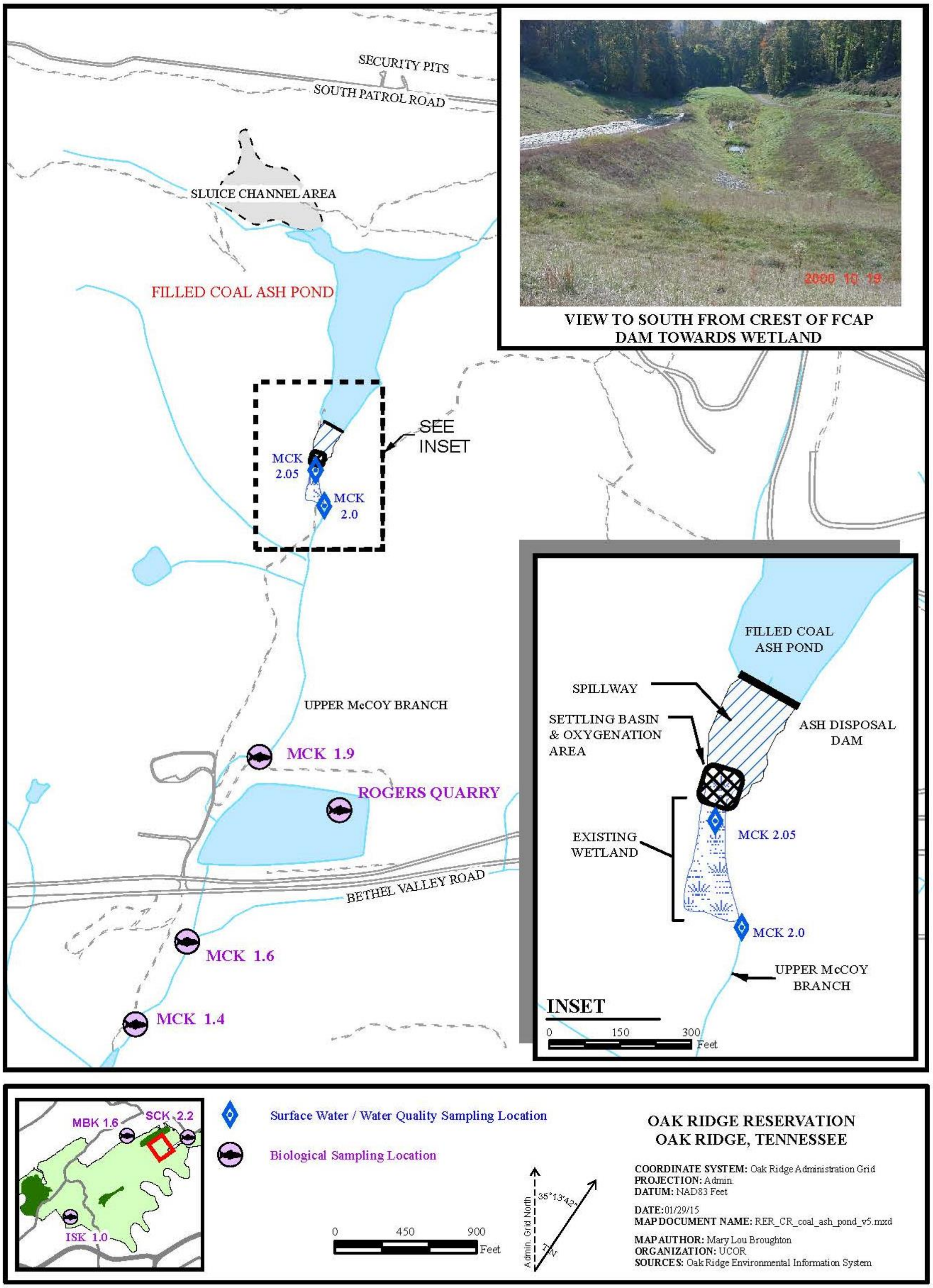


Figure 5.5. FCAP.

5.4.1.2 Evaluation of Performance Monitoring Data

5.4.1.2.1 Surface Water

To fulfill the performance monitoring goals and objectives, the monitoring data evaluation for the FCAP RA focuses on comparison of metals contaminant concentrations to pre-action levels and overall reduction of metals between the inlet and outlet sampling locations at the wetland. Water quality monitoring at the site includes anions, metals, and gross alpha/beta activity. Elevated concentration of arsenic is the water quality issue at FCAP. DOE monitors a broad suite of metals in the wetland influent and effluent to evaluate the metals attenuation effectiveness of the action. Data are presented below for the metals arsenic, zinc, iron, and manganese. Past monitoring results show that arsenic is the most significant metal present in the site discharge. Lead is not detected in water samples at FCAP and antimony, zinc, and mercury are present at concentrations far lower than their respective water quality criteria levels. Iron and manganese are common and abundant metals present in coal ash leachate. These elements form solid metal oxide precipitates when the leachate water comes in contact with free oxygen, such as when leachate contacts air or other water rich in dissolved oxygen. AWQC for arsenic and zinc are used as screening criteria for evaluating the performance of the remedy.

Table 5.6 summarizes monitoring data from FY 1996 prior to the RA, while Table 5.7 summarizes the FY 2015 monitoring results. The upstream (before flow through the wetland) sampling location is MCK 2.05 and the downstream (after flow through the wetland) is MCK 2.0. For the baseline event, the data summary is based on both filtered and unfiltered sample results for which four replicate samples were collected on the same date. Percent reduction of metals concentrations for average dissolved (filtered sample results) and average total (unfiltered sample results) shows that for arsenic concentrations in the wetland effluent water were higher than in the influent water. Because filtered results were non-detects for iron and zinc in the 1996 dataset, no reduction factor is calculated. The total iron concentration was reduced about 17% in the 1996 dataset. Dissolved manganese was reduced by about 11% although the total manganese concentration in the wetland effluent was over six times the level measured in the influent. The total zinc concentration in wetland effluent was slightly greater than twice the influent concentration.

Table 5.7 summarizes FY 2015 results from single unfiltered and field-filtered samples collected at the downstream site under wet season (March) and dry season (September) conditions and regular plus duplicate samples collected at the upstream location. The FY 2015 results for zinc show no screening criterion exceedances. During the wet season sampling event (February), arsenic concentrations in the upstream location (MCK 2.05) unfiltered sample exceeded the human health recreational scenario criterion; however, the filtered sample levels were less than the criterion. The wet season sample from the downstream location (MCK 2.0) attained the human health recreational scenario criterion in both the unfiltered and filtered samples. During the wet season, there was an 87% reduction in total arsenic concentration in wetland effluent although there was a measured 20% increase in the dissolved (filtered aliquot) concentration with neither sample exceeding the AWQC. During the dry season sampling event (September), the human health recreational scenario criterion was exceeded in the unfiltered upstream (MCK 2.05) sample with a result equal to the criterion in the filtered aliquot. At the downstream sample location (MCK 2.0), the arsenic human health recreational scenario concentration was exceeded in both the unfiltered and filtered aliquots. During the dry season the total arsenic concentration was reduced by 28% in the wetland effluent while there was a 20% increase in the dissolved (filtered aliquot) arsenic concentration. Figure 5.6 shows the downstream (MCK 2.0) total arsenic and filtered arsenic concentration results.

Table 5.6. Summary of FCAP pre-remediation monitoring results, FY 1996

Analyte	Units	MCK 2.05[a] (filtered)			MCK 2.05[a] (unfiltered)			MCK 2.0[b] (filtered)			MCK 2.0[b] (unfiltered)			Percent reduction[c]	
		Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev	Filtered	Unfiltered
Arsenic[d]	mg/L	0.007	**0.011**	0.004	**0.484**	**1.4**	0.623	**0.014**	**0.017**	0.003	**0.572**	**1.2**	0.606	-100	-18
Iron	mg/L	--[e]	0.014	--[e]	20.1	48	23.1	0.091	0.26	0.114	16.7	43	17.7	-	17
Manganese	mg/L	0.089	0.17	0.087	1.94	3.8	1.48	0.079	0.15	0.077	13.8	39	17.9	11	-611
Zinc[f]	mg/L	0.022	0.052	0.022	0.035	0.056	0.023	--[e]	0.009	--[e]	0.072	0.2	0.091	-	-106

Bold value indicates sample concentration exceeds AWQC.

[a]Dam effluent/wetland influent.
[b]Wetland effluent.
[c]Percent reduction is difference between upstream and downstream samples in proportion to the upstream concentration.
[d]AWQC screening criterion for arsenic is 0.01 mg/L.
[e]Value not determined because only one valid result was available.
[f]AWQC screening criterion for zinc is 0.12 mg/L.

Avg = average
AWQC = ambient water quality criteria
FCAP = Filled Coal Ash Pond
FY = fiscal year
Max = maximum
MCK = McCoy Branch kilometer
Stdev = standard deviation

Table 5.7. Summary of FY 2015 post-remediation data from MCK 2.05 and 2.0

Analyte	Units	Wet-season sample		Percent reduction[a]		Dry-season sample		Percent reduction[a]		AWQC
		MCK 2.05[b] Feb-2 Unfiltered/Filtered	MCK 2.0[c] Mar-18 Unfiltered/Filtered	Filtered	Unfiltered	MCK 2.05[b] Sep-21 Unfiltered/Filtered	MCK 2.0[c] Sep-21 Unfiltered/Filtered	Filtered	Unfiltered	
Arsenic[d]	mg/L	**0.032** / 0.0074	0.0042 / 0.0089	-20	87	**0.043** / **0.01**	**0.031** / **0.012**	-20	28	0.01[e]
Iron	mg/L	0.65 / <0.1 U	0.2 / <0.1 U	-	69	1.6 / <0.1 U	0.91 / <0.1 U	-	43	N/A
Manganese	mg/L	0.35 / 0.13	0.12 / 0.0009	99	66	0.72 / 0.14	0.8 / 0.019	86	-11	N/A
Zinc[f]	mg/L	<0.01 U / <0.01 U	<0.01 U / <0.01 U	-	-	<0.01 U / <0.01 U	0.0098 J / <0.01 U	-	-	0.12[g]

Bold value indicates sample concentration exceeds AWQC.

[a]Percent reduction is difference between upstream and downstream samples in proportion to the upstream concentration.
[b]Dam effluent/wetland influent.
[c]Wetland effluent.
[d]AWQC screening criterion for arsenic is 0.01 mg/L.
[e]Source: TDEC 0400-40-03-.03(4) recreational criteria – organisms only.
[f]AWQC screening criterion for zinc is 0.12 mg/L.
[g]Source: TDEC 0400-40-03-.03(3) criteria continuous concentration for protection of fish and aquatic life. AWQC for zinc are hardness dependent. The 0.12 mg/L ambient water quality criterion for zinc is based on the most conservative criterion for hardness.

AWQC = ambient water quality criteria
FY = fiscal year
MCK = McCoy Branch kilometer
N/A = not applicable
TDEC = Tennessee Department of Environment and Conservation
U = not detected

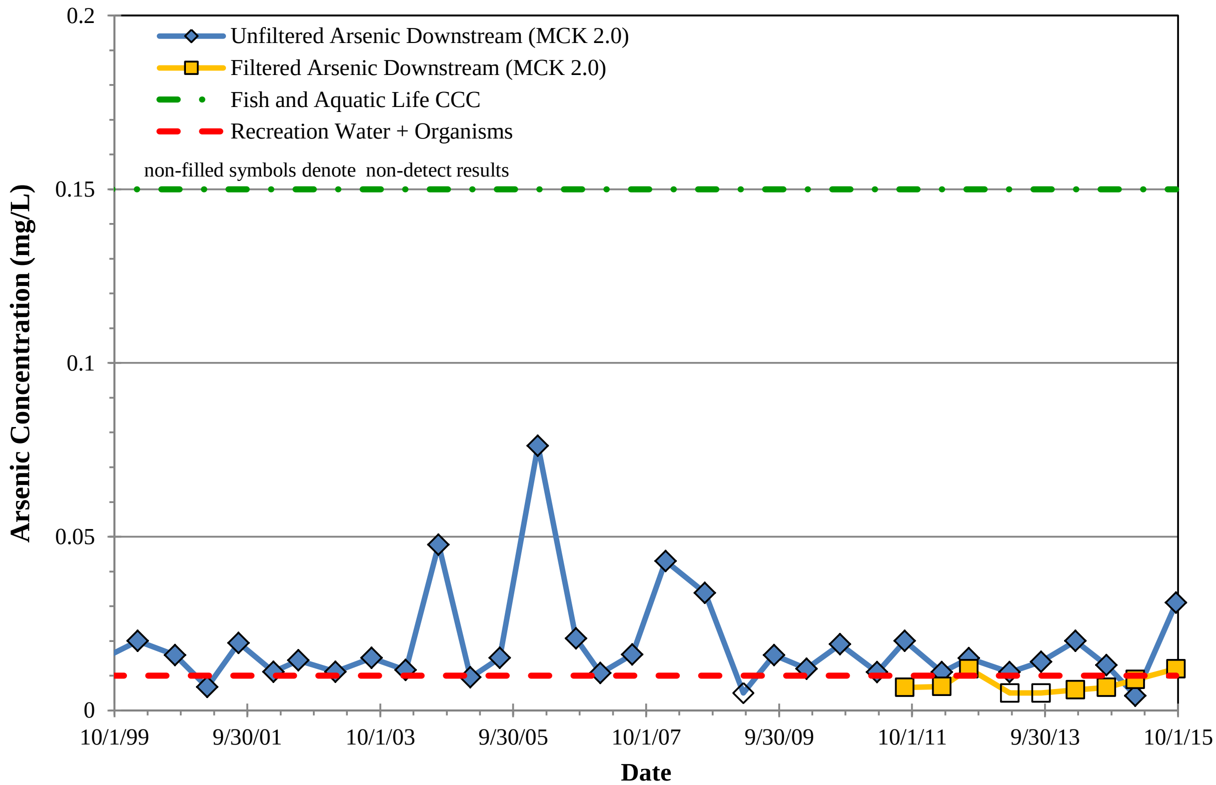


Figure 5.6. History of arsenic concentration in FCAP wetland effluent (MCK 2.0).

The goal of FCAP remediation is to reduce metals discharges from the coal ash to surface water in McCoy Branch. The remedy included two elements – replacement of the dam which held the coal ash with a new structure to prevent erosion and direct transport of the ash downstream, and enhancement of an existing wetland to passively reduce metals concentrations downstream. Arsenic has been identified above as the principal AWQC contaminant of concern. Two metrics are used to evaluate the overall performance of the FCAP remedy.

The first metric of interest is the percentage reduction of total arsenic concentrations over time for both the upstream (MCK 2.05) and downstream (MCK 2.0) monitoring locations. Figure 5.7 shows the percent reductions in total arsenic concentrations for the time period 1998 through 2015. At the upstream monitoring location, the percent reduction attributable to the FCAP dam improvements is typically greater than 75%, although three samples experienced very poor reduction factors that actually plot in the negative reduction range indicating increased concentrations downstream compared to upstream. Increases in total metals concentration downstream are typically associated with suspended particulates.

The second metric of interest is the percent reduction in arsenic concentration between water entering the wetland at MCK 2.05 and water leaving the downstream end of the wetland at MCK 2.0. Figure 5.8 shows the percent of total (dissolved) arsenic at MCK 2.0 compared to average of arsenic concentrations measured in both the regular sample and a field duplicate sample collected at MCK 2.05. The percent reduction of arsenic during flow through the wetland is typically greater than about 20% although the reduction factors are highly variable. As shown on Figure 5.8, there appears to be some decreasing arsenic removal effectiveness over time. The sample events with lower arsenic reduction factors are not seasonally dependent.

The post-action wetland is more effectively reducing metals effluent from the site than under the pre-existing condition. Although AWQC were not specified as performance criteria for the action, the post-action concentration comparisons for arsenic to the criteria shows that the levels of exceedance are much smaller subsequent to completion of the remedy than prior to remedy completion and exceedances are less frequent.

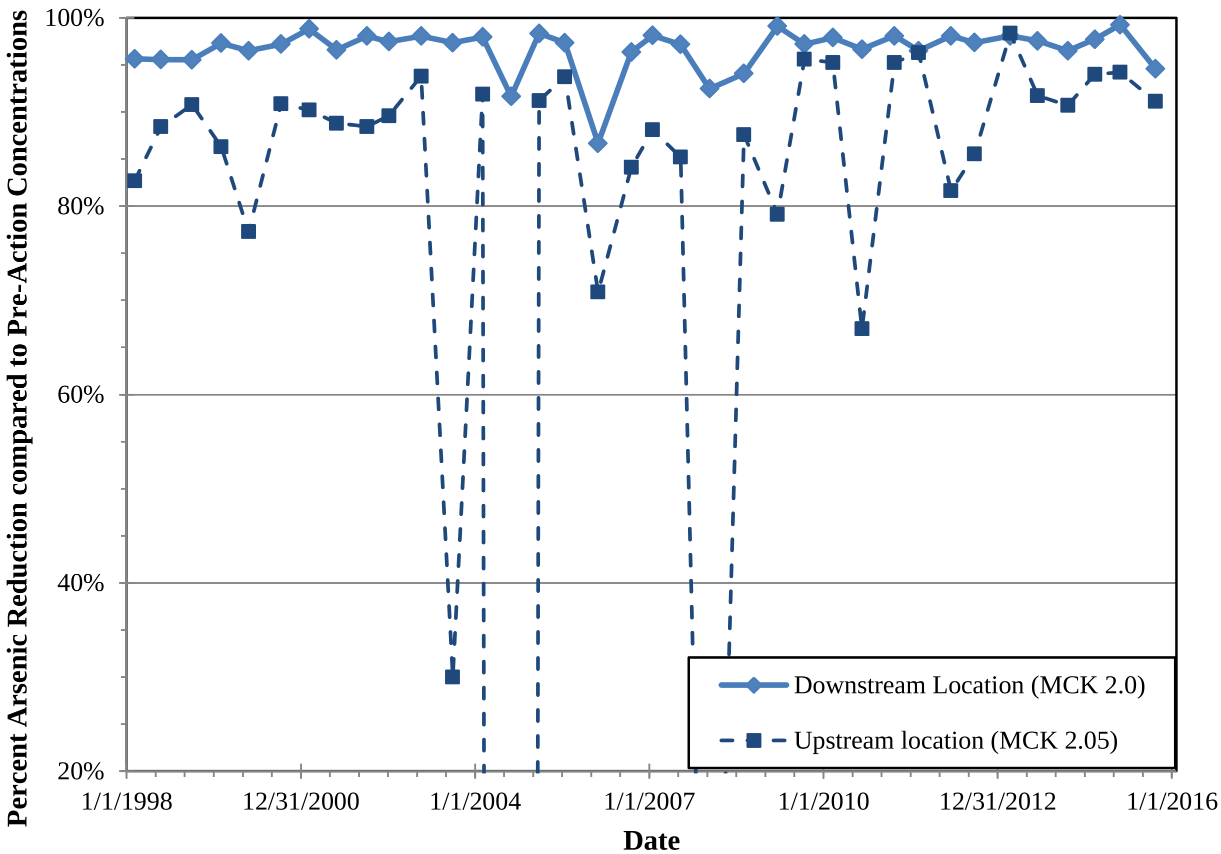


Figure 5.7. Post-remediation percent reductions of total arsenic concentrations in McCoy Branch compared to pre-remediation levels.

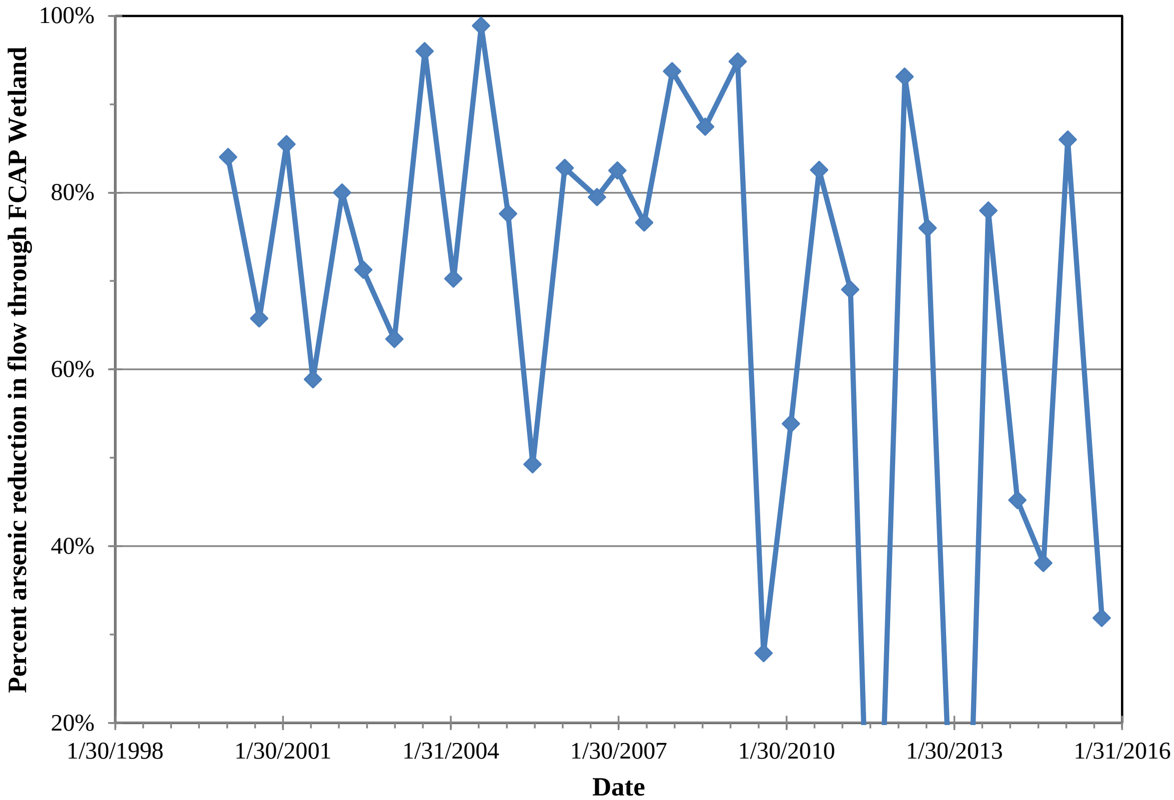


Figure 5.8. Percent reduction of total arsenic between inflow (MCK 2.05) and discharge (MCK 2.0) samples.

5.4.1.2.2 Biota

Fly-ash disposal from Y-12 into the FCAP, as well as direct disposals of ash into Rogers Quarry (Figure 5.5), affected water quality in the lower reaches of McCoy Branch and the quarry. Biological monitoring studies have documented contaminants in fish and impacts to biota in the lower reaches of the McCoy Branch watershed and Rogers Quarry. To evaluate in-stream exposure and potential human health risks in the McCoy Branch watershed, adult largemouth bass were collected from Rogers Quarry and analyzed for concentrations of key contaminants of concern. An evaluation of overall ecological health in the stream was conducted by monitoring the fish and benthic macroinvertebrate communities.

Average mercury and selenium concentrations in largemouth bass collected from Rogers Quarry remained in the range of concentrations seen in recent years (1.33 µg/g for selenium and 0.73 µg/g for mercury). Selenium concentrations in this species remain above typical background concentrations (approximately 0.5 µg/g), and mercury concentrations are above EPA's recommended AWQC (0.3 µg/g mercury in fish fillet), suggesting continuing low level inputs from the FCAP (Figure 5.9). Arsenic concentrations continued to be near background levels since 2007 (Figure 5.9).

The species richness (number of species) of the fish community at MCK 1.6 in McCoy Branch has shown a wide range of variation since sampling began in the late 1980s (Figure 5.10). The wide variation at MCK 1.6 may be related to the proximity of the site to Melton Hill Reservoir which serves as a source for many species, including those not generally expected in a smaller stream (i.e. non-resident species such as threadfin shad *Dorosoma petenense*). This variation is also influenced by the presence of beaver activity which can sometimes inhibit species migration. The species richness at MCK 1.9 remained stable in 2015, where introduction of the western blacknose dace appears to be successful, and the recently

introduced creek chub were still present in 2015 samples, increasing total richness to three (Figure 5.10). A significant number of creek chub were collected in the fall of 2014 and spring 2015, suggesting that stream conditions are sufficient for a reproducing population to persist. Both sites were below mean reference stream values for 2015, had far fewer sensitive species, such as darters, and were dominated by tolerant species.

The number of pollution-intolerant benthic macroinvertebrate taxa (EPT taxa richness) continued to show a strong seasonal trend at MCK 1.4, with the highest values consistently occurring in April (Figure 5.11). There continues, however, to be no such strong seasonal trends at MCK 1.9. EPT richness continues to be lower than the reference range at both McCoy Branch sites. Drought conditions may have contributed to a reduction in EPT richness at MCK 1.9 in 2007, and there appears to be some evidence that the drought likely had a negative effect at some reference sites as well. However, EPT richness at reference sites appeared to rebound after 2007, while the rebound at MCK 1.9 appeared to be more limited. Since the drought in 2007, annual rainfalls have generally been near or above normal. The structure of the stream channel and substrate at MCK 1.9 have shown strong evidence of significant scouring, down-cutting, and bank erosion since 2008, and fly ash containing sediments persist in the upper stream sections. More detailed causal investigations have not been conducted, but potential stressors to instream invertebrate communities include chemical exposure from fly ash, flashy stream flows, and poor habitat (e.g. sedimentation and increased pool habitat from beavers). Even with a reduction in the number of pollution-intolerant taxa at MCK 1.9, the site still supports some taxa that are generally intolerant of poor water quality and are typically found predominantly at reference sites (e.g., the stoneflies *Leuctra* and *Tallaperla*). MCK 1.4, on the other hand, generally has higher densities of taxa that typically dominate sites with mildly to moderately poor water quality (e.g., filter-feeding caddisflies and Orthocladiinae midges).

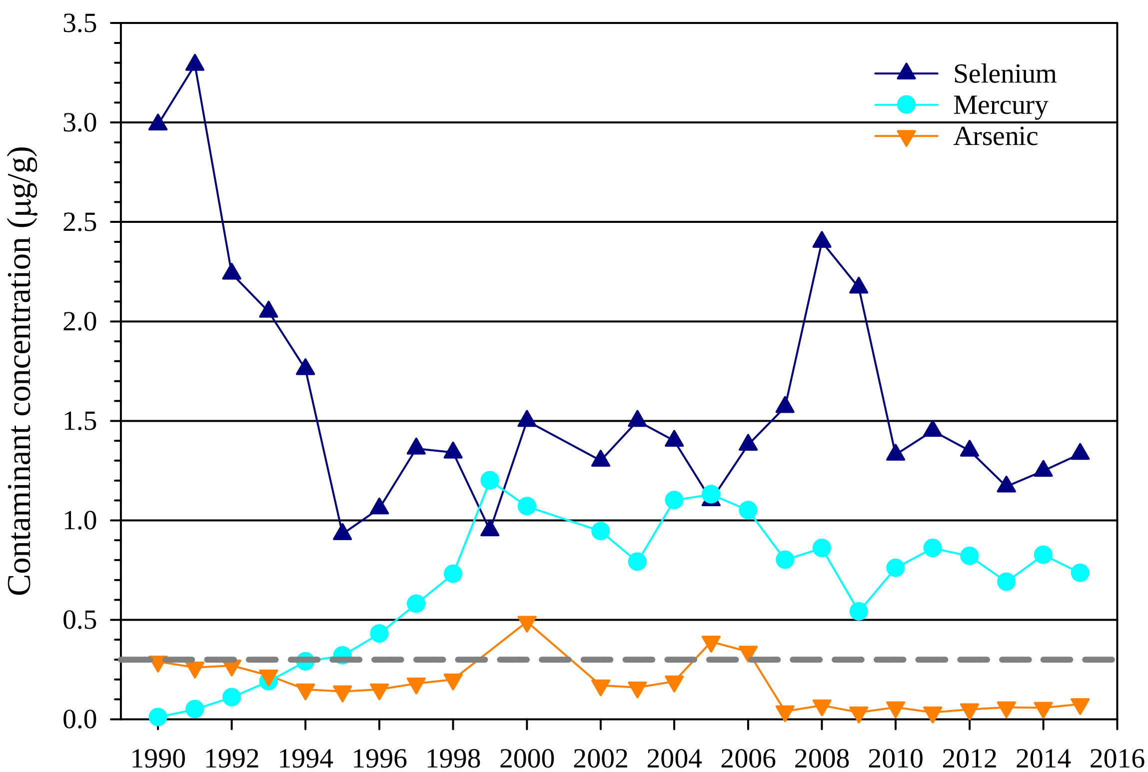


Figure 5.9. Mean concentrations of selenium, mercury, and arsenic in fillets of largemouth bass from Rogers Quarry (1990 – 2015; n=6 fish/yr).

Dashed gray line indicates federal recommended AWQC for mercury in fish fillets (0.3 µg/g).

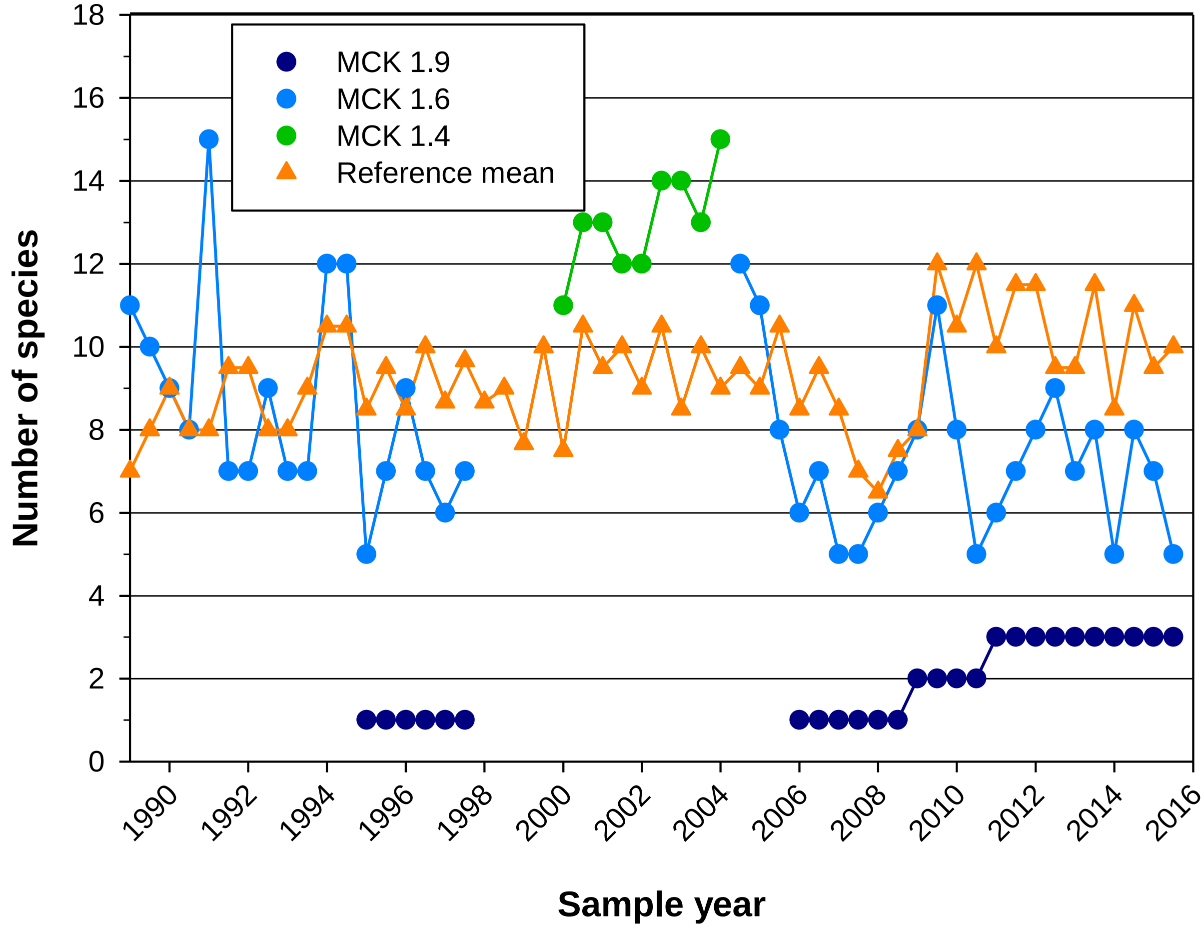


Figure 5.10. Species richness (number of species) in samples of the fish community in McCoy Branch (MCK) and the mean value of two-three reference streams, Scarboro Creek, Mill Creek, and Ish Creek, 1989 – 2015.

See Figure 5.5 for locations of reference sampling sites. Interruptions in data lines for MCK sites indicate no results available for those periods.

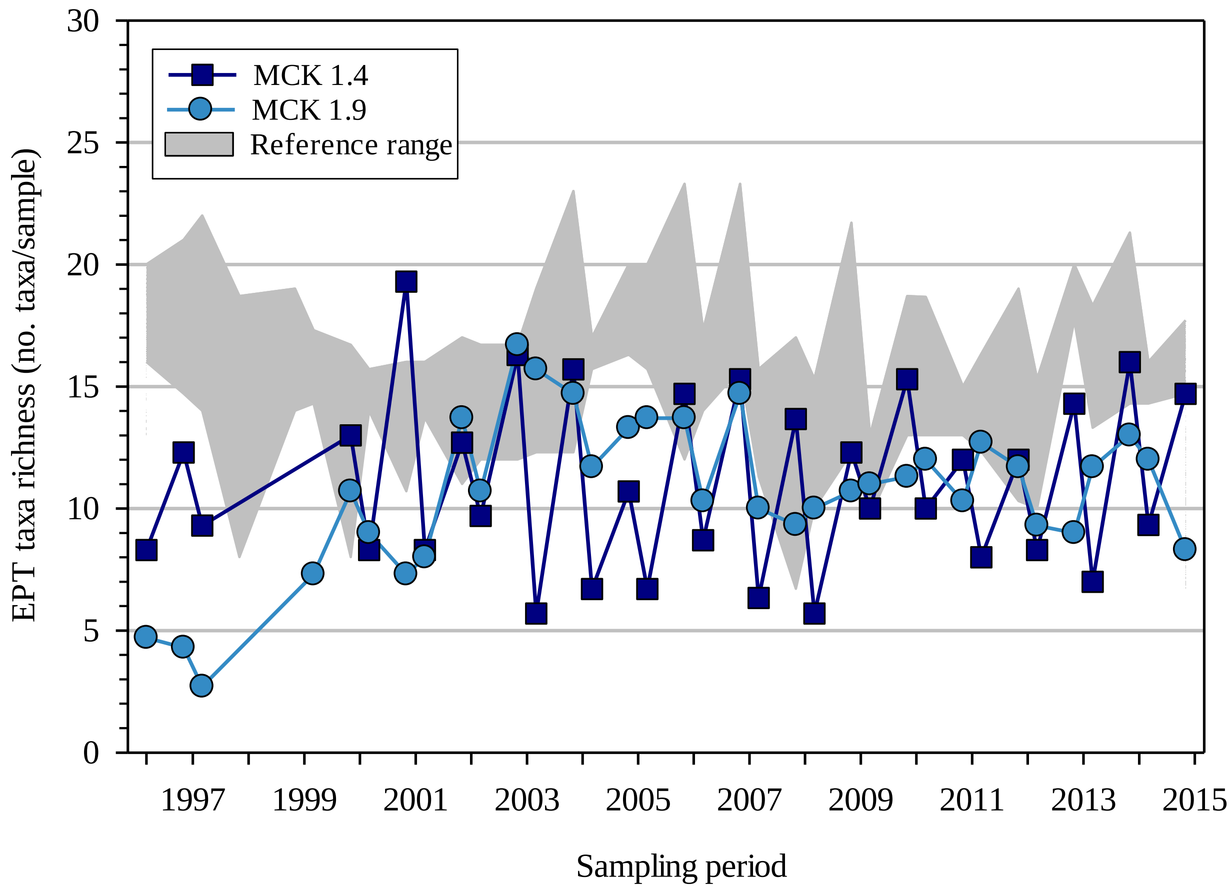


Figure 5.11. Taxonomic richness of pollution-intolerant taxa (EPT taxa richness) in the benthic macroinvertebrate community at sites in McCoy Branch, and the range of mean values at reference streams (First Creek, Fifth Creek, Gum Hollow Branch, Mill Branch, Walker Branch, and WOC), 1996 – 2015 (FY 2015).

Each symbol represents the mean of three samples for April and October sampling periods beginning with October 1996. Tick marks for the x-axis are centered between results for the April and October sampling periods in a given year.

The gray shading is the range of mean values for reference sites.

5.4.1.3 Performance Summary

The monitoring results since the RA indicate that the remedy is reducing metals contamination from the coal ash in surface water in McCoy Branch. The ROD for FCAP did not stipulate that the RA would attain AWQC in McCoy Branch but did stipulate that the action would reduce contaminant loading in the stream at least as well as the pre-existing natural wetland. Although concentrations have decreased significantly since implementation of the RA, total arsenic concentrations often exceed the screening criterion (0.01 mg/L) in both the upgradient and downgradient locations at the FCAP wetland. Based on the sampling for the FY 2011 through FY 2015 period, the passive wetland treatment area reduces total arsenic concentrations by about 93% with associated reductions of dissolved arsenic of about 19%. Arsenic levels in Rogers Quarry fish have been near background. However, selenium and mercury concentrations remain higher in fish relative to typical background concentrations for selenium and relative to federal AWQC guidelines for mercury, suggesting continuing low-level inputs from either the FCAP or stream and/or quarry ash deposits downstream. Stream community measures show that McCoy Branch remains below, or at the lower end, of values observed in reference streams.

5.4.2 Other LTS Requirements

5.4.2.1 Requirements

The *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (DOE/OR/01-1596&D1) requires that inspections of the site be conducted quarterly throughout the post-remediation care period, and any required maintenance be conducted based on inspection findings. Post-remediation performance of FCAP is dependent on adequate inspection and maintenance of the dam, spillway channel, adjacent slopes, settling basin, and wetlands. Because erosion damage is of great concern, the dam and spillway will also be inspected following any rainfall event equivalent to a 25 y, 24 h intensity.

5.4.2.2 Status of Requirements

All components of the FCAP were inspected quarterly in FY 2015 by the Y-12 S&M Program including dam and slope stability, vegetative cover of dam and adjacent slopes, settling basin, spillway, underdrain discharge pipe, wetland area, benchmarks, and site security and access controls. Maintenance in FY 2015 included removing vegetation growing in the revetment mat.

5.4.3 FCAP/Upper McCoy Branch Issues and Recommendations

There are no issues or recommendations.

5.5 CHESTNUT RIDGE ISSUES AND RECOMMENDATIONS

The issues and recommendations for Chestnut Ridge are in Table 5.8.

Table 5.8. Chestnut Ridge issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
		Current Issue	
None			
		Issue Carried Forward	
None			
		Completed/Resolved Issues[b]	
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

5.6 REFERENCES

65 FR 76708 – 76753, *National Primary Drinking Water Regulations; Radionuclides; Final Rule*, December 7, 2000, Environmental Protection Agency.

DOE 1991. *Record of Decision United Nuclear Corporation Disposal Site Declaration, Y-12 Plant, Oak Ridge, Tennessee*, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, TN.

DOE/OR/01-1128&D1. *Post-Construction Report for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1993, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1596&D1. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1398&D2. *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1410&D3. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee*, 1996, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR-1014. *Federal Facility Agreement for the Oak Ridge Reservation*, 1992, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

ES/ER-15&D1. *Feasibility Study for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* 1991, Y/ER/Sub-90/VK168/3&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

TNHW-088. *Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* EPA I.D. No. TN 3 89 009 0001, June 1996, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

TNHW-128. *RCRA Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime, Y-12 National Security Complex, Oak Ridge, Tennessee,* EPA I.D. No. TN3 89 009 0001, September 2006, Tennessee Department of Environment and Conservation-Division of Solid Waste Management, Nashville, TN.

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6. UPPER EAST FORK POPLAR CREEK WATERSHED

6.1 INTRODUCTION AND STATUS

6.1.1 Introduction

The UEFPC watershed contains most of the active facilities and a considerable fraction of the CERCLA facilities and contaminated sites at Y-12. Table 6.1 lists the CERCLA actions within the watershed and identifies those with monitoring or other LTS requirements. Figure 6.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action will be assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Only sites that have LTS requirements (Table 6.1) are included in these performance evaluations. End uses of a site form the basis of RAOs and determine access restrictions and allowable activities at the site. Figure 6.2 shows ROD-designated end uses within the watershed and interim controls requiring LTS.

Completed CERCLA actions in the UEFPC watershed are gauged against their respective action specific goals. However, CERCLA actions have yet to be fully implemented within the watershed. Therefore, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provides a preliminary evaluation of the early indicators of effectiveness at the watershed scale.

For a complete description of background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 7 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

6.1.2 Status Update

<u>Watershed-Scale Actions</u>

Focused Feasibility Study, Proposed Plan, and Outfall 200 Conceptual Design. The revised *Focused Feasibility Study for Supplemental Mercury Abatement Actions under the Record of Decision for the Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge Tennessee* (DOE/OR/01-2660&D3) was approved in July 2015. Following that, the *Proposed Plan for Water Treatment at Outfall 200 under the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee (*DOE/OR/01-2661&D2) was approved in August 2015. An amendment to the UEFPC Phase I ROD to include the Outfall 200 Mercury Treatment Facility (MTF) was submitted to the regulators in November 2015 (*Amendment to the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee Water Treatment at Outfall 200* [DOE/OR/01-2697&D1]). Figure 6.3 shows a sampling platform for Outfall 200 pre-design studies and Figure 6.4 illustrates Outfall 200 and the headwaters of UEFPC.

Table 6.1. CERCLA actions in UEFPC watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Watershed-scale actions			
Phase I Interim Source Control Actions	ROD (DOE/OR/01-1951&D3): 05/02/02	**Watershed-scale Requirements**	Yes (see Table 6.2)/Yes (see Table 6.7)
		Actions complete	
	NSC: 10/05/06, mercury monitoring NSC: 05/17/07, 9201-5 sump water	PCCR for BSWTS for Building 9201-2 (DOE/OR/01-2218&D1) approved 07/01/05	Yes/Yes
	Erratum to the 10/05/06 NSC: 06/09/08, sampling at Outfall 163 NSC: 09/30/09; sump water	PCCR WEMA storm sewer remediation (DOE/OR/01-2526&D2) approved 08/31/12	Yes/No
	ESD (DOE/OR/02-1539&D2): 08/29/12, updates to selected remedy		
	NSC: submitted 03/14/14; UEFPC monitoring to be managed in RAR CMP		
Phase II Interim RA for Contaminated Soils and Scrapyard	ROD (DOE/OR/01-2229&D3): 04/21/06	**Watershed-scale Requirements**	No/Yes (see Table 6.7)
		Actions complete	
		PCCR for Y-12 Salvage Yard – Scrap Removal (DOE/OR/01-2481& D1) approved 10/11/11	No/No
		PCCR for Y-12 Salvage Yard Soil (DOE/OR/01-2564&D1) approved 11/01/12	No/No
		(DOE/OR/01/-2481&D1/A1) addendum for removal and disposal of five tanks approved 02/11/14	No/No
Single-project actions			
		Actions complete	
Y-12 EEVOC Plume	AM (DOE/OR/01-1819&D2): 06/25/99 NSC: 03/06/13	RmAR (DOE/OR/01-2297&D1) approved 06/07/06 • Erratum to establish monitoring POC: submitted 03/05/13 (no approval required)	Yes/Yes

Table 6.1 CERCLA actions in UEFPC watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Union Valley	IROD (DOE/OR/02-1545&D2): 07/10/97	--[c]	No/Yes
Mercury Tanks (Tanks 2100-U, 2101-U, 2104-U)	IROD (DOE/OR/02-1164): 09/26/91	RAR (DOE/OR/01-1169&D1) approved 03/02/94	No/No
Plating Shop Container Areas	ROD (DOE/OR-1049&D3): 09/30/92	NFA	No/No
Abandoned Nitric Acid Pipeline (UEFPC Operable Unit 2)	ROD (DOE/OR/02-1265&D2): 09/12/94	NFA	No/No
Building 9201-4 Exterior Process Piping	AM (DOE/OR/02-1571&D2): 04/22/97	RmAR (DOE/OR/02-1650&D1) approved 09/30/99	No/No
Lead Source Removal of Former YS-860, Firing Range Removal Action	AM (DOE/OR/02-1622&D1): 03/10/98	RmAR (DOE/OR/01-1774&D2) approved 02/24/99	No/No
9822 Sediment Basin and 81-10 Sump Removal Action	AM (DOE/OR/01-1716&D2): 06/19/98	RmAR (DOE/OR/01-1763&D2) approved 02/24/99	No/No
Removal of Mercury from Storm Sewer System	Time-critical AM (DOE/OR/01-2574&D1): 07/19/12	RmAR for Mercury Reduction Project (DOE/OR/01-2595&D1) approved 02/11/14	No/Yes
		Actions in progress	
Removal of Debris and Soil from the Haul Road Ravine Disposal Area	Time-critical AM (DOE/OR/01-2662&D1): 10/06/14	RmAR (DOE/OR/01-2668&D1) submitted 10/15/15	TBD[d]
Removal of Contaminated Soil and Debris from UPF Construction Area	Time-critical AM (DOE/OR/01-2678&D1): 12/16/14	Removal action to be completed as needed for contaminated soil and debris encountered during UPF construction.	TBD[d]
Demolition Projects			
		Actions complete	
Removal of legacy materials from Buildings 9201-5 and 9204-4	Time-critical AM (DOE/OR/01-2404&D1): 05/04/09 Addendum (DOE/OR/01-2404&D1/A1): 10/03/11	RmAR (DOE/OR/01-2519&D2) approved 02/27/12	No/No
Demolition of Buildings 9735 and 9206 filterhouse	Time-critical AM (DOE/OR/01-2405&D1): 05/04/09	RmAR (DOE/OR/01-2502&D1) approved 02/15/12	No/No
Demolition of Buildings 9211, 9220, 9224, and 9769 (Biology Complex)	Time-critical AM (DOE/OR/01-2406&D1): 05/04/09	RmAR (DOE/OR/01-2508&D2) approved 02/13/12	No/No

Table 6.1 CERCLA actions in UEFPC watershed (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required[b]
Y-12 Facilities Deactivation/Demolition	AM (DOE/OR/01-2462&D2): 09/29/10	Project Completion Report (Beta-3 Legacy Material) (DOE/OR/01-2570&D1) approved 11/05/12	No/No
		RmAR Just In Case Yard (DOE/OR/01-2532&D1) approved 11/05/12	No/No
		PCCR for Secondary Pathways Project (DOE/OR/01-2596&D1) approved 02/11/14	No/Yes
		PCCR for Building 9206 Duct and Fan Removal (DOE/OR/01-2613&D1) approved 07/21/14	No/No

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]"No/No" indicates no monitoring/other LTS requirements are identified in the CERCLA action completion document beyond those identified in the watershed RODs. Refer to Table 6.2 for watershed-scale monitoring requirements and Figure 6.2 and Table 6.7 for watershed-scale LUCs and other LTS requirements.

[c]This action was completed prior to uniform adherence to the RAR process; hence, no RAR exists for this decision.

[d]The completion document was not approved during the FY 2015 reporting period.

AM = Action Memorandum
BSWTS = Big Spring Water Treatment System
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
ESD = Explanation of Significant Differences
EEVOC = East End Volatile Organic Compound
FY = fiscal year
IROD = Interim Record of Decision
LTS = long-term stewardship
LUC = land use control
NFA = No Further Action
NSC = Non-Significant Change
PCCR = Phased Construction Completion Report
POC = point-of-compliance
RA = remedial action
RAR = Remedial Action Report
RmAR = Removal Action Report
ROD = Record of Decision
TBD = to be determined
UEFPC = Upper East Fork Poplar Creek
UPF = Uranium Processing Facility
WEMA = West End Mercury Area
Y-12 = Y-12 National Security Complex

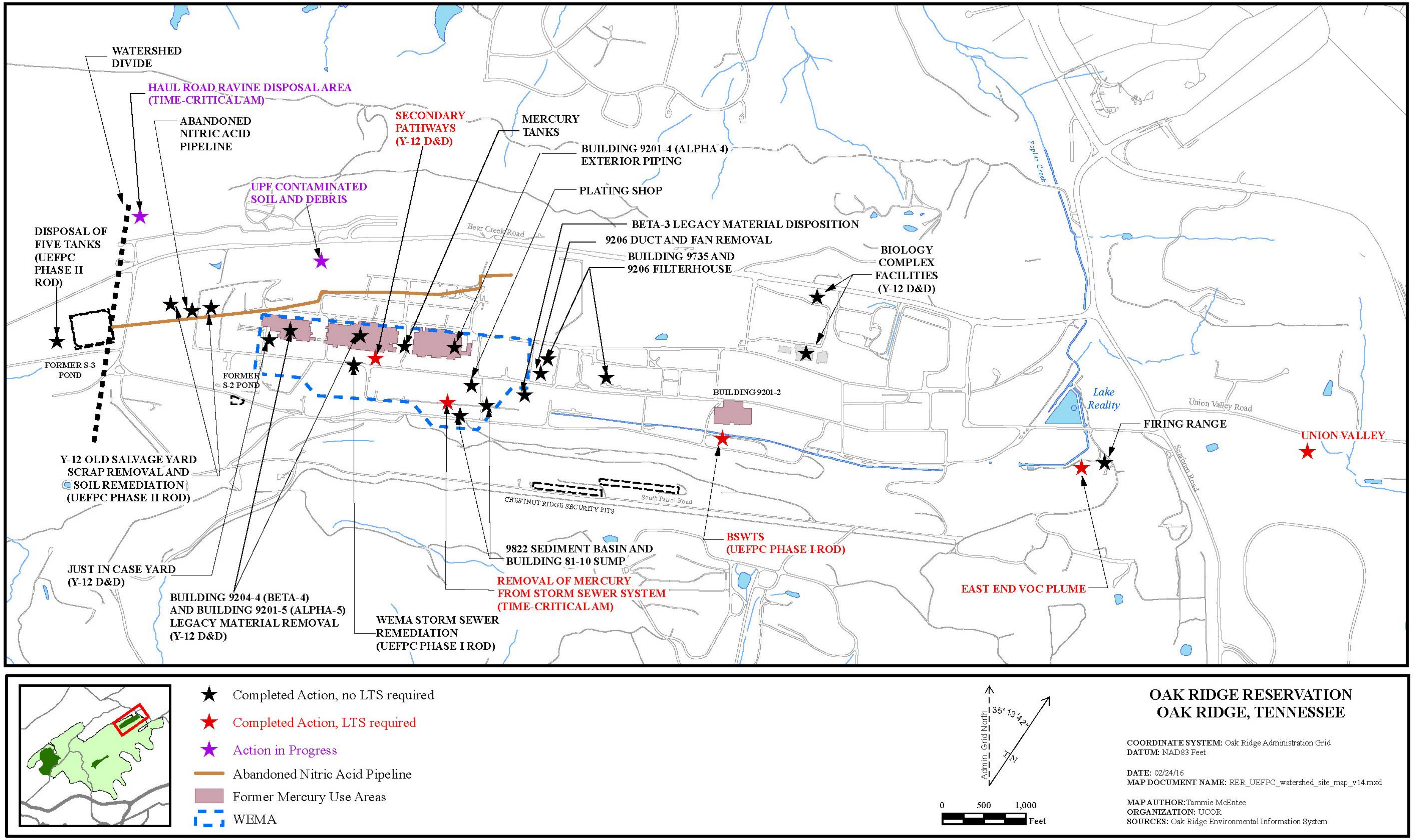

Figure 6.1. UEFPC watershed.

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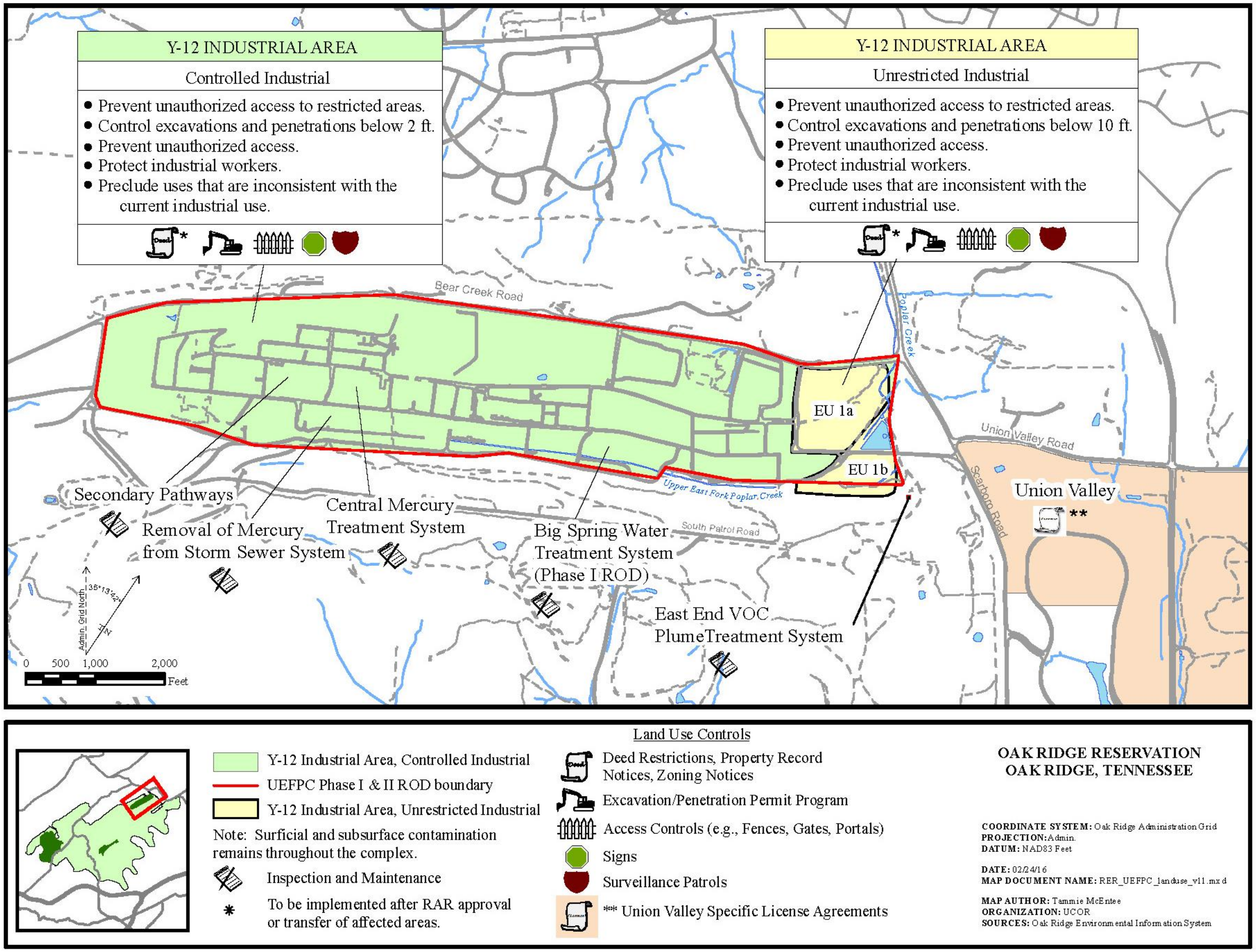

Figure 6.2. UEFPC Phase I and II ROD-designated end use and interim controls requiring LTS.

Figure 6.3. Sampling platform for Outfall 200 pre-design studies.

Figure 6.4. Outfall 200 and the headwaters of UEFPC.

Single-Project Actions

Time-critical Removal Action for Haul Road Ravine Disposal Area. During excavation for the Uranium Processing Facility (UPF) haul road construction project, uncontaminated debris, radioactive debris, and mercury-contaminated debris were encountered in FY 2014. The debris was located in an area at the western end of Y-12 just northeast of the Bear Creek Road/Old Bear Creek Road intersection. EPA and TDEC were notified and work and waste management were re-evaluated.

The FFA parties agreed that the removal of contaminated debris from the road corridor and subsequent treatment and disposal would be conducted pursuant to a time-critical action memorandum. The *Action*

Memorandum for Time-Critical Removal Action for the Removal of Debris and Soil from the Haul Road Ravine Disposal Area, at the Y-12 National Security Complex, Oak Ridge, Tennessee (DOE/OR/01-2662&D1) was approved in October 2014. Uncontaminated debris was disposed at the ORR landfill; radioactively contaminated debris was disposed at Nevada National Security Site (NNSS); and mercury contaminated debris was treated and disposed at Energy Solutions – Utah. A RmAR (*Removal Action Report for Time-Critical Removal of Debris and Soil from the Haul Road Ravine Disposal Area at the Y-12 National Security Complex, Oak Ridge, Tennessee* [DOE/OR/01-2668&D1]), to document completion of the action was submitted in October 2015.

Time-Critical Removal Action for UPF Contaminated Soil and Debris. As discussed above, unrecorded contaminated soil and debris were encountered during haul road construction in support of the UPF project. The unearthed debris is inferred to have been buried many years ago as the burial is not recorded in Y-12 operating records. As a result, the FFA parties agreed that the removal and disposal of any additional contaminated soil and debris encountered during the construction of the UPF facility and the haul road expansion would also be conducted as a time-critical removal action. The *Action Memorandum for Time Critical Removal Action for the Removal of Contaminated Soil and Debris from the Uranium Processing Facility Construction Area, at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2678&D1) was approved December 16, 2014. A WHP for disposal of contaminated soil and debris that may be encountered was approved in July 2015.

6.2 PHASE I INTERIM SOURCE CONTROL ACTIONS IN THE UEFPC CHARACTERIZATION AREA

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3), referred to as the UEFPC Phase I ROD, addresses principal threat source material control remedies designed to reduce mercury loading within UEFPC. The RAO for the selected remedy is to restore surface water to human health recreational risk-based values at Station 17. Principal components of the decision include:

- hydraulic isolation (e.g., capping contaminated soils) of the West End Mercury Area (WEMA)[1];
- removal of contaminated sediments in storm sewers, UEFPC, and Lake Reality;
- treatment of discharge from Outfall 51 (including a large-volume spring) and Building 9201-2 sumps;
- temporary water treatment using existing facilities East End Mercury Treatment System and the Central Mercury Treatment System (CMTS);
- LUCs to prevent consumption of fish from UEFPC and to control/monitor access by workers and the public; and
- monitoring of surface water (Station 17).

The Big Spring Water Treatment System (BSWTS) was constructed to treat discharge from Outfall 51 (including the large-volume spring) and to treat water from the Building 9201-2 sumps. Mercury contaminated water was rerouted from Building 9201-2 sumps and the East End Mercury Treatment

[1]Capping of contaminated soils in the West End Mercury Area (WEMA) was never implemented. An *Explanation of Significant Differences for the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-2539&D2) was approved in August 2012 to remove the action from the selected remedy in the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3).

System to the BSWTS in December 2006. The East End Mercury Treatment System and Outfall 550 are no longer in operation.

6.2.1 Performance Monitoring

6.2.1.1 Performance Monitoring Goals and Objectives

Performance measures and monitoring requirements for watershed-scale and single-project actions in UEFPC are summarized in Table 6.2, and monitoring locations are shown in Figure 6.5.

6.2.1.2 Evaluation of Performance Monitoring Data

6.2.1.2.1 Surface Water

6.2.1.2.1.1 Surface Water Quality Goals and Monitoring Requirements

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) includes a 200 ppt performance metric for mercury in surface water at the UEFPC integration point (Station 17) based on an adult recreator consuming only fish. Surface water monitoring at Station 17, including analysis for uranium and zinc, is conducted to gauge the cumulative effects of the various actions as they are completed. In addition, biological monitoring is performed to assess reductions of mercury in fish tissue at East Fork Poplar Creek kilometer (EFK) 23.4. To achieve the watershed-wide mercury reduction objectives, individual components of the Phase I remedy have action-specific performance standards. The BSWTS and CMTS effluent must meet the 0.2 µg/L (200 ppt) interim performance goal for mercury.

In November 2011, the TDEC issued a new NPDES Permit applicable to the Y-12 site. In that permit the state of Tennessee included a target average mercury concentration of 87.5 ng/L and a median annual daily mercury load of 2.42 g/d in water at Station 17 that was expected to allow mercury in fish tissue to decrease to the EPA-recommended AWQC (0.3 µg/g mercury in fish). This target mercury concentration in surface water at Station 17 is significantly less than the 200 ng/L goal set in the approved *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3). The 2011 Permit also included requirements for the DOE to perform several activities that were deemed appropriate to reduce the site mercury discharges to the permit-specified level. Some of the activities required by the permit were consistent with modification of actions required in previous permits (e.g. modification of location and amount of supplemental flows to the creek) while others were enforcement of CERCLA actions. In November 2011, the DOE filed an appeal to remove the performance of CERCLA actions, most of which were already subject to implementation under the EM Program under the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014). DOE and TDEC continue to negotiate over a potential settlement of the permit appeal.

Table 6.2. Performance measures for UEFPC watershed

Site	ROD goal	Performance standard	Monitoring location	Schedule and parameters
		Watershed-scale actions (Section 6.2)		
Station 17	Reduce mercury levels to a level protective of a recreational receptor based on fish consumption	0.2 μg/L (200 ppt) total mercury Specific numeric standards not defined for Uranium or Zinc monitoring; Performance determined from trend evaluation	Station 17	Continuous flow-paced monitoring for mercury and uranium (weekly collection); weekly grab sample for zinc
Building 9201-2 WTS (BSWTS)	Reduce mercury levels to a level protective of a recreational receptor based on fish consumption	200 ppt mercury	WTS effluent discharge point	Quarterly grab samples for VOCs and semiannual monitoring for mercury and uranium
CMTS	Ongoing treatment of effluents from WEMA pending demonstration of effectiveness of remedy (hydraulic controls, capping)	200 ppt mercury	Outfall 551	Continuous flow-paced monitoring for mercury (minimum weekly collection frequency); continue current system performance monitoring as required by operations and maintenance specifications
East End Mercury Treatment System no longer operational	Treatment of effluents from Building 9201-2 sumps was tied-in to BSWTS December 2006	200 ppt mercury	Outfall 550 flow piped to the BSWTS in December 2006	Discontinued
WEMA	Protect recreational surface water users	Reduction by approximately 50% of mercury flux in WEMA outfalls. Reduction will be monitored in outfalls and is anticipated within one year of remediation.[a]	Outfalls 150, 160, 163, and 169a	Continuous flow-paced monitoring for mercury (minimum weekly collection frequency) prior to remediation
UEFPC and Lake Reality	Protect recreational surface water users	Reduction of 70% of Station 8 area ungauged mercury flux and up to 100% of ungauged mercury flux between Stations 8 and 17. Reduction will be monitored at Station 8 and Station 17 and is anticipated within one year of remediation.	Station 8 and Station 17	Grab samples at Station 8 weekly. Weekly monitoring at Station 17 for mercury.

Table 6.2. Performance measures for UEFPC watershed (cont.)

Site	ROD goal	Performance standard	Monitoring location	Schedule and parameters
Single – Project actions (Section 6.4)				
EEVOC Plume	Reduce risk from exposure in off-site areas and mitigate off-site migration of contamination.	No specific numeric performance standards established System performance: trend VOC concentrations downgradient of extraction well Treatment system discharge at downstream POC (LRBP-1) must not exceed AWQC recreational (for organism only) 16 µg/L carbon tetrachloride	Treatment system influent and effluent and LRBP-1 GW-722, GW-169 and GW-170	Quarterly grab samples of system influent/effluent for metals, VOCs, nitrate, and uranium Quarterly grab samples at LRBP-1 for VOCs Semiannual grab samples of downgradient wells for VOCs

[a]Baseline monitoring re-instated FY 2010.

AWQC = ambient water quality criteria
BSWTS = Big Spring Water Treatment System
CMTS = Central Mercury Treatment System
EEVOC = East End Volatile Organic Compound
FY = fiscal year
GW = groundwater well
LRBP = Lake Reality By-Pass
POC = point-of-compliance
ROD = Record of Decision
UEFPC = Upper East Fork Poplar Creek
VOCs = volatile organic compounds
WEMA = West End Mercury Area
WTS = Water Treatment System

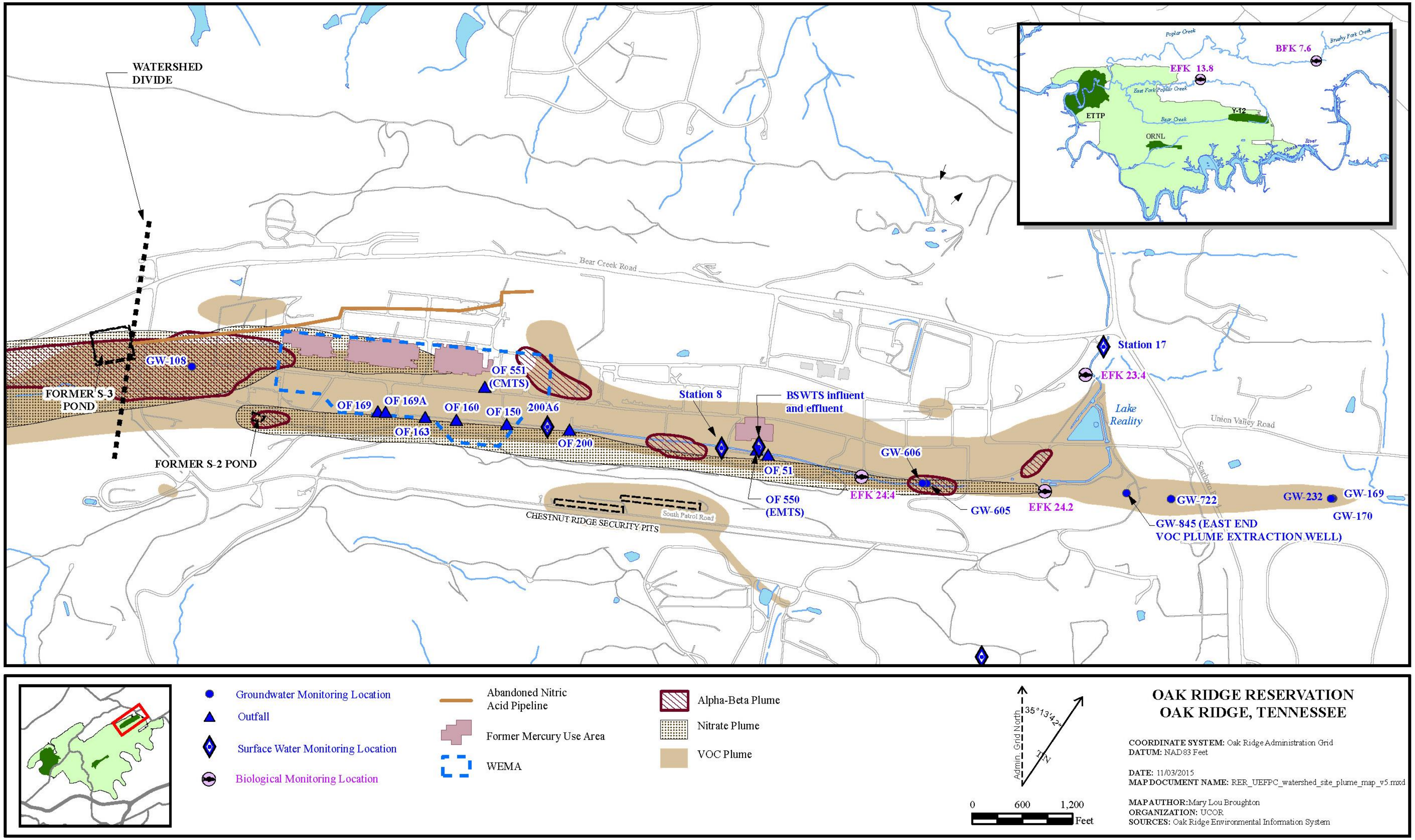

Figure 6.5. Monitoring locations in UEFPC watershed.

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6.2.1.2.1.2 Surface Water Monitoring Results

Mercury Treatment and Capture Systems Performance

DOE operates two mercury wastewater treatment systems in the UEFPC watershed (CMTS or Outfall 551) and BSWTS. Locations of these systems are shown on Figure 6.5. In addition to treatment of mercury in contaminated water, elemental mercury is captured from locations in the SD network in the WEMA.

Continued monitoring of effluent from the CMTS, which treats building sump discharges from the WEMA, is specified in the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) pending demonstration of the effectiveness of actions.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) states that the mercury limit for the CMTS is 200 ppt. The CMTS effluent discharges through Outfall 551. Effluent samples were collected from weekly composites at Outfall 551 and analyzed for mercury. In 2015, the average concentration of the CMTS effluent samples was less than the 200 ppt UEFPC goal for total mercury in surface water and the CMTS operated within the design and NPDES permit limits for the facility. Because of a 2005 accidental introduction of methanol from a leaking Alpha 5 cooling (brine) system that interfered with mercury treatment, a *Non-Significant Change to the Record of Decision for Phase 1 Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3/R2) was approved in May 2007 so that the CMTS no longer receives water from sump pumps located in the basement of Building 9201-5. The CMTS continues treatment of Building 9201-4 sump water (a much larger source of mercury). The CMTS experienced no downtime during FY 2015.

Extensive mercury contamination exists in the WEMA as a result of historic process leaks and spills. Some of the mercury remains in the soil as elemental mercury metal. Movement of elemental mercury in the soil can occur as a result of pore pressure changes related to groundwater level fluctuations and rainfall percolation processes. As the mercury moves downward and laterally, it seeps into the subsurface SDs through cracks and open joints. Once in the SDs, the mercury accumulates in low points and moves with the current of storm water. An estimated 114 g (0.25 lb) of elemental mercury was removed from SDs during FY 2015 by using a suction pump to remove visible mercury from a catch basin.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) states that approximately 25% of the mercury discharged from the site via the UEFPC originated from Outfall 51. The ROD further stipulated construction of a mercury water treatment system with a 300 gpm capacity and an effluent mercury concentration limit of 200 ppt. The main source of flow at Outfall 51 was Big Spring, located near the southeast corner of Building 9201-2. Mercury contamination within shallow groundwater beneath and adjacent to Building 9201-2 discharges at this spring. The source area extent that feeds Big Spring is not well understood and much of the flow and contamination is thought to originate from source areas to the west in the WEMA. At the time of Building 9201-2 construction in 1943, the spring discharge was captured within a brick enclosure (spring box) and directed to UEFPC via a drainpipe. In the latter part of FY 2005, Big Spring flow was routed to the new BSWTS during test and start-up operations. As a result, the flow at Outfall 51 decreased significantly. While it was anticipated that construction and operation of BSWTS would cut off flow to Outfall 51, during BSWTS construction it was discovered that, in addition to flow from the spring box, Outfall 51 also provides a conduit for drainage of the BSWTS area shallow subsurface flow.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) specifies a 0.2 µg/L (200 ppt) goal for mercury in BSWTS effluent. Outfall 51 and BSWTS effluent are separate monitoring locations. The BSWTS influent is grab sampled on a monthly frequency inside the treatment facility upstream of any treatment processes. BSWTS effluent is sampled using a continuous, flow-paced autosampler to obtain representative samples of the total effluent on a seven day integration basis. At Outfall 51 flow rate is monitored continuously and under baseflow conditions grab samples are collected monthly from the end of pipe. During prolonged rainy periods, often observed in winter, when the Outfall 51 flow rate is greater than 60 gpm, grab samples are collected on a weekly frequency from end of pipe to provide more data for mercury mass discharge from this area.

Figure 6.6 provides a comparison of mercury concentrations at Outfall 51 and the BSWTS effluent. During FY 2015, the average BSWTS influent concentration was about 4.4 µg/L. In FY 2015, the BSWTS treated approximately 96 million gal of contaminated water. Since July 2008, the BSWTS effluent is sampled continuously and weekly composite samples are analyzed for total mercury. The average mercury concentration in BSWTS effluent during FY 2015 was 0.029 µg/L, which is nearly an order of magnitude less than the 0.2 µg/L goal specified in the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3). None of the weekly composite samples exceeded the 0.2 µg/L effluent goal during FY 2015. The FY 2015 total mercury flux discharged in the treated BSWTS effluent was approximately 9.6 g. Based on comparison of the average influent and effluent mercury concentrations for FY 2015, the treatment effectiveness was 99%.

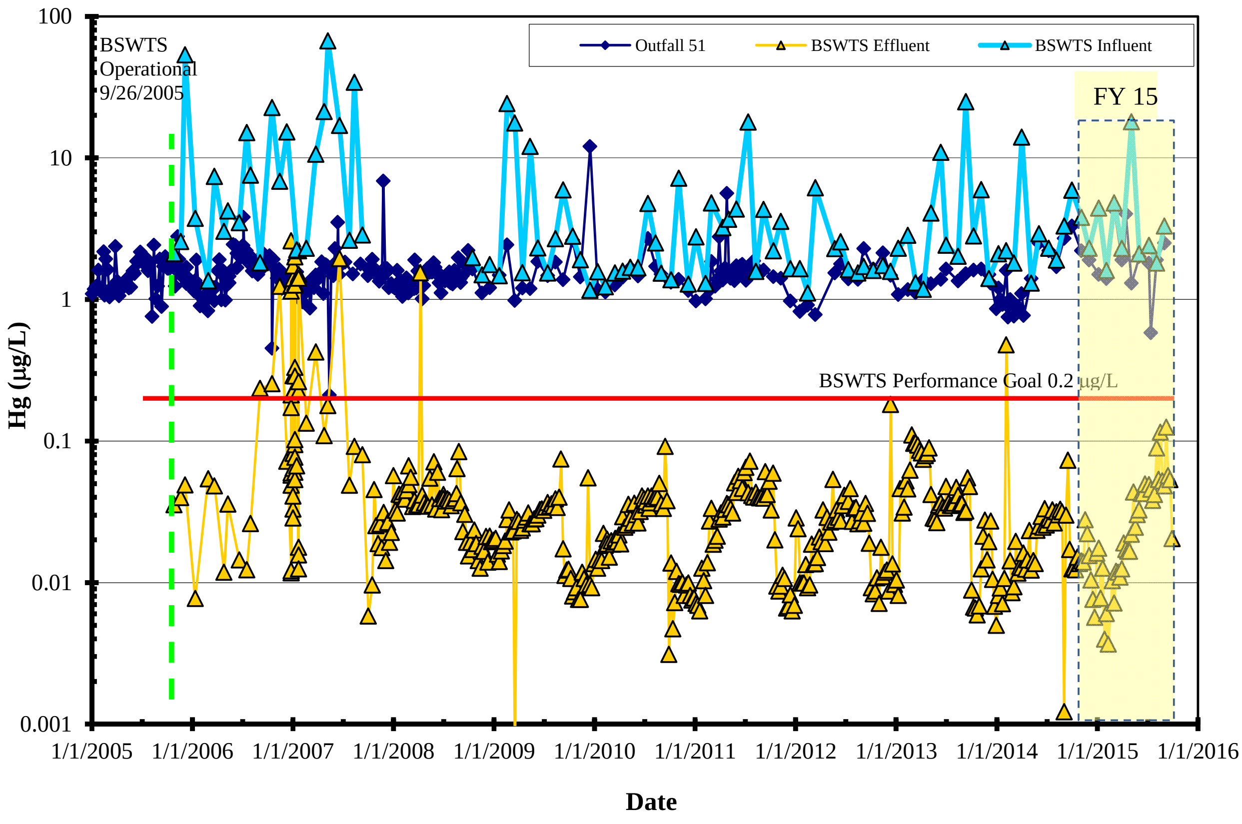


Figure 6.6. Mercury concentrations at Outfall 51 and BSWTS.

Since the BSWTS was designed to operate at a maximum capacity of 300 gpm, there are times during prolonged rainy periods when the system receives more inflow volume than can be treated. At those times there is treatment system bypass flow. Although such conditions can occur in any season, the majority of bypass flows occur during the winter and spring months when groundwater recharge amounts are greatest. During FY 2015 the annual rainfall total was slightly higher than the long-term average in Oak Ridge. The amount of inflow exceeded the system design treatment capacity during portions of FY 2015, which necessitated allowing bypass flows to occur during 30 weeks out of the year. The majority of bypass flows occurred during nine weeks in the months December, January, April, May, July, and August. The total discharge volume was 946,000 gal and the total measured bypass mercury discharge was about 4.5 g during the year.

During FY 2015, flow monitoring continued at Outfall 51 to measure wet season flows discharging from the outfall. Instantaneous flow measurements from Outfall 51 ranged from about 17 gpm in mid-September 2015 to about 180 gpm during mid-July. The total estimated mercury discharge from Outfall 51 during FY 2015 is estimated to be approximately 0.21 kg. The average mercury concentration from Outfall 51 was 2.2 µg/L during FY 2015, which is slightly higher than the average concentration during FY 2013 and FY 2014.

UEFPC Mercury Mass Balance

DOE operates continuous mercury monitoring systems at multiple locations in the UEFPC watershed including mercury treatment facility discharges, several manhole locations within the WEMA, and at instream locations in UEFPC (Figure 6.5). High level summary results of the mercury monitoring are provided in Table 6.3 which includes daily total mercury flux and total annual flux summaries.

Table 6.3. Summary statistics for daily mercury discharge from monitored locations in UEFPC watershed, FY 2015

Outfall	Median[a]	Mean[a]	Maximum[a]	Mercury flux[b]
169 / 169a[c]	1.2	2.2	25.4	803
163	1.4	1.7	8.9	625
160	0.4	0.5	1.6	176
150	0.57	0.89	8.18	327
Sum of WEMA Outfalls				1,931
200A6	3.74	5.96	54.9	2,176
51	0.41	0.57	1.7	207
BSWTS	0.02	0.026	0.094	9.6
BSWTS bypass flow (intermittent)	-	-	-	4.5
Station 8	8.3	10.2	51.4	3,713
Station 17[d]	7.25	22.3	700	8,138

[a]Values are g/d.
[b]Mercury flux is total g measured/estimated for FY 2015.
[c]OF169 sampling location was replaced by OF 169A located approximately 120 ft downstream in the SD pipe.
[d]EM operates continuous flow-paced sampling at a mid-channel location at Station 17.

BSWTS = Big Spring Water Treatment System
EM = Environmental Management
FY = fiscal year
SD = storm drain
UEFPC = Upper East Fork Poplar Creek
WEMA = West End Mercury Area

Since January 2010, flow-paced continuous sampling has been operated at five locations in the WEMA. In early January 2010, flow-paced continuous sampling devices became operational at Outfalls 150, 160, 163, and 169. These outfalls carry the principal WEMA drainages into the main SD pipes that discharge at Outfall 200 and make up the headwater of UEFPC. Continuous flow-paced monitoring at Outfall 200A6 has been implemented since the beginning of FY 2007. Outfall 200A6 is located in the main SD that carries discharge from the WEMA to the headwater of the UEFPC and the other outfalls are located to the west and upstream in the SD network (Figure 6.5). Outfall 200A6 serves as an integration point for contamination leaving the WEMA. During FY 2014 knowledge came to light that the OF169 sampling location was subject to bypass flows via an alternate branch of the SD system in that area. An alternate location designated as OF169A (shown on Figure 6.5) was selected to ensure that all stormwater from the far west end of the UEFPC SD networks is represented in composite samples. During FY 2015 there was duplicate flow-paced composite sampling conducted at both OF169 and OF169A from February 5 through June 24. The average mercury concentrations and flux rates obtained from both locations have been used in calculating the FY 2015 summary statistics for OF169A. Data from both monitoring locations are archived in the Oak Ridge Environmental Information System (OREIS).

During FY 2011, a major SD sediment removal and drain pipe repair project was conducted to remove accumulated sediment and repair deteriorated pipe sections in portions of the WEMA. The project field work occurred between late February and the end of September 2011. Coincident with work in the SDs there were increases in mercury concentration and flux at the WEMA manholes (Outfalls 150, 160, 163, and 169), at Outfall 200A6, and at Station 17. Monitoring conducted during FY 2015 shows that the daily mercury load decreased to the lowest level measured since the continuous monitoring at Outfall 200A6 started in FY 2007. Table 6.4 tabulates the median daily mercury load measured at Outfall 200A6 for the time period FY 2007 through FY 2015. The elevated mercury discharge during FY 2011 stands out in Table 6.4 as does the subsequent decrease which has continued through FY 2015.

Table 6.4. Median Daily Mercury Flux measured at Outfall 200A6

FY	Median Daily Mercury Discharge (g/d)
2007	4.7
2008	6.2
2009	7.3
2010	6.9
2011	13.8
2012	5.4
2013	5.9
2014	4.5
2015	3.7

FY = fiscal year

Table 6.3 includes summary statistical data for the amount of mercury measured at the four WEMA outfalls, Station 200A6, Outfall 51, Station 8, and Station 17. Median, mean, and maximum calculated daily mercury discharge masses are included as is the measured total mercury flux measured at each location during FY 2015. There is an obvious increase in the mercury flux from upstream to downstream from OF200A6 through the Station 8 site to Station 17. As surface water flows down the channel of UEFPC from Outfall 200 to Station 17, two significant processes affect the forms of mercury in the water column. The first of these processes is the adsorption of dissolved mercury onto sediment, both that

suspended in the water column and channel bottom and side sediment. The second process is scour of contaminated stream channel sediment with transport downstream and past Station 17. The results of these processes are exemplified in the data shown in Table 6.5. The frequency of detection of suspended sediment in the weekly composite samples at each location show that sediment transport out of the SDs is less frequent than the transport at the downstream locations. The average and maximum measured suspended sediment concentrations are variable among the sampling locations but the highest concentrations are measured at Station 17. The pattern of mercury concentration and distribution shows that average total mercury concentrations are lower at Outfall 200 than at the downstream monitoring locations and the percent dissolved mercury decreases significantly from approximately 60% at Outfall 200 to approximately 6% at Station 17. Just as there is an increasing particle association of mercury from Outfall 200 downstream to Station 17, there is an increase in flow volume attributable to both facility discharges and groundwater influx to the stream. The combined effects of the increased flow volume along with greater particle association of mercury and generally higher suspended solids load downstream is an increasing total mercury load in the UEFPC at Station 17 than at upstream monitoring locations. Inspection of the annual mercury flux column in Table 6.3 clearly shows this.

Table 6.5. Summary of suspended solids and mercury data at OF200A6, Station 8, and Station 17

Location	TSS No. detects / Number of samples	Average detected TSS (mg/L)[a]	Average of all TSS results (mg/L)[b]	Max TSS (mg/L)	Average total mercury (ng/L)	Average dissolved mercury (ng/L)	Percent dissolved mercury
OF200A6	32 / 54	27	18	110	916	556	61%
Station 8	50 / 53	16	15	49	1,003	137	14%
Station 17	51 / 54	33	32	300	1,030	59	6%

[a]Average of all detected TSS results that were greater than the detection limit.
[b]Average of all TSS results including non-detected results assumed to equal to the detection limit concentration (4 mg/L).

Max = maximum
TSS = total suspended solids

Figure 6.7 shows the relative contributions of mercury from WEMA Outfalls 150, 160, 163, and 169/169a to the sum of their mercury discharges.

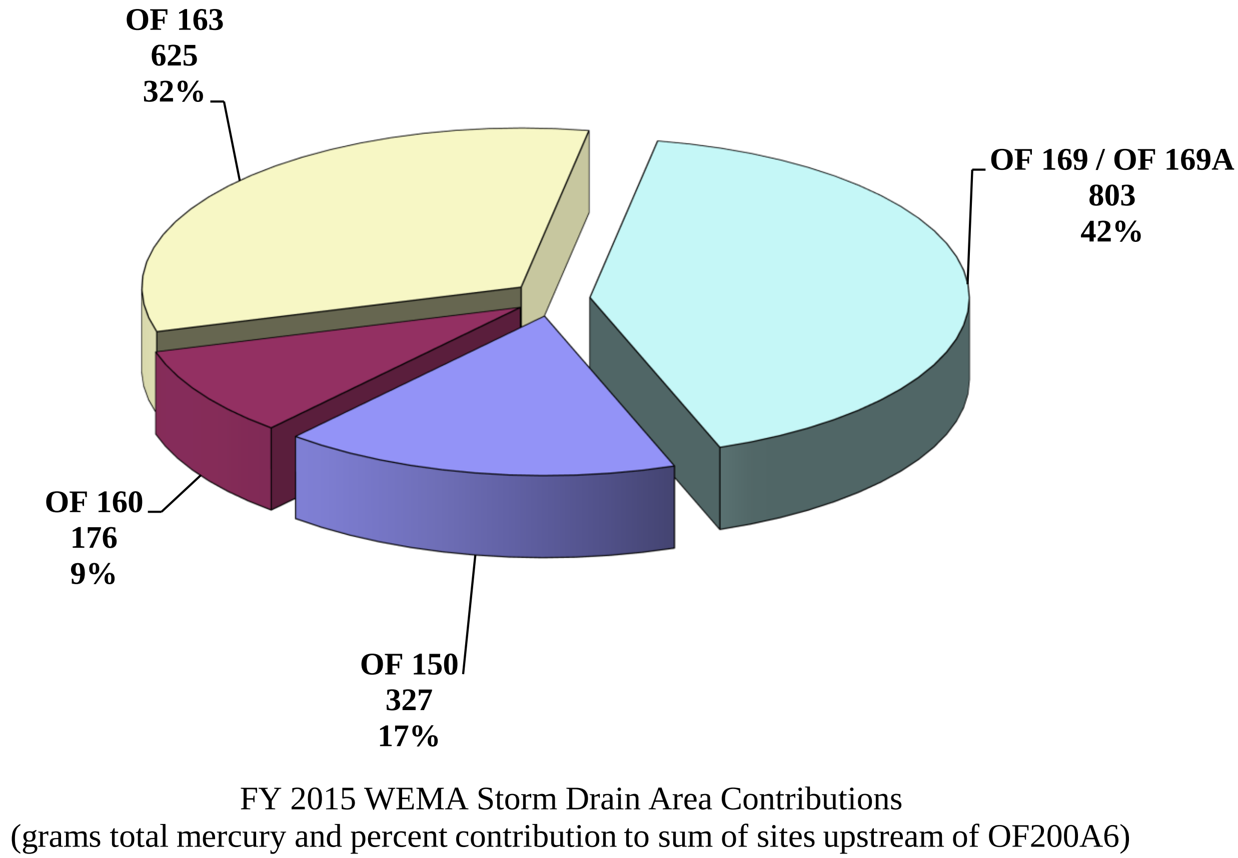


Figure 6.7. Relative contributions of mercury from WEMA SD outfalls.

Figure 6.8 shows the FY 2015 weekly mercury concentration, daily rainfall and average flow rate, along with the calculated daily mercury discharge at Outfall 200A6. Total mercury concentration hovered in the range of 800 – 1,000 ppt with concentration spikes typically coinciding with intense rainfall periods. The mercury discharge behavior exhibited during FY 2015 was typical of pre-SD cleanout conditions.

Month	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Total
Hg Fux (grams)	218	86	145	149	323	308	232	88	130	224	111	162	2,176

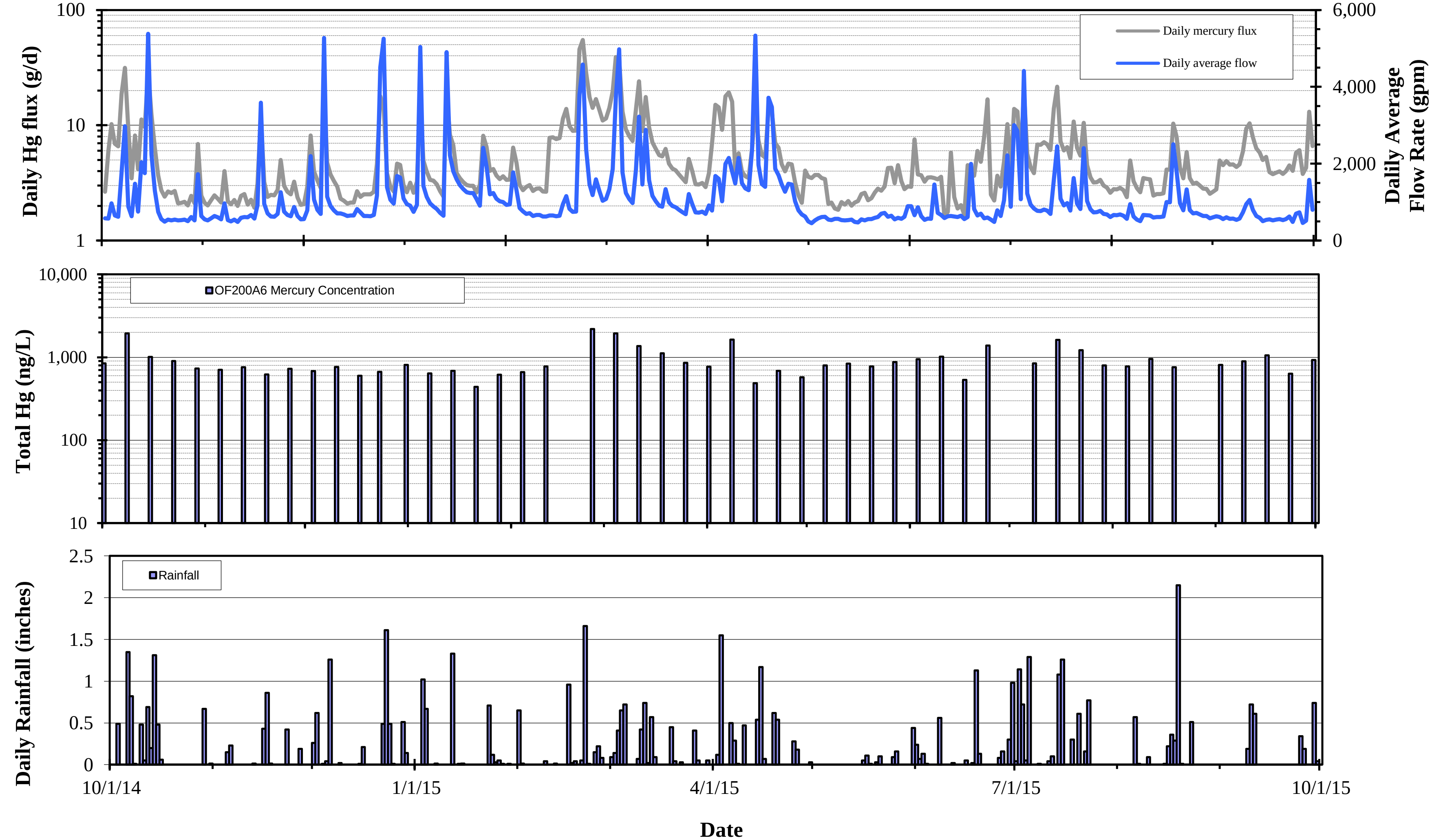


Figure 6.8. OF200A6 mercury discharges during FY 2015.

Integration Point Monitoring Results at Station 417

Station 17 is the integration point where the stream leaves Y-12 and DOE property. The UEFPC watershed remediation goals focus on reduction of mercury in surface water in and downstream of Y-12. Uranium and zinc are also contaminants of concern in the UEFPC surface water.

Figure 6.9 shows the Station 17, daily average flow and mercury flux calculated as the flow-weighted fraction of the weekly total mercury concentration (top graph), weekly total mercury concentration (middle graph), and daily rainfall (bottom graph) for FY 2015. Also noted on the center graph panel is the 200 ppt ROD goal for total mercury concentration at this location. Several of the weekly composite samples had total mercury concentrations less than the 200 ppt ROD goal level although the annual average concentration from the composite samples was 1,030 ppt. Total mercury concentrations and calculated daily fluxes during FY 2015 decreased compared to levels measured during FY 2014.

Annual fluxes and average concentrations of uranium and mercury at Station 17 from FY 2000 through FY 2015 are listed in Table 6.6. Figure 6.10 is a graph of annual average mercury concentrations and fluxes and uranium fluxes at Station 17. The decrease in annual average total mercury concentration at Station 17 from 2012 through 2015 in the EM Program data demonstrate that the effects of the FY 2011 mercury discharges from Outfall 200 associated with the SD cleanout work are subsiding.

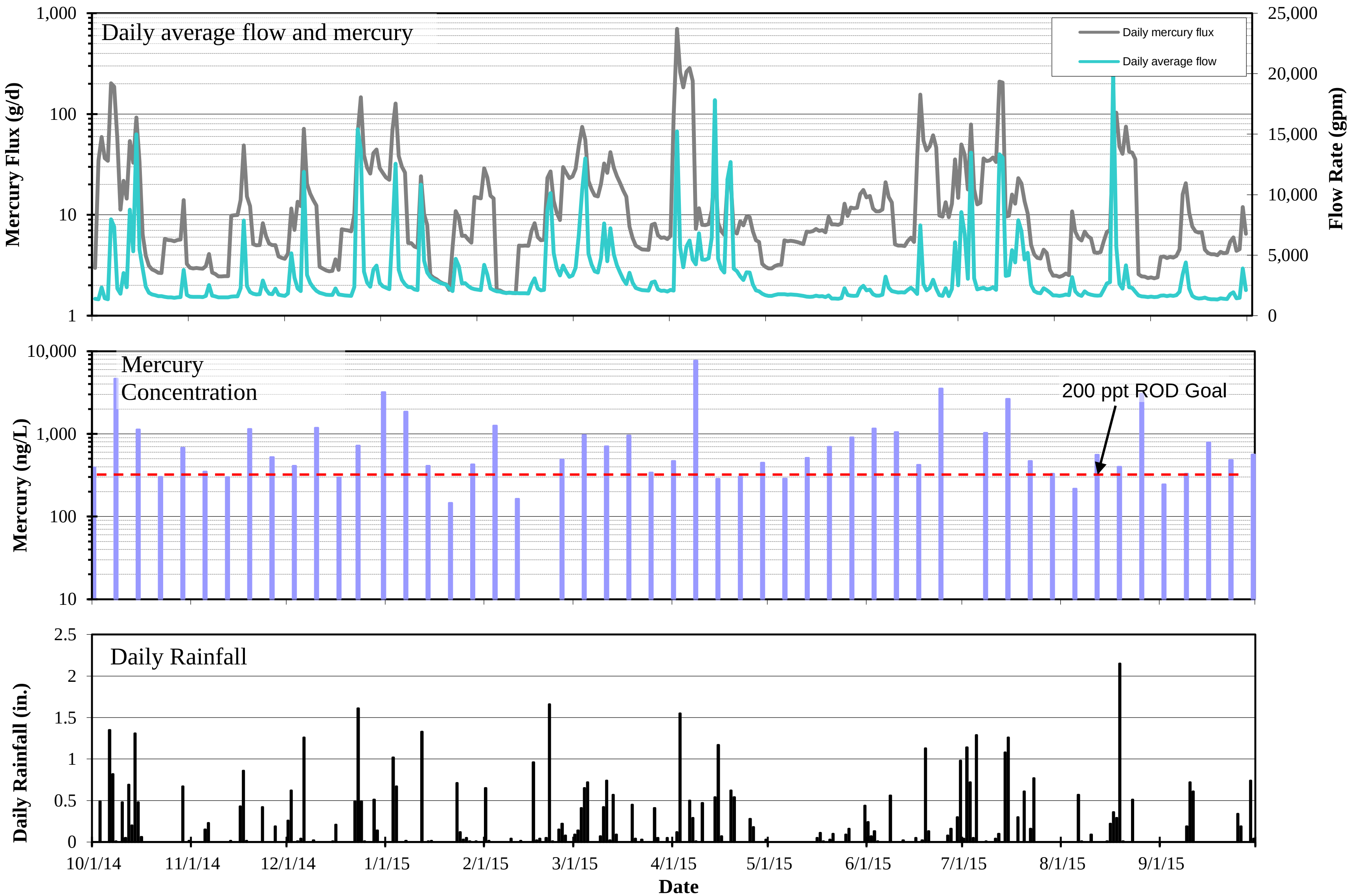


Figure 6.9. Summary of FY 2015 mercury discharge data for Station 17.

Table 6.6. Annual uranium and mercury fluxes[a] and average concentrations at Station 17

Date	Mercury flux (kg)[b]	Average mercury (µg/L)[b, c]	Uranium flux (kg)[d]	Average uranium (mg/L)[d]	Annual rainfall (in.)[e]
2000	12.0	**0.746**	143	0.012	52
2001	9.4	**0.638**	85	0.007	45.98
2002	7.3	**0.536**	172	0.014	52.67
2003	8.8	**0.597**	148	0.011	73.73
2004	8.2	**0.524**	119	0.010	56.38
2005	14.6	**0.742**	157	0.012	58.96
2006	4.0	**0.328**	89	0.008	46.42
2007	4.0	0.198	86	0.007	36.26
2008	2.7	**0.221**	98	0.009	46.02
2009	3.9	**0.273**	177	0.014	62.5
2010	7.0	**0.476**	198	0.016	55.8
2011	12.2 / 24[d]	**0.817 / 1.66**[d]	173	0.013	60.4
2012	11.1 / 21.5[d]	**0.880 / 1.78**[d]	161	0.014	61.8
2013	5.2 / 20[d]	**0.413 / 1.71**[d]	181	0.015	63.7
2014	14.4[d]	**1.49**[d]	120	0.012	48.8
2015	8.1[d]	**1.03**[d]	178	0.025	55.9

[a]*Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) flux goals for uranium and mercury at Station 17 do not exist.
[b]Reported value is for NPDES reported seven day continuous flow-paced samples unless indicated otherwise.
[c]**Bold** values exceed *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) mercury concentration goal of 200 ppt (0.2 µg/L) for Station 17.
[d]Reported mercury and uranium results are from composite samples collected and analyzed by EM Program.
[e]Average annual rainfall = 54 in.

EM = Environmental Management
NPDES = National Pollutant Discharge Elimination System

The daily mercury flux measured at Station 17 from FY 2000 through FY 2015 has been examined to determine the differences between the years pre- and post-startup of the BSWTS and to show the changed conditions during and after the FY 2011 SD cleanout project. All the calculated daily mercury flux results were ranked and cumulative distribution datasets were created. Figure 6.11 shows the results of this data evaluation. The average and standard deviation of ranked daily flux for the pre- and post-BSWTS time periods are shown along with the FY 2011 through FY 2013 NPDES and EM daily flux data. The NPDES data set shows median daily mercury flux at Station 17 from FY 2000 through FY 2005 was 11.4 g/d and the median for FY 2006 through FY 2010 was 7.0 g/d. The data from the two time periods show a separation from the lowest fluxes to about the 80th percentile, above which the separation diminishes. At daily flux values above the 95th percentile overlap occurs because of high daily fluxes observed during FY 2010. The FY 2011 through FY 2013 NPDES data show the increase in mercury flux with a median value similar to the pre-BSWTS median value and maximum values at the upper end of the distributions measured during FY 2000. The FY 2011 through FY 2013 EM data also show the effects of higher concentrations measured in the EM samples. The FY 2014 data showed that the mercury discharge behavior remained higher than prior to the SD cleanout project. The FY 2015 data show that the mercury discharges are approaching pre-SD project levels for the median and lower levels but remain somewhat elevated with respect to the pre-SD project levels. The FY 2015 Station 17 median daily mercury flux of

7.25 g/d is quite close to the 2006 – 2010 post-BSWTS but pre-SD project value of 7.0 g/d. The current NPDES Permit for the Y-12 facility does not require continuous mercury monitoring by the Y-12 Environmental Compliance Program and therefore the EM monitoring data is used to assess site conditions.

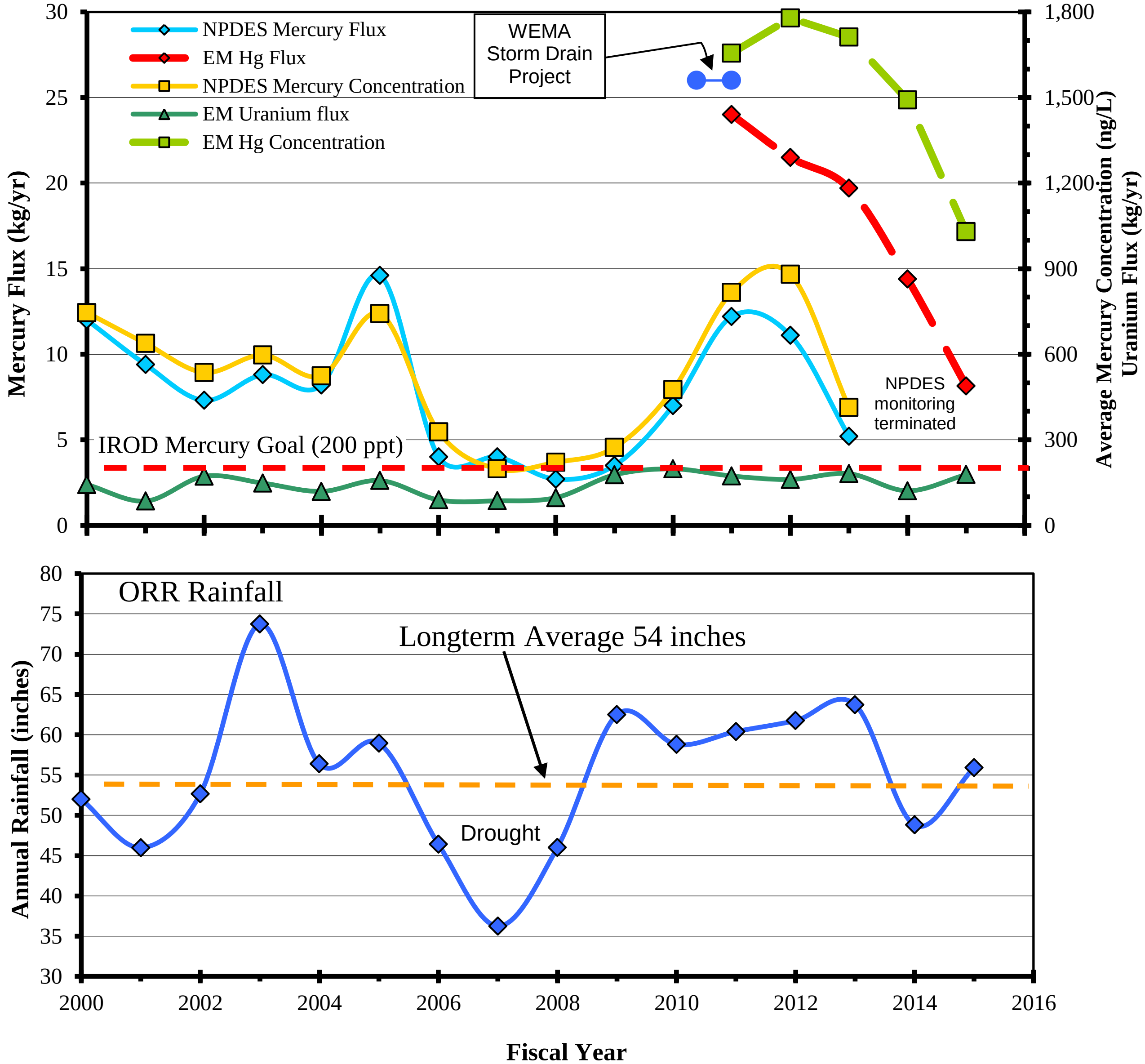


Figure 6.10. Annual mercury and uranium fluxes at Station 17 and annual rainfall.

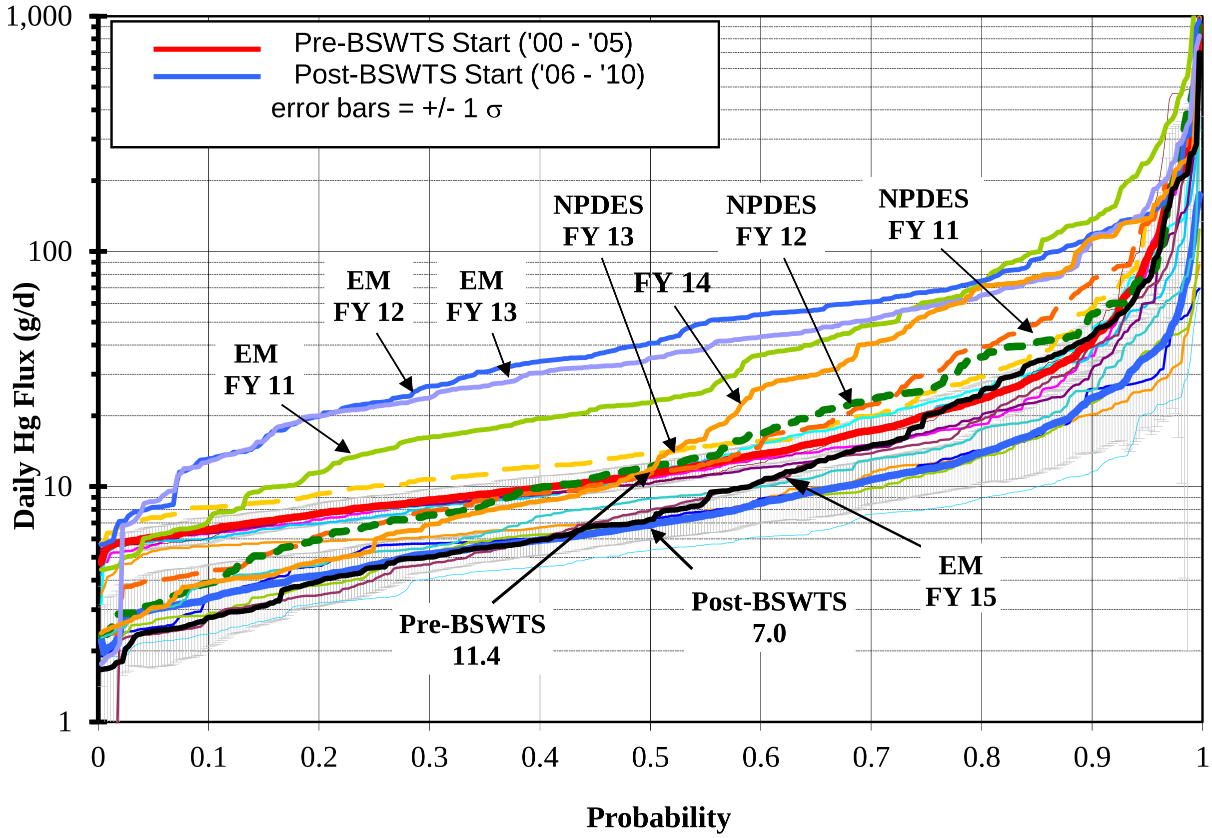


Figure 6.11. Pre- and post-BSWTS startup mercury daily flux at Station 17.

Contaminants of concern in the UEFPC watershed also include zinc and uranium. Areas of radiologically contaminated groundwater in the UEFPC Watershed are shown on Figure 6.5. Areas of uranium contamination in groundwater (alpha activity plumes) and combined uranium/technetium (alpha/beta activity plumes) are shown. Uranium contamination in the UEFPC originates from groundwater seepage and storm water transport of surface contamination in Y-12. Groundwater contamination in the WEMA is a source of uranium flux at Outfall 200A6. Other significant source of uranium located in the eastern end of Y-12 that may enter UEFPC are the former Oil Skimmer Basin located adjacent to the original UEFPC channel in the eastern end of the plant area, an unknown source adjacent to wells GW-605/606, and the Uranium Oxide Vault/Building 9418-3. As shown in Table 6.6 and Figure 6.10, the uranium flux and average concentrations measured at Station 17 during FY 2015 increased somewhat in comparison to the lower quantity measured during FY 2014. The annual uranium flux is generally proportional to annual rainfall with higher uranium fluxes occurring during years of higher rainfall. The average uranium concentration measured at Station 17 in FY 2015 was about 25 µg/L. During FY 2015, 13 of the uranium concentrations in the weekly composite samples exceeded the 30 µg/L MCL (for UEFPC surface water, the uranium MCL is used only as a screening level). The maximum detected uranium concentration was 127 µg/L which was measured on December 3, 2014.

Zinc was analyzed in weekly grab samples collected at Station 17 during FY 2015 for comparison to the AWQC (120 µg/L). Zinc was not detected in four of the 52 weekly samples. The average detected zinc concentration during FY 2015 was 20 µg/L, and the maximum detected zinc concentration was 92 µg/L. None of the zinc samples exceeded the AWQC.

6.2.1.2.2 Groundwater

The *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant* (DOE/OR/01-1641/V1-V4&D1) estimated that groundwater contamination underlies about half of the industrial portion of the UEFPC watershed, and VOCs, radionuclides, nitrate, and metals are the prevalent groundwater contaminants. Figure 6.5 shows the UEFPC groundwater contaminant plume map that shows several areas of VOC and radiological contamination, as well as monitoring locations. Well GW-108 is a 58 ft deep well located in the eastern portion of the S-3 Ponds Plume. Figure 6.12 shows analytical results for ^{99}Tc and nitrate in well GW-108. These contaminants, which far exceed their drinking water MCL or MCL-DC (10 mg/L MCL for nitrate and 900 pCi/L MCL-DC for ^{99}Tc), originate from the S-3 Ponds in a low pH plume finger that seeps eastward into the UEFPC watershed. The nitrate concentrations are undergoing a long-term decreasing trend with one obvious outlier datapoint in 2005. The ^{99}Tc activities are also showing a decreasing trend since the summer of 2010.

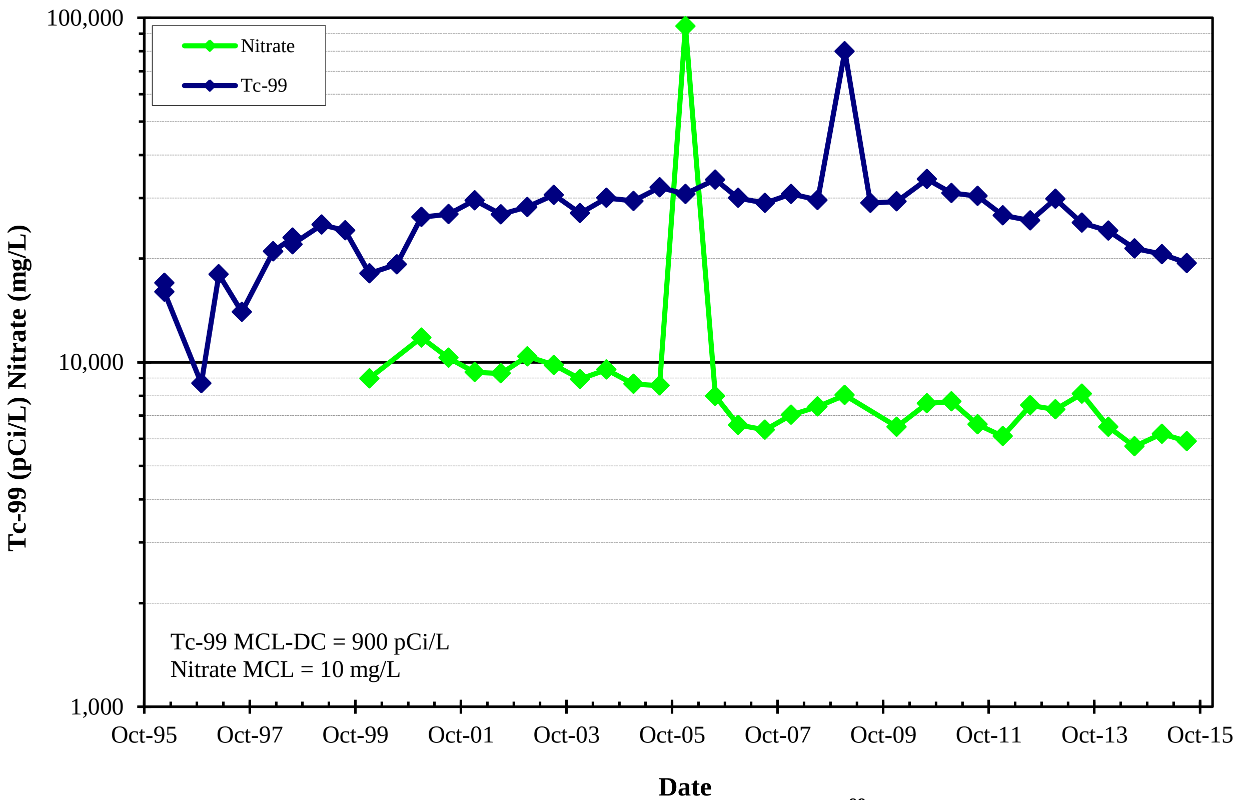
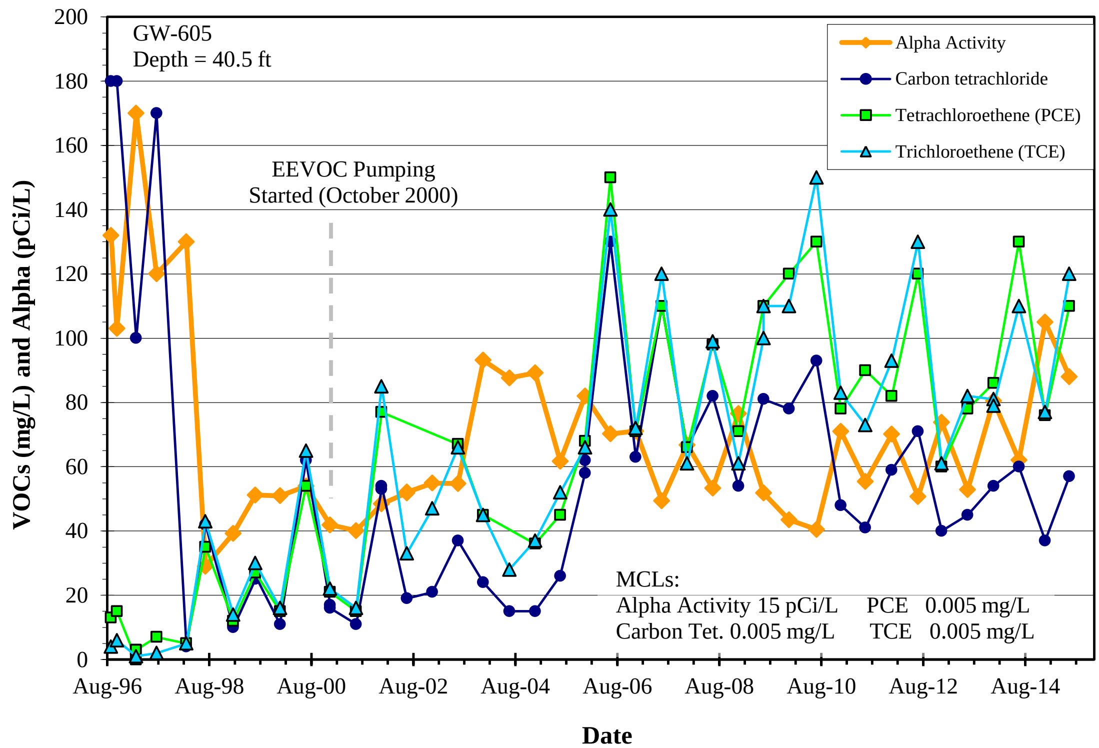


Figure 6.12. Well GW-108 nitrate concentration and ^{99}Tc activity.

Wells GW-605 and GW-606 are located in the Maynardville Limestone exit pathway upgradient of the EEVOC plume interception and treatment system (Figure 6.5). Well GW-605 is a relatively shallow well (40.5 ft deep), while GW-606 is deeper (175 ft deep). Figure 6.13 shows concentrations of signature contaminants in wells GW-605 and GW-606. These wells are located near the upgradient edge of the capture zone for the EEVOC pump and treat system and the date of startup of that groundwater remediation system is shown on Figure 6.13. Although cause and effect of variations in contaminant levels in the wells are not positively confirmed, some of the contaminant signatures appear to be influenced by possible changes in groundwater flow paths associated with establishment of the pump and treat system capture zone.



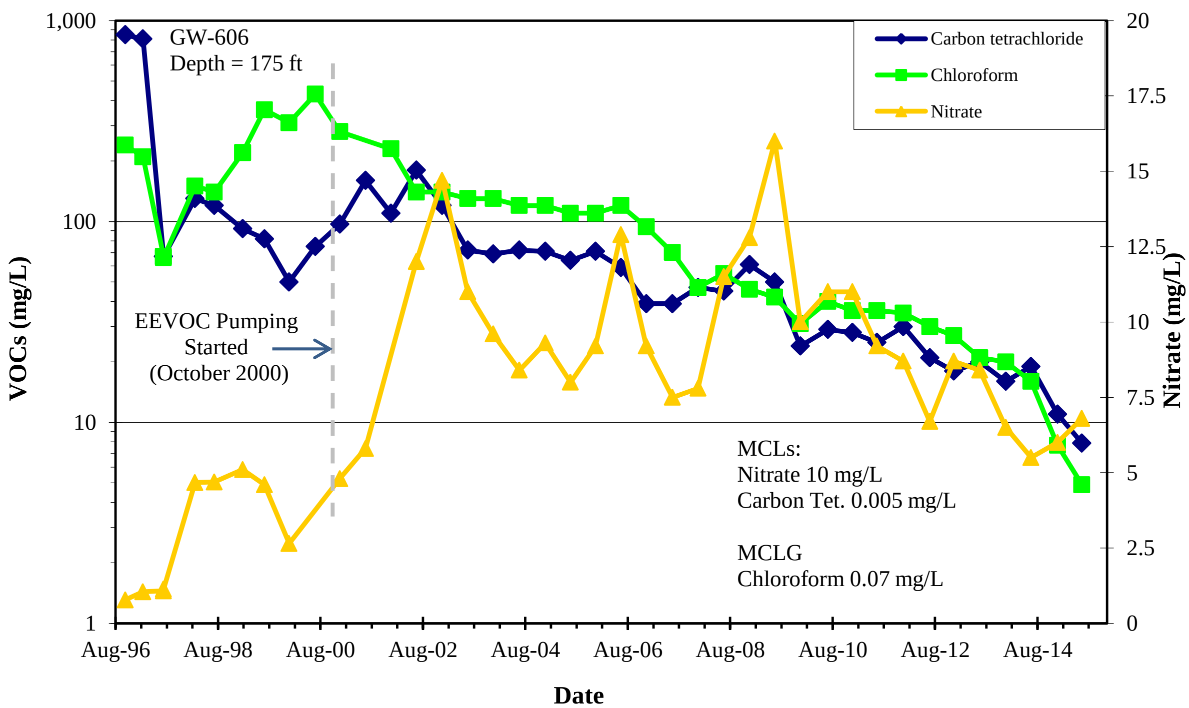


Figure 6.13. Wells GW-605 and GW-606 signature contaminant concentrations.

The alpha activity in well GW-605 is attributed to uranium which was present in the well at concentrations of approximately 200 µg/L in FY 2015. The concentration behavior of three chlorinated VOCs, carbon tetrachloride, PCE, and TCE in well GW-605 show that a significant increase occurred in the summer of 2006 followed by somewhat erratic concentration fluctuation. The cause of the significant increase in 2006 is not known although deactivation and demolition of facilities in the area may be related to a change in groundwater conditions. Well GW-605 is sampled semiannually with samples typically collected in January and July. Samples collected during the summer typically have higher VOC concentrations than those collected during the winter. Prominent July peaks of concentration have been observed in 2006, 2007, 2010, 2012, 2014, and 2015. This pattern of higher versus lower concentrations suggests winter season dilution of groundwater in the vicinity of this well. Since the alpha and VOC concentration fluctuation patterns are opposite one another in the seasonal sense it is probable that the uranium, which causes the alpha signal originates from shallower contamination that is mobilized during winter groundwater recharge events, while the VOCs originate from a different groundwater source that exhibits a dilutional response during the winter higher groundwater recharge season.

At well GW-606, concentrations of carbon tetrachloride and its degradation product chloroform have decreased since the EEVOC plume collection and treatment started operation in FY 2000. Nitrate was present in well GW-606 prior to initiation of groundwater withdrawal and treatment. As shown in Figure 6.13, the nitrate concentration increased after groundwater withdrawal started and has fluctuated in concentration between 8 and 16 mg/L. Since January 2011, nitrate in GW-606 has been measured at concentrations less than the 10 mg/L MCL, and concentrations have decreased to less than 7 mg/L as of the summer of 2015. During FY 2015, well GW-606 contained 5 to 7 µg/L of uranium and PCE was present at 3.7 – 4.7 µg/L. TCE was not detected during FY 2015 although it has been present historically. Like the VOCs detected in well GW-605, the nitrate contamination represented by the GW-606 data is thought to be captured in the zone of influence of the EEVOC treatment system. Section 6.4.1 presents performance monitoring data relevant to the Y-12 EEVOC plume removal action that includes annual nitrate and uranium data.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) did not specify target groundwater contaminant levels or other ARAR-based performance criteria for groundwater; SDWA MCLs are used as screening criteria to evaluate performance.

6.2.1.2.3 Aquatic Biology

Bioaccumulation of contaminants of concern in fish and stream ecological health has been monitored in UEFPC since 1985. Data collected on contaminant bioaccumulation and the composition and abundance of communities of aquatic organisms provide direct evaluation of the effectiveness of abatement and remedial measures in improving ecological conditions in the stream (Peterson et al., 2011). For the last 10 years, the bioaccumulation studies have been augmented by twice yearly monitoring of aqueous mercury concentrations and speciation at sites throughout the length of UEFPC.

Aqueous mercury concentrations at Station 17 have fluctuated significantly in recent years. During the 1990s, concentrations decreased drastically, eventually leveling off at approximately 0.4 µg/L by the early 2000s. After the implementation of the BSWTS in 2007, aqueous concentrations dropped again, reaching a new "baseline" of approximately 0.30 µg/L that lasted until 2010. Following WEMA SD clean-out activities beginning in 2010, average aqueous mercury concentrations increased sharply, peaking at approximately 0.93 µg/L in the spring of 2011. For the past three years, concentrations at this site have significantly decreased, approaching concentrations comparable to those prior to the SD clean out activities (Figure 6.14). Mean concentrations in the spring of 2014 were approximately 0.27 µg/L, approaching the 0.2 µg/L ROD performance goal.

Despite the substantial fluctuations in aqueous mercury concentrations seen at Station 17 in recent years, mercury concentrations in rock bass collected at this site (i.e., EFK 23.4) have not fluctuated accordingly, but remained comparable to concentrations seen in recent years (Figure 6.14). However, redbreast collected from EFK 23.4 and at the EFK 24.2 sampling site, approximately 1 km upstream of Station 17, appear to have responded to the recent peak and decline in aqueous mercury concentrations. Mean concentrations at EFK 24.2 increased from approximately 0.6 µg/g in 2011 to above 1 µg/g in 2012, and then decreased back down to approximately 0.65 µg/g in 2015 (Figure 6.15). That this species appears to have responded to changes in water mercury concentrations in the upper reaches of the creek is interesting, given they have not responded to decreases in aqueous total mercury concentrations at downstream sites throughout East Fork Poplar Creek in the past 20 years. So far, fish mercury concentrations appear to be stable after flow augmentation shutoff in spring 2014.

In April 2014, flow augmentation, which had been in place since the late 1990s was discontinued. Flow management was instituted in EFPC in 1997 in response to a significant drop in baseflow as a result of reductions in the volume of discharge from the Y-12 Complex starting in the mid-1980s. Flow management was a negotiated agreement with TDEC to improve stream conditions for aquatic life in the stream. To augment the flow in the upper reaches of EFPC, water was pumped from the Clinch River at Melton Hill Reservoir to a site in upper EFPC approximately 15 m below Outfall 200 to maintain a minimum flow at Station 17 near the boundary of the Y-12 Complex as required by the facility's NPDES Permit. While there have been measurable changes in dissolved mercury concentrations throughout the creek since the shut off of flow augmentation, so far, fish mercury concentrations appear to be stable. Future monitoring will tell whether the reduction in flow in the upper reaches of EFPC will affect mercury bioaccumulation throughout the creek.

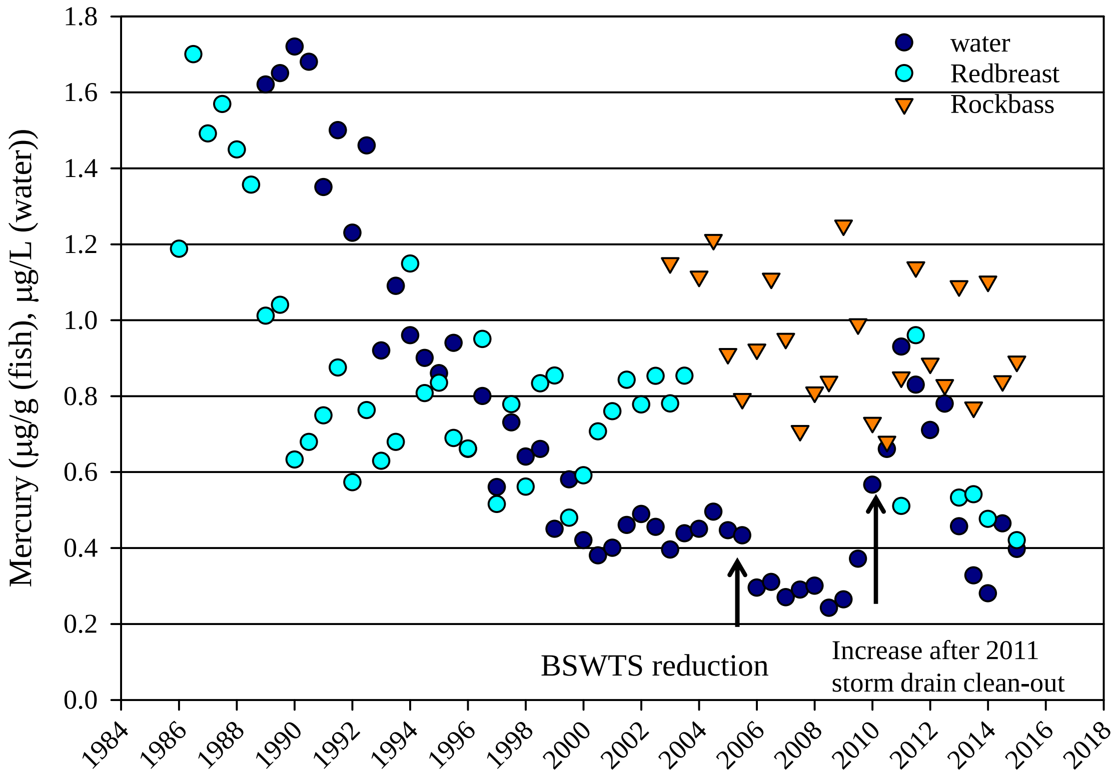


Figure 6.14. Mean concentration of mercury in redbreast sunfish and rockbass fillets at EFK 23.4 versus trailing 6 mo. mean concentration of mercury in water.

BSWTS = Big Spring Water Treatment System

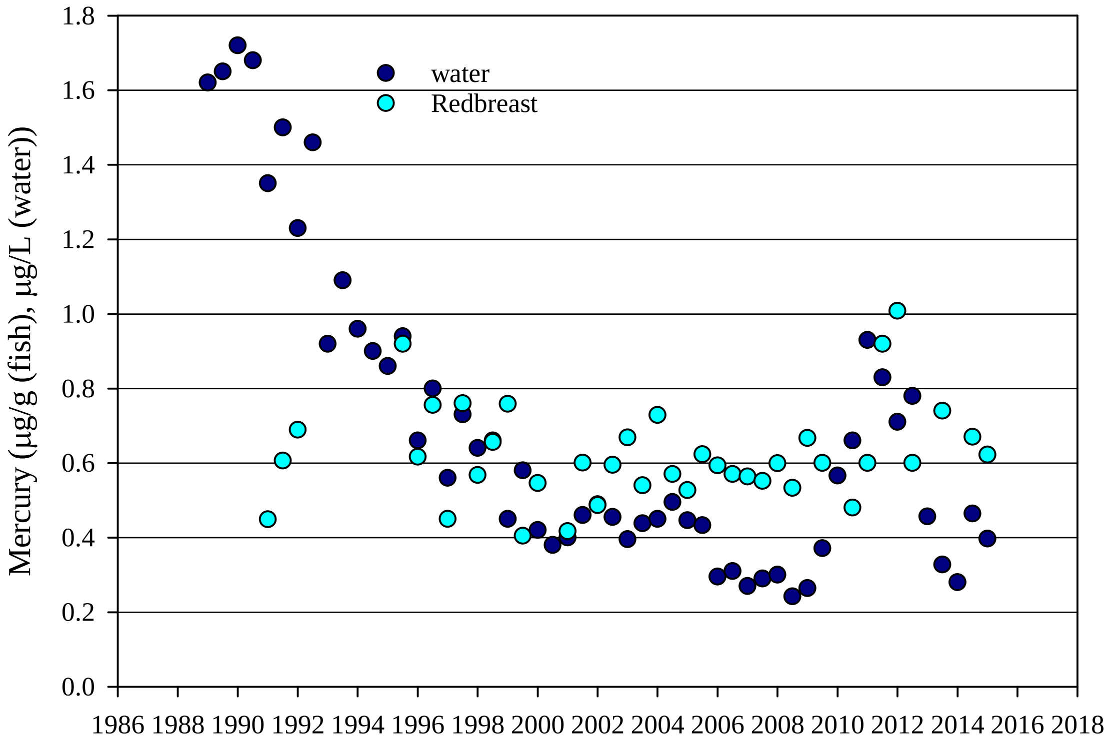


Figure 6.15. Mean concentration of mercury in redbreast sunfish fillets at EFK 24.2 versus trailing 6 mo. mean concentration of mercury in water at Station 17 (EFK 23.4).

The relationship between aqueous total mercury concentrations and fish tissue concentrations is complex. A recent study examined the relationship between aqueous total mercury and mercury in fish from three mercury contaminated streams on the ORR (East Fork Poplar Creek, WOC, and Mitchell Branch) and one reference site (Hinds Creek) (Mathews et al., 2013). This study reported a non-linear relationship between water and fish tissue concentrations, and suggested a threshold aqueous mercury concentration above which fish do not respond. However, because mercury is predominantly accumulated through the food chain rather than through aqueous exposure, understanding food web structures and transfer pathways for mercury to fish is a key component critical to identifying strategies to mitigate mercury bioaccumulation. Uptake at the base of the aquatic food chain (algae/periphyton, invertebrates) is the most important concentration step for mercury into the aquatic food chain (with mercury concentrating over 10,000-fold between water and algae) but, while the relationship between mercury concentrations in water and fish has been characterized, the transfer pathways from the base of the food chain remain largely unknown. As part of the Technology Demonstration mercury project, future work will focus on quantifying the trophic transfer efficiency of mercury through the EFPC food chain and identifying the critical linkages for mercury transfer to fish.

Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused TMDLs, including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the state of Tennessee, assessments of impairment for water body segments as well as public fishing advisories are based on fish tissue concentrations. Historically, the FDA threshold limit of 2 µg/g PCBs in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. The remediation goal for fish fillet at the ETTP K-1007-P1 Pond is 1 µg/g PCBs. Most recently, the water

quality criterion has been used to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2007), and this concentration is 0.02 mg/kg PCBs in fish fillet (TDEC 2010a,b,c). TMDLs are used by TDEC to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in UEFPC, at approximately 0.5 mg/kg in fish fillet, are well above this concentration.

Because the consumption of contaminated fish represents the largest dose of many bioaccumulative contaminants to humans, fish fillet concentrations are relevant to assessing human health risks, while whole body fish are relevant to assessing ecological risks. In EFPC, whole body forage fish (largescale stonerollers) and fillets of sunfish were analyzed for PCBs. Mean PCB concentrations in whole body composites of stoneroller minnows at EFK 24.4 decreased from 2.76 $\pm$ 0.12 µg/g in 2014 to 2.39 $\pm$ 0.24 µg/g in 2015. The mean whole-body concentration in 2015 exceeds the whole body fish remediation goal of 2.3 µg/g agreed to by EPA and TDEC and established for ETTP's K-1007-P1 Pond (DOE/OR/01-2456&D1/R1). Total PCB concentrations in sunfish fillets at EFK 23.4 decreased significantly in 2015 (0.56 µg/g), remaining comparable to recent years and much lower than the peak levels observed in the mid-1990s (Figure 6.16).

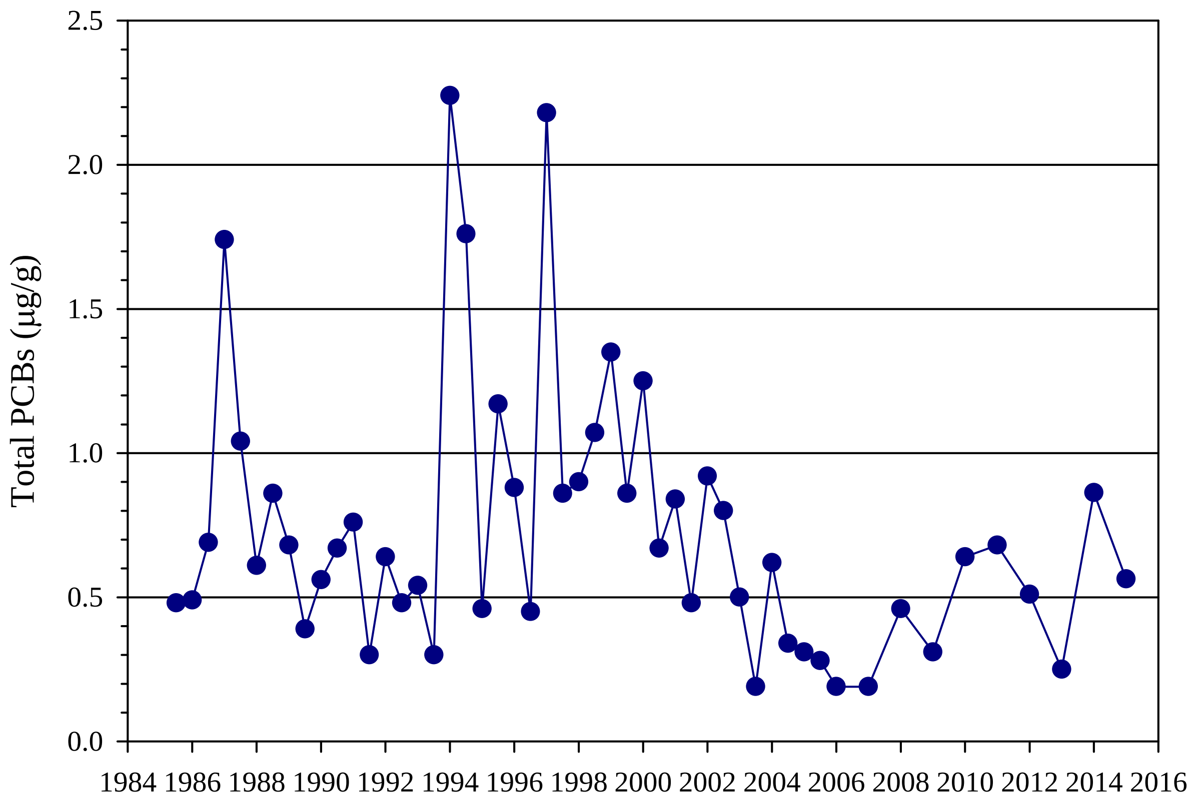


Figure 6.16. Mean concentrations of PCBs in redbreast sunfish and rockbass at EFK 23.4, 1985 – 2015.

After substantial increases in fish species richness (number of species) at EFK 23.4 in the late 1980s and early to mid-1990s, the number of fish species has experienced moderate fluctuations and little overall growth. In recent years, there has been a slight increase in fish richness values at EFK 23.4, however, the species richness remains below comparable reference fish communities (Figure 6.17). UEFPC has experienced occasional fish kills since 2011, which could be influencing the ability of new species to colonize this area. In contrast, the species richness of the fish community further downstream at EFK 13.8

has continued to improve since the late 1980s, and now routinely meets or exceeds richness at the reference site. The improvement at EFK 13.8 includes more sensitive species, such as darters and suckers, but the density of these sensitive species is still below reference values while the density of more tolerant species remains high. Recent collections (since 2012) appear to be on a decreasing trend at both sites, but whether that reflects change in water quality or short-term natural variability in unknown. Sampling in the near future will help elucidate whether actions such as removal of flow augmentation in the spring of 2014 have influenced the fish community EFPC sites.

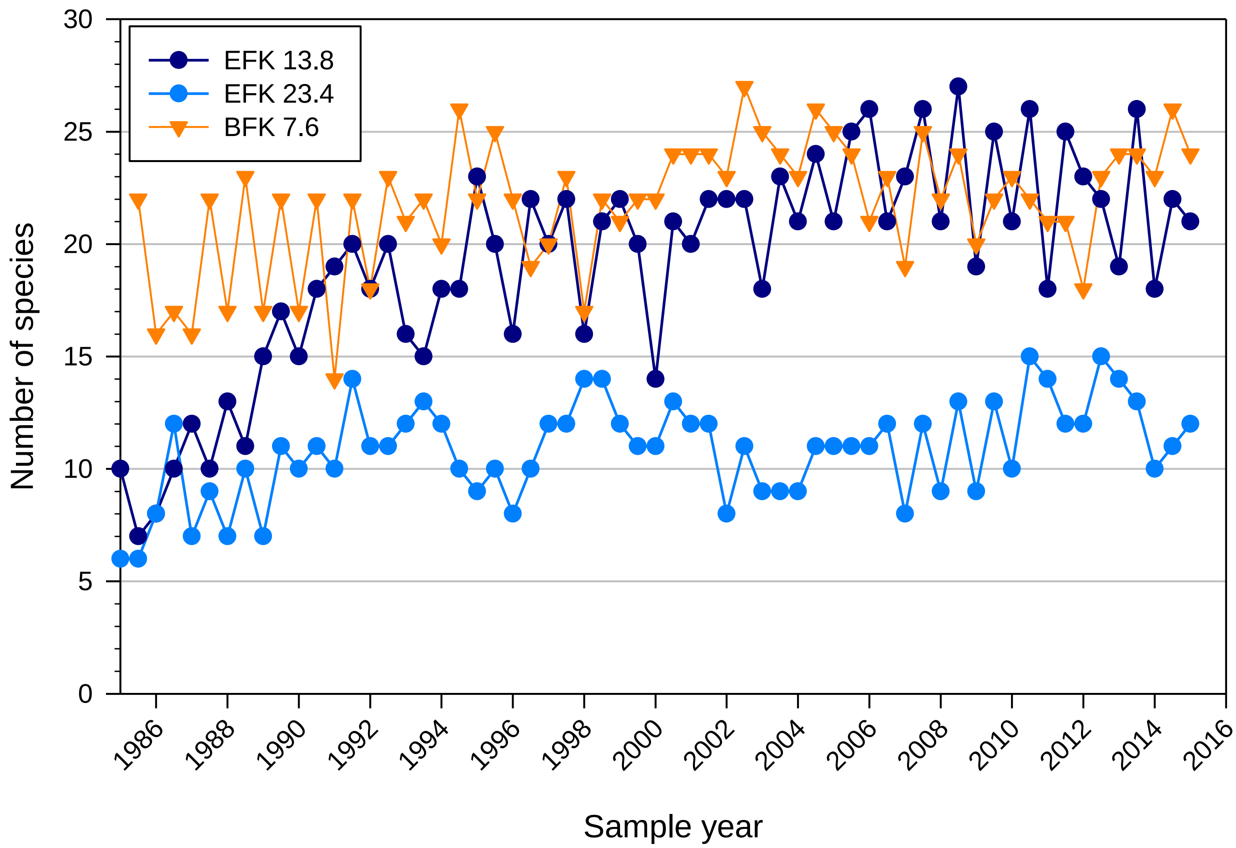


Figure 6.17. Species richness (number of species) in samples of the fish community at two sites in East Fork Poplar Creek and a reference stream, Brushy Fork, 1985 – 2015.

Declines were observed in taxonomic richness of the pollution-intolerant benthic macroinvertebrates (i.e., EPT taxa richness) at all sites in April 2015, but values from each site were still within their respective historic ranges since the mid-2000s (Figure 6.18), indicating that conditions at all three sites remain relatively stable. Even with the lower EPT taxa richness estimates in 2015, results for EFK 23.4 continued to suggest that further recovery has occurred at that site after 2006. Possible factors contributing to the lower values in 2015 include 1) the occurrence of several notable rain events in the three weeks prior to sample collection that may have scoured the substrate and negatively affected the invertebrate community, 2) less flow and water chemistry changes associated with flow augmentation shut off in May of 2014 (the 2014 invertebrate sampling was before flow cutoff), and 3) simply natural annual variation. Longer-term sampling will help elucidate if recent changes are of short duration or a more lasting trend.

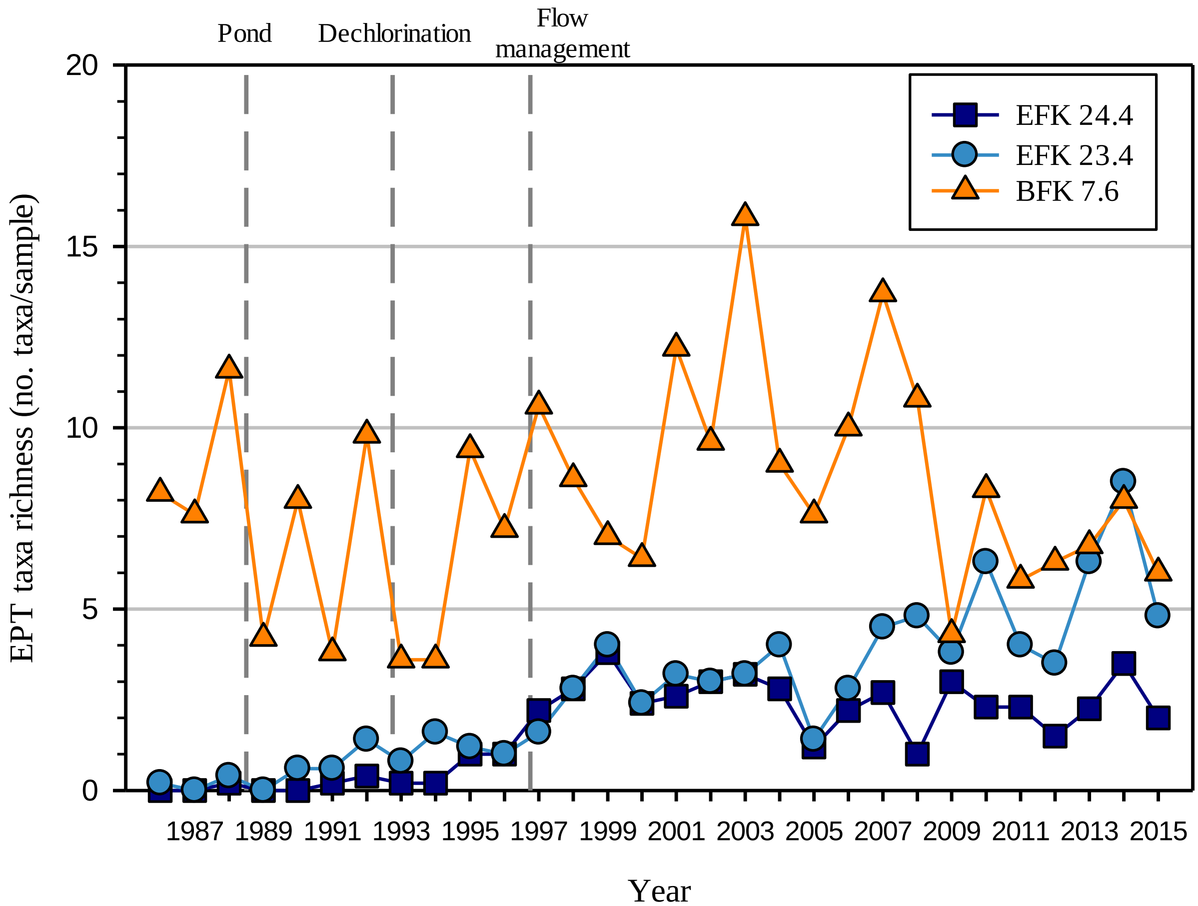


Figure 6.18. Mean (n = 5; n = 4 after 2006) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in UEFPC and Brushy Fork, April sampling periods, 1986 – 2015.[a,b]

[a]Major events in the 1980s and 1990s include New Hope Pond replacement with Lake Reality, dechlorination of discharges, and the start-up of flow management.
[b]EFK = East Fork Poplar Creek kilometer; BFK = Brushy Fork kilometer; EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

6.2.1.3 Performance Summary

Following is a summary of the FY 2015 UEFPC watershed performance monitoring:

- The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) goal for mercury in surface water at Station 17 is 200 ng/L. The average flow-paced composite mercury concentration during FY 2015 was 1,030 ng/L, down from 1,491 ng/L in FY 2014. Total mercury concentrations in one of the weekly composite samples collected at Station 17 during FY 2015 was less than the 200 ng/L ROD goal. Based on comparison of the mercury concentration in filtered and unfiltered sample aliquots from the weekly composite samples, approximately 90% or more of the mercury leaving the site is associated with suspended particulates in the water column.
- The BSWTS was fully operational during FY 2015. Although no significant downtime or operational problems occurred, winter and early spring seasonal rainfall caused the influent to BSWTS groundwater collection system to exceed the treatment system's design capacity. This necessitated

bypassing the system during 30 weeks. Because of the somewhat sporadic rainfall pattern in FY 2015 with interspersed dry periods and above average rainfall periods, the system bypass occurrences included several periods during December/January, April, May, July, and August. Approximately 4.5 g of mercury were discharged to UEFPC during the year (less than 0.1% of measured flux at Station 17).

- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux at Station 17 in FY 2015 increased relative to levels measured during FY 2014.
- Aquatic biological monitoring shows that mercury concentrations in rock bass at Station 17 generally remain stable, and have not responded to either increases or decreases in aqueous mercury concentrations. However, at upstream locations EFK 23.4 and EFK 24.2, mercury concentrations in redbreast appear to have been responsive to water increases and decreases associated with the SD cleanout. No changes in fish mercury concentrations are so far evident in fish sampling results post flow augmentation shutoff.

6.2.2 Other LTS Requirements

Other LTS requirements for UEFPC Phase I ROD areas are listed in Table 6.7 and described below.

6.2.2.1 Requirements

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3) specifies maintenance and LUCs to reduce the risk of human exposure to contaminants. The LUCs include an EPP program, property record restrictions, property record notices, zoning notices, signs, and surveillance patrols for the former mercury use areas in Y-12. Additionally, completed actions under this ROD require operation and maintenance of water treatment systems.

6.2.2.2 Status of Requirements

LUCs in UEFPC Phase I ROD areas were maintained, including signs to control access, surveillance patrols, and an ongoing EPP program. Operation and maintenance of water treatment systems (CMTS and BSWTS) are discussed in Section 6.2.1.2.1.2.

6.3 PHASE II INTERIM RAs FOR CONTAMINATED SOILS AND SCRAPYARD IN UEFPC

The *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek* (DOE/OR/01-2229&D3), referred to as the UEFPC Phase II ROD, addresses contaminated soil, scrap, buried, waste, and subsurface structures (including slabs) at the Y-12 which is located in the UEFPC watershed. As stated on page 1-3 of the ROD:

- *A primary objective of the remediation measures presented in this ROD is to protect industrial workers from exposure to hazardous substances at Y-12. The focus of efforts is aimed at eliminating or reducing existing contamination to below unacceptable risk-based levels for workers on-site. This is done through the remediation of areas and contamination and the application of LUCs, including institutional controls. Another objective in this ROD is to protect groundwater and surface water by removing contamination in soil, buried waste, or subsurface structures that could contribute to future contamination above unacceptable risk levels.*

The selected remedy includes the following principal actions (from pages 1-4 and 1-5 of the ROD):

- *Predesign characterization will be conducted to confirm and fully delineate areas of contamination and to identify sources of unacceptable releases to groundwater and surface water.*

- *Accessible unacceptably contaminated soils (defined as that not under buildings or critical active utilities or roads) exceeding the remediation level will be excavated to allow for controlled industrial[2] land use up to a depth of 2 ft. Accessible unacceptably contaminated soils in the easternmost areas of Y-12 will be excavated up to a depth of 10 ft to allow for more aggressive future DOE development. This remedy includes all Y-12 soils as, over time, currently inaccessibility soil will become accessible and will be addressed. Removed soils that meet the waste acceptance criteria (WAC) at the Environmental Management Waste Management Facility (EMWMF) or another appropriate ORR disposal facility will be disposed at those facilities. If the soil does not meet the ORR WACs, the soil will be sent off-site for disposal.*

- *Accessible unacceptably contaminated soils exceeding the remediation levels for protection of groundwater and surface water will be excavated to the water table or bedrock to protect against unacceptable releases to underlying groundwater or surface water. Removed soils that meet the WAC at the EMWMF or another appropriate ORR disposal facility will be disposed at those facilities. If the soil does not meet the ORR WACs, the soil will be sent off-site for disposal.*

- *Scrap located in the Y-12 Salvage Yard will be removed. Scrap will be characterized and size-reduced as needed. Contaminated scrap that meets the WAC at the EMWMF or another appropriate ORR disposal facility will be disposed at those facilities. If the scrap does not meet the ORR WACs, it will be sent off-site for disposal.*

- *Limited groundwater monitoring near deep soil excavation areas will be conducted for a minimum of five years to assess the effectiveness of source removal to protect groundwater. Surface water monitoring is already being conducted under the Phase I ROD* (DOE/OR-01-1951&D3)*, and no additional surface water monitoring is included as part of this ROD.*

- *LUCs will be implemented to prohibit use of land for any non-industrial activity and to prevent unacceptable exposures to residual contamination in that area. The LUCs will extend to the entire Y-12 industrial area.*

No performance monitoring is currently required under the UEFPC Phase II ROD.

Actions completed to date under the UEFPC Phase II ROD are Y-12 Salvage Yard scrap removal and soil remediation and removal and disposal of five tanks (Figure 6.1). Completion of these UEFPC Phase II ROD actions is documented in PCCRs listed in Table 6.1. There are no specified monitoring or other LTS requirements for these actions.

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[2]*Controlled industrial—defined by the Oak Ridge Reservation (ORR) End Use Working Group as industrial land use with excavation limited to 2 ft.*

6.3.1 Other LTS Requirements

Other LTS requirements for UEFPC Phase II ROD areas are listed in Table 6.7 and described below.

6.3.1.1 Requirements

The *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek* (DOE/OR/01-2229&D3) specifies LUCs will be implemented to prohibit use of land of any non-industrial activity and to prevent unacceptable exposures to residual contamination in that area. The LUCs include property record restrictions, property record notices, zoning notices, an EPP program, and continued existing surveillance patrols. The LUCs will extend to the entire Y-12 industrial area indicated by the ROD boundaries depicted in Figure 6.2. There are no completed actions under this ROD that require additional LUCs.

6.3.1.2 Status of Requirements

LUCs in UEFPC Phase II ROD areas were maintained, including surveillance patrols and an ongoing EPP program.

6.4 SINGLE-PROJECT ACTIONS IN THE UEFPC WATERSHED

6.4.1 EEVOC Plume

The EEVOC plume (DOE/OR/01-1819&D2) extraction/treatment system began operation in 2000 to prevent further migration of the VOC-contaminated groundwater plume off the ORR. At the request of the regulators, the system operated for five years to evaluate performance before preparation and approval of the *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1). The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1) recommended continuation of the current plume interception system and specified evaluation of the system performance in the annual RER.

6.4.1.1 Performance Monitoring

6.4.1.1.1 Performance Monitoring Goals and Objectives

The goals of the removal action (DOE/OR/01-1819&D2) are to reduce health and environmental risks associated with the migration of VOC-contaminated groundwater from the east end of Y-12, to reduce the potential risk from exposure to this contamination in off-site areas, and to mitigate off-site migration of contaminants. No specific numeric performance standards were established. Existing human health or ecological risks specific to groundwater were evaluated during the *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant* (DOE/OR/01-1641/V1-V4&D1), and a *Union Valley Interim Study Remedial Site Evaluation* (Y/ER-206/R1) was incorporated into the removal action. The risk assessments presented in the Union Valley Interim Study addressed hypothetical risks related to groundwater use, as well as potential risk related to exposure to spring discharges in Union Valley.

System performance is measured by evaluating reductions in VOC concentrations downgradient of the extraction well (GW-845) (DOE/OR/01-1819&D2). The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1) identified changes to monitoring frequencies and analysis, which were implemented in the FY 2007 monitoring. As shown in Table 6.2, quarterly sampling is performed on extracted groundwater from GW-845 with analysis including VOCs, metals, nitrate, and uranium. Additional analysis is performed on the effluent from the treatment system discharging to UEFPC. The treatment system discharge measured at the downstream POC, monitoring location LRBP-1, must not exceed the applicable AWQC (16 µg/L carbon tetrachloride). Semiannual sampling is performed at the downgradient multiport well (GW-722) and downgradient well cluster (GW-169 and GW-170) for VOC analysis.

Table 6.7. Other LTS requirements for the UEFPC watershed

Other LTS requirements for LUCs [a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ Implementation**
***Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3)**					
1. Property Record Restrictions[b] *A. Land use* *B. Groundwater*	*WEMA mercury-contaminated areas*	*Restrict use of property by imposing limitations.* *Prohibit uses of groundwater*	*Indefinitely*	*Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
2. Property Record Notices[c]	*WEMA mercury-contaminated areas*	*Provide notice to anyone searching records about the existence and location of contaminated areas*	*Indefinitely*	*Initial Notice recorded by DOE in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD; 2) upon transfer of affected areas; 3) final Notice upon completion of all other remedial actions*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
3. Zoning Notices[d]	*WEMA mercury-contaminated areas*	*Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes*	*Indefinitely*	*Copy of initial Property Notice filed with County Register of Deed office to be filed by DOE with City Planning Commission as soon as practicable after signing of the ROD; survey plat upon completion of all remedial actions.*	DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission
4. Excavation/Penetration Permit Program[e]	*WEMA mercury-contaminated areas*	*Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity*	*As long as property remains under DOE control*	• *Implemented by DOE and its contractors* • *Initiated by permit request*	DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedures

Table 6.7. Other LTS requirements for the UEFPC watershed (cont.)

Other LTS requirements for LUCs [a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ Implementation**
5. Signs [f]	*UEFPC surface water* [g]	*Provide notice or warning to prevent unauthorized access*	*Indefinitely*	*Signage maintained by DOE*	DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)
6. Surveillance Patrols	*UEFPC surface water* [g]	*Control and monitor access by workers/public*	*Indefinitely*	• *Established and maintained by DOE* • *Necessity of patrols evaluated upon completion of remedial actions*	DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted
Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek **(DOE/OR/01-2229&D3)**					
1. DOE land notation (Property record restrictions) [b]	*Throughout entire Y-12 industrial area*	*Restrict use of property consistent with LUC objectives*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Drafted and implemented by DOE upon completion of remediation activities per this ROD or transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office.*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
2. Property record notices [c]	*Throughout entire Y-12 industrial area*	*Provide notice to anyone searching records about the existence and location of contaminated areas*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Notice provided by DOE EM to the public as soon as practicable, but no later than 90 days after approval of the LUCIP.*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)

Table 6.7. Other LTS requirements for the UEFPC watershed (cont.)

Other LTS requirements for LUCs [a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ Implementation**
3. Zoning notices[d]	*Throughout entire Y-12 industrial area*	*Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after approval of the LUCIP; final Zoning Notice and survey plat files with City Planning Commission upon completion of all remedial actions*	DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission
4. Excavation/penetration permit program[e]	*Throughout entire Y-12 industrial area*	*Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity*	*As long as property remains under DOE control, including transferred property remaining subject to the excavation/penetration permit program*	*Implemented by DOE and its contractors; initiated by permit request*	DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedures
5. Security guards/surveillance patrols	*Patrol of selected areas throughout Y-12, as necessary*	*Control and monitor access by workers/public*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure as well as established programmatic needs*	*Established and maintained by DOE; necessity of patrols evaluated upon completion of remedial actions. Existing routine patrols continued.*	DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/ Implementation**
***Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3)**			
BSWTS	PCCR (DOE/OR/01-2218&D1)	• Operate and maintain in accordance with the developed procedure to address startup, operation, and shutdown • General and routine maintenance will be performed in accordance with the Preventative Maintenance, Calibrations and Inspection Plan	Not stated
CMTS	Phase I ROD (DOE/OR/01-1951&D3)	• The existing sump collection and treatment systems (pumps, valves, piping, and treatment components) will continue to be inspected and maintained in accordance	Until implementation and effectiveness

Table 6.7. Other LTS requirements for the UEFPC watershed (cont.)

Areas	Project Documents	Other LTS Requirements	Frequency/ Implementation
Other LTS requirements for Specific Areas			
		with current NPDES Permit Compliance Program requirements	evaluation of the remaining hydraulic isolation components (e.g., horizontal well) are complete
Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee **(DOE/OR/01-1819&D2)**			
Y-12 EEVOC Plume	RmAR (DOE/OR/01-2297&D1)	• O&M parameters, such as influent/effluent concentrations, system uptime versus downtime, unusual occurrences, average pumping rate, and total volume treated, are recorded, and an evaluation of system performance is performed annually • The cartridge filters are changed out as fine particles and grit collect on the filter media • The air-stripper trays are removed and cleaned as scale builds up on the surface. The scale is removed to prevent plugging of the holes in the trays resulting in reduced stripper efficiency	Annual evaluation of system performance documented in the RER
Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/01-1641/V1-V4&D2)**			
Union Valley	IROD (DOE/OR/02-1545&D2)	• License agreements with property owners notifying them of the potential contamination and requiring them to notify DOE of any changes in use of groundwater or surface water in certain areas • Appropriate verification by DOE of compliance with the agreements and notification of state and local agencies • The DOE Real Estate Office and DOE's management and operations contractor's real estate office are responsible for (1) completing the annual title search by the anniversary date of this ROD to determine whether any affected property has changed hands; (2) notifying property owners, the Oak Ridge city manager, and the TDEC/DOE Oversight Division (now called the TDEC/DOE Oversight Office) of their obligations under the agreements and updating them on the status of the environmental investigations; (3) surveying owners by telephone to determine whether any new groundwater wells have been constructed or planned of there are any new uses for surface water; and (4) notifying licensed well drillers in Tennessee of the license agreements and their terms.	The DOE Real Estate Office shall report search results to the DOE Program Office annually

Table 6.7. Other LTS requirements for the UEFPC watershed (cont.)

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/ Implementation**
Action Memorandum for Time-Critical Removal Action for the Removal of Mercury from the Storm Sewer System at the Y-12 National Security Complex, Oak Ridge, Tennessee **(DOE/OR/01-2574&D1)**			
Mercury Storm Sewer Traps	RmAR (DOE/OR/01-2595&D1)	• Collect, store, treat, and dispose of elemental mercury and associated contaminated sediments from specified SD locations • Periodically visually inspect nine trap locations for material accumulated in the traps	The results of the removals are to be summarized in the annual RER
Action Memorandum for the Y-12 Facilities Non-Time-Critical Removal Action Deactivation/Demolition Project, Oak Ridge, Tennessee **(DOE/OR/01-2462&D2)**			
Secondary Pathways	PCCR (DOE/OR/01-2596&D1)	• Long-term operation and maintenance requirements associated with the drainage improvements • Clean out and other maintenance work will be performed as needed	As needed

[a]Source for LUCs: *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3) and *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek* (DOE/OR/01-2229&D3).

[b]*Property Record Restrictions—Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.*

[c]*Property Record Notices—Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.*

[d]*Zoning Notices—Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.*

[e]*Excavation/Penetration Permit Program—Refers to the internal DOE/DOE contractor administrative program(s) that requires permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.*

[f]*Signs—Posted command, warning, or direction*

[g]To prevent consumption of fish from UEFPC.

BSWTS = Big Spring Water Treatment System
CMTS = Central Mercury Treatment System
DOE = U.S. Department of Energy
EEVOC = East End Volatile Organic Compound
EM = Environmental Management
IROD = Interim Record of Decision
LTS = long-term stewardship
LUC = land use control
LUCIP = Land Use Control Implementation Plan
NPDES = National Pollutant Discharge Elimination System
O&M = operations and maintenance
PCCR = Phased Construction Completion Report
RER = Remediation Effectiveness Report
RmAR = Removal Action Report
ROD = Record of Decision
SD = storm drain
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek
WEMA = West End Mercury Area
Y-12 = Y-12 National Security Complex

6.4.1.1.2 Evaluation of Performance Monitoring Data

6.4.1.1.2.1 Groundwater

Figures 6.19 and 6.20 show the EEVOC chlorinated hydrocarbon concentrations before pumping at well GW-845 was started in FY 2000, and in FY 2015 showing the region of maximum contaminant removal, respectively. Concentrations represent the sum of chlorinated VOCs. Two distinct contaminant sources are evident – a carbon tetrachloride source near the southwestern portion of the plume and a source of PCE and TCE near the northwestern portion of the plume. Comparison of the two figures shows that the groundwater pump and treat system has decreased chlorinated VOC concentrations along the extent of the southern half of the plume, while concentrations along the northern edge have remained essentially constant. This contrast is attributed to the occurrence of less permeable bedrock at the base of the Maynardville Limestone near its contact with the Nolichucky Shale. The groundwater extraction system has effectively withdrawn contaminant mass from the more permeable limestone strata, but the contaminated groundwater is not as effectively withdrawn from the shale bedrock. PCE and TCE are detected at low concentrations in the extracted groundwater that is sent to the treatment system, suggesting that there is capture of that portion of the plume, although the mass removal is small.

Figure 6.21 shows the drawdown feature created by pumping of well GW-845 in plan view and in cross-sectional views. The asymmetrical drawdown feature is created because of the dipping attitude of bedrock and spatial variability of permeability. The screened interval of well GW-845 is 280 ft long, as shown in Figure 6.21, which allows the well to capture contaminants from a large vertical region in bedrock. This extensive vertical capture capability increases the likelihood that this system will intercept contaminants seeping eastward in the Maynardville Limestone from source areas to the west in the Y-12 industrial area.

As stated in the *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-1819&D2), system performance is measured by evaluating reductions in VOC concentrations downgradient of the extraction well (GW-845). The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1) specified quarterly sampling and analysis at the extraction well; well GW-722 located approximately 180 m (600 ft) downgradient of the extraction well; and wells GW-169, -170, and -232 located about 730 m (2400 ft) east along geologic strike in Union Valley (Figures 6.19 and 6.20). Additional analyses for uranium, mercury, and nitrate were specified to evaluate whether long-term pumping mobilizes metals, radiological contaminants, or nitrate from upgradient sources within Y-12, such as the former Oil Skimmer Basin located approximately 300 m (1000 ft) west of well GW-845 (Figures 6.19 and 6.20). Consistent with recommendations in the approved *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2289&D3) and *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1), sampling of well GW-232 in Union Valley has been discontinued and sampling frequency and target analytes at other wells specified in the AM have been modified.

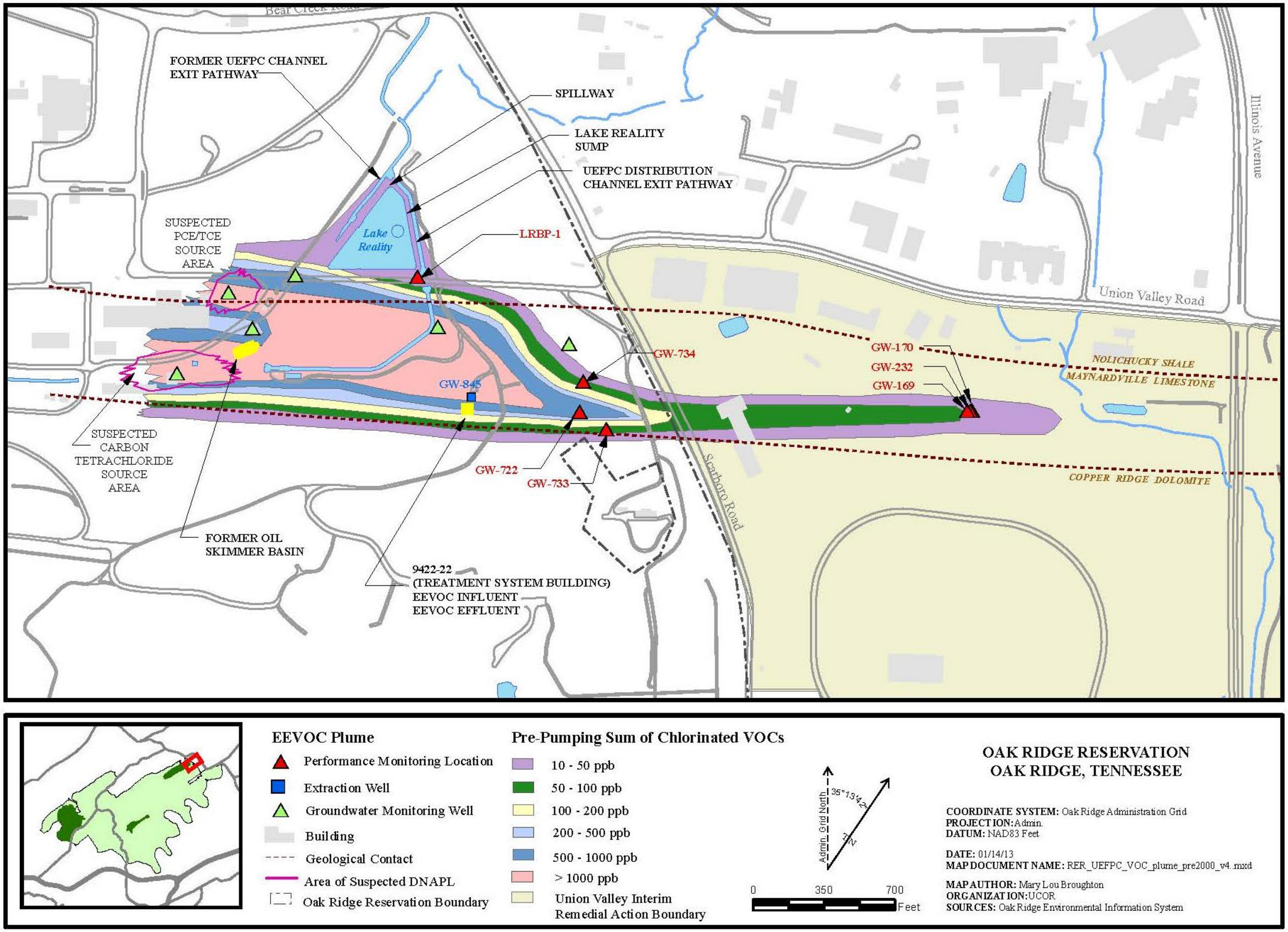

Figure 6.19. EEVOC Plume before pump and treatment system startup (1998 – 2000).

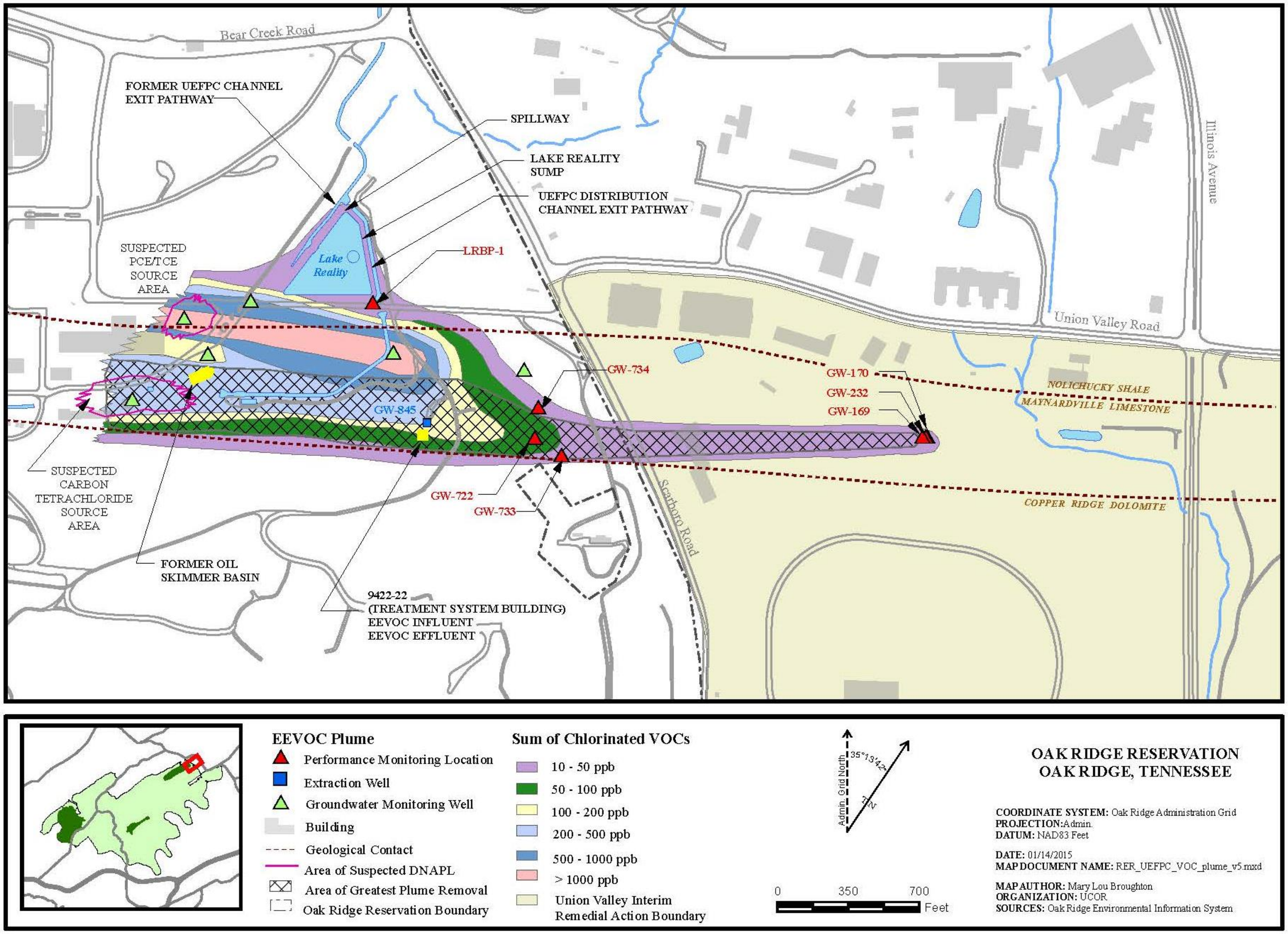

Figure 6.20. EEVOC plume in FY 2015 showing region of maximum chlorinated VOC removal.

Treated groundwater is continuously discharged into UEFPC. The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-2297&D1) requires at least quarterly sampling and analysis of influent and effluent for VOCs, metal, nitrate, and uranium. The AWQC for carbon tetrachloride (currently 16 µg/L) is the ARAR for the treated discharge monitored at LRBP-1, the downstream POC.

6.4.1.1.2.1.1 Maynardville Limestone Exit Pathway

The EEVOC influent station has a valved sample port that allows collection of water before treatment to represent groundwater concentrations from well GW-845 completed in the Maynardville Limestone exit pathway. Data obtained to date indicate that carbon tetrachloride concentrations in the pumping well have stabilized at an average concentration of about 130 – 140 µg/L (Figure 6.22). Likewise, chloroform concentrations have stabilized at about 10 µg/L.

Signature VOCs within the intermediate and deep intervals of the Maynardville Limestone directly downgradient of the pumping well (Figure 6.21) also decreased significantly relative to baseline data. This pathway is monitored via well GW-722 (Port 14 at 425 ft bgs, Port 17 at 385 ft bgs, Port 20 at 333 ft bgs, and Port 22 at 313 ft bgs). The ports discussed here contain the highest concentrations of contaminants. Other ports in well GW-722 are sampled by the Y-12 GWPP. That monitoring confirms that carbon tetrachloride, PCE, and TCE are generally not detected or occur at concentrations below MCLs in other ports since the pump and treatment operation started. The FY 2015 analytical results for several signature VOCs in well GW-722, Port 14 and Port 17, are in Table 6.8. Sample Port 17 has historically shown some of the highest and most consistent VOC results; therefore, data from this sampling point are used to best illustrate carbon tetrachloride trends over time (Figure 6.22). Since operation of the extraction system, carbon tetrachloride concentrations have decreased from the 200 – 1,000 µg/L range to less than 50 µg/L. Overall, since system operations began, concentrations of PCE have decreased by a factor of about ten and similar trends have also been noted for TCE and DCE. The other sampling zones in well GW-722 show similar decreases in VOC concentrations.

In Union Valley east of Scarboro Road (Figures 6.19 and 6.20), signature VOCs (Table 6.8) have historically been detected in wells GW-169 (water table interval) and GW-170 (intermediate interval; 120 ft bgs), which are directly along strike to the east of Y-12. Well GW-170 has historically had the highest off-site levels of carbon tetrachloride and chloroform with highly variable concentrations, but with an overall decline since 1994. Since EEVOC operation started in 2000, carbon tetrachloride concentrations have stabilized at about 5 µg/L or less and since about 2007 concentrations have further decreased to levels below 2 µg/L with some non-detect results. A sharp decrease of carbon tetrachloride concentrations occurred in well GW-170 prior to the EEVOC Plume treatment system start-up in October 2000, which correlated to an increase in pH. The available data suggest that water quality in the Union Valley area west of Illinois Avenue may have been affected by large-scale construction activities near Scarboro Road, resulting in elevated pH conditions and increased surface water dilution in the shallow and intermediate zones of the Maynardville Limestone in this area. Signature VOCs observed in well GW-169 have remained consistently low over time at between 1 and 4 µg/L.

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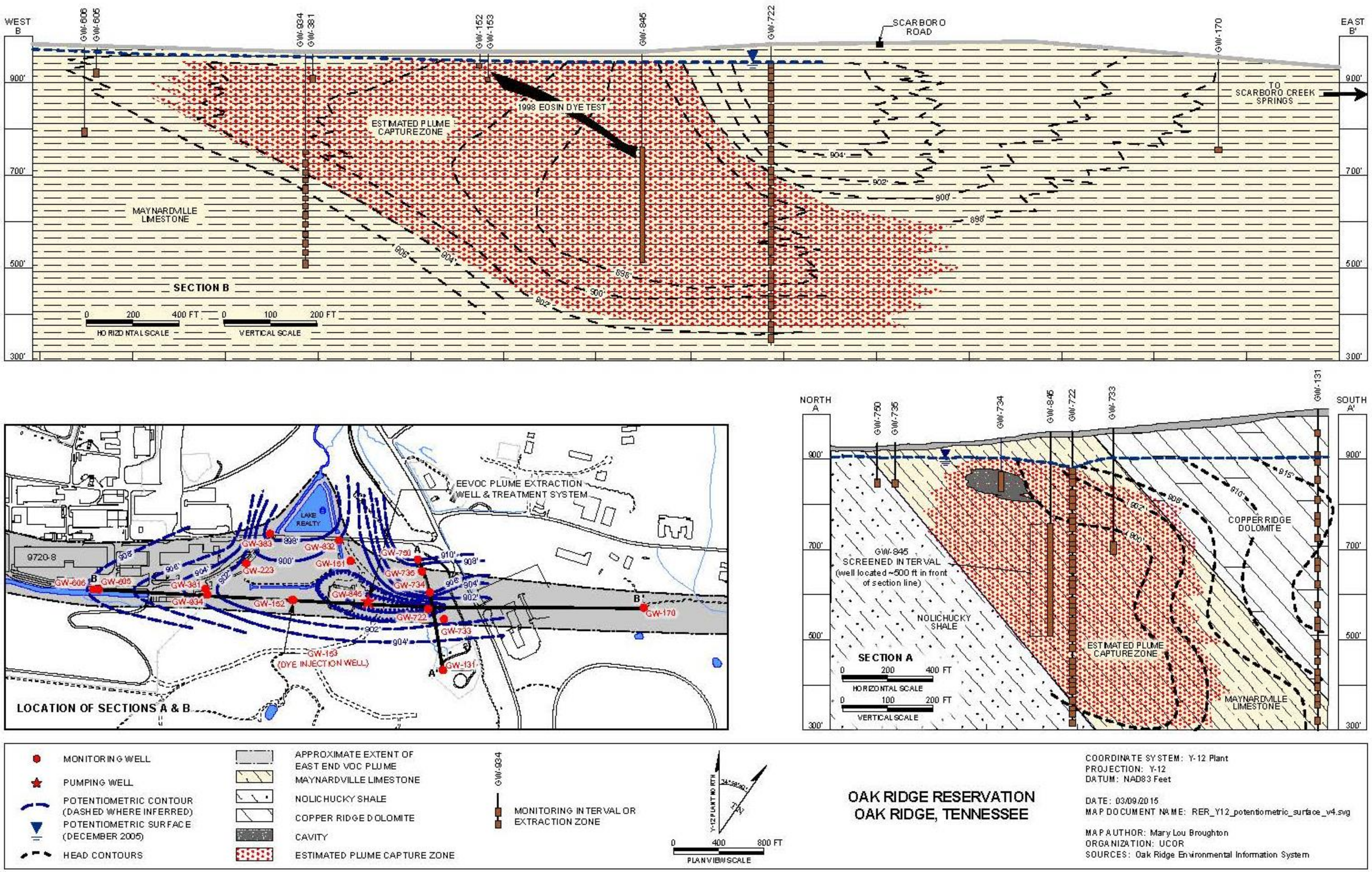

Figure 6.21. Potentiometric data and subsurface plume distribution at the eastern Y-12 Administrative site.

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6.4.1.1.2.1.2 Treatment System Performance

Treatment system performance monitoring began in November 2000, following startup. Figure 6.23 shows the cumulative actual EEVOC treated water volume in FY 2015, which varied between about 0.7 and 1.3 million gal/mo. and totaled about 11.5 million gal. During FY 2015, the treatment system performed well with only five short outages (less than 24 hr each) for various maintenance activities. During the CERCLA FYR site visit that occurred in summer of 2015, it was noted by the facility operators that mineral scaling of system components downstream of the groundwater extraction system (plant internal piping and air strippers) is a chronic problem. The mineral scale appears to be comprised of both calcium carbonate (crystalline growths that cause pipe diameter narrowing) and iron oxides (red-brown scale accumulations). Replacement of portions of the plant internal piping is ongoing to maintain the system.

To evaluate the effectiveness of the treatment system, influent and corresponding effluent samples have been collected since operations began. In FY 2015, concentrations of carbon tetrachloride in treatment system influent (from well GW-845) ranged from 78 μg/L to 160 μg/L and averaged 134 μg/L for the year (Table 6.9). The concentration range for carbon tetrachloride in the effluent stream was 3.7 μg/L to 84 μg/L and averaged 29 μg/L. Removal efficiency for carbon tetrachloride ranged from about 48% to 97% and averaged about 87% in FY 2015 while removal efficiency for chloroform ranged from 13% to greater than 80% and averaged about 62%. Table 6.10 summarizes total mass removals for the principal VOCs since operations began in 2000. Inspection of Table 6.10 shows that there was a gradual deterioration in treatment system efficiency over the FY 2009 through FY 2011 period, better performance during FY 2012 and deteriorated performance during FY 2013 with improvements during FY 2014 and FY 2015. Facility operators investigated a performance issue in the autumn of 2013 and corrected a problem in the air stripper ducting which dramatically improved performance in the November 2013 sample results and for the remainder of FY 2014 through FY 2015.

Table 6.8. Selected FY 2015 data for Y-12 EEVOC plume performance

Chemical	Station name Sample date Units	GW-169 3/11/2015	GW-169 7/33/2015	GW-170 3/11/2015	GW-170 7/23/2015
Alpha activity (MCL = 15 pCi/L)	pCi/L	0.464 (U)	1.49	0.297 (U)	1.2 (U)
Beta activity (MCL screen = 50 pCi/L)	pCi/L	2.98 ± 1.54	3.17 ± 1.61	11 ± 1.95	14.1 ± 2.14
Carbon tetrachloride (MCL = 5 μg/L)	μg/L	<1 (U)	<1 (U)	0.78 J	0.93 J
Chloroform (MCLG = 70 μg/L)	μg/L	<1 (U)	<1 (U)	0.36 J	0.41 J
PCE (MCL = 5 μg/L)	μg/L	1.3	1.4	0.65 J	0.6 J
TCE (MCL = 5 μg/L)	μg/L	0.44	0.52	0.98	0.92
Nitrate (MCL = 10 mg/L)	mg/L	0.85	0.89	0.41	0.4
Chemical	**Station name Sample date Units**	**GW-722-17 3/11/2015**	**GW-722-17 7/15/2015**	**GW-722-14 3/11/2015**	**GW-722-14 7/14/2015**
Carbon tetrachloride (MCL = 5 μg/L)	μg/L	14	11	15	5
Chloroform (MCLG = 70 μg/L)	μg/L	3.1	5 U	1.5	5 U
PCE (MCL = 5 μg/L)	μg/L	3.4	5 U	2.2	5 U
TCE (MCL = 5 μg/L)	μg/L	0.98	5 U	1.1	5 U

Table 6.8. Selected FY 2015 data for Y-12 EEVOC Plume performance (cont.)

EEVOC = East End Volatile Organic Compound
FY = fiscal year
GW = groundwater well
J = estimated value
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
PCE = tetrachloroethene
TCE = trichloroethene
U = Not detected or result less than minimum detectable
Y-12 = Y-12 National Security Complex

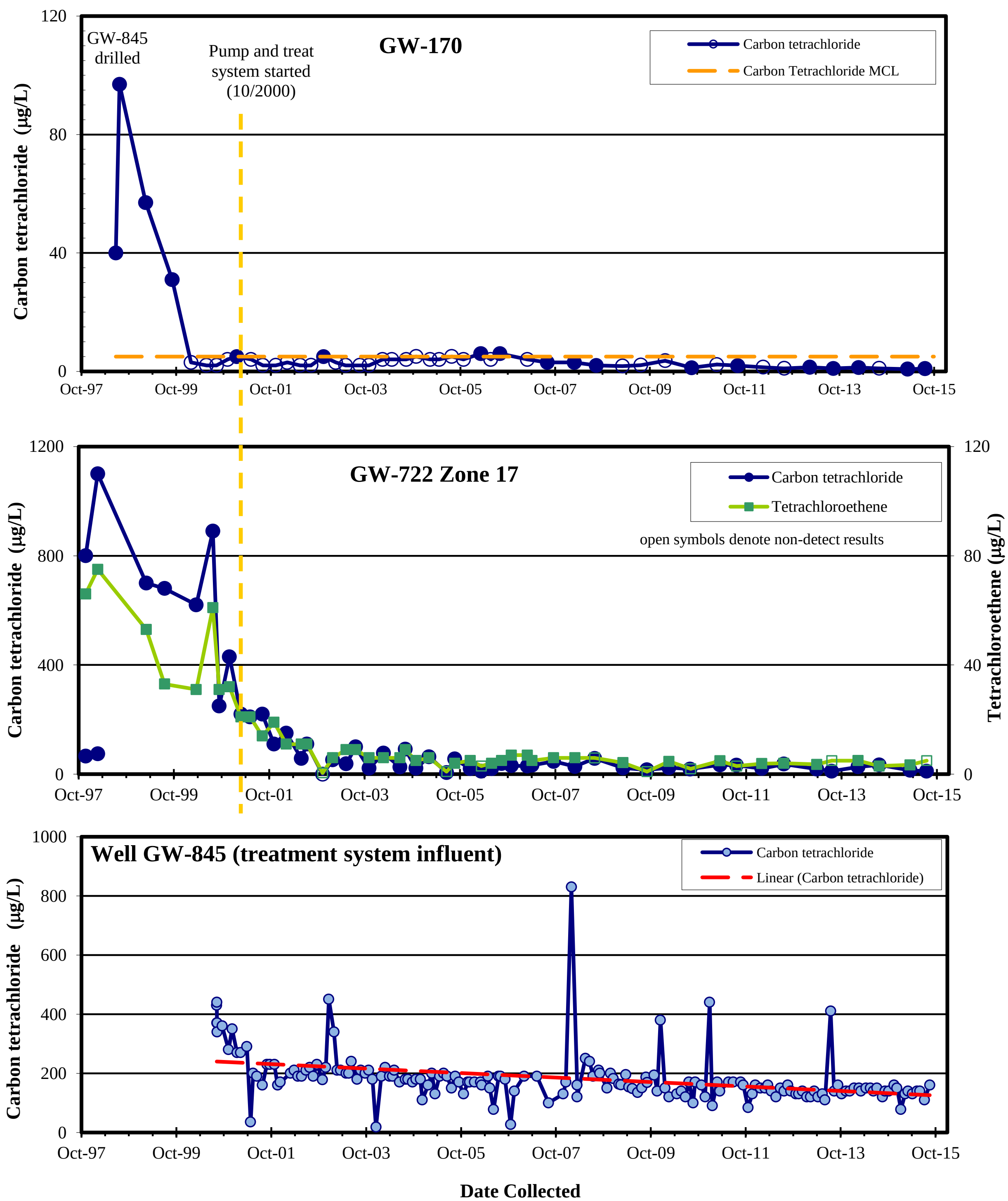

Figure 6.22. Selected VOC trends in the Maynardville Limestone exit pathway.

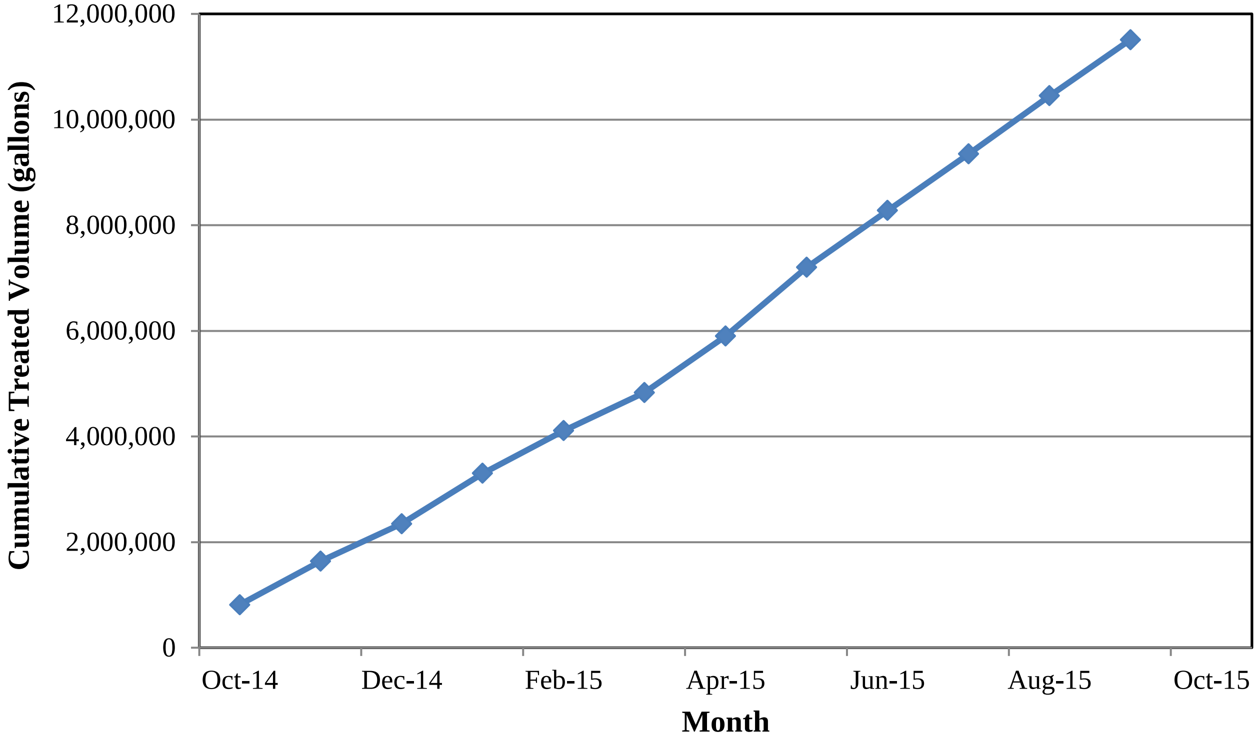

Figure 6.23. EEVOC treatment system cumulative water treated during FY 2015.

Effluent concentration limits were not stipulated for the treatment system. However, to maintain protectiveness of the environment and to monitor the effectiveness of the treatment system, the EEVOC treatment system effluent is sampled and analyzed monthly for VOCs. Three of the monthly grab samples collected early in FY 2015 contained carbon tetrachloride at concentrations greater than the AWQC value of 16 µg/L. To evaluate potential impacts in surface water in the UEFPC, grab samples were collected at LRBP-1, the POC in the receiving stream downstream of the location where treated water is discharged. No AWQC exceedances were measured for carbon tetrachloride or the other signature VOCs in the EEVOC effluent in the stream.

Maximum FY 2015 results of selected organic and radiological constituents in both influent and effluent samples are in Table 6.11. Reductions observed for other signature VOCs detected in the influent stream (Table 6.9 and Table 6.11) are consistent with the relative ranking of their volatility, as indicated by their respective Henry's Law constants (i.e., carbon tetrachloride >PCE >chloroform).

Table 6.9. EEVOC plume treatment system performance data, FY 2015

Chemical	Date	Influent result (µg/L)	Effluent result (µg/L)	Percent reduction	Estimated net mass removal (kg)[a]
Carbon tetrachloride	10/7/2014	140	4.3	97%	0.418
	11/17/2014	160	84	48%	0.238
	12/8/2014	150	33	78%	0.314
	1/8/2015	78	16	79%	0.223
	2/9/2015	130	3.7	97%	0.386
	3/4/2015	140	6.1	96%	0.367
	4/6/2015	130	8.9	93%	0.489
	5/13/2015	140	9.2	93%	0.645
	6/2/2015	140	14	90%	0.514
	7/8/2015	110	14	87%	0.389
	8/18/2015	160	12	93%	0.617
	9/21/2015	130	11	92%	0.478
FY 2015 annual average:		**134**	**29**	**87%**	
FY 2015 annual mass removal:					**5.1 kg**
Chloroform	10/7/2014	9.6	1.6	83%	0.025
	11/17/2014	11	9.6	13%	0.004
	12/8/2014	9.9	6	39%	0.010
	1/8/2015	8.9	3.7	58%	0.019
	2/9/2015	8.5	1.7	80%	0.021
	3/4/2015	9.2	2.3	75%	0.019
	4/6/2015	9.7	3	69%	0.027
	5/13/2015	9.5	3.1	67%	0.032
	6/2/2015	9.9	4	60%	0.024
	7/8/2015	8.2	3.3	60%	0.020
	8/18/2015	9.7	2.9	70%	0.028
	9/21/2015	10	2.9	71%	0.029
FY 2015 annual average:		**9.1**	**4.3**	**62%**	
FY 2015 annual mass removal:					**0.26 kg**
PCE	10/7/2014	21	<1 U	95%	0.062
	11/17/2014	23	16	30%	0.022
	12/8/2014	21	6	71%	0.040
	1/8/2015	18	3	83%	0.054
	2/9/2015	19	0.86 J	95%	0.055
	3/4/2015	17	1.2	93%	0.043
	4/6/2015	19	1.9	90%	0.069

Table 6.9. EEVOC plume treatment system performance data, FY 2015 (cont.)

Chemical	Date	Influent result (μg/L)	Effluent result (μg/L)	Percent reduction	Estimated net mass removal (kg)[a]
	5/13/2015	22	2.2	90%	0.098
	6/2/2015	21	3.3	84%	0.072
	7/8/2015	20	3.3	84%	0.068
	8/18/2015	23	2.6	89%	0.085
	9/21/2015	27	2.8	90%	0.097
FY 2015 annual average:		**21**	**5.43**	**83%**	
FY 2015 annual mass removal:					**0.77 kg**

[a]Estimated net mass removal is based on treated volume for the sample month. Influent and effluent concentrations are assumed to be applicable to total treated volume.

EEVOC = East End Volatile Organic Compound
FY = fiscal year
J = estimated value
PCE = tetrachloroethene
U = Not detected or result less than minimum detectable

Table 6.10. Estimated mass removals for key EEVOC plume constituents since inception of treatment operations

FY	Carbon tetrachloride (kg)	Chloroform (kg)	PCE (kg)
2001	9.2	0.81	0.74
2002	7.7	0.39	0.81
2003	9.9	0.44	1.03
2004	7.4	0.27	0.83
2005	6.3	0.29	0.86
2006	6.7	0.34	0.86
2007	5.7	0.22	0.63
2008	7.2	0.37	1.1
2009	6.8	0.20	0.88
2010	4.9	0.21	0.68
2011	2.7	0.04	0.31
2012	5.5	0.22	0.73
2013	3.9	0.19	0.64
2014	5.1	0.23	0.72
2015	5.1	0.26	0.77
Totals	94	4.5	12

EEVOC = East End Volatile Organic Compound
FY = fiscal year
PCE = tetrachloroethene

Table 6.11. Summary of EEVOC plume groundwater treatment system performance results, FY 2015

Analyte[a]	Units	Maximum influent detect (GW-845)	Maximum effluent detect
2-Butanone	μg/L	10 (U)	10 (U)
Carbon tetrachloride	μg/L	160	84
Chloroform	μg/L	11	9.6
1,1-DCA	μg/L	<1 (U)	1.2
1,1,1-TCA	μg/L	<1 (U)	<1 (U)
Cis-1,2-DCE	μg/L	3.4	3
Trans-1,2-DCE	μg/L	<1 (U)	<1 (U)
PCE	μg/L	23	16
TCE	μg/L	44	2.8
Nitrate[b]	mg/L	1.3	1.3
Total uranium[b]	mg/L	0.0055	0.0057
^{234}U[b]	pCi/L	4.32 ± 0.68	4.17 ± 0.644
^{235}U[b]	pCi/L	0.667 ± 0.27	0.261 ± 0.194 (U)
^{238}U[b]	pCi/L	2.74 ± 0.539	2.84 ± 0.518

[a]All VOCs detected are listed.
[b]Note system design and remedy is targeted for VOCs.

DCA = dichloroethane
DCE = dichloroethene
EEVOC = East End Volatile Organic Compound
FY = fiscal year
GW = groundwater well
PCE = tetrachloroethene
TCA = trichloroethane
TCE = trichloroethene
U = Result less than method reporting limits or minimum detectable activity
VOC = volatile organic compound

During FY 2015, monitoring data for treatment system influent show that ^{234}U and ^{238}U reached their highest activities for the year in December. Figure 6.24 is a graph of the measured activities of ^{234}U and ^{238}U throughout the EEVOC treatment system operations through FY 2015. Table 6.11 includes the maximum EEVOC treatment system influent and effluent uranium isotopic activities. The uranium concentration calculated from the isotopic activities in influent and effluent ranged from about 3 to 9 µg/L and averaged 4 µg/L during FY 2015. These levels are less than the 30 µg/L MCL reference concentration. Based on the monthly groundwater withdrawal rate throughout FY 2015, the uranium mass discharged from the EEVOC system was approximately 0.16 kg for the year. This mass is a minor contribution to the yearly uranium mass measured at Station 17 (Section 6.2.1.2.1.2). During FY 2015 the strong seasonal fluctuations of uranium concentrations noted over the past several years continued, with higher activities measured during winter and spring than during summer and early autumn. This cyclic contaminant concentration signature is indicative of the role of dynamic groundwater plume transport in response to seasonal climatic drivers.

The *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-1819&D2) acknowledged the potential for other contaminants to increase in the EEVOC collected groundwater over time as a result of the groundwater withdrawals. The AM recognized the possibility that the treatment process can be modified to accommodate treatment of other contaminants, as warranted.

6.4.1.1.3 Performance Summary

The EEVOC plume removal action is measured through two metrics. The first metric is the effectiveness of the groundwater withdrawals at reducing VOC concentrations in the plume off DOE property to the northeast in Union Valley. The second metric is the performance of the air stripper at removing the signature VOCs from the water discharged to UEFPC. FY 2015 data indicate that the groundwater pump and treatment system has effectively withdrawn groundwater and has limited off-site plume migration. Evidence of that performance is the below drinking water limit concentrations of carbon tetrachloride in off-site monitoring wells in Union Valley. During FY 2015, the air stripper system performed well after a mechanical problem noted in November 2014 was corrected. A problem with airflow in the air stripper was identified and corrected which significantly improved VOC removal efficiency.

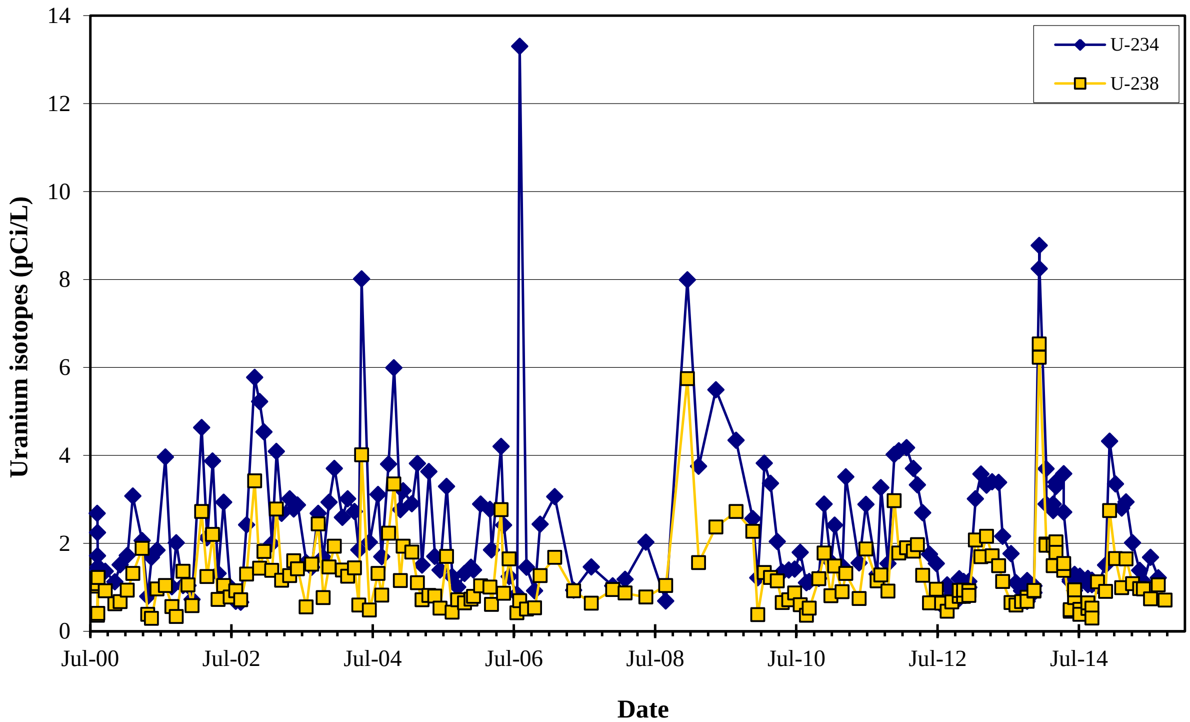

Figure 6.24. Activities of ^{234}U and ^{238}U in EEVOC treatment system influent.

6.4.1.2 Other LTS Requirements

Other LTS requirements for EEVOC plume treatment system are listed in Table 6.7 and described below.

6.4.1.3 Requirements

Other than operation and maintenance of the EEVOC plume treatment system discussed above in Section 6.4.1, no requirements were specified in the *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE/OR/01-1819&D2).

6.4.1.4 Status of Requirements

Although no requirements are specified other than operation and maintenance of the EEVOC plume treatment system, the site remained protected by the DOE 229 Boundary access controls (this security boundary is designated pursuant to Section 229 of the Atomic Energy Act of 1954 which prohibits

unauthorized entry) and was regularly patrolled by security personnel. In addition, groundwater use remained restricted within Y-12 and Union Valley.

6.4.2 Union Valley

Location of the Union Valley Interim Action (DOE/OR/02-1545&D2) is shown on Figure 6.1. The primary objective of this interim action was to protect human health from a contaminated plume originating from beneath Y-12 and detected in the groundwater below privately owned land in Union Valley.

6.4.2.1 Performance Monitoring

Institutional controls were selected as the interim remedy to ensure that public health is protected while final actions are being developed and implemented and to identify and prohibit, if necessary, future activities with a potential to accelerate the rate of contaminant migration from the contaminated area or increase the extent of the contaminant plume.

No surface water or groundwater monitoring is required as part of this interim action. An associated action, the EEVOC Plume removal action, included construction of a groundwater treatment facility to prevent further migration of the VOC-contaminated groundwater plume off of the ORR into Union Valley. The EEVOC plume performance monitoring objectives are discussed in Section 6.4.1.1.1.

6.4.2.2 Other LTS Requirements

Other LTS requirements for Union Valley are listed in Table 6.7 and described below.

6.4.2.2.1 Requirements

The *Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area* (DOE/OR/02-1545&D2) requires that DOE ensure that the required property title searches and appropriate notifications are made until a final ROD is issued for the UEFPC contaminated area. DOE is responsible for the following institutional controls:

- Complete an annual title search by the anniversary date of the ROD to determine whether any affected property has changed hands;
- Notify property owners, the Oak Ridge city manager, and the TDEC/DOE Oversight Office of their obligations under the agreements and update them on the status of the environmental investigations;
- Survey owners by telephone to determine whether any new groundwater wells have been constructed or planned or there are any new uses for surface water; and
- Notify licensed well drillers in Tennessee of the license agreements and their terms.

6.4.2.2.2 Status of Requirements

Compliance with all requirements was verified in FY 2015. The DOE ORO Realty Officer provided documentation that property owners, the Oak Ridge City Manager, and TDEC/DOE Oversight Office, now called TDEC, Division of Remediation Oak Ridge Office, had been notified of their respective obligations and that Tennessee licensed well drillers were notified of the license agreements and terms. Documentation that all required title searches were conducted and that property owners were surveyed by telephone, as required, was provided by the DOE Property Management Office. LUC verification

information used to document these results was compiled by the DOE Property Management Office in conjunction with DOE Realty Office. A copy of the documentation is submitted to the WRRP for use in the annual RER. Original documents are maintained by the Project Document Control Center.

6.4.3 Removal of Mercury from Storm Sewer System

Location of the action addressed in the *Action Memorandum for Time-Critical Removal Action for the Removal of Mercury from the Storm Sewer System at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2574&D1) is shown on Figure 6.1. The goal of the removal action was to reduce the release of mercury to UEFPC by capturing ongoing releases of mercury to the SD system, upstream of Outfalls 150, 160, 163, and 169. The project included reworking selected manholes; reworking selected SD junction boxes; installing mercury collection sumps (traps); installing mercury removal mechanisms; and collecting mercury from those features and other locations.

6.4.3.1 Other LTS Requirements

Other LTS requirements for the removal action are listed in Table 6.7 and described below.

6.4.3.2 Requirements

The *Removal Action Report for the Mercury Reduction Project* (DOE/OR/01-2595&D1) requires that the SD locations identified in the RmAR will continue to be monitored and maintained. Elemental mercury and associated contaminated sediments will continue to be collected, stored, treated, and disposed as described in the RmAR. The results of the removals are to be summarized in the annual RER.

6.4.3.3 Status of Requirements

Inspection of traps was performed in FY 2015. The nine trap locations are visually inspected periodically and material accumulated in the traps, including elemental mercury and associated sediments, is removed as needed for waste storage, treatment, and disposal. No mercury was removed from the traps in FY 2015. Performance of this project will be evaluated in the FY 2016 FYR process.

6.4.4 Secondary Pathways Project

The purpose of the Secondary Pathways Project was to identify and/or correct potential mercury infiltration and migration points at each of the three major mercury use facilities at Y-12. Scope included completion of mercury reduction actions outside Buildings 9201-5 (Alpha 5) and 9201-4 (Alpha 4). Additional actions included the investigation, identification and confirmation of potential mercury source points inside both facilities and Building 9204-4 (Beta 4) using available drawings of piping systems and floor drains. The project consisted of work to improve and control storm water runoff from the north and south sides of Alpha 5 and the south side of Alpha 4. The work included modifying drains, drainage systems and installing graded impervious surfaces to route runoff to SDs, reducing percolation through mercury contaminated soil. Work inside Alpha 5 and Beta 4 identified and confirmed the location of existing open drains inside each building. Prior activities in Alpha 4 have already been completed to eliminate potential mercury migration pathways.

6.4.4.1 Other LTS Requirements

Other LTS requirements for the Secondary Pathways Project are listed in Table 6.7 and described below.

6.4.4.2 Requirements

The *Phased Construction Completion Report for the Secondary Pathways Project* (DOE/OR/01-2596&D1) states that the Y-12 Utilities Management Division is responsible for long-term operation and maintenance requirements associated with the drainage improvements. Clean out and other maintenance work will be performed as needed.

6.4.4.3 Status of Requirements

Compliance with the requirements of the PCCR were verified in FY 2015. The drainage improvements were maintained as needed.

6.5 UEFPC WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the UEFPC watershed are in Table 6.12.

Table 6.12. UEFPC watershed issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issues Carried Forward[b]			
None			
Completed/Resolved Issues			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year of the RER in which the issue originated is provided in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report
UEFPC = Upper East Fork Poplar Creek

6.6 REFERENCES

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7. OFF-SITE ACTIONS

7.1 INTRODUCTION AND STATUS

7.1.1 Introduction

Table 7.1 lists the CERCLA actions outside of the ORR and identifies those with monitoring or other LTS requirements. Figure 7.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Figure 7.2 shows interim controls requiring LTS.

Poplar Creek, the Clinch River, and Watts Bar Reservoir comprise a single, hydrologically connected system through which contaminants originating on the ORR are transported. In September 1999, the monitoring plans for the Clinch River/Poplar Creek and LWBR were combined in the *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1820&D2), now referred to as the *Lower Watts Bar Reservoir and Clinch River Poplar/Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee (*DOE/OR/01-1820&D3), to better identify and evaluate changes in contaminants of concern concentrations in fish. However, the CERCLA decisions and evaluations of effectiveness are discussed separately (Sections 7.3 and 7.4).

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions for off-site actions is provided in Chapter 4 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

7.1.2 Status Update

A Non-Significant Change (NSC) to the *Record of Decision for the Lower Watts Bar Reservoir* (DOE/OR/02-1373&D3) was approved in November 2014. The NSC clarifies that the CERCLA decision included ecological protection and that the basis of the monitoring being performed is to detect changes in LWBR.

Table 7.1. CERCLA actions at off-site locations

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Other LTS required
Completed actions			
LEFPC	ROD (DOE/OR/02-1370&D2): 08/17/95 ESD (DOE/OR/02-1443&D2): 11/15/96, increase in soil excavation volume	RAR (DOE/OR/01-1680&D5) approved 08/15/00	Yes/Yes
Clinch River/Poplar Creek	ROD (DOE/OR/02-1547&D3): 09/23/97	RAR (DOE/OR/02-1627&D3) approved 06/14/99 • LWBR and Clinch River/Poplar Creek Watershed RAR CMP (DOE/OR/01-1820&D3)	Yes/Yes
LWBR	ROD (DOE/OR/02-1373&D3): 09/29/95 NSC: approved 11/04/14, ecological protection clarification	RAWP[b] (DOE/OR/02-1376&D3) approved 05/25/96 • LWBR and Clinch River/Poplar Creek Watershed RAR CMP (DOE/OR/01-1820&D3)	Yes/Yes

[a]Detailed information of the status of ongoing actions is from Appendix E of the FFA and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.
[b]This action was completed prior to uniform adherence to the RAR process; hence, no RAR exists for this decision.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
ESD = Explanation of Significant Differences
FFA = Federal Facility Agreement
LEFPC = Lower East Fork Poplar Creek
LTS = long-term stewardship
LWBR = Lower Watts Bar Reservoir
NSC = Non-Significant Change
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
ROD = Record of Decision

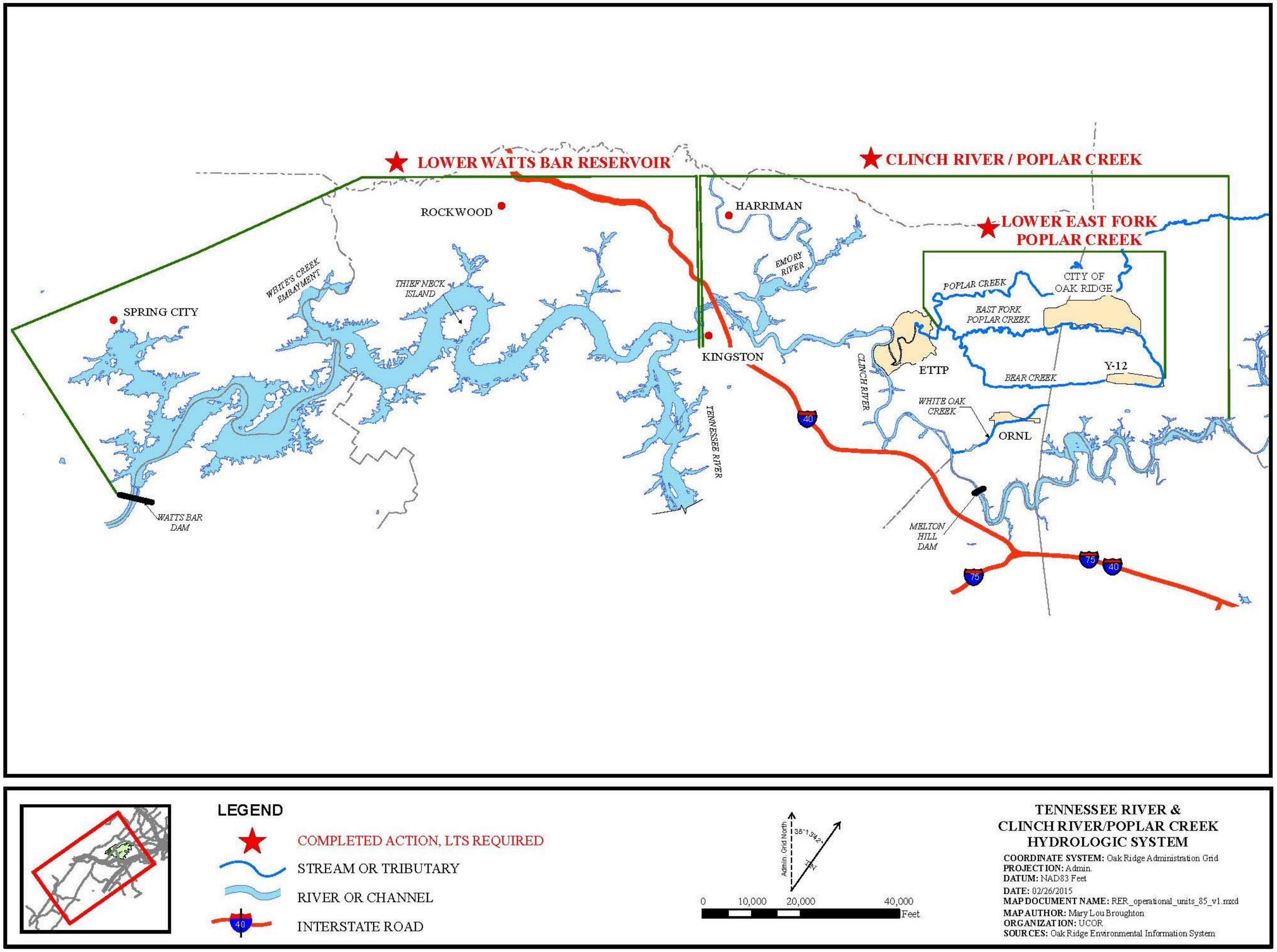

Figure 7.1. CERCLA actions at off-site locations.

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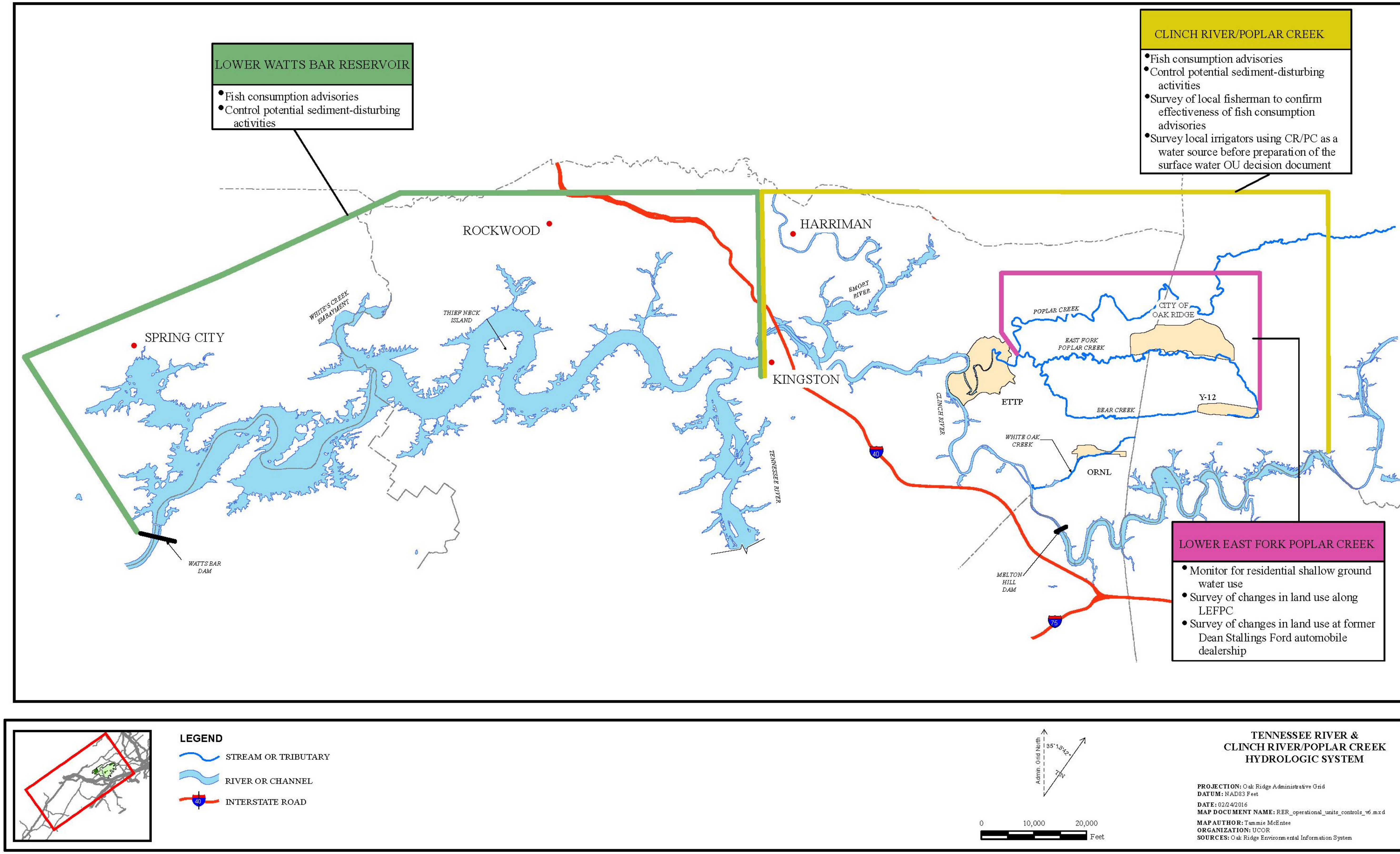

Figure 7.2. Interim controls requiring LTS at off-site locations.

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7.2 LEFPC

7.2.1 Performance Monitoring

7.2.1.1 Performance Monitoring Goals and Objectives

The *Record of Decision for Lower East Fork Poplar Creek* (DOE/OR/02-1370&D2) addressed the mercury contamination in the floodplain sediments of the creek that runs from Y-12 (in the UEFPC watershed) through the city of Oak Ridge (Figure 7.3).

A major component of the selected remedy for LEFPC was to perform appropriate monitoring to ensure effectiveness. The *Remedial Action Report on the Lower East Fork Poplar Creek Project* (DOE/OR/01-1680&D5) provides a description of all measures taken during the remedial activities to comply with ARARs and supplemental monitoring activities. During FY 2015, mercury inputs from UEFPC to LEFPC were monitored at Station 17. This requirement is covered by the mercury monitoring at Station 17 required by the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE/OR/01-1951&D3).

7.2.1.2 Evaluation of Performance Monitoring Data

7.2.1.2.1 Watershed Data

As a requirement of the *Remedial Action Report on the Lower East Fork Poplar Creek Project*, (DOE/OR/01-1680&D5) mercury releases from Y-12 have been, and continue to be, measured at Station 17, the point at which the government land transitions to city property along LEFPC (Figure 7.3). A full discussion of the historical and current trends in mercury releases at Station 17 is presented in Section 6.2.

The effect of the upstream mercury source on LEFPC and downstream spatial trends in mercury bioaccumulation in various sunfish species (rock bass, redbreast, and bluegill) are depicted in Figure 7.4. Different species of fish are encountered at different sites, and these species can vary in their mercury content. In contrast to aqueous mercury concentrations which tend to decrease with increasing distance downstream, there is a general trend of stable to increasing mercury concentrations in fish with increasing distance downstream within LEFPC. Although there is variability in mercury concentrations between sites and species of fish, mercury concentrations are highest in fish that feed at higher trophic levels such that concentrations in rock bass >redbreast >bluegill collected at the same site and season. In FY 2015, similar to trends seen in recent years, the highest concentrations were seen at EFK 13.8 for redbreast (1.07 μg/g), while concentrations in rock bass were comparable at EFK 18.2, EFK 13.8, and EFK 6.3 (approximately 1.4 μg/g). Similarly to trends seen in FY 2014, concentrations in redbreast in Poplar Creek just downstream of the confluence with East Fork Poplar Creek (Poplar Creek mile [PCM] 5.1) were even higher than within East Fork Poplar Creek (0.84 μg/g). Regardless of the sunfish species, it is evident that the mercury content in fillets of sunfish is above EPA's recommended AWQC of 0.3 µg/g mercury in fish throughout LEFPC and at the mouth of Poplar Creek, but decreases below this threshold within a few kilometers downstream in lower Poplar Creek and the Clinch River (at least in 2015; sunfish occasionally do exceed the value in lower Poplar Creek and the Clinch River sites).

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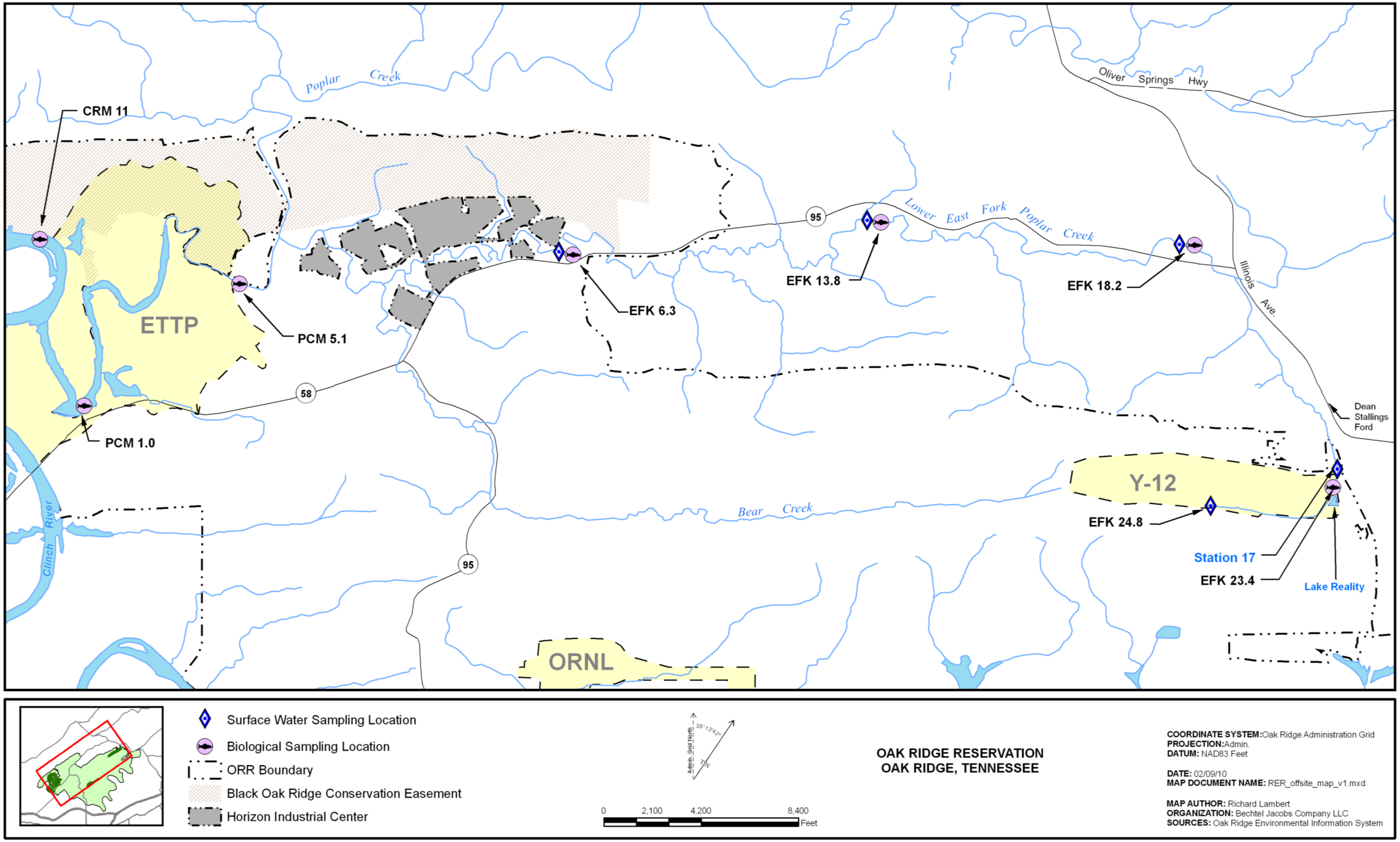

Figure 7.3. LEFPC.

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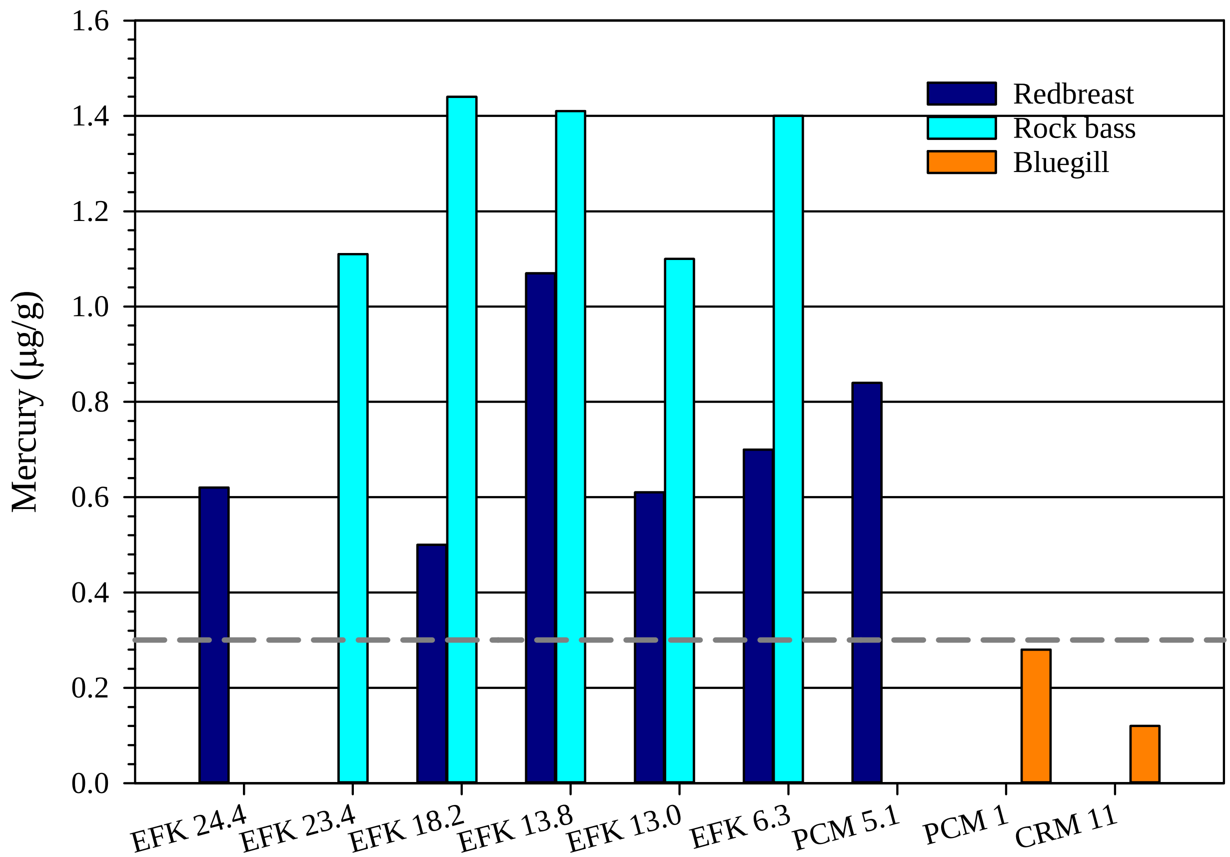

Figure 7.4. Spatial pattern of mercury bioaccumulation in various fish species in LEFPC (EFK), Poplar Creek (PCM) and the Clinch River (CRM) in FY 2015.

Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

At EFK 6.3, the long-term trend since the 1980s is of increasing mercury concentrations in fish (Southworth et al., 2011; Figure 7.5). However, trend analysis is again complicated by the change in fish species availability. If considering redbreast or rock bass temporal trends only, there is no clear evidence of an increasing or decreasing trend in recent years (especially over the 2003 – 2015 time period).

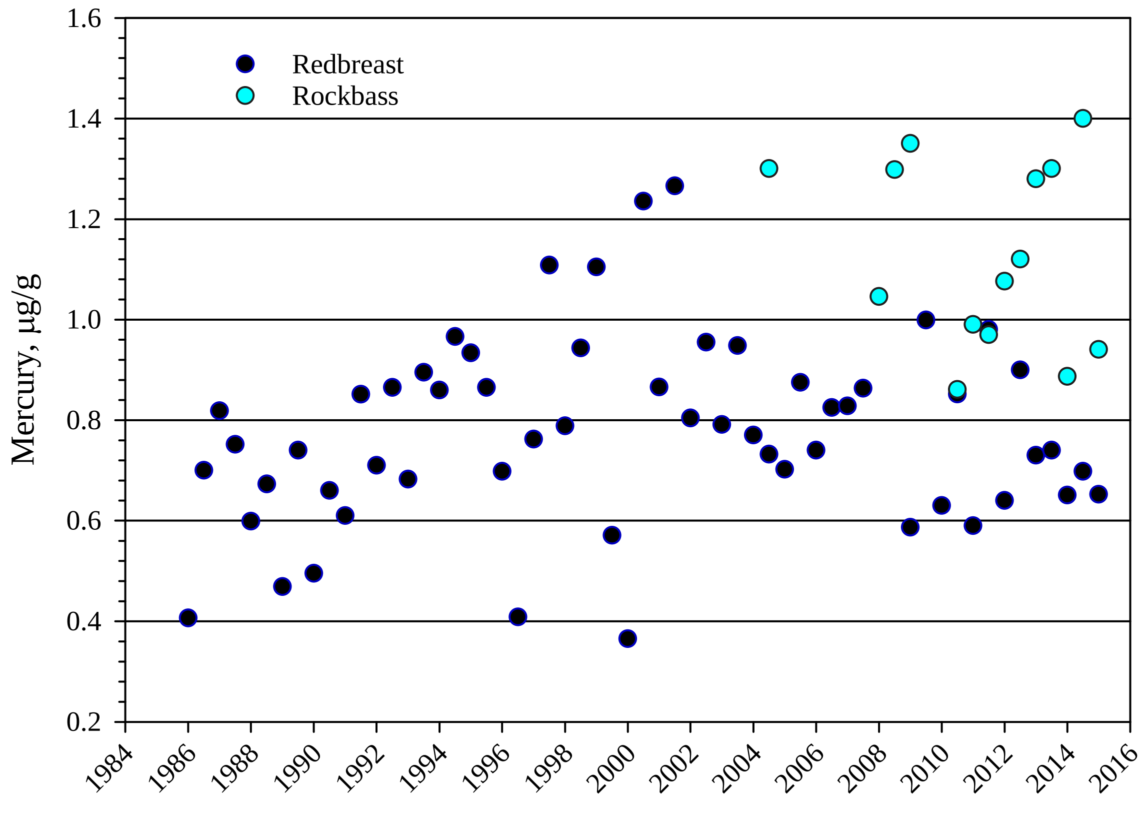

Figure 7.5. Mean mercury concentration in muscle tissue of redbreast sunfish at EFK 6.3.[a]

[a]When redbreast sunfish could not be found, rock bass (light blue circles) were collected instead.

7.2.1.3 Performance Summary

Monitoring at Station 17 is conducted to measure the concentration and mass flux of mercury that is discharged from the UEFPC watershed into LEFPC. During FY 2015, the flow-paced continuous monitoring detected an average concentration of 1,030 ng/L, down from 1,491 ng/L in FY 2014, and a mass flux of 8.1 kg mercury, down from 14.4 kg in FY 2014 (Section 6.2.1). The levels of mercury in fish tissue in the LEFPC have remained elevated.

7.2.2 Other LTS Requirements

Other LTS requirements for LEFPC are listed in Table 7.2 and described below.

7.2.2.1 Requirements

The *Record of Decision for Lower East Fork Poplar Creek, Oak Ridge, Tennessee* (DOE/OR/02-1370&D2) states that although residential use of soil horizon (shallow) groundwater is not realistic, as a safeguard, DOE will monitor to detect any future residential use of shallow groundwater.

The *Remedial Action Report on the Lower East Fork Poplar Creek* (DOE/OR/01-1680&D5) requires an annual survey to verify land use in the area of the former Dean Stallings Ford automobile dealership parking lot has not changed since the issuance of the ROD (DOE/OR/02-1370&D2) and exposure pathways remain protected. Additionally, the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*

(DOE/OR/01-2516&D2) identified that the property is for sale and that could result in a change in land use. It was stated that if changes occur DOE will evaluate the need for additional institutional controls and other response activities. The verification of this LUC is institutionalized as part of a LUC program.

7.2.2.2 Status of Requirements

A periodic survey to detect residential use of shallow groundwater was last performed in FY 2012. There were no new wells identified for residential use along LEFPC.

Visual inspections in FY 2015 confirmed that land use of the property of the former Dean Stallings Ford automobile dealership has not changed. The area is now leased to Ole Ben Franklin Motors used car dealership which opened for business in January 2014.

Table 7.2. Other LTS requirements for Off-Site

Other LTS requirements for Completed Actions Off-Site[a]			
Specific Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
LEFPC	ROD (DOE/OR/02-1370&D2) RAR (DOE/OR/01-1680&D5)	• DOE will monitor to detect any future residential use of the shallow soil horizon groundwater • A survey to determine any changes in land use patterns along LEFPC • Annual survey to verify land use in the area of the Dean Stallings Ford automobile dealership parking lot shall be performed to verify that the land use has not changed since the issuance of the EFPC RIR	• A FYR will be required to evaluate whether the selected remedy remains protective • Before FYR, a survey will be performed to re-evaluate land-use patterns along LEFPC to ensure that the land-use assumption used to develop the 400 ppm mercury cleanup level remains valid
Clinch River/Poplar Creek	RAR (DOE/OR/02-1627&D3) CMP (DOE/OR/01-1820&D3)	• Survey of local fisherman to confirm the effectiveness of fish consumption advisories • Irrigation survey – identify and survey local irrigators using Clinch River or Poplar Creek as a water source for irrigating crops, fields, or gardens • Fish consumption advisories to reduce exposure to contaminants in fish tissue • Existing institutional controls to control potential sediment-disturbing activities	• Fish advisory survey conducted one time only in 2000. Results reported in 2001 RER. • Conduct irrigation survey before preparation of the decision document for the surface water OU • Fish consumption advisories are issued by the TDEC Division of Water Pollution Control • DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments
LWBR	RAWP (DOE/OR/02-1376&D3) CMP (DOE/OR/01-1820&D3)	• Fish consumption advisories to reduce exposure to contaminants in fish tissue • Existing institutional controls to control potential sediment-disturbing activities	• Fish consumption advisories are issued by the TDEC Division of Water Pollution Control • DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments

[a] LTS for specific areas is determined by each remediation project and listed in the project specific completion report.

CMP = Comprehensive Monitoring Plan
DOE = U.S. Department of Energy
EFPC RIR = East Fork Poplar Creek-Sewer Line Beltway Remedial Investigation Report
FYR = Five-Year Review
LEFPC = Lower East Fork Poplar Creek
LTS = long-term stewardship
LWBR = Lower Watts Bar Reservoir
OU = operable unit
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
RER = Remediation Effectiveness Report
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
WBIWG = Watts Bar Interagency Working Group

7.2.3 LEFPC Issues and Recommendations

In response to EPA comments on the draft *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2), two LEFPC action plans were developed and agreed to that focused on issues and uncertainties in the FYR protectiveness determination. The Action Plans are included in Appendix C of this document. The action plans center on two identified issues:

1) New information suggests mobilization of mercury from East Fork Poplar Creek streambed and stream banks is a major source of mercury exposure during high-flow conditions. The current *Record of Decision for Lower East Fork Poplar Creek, Oak Ridge, Tennessee* (DOE/OR/02-1370&D2) did not fully consider the entire hydrologic system and did not explicitly address creek bank or creek bed sediments.

   The agreed-to action plan to evaluate the contributions of downstream sources and mobilization of mercury at a watershed scale includes field and laboratory investigations to close data gaps. Newly collected data will be used to develop conceptual and systems-based models that can be used as tools to refine source estimates. The evaluations will be conducted over the period leading to the *2016 Five-Year Review*, and progress reported annually in the RER (See Action Plan #1 in Appendix C).

2) New mercury bioaccumulation studies show mercury uptake in spiders along LEFPC.

   To address the issue of elevated mercury concentrations in spiders, literature reviews and risk calculations were performed using estimates of key parameters from the literature. It was determined, after results were attained, that more conclusive site-specific floodplain information is needed to decrease uncertainty. The results of analysis to date and DOE's planned path forward to determine an LEFPC protectiveness statement are described in Action Plan #2 in Appendix C.

No changes for LEFPC are recommended.

7.3 CLINCH RIVER/POPLAR CREEK

7.3.1 Performance Monitoring

7.3.1.1 Performance Monitoring Goals and Objectives

The Clinch River/Poplar Creek Operable Unit extends 34 river miles from the mouth of the Clinch River at Tennessee River mile (TRM) 567.5 (Clinch River mile [CRM] 0.0) at Kingston, upstream past the Melton Hill Reservoir dam at CRM 23.1, to the upstream boundary of the ORR at CRM 43.7 (Figure 7.6). The Clinch River/Poplar Creek Operable Unit also includes the lower portion of Poplar Creek from the mouth of Poplar Creek on the Clinch River at CRM 12.0, upstream to its confluence with LEFPC at PCM 5.5 (Figure 7.3).

A major component of the *Record of Decision for the Clinch River/Poplar Creek Operable Unit* (DOE/OR/02-1547&D3) is appropriate monitoring to ensure the institutional controls remain protective against the risk of potential exposure to contaminants of concern in sediments and fish tissue.

The original monitoring plans for the action are in the *Remedial Action Report for Clinch River/Poplar Creek* (DOE/OR/02-1627&D3). However, in September 1999, DOE recommended two broad changes to the monitoring plans. The first was to combine the two operable units into a single entity for monitoring

purposes. The second was to change the number and locations of monitoring stations and sampling techniques in both operable units. Based on these recommendations, which were based on the hydrological connection of Poplar Creek, Clinch River, and Watts Bar Reservoir, a *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units* (DOE/OR/01-1820&D2) was prepared.

Based on sampling results from 1999 – 2004, the combined monitoring plan was revised in FY 2004. This monitoring plan is now referred to as the *Lower Watts Bar Reservoir and Clinch River Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1820&D3) and consists of two components for the Clinch River/Poplar Creek – annual monitoring of major contaminants of concern in fish and additional monitoring for Clinch River/Poplar Creek (sediment, surface water, turtles) once every five years to support the CERCLA FYR (Table 7.3).

The combined monitoring program uses a scientifically rigorous sampling design supporting the identification and evaluation of changes in contaminants of concern concentrations in fish. This evaluation is directly applicable to the ROD-specified requirements to detect changes in fish contaminant concentrations and to evaluate whether institutional controls, i.e., the fish consumption advisory, are effective (DOE/OR/01-1820&D3). If concentrations of contaminants in tissues of these species increase substantially, a study to determine the cause of the change may be warranted. Conversely, decreases in contaminants of concern concentrations would support the evaluation of the need for continuing the fish advisory.

The ROD requirements for the Clinch River/Poplar Creek hydrologic unit are satisfied by conducting annual sampling of contaminant concentrations in fish. Sites sampled in FY 2015 include four sites in the Clinch and Tennessee Rivers between Melton Hill Dam and the Watts Bar Dam, a site in Poplar Creek, and two Clinch River reference sites (upstream of Melton Hill Dam) that are sampled for comparison purposes (Figure 7.6). The sites sampled are based on their position below key DOE inputs and stream/river exit points, as well as their importance as long-term measures of change. Most of the designated sites have been monitored annually since the mid-1980s and are important sites for evaluating long-term change (DOE/OR/01-2058&D2). Target species are channel catfish, largemouth bass, and striped bass. Depending on the site and species, PCBs, mercury, and ^{137}Cs concentrations are determined in fish fillets. Historically, striped bass were monitored below the Bull Run and Kingston steam plants (CRM 48 and CRM 3, respectively), but since 2008 Tennessee Valley Authority (TVA) steam plant generators have not been running on regular schedules and so striped bass have rarely been available at Bull Run steam plant. Since 2014, striped bass were collected in Norris Lake as the upstream reference site.

Starting in FY 2013, largemouth bass were no longer collected annually in the summer. Largemouth are now collected for mercury bioaccumulation on an annual cycle in the fall. Channel catfish will continue to be collected annually in the summer.

Fish consumption advisories are issued by the TDEC and posted at the Tennessee Wildlife Resources Agency (TWRA) website. The advisories are based on a calculation of fish concentration thresholds from the aqueous PCB AWQC, and also TDEC interpretation of site-specific risks.

Signs are placed at main public access points and a press release is submitted to local newspapers. The list of advisories is also published in TWRA’s annual fishing regulations.

Table 7.3. Monitoring locations in Clinch River/Poplar Creek

Monitoring stations	Analyses[a]
Surface water: CRM 48, CRM 23.4–24.7, WOCE, K-1007-P1 Pond, K-901-A Pond, CRM 10.5–12, and CRM 1, once every five years	Surface water—isotopic uranium, total mercury, TAL metals, and hydrolab profile
Sediment: CRM 48, CRM 23.4–24.7, CRM 14–15, PCM 1, CRM 10.5–12, CRM 6–7, and CRM 1, once every five years	Total metals, total mercury, and ^{137}Cs. Samples from Poplar Creek will also be analyzed for ^{99}Tc, $^{234/235/238}U$, ^{60}Co, and PCBs
Fish: CRM 23, PCM 1, and CRM 11 (catfish and largemouth bass) and CRM 20 (catfish only), annually. As of FY 2013, largemouth bass are collected in the fall and channel catfish in summer Downstream Clinch River (CRM 3, or as needed from downstream of DOE facilities), and upstream Clinch River (CRM 48, or Norris Lake reference site (NORRIS) (striped bass), winter only	Catfish: PCBs , total mercury, ^{137}Cs (CRM 20 only), and total lipid Largemouth bass: total mercury Striped Bass: PCBs and total lipid
Turtles: CRM 23, CRM 20, and CRM 11, once every five years in summer	PCBs, total mercury, ^{137}Cs, and total lipid

[a]Analyses listed are those required to monitor action effectiveness.

CRM = Clinch River mile
DOE = U.S. Department of Energy
FY = fiscal year
PCB = polychlorinated biphenyl
PCM = Poplar Creek mile
TAL = target analyte list
WOCE = White Oak Creek Embayment

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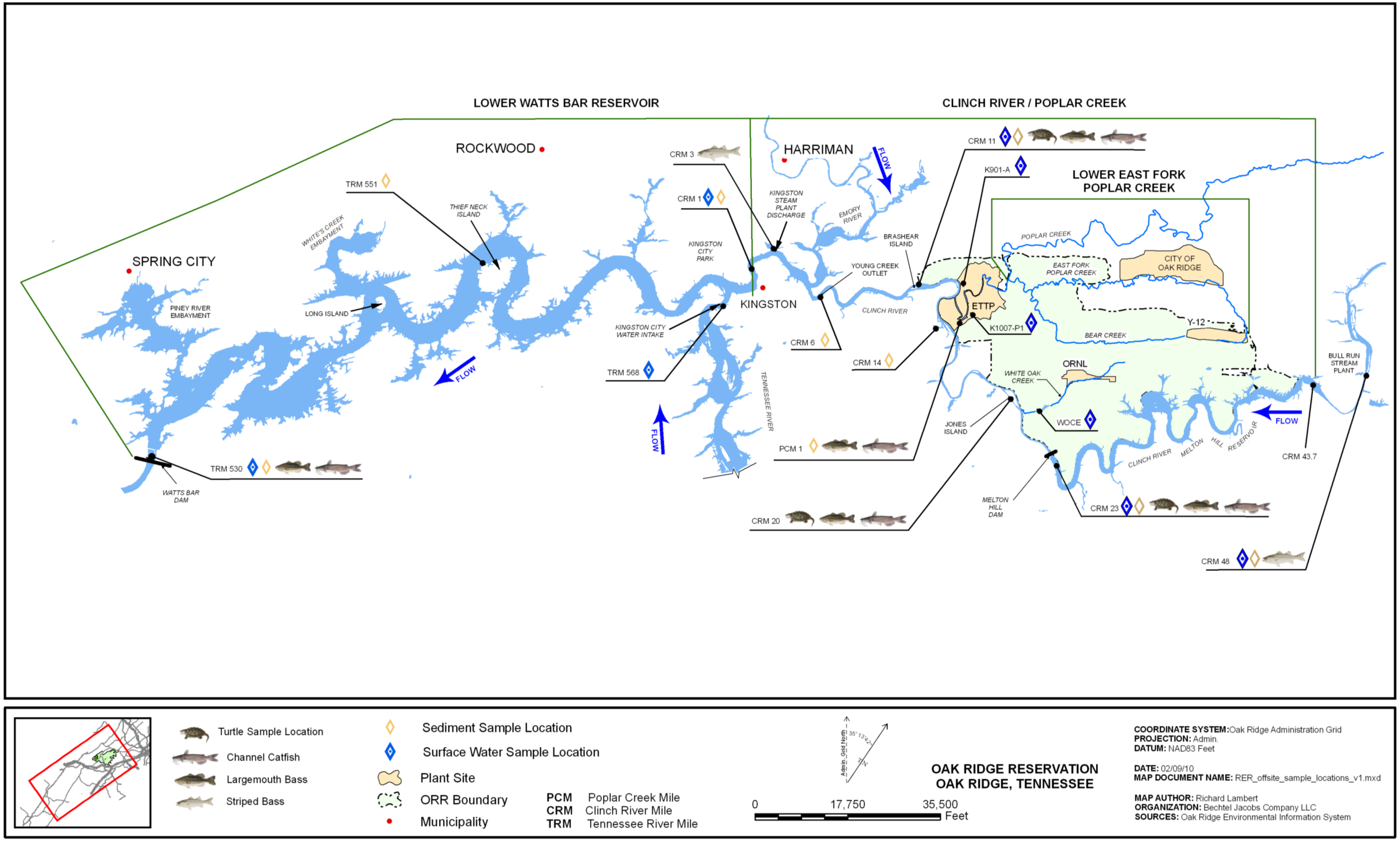

Figure 7.6. Monitoring locations in the Clinch River/Poplar Creek and LWBR operable units.

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7.3.1.2 Evaluation of Performance Monitoring Data

The selected remedy identified in the *Record of Decision for the Clinch River/Poplar Creek Operable Unit* (DOE/OR/02-1547&D3) is still in place and effective. Institutional controls prevent exposure to contaminated sediment (via the Watts Bar Interagency Working Group [WBIWG]); fish consumption advisories are issued by TDEC; and annual monitoring is conducted to evaluate changes in contaminant levels. Performance monitoring for the Clinch River/Poplar Creek has primarily focused on contaminant trending in fish to address the requirement for annual monitoring to detect changes in contaminant levels or mobility.

Results of FY 2015 monitoring for Poplar Creek and the Clinch River arm of Watts Bar Reservoir are provided in Table 7.4. PCB concentrations in Clinch River channel catfish were similar in 2015 compared to the past few years and have been trending downward for more than a decade, although there is substantial year-to-year variability (Figure 7.7). PCBs in channel catfish from Poplar Creek are similarly variable (Figure 7.7). The highest mean PCB concentrations in catfish have historically been found in Poplar Creek, but the concentrations at this site have been decreasing steadily for the past four years, such that concentrations in these fish have been approaching those in fish from the Clinch River. PCB concentrations in striped bass collected from CRM 2.6 were significantly higher than those seen at the Norris Lake reference site (Table 7.4). These concentrations were comparable to values seen in recent years, and within the range of normal inter-annual variation observed at these sites.

Evaluations of PCB concentrations in fish must carefully consider the species of fish sampled and the assumptions used in any risk analyses. Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused TMDLs, including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the state of Tennessee, assessments of impairment for water body segments as well as public fishing advisories are based on fish tissue concentrations. Historically, the FDA threshold limit of 2 µg/g in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. Most recently, the water quality criterion (0.00064 µg/L for total PCBs) has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2007) under its TMDL Program, and this concentration is 0.02 mg/kg in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in the Clinch River and Watts Bar are still well above the calculated TMDL concentration.

Temporal trends in mean mercury concentrations in largemouth bass from Poplar Creek, the Clinch River, and Lower Watts Bar are shown in Figure 7.8. Although there is some inter-annual variability, concentrations have remained fairly constant over the time period studied at all sites monitored.

Bluegill and redbreast sunfish have also been collected for mercury analysis from PCM 1 and PCM 5 (also described as Poplar Creek kilometer [PCK] 8.2). The PCM 5 sampling location is centered at the confluence of EFPC and Poplar Creek and has been monitored since 2006 (Figure 7.9). Mercury concentrations at the PCM 5 site have consistently been higher than at PCM 1, consistent both with the pattern of downstream dilution of mercury within Poplar Creek and also with the difference in species collected at the two sites. Previous studies have shown that redbreast sunfish accumulate 25 – 50% more mercury than similarly sized bluegill sunfish collected from the same sites (Southworth et al., 1994). Regardless, mercury concentrations in sunfish at both of these sites have been slowly but steadily

increasing since 2006, with a significant increase seen in redbreast collected at the upper site from 2012 – 2014. This time period is just after significant increases were observed in both aqueous mercury and sunfish mercury concentrations in UEFPC which have been attributed to SD cleanout activities from 2010 – 2011. The concentrations in redbreast continue to exceed the AWQC and were lower than concentrations seen for this species in EFPC in 2014. Mean mercury concentrations in bluegill collected from PCM 1 have been fluctuating around the AWQC, slightly exceeding this limit in 2014. In 2015 mercury concentrations in fish at both locations declined in Poplar Creek relative to 2014, suggesting that levels associated with the SD cleanout may have peaked and now may be headed to more normal historical levels.

Mercury concentrations in catfish were below the EPA fish tissue criterion at all sites monitored in 2015 (Table 7.4). Of all the sites monitored in off-site locations, mercury concentrations in largemouth bass have been highest in Poplar Creek (PCM 1, just downstream of where the K-1007-P1 Pond exchanges with Poplar Creek). Levels of cesium were below analytical detection limits in all fish collected from the Clinch River sample site immediately downstream of WOC (which flows from ORNL).

7.3.1.3 Performance Summary

Performance monitoring of the Clinch River and Poplar Creek continues to indicate an overall downward trend in fish PCB concentrations. The decreasing PCB trends in fish are some of the most dramatic observed by the long-running Oak Ridge biological monitoring programs (Figure 7.7). However, striped bass are routinely above PCB advisory limits, especially larger fish. Mercury concentrations in fish at monitored sites continue to indicate the influence of mercury sources from East Fork Poplar Creek, with elevated levels in fish in upper Poplar Creek and lower levels with distance downstream. Overall, the performance monitoring has been successful in addressing the ROD goal of evaluating changes in fish contaminant levels and how those levels compare to fish advisory limits.

Table 7.4. Mean concentrations (n = 6 fish, ± standard error) of total PCBs (Aroclor-1248+1254+1260), total mercury, and ^{137}Cs in fish muscle fillet from Off-site locations in FY 2015

Monitoring location		Total PCBs (mg/kg)		Mercury (mg/kg)		^{137}Cs (pCi/g)
Site	**Description**	**Channel catfish**	**Striped bass**	**Largemouth bass**	**Channel catfish**	**Channel catfish**
		Clinch River				
CRM 20	Jones Island downstream of WOC	0.13 ± 0.02		0.18 ± 0.04	0.06 ± 0.01	<0.25
CRM 11	Brashear Island downstream of Poplar Creek	0.17 ± 0.03		0.36 ± 0.05	0.18 ± 0.03	
CRM 3	Kingston Steam Plant discharge					
		Poplar Creek				
PCM 1	Near K-1007-P1 outlet	0.13 ± 0.02		0.50 ± 0.05	0.12 ± 0.04	
		LWBR				
TRM 530	Watts Bar Reservoir forebay	0.11 ± 0.03		0.10 ± 0.02	0.10 ± 0.02	
		Reference sites (upstream of Clinch River/Poplar Creek-LWBR)				
CRM 23	Melton Hill Reservoir forebay	0.08 ± 0.01		0.11 ± 0.03	0.06 ± 0.01	
CRM 2.6	Kingston Fossil Plant		0.46 ± 0.12			
CRM 95	Norris Lake		0.06 ± 0.01			

CRM = Clinch River mile
FY = fiscal year
LWBR = Lower Watts Bar Reservoir
PCB = polychlorinated biphenyl
PCM = Poplar Creek mile
TRM = Tennessee River mile
WOC = White Oak Creek

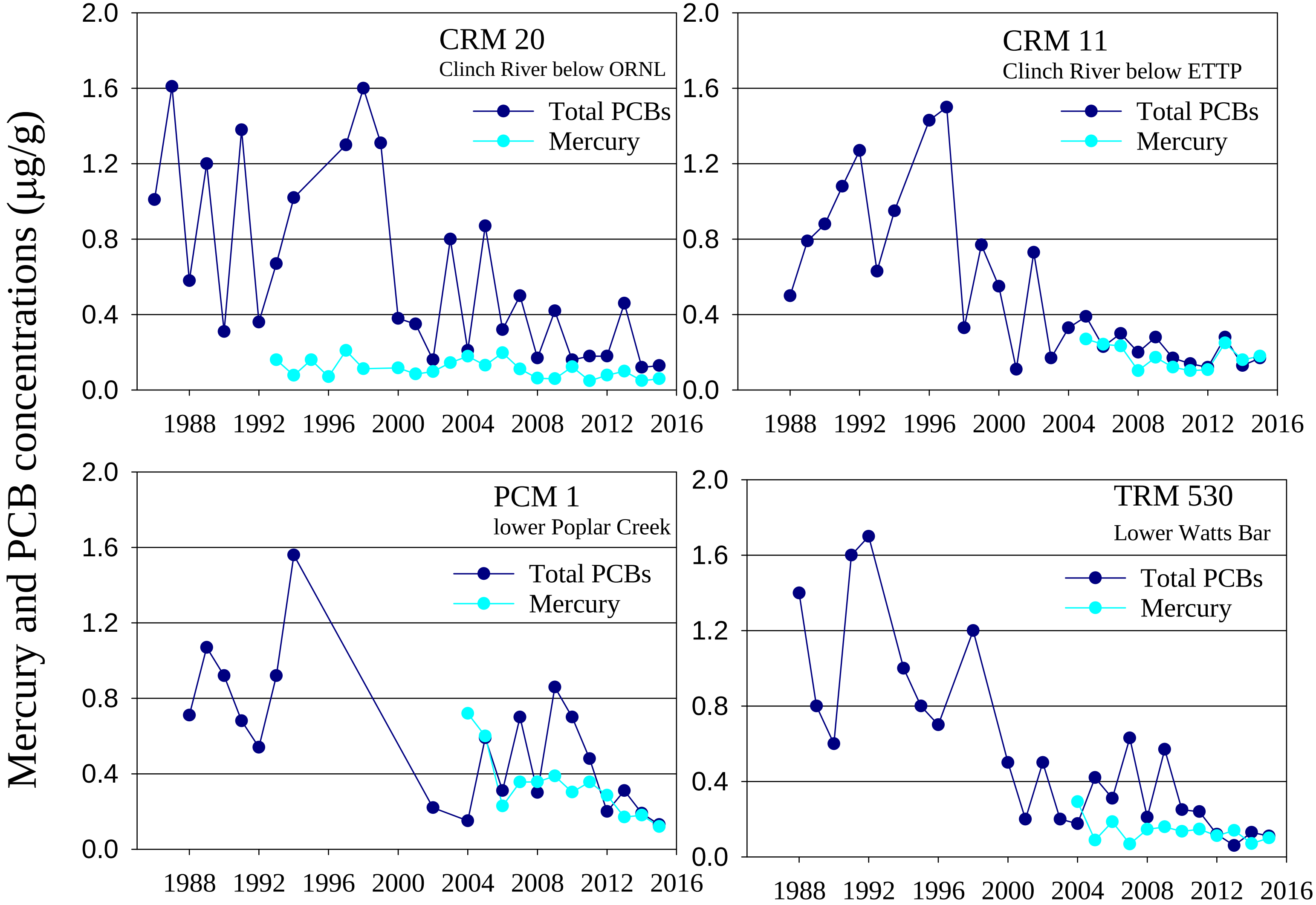

Figure 7.7. Average mercury and PCB concentrations in channel catfish from Clinch River/Poplar Creek and LWBR sites, 1986 – 2015.

(Courtesy of multiple programs in the early years, including Biological Monitoring and Abatement program, Annual Site Environmental Report, and TVA, 1986 – 2003).

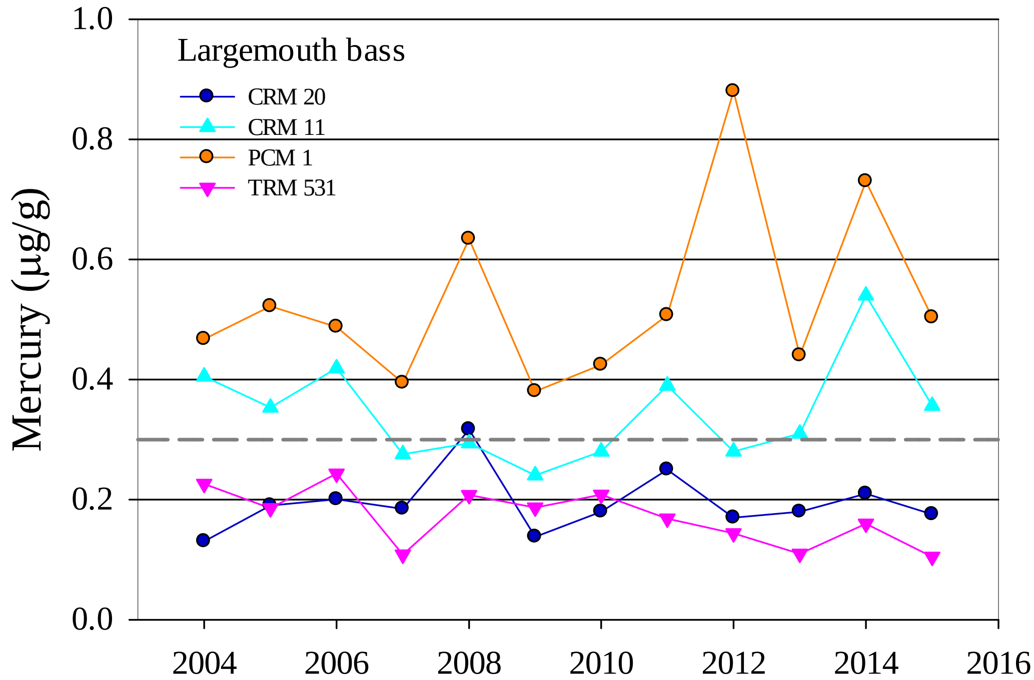

Figure 7.8. Mean mercury concentrations in largemouth bass from Clinch River/Poplar Creek and LWBR sites, 2004 – 2015.

Dashed gray line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

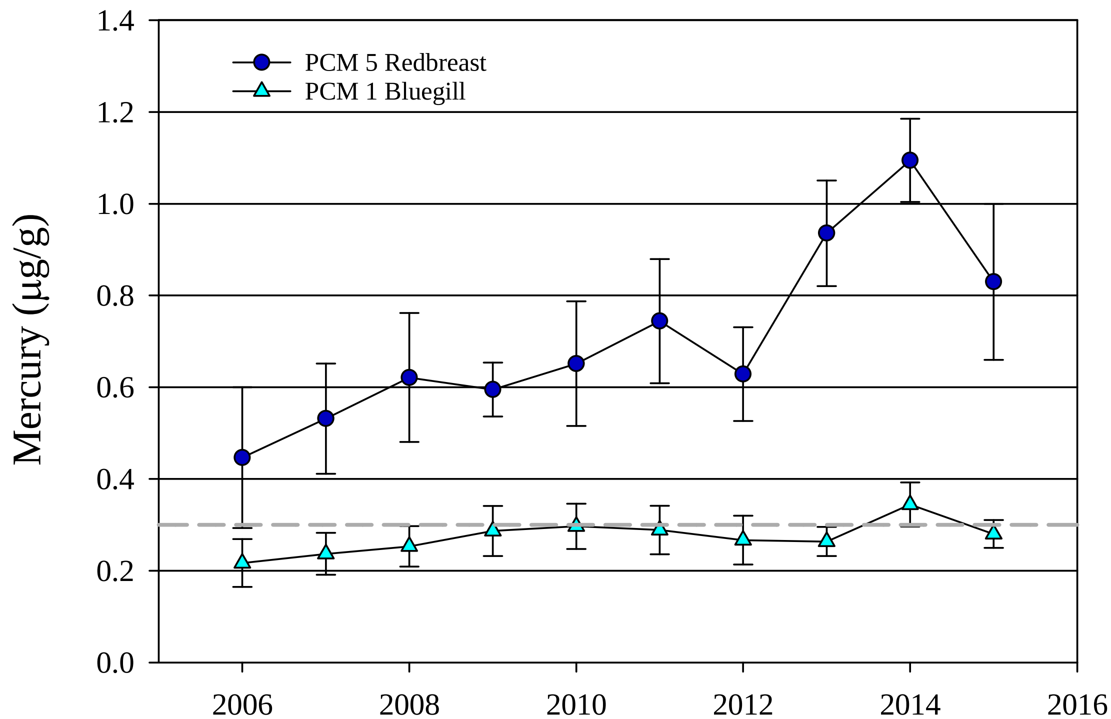

Figure 7.9. Mean mercury concentrations in sunfish from Poplar Creek, 2006 – 2015.

Dashed gray line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

7.3.2 Other LTS Requirements

Other LTS requirements for Clinch River/Poplar Creek are listed in Table 7.2 and described below.

7.3.2.1 Requirements

Requirements specified in the *Remedial Action Report for Clinch River/Poplar Creek* (DOE/OR/02-1627&D3) include institutional controls for the Clinch River/Poplar Creek:

- continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish;
- continued scrutiny of sediment-disturbing activities in Chestnut Ridge/Poplar Creek by the WBIWG, comprised of TDEC, TVA, Army Corps of Engineers, and DOE, to prevent exposure to potentially contaminated dredged soil;
- conduct of a survey of irrigation practices before the preparation of the decision document for the surface water operable unit;
- one-time survey of local fishermen to determine the effectiveness, i.e., awareness of fish consumption advisories.

7.3.2.2 Status of Requirements

TDEC, Division of Water Pollution Control, maintains fish consumption advisories for the local area. The TWRA posts these advisories on their web site, and it was last updated in August 2010. These same advisories are included in the TWRA's 2015 – 2016 Tennessee Fishing Guide that is available on-line and where fishing licenses are sold.

The WBIWG provided continued controls on sediment-disturbing activity in the deep-water channel. In FY 2015, four dredging permit applications were received and approved for Clinch River/Poplar Creek and LWBR.

A survey of irrigation practices will be conducted when the RI for Chestnut Ridge/Poplar Creek surface water is performed, which is scheduled in the outyears of ORR cleanup.

The fish advisory survey was conducted in 2000 and results were reported in the 2001 RER.

A review of the efficacy of institutional controls preventing sediment exposure and the effectiveness of the fish consumption advisory was provided in the *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2289&D3) and referenced again in the *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2516&D2). The results of that review suggest that institutional controls in place are effective in limiting human exposure, although some areas of the reservoir are not well posted and there are some groups of fishermen who do not follow advisories. The state of Tennessee is responsible for issuing fish consumption advisories and communicating relevant health information to the public.

7.3.3 Clinch River/Poplar Creek Issues and Recommendations

There are no issues or recommendations.

7.4 LWBR

7.4.1 Performance Monitoring

7.4.1.1 Performance Monitoring Goals and Objectives

The LWBR operable unit extends 38 river miles from TRM 567.5, at the mouth of the Clinch River, downstream to the Watts Bar Reservoir dam at TRM 529.9 (Figure 7.6).

The original post-ROD monitoring plans for the action are in the *Remedial Action Work Plan for Lower Watts Bar Reservoir* (DOE/OR/02-1376&D3). As discussed in Section 7.3.1, monitoring requirements for the LWBR are included with requirements for Clinch River/Poplar Creek in the *Lower Watts Bar Reservoir and Clinch River Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1820&D3).

The overall goal of the remedy for LWBR is to protect human health and the environment by reducing exposure to contaminated sediment in the main river channel and contaminants in fish. The monitoring strategy is provided in the *Lower Watts Bar Reservoir and Clinch River Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1820&D3) and summarized in Table 7.5.

Table 7.5. Monitoring locations in LWBR

Monitoring stations	Analyses[a]
Surface water: TRM 568.4 and TRM 530–532, once every five years[b]	Surface water—isotopic uranium, total mercury, TAL metals, and hydrolab profile
Sediment: TRM 551–556 and TRM 530–532, once every five years[b]	Total metals, total mercury, and ^{137}Cs
Fish: TRM 530 (catfish and largemouth bass), annually. As of FY 2013, largemouth bass are collected in the fall and channel catfish in summer.	Catfish: PCBs, total mercury, and total lipid Largemouth bass: total mercury

[a]Analyses listed are those required to monitor effectiveness.
[b]Sampling takes place the year before the FYR, e.g., FY 2010 for the 2011 FYR.

FY = fiscal year
FYR = Five-Year Review
LWBR = Lower Watts Bar Reservoir
PCB = polychlorinated biphenyl
TAL = target analyte list
TRM = Tennessee River mile

Fish consumption advisories are maintained by the TDEC and posted at the TWRA website. The advisories are based on a calculation of fish concentration thresholds from the aqueous PCB AWQC, and also TDEC interpretation of site-specific risks.

Signs are placed at main public access points and a press release is submitted to local newspapers. The list of advisories is also published in TWRA's annual fishing regulations.

7.4.1.2 Evaluation of Performance Monitoring Data

Performance monitoring in LWBR has primarily focused on the *Lower Watts Bar Reservoir and Clinch River Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-1820&D3) requirements to evaluate changes in fish contaminant levels. These trending results are directly related to the ROD requirement that monitoring of water, sediment, and biota be continued to determine if there is a change in the currently calculated risk that would pose a threat to

human health and/or the environment. The ROD indicated that the response action (namely, monitoring of contaminant levels or mobility) was considered applicable to reducing ecological risk.

Monitoring results indicate that PCB concentration at TRM 530 in 2015 averaged 0.11 µg/g in channel catfish (Table 7.4), which is comparable to the concentration observed at this site in FY 2014. As was previously discussed, regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. Although historically fish advisories were considered when fish fillets were in the 0.8 to 1 µg/g range, the current target concentration for Watts Bar Reservoir is 0.02 mg/kg in fish fillet (TDEC 2010a,b,c). The fish PCB concentrations in LWBR are still above this concentration. The good news is that the current levels are substantially lower than the concentrations observed in the 1980s and 1990s when the advisories were first issued (Figure 7.7).

Mercury concentrations in fish from LWBR are also low, averaging equal to or less than 0.11 µg/g depending on species (Table 7.4). This level is less than the EPA recommended AWQC of 0.3 µg/g mercury in fish. Mercury concentrations in the 0.2 µg/g range are typical of largemouth bass and channel catfish in Tennessee reservoirs.

7.4.1.3 Performance Summary

Performance monitoring results from LWBR obtained during FY 2015 continue to indicate that mercury and PCB levels in fish are decreasing from historical levels.

7.4.2 Other LTS Requirements

Other LTS requirements for LWBR are listed in Table 7.2 and described below.

7.4.2.1 Requirements

The Remedial Action Work Plan for Lower Watts Bar Reservoir (DOE/OR/02-1376&D3) requires institutional controls, including continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish and continued scrutiny of sediment-disturbing activities in LWBR by the WBIWG to prevent exposure to potentially contaminated dredged soil.

7.4.2.2 Status of Requirements

TDEC, Division of Water Pollution Control, maintains fish consumption advisories for the local area. The TWRA posts these advisories on their web site and it was last updated in August 2010. These same advisories are also published in the TWRA's 2015 – 2016 Tennessee Fishing Guide that are available online and where fishing licenses are sold.

The WBIWG provided continued controls on sediment-disturbing activity in the deep-water channel. In FY 2015, four dredging permit applications were received and approved for Clinch River/Poplar Creek and LWBR.

A review of the efficacy of institutional controls preventing sediment exposure and the effectiveness of the fish consumption advisory was provided in the *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2289&D3) and referenced again in the *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2516&D2). The results of that review suggest that institutional controls in place are effective in limiting human exposure, although some areas of the reservoir are not well posted and there are some groups of fisherman who do not follow

advisories. The state of Tennessee is responsible for issuing fish consumption advisories and communicating relevant health information to the public.

7.4.3 LWBR Issues and Recommendations

There are no issues or recommendations.

7.5 OFF-SITE ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Off-Site areas are in Table 7.6.

Table 7.6. Summary of technical issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issue Carried Forward			
None			
Completed/Resolved Issues[b]			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g. (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

7.6 REFERENCES

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DOE/OR/02-1627&D3. *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee,* 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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TDEC 2007. State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 2007. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Approved March 2008.

TDEC 2010a. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

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8. EAST TENNESSEE TECHNOLOGY PARK

8.1 INTRODUCTION AND STATUS

8.1.1 Introduction

ETTP contains contaminated facilities and media from the operation of the gaseous diffusion and centrifuge processes and associated support facilities. Table 8.1 lists the CERCLA actions at ETTP and identifies those with monitoring or other LTS requirements. Figure 8.1 locates the key CERCLA sites and actions. In subsequent sections, the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Only sites that have LTS requirements (Table 8.1) are included in these performance evaluations. End uses of a site form the basis of RAOs and determine access restrictions and allowable activities at the site. Figure 8.2 shows ROD-designated end uses at ETTP and interim controls requiring LTS.

Completed CERCLA actions at ETTP are gauged against their respective action specific goals. However, CERCLA actions have yet to be fully implemented at ETTP. Therefore, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provides a preliminary evaluation of the early indicators of effectiveness for each subwatershed.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions at ETTP within the context of a contaminant release conceptual model is provided in Chapter 10 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

8.1.2 Status Update

To date, many of the completed actions at ETTP have been single-project actions to address primary sources of contamination or primary release mechanisms. Concurrent with these actions, demolition of buildings at ETTP is occurring under CERCLA removal authority. While these actions ultimately help to reduce contaminant loading or minimize the potential for future contaminant releases, the goals of many of these actions have not included specific, measurable performance objectives for reductions in flux or risk in surface water and groundwater at the watershed scale. Watershed-scale decisions for Zone 1 and Zone 2 (*Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* [DOE/OR/01-1997&D2], referred to as the Zone 1 ROD, and *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* [DOE/OR/01-2161&D2], referred to as the Zone 2 ROD), relate to soil, buried waste, and subsurface structures for the protection of human health and to limit further contamination of groundwater through source reduction or removal. The remaining media, e.g., groundwater, surface water/stormwater, and sediments, and ecological receptors will be evaluated and addressed by future CERCLA decision(s).

Table 8.1. CERCLA actions at the ETTP

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
Watershed-scale actions			
Zone 1 Interim Actions	ROD (DOE/OR/01-1997&D2): 11/08/02	**Watershed-scale requirements**	No/Yes (see Table 8.2)
		Actions complete	
		Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2) approved 04/03/06	No/No
		• Duct Island/K-901 Area PCCR Addendum (DOE/OR/01-2261&D2/A1/R2) approved 02/28/11	No/No
		K-1007 Ponds/Powerhouse PCCR (DOE/OR/01-2294&D2) approved 10/04/06	No/No
		• K-1007 Ponds/Powerhouse PCCR Addendum (DOE/OR/01-2294&D2/A1/R1) approved 12/31/11	No/No
		• K-1007 Ponds/Powerhouse PCCR Addendum (DOE/OR/01-2294&D2/A2) submitted 06/20/11	No/No[f]
		K-770 Scrap Removal PCCR (DOE/OR/01-2348&D1) approved 05/30/07	No/No
		• K-770 Scrap Removal PCCR Addendum (DOE/OR/01-2348&D1/A1) approved 12/03/10	No/No[c,j]
		FY 2008 PCCR for Units Z1-01, Z1-03, Z1-38, Z1-49 (DOE/OR/01-2367&D2) approved 04/23/08	No/No
Zone 2 Soil, Buried Waste, and Subsurface Structure Interim Actions	ROD (DOE/OR/01-2161&D2): 04/19/05	**Watershed-scale requirements**	Yes (see Table 8.3)/Yes (see Table 8.2)
		Actions complete or in progress	
		FY 2006 PCCR for EUs 2, 7, 9, 10, 27, and 42 (DOE/OR/01-2317&D2) approved 02/08/07	No/No
		FY 2007 PCCR for EUs 1, 3, 8, 23, 24, 28, 33, 34, 35, 36, 37, 41, 43, and 44 (partial) (DOE/OR/01-2723&D2) approved 06/09/08	No/No

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
		• FY 2007 PCCR Addendum for EU 44 (DOE/OR/01-2723&D2/A1) approved 10/07/14 with submission of Erratum	No/No
		FY 2008 PCCR for EU Z2-33 (DOE/OR/01-2368&D2/R1) approved 09/28/09	No/No
		• FY 2008 PCCR for EU Z2-33 – Erratum (DOE/OR/01-2368&D2/R2 approved 12/16/09	No/No
		FY 2009 PCCR for EU Z2-36 (DOE/OR/01-2399&D1) approved 06/03/09	No/No
		FY 2009 PCCR for EUs 11, 12, 17, 18, 29, 38 (DOE/OR/01-2415&D2) approved 04/02/10	No/No
		FY 2010 PCCR for EU Z2-31 (DOE/OR/01-2443&D2) approved 10/22/10	No/No
		FY 2010 PCCR for EU Z2-32 (DOE/OR/01-2452&D1) approved 04/08/10	No/No
		PCCR for EU Z2-30 (K-1070-B Burial Ground) (DOE/OR/01-2521&D2) approved 03/15/13	No/No
		• PCCR for EU Z2-30 – Erratum (K-1070-B Burial Ground) (DOE/OR/01-2521&D2) submitted 5/16/13 (no approval required)	No/No
		PCCR for EUs 4 and 5 (K-33 slab) (DOE/OR/01-2590&D1) approved 02/11/13	No/No
		PCCR for EU 35 Sumps (DOE/OR/O1-2618&D2) approved 05/07/14	No/No
Single-project actions			
		Actions complete	
K-1417-A/B Drum Storage Yards	ROD (DOE/OR-991&D1): 09/19/91	RAR (Letter) approved 03/02/95	No/No

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
K-1070-C/D SW-31 Spring	IROD (DOE/OR-1050&D2): 09/30/92 ESD (DOE/OR/02-1132&D2): 07/08/93	RAER (DOE/OR/01-1520&D1/R1) approved 12/11/96	Superseded by RAER Addendum – Erratum (DOE/OR/01-1520&D1/R1/A1) to eliminate monitoring[k]
		• RAER Addendum (DOE/OR/01-1520&D1/R1/A1) to terminate action approved 02/28/07	
		• RAER Addendum – Erratum (DOE/OR/01-1520&D1/R1/A1) to eliminate monitoring approved 10/03/13	No/No
K-1407-B/C Ponds	ROD (DOE/OR/02-1125&D3): 09/30/93 (Also, closed under RCRA)	RAR (DOE/OR/01-1371&D1) approved 08/16/95	Superseded by RAR Erratum[k]
		• RAR Erratum (DOE/OR/01-1371&D1) approved 05/26/15	Yes/Yes
K-1401 and K-1420 Sumps	AM (DOE/OR/02-1610&D1): 08/18/97 NSC (DOE/OR/02-1610/R1): 10/23/07 (reroute K-1401 sump discharge to sanitary wastewater treatment)	RmAR (DOE/OR/01-1754&D2) approved 02/01/99	Terminated by RmAR Addendum (DOE/OR/01-1754&D2/A1)
		• RmAR Addendum (DOE/OR/01-1754&D2/A1) to terminate operation approved 04/21/06	
K-1070-C/D and Mitchell Branch	AM (DOE/OR/02-1611&D2): 08/25/97	RmAR (DOE/OR/01-1728&D3) approved 03/02/99	Terminated[d]
		• Approval to terminate operation of non-cost effective system 12/17/04	
K-901-A and K-1007-P Pond	AM (DOE/OR/02-1550&D2): 10/15/97 (superseded by AM (DOE/OR/01-2314&D2)	RmAR (DOE/OR/01-1767&D2) approved 11/12/99	Superseded by RmAR (DOE/OR/01-2456&D1/R1)[k]
K-1070-C/D G-Pit and Concrete Pad	ROD (DOE/OR/02-1486&D4): 01/23/98	RAR (DOE/OR/01-1964&D2) approved 10/15/03	Superseded by RAR Erratum[k]
		• Completion letter (waste) approved 10/29/03	No/No
		• RAR Erratum (DOE/OR/01-1964&D2) approved 03/13/15	No/Yes[e]
K-1070-A Burial Ground	ROD (DOE/OR/01-1734&D3): 01/13/00	RAR (DOE/OR/01-2090&D1) approved 11/28/03	Superseded by Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2) approved 04/03/06[k]

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
K-1085 Old Firehouse Burn Area Drum Burial Site Removal Action	AM (DOE/OR/01-1938&D1): 03/27/01	RmAR (DOE/OR/01-2050&D1) conditionally approved 02/18/03	No/No
		Completion Letter approved 01/19/07	
Outdoor LLW Removal	AM (DOE/OR/01-2109&D1): 11/14/03	RmAR (DOE/OR/01-2225&D2) approved 08/24/05	No/No
ETTP Ponds removal action	AM (DOE/OR/01-2314&D2): 03/12/07 (K-1007-P and K-901-A holding ponds, K-720 Slough, and 770 Embayment) (supersedes DOE/OR/01-1550&D2)	RmAR (DOE/OR/01-2456&D1/R1) approved 03/10/11 (supersedes DOE/OR/01-1767&D2)	Yes/Yes
Mitchell Branch Chrome Reduction	AM (DOE/OR/01-2369&D1): 12/20/07 (Reduction of Hexavalent Chromium Releases to Mitchell Branch Time-Critical)	RmAR (DOE/OR/01-2384&D1) submitted 07/30/08; review and approval suspended 10/09/08	Superseded by RmAR (DOE/OR/01-2598&D2)[k]
	AM (DOE/OR/01-2448&D1) (Long-Term Reduction of Hexavalent Chromium Releases to Mitchell Branch) approved 04/13/10 (supersedes DOE/OR/01-2369&D1)	RmAR (DOE/OR/01-2598&D2) approved 04/04/13	Yes/Yes
Demolition projects			
		Actions complete	
K-25 Auxiliary Facilities Group I Building Demolition removal action	AM (DOE/OR/02-1507&D2): 01/17/97	RmAR (DOE/OR/01-1829&D1) issued August 1999	No/No[j]
		• RmAR Addendum I (DOE/OR/01-1829&D1/A1) approved 06/02/05	No/No
		• RmAR Addendum II (DOE/OR/01-1829&D1/A2) approved 06/05/06	No/No
K-29, K-31, and K-33 Equipment Removal and Building Decontamination removal action	AM (DOE/OR/02-1646&D1): 09/30/97	RmAR (DOE/OR/01-2290&D3) approved 06/08/07	No/No
		• RmAR Addendum (DOE/OR/01-2290&D3/A2) approved 03/16/09	No/No
K-25 Auxiliary Facilities Group II, Phase I Building Demolition, Main Plant removal action	AM (DOE/OR/01-1868&D2): 08/03/00	RmAR (DOE/OR/01-2116&D2) approved 09/24/04	No/No[j]

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
K-25 Auxiliary Facilities Group II, Phase II Building Demolition, K-1064 Peninsula Area removal action	AM (DOE/OR/01-1947&D2): 07/31/02	RmAR (DOE/OR/01-2339&D1) approved 06/27/07	No/No[j]
		• PCCR (DOE/OR/01-2183&D1) approved 01/31/06	Superseded by RmAR (DOE/OR/01-2339&D1)[k]
		• PCCR Addendum (DOE/OR/01-2183&D1/A1) approved 04/10/06	
		• PCCR Addendum (DOE/OR/01-2184&D1/A2) approved 10/03/06	
		Action in progress	
K-25 and K-27 Buildings Demolition removal action	AM (DOE/OR/01-1988&D2): 02/13/02 NSC (DOE/OR/01-2259&D1): 12/16/05 NSC (DOE/OR/01-2582&D1): 08/09/12	PCCR for Hazardous Materials Abatement conditionally (DOE/OR/01-2275&D1) approved 12/19/05	No/No
		Completion of mercury ampoules disposal in accordance with the PCCR (DOE/OR/01-2275&D1) approved 03/17/06	No/No
		Completion Letter, Disposition of Centrifuge and Y-12 Materials, Excess Materials Removal, K-25/K-27 D&D approved 06/30/08	No/No
		PCCR for FY 2008 Earned Value (DOE/OR/01-2396&D2) approved 09/17/09	No/No
		• PCCR for FY 2008 Earned Value – Erratum (DOE/OR/01-2396&D2) submitted 10/30/09 (no response required)	No/No
		PCCR for FY 2009 Earned Value (DOE/OR/01-2436&D2) approved 06/29/10	No/No
		PCCR for Excess Material Removal (DOE/OR/01-2392&D4) approved 04/23/12	No/No
		PCCR for FY 2010 Earned Value (DOE/OR/01-2494&D2) approved 08/03/11	No/No
		PCCR (K-25 East Wing Characterization, Foaming, NE Bridge) (DOE/OR/01-2538&D2) approved 04/28/12	No/No
		PCCR for FY 2012 (DOE/OR/01-2577&D2) approved 08/27/14	No/No
		PCCR for FY 2013 (DOE/OR/01-2624&D2)	No/No[f,j]

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
		submitted 03/06/14	
		• PCCR for FY 2013 – Erratum (DOE/OR/01-2624&D2) submitted 06/16/14 (no approval required)	No/No
		K-25 Completion Report (DOE/OR/01-2651&D2) submitted 03/20/15	TBD[f]
		PCCR for FY 2014 (DOE/OR/01-2681&D2) approved 08/25/15	No/No
		Action in progress	
K-25 Group II, Phase 3 Building Demolition, Remaining Facilities removal action	AM (DOE/OR/01-2049&D2): 09/30/03	FY 2004 PCCR PUF (DOE/OR/01-2193&D2) approved 03/28/05	No/No
		FY 2005 PCCR PUF (DOE/OR/01-2269&D2) approved 02/15/06	No/No
		FY 2005 PCCR LR/LC Facilities (DOE/OR/01-2270&D2) approved 02/15/06	No/No
		FY 2006 PCCR PUF (DOE/OR/01-2326&D2) approved 11/05/09	No/No
		FY 2006 PCCR LR/LC Facilities (DOE/OR/01-2327&D2) approved 12/02/09	No/No[g,j]
		Balance of Site-Laboratory Area Facilities PCCR (DOE/OR/01-2309&D2) approved 08/30/07	No/No[h,j]
		FY 2007 PCCR PUF (DOE/OR/01-2363&D2) approved 06/25/08	No/No
		FY 2007 PCCR LR/LC Facilities (DOE/OR/01-2362&D3) approved 09/27/10	No/No[j]
		K-29 PCCR (DOE/OR/01-2336&D2) approved 10/18/07	No/No[j]
		K-1420 PCCR (DOE/OR/01-2341&D2) approved 10/26/07	No/No[j]
		Building K-1401 PCCR (DOE/OR/01-2365&D2) approved 02/27/09	No/No[i]

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
		• Building K-1401 PCCR erratum (DOE/OR/01-2365&D2/A1) approved 04/08/09	No/No
		FY 2008 PCCR LR/LC Facilities (DOE/OR/01-2394&D1) approved 03/13/09	No/No[j]
		FY 2008 PCCR PUF (DOE/OR/01-2395&D1) approved 02/09/09	No/No
		FY 2009 PCCR for LR/LC Facilities (DOE/OR/01-2434&D2) approved 09/14/11	No/No[j]
		FY 2009 PCCR for PUF (DOE/OR/01-2435&D2) approved 04/12/10	No/No
		PCCR for Poplar Creek 3 High Risk Facilities (DOE/OR/01-2444&D2) approved 07/28/10	No/No[j]
		PCCR (SW-31 Spring Transfer Line) (DOE/OR/01-2520&D1) approved 02/10/12	No/No
		PCCR for K-33 (DOE/OR/01-2541&D1) approved 02/06/12	No/No
		• PCCR for K-33 above-ground utility piping (DOE/OR/01-2541&D2 approved 07/03/13	No/No
		FY 2011 PCCR for Poplar Creek – four tie lines (DOE/OR/01-2524&D3) approved 12/28/12	No/No
		FY 2011 PCCR for LR/LC Facilities (DOE/OR/01-2547&D2) approved 07/09/12	No/No[j]
		FY 2011 PCCR PUF (DOE/OR/01-2554&D2) approved 05/31/12	No/No
		Building K-33 PCCR (DOE/OR/01-2541&D2) approved 07/03/13	No/No
		PCCR for K-33/K-31 Process Tie Line (DOE/OR/01-2620&D1) submitted 10/08/13	TBD[f]
		PCCR for Decommissioning Central Neutralization Facility (DOE/OR/01-2619&D2) approved 11/24/14	No/Yes
		• PCCR for Decommissioning Central Neutralization Facility – Erratum (DOE/OR/01-2619&D2)	No/Yes

Table 8.1. CERCLA actions at the ETTP (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/Other LTS required[b]
		submitted 10/23/14, approved 11/24/14	
		FY 2014 PCCR for LR/LC Facilities (DOE/OR/01-2679&D2) approved 09/09/15	No/No
		FY 2014 PCCR PUF (DOE/OR-01-2680&D2) approved 07/01/15	No/No
		Building K-31 PCCR (DOE/OR/01-2692&D1) submitted 10/09/15	TBD[f]

[a]Information on the enforceable agreement milestones for ongoing actions is in Appendix E of the FFA for the ORR (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.

[b]"No/No" indicates no monitoring/other LTS requirements are identified in the CERCLA action completion document beyond those identified in the watershed RODs. Refer to Table 8.3 for watershed-scale monitoring requirements and Figure 8.2 and Table 8.2 for watershed-scale LUCs and other LTS requirements.

[c]The *Addendum II to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2294&D2/A2) documents the characterization and remediation of the associated EUs and recommends NFA because all remediation levels were met. The EPA and TDEC have not approved the *Addendum* but have no technical disagreement with the conclusions. Therefore, the interim LTS requirements in the *Phased Construction Completion Report for the K-770 Scrap Removal Project of the Zone 1 Remediation at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2348&D1) are no longer required for areas in these Zone 1 EUs.

[d]In a letter dated December 1, 2004, DOE proposed to EPA and TDEC to discontinue operation of the groundwater collection system because it was not cost-effectively reducing contaminant flux. TDEC and EPA approved the proposal on December 15, 2004 and December 17, 2004, respectively, and the groundwater collection system was terminated.

[e]The action for the K-1071 concrete pad is an interim action, and a final RA will be performed under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2).

[f]Completion document not approved during FY 2015 reporting period.

[g]Controls were removed because the slab was removed as documented in the *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and North Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2294&D2/A1).

[h]The *Phased Construction Completion Report for the Laboratory Area Facilities of the Remaining Facilities Demolition Project at the East Tennessee Technology Park* (DOE/OR/01-2309&D2) required surveys and monitoring of the slabs from K-1004 and K-1015. These slabs were removed in FY 2007 and monitoring is no longer required. The LTS of these sites is no longer reported in the RER.

[i]Although the Building K-1401 PCCR documents the building demolition and prescribes LTS requirements for the remaining slab, the K-1401 slab was removed in 2009 and LTS requirements are no longer implemented at the site. The removal of the slab is documented in the *Fiscal Year 2010 Phased Construction Completion Report for EU Z2-31 in Zone 2* (DOE/OR/01-2443&D2).

[j]Interim LTS requirements for potentially contaminated slabs following building demolition were the subject of a closed issue identified in Table 8.14. The process for managing potentially contaminated slabs has been determined and is being implemented. If monitoring or other LTS requirements are identified through this process, then those requirements will be documented in the ETTP RAR CMP and assessed in the following RER.

[k]The "Monitoring/Other LTS" requirements in a completion document have been superseded, or replaced, by the requirements in the subsequent, referenced completion document.

AM = Action Memorandum
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
D&D = decontamination and decommissioning
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ESD = Explanation of Significant Difference
ETTP = East Tennessee Technology Park
EU = exposure unit

Table 8.1. CERCLA actions at the ETTP (cont.)

FFA = Federal Facility Agreement
FY = fiscal year
IROD = Interim Record of Decision
LLW = low-level waste
LR/LC = Low Risk/Low Complexity
LTS = long-term stewardship
LUC = land use control
NE = northeast
NFA = no further action
NSC = Non-Significant Change
ORR = Oak Ridge Reservation
PCCR = Phased Construction Completion Report
PUF = Predominantly Uncontaminated Facilities
RA = remedial action
RAER = Remedial Action/Effectiveness Report
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
RER = Remediation Effectiveness Report
RmAR = Removal Action Report
ROD = Record of Decision
TBD = to be determined
TDEC = Tennessee Department of Environment and Conservation
Y-12 = Y-12 National Security Complex

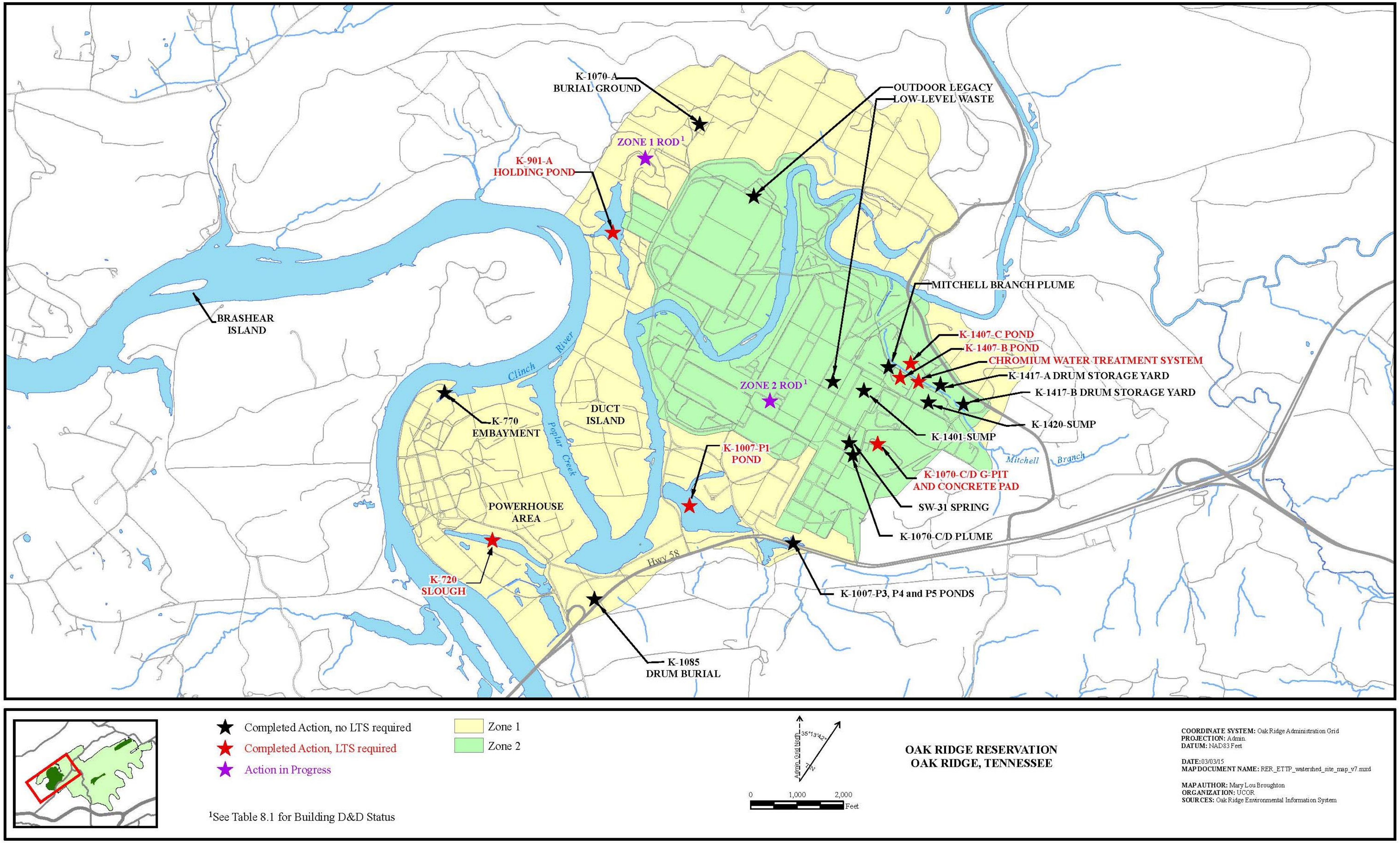

Figure 8.1. ETTP.

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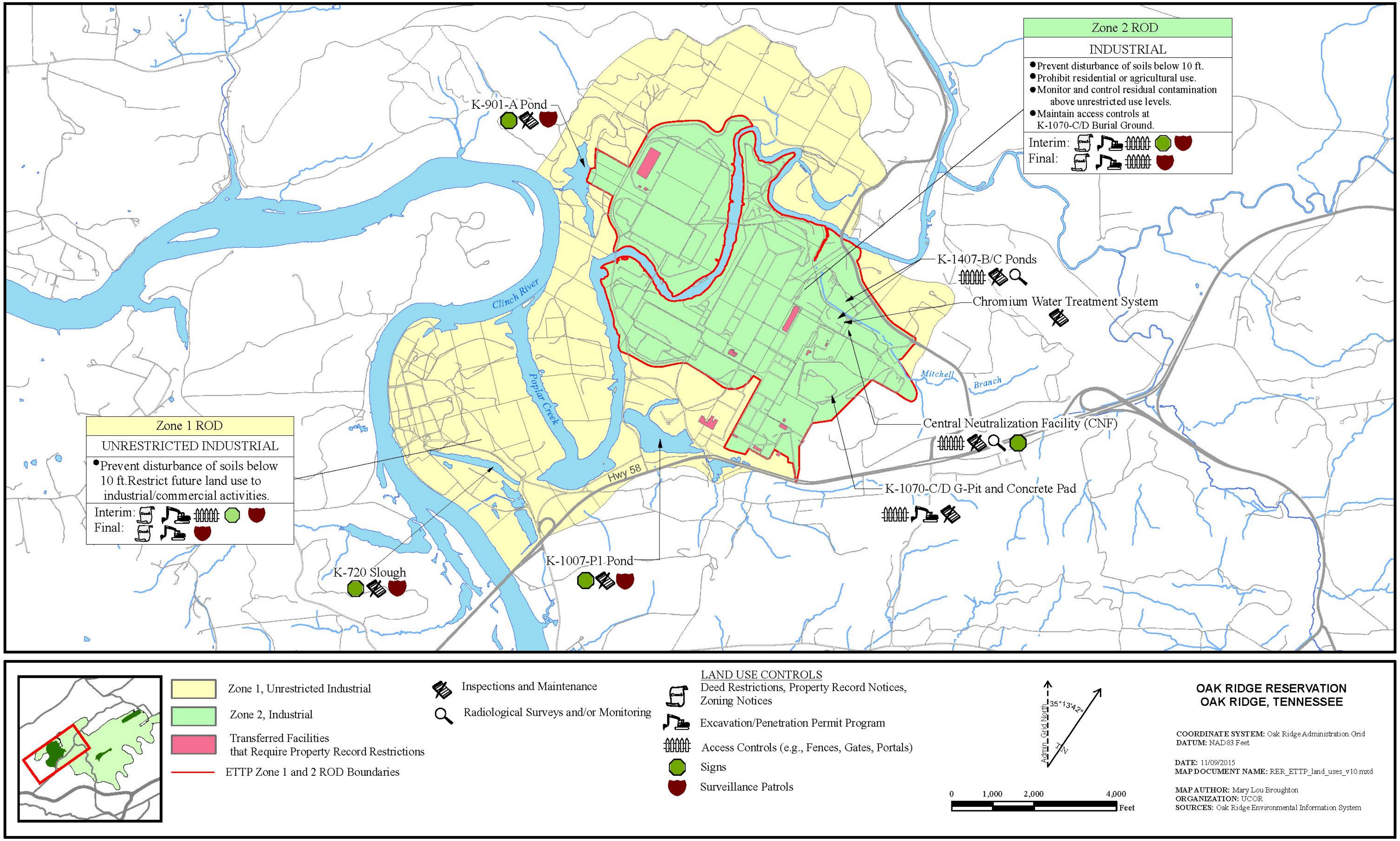

Figure 8.2. ETTP Zones 1 and 2 ROD-designated end uses and interim controls requiring LTS.

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Watershed-Scale Actions

For RA purposes, ETTP is divided into zones. Zone 1 comprises approximately 1,400 acres outside the main plant area, and Zone 2 comprises approximately 800 acres of the main plant area (Figure 8.1). The remainder of the site, which encompasses approximately 2,800 acres surrounding Zones 1 and 2, is primarily uncontaminated and is part of DOE's NPL Boundary Definition effort (Section 1.4).

Zone 1

The remediation required by the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) for unrestricted industrial use to a depth of 10 ft and for sources of groundwater contamination has been completed. Zone 1 was divided into 80 exposure units (EUs) for evaluation purposes. The status of Zone 1 is summarized in Figure 8.3.

Work continued in FY 2015 on a final Zone 1 ROD addressing soil and ecological protection. The *Final Zone 1 Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2561&D3) was approved by EPA and TDEC in FY 2015. The *Final Proposed Plan for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D3) was submitted to the regulators for review.

Zone 2

The *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2) includes RAs for unrestricted industrial use to a depth of 10 ft and for sources of groundwater contamination. Zone 2 was divided into 44 EUs for evaluation purposes. The status of Zone 2 is summarized in Figure 8.4 and discussed below:

- In FY 2014 characterization of the footprint of Building K-25 (EUs Z2-20, -21, and -22) was completed and evaluation of the data was initiated. In FY 2015, evaluation of the data continued. The 40 acre footprint of Building K-25 (EUs Z2-20, -21, and -22 shown on Figure 8.4) has been declared the K-25 Preservation footprint that is dedicated for historical commemoration and interpretation activities. In order to determine how to preserve this footprint, a study to evaluate potential end states of the slab was continued in FY 2015.

- In FY 2014 characterization of EU Z2-6 (Building K-31 footprint) was completed, and evaluation of the data was initiated. Demolition of Building K-31 and removal of the slab were completed during FY 2014, so characterization of EU Z2-6 was designed to verify that the demolition did not contaminate the soil. In FY 2015 sub-slab soil was characterized and evaluated, and the evaluation determined that demolition of Building K-31 and removal of the slab did not contaminate the soil. Preparation of the PCCR for EU Z2-6 was initiated.

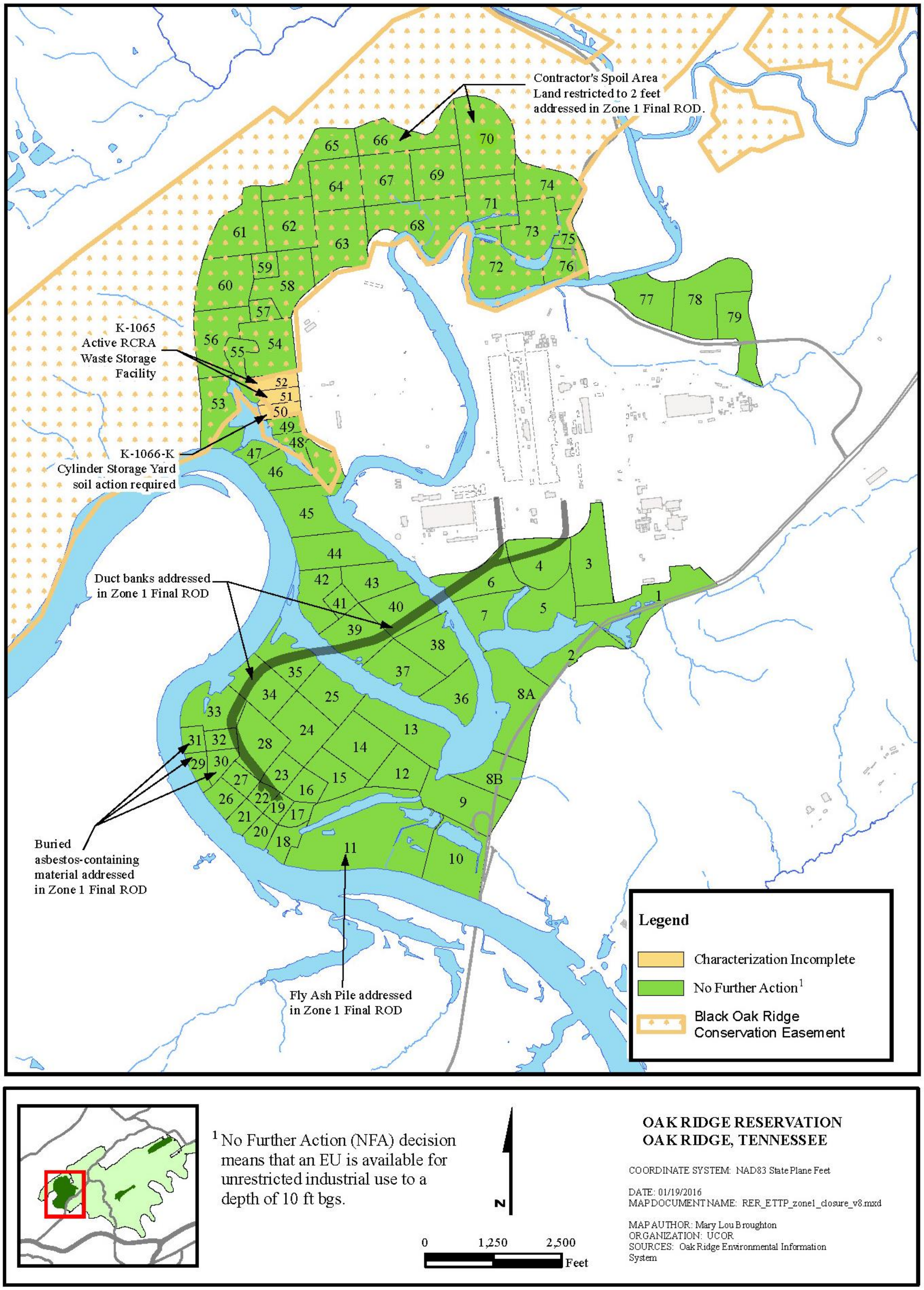
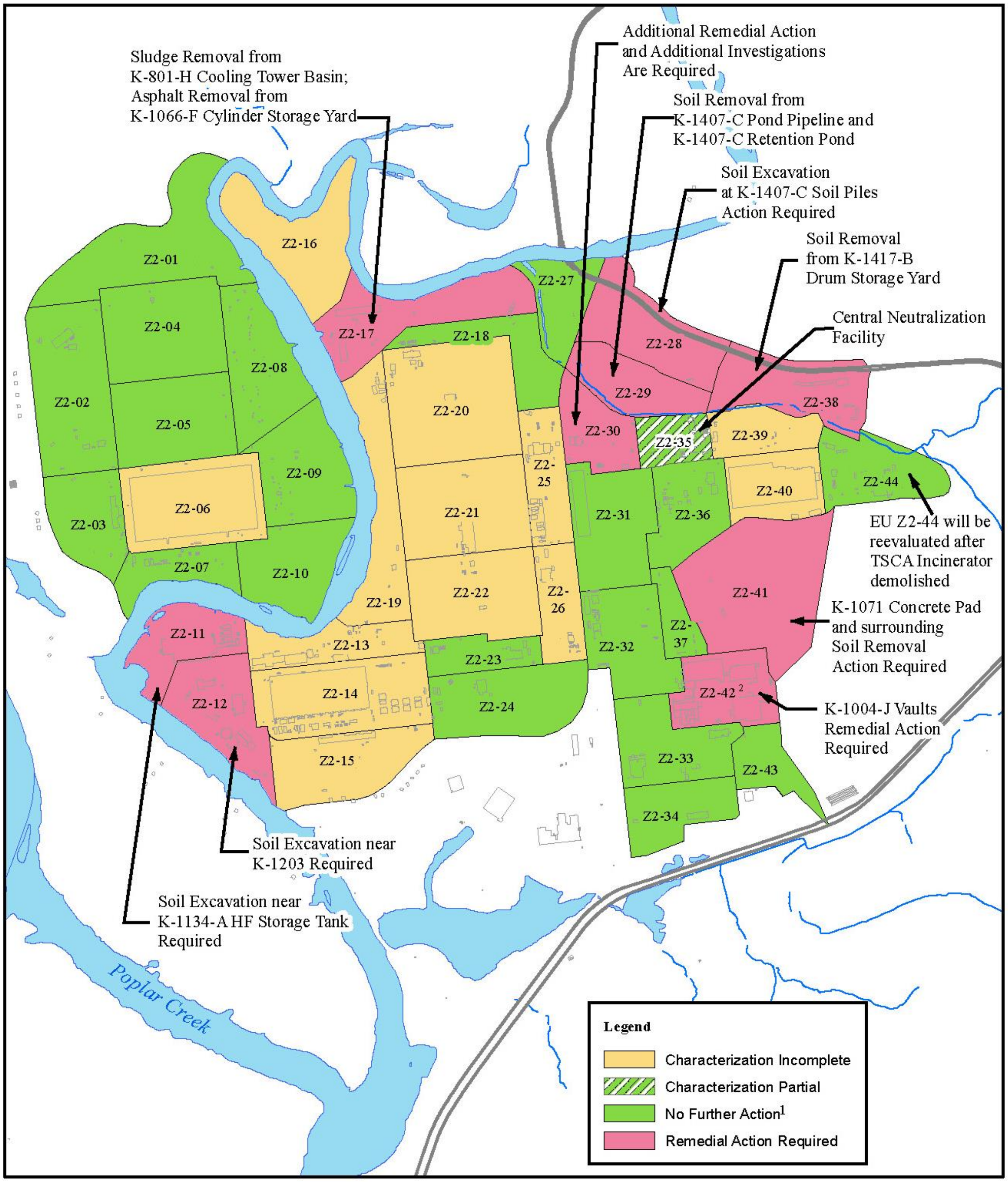
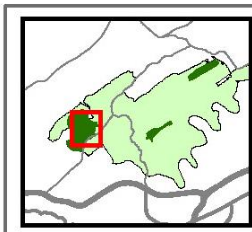


Figure 8.3. ETTP Zone 1 status.





[1]No Further Action (NFA) decision means that an EU is available for unrestricted industrial use to a depth of 10 ft bgs.

[2]EU Z2-42: DVS Characterization completed under the FY2006 Zone 2 PCCR, however additional characterization still remains at the K-1004-T Centrifuge Laboratory and at the K-1210-A Substation once operations cease in order to determine the final status of these two facilities.

N

0 500 1,000 Feet

OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE

COORDINATE SYSTEM: NAD83 State Plane Feet

DATE: 02/17/2016
MAP DOCUMENT NAME: RER_ETTP_zone2_closure_v13.mxd

MAP AUTHOR: Mary Lou Broughton
ORGANIZATION: UCOR
SOURCES: Oak Ridge Environmental Information System and RSI

Figure 8.4. ETTP Zone 2 closure document and action status.

The *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4) was revised in FY 2015 to update the QAPP, include alternate remediation levels for the Building K-25 preservation footprint, include a groundwater soil screening level for ^{99}Tc, include the management of potentially contaminated slabs, and include the Dynamic Work Plan. The revisions to the document were reviewed and accepted by EPA and TDEC in FY 2015, and the final version was submitted for approval in November 2015. This resolves issues on the management of potentially contaminated slabs identified in Table 8.14.

<u>Single-Project Actions</u>

An Erratum to the *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin* (DOE/OR/01-1371&Dl) and an Erratum to the *Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1964&D2) were approved in FY 2015 to change the frequency of inspections.

<u>Demolition Projects</u>

<u>Buildings K-25 and K-27</u>

The *Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1988&D2; DOE/OR/01-2259&D1; DOE/OR/01-2582&D1) requires the buildings be demolished to slab. Completion of demolition progress has been documented by several PCCRs (Table 8.1). The FY 2015 status of the demolition of Buildings K-25 and K-27 follows:

- Demolition of Building K-27 (Figure 8.5), the last remaining gaseous diffusion cascade building at ETTP, has begun. The building is one of the highest priorities at ETTP due to its risk and deteriorated state. It spans more than 8 acres and is approximately 900 ft long, 400 ft wide, and 58 ft in height.

- During FY 2015, the removal of external transite siding began in August, marking the start of demolition (Figure 8.6). Removal of the remaining transite siding and other asbestos in the building continues. Characterization of the building structure, equipment, and piping was completed for the purpose of waste disposal. One hundred five samples of the building structure and 184 samples of equipment and piping were collected. Oil and other fluids were drained from electrical equipment in the transformer vaults, the motors on the Operations Floor, and lube oil storage tanks. The application of polyurethane foam in process gas equipment, the off-site shipment of sodium fluoride traps, the removal of ^{99}Tc cylinders, and the removal of high-risk equipment were completed (Figure 8.7). Removal of process gas equipment from the Cell Floor in Units K-402-8 and -9 was completed in August 2015. Removal of process gas equipment with nuclear criticality safety exceedances is ongoing and is expected to be completed in early FY 2016. The Nuclear Criticality Safety Determination was developed to eliminate the Radiation Criticality Accident Alarm System coverage for the remaining activities leading to demolition. The document is currently under review and revision. The pipes connected to compressors and converters were cut to facilitate removal of the equipment during demolition. The Storm Water Pollution Prevention Plan was completed, and plugging of slab penetrations was initiated.

Figure 8.5. Building K-27.

Figure 8.6. Removal of transite panels from Building K-27.

Figure 8.7. Loading of pipe into a B-25 waste container.

Remaining Facilities

The *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2049&D2) requires approximately 500 facilities be demolished to slab. Demolition progress has been documented by several PCCRs (Table 8.1). The FY 2015 status of demolition follows:

- Demolition of Building K-31 (Figure 8.8) was completed in June 2015, and the final debris was disposed in September 2015. The *Phased Construction Completion Report for Building K-31 of the Remaining Facilities Demolition Project at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2692&D1) was prepared to document demolition and was submitted to EPA and TDEC in October 2015.

Figure 8.8. Building K-31 before and after demolition.

- The Central Neutralization Facility (CNF) was decommissioned in FY 2014. The decommissioning resulted in all RCRA hazardous waste being removed and disposed and all facility components being decontaminated to the point at which RCRA-listed waste codes are no longer associated with any items, i.e., equipment, sumps, pipelines, or structures. The *Phased Construction Completion Report for Decommissioning the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2619&D2) was approved by EPA and TDEC in FY 2015. Because of residual contamination, engineering and LUCs are required at CNF and listed in Table 8.2. These provisional controls will remain in effect until the facility is demolished under the *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Park, Oak Ridge, Tennessee* (DOE/OR/01-2049&D2) and the soil is remediated under the Zone 2 ROD (DOE/OR/01-2161&D2). The provisional controls are based on a combination of process knowledge and the radiological surveys performed on the decommissioned facilities.

8.2 ZONE 1 ROD

Major components of the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) are:

- excavation of Blair quarry and associated contaminated soil,
- excavation of contaminated soil in the K-895 Cylinder Destruct Facility and the Powerhouse Area,
- removal of scrap metal and debris from the K-770 Area,
- removal of sludge and demolition of the K-710 sludge beds and Imhoff tanks,
- implementation of LUCs, and
- characterization of the soil and removal of soil up to 10 ft in depth that exceeds remediation levels set to protect a future industrial worker; removal of soil to bedrock, water table, or acceptable levels of contamination to protect underlying groundwater to meet drinking water MCLs.

Completion of these Zone 1 ROD actions is documented in PCCRs listed in Table 8.1. No performance monitoring is required under the Zone 1 ROD (DOE/OR/01-1997&D2).

8.2.1 Other LTS Requirements

Other LTS requirements for the Zone 1 ROD are listed in Table 8.2 and described below.

8.2.1.1 Requirements

This ROD (DOE/OR/01-1997&D2) establishes “unrestricted industrial” as the end use for Zone 1 and requires LUCs to prevent disturbance of soils below 10 ft in depth and to restrict future land use to industrial/commercial activities. To implement restrictions that are in accordance with this land use and to restrict access to this area until that land use has been achieved, seven LUCs will be implemented.

Table 8.2. Other LTS requirements for the ETTP

Other LTS requirements for LUCs - Watershed-scale requirements					
Type of control	**Affected areas[a]**	**Purposes of control**	**Duration**	**Implementation**	**Frequency**
***Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park* (Zone 1 ROD) (DOE/OR/01-1997&D2)**					
1. Property Record Restrictions[b] *A. Land use* *B. Groundwater*	*Throughout all of Zone 1.*	*Restrict use of property by imposing limitations.* *Prohibit uses of groundwater.*	*Indefinitely*	*Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office.*	*Verify annually that information is being maintained properly.*
2. Property Record Notices[c]	*Throughout all of Zone 1.*	*Provide notice to anyone searching records about the existence and location of contaminated areas and limitations on their use.*	*Indefinitely*	*Notice recorded by DOE in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD; 2) upon transfer of affected areas; 3) upon completion of all remedial actions.*	*Verify annually that information is being maintained properly.*
3. Zoning Notices[d]	*Throughout all of Zone 1.*	*Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes.*	*Indefinitely*	*Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after signing of the ROD; final Zoning Notice and survey plat filed with City Planning Commission upon completion of all remedial actions*	*Verify annually that information is being maintained properly.*
4. Excavation/ Penetration Permit Program[e]	*All areas where hazardous substances are left in the subsurface below 10 ft or that are not yet discovered in areas with more limited characterization requiring land use and/or groundwater restrictions.*	*Provide notice to worker/ developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/ penetration activity.*	*As long as property remains under DOE control.*	*Implemented by DOE and its contractors. Initiated by permit request. Provide permits program with contamination information as soon as practicable after signing of the ROD, and update information regularly while remediation proceeds.*	*Monitor annually to ensure it is functioning properly.*
5. Access Controls[f] (e.g., fences, gates, and portals)	*Specific locations will, if necessary, be determined by each remediation project.*	*Control and restrict access to workers and the public to prevent unauthorized uses.*	*Indefinitely*	*Controls maintained by DOE.*	*Inspect no less than annually.*
6. Signs[g]	*At select locations throughout Zone 1.*	*Provide notice or warning to prevent unauthorized access.*	*Indefinitely*	*Signage maintained by DOE.*	*Inspect no less than annually.*

Table 8.2. Other LTS requirements for the ETTP (cont.)

Other LTS requirements for LUCs - Watershed-scale requirements					
Type of control	**Affected areas[a]**	**Purposes of control**	**Duration**	**Implementation**	**Frequency**
7. Surveillance Patrols	*Patrol of selected areas throughout Zone 1, as necessary.*	*Control and monitor access by workers/public.*	*Indefinitely*	*Established and maintained by DOE. Necessity of patrols evaluated upon completion of remedial actions.*	*Adequacy of necessary patrols assessed no less than annually.*
***Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park* (Zone 2 ROD) (DOE/OR/01-2161&D2)**					
1. Property Record Restrictions[b]	*Throughout all of Zone 2.*	*Restrict use of property by limiting penetrations deeper than 10 ft bgs and all uses involving exposures to human receptors greater than industrial use exposures.*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure.*	*Drafted and implemented by DOE upon completion of all remediation activities or transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office.*	*Verify annually that information is being maintained properly.*
2. Property Record Notices[c]	*Throughout all of Zone 2.*	*Provide information to the public about the existence and location of contaminated areas and limitations on their use.*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure.*	*Notice recorded by DOE EM in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD but no later than 90 days after approval of the LUCIP, 2) upon transfer of affected areas; 3) upon completion of all remedial actions.*	*Verify annually that information is being maintained properly.*
3. Zoning Notices[d]	*Throughout all of Zone 2.*	*Provide notice to city and county about the existence and location of waste disposal and residual contamination areas and limitations on their use for zoning/planning purposes.*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure.*	*Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after signing of the ROD; final Zoning Notice and survey plat filed with City Planning Commission upon completion of all remedial actions.*	*Verify annually that information is being maintained properly.*
4. Excavation/ Penetration Permit Program[e]	*All areas where hazardous substances are left in the subsurface below 10 ft or where hazardous substances may be present but have not been detected because of the limits on characterization performed.*	*Provide notice to worker/ developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity.*	*As long as property remains under DOE control, including transferred property remaining subject to excavation/ penetration permit program.*	*Implemented by DOE and its contractors. Initiated by permit request. Provide permits program with contamination information as soon as practicable after signing of the ROD, and update information regularly while remediation proceeds.*	*Monitor annually to ensure it is functioning properly.*

Table 8.2. Other LTS requirements for the ETTP (cont.)

Other LTS requirements for LUCs - Watershed-scale requirements					
Type of control	**Affected areas**[a]	**Purposes of control**	**Duration**	**Implementation**	**Frequency**
5. Access Controls[f] *(e.g., fences, gates, and portals)*	*Specific locations will, if necessary, be determined by each remediation project in the near term. At K-1070-C/D until security is no longer an issue.*	*Control and restrict access to workers and the public to prevent unauthorized uses.*	*Until remediation is complete or until security is no longer an issue at K-1070-C/D.*	*Controls maintained by DOE.*	*Inspect no less than annually.*
6. Signs[g]	*At select locations throughout Zone 2. At K-1070-C/D until security is no longer an issue.*	*Provide notice or warning to prevent unauthorized access.*	*Until the concentrations of hazardous substances left beneath 10 feet allow for industrial use and for K-1070-C/D until security is no longer an issue.*	*Signage maintained by DOE.*	*Inspect no less than annually.*
7. Surveillance Patrols	*Patrol of selected areas throughout Zone 2, as necessary until remediation is complete. Then at K-1070-C/D until security is no longer an issue.*	*Control and monitor access by workers/public.*	*Until remediation is complete or until security is no longer an issue at K-1070-C/D.*	*Established and maintained by DOE.*	*Adequacy of necessary patrols assessed no less than annually.*

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Implementation/Frequency**
Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee **(DOE/OR/02-1486&D4)**			
K-1070-C/D OU K-1071 Concrete Pad soil cover	• K-1070-C/D G-Pit and Concrete Pad RAR (DOE/OR/01-1964&D2) • RAR Erratum (DOE/OR/01-1964&D2)	From RAR Erratum: • To maintain the effectiveness of the soil cover over the pad, the cover is inspected annually • Any needed maintenance of the K-1071 Concrete Pad soil cover is provided through the S&M program • The grass on the cover will be mowed as needed but not less than annually • If erosion of the cover is found, soil is used to repair the eroded area, and the area is re-seeded, if necessary • A radiological walkover on the concrete pad cover will occur only if there is activity within the area • The interim LUCs include the fence that is present and the excavation permits system that is in place under DOE's control • The existing fence is evaluated for its integrity as needed, but no less than annually	Annual inspection of soil cover Grass on the cover will be mowed as needed but no less than annually Radiological walkover on the concrete pad cover will occur only if there is activity within the area Fence will be evaluated for its integrity as needed, but no less than annually

Table 8.2. Other LTS requirements for the ETTP (cont.)

Other LTS requirements for Specific Areas			
Areas	**Project Documents**	**Other LTS Requirements**	**Implementation/Frequency**
***Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE/OR/02-1125&D3)**			
K-1407-B/C Ponds	• K-1407-B/C Ponds RAR (DOE/OR/01-1371&D1) • RAR Erratum (DOE/OR/01-1371&D1)	From RAR and Erratum: • Conduct annual inspections and annual inspections and perform radiological and industrial hygiene surveillance and other assessment activities only as needed if activities are conducted at the site that are necessary to keep the remediated ponds in compliance with environmental, safety, and health requirements and maintain records of all related activities • Maintenance activities required as a result of inspections are implemented • Access and activity controls have been established and are maintained, as required • DOE (or its successor) will conduct a review of the remedy and current site conditions prior to transfer of the K-25 Site from DOE (or its successor) to another person or entity. Any property transfer will follow the procedure outlined in the FFA (DOE/OR-1014), Section XLIII, Property Transfer	Annual inspections Verify annually that controls are being implemented
***Action Memorandum for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2448&D1)**			
CWTS	Mitchell Branch Chromium Reduction • RmAR (DOE/OR/01-2598&D2)	• The groundwater interception wells require ongoing operation and maintenance • The CWTS will be operated and maintained in accordance with a contractor procedure	Verify system operation monthly
***Action Memorandum for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee, K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment* (DOE/OR/01-2314&D2)**			
K-1007-P1 Holding Pond K-901-A Holding Pond K-720 Slough	ETTP Ponds Removal Action • AM (DOE/OR/01-2314&D2) • RmAR (DOE/OR/01-2456&D1/R1)	1. DOE land notation (property record restrictions)[b] 2. Property record notices[c] 3. Zoning notices[d] 4. EPP program[e] • As long as property remains under DOE control, including transferred property remaining subject to EPP program 5. Signs[g,h] • All ponds: Provide notice or warning to prevent unauthorized access by fishermen • K-1007-P1: Provide notice or warning that prohibits mowing in the buffer zone 6. Surveillance patrols to control and monitor access by fishermen	1-3. Until the concentration of PCBs in fish are at such levels to allow for unrestricted use and exposure 5-6. Until PCB fish advisories are lifted in the Clinch River and PCB concentrations in fish are protective for the recreation user

Table 8.2. Other LTS requirements for the ETTP (cont.)

Other LTS requirements for Specific Areas				
Facility	**Facility name**	**Engineering control**	**Land use control**	**Radiological survey**
Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee **(DOE/OR/01-2049&D2)**				
Project Document: ***Phased Construction Completion Report for Decommissioning the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee*** **(DOE/OR/01-2619&D2)**				
K-1310-BB	*Office Trailer - CNF*	*None*	*Breezeway between buildings is designated as and controlled as a Radioactive Material Area for storage*	*Survey results for removable alpha and beta/gamma were below detection limits.*
K-1310-BC	*Office Trailer - CNF*			
K-1407-H	*Neutralization Facility - CNF*	*Encapsulation in sludge thickener*	• *Sludge thickener is designated as and controlled as a Fixed Contamination Area* • *Neutralization Tanks F-240-A and F-240-B are designated as and controlled as Contamination Areas*	• *For the sludge thickener the highest smear readings were 230 dpm/100cm2 alpha and 722 dpm/100 cm2 beta/gamma and the highest total readings were 8002 dpm/100 cm2 alpha and 312,904 dpm/100 cm2 beta/gamma prior to encapsulation.* • *No readings for F-240-A and F-240-B land use control based on process knowledge.*
K-1407-J	*Settling Basin - CNF*	*Encapsulation in settling basins F-261 and F-262*	*Settling basins F-261 and F-262 and dike are designated as and controlled as Fixed Contamination Areas*	• *For the settling basins, the smear readings were below detection limits and the highest total readings were 242 dpm/100 cm2 alpha and 62,783 dpm/100 cm2 beta/gamma.* • *For the dike, the highest smear readings were 34 dpm/100 cm2 alpha and 524 dpm/100 cm2 beta/gamma and the highest total readings were 88 dpm/100 cm2 alpha and 16,796 dpm/100 cm2 beta/gamma.*
K-1407-X	*Secondary Containment - CNF*	*Steel cover over annex*	*Annex is designated as and controlled as a Contamination Area*	*Highest smear reading were 9 dpm/100 cm2 alpha, and below detection limits for beta/gamma. Highest total readings were 156 dpm/100 cm2 alpha and 6,316 dpm/100 cm2 beta/gamma.*
K-1419	*CNF Facility*	*None*	*Centrifuge area is designated as and controlled as a Contamination Area*	*No readings. Posting based on process knowledge.*
	Above- and below-grade process piping	*None*	*Posted as Caution Internal Contamination*	*No readings. Posting based on process knowledge.*
	Overhead transfer lines	*None*	*Posted as Caution Internal Contamination*	*No readings. Posting based on process knowledge.*

Table 8.2. Other LTS requirements for the ETTP (cont.)

Other LTS requirements for Specific Areas		
Location	**Activity**	**Frequency**
Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee **(DOE/OR/01-2049&D2)** **Project Document:** ***Phased Construction Completion Report for Decommissioning the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee*** **(DOE/OR/01-2619&D2)**		
CNF facilities K-1310-BB, K-1310-BC, K-1407-H, K-1407-J, and K-1419	*Gross alpha and gross beta surveys*	*Annually*
K-1407-H sludge thickener, and K-1407-J settling basins F-261 and F-262	*Inspect encapsulation*	*Annually to assess integrity*
K-1407-X steel cover over annex	*Inspect integrity*	*Annually to assess integrity*
CNF	*Inspect postings*	*Annually to assess integrity*
Storm drain-170	*Gross alpha, gross beta, uranium isotopic, and technetium-99 water sample*	*Once per National Pollutant Discharge Elimination System reporting period to identify releases*
Mitchell Branch K-1700 weir	*Gross alpha, gross beta, uranium isotopic, and technetium-99 water sample*	*Annually to identify releases*

[a]*Affected areas – Specific locations identified in the Zone 1 LUCIP, subsequent post-ROD documents, or the Zone 2 LUCIP as part of a remedial design report/remedial action work plan.*

[b]*Property Record Restrictions – Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.*

[c]*Property Record Notices – Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.*

[d]*Zoning Notices – Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.*

[e]*Excavation/Penetration Permit Program – Refers to the internal DOE/DOE contractor administrative program(s) that require the permit requestor to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.*

[f]*Access Controls – Physical barriers or restrictions to entry.*

[g]*Signs – Posted command, warning, or direction.*

[h]Specific sign requirements at the K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough to provide notice or warning to prevent unauthorized access by fisherman, and specific signs at the K-1007-P1 Holding Pond to provide notice or warning that prohibits mowing in the buffer zone.

AM = Action Memorandum
bgs = below ground surface
CNF = Central Neutralization Facility
CWTS = Chromium Water Treatment System
DOE = U.S. Department of Energy
EM = Environmental Management
EPP = excavation/penetration permit
ETTP = East Tennessee Technology Park

Table 8.2. Other LTS requirements for the ETTP (cont.)

FFA = Federal Facility Agreement
LTS = long-term stewardship
LUC = land use control
LUCIP = Land Use Controls Implementation Plan
OU = operable unit
PCB = polychlorinated biphenyl
RAR = Remedial Action Report
RmAR = Removal Action Report
ROD = Record of Decision
S&M = surveillance and maintenance

The objectives of these Zone 1 LUCs follow:

- Property record restrictions to restrict uses of the property by imposing limitations on its use and to prohibit uses of groundwater;
- Property record notices to provide notice to anyone searching records about the existence and location of contaminated areas and limitations on their use;
- Zoning notices to provide notice to the city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes;
- An EPP program to provide notice to permit requestors of the extent of contamination and prohibiting or limiting excavation/penetration activity;
- Access controls to control and restrict access to workers and the public in order to prevent unauthorized uses;
- Signs that provide notice or warning to prevent unauthorized access; and
- Surveillance patrols to control and monitor access by workers and the public.

Until the land use is achieved, reliance will be primarily on property record and zoning notices, the EPP program, access controls, and surveillance patrols. Once it has been established that Zone 1 is safe for unrestricted industrial use, property record restrictions, property record notices, zoning notices, excavation permits, and less significant surveillance patrols will be used. These controls and their implementation are summarized in Table 8.2.

The PCCRs completed under the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) state that the NFA decision means that an EU is available for unrestricted industrial use to a depth of 10 ft bgs and NFA is required beyond the LUCs specified in the Zone 1 Interim ROD. All Zone 1 EUs have been cleared for industrial use to a depth of 10 ft. However, the following areas (Figure 8.3) have issues with unrestricted industrial use that are not addressed in the Zone 1 Interim ROD but will be addressed in the Zone 1 Final ROD.

- The Black Oak Ridge Conservation Easement (BORCE) is managed by the state of Tennessee as a Wildlife Management Area and State Natural Area. Two EUs in the northern section of Zone 1 (EU 66 and EU 70) are located in the BORCE. A large portion of these two EUs (15.6 acres) comprises the Contractors Spoil Area construction debris and fly-ash landfill. The recreational end use of these EUs in the BORCE is different from the end use identified in the Zone 1 Interim ROD. This is being addressed in the Zone 1 Final ROD.
- EU 11 is considered NFA; however, groundwater beneath the K-720 Fly Ash Pile is contaminated with semivolatile organic compounds, metals, and radionuclides. The K-720 Fly Ash Pile is included in the *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1* (DOE/OR/01-2294&D2/A1). No site-specific controls are recommended, but the Addendum recommends the K-720 Fly Ash Pile be reevaluated in conjunction with a groundwater decision so that all media can be addressed. A soil cap was constructed over the fly-ash pile in anticipation of a final Zone 1 ROD to address the fly ash pile and the impact on groundwater. The soil cap is in place but requires controls to maintain the cap to prevent possible releases of fly ash.

- EUs 27 – 33 are addressed in the second *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area* (DOE/OR/01-2294&D2/A2). Observations made during confirmatory radiological walkover and geophysical surveys indicated that asbestos-containing material and metal debris may remain buried. While meeting the Zone 1 criteria for a NFA determination, an end use change is proposed for EUs 29, 30, and 31 due to the asbestos-containing material and metal debris that remain buried on site. This is being addressed in the Zone 1 Final ROD.

- Active RCRA waste storage facilities are located on EUs Z1-50, -51, and -52.

8.2.1.2 Status of Requirements

General LUCs for Zone 1 remained in place during FY 2015. Restrictions were maintained for government-controlled industrial land use. The EPP functioned according to established procedures and plans for the site. Additionally, signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections.

The northern section of Zone 1 was identified as a conservation easement, the BORCE, on March 14, 2005 (Figure 8.3). The BORCE is utilized for recreational use, e.g., hiking, bicycling, and select controlled deer hunts. The trailhead is posted with a sign which designates the trails that are available for use in the conservation easement. Additionally, trail maps are located within the conservation easement at key intersections. The trailhead sign also states that there is no motorized use (except for select hunts) and users are to stay on the trails. However, the end use identified in the Zone 1 Interim ROD (DOE/OR/01-1997&D2) is unrestricted industrial, i.e., recreational use was not designated. The determination in the Proposed Plan that industrial use goals for Zone 1 are also protective of recreational uses is planned to be included in the Zone 1 Final Soils ROD to address this issue (Table 8.14).

8.3 ZONE 2 ROD

8.3.1 Performance Monitoring

8.3.1.1 Performance Monitoring Goals and Objectives

Major components of the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2) (Figure 8.4) selected remedy are:

- Assess data sufficiency for each EU and supplement data as necessary to determine if remediation levels are exceeded.

- Remove soil up to 10 ft in depth that exceeds remediation levels set to protect a future industrial worker.

- Remove soil to water table, bedrock, or acceptable levels of contamination, whichever is the shallowest, to protect underlying groundwater to MCLs and to protect human health and the environment.

- Remove or decontaminate the contaminated portions of slabs, vaults, basements, pits, tanks, pipelines, or any other subsurface structure that exceed the remediation levels to protect a future

industrial worker to a depth no more than 10 ft. Use soil or concrete debris that meets Zone 2 remediation levels as backfill material in basements and deep excavations.

- Remove the debris in the K-1070-B Burial Ground, regardless of depth to minimize potential future impact to surface water and soil that exceeds remediation levels for protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).

- Remove the debris and soil in the K-1070-C/D Burial Ground that exceeds remediation levels for the protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).

- Verify all acreage in Zone 2 as compliant with soil remediation levels established by the ROD.

- Implement LUCs to prevent exposure to residual solid contamination left on-site and/or to prevent residential use of the land.

Zone 2 was divided into 44 EUs for planning and evaluation purposes (Figure 8.4). Final status assessments and associated data gap sampling efforts for EUs in Zone 2 are being conducted using a Dynamic Verification Strategy (DVS) in accordance with the *Remedial Design Report/Remedial Action Work Plan for the Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4). Successful completion of the Zone 2 cleanup requires that each of these 44 EUs be characterized, evaluated against the Zone 2 risk criteria, and remediated if necessary.

The RAOs for Zone 2 are to:

- *Protect human health under an industrial land use to an excess cancer risk level at or below 1 x* 10^{-4} *and non-cancer risk levels at or below an HI [Hazard Index] of 1, and*

- *Protect groundwater to levels at or below MCLs.*

Drinking water MCLs are used as screening criteria for evaluating the effectiveness of soil, buried waste, and subsurface structure cleanup. The ROD, however, specifically defers groundwater and surface water cleanup to a later CERCLA action and does not include ARAR-based performance objectives for groundwater cleanup.

The monitoring requirements are monitoring of groundwater adjacent to potential sources of groundwater contamination, including the K-1070-C/D Burial Ground (DOE/OR/01-2161&D2). This monitoring will continue until the Sitewide ROD is approved.

Table 8.3 lists performance monitoring conducted for the Zone 2 ROD and other CERCLA actions at ETTP. Figure 8.9 shows watershed scale and CERCLA performance monitoring locations at ETTP (groundwater monitoring locations are shown on separate figures as indicated). ETTP does not have a sole surface water integration point at which all upstream contaminant releases converge to exit the watershed but has several subwatersheds. Therefore, there are several surface water integration points.

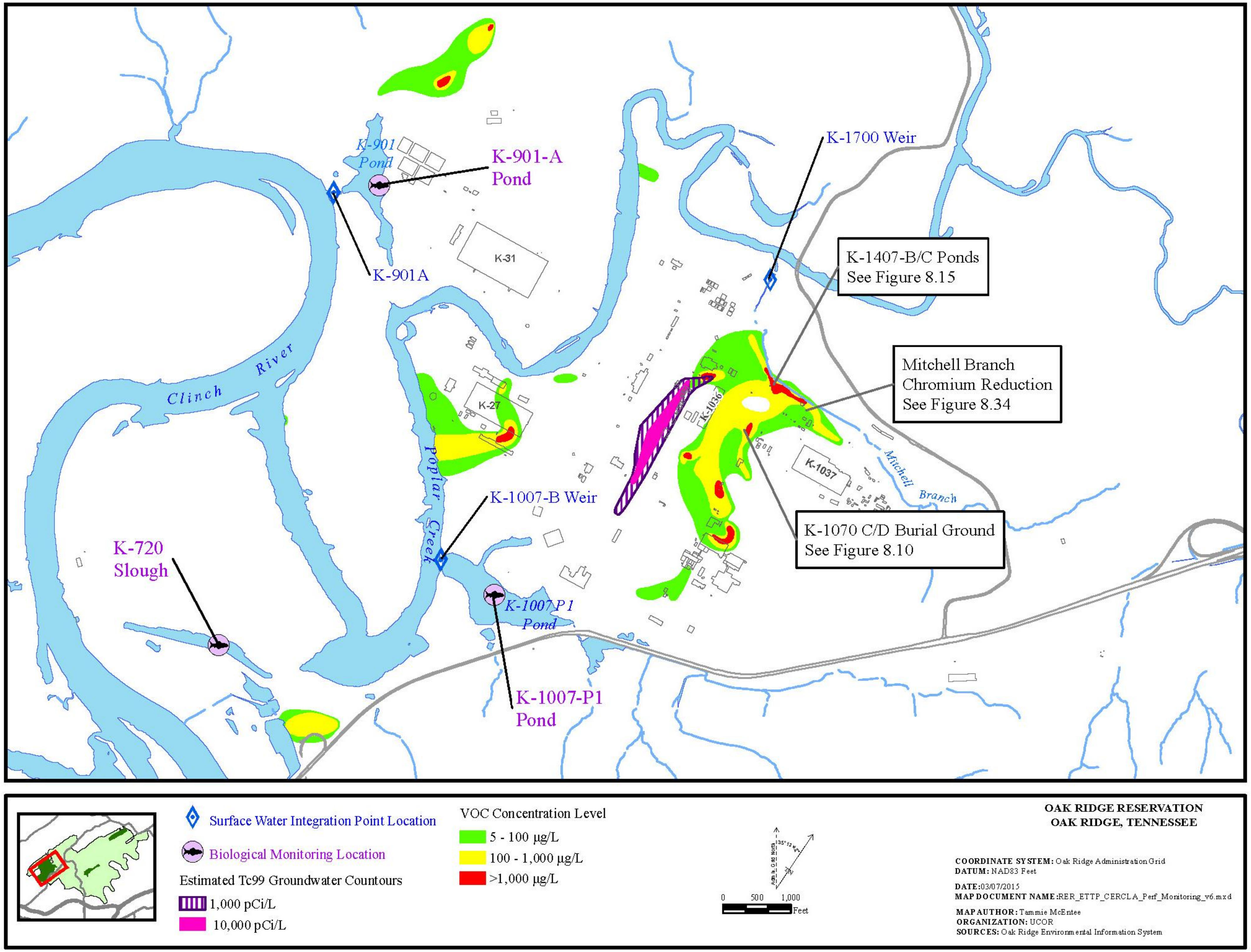


Figure 8.9. Watershed scale and CERCLA performance monitoring locations at ETTP.

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Table 8.3. CERCLA action performance monitoring in the ETTP Administrative watershed[a]

CERCLA action	Performance goal	Performance standard	Monitoring location(s)	General schedule and monitored parameters
Performance Monitoring				
Zone 2 Soil, Buried Waste, and Subsurface Structure RAs (includes K-1070-C/D Burial Ground)	Protect human health under an industrial land use to an ELCR at or below 1 x 10^{-4} and non-cancer risk levels at or below a HI of 1 Protect groundwater to levels at or below MCLs for drinking water	Drinking water MCLs	*Groundwater* TMW-011 UNW-064 UNW-114	Semiannual sampling (seasonally wet and dry conditions) Laboratory analyses for VOCs and water quality parameters
Long-term Reduction of Hexavalent Chromium Releases to Mitchell Branch (Non-TC RmA)	Collect and treat hexavalent chromium-contaminated groundwater to reduce its toxicity prior to discharge into Mitchell Branch Protect water quality in Mitchell Branch at levels consistent with AWQC	Hexavalent chromium concentrations below 0.011 mg/L AWQC in Mitchell Branch immediately downstream of SD-170 discharge	*Surface water* MIK-0.79 SD-170 *Groundwater* TP-289 IW-416 and IW-417 *Treatment System Discharge*	Quarterly sampling of all monitoring locations Laboratory analyses (unfiltered samples) for total and hexavalent chromium in surface water, groundwater, and treatment system discharge samples Treatment system discharge samples also analyzed for pH, total uranium, VOCs, gross alpha and beta, and select radionuclides
K-1407-B/C Ponds RA	Reduce potential threats to human health and the environment posed by residual contamination in pond soils by providing isolation and shielding with rock fill and intact soil cover	Remediation target concentrations were not established in the CERCLA decision or post-decision documents	*Surface water* K-1700 Weir *Groundwater* UNW-003 UNW-009	Semiannual sampling Laboratory analyses for nitrate, field parameters, VOCs, metals, gross alpha and beta, ^{99}Tc, ^{90}Sr, ^{137}Cs, ^{230,232}Th, and $^{234/238}$U

Table 8.3. CERCLA action performance monitoring in the ETTP Administrative watershed[a] (cont.)

CERCLA action	Performance goal	Performance standard	Monitoring location(s)	General schedule and monitored parameters
K-901-A and K-1007-P1 Holding Ponds and K-720 Slough RA	The goal of the ecological enhancement performed at the K-1007-P1 Holding Pond is to establish a new steady-state condition within the pond that reduces risks from PCBs by enhancing components of the ecology that minimize PCB uptake, which will reduce risks to human and piscivorous wildlife by interdicting contaminant exposure pathways associated with these receptors	PCB concentration of 1 mg/kg in fish fillets (2.3 mg/kg whole body)	Operational Monitoring at K-1007-P1 Pond only:	
			1. Presence of original fish	1. Once, after fish removal
			2. PCBs in fish	2. Annually
			3. Condition of vegetation	3. 2x/yr during growing season
			4. Species of fish	4. Annually
			5. Water quality	5. 3x/yr during growing season
			6. PCBs in clams	6. Four locations annually for a four week exposure
			7. Geese/waterfowl population	7. Monthly identification and enumeration of all waterfowl in and around pond
			Performance Monitoring at K-1007-P1 & K-901-A Holding Ponds, and K-720 Slough:	
			1. PCBs in fish	1. Annually for four years, then reassess for every other year until acceptable risk documented for each pond
			2. Species of fish in K-1007-P1 only	2. Annually for four years (reassess after four years, as above)
			3. PCBs in clams in K-1007-P1 only	3. Four locations annually for a four week exposure (reassessed after four years, as above)

[a]Changes to performance monitoring for RAs require prior approval from the EPA and TDEC.

AWQC = ambient water quality criteria
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
HI = hazard index
MCL = maximum contaminant level
MIK = Mitchell Branch kilometer
PCB = polychlorinated biphenyl
RA = remedial action
RmA = Removal Action
TDEC = Tennessee Department of Environment and Conservation
TC = time critical
VOC = volatile organic compound

8.3.1.2 Evaluation of Performance Monitoring Data

Monitoring locations, analytical parameters, and clean-up levels were not specified for groundwater monitoring at the K-1070-C/D Burial Ground (Figure 8.10), although the primary COCs in that area are VOCs. Semiannual samples are analyzed for VOCs and general water quality parameters in wells and surface water locations outside the perimeter of the K-1070-C/D Burial Ground. Monitoring at the site is focused on providing data for evaluating changes in contaminant concentrations near the source units or potentially discharging to surface water within the boundaries of the ETTP. Approximately 9,000 gal of mixed volatile organic liquids were disposed in G-Pit. Historic data showed that 1,1,1-TCA was present at very high concentrations in wells monitored near the site. 1,1,1-TCA is amenable to biodegradation to 1,1-DCA by microbes in the *Dehalobacter* genus. Although 1,1-DCA is also amenable to degradation by some species of *Dehalobacter*, the presence of cis-1,2-DCE and VC tend to inhibit the biodegradation of 1,1-DCA. Cis-1,2-DCE and VC are common biodegradation products of PCE and TCE which are also present in groundwater at the site along with 1,1-DCE, another biodegradation product of PCE and TCE.

Following remediation of G-Pit, monitoring wells UNW-114, TMW-011, and UNW-064 (Figure 8.10) were selected to monitor the VOC plume leaving the K-1070-C/D Burial Grounds because they were located in the principal known downgradient groundwater pathway. Results of monitoring at these wells show elevated VOC concentrations. VOC concentrations at these three wells were decreasing prior to the excavation of the G-Pit contents (during FY 2000) and continue to decrease. Although 1,1,1-TCA was formerly present at concentrations far greater than its 200 µg/L MCL, natural biodegradation has reduced its concentrations to less than the drinking water standard. Several direct push monitoring points were installed to the west of UNW-114 during investigations conducted in support of a Sitewide Groundwater RI in 2005. The purpose of these monitoring points was to investigate groundwater contamination in an area along potential geologically controlled seepage pathways that may have connected the G-Pit contaminant source to the former SW-31 Spring. DOE continues to monitor two of these points (DPT-K1070-5 and DPT-K1070-6) to measure VOC concentrations and their fluctuations.

Of the three wells monitored at this site, well UNW-114 is closest to the source area. Monitoring data for well UNW-114 (Figure 8.11) show that concentrations of most VOCs have been variable since 2005 and exhibit no trend or a stable trend. Concentrations of 1,1-DCA have gradually increased from a minimum of about 140 µg/L in 2007 to a recent concentration of 890 µg/L. 1,1,1-TCA was not detected in the March 2015 sample but was detected at 0.3 J µg/L in an August 2015 sample from well UNW-114 during FY 2015. The lingering 1,1-DCA residual in groundwater is evidence of the former presence of high concentrations of 1,1,1-TCA in the area. Recent concentrations of most chlorinated VOCs in well UNW-114 are within factors of about two to five times their MCLs.

Well UNW-064 is located slightly further downgradient from the contaminant source area than UNW-114 and its monitoring data exhibit a slightly different behavior. Similar to the overall trend observed at UNW-114, the majority of VOC concentrations at UNW-064 (Figure 8.12) decreased from about 2002 through 2005. Concentrations remained relatively low through the drought years of 2006 into 2008 and increased between 2008 and 2010. Since 2010 VOCs in well UNW-064 have exhibited stable to gradually decreasing concentrations with fairly strong seasonal fluctuations. At UNW-064 the 1,1-DCA, 1,1-DCE, cis-1,2-DCE, and TCE show a seasonal concentration fluctuation with higher concentration during winter than during summer. This seasonal fluctuation suggests that contaminant mass transport responds to increased groundwater recharge and seepage through the plume. DOE suspects that increased seasonal recharge drives mass transfer in the plume through two combined mechanisms. One mechanism is a rise in groundwater elevation in the source area (residual liquid waste beneath “G-Pit”) which allows groundwater seepage through fractures of higher permeability at a somewhat shallower depth. The second mechanism is simply a higher flow volume through the source area and downgradient fractures caused by the higher head imposed on the whole saturated zone. Cis-1,2-DCE, PCE, and VC have decreased to

concentrations less than their respective MCLs in well UNW-064. TCE continues to fluctuate at concentrations approximately two to five times its MCL and 1,1-DCE concentrations are about five to 10 times the MCL.

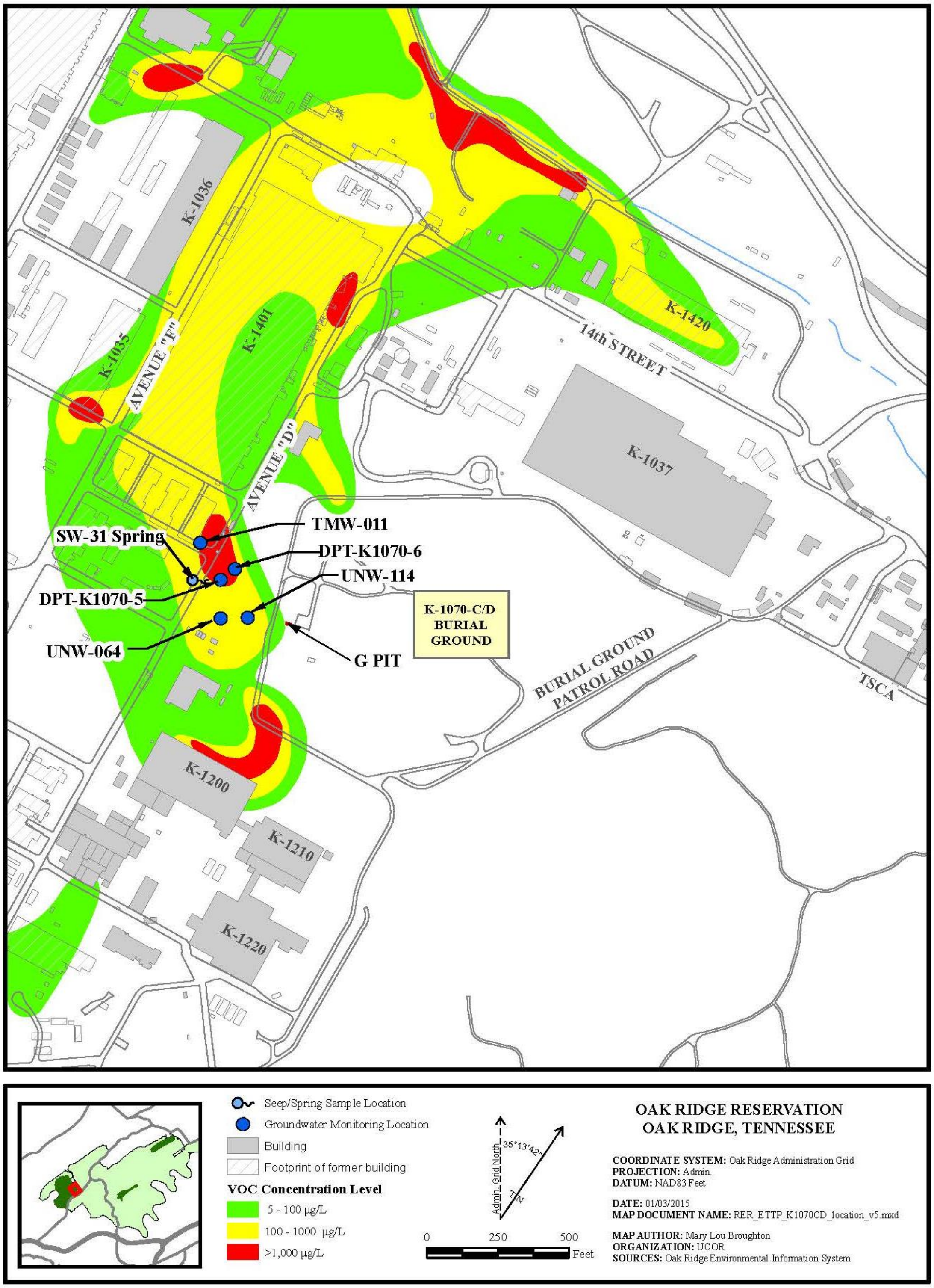

Figure 8.10. Location map for K-1070-C/D Burial Ground.

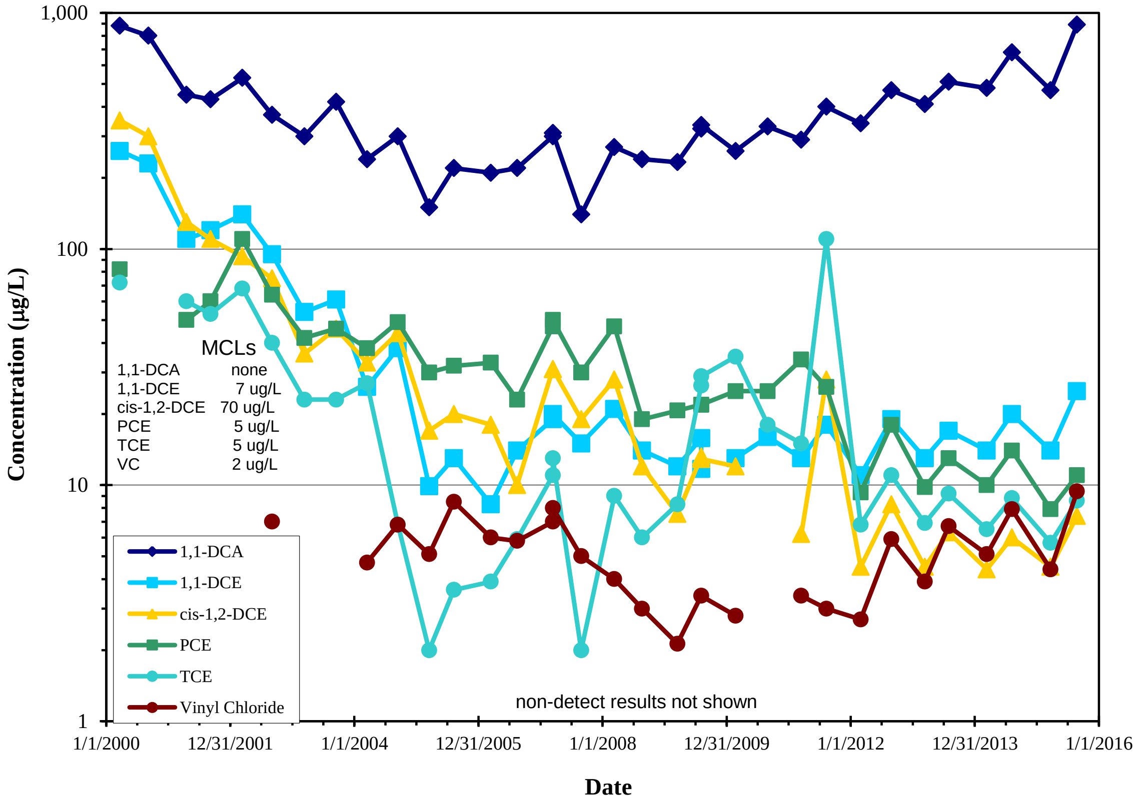

Figure 8.11. VOC concentrations in well UNW-114 for FY 2002 – FY 2015.

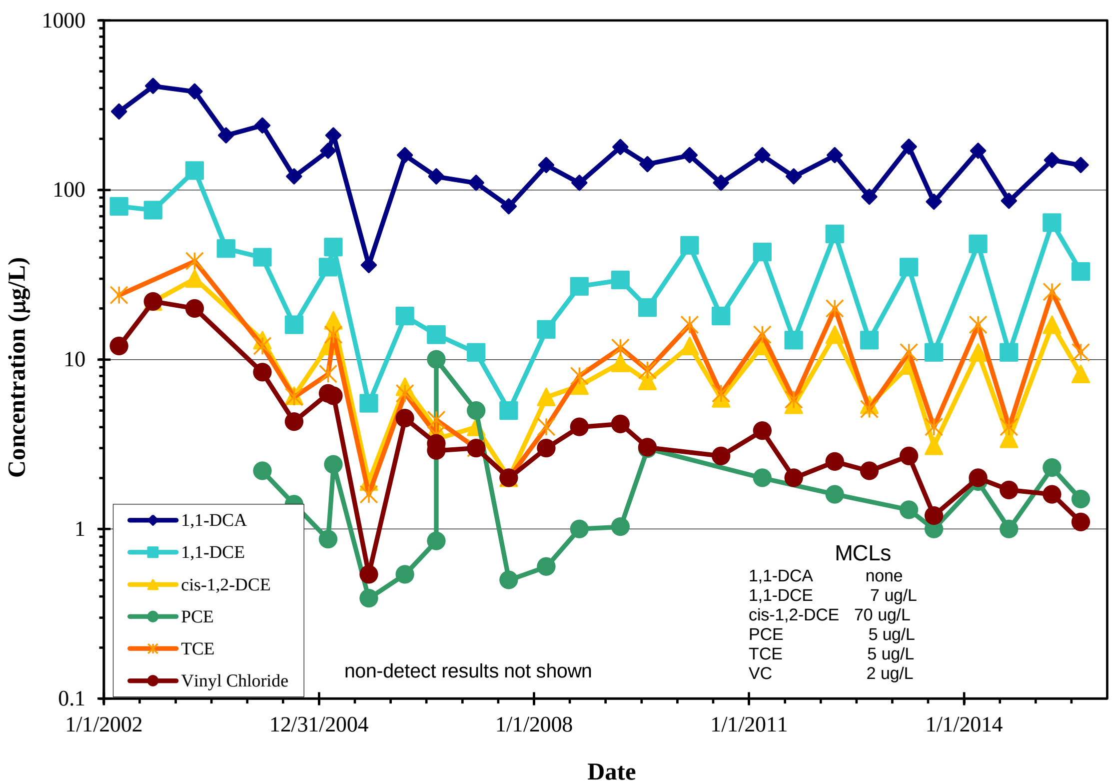

Figure 8.12. VOC concentrations in well UNW-064 for FY 2000 – FY 2015.

Well TMW-011 is located furthest from the contaminant source area near the base of the hill below K-1070-C/D. VOC concentrations at TMW-011 tend to fluctuate in a fashion similar to those at UNW-064 except that the seasonal signature is reversed with higher concentration in summer than during winter. This relationship suggests that groundwater recharge during winter tends to dilute the VOCs near TMW-011 rather than cause a pulse of higher concentration groundwater as was observed at the mid-slope location near UNW-064. Like the other two wells, VOC concentrations (Figure 8.13) decreased from 2000 until early 2005, after which concentrations have fluctuated seasonally within a gradual downward trend through about 2011. Since the summer of 2012, concentrations have experienced another step-like decrease. Cis-1,2-DCE and PCE have remained below their respective MCLs since the winter of 2012. Since the winter sampling event in 2012, VC concentrations have fluctuated with winter concentrations being below the MCL and summer concentrations exceeding the MCL by factors of two to three. TCE and 1,1-DCE concentrations fluctuate at concentrations about five to 15 times their respective MCLs.

Monitoring locations DPT-K1070-5 and DPT-K1070-6 (Figure 8.10) were installed using direct-push technology and therefore they sample groundwater just at, and somewhat above the top of bedrock. At these locations very high concentrations of 1,1,1-TCA, 1,1-DCE, and TCE persist (Figure 8.14). Overall decreasing trends for TCE, 1,1,1-TCA and its degradation product 1,1-DCE are apparent at well DPT-K1070-5 while 1,1,1-TCA in DPT K-1070-6 fluctuates in a concentration range well above its MCL. High concentrations (500 – 1,000 µg/L) of cis-1,2-DCE are present in addition to some values for 1,1,1-TCA, 1,1-DCA, 1,1-DCE, and TCE in this concentration range. Other VOCs that were found in the excavated material from G-Pit, such as 1,1,2-TCA, 1,2-dimethylbenzene, and chloroform, continue to be detected in these monitoring points.

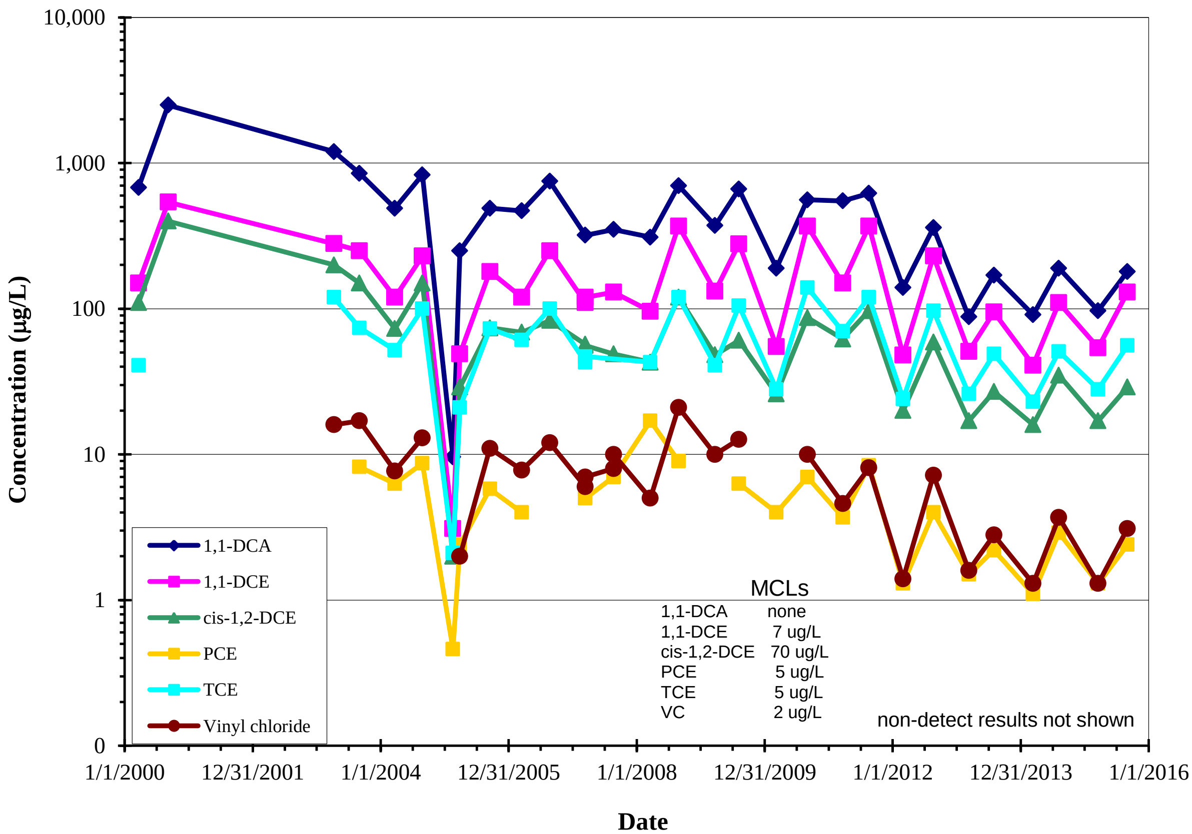

Figure 8.13. VOC concentrations in well TMW-011 for FY 2000 – FY 2015.

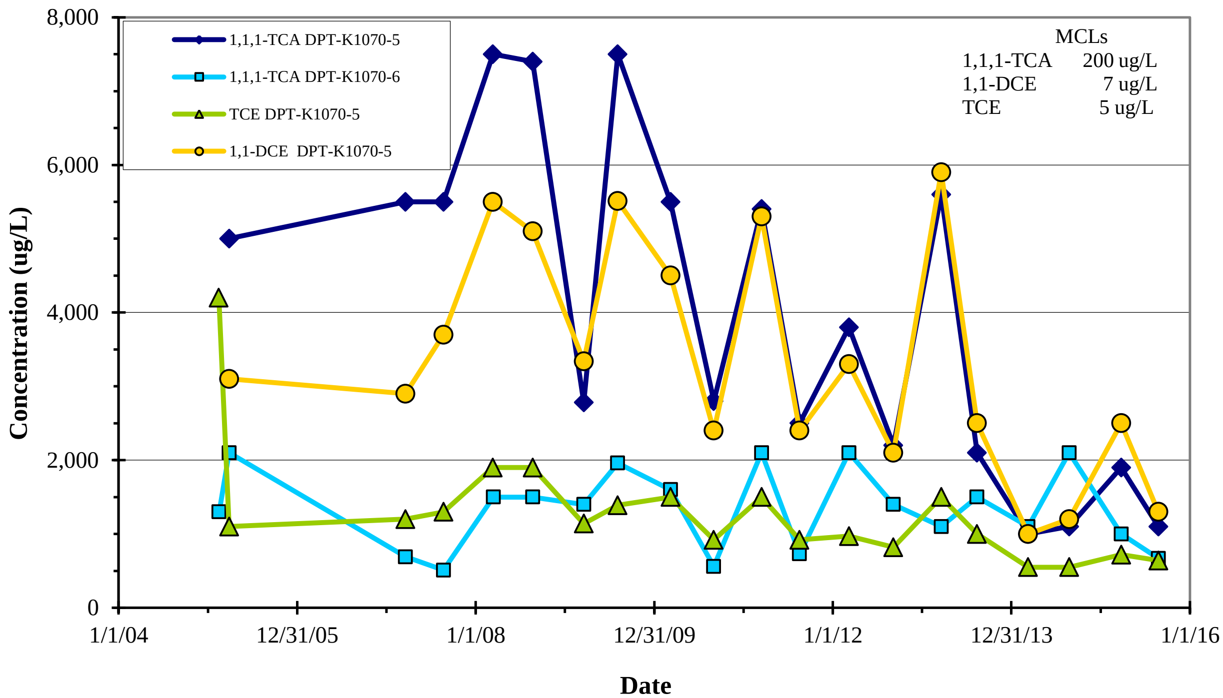

Figure 8.14. Concentrations of selected VOCs in DPT-K1070-5 and DPT-K1070-6.

8.3.1.3 Performance Summary

VOC concentrations in wells monitored downgradient of K-1070-C/D show that a broad area is affected by the releases from the G-Pit liquid VOC disposals. While concentrations along one portion of the impacted area continue to decrease, there remains a known area with very high concentrations of the contaminants disposed at the site. The persistent, very high concentrations of these VOCs suggest that a DNAPL source beneath and/or downgradient of the G-Pit continues to release mass into the plume.

8.3.2 Other LTS Requirements

Other LTS requirements for the Zone 2 ROD are listed in Table 8.2 and described below.

8.3.2.1 Requirements

The *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2) establishes "industrial" as the land use to a depth of 10 ft. To implement restrictions that prohibit residential or agricultural use of this area under the ROD and to restrict access to this area until that end use has been achieved, seven LUCs will be implemented: (1) property record restrictions, (2) property record notices, (3) zoning notices, (4) EPP program, (5) access controls, (6) signs, and (7) surveillance patrols. The objectives of these Zone 2 LUCs follow:

- Control land use to prevent exposure to contamination by controlling excavations or soil penetrations below 10 ft and prevent uses of the land involving exposures to human receptors greater than those from industrial use. Significant accumulations of material with residual contamination above unrestricted use levels will also be monitored and controlled. This will avoid accumulation of contamination placed in an area not currently designated for disposal that could reestablish a risk to a future industrial user.

- Prohibit the development and use of property for residential housing, elementary or secondary schools, childcare facilities, children's playground, other prohibited commercial uses, or agricultural use.

- Maintain the integrity of any existing or future monitoring system until the ETTP sitewide residual contamination RA is implemented.

- Control and restrict access to workers and the public to prevent unauthorized uses and maintain signs to provide notice or warning to prevent unauthorized access.

- Maintain the integrity of access controls and signs at the K-1070-C/D Burial Ground for as long as the residual debris represents a concern.

Until remediation is complete and the industrial land use is achieved, the seven LUCs mentioned above will be implemented to restrict residential or agricultural use of the land. Reliance will be primarily on property record and zoning notices, the EPP program, access controls, and surveillance patrols. Once remediation is complete, property record restrictions, property record and other public notices, zoning notices, excavation permits, and less intensive surveillance patrols and fences for the short-term at the K-1070-C/D Burial Grounds will be used. In addition, when an area within Zone 2 is transferred, property record restrictions and notices will be implemented. These controls and their implementation are summarized in Table 8.2.

The PCCRs completed under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2) state that the NFA decision means that an EU is available for unrestricted industrial use to a depth of 10 ft bgs and NFA is required beyond the LUCs specified in the Zone 2 ROD. Figure 8.4 illustrates EUs that have NFA decisions, EUs that have characterization yet to be completed, and EUs that will require RA.

8.3.2.2 Status of Requirements

General LUCs for Zone 2 remained in place during FY 2015. Signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections. The EPP program functioned according to established procedures and plans for the site. Required mowing was performed. Additionally, signs and access controls at the K-1070-C/D Burial Ground were inspected annually by the ETTP S&M Program.

8.4 SINGLE-PROJECT ACTIONS

8.4.1 K-1407-B/C Ponds

The *Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE/OR/01-1125&D3) addressed potential risks associated with residual wastes and soils remaining in the K-1407-B/C Ponds from the initial removal of sludge conducted as a previous RCRA closure action. The location of the K-1407-B/C ponds at ETTP is shown in Figures 8.1 and 8.15.

Components of the selected remedy include the following activities:

- Placement of clean soil and rock fill for isolation and shielding,

- Maintenance of institutional controls, and

- Groundwater monitoring to assess performance of the action and develop information for use in reviewing the effectiveness of the remedy.

8.4.1.1 Performance Monitoring

8.4.1.1.1 Performance Monitoring Goals and Objectives

The objective of the K-1407-B/C Ponds remediation was to reduce potential threats to human health and the environment posed by residual metal, radiological, and VOC contamination within the pond soils (DOE/OR/01-1125&D3).

The *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin, Oak Ridge*, *Tennessee* (DOE/OR/01-1371&D1) proposes semiannual groundwater monitoring for nitrate, metals, and selected radionuclides, including gross alpha and beta activity, ^{99}Tc, ^{90}Sr, ^{137}Cs, $^{230/232}Th$, and $^{234/238}U$. Target concentrations for these parameters were not established in the CERCLA documents (DOE/OR/01-1125&D3; DOE/OR/01-1371&D1) for use in post-remediation monitoring to evaluate effectiveness. Performance monitoring is conducted in wells UNW-003, UNW-009, and the Mitchell Branch weir (K-1700 Weir), shown on Figure 8.15.

8.4.1.1.2 Evaluation of Performance Monitoring Data

The primary groundwater contaminants in the K-1407-B and -C ponds area are VOCs. VOCs are widespread in this portion of ETTP, including contaminant sources upgradient of the ponds. Groundwater samples were collected at UNW-003 and UNW-009 in March and August/September 2015. VOCs are not detected in shallow groundwater north of Mitchell Branch in well UNW-009. VOC concentration data for well UNW-003 for the time span 2001 through 2015 are shown on Figure 8.16. Monitoring results for FY 2015 at the wells are generally consistent with results from previous years although concentrations of PCE and TCE have increased during FY 2014 and 2015 compared to levels measured during the preceding several years. The detection of VOCs at concentrations well above 1,000 µg/L and the steady concentrations over recent years suggest the presence of DNAPLs in the vicinity of well UNW-003. The sitewide ROD will address groundwater contamination present in the area of the former ponds.

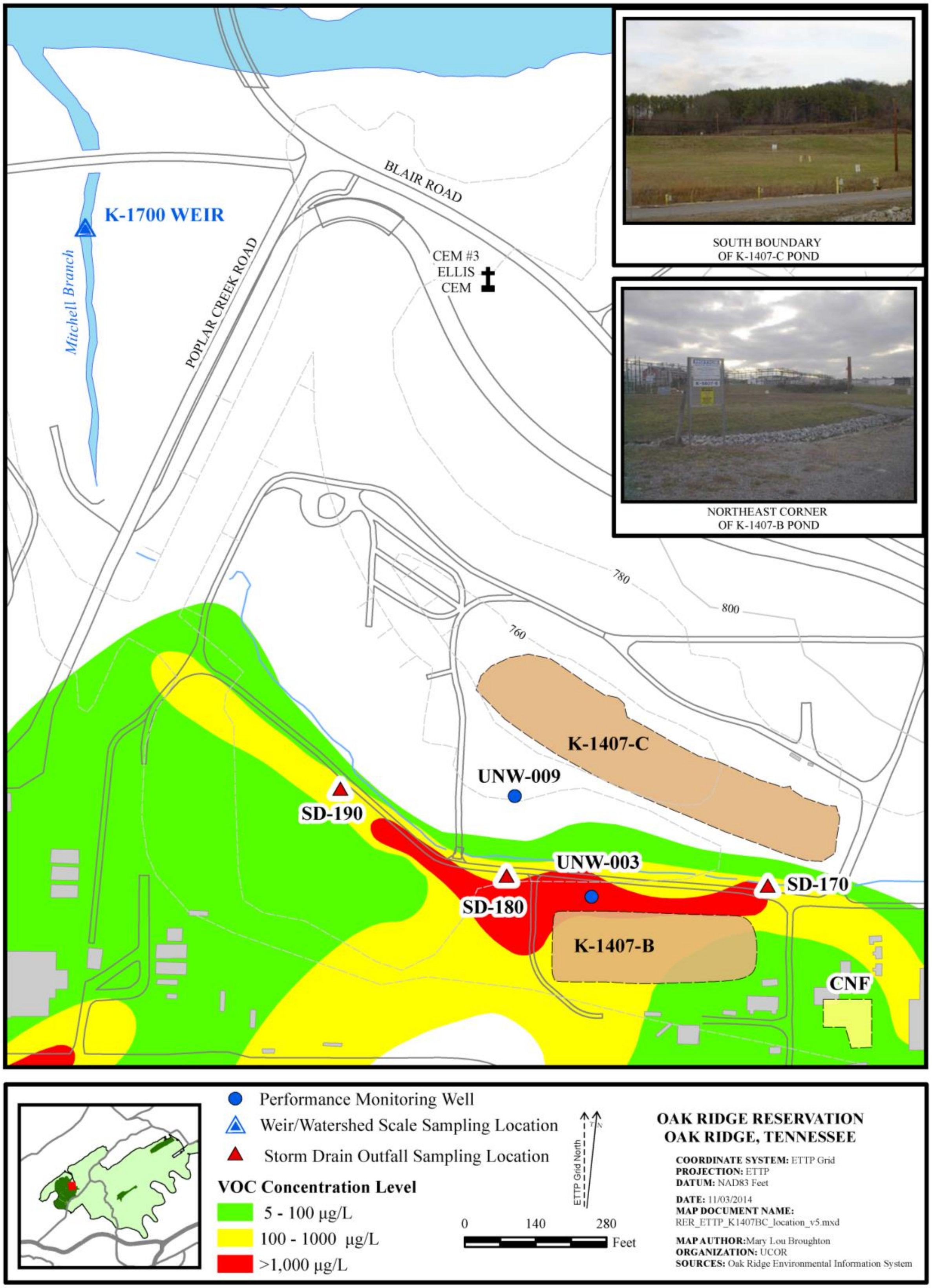

Figure 8.15. Location of K-1407-B/C Ponds.

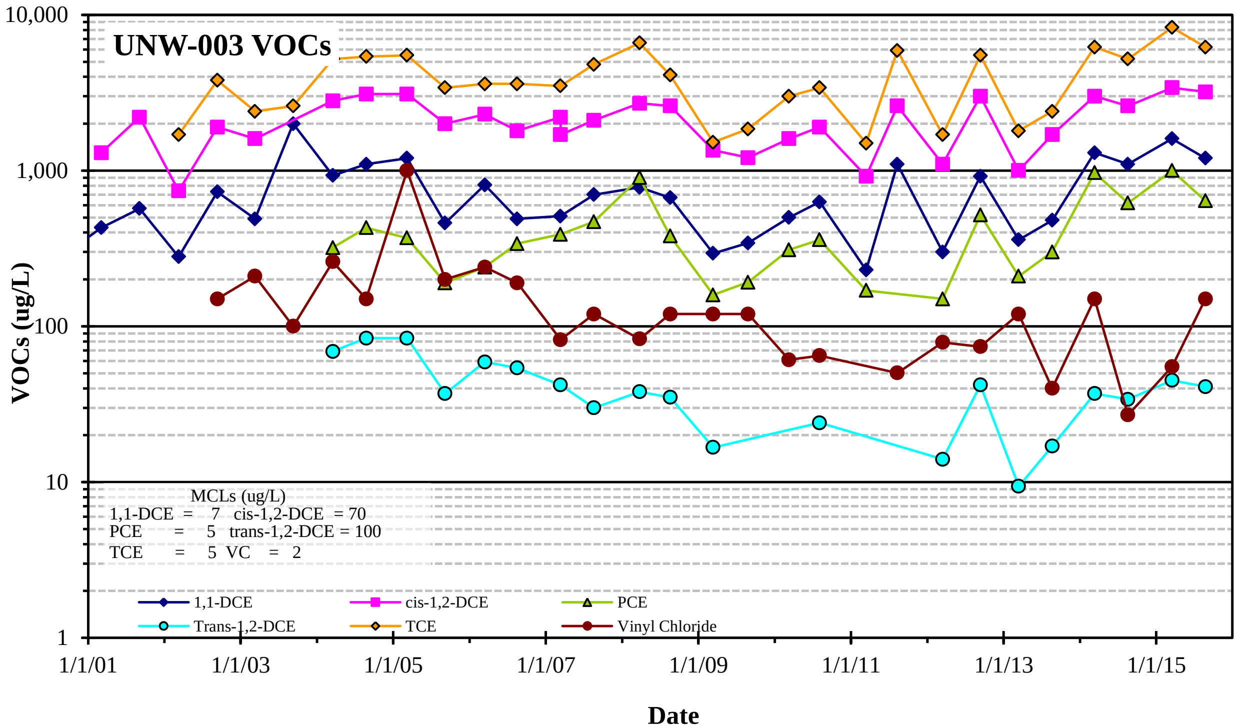

Figure 8.16. VOC concentrations in well UNW-003, 2001 – 2015.

8.4.1.2 Other LTS Requirements

8.4.1.2.1 Requirements

LTS requirements specified in the *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin* (DOE/OR/01-1371&D1) were clarified in an erratum approved May 2015 and included maintenance of institutional controls (Table 8.2).

The erratum states, *"Conduct annual inspections and perform radiological and industrial hygiene surveillance and other assessment activities only as needed if activities are conducted at the site that are necessary to keep the remediated ponds in compliance with environmental, safety, and health requirements and maintain records of all related activities"*.

8.4.1.2.2 Status of Requirements

All components of the K-1407-B/C Ponds site were inspected in FY 2015 by the ETTP S&M Program, including access controls and sign conditions; condition of vegetation including dead spots, excessive weeds or deep rooted vegetation, grass mowing, discoloration or withering of vegetation; soil/surface condition including evidence of soil erosion, gullies or rills, staining, debris or trash. The site underwent routine mowing. Minor maintenance included removing vegetation from signs.

8.4.2 ETTP Ponds

8.4.2.1 Performance Monitoring

8.4.2.1.1 Performance Monitoring Goals and Objectives

The *Action Memorandum for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee* (DOE/OR/01-2314&D2) (Figure 8.1) includes the following actions:

- K-1007-P1 Holding Pond
  - Drain pond, modify the weir, kill undesirable fish, establish vegetation within the pond and the riparian zone, replace desirable fish, and adjust water quality to protect piscivorous wildlife and recreational fishermen.
  - Implement institutional controls to prevent residential use.
  - Monitor.
- K-901-A Holding Pond
  - Implement institutional controls to prevent residential use.
  - Monitor.
- K-720 Slough
  - Implement institutional controls to prevent residential use.
  - Monitor.
- K-770 Embayment
  - No action (Institutional controls specified in Zone 1 ROD remain in effect).
- K-1007-P3, P4, and P5 Holding Ponds
  - No action (Institutional controls specified in Zone 1 ROD remain in effect).

This AM superseded the previous *Action Memorandum for the K-901-A Holding Pond and the K-1007-P1 Pond Removal Action, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/02-1550&D2).

The goal of the removal action is to establish a new steady-state condition within the pond that reduces risks from PCBs by enhancing components of the ecology that minimize PCB uptake. Implementation details were provided in the *Removal Action Work Plan for the Removal Action at the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2359&D2). Completion of the removal action is documented in the *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment* (DOE/OR/01-2456&D1/R1).

Monitoring of the K-1007-P1 Holding Pond will be performed in two phases (DOE/OR/01-2456&D1/R1). The first phase is operational monitoring that began after the pond was restocked and will continue until the pond has achieved a state where aquatic vegetation and a desirable mix of fish species have been established.

The second phase is performance monitoring, and focuses on the changes in PCB concentrations in fish after the completed action and evaluation of fish PCB levels relative to the target concentrations. Per the *Action Memorandum for the Ponds at the East Tennessee Technology Park* (DOE/OR/01-2314&D2), "*….A PCB concentration level of 1 µg/g in fish fillets (2.3 µg/g whole body) was set based upon levels shown to be protective of piscivorous wildlife, consistent with surrounding water bodies, and below FDA recommendations…".*

8.4.2.2 Evaluation of Operational Monitoring Data

Operational monitoring is conducted at the K-1007-P1 Holding Pond (Figure 8.17) to ensure that the ecological enhancement measures have been implemented as intended. Monitoring of plants, wildlife, water quality, and fish (which is also a performance metric) was conducted in 2015 in accordance with the *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE/OR/01-2456&D1/R1). The ecological information obtained is used to evaluate whether modifications are needed to attain the desired end state – i.e., a heavily vegetated, clear water pond dominated by sunfish with significantly diminished or at least downwardly trending PCB levels.

Figure 8.17. Heavy vegetation (top) and fish sampling (bottom) at the K-1007-P1 Pond.

The fish community in the K-1007-P1 Holding Pond was sampled in:

- May 2007 (baseline conditions; two years prior to piscicide application).
- 2009 – 2015 following remediation actions, including piscicide application, native plantings, and ongoing fish removal efforts.

The fish diversity in K-1007-P1 Holding Pond has reached or exceeded levels observed in 2007, prior to the initiation of remediation efforts and pond manipulations. Only one of the 10 species recorded in the pond during the baseline sampling in 2007 has not been recorded since, and that is white crappie (*Pomoxis annularis*), a species that at the time comprised approximately 12% of all fish in the pond. Bluntnose minnows (*Pimephales notatus*), spotted suckers (*Minytrema melanops*), western mosquitofish (*Gambusia affinis*), and redear sunfish (*Lepomis microlophus*) were known to occur in the pond prior to remediation efforts, but were not collected during the 2007 survey. Those species are again present in the pond, with bluntnose minnows, western mosquitofish, and redear sunfish having been stocked. Post-remediation evidence of spotted sucker comes from a single specimen collected in July 2012 and it is presumed to have found its way into the pond from Poplar Creek.

Four of the species found during fish population surveys, gizzard shad (*Dorosoma cepedianum*), largemouth bass (*Micropterus salmoides*), smallmouth buffalo (*Ictiobus bubalus*), and common carp (*Cyprinus carpio*), were eliminated from the pond by the Rotenone application in June 2009. These four species, as well as threadfin shad (*Dorosoma petenense*) and several other species, are believed to have entered the K-1007-P1 Holding Pond from Poplar Creek during a storm event in May 2010 when the weir separating the pond from Poplar Creek was damaged. Although no threadfin shad have been collected since 2012 sampling events, all five of these species continue to be removed as they are encountered, and such efforts have apparently put considerable pressure on four of the five species – gizzard shad being the notable exception. The numbers of these five species removed from P1 Pond since May 2010 is illustrated in Figure 8.18.

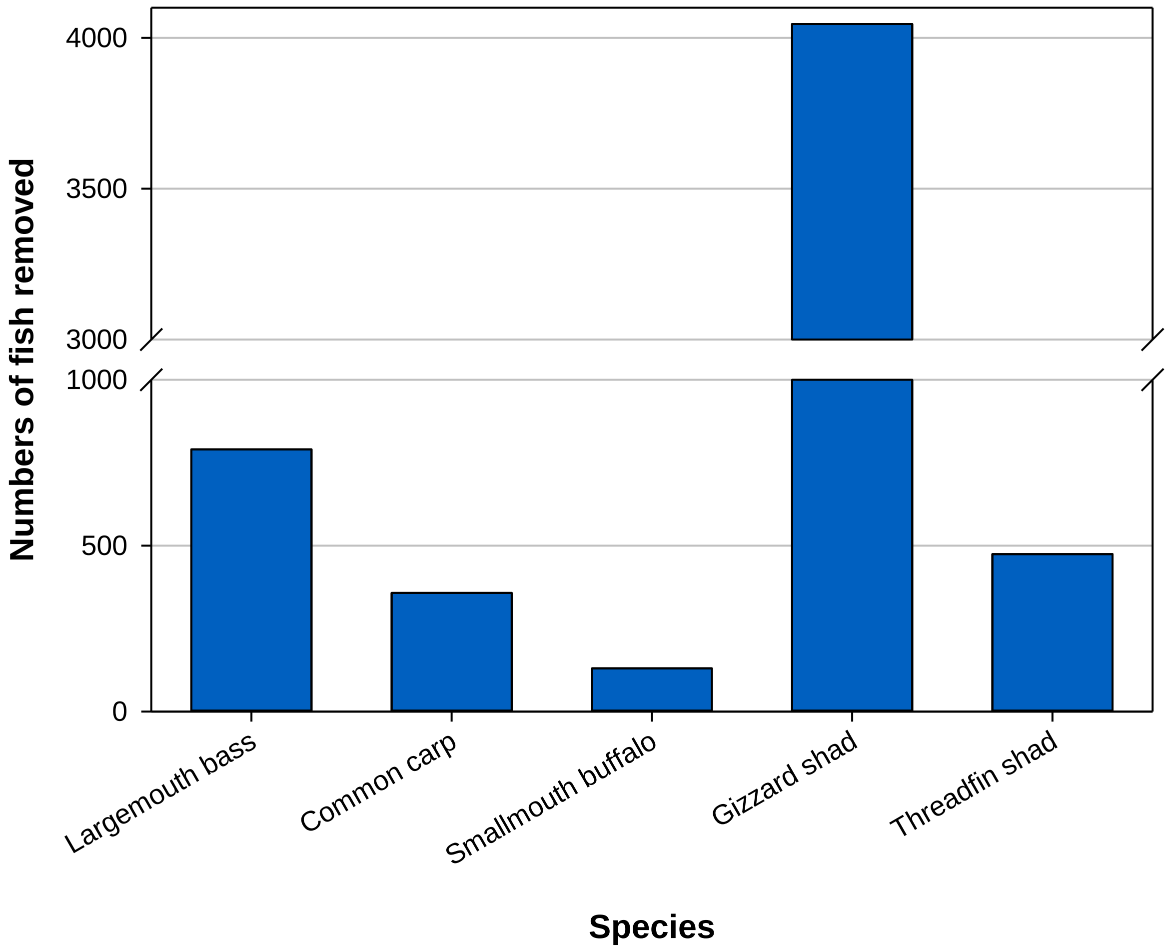

Figure 8.18. Numbers of five species of fish removed from K-1007-P1 Holding Pond in 2010 – 2015, following the weir breach in May 2010.

Changes in the fish community of the K-1007-P1 Holding pond have been considerable since the 2007 survey (Figure 8.19). Bluegill and gizzard shad have consistently been among the most dominant species each year and this trend continued in 2015. Bluegill reproduction appears to be good, and year classes 0 – 4 were present when the pond was sampled in March 2015. Bluegill lifespan averages 5 – 6 years (Etnier and Starnes, 1993). Adult gizzard shad tend to be a very pelagic fish preferring open water without obstructions. This is a habitat type that is decreasing in the P1 pond during the summer plant growth, which expands each year. It is hopeful that this, in conjunction with fish removal efforts, will reduce the gizzard shad populations over time. There was a noticeable consistency in the size class of shad collected in 2015, with all of the fish collected being over 26 cm total length, indicating they were most likely three year old fish (Williams and Nelson, 1985). It is hopeful that successful reproduction has been hindered by the vegetation and no new recruitment of juvenile gizzard shad is occurring in the pond. Despite this observation, gizzard shad continue to show large biomass values over the last several years with a sizable jump in 2014 (Figure 8.20). Their current biomass is about 45%, which is within the range expected from reports for reservoirs which range from 40 – 80% (Etnier and Starnes, 1993). It should be noted that fish removal efforts did not occur in 2013 outside of the annual population survey, which may have had a bearing on the number of fish collected in February 2014.

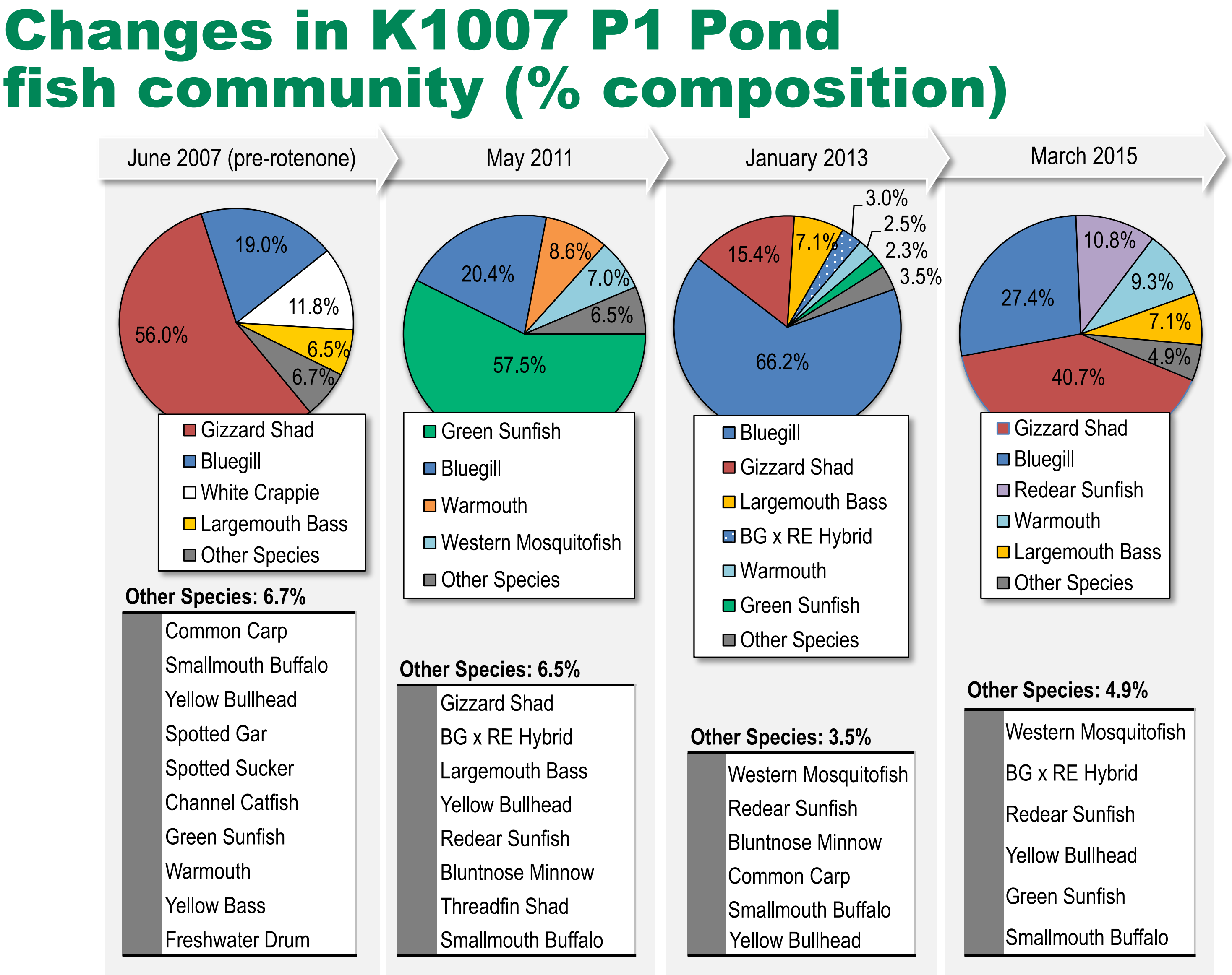

Figure 8.19. Changes in K-1007-P1 Holding Pond fish community composition.

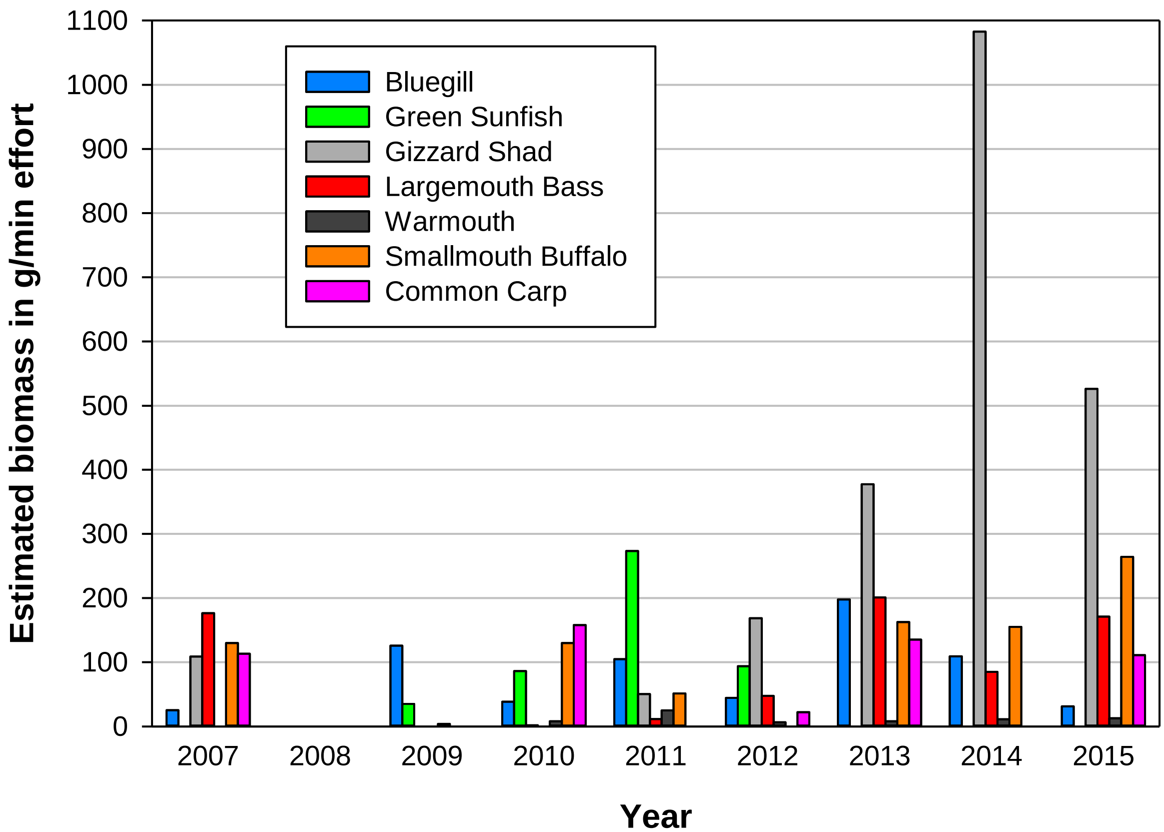

Figure 8.20. Estimated biomass in g/min of effort for seven species collected during fish population surveys, by boat electrofishing, K-1007-P1 Holding Pond, 2007 – 2015.

2009 estimates and 2010 shad, buffalo, and carp estimates are based on extrapolation of weight data from other years).

Positive changes in the fish community post-action are the total removal of grass carp, which were known to negatively impact aquatic vegetation, the low numbers of common carp, and the absence of threadfin shad in the 2013 – 2015 surveys. Largemouth bass, which are also deemed an undesirable species for the pond, become reproductively mature at age two to three, depending on when they were spawned, so any removal efforts that target these individuals should be effective at reducing the presence of this species from the ponds. Since the weir breach in 2010, 790 bass have been removed from the pond. The majority of these fish were from age class two and three and these removal efforts should reduce the next generation of bass spawned in the pond.

The plant community within the pond has also changed dramatically since the pond was re-contoured and vegetation planted as part of the remediation action. In 2007, the pond was largely devoid of plants except for algae. In 2010 – 2015, surveys found coverage had increased as much as seven-fold along some transects, reaching nearly 100% coverage, including one transect (T4) where soils were not added during remediation (Figure 8.21). This increased cover is due in part to excessive growth of the carnivorous humped bladderwort (*Utricularia gibba*) (Figure 8.22). This species is relatively common in middle and far west Tennessee but is a fairly unusual find in east Tennessee. Despite the increase in plant cover observed in this unmodified transect over 85% of the transect was covered with *Utricularia gibba* which, similar to algae, is not rooted and provides no sediment stability – a potential concern if the species begins to crowd out submergent vegetation over time. Plant richness decreased slightly in 2015 (Figure 8.23) including both species planted during the removal action and volunteer species that may have been present along the periphery of the pond. An additional survey of the root penetration of aquatic

plants in 2014 revealed that despite the predominance of clay soils in the east portion of the pond, roots of aquatic plants penetrate on average to a depth of 17.5 cm and seem to be stabilizing all sediments in which they occur. The establishment of the plant community in the K-1007-P1 Holding Pond is highlighted by aerial photo comparisons between 2009, 2011, and 2014 (Figure 8.24). By the end of the growing season in 2014, floating leaf plants had extended across the pond to cover about 90% of the pond's surface.

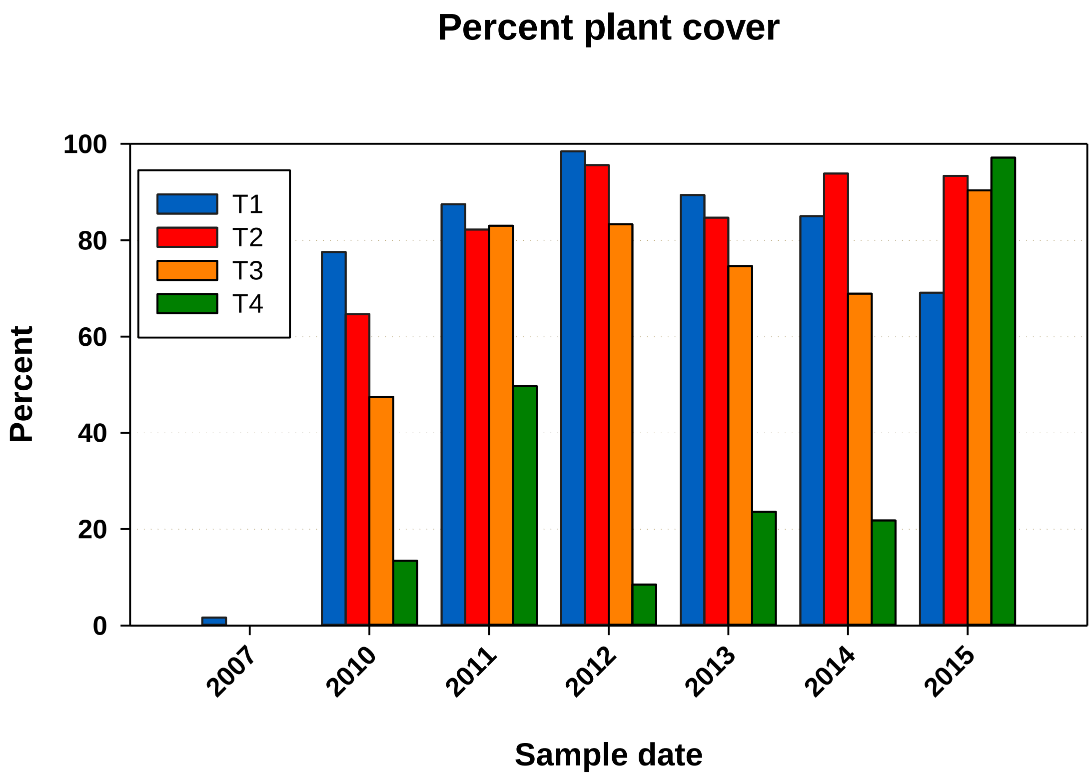

Figure 8.21. Mean percent vascular plant cover for four transect survey lines in K-1007-P1 Holding Pond prior to and after the remediation in 2009.

Figure 8.22. Humped bladderwort (*Utricularia gibba*) and flower in the P1 Pond during 2015.

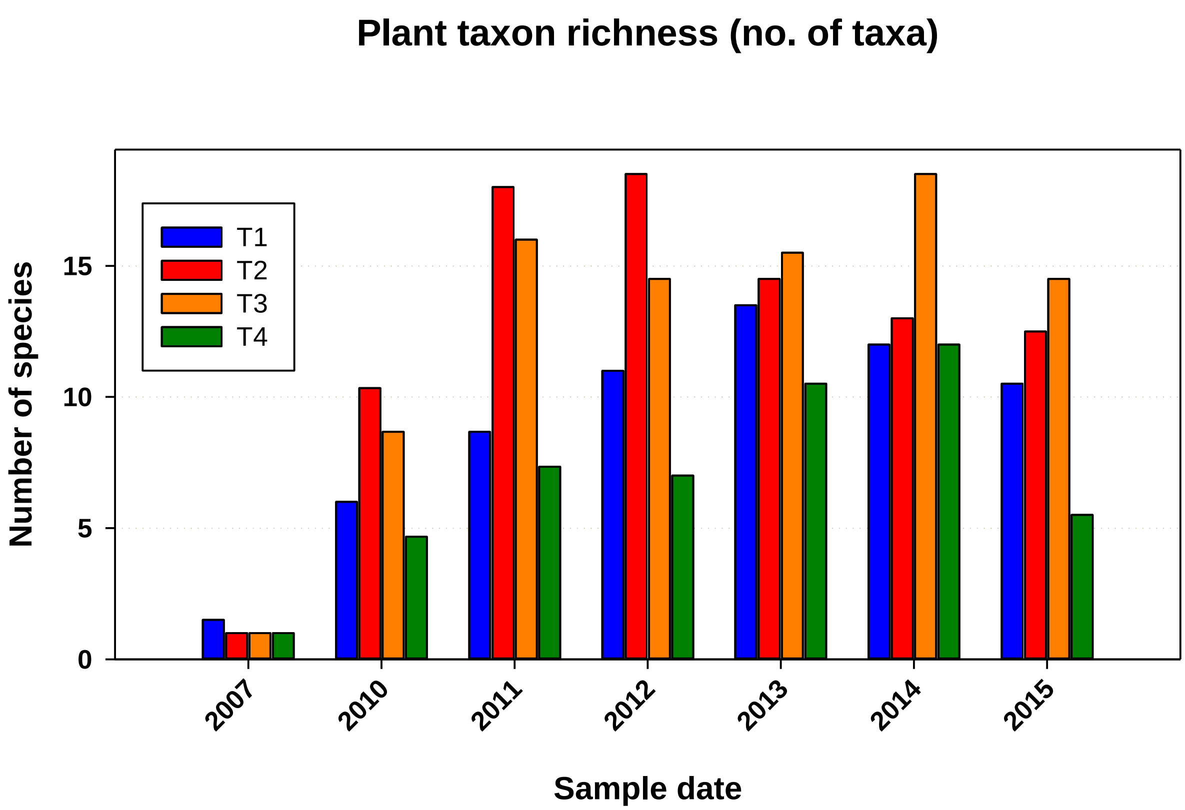

Figure 8.23. Mean plant taxon richness for four transect survey lines in K-1007-P1 Holding Pond prior to and after the remediation in 2009.

Figure 8.24. Aerial photos of the K-1007-P1 Holding Pond showing changes in plant coverage between the end of the first year of planting, 2009 (top), after the growing season, in 2011 (middle), and after the growing season in 2014 (bottom).

The success of vegetation growth may be due, in part, to control of Canada geese (*Branta canadensis*) and herbivorous fish species such as grass carp (*Ctenopharyngodon idella*). Canada geese are aggressive herbivores known to damage freshly planted aquatic vegetation, and grass carp, well known for controlling overgrowth of aquatic vegetation, are almost entirely herbivorous. Improvements in habitat, coupled with a decrease in the goose population (Figure 8.25), have no doubt contributed to increased use of the pond by ducks (Figure 8.26) and other water birds, such as grebes, herons, and sandpipers.

The data in Figures 8.25 and 8.26 are reported on a calendar year basis. The mean number of geese observed per survey is reported for the first 10 mo. of 2015 because approximately 95% of giant Canada geese in East Tennessee are non-migratory (Roy et al., 2004). Once all surveys in CY 2015 have been completed however, the actual number of geese observed per survey is likely to differ slightly from the 1.8 geese/survey currently shown in Figure 8.25 (any difference is expected to be slight because this species is largely a year-round resident). Duck observations, however, are not reported until all surveys in a calendar year are complete. This is because there are only two duck species, wood duck (*Aix sponsa*) and mallard (*Anas platyrhynchos*), which are considered year-round residents (Roy et al., 2014), and reporting these data prior to the arrival of migratory species can greatly affect the mean number of ducks observed per survey in a calendar year. Nevertheless, the mean number of ducks (all species) observed on P1 Pond in CY 2015 is expected to be somewhat higher in 2015 than in 2014.

Least bitterns (*Ixobrychus exilis*), which are not known to have ever been observed on the ORR, were recorded using the P1 Pond on three occasions between July 2012 and July 2013 (Roy et al., 2014). Two other species of birds, previously known from historic records only (on the ORR), have been observed at P1 Pond following initiation of RAs: Virginia rails (*Rallus limicola*) were seen or heard approximately a half dozen times between April 2012 and October 2013 and an American tree sparrow (*Spizella arborea*) was observed in April 2015. Prior to these observations, neither of these species had been recorded on the ORR in more than 60 years (Roy et al., 2014). Other rare bird species observed recently at P1 Pond include vesper sparrow (*Pooecetes gramineus*; October – November 2014), Lincoln's sparrow (*Melospiza lincolnii*; October 2015), and Wilson's warbler (*Cardellina pusilla*; October 2015). The discovery of these rare bird species on the ORR coincides well with the expansion of diverse aquatic and riparian plant communities at P1 Pond, which resulted in relatively rapid habitat changes from 2009 to 2014 (Figure 8.24). The numbers of wintering bird species using P1 Pond riparian zones, such as swamp sparrows (*Melospiza georgiana*), also increased substantially following RAs (low of seven species in the winter of 2009 – 2010 to a high of 28 species in the winter of 2012 – 2013).

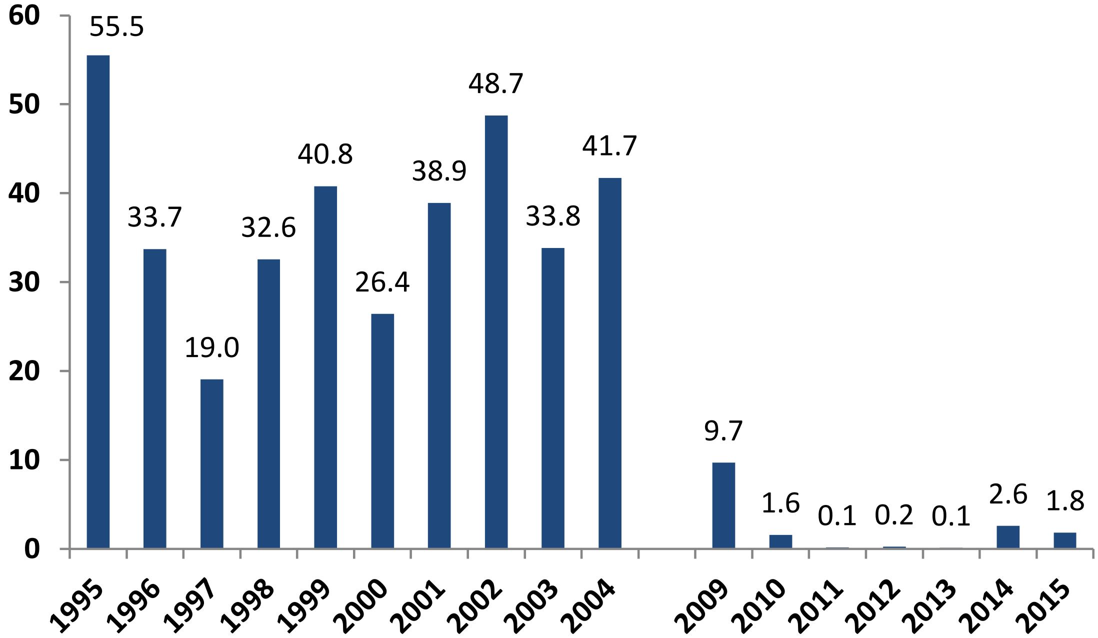

Figure 8.25. Mean numbers of geese observed per survey at the P1 Pond, prior to (1995 – 2004) and after (2009 – 2015) RAs.

All observations are based on calendar year, except that 2009 contains no data from January through April and 2015 contains no data after October. Number of surveys conducted each year as follows: 1995 – 1997 & 1999 (*n*=24), 1998 (*n*=22), 2000 (*n*=17), 2001 (*n*=18), 2002 & 2004 (*n*=11), 2003 (*n*=12), 2005 – 2008 (no formal surveys were conducted), 2009 (*n*=30), 2010 (*n*=49), 2011 (*n*=44), 2012 (*n*=50), 2013 (*n*=24), 2014 (*n*=14), 2015 (*n*=17).

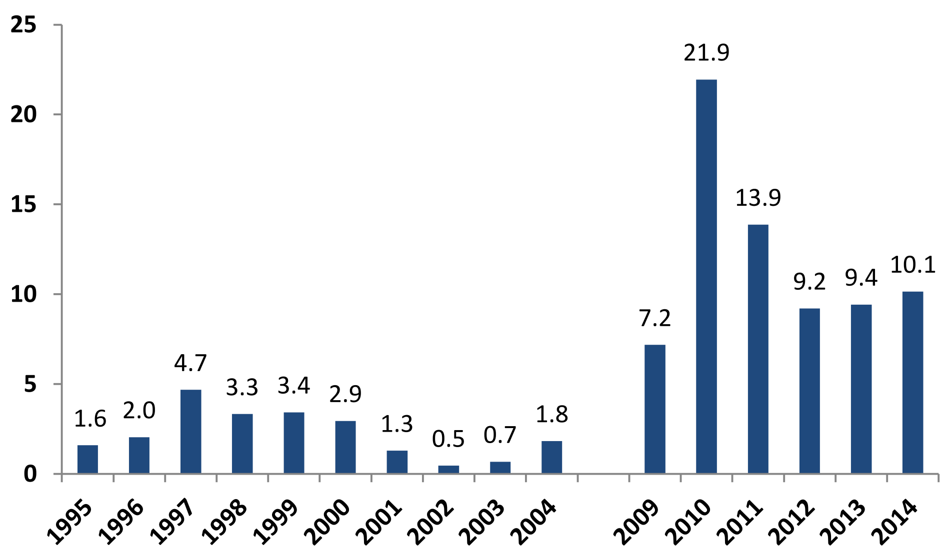

Figure 8.26. Mean numbers of ducks (all species) observed per survey at the P1 Pond, prior to (1995 – 2004) and after (2009 – 2014) RAs.

All observations are based on calendar year except that 2009 contains no data from January through April. Number of surveys conducted each year as follows: 1995 – 1997 & 1999 (*n*=24), 1998 (*n*=22), 2000 (*n*=17), 2001 (*n*=18), 2002 & 2004 (*n*=11), 2003 (*n*=12), 2005 – 2008 (no formal surveys were conducted), 2009 (*n*=30), 2010 (*n*=49), 2011 (*n*=44), 2012 (*n*=50), 2013 (*n*=24), 2014 (*n*=14).

Compared with the previous five years, the average total suspended solids (TSS) concentration in P1 Pond in 2015 was higher, but still much lower than in the pre-removal period (Figure 8.27, top graph). At least some of the increase in TSS was attributable to the presence of larger pieces of dead lotus leaves in the samples, especially in August. As in past years, TSS concentrations were similar among transects in early summer, but by late summer concentrations increased, most notably at Transect C (near the dam).

In contrast to TSS, water clarity (i.e., Secchi depth) continued a trend of increasing in 2015 (Figure 8.27, bottom graph). In 2015 mean water clarity was the highest since measurements began in 2004, and exceeded the pond goal of 150 cm by nearly 15 cm. Secchi depths were greater than in 2010 – 2013, and approximately three times greater than in 2004 and 2007. As in the previous two years, Secchi depths equaled the water depth at all cells along Transect A on all sampling dates. Thus, differences in Secchi depths at this transect between sampling periods and years since 2012 have not been associated with actual variation in water clarity, rather they have been directly the result of variations in water depth and the specific locations where measurements have been taken. Seasonally, the trend for water clarity is similar to that of TSS at Transects B and C; as summer progresses water clarity generally declines at these transects.

In summary, the operational performance data suggests that the water quality, plant community, and wildlife manipulations are progressing well toward the desired end state, although in each case changes are continuing and a stable end-state has not been reached. The fish community has had some positive developments in removing or controlling carp species and maintaining a healthy and dominant sunfish community. However, some undesirable species that entered the pond after the weir breach, especially largemouth bass and shad, are increasing in numbers and/or biomass. Given the rapidly changing conditions in the pond, and the important roles of water chemistry, biology (food chain effects, bioturbation), and plant-sediment interactions on PCB bioaccumulation, operational monitoring will continue in 2015. It may take a number of years for the pond conditions to stabilize such that the success or failure of the remedy is fully determined. Operational data will provide useful process-level information as to the major factors affecting bioaccumulation and the desire or need for further modifications of the action in the future.

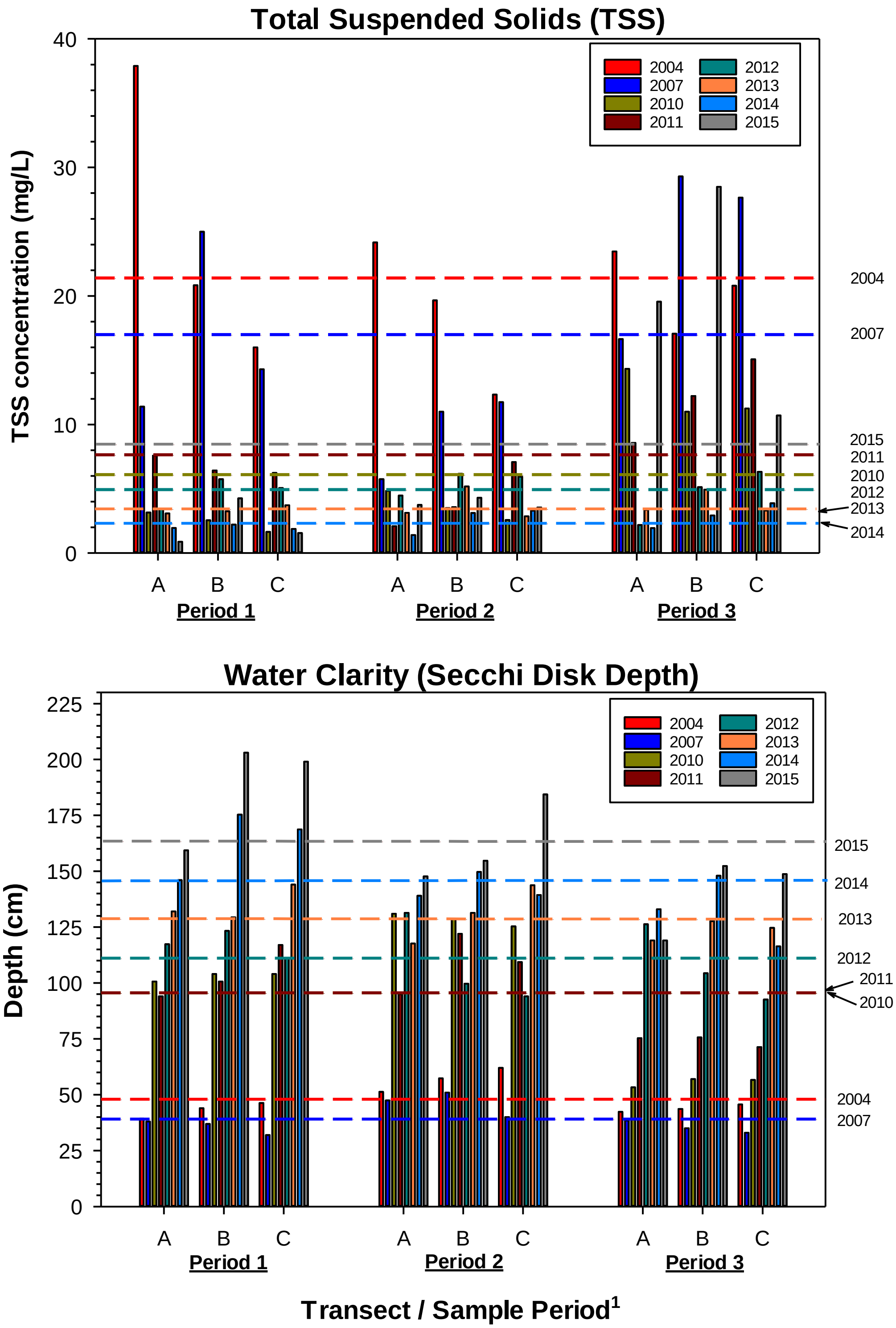

Figure 8.27. TSS and water clarity results by transect and sample period, prior to (i.e., 2004 and 2007) and after (i.e., 2010 – present) the removal action.

[1]Transects run from north to south and are located approximately 506 m (Transect A), 305 m (Transect B), and 152 m (Transect C) from the pond's dam. Sampling periods 1-3 generally refer to spring, early summer, and late summer, during periods of the year with the greatest suspended solids and plankton growth.

Dashed lines reflect annual means.

8.4.2.3 Evaluation of Performance Monitoring Data

Assessment of PCB exposure and bioaccumulation in the K-1007-P1 Holding Pond continued in 2015, with the primary emphasis on monitoring PCBs in fish and caged clams. Fish samples were also collected from the K-901-A Holding Pond and K-720 Slough for analysis of PCBs. Since the 2009 RA to remove fish from the K-1007-P1 Pond, the target species for fish bioaccumulation monitoring in the K-1007-P1 Holding Pond has been bluegill sunfish (*Lepomis macrochirus*). In 2015, fillets from 20 individual bluegill and six whole body composites (10 bluegill per composite) were analyzed for PCBs to assess the ecological and human health risks associated with PCB contamination in the K-1007-P1 Pond.

Average PCB concentrations in biota collected from the K1007-P1 Pond have fluctuated significantly in the five years post-remediation, but appear to be decreasing overall. Mean concentrations in fillets of bluegill collected from the K1007-P1 Pond in 2015 was 0.45 μg/g (compared to 0.62 in 2014) and the mean concentration in whole body composites of bluegill collected from this site was 2.03 μg/g (compared to 3.21 μg/g in 2014) (Table 8.4, Figures 8.28 and 8.29). This represents a significant decrease in fish PCB concentrations at this site, with whole body concentrations dropping below the remediation target of 2.3 μg/g for the first time since remediation actions were taken six years ago. Bluegill fillet concentrations have remained below the remediation goal of 1 μg/g for three consecutive years. PCB concentrations in largemouth bass had historically been well above state and federal guidelines for assessing human health concerns before remediation activities. In 2015, largemouth bass were collected from the K1007-P1 Pond for the first time since these fish were removed as part of remediation activities in 2009. The mean PCB concentration in largemouth bass fillets in 2015 was 5.33 μg/g, compared to 15.3 μg/g in similarly-sized fish in 2009. While monitored concentrations in this species remain above remediation targets, these results are encouraging, as they represent an almost 3-fold decrease in six years. Fish, especially upper trophic level fish, can often take several years to respond to decreases in contaminant concentrations. Multiple lines of evidence suggest that concentrations in largemouth bass should continue to decrease over time.

Caged Asiatic clams (*Corbicula fluminea*) collected from the Little Sewee Creek reference site were placed near and within various SDs entering the K-1007-P1 Holding Pond for a four week exposure period (May – June 2015) (Figures 8.30 and 8.31). PCB concentrations in clams placed at the K1007-P1 outfall were significantly lower than in 2014 (Figure 8.30). PCB concentrations in clams placed at lower SD 100 have fluctuated significantly since remediation actions in 2009, but appear to be trending downwards overall, averaging approximately 1 μg/g in 2015 (Figure 8.31). The observed fluctuations in PCB concentrations seen in biota suggest that this system is still in transition and that as the fish and plant communities stabilize, further decreases in PCB bioaccumulation may become apparent.

The target fish species for analysis of PCBs in the K-901-A Holding Pond and K-720 Slough were gizzard shad (*Dorosoma cepedianum*) and largemouth bass (*Micropterus salmoides*). It was not possible to collect the target number of bass (20) from each body of water, and so common carp (*Cyprinus carpio*) were collected to provide a combined total of 20 fish. Carp were selected as surrogate species for bass because they are widely distributed, they are present at both locations, and they have been used historically in other monitoring efforts on the ORR for contaminant analyses. A total of five largemouth bass and 15 carp were collected from the K-901-A Holding Pond, and eight bass and 12 carp were collected from the K-720 Slough in 2015.

At the K-901-A Holding Pond, PCBs concentrations in largemouth bass have fluctuated annually, but these fluctuations are likely linked to fluctuations in their prey. Mean concentrations in both largemouth bass and carp from this pond in 2015 (0.66 μg/g in largemouth bass and 1.77 μg/g in carp) were similar to concentrations seen in 2014 and remain within the range of those seen in recent years (Figure 8.32).

Whole body gizzard shad from the K-901-A Pond, collected as a measure of potential ecological risk to terrestrial wildlife, were substantially higher in concentration (5.41 μg/g) than the fillets of bass and carp, but were lower than the concentrations seen in this species in 2014. Routine bioaccumulation monitoring in the K-720 Slough began in 2009. In all cases PCB concentrations in fish collected from the K-720 Slough were significantly lower than in the K-901-A Holding Pond for the same species. PCB concentrations in largemouth bass collected from the K-720 Slough were significantly lower than in the other monitored ponds, averaging 0.08 μg/g in 2015 (Figure 8.32). Concentrations in carp collected from the Slough were higher than in bass, averaging 0.35 μg/g.

Table 8.4. PCB concentrations (expressed as the sum of Aroclors 1248, 1254, and 1260, in μg/g) in fish from the K-1007-P1 Holding Pond, K-720 Slough, and K-901-A Holding Pond, 2015

Site	Species	Sample type	Sample size (*n*)	Total PCBs (μg/g; mean ± SE)	Range of PCB values	No. >target (PCBs)/*N*
K-1007-P1 Pond	Bluegill	Fillets	20	0.45 ± 0.09	0.13 – 1.76	2/20
		Whole body composites	6	2.03 ± 0.18	1.44 – 2.65	2/6
	Largemouth bass	Fillets	6	5.33 ± 1.30	1.01 – 10.64	6/6
K-901-A Pond	Largemouth bass	Fillets	5	0.66 ± 0.07	0.44 – 0.89	0/5
	Common carp	Fillets	15	1.77 ± 0.24	0.42 – 3.39	10/15
	Gizzard shad	Whole body composites	6	5.41 ± 0.37	4.14 – 6.39	0/6
K-720 Slough	Largemouth bass	Fillets	8	0.08 ± 0.01	0.06 – 0.11	0/8
	Common carp	Fillets	12	0.35 + 0.09	0.06 – 1.19	1/12
	Gizzard shad	Whole body composites	6	0.39 ± 0.04	0.27 – 0.55	0/6

PCB = polychlorinated biphenyl
SE = standard error

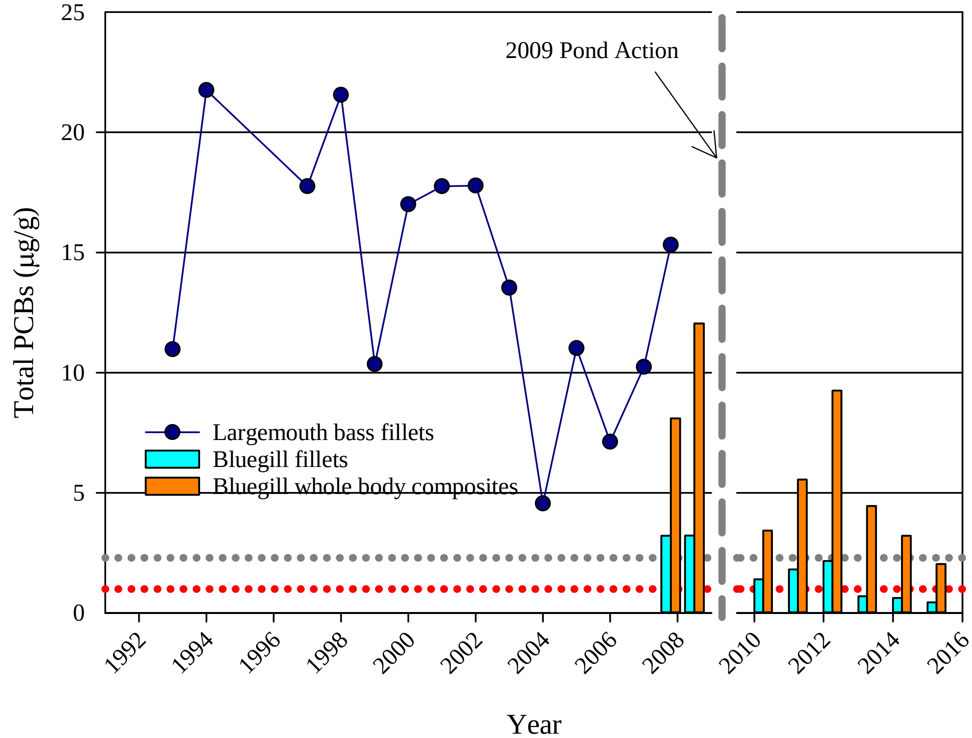

Figure 8.28. Mean concentrations of PCBs in fish from K-1007-P1 Holding Pond, 1993 – 2015.

Dotted red line signifies PCB goal of 1 µg/g in fillets, and dotted gray line signifies PCB goal of 2.3 µg/g whole body.

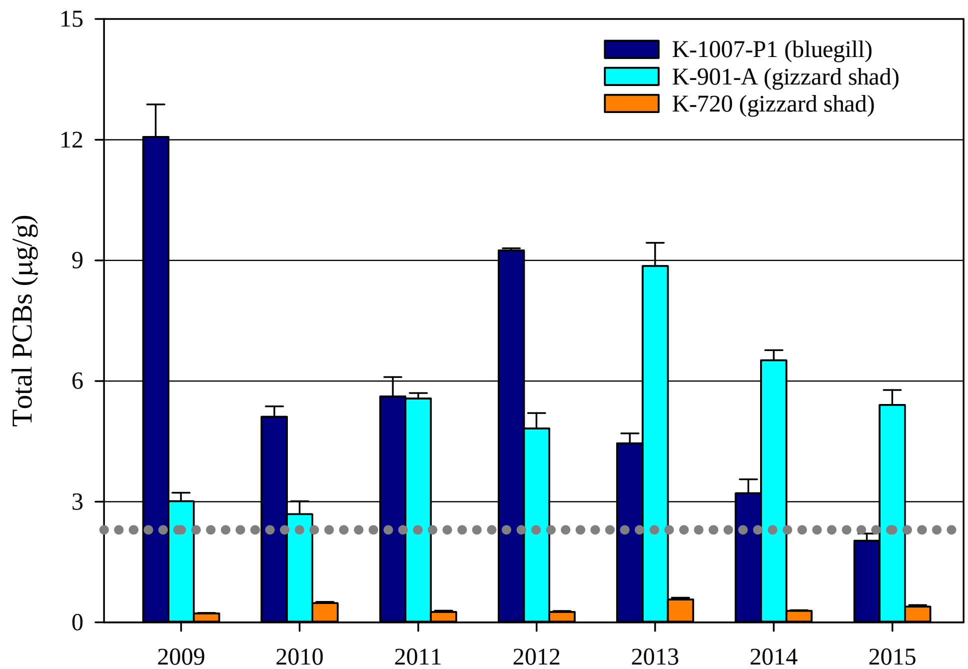

Figure 8.29. Mean concentrations of PCBs in whole body fish from K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough, 2009 – 2015.

Dotted gray line signifies goal of 2.3 µg/g total PCB concentrations in whole body fish collected from ETTP ponds.

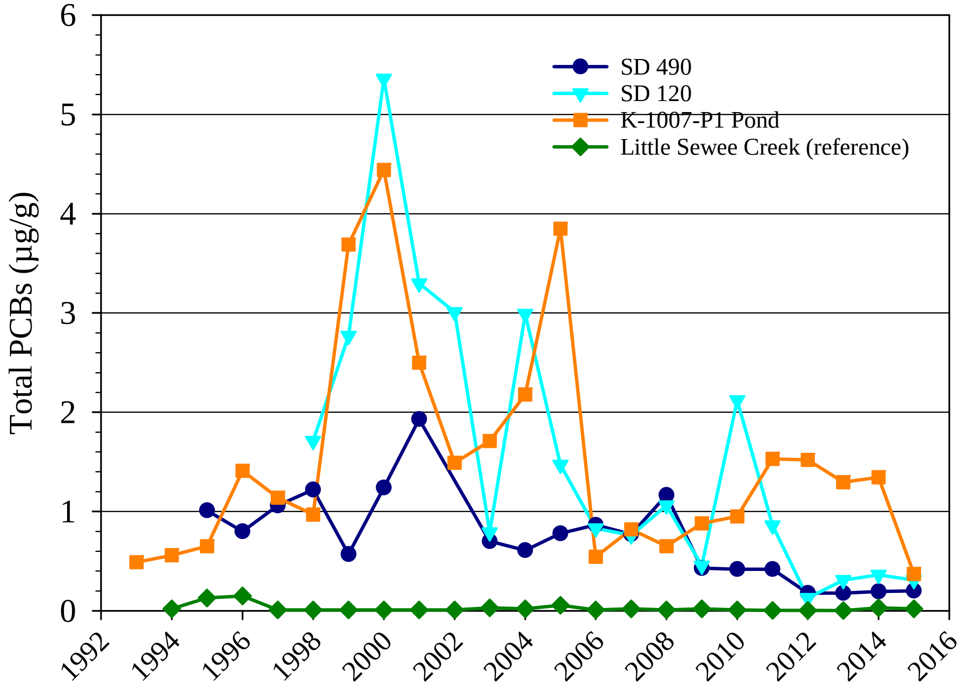

Figure 8.30. Mean total PCB concentrations (µg/g, wet wt; 1993 – 2015) in the soft tissues of caged Asiatic clams deployed in the P1 Pond near the weir and SD-490 and SD-120.

N=2 composites of 10 clams each per year. Shown in green are data for clams collected from the reference site, Little Sewee Creek (Sweetwater, Tennessee). Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.

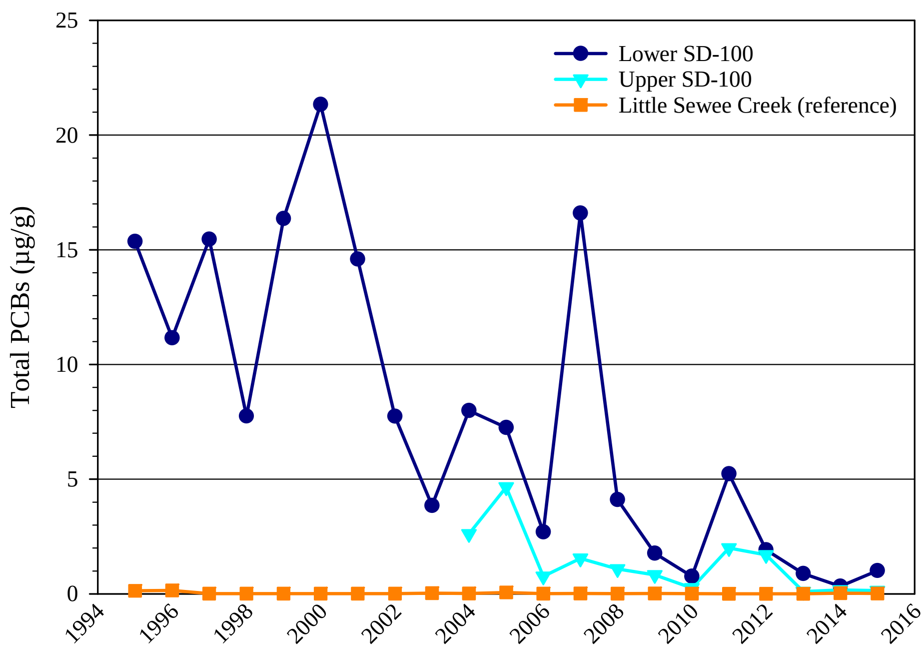

Figure 8.31. Mean total PCB concentrations (µg/g, wet wt; 1995 – 2015) in the soft tissues of caged Asiatic clams deployed at two locations in SD-100: "upper SD-100", upstream of any possible pond related sources, and "lower SD-100" at the culvert entering the pond and potentially influenced by pond sediment sources.

N=2 composites of 10 clams each per year. Shown in orange are data for clams collected from the reference site, Little Sewee Creek (Sweetwater, Tennessee). Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.

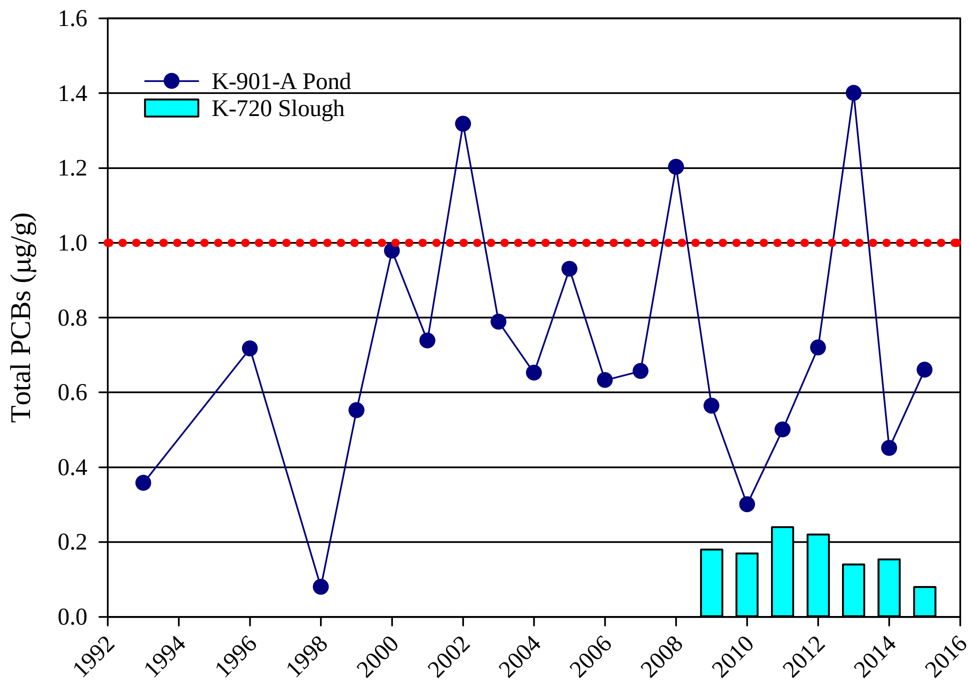

Figure 8.32. Mean concentrations of PCBs in largemouth bass fillets from K-901-A Holding Pond and K-720 Slough, 1993 – 2015.

Dotted red line signifies goal of 1 µg/g total PCB concentrations in fillets of fish collected from ETTP ponds.

8.4.2.3.1 Performance Summary

Performance monitoring at the K-1007-P1 Holding Pond began in 2010. The performance monitoring focus has been on tracking PCB accumulation in bluegill fillets (to assess human health concerns) and bluegill whole bodies (to evaluate ecological risk concerns). In FY 2015, the bluegill sunfish PCB concentrations were lower than the human and ecological risk goals for the pond. Largemouth bass fillets, which were monitored in FY2015 for the first time since the remedial action, did exceed the human health target but were three times lower than pre-action concentrations. In general, plant, wildlife, and water quality sampling have indicated improving trends toward reaching the desired end state, while the fish population has changed dramatically from one year to the next. It will take some time for environmental conditions in the pond to fully stabilize, allowing a better assessment of whether PCB exposure in the pond has sufficiently decreased.

8.4.2.4 Other LTS Requirements

8.4.2.4.1 Requirements

The *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee* (DOE/OR/01-2456&D1/R1) requires signs at K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough to provide notice or warning to prevent unauthorized access by fishermen and specific signs at the K-1007-P1 Holding Pond to provide notice or warning that prohibits mowing in the buffer zone. The RmAR also requires surveillance patrols be established and maintained to control and monitor access by fishermen (Table 8.2).

8.4.2.4.2 Status of Requirements

Activities conducted at the ponds in FY 2015 included inspections by the ETTP S&M Program for visible evidence of storm or flood damage, inspections of the weirs for evidence of debris or vegetation or erosion of the banks, and inspections of the warning signs. Maintenance of the K-1007-P1 weir included removing debris from the weir grate.

8.4.3 K-1070-C/D G-Pit and Concrete Pad

The K-1070-C/D G-Pit is the primary source of organic contaminant releases to soil and groundwater in the area. The K-1071 Concrete Pad, located in the southeastern portion of the K-1070-C/D area, was determined to pose an unacceptable health risk to workers from future exposure to soil radiological contaminants (DOE/OR/02-1486&D4). The location of the area at ETTP is shown in Figures 8.1 and 8.33. Components of the remedy included:

- Excavation of the G-Pit contents, interim storage of the material, treatment, and disposal, and

- Placement of an interim 2 ft soil cover over the Concrete Pad until remediated.

8.4.3.1 Other LTS Requirements

8.4.3.1.1 Requirements

The *Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/02-1486&D4) and *Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park*, *Oak Ridge*, *Tennessee* (DOE/OR/01-1964&D2) require interim LTS activities including maintaining institutional controls (see Table 8.2). An erratum to the K-1070-C/D G-Pit and K-1071 Concrete Pad RAR (DOE/OR/01-1964&D2) approved in May 2015 contains revised frequencies. Specifically, annual inspections of the soil cover over the pad are to be conducted to look for erosion; the grass on the cover is to be mowed as needed, but not less than annually; radiological walkover surveys are to be conducted only if there is activity in the area to confirm the effectiveness of the K-1071 Concrete Pad soil cover in preventing exposure to ionizing radiation; and inspections of the fence are to be performed as needed, but no less than annually. Existing institutional controls will continue to include ensuring the existing EPP program remains in place.

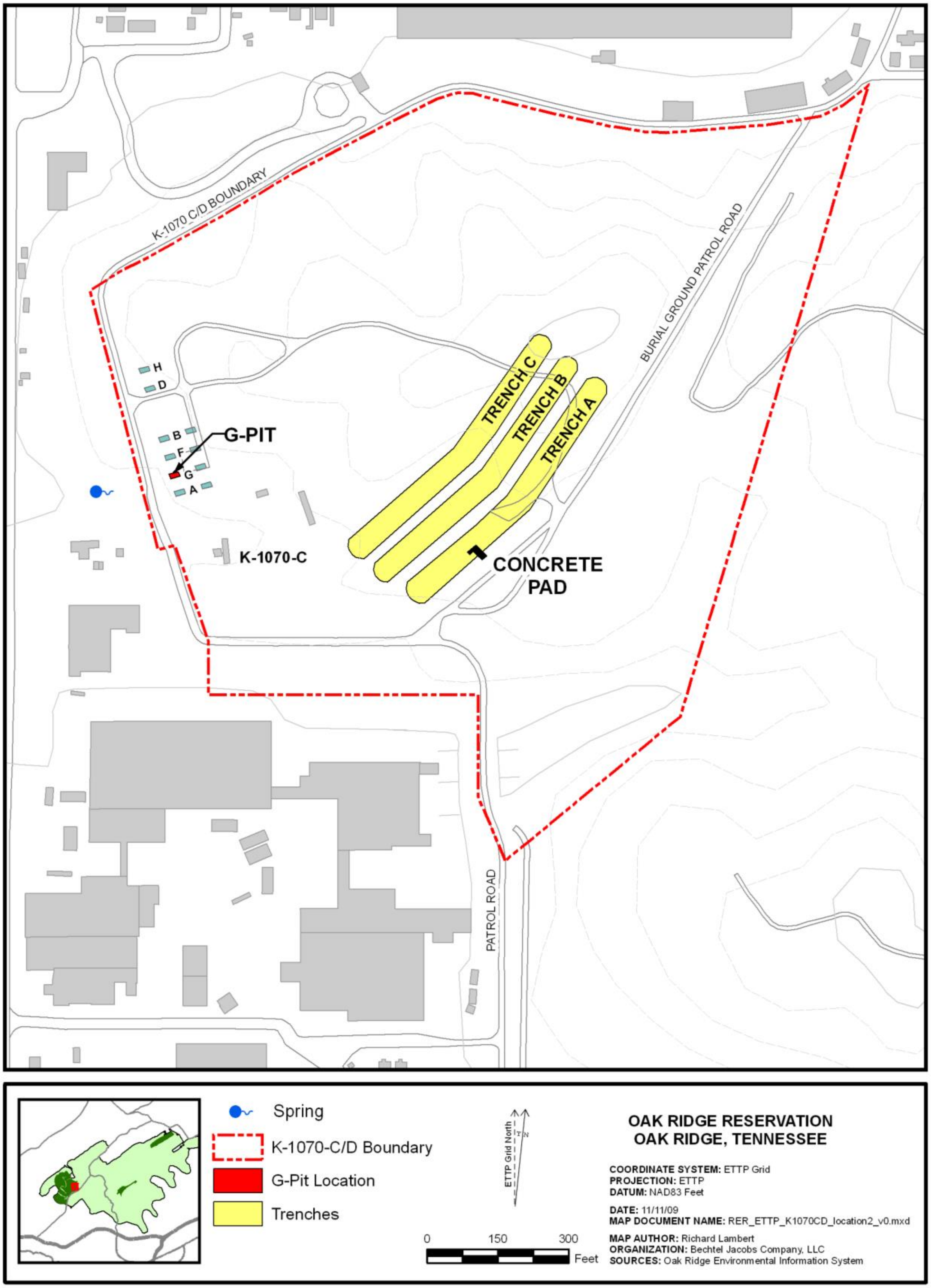

Figure 8.33. Location of K-1070-C/D G-Pit and Concrete Pad.

8.4.3.1.2 Status of Requirements

The site was inspected by the ETTP S&M Program in FY 2015 for items including condition of the warning signs, condition of fencing and locked gate, condition of the K-1071 Concrete Pad soil cover and maintenance of vegetation including the presence of excessive weeds or deep-rooted vegetation, need for grass mowing, or discoloration or withering of vegetation. No maintenance was required.

8.4.4 Mitchell Branch Chromium Reduction

8.4.4.1 Performance Monitoring

8.4.4.1.1 Performance Monitoring Goals and Objectives

During FY 2007, hexavalent chromium was detected in surface water in Mitchell Branch at levels exceeding the applicable AWQC of 11 µg/L. The source of the discharge was determined to be from groundwater infiltration into the Outfall 170 (SD-170 on Figure 8.34) piping as well as seep flows through the outfall headwall. In response to this condition, a time-critical removal action was performed to install and operate groundwater collection pumps to capture chromium-contaminated groundwater associated with the Outfall 170 discharge. The time-critical removal action to address releases of hexavalent chromium into Mitchell Branch was documented in the *Action Memorandum for Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2369&D1). The location of the removal action is noted on Figures 8.1 and 8.34.

Figure 8.34 shows the locations of Mitchell Branch, relevant monitoring locations, the affected SD piping section, and the hexavalent chromium plume. The plume discharge resulted in levels of hexavalent chromium that exceeded state hexavalent chromium water quality chronic criterion of 11 µg/L for the protection of fish and aquatic life. At Mitchell Branch kilometers (MIKs) 0.71 and 0.79, which are locations in Mitchell Branch immediately downstream from the Outfall 170 discharge point, hexavalent chromium levels were measured at levels as high as 780 µg/L. On July 20, 2007, TDEC Division of Water Pollution Control issued a Notice of Violation to DOE for the hexavalent chromium release. Since hexavalent chromium has not been used in process operations at ETTP for over 30 years, the release of hexavalent chromium into Mitchell Branch is a legacy problem and not an ongoing, current operations issue. Therefore, DOE in coordination with EPA and TDEC determined that the appropriate response to this release was a CERCLA time-critical removal action. On November 5, 2007, DOE notified the EPA and TDEC of their intent to conduct a CERCLA time-critical removal action.

Activities associated with the removal action included:

- Located the hexavalent chromium release path to the SD system and into Mitchell Branch.

- Installed a grout wall to impede the release of hexavalent chromium through Outfall 170 headwall seeps into Mitchell Branch.

- Installed two interception wells into the gravel bed that surrounds the Outfall 170 discharge pipes to collect the hexavalent chromium groundwater plume before it infiltrates the Outfall 170 collection system network piping. These wells are labeled as interception well (IW) 416 and IW 417 on Figure 8.34.

- Began operating the two IWs in December 2007. The collected groundwater was initially treated at the CNF. The treatment of the collected groundwater transitioned to the Chromium Water Treatment System (CWTS) in FY 2012.

A *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2384&D1) for the time-critical removal action was issued in July 2008.

For a long-term solution to the release of hexavalent chromium to Mitchell Branch, an *Engineering Evaluation/Cost Analysis for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2422&D1) recommending *ex situ* treatment by chromium reduction was approved in December 2009. The non-time critical *Action Memorandum for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2448&D1) for a long-term solution to the release of hexavalent chromium to Mitchell Branch was approved on March 26, 2010, superseding the time-critical removal action (DOE/OR/01-2369&D1). The *Removal Action Work Plan for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2484&D1) was approved in November 2010.

Construction of the CWTS was initiated in the spring of 2011 with final process installation completed in FY 2012. The treatment unit initiated sustained continuous operations in May 2012. The *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2598&D2) was approved in April 2013.

Monitoring of the removal action was first documented in the *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2598&D2). Monitoring is now included in the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D1), which documents any monitoring changes. The water quality performance monitoring is performed and evaluated by the Environmental Compliance organization, and the data is presented in the Annual Site Environmental Report as well as the annual RER. The Outfall 170 quarterly sampling outfall results are also reported in the NPDES Permit Discharge Monitoring Report. The goals of the removal action are to collect and treat the hexavalent chromium contaminated groundwater to reduce its toxicity prior to discharge and to protect the water quality in Mitchell Branch at levels consistent with the AWQC. The total chromium and hexavalent chromium performance sampling points identified in the *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2598&D2) are:

- Outfall 170 discharge point.
- Mitchell Branch in-stream location (MIK 0.79) that is downstream from Outfall 170. The in-stream location below Outfall 170 provides an opportunity for the discharges to mix with the Mitchell Branch receiving stream, which is considered the appropriate location to compare hexavalent chromium concentrations with the AWQC value of 11 µg/L.
- Collection system that captures the combined flow from IWs 416 and 417.
- Monitoring well TP-289, which is located in the groundwater plume.

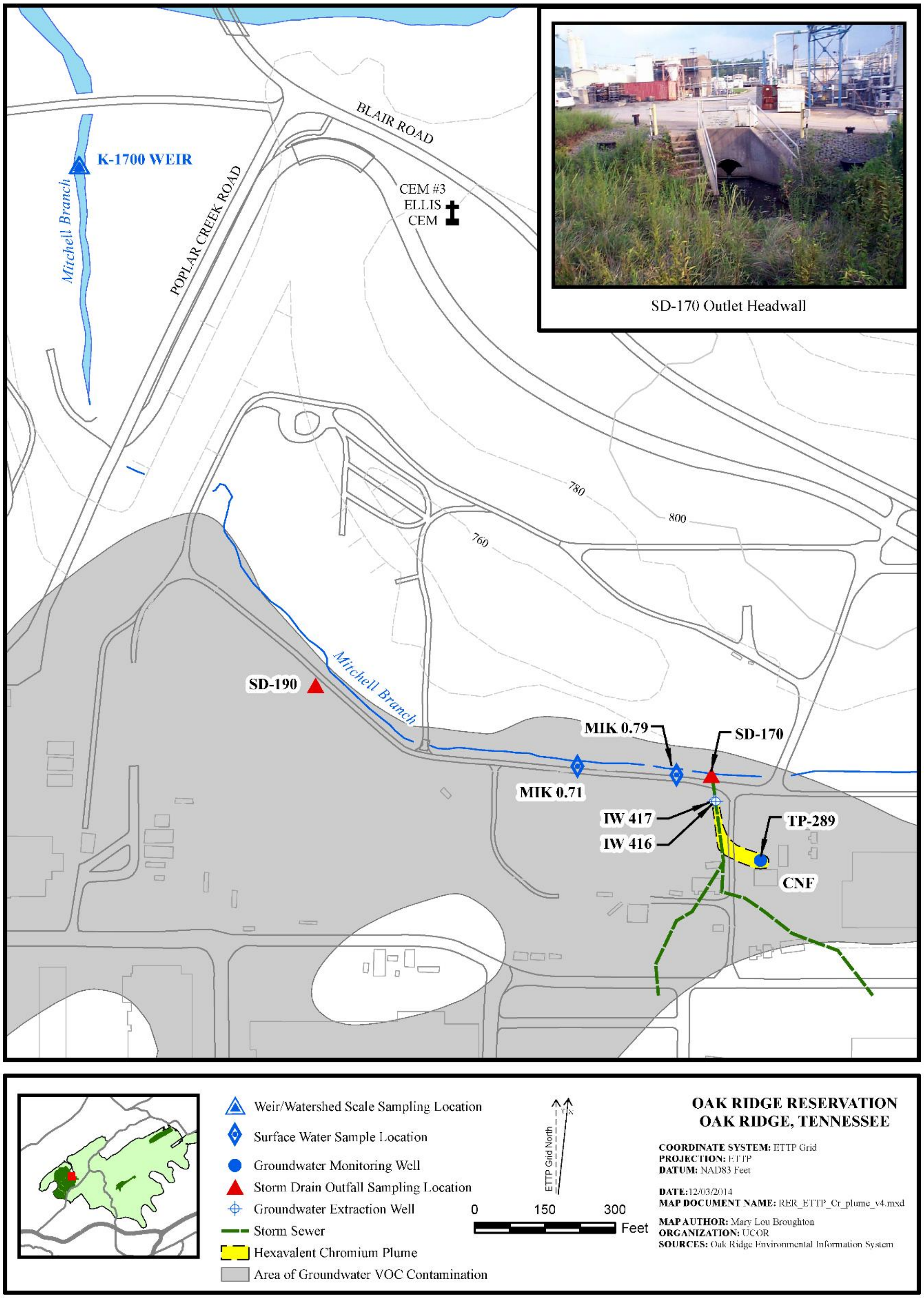

Figure 8.34. Location of hexavalent chromium releases to Mitchell Branch.

8.4.4.1.2 Evaluation of Performance Monitoring Data

The long-term water quality monitoring results for total chromium in Mitchell Branch downstream from Outfall 170 at MIK 0.79 are shown in Figure 8.35. Total chromium results were used for trending purposes instead of hexavalent chromium because there is a lack of historical hexavalent chromium data for all the sampling events, the majority of the total chromium discharged is in the hexavalent chromium form, and the total chromium analysis provides lower detection limits in comparison to hexavalent chromium analysis. During FY 2015, hexavalent chromium comprised almost 100% of the total chromium values as measured at the groundwater plume monitoring well location. The hexavalent chromium AWQC of 11 µg/L is provided in Figure 8.35 for reference and comparison purposes.

The surface water results in Mitchell Branch at MIK 0.79 show that the chromium collection system has been very effective in reducing the levels of chromium from a maximum measured value of 780 µg/L during the summer of 2007 as reflected in the maximum levels on Figure 8.35 to levels that are now consistently well below the hexavalent chromium AWQC value of 11 µg/L during dry and wet weather periods. During FY 2015, the MIK 0.79 in-stream hexavalent chromium results as shown in Table 8.5 were non-detect values at laboratory detection levels of 6 µg/L.

The hexavalent chromium quarterly performance monitoring results for FY 2015 are included in Table 8.5 and are a component of the 2010 – 2015 trend graph for all four monitoring locations as shown in Figure 8.36. Historical sampling and analysis of the chromium in the groundwater plume and in Outfall 170 have established that essentially all of the detected chromium is hexavalent chromium.

The results for hexavalent chromium at Outfall 170 varied from a maximum value of 6 µg/L in October 2014 to non-detect levels in the following three quarters. As previously noted, the hexavalent chromium in-stream sampling results at the MIK 0.79 POC were non-detect values at a detection level of 6 µg/L for all four quarters of 2015. The hexavalent chromium results for the CWTS influent (combined water flows that are collected in IWs 416 and 417) varied from a low of 150 µg/L to a maximum value of 170 µg/L. The hexavalent chromium results at well TP-289 varied from a low of 650 µg/L to a maximum value of 880 µg/L.

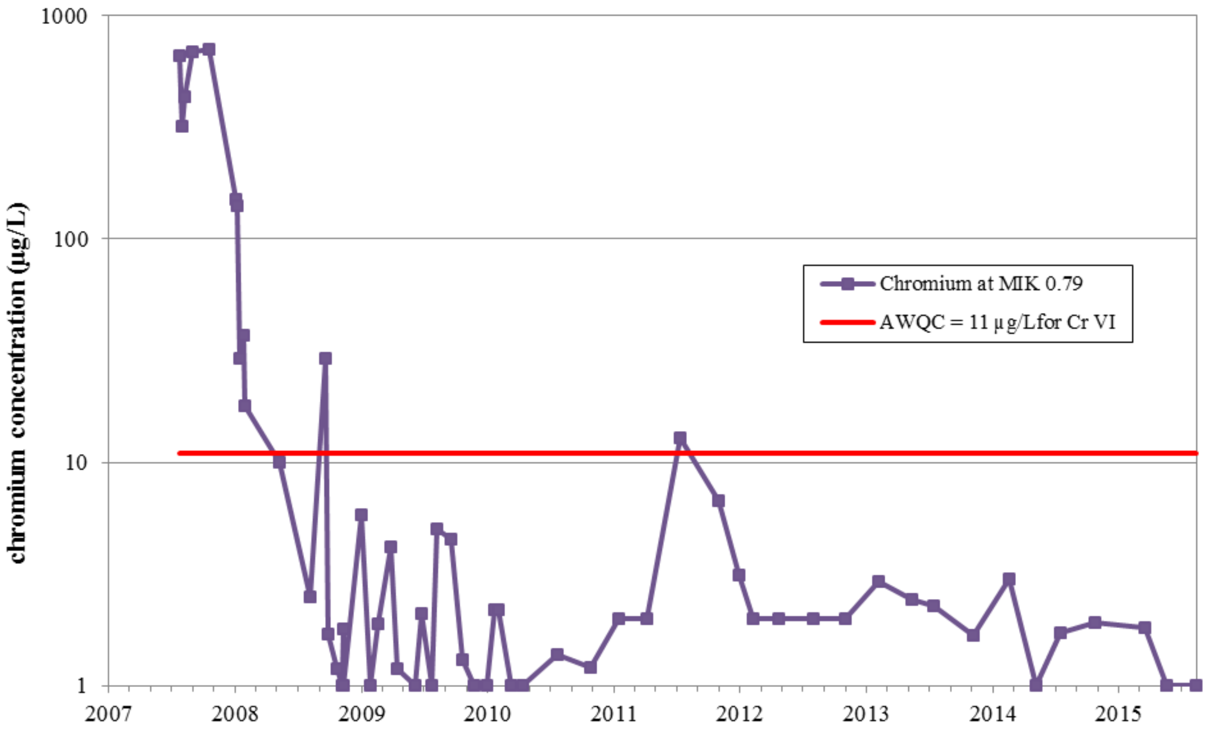

Figure 8.35. Mitchell Branch (MIK 0.79) total chromium concentrations, FY 2007 – 2015.

Table 8.5. FY 2015 performance monitoring results for reduction of hexavalent chromium releases into Mitchell Branch

Sample Date	October 2014	March 2015	May 2015	August 2015
Location Description	**Hexavalent Chromium (µg/L)**	**Hexavalent Chromium (µg/L)**	**Hexavalent Chromium (µg/L)**	**Hexavalent Chromium (µg/L)**
MIK 0.79 downstream from Outfall 170	6 U	6 U	6 U	6 U
Outfall 170	6	6 U	6 U	6 U
CWTS influent (CWTS-INF)	170	160	160	150
Well TP-289	850	650	780	880

CWTS = Chromium Water Treatment System
FY = fiscal year
INF = influent
MIK = Mitchell Branch kilometer
U = indicates non-detection at the analytical detection limit.

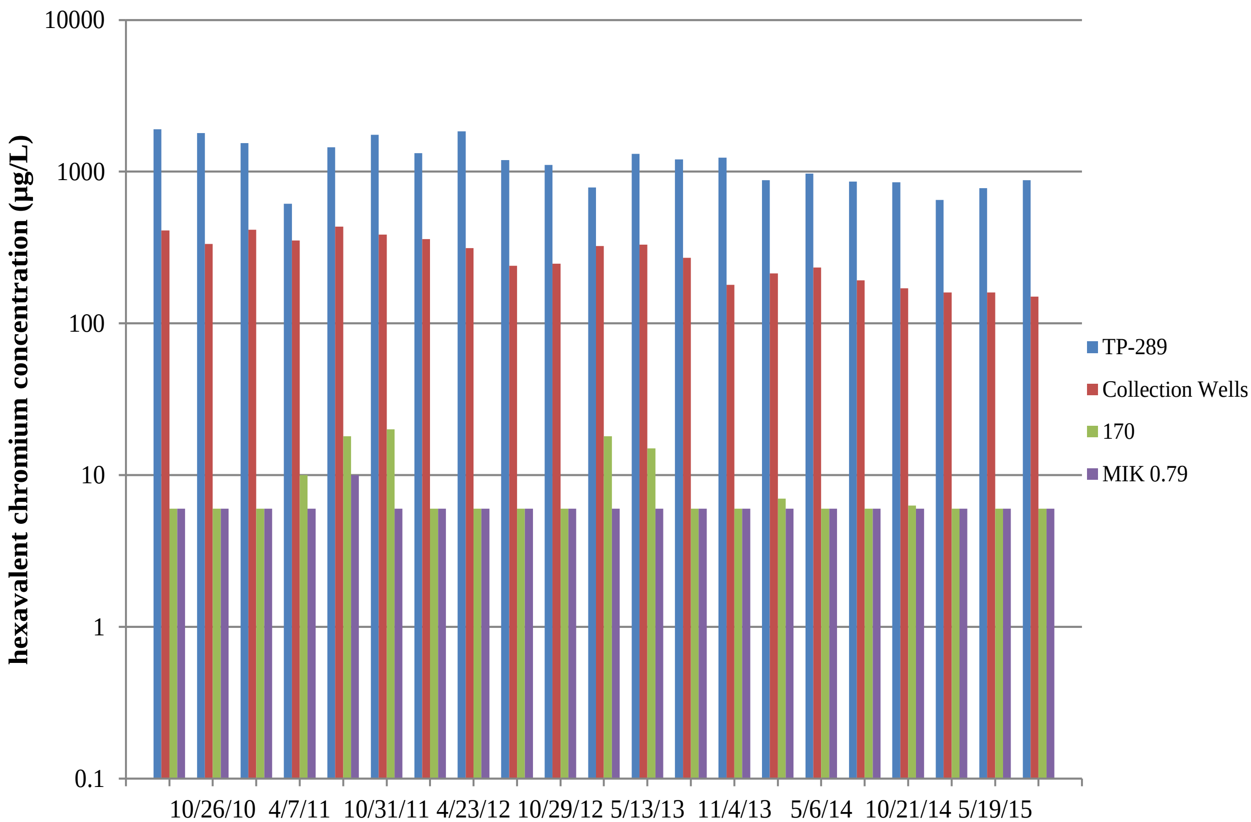

Figure 8.36. Hexavalent chromium performance trends from 2010 – 2015.

8.4.4.1.3 Performance Summary

Water sampling in FY 2015 indicates the removal action continues to be highly effective in achieving the goal to meet AWQC levels of 11 µg/L for hexavalent chromium in Mitchell Branch immediately downstream from the Outfall 170 discharge at the MIK 0.79 POC.

8.4.4.2 Other LTS Requirements

8.4.4.2.1 Requirements

The *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park* (DOE/OR/01-2598&D2) states that the CWTS will be operated and maintained in accordance with contractor procedures. The procedures will describe all components of the system, the operating instructions, alarm response, waste acceptance criteria, and surveillance monitoring. No interim LUCs beyond those already established for ETTP are required.

The primary components of the completed removal action consist of:

- Groundwater extraction wells;
- Grout barrier wall installed in the Outfall 170 gravel bed;
- Reduction of hexavalent chromium to trivalent chromium using steel wool;
- One-Flow Anti-Scaling System;

- Removal of VOCs with an air stripper;
- Discharge to the Clinch River;
- Operations and maintenance;
- Monitoring.

8.4.4.2.2 Status of Requirements

Construction of CWTS was completed in FY 2012 as the facility transitioned to continuous operations in May 2012, as described in the *Removal Action Report for the Long-term Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2598&D2).

During FY 2015, the chromium collection system wells operated during 100% of the days with only short duration periods where collection system pumping volumes were limited due to treatment facility operational constraints. The total volume of wastewater that was treated in FY 2015 was approximately 6 M gal.

An operational challenge for CWTS from the start of the pump and treat operations is associated with high levels of calcium and magnesium in the plume groundwater that creates scale buildup on the facility pumps, valves, and piping. The high levels of calcium and magnesium required changes to earlier CNF water chemistry treatment recipes and in 2009 the initially installed pneumatic pumps were replaced with electric pumps. The electric pumps have provided the capacity for higher pumping rates while also providing more consistent performance by reducing maintenance requirements. CWTS operational changes were implemented to help address the scale buildup issues by installing the One-Flow Anti-Scaling System upstream of the air stripper in February 2013. The additional equipment in the treatment train seemed to reduce the rate of the scale buildup, but repairs for the air stripper and day tank pumps were still required during the past year.

Pump scale buildup was the cause of a treatment system bypass that occurred in early October 2014 for a period of approximately 48 hr. The volume of plume water that bypassed treatment for a direct discharge into the Clinch River was approximately 22,000 gal. As described in the *Removal Action Report for the Long-term Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE/OR/01-2598&D2), notifications were provided to the CERCLA regulatory project teams for a bypass that exceeds four hours in duration. The notification provided information on the cause of the event, volume of water bypassed, the most recent quarterly sampling results, and the point when the treatment unit pumps were repaired. Facility modifications are being evaluated to determine if cost effective changes could be implemented to decrease the water scaling pump and valve maintenance issues.

To continue to address the system scaling issues, a process improvement initiative was approved and initiated at the CWTS facility in FY 2015. The process improvement actions include the following:

Electrocoagulation Unit Removal:

- Because of problems with mineral scaling, the Electrocoagulation Unit (ECU) Removal was no longer used as a functional piece of equipment in CWTS. The removal of the excess ECU equipment has provided more operational room at the facility for routine maintenance and will provide additional flexibility for future treatment system adjustments as needed.

Phosphate Injection System:

- To further reduce scaling buildup, a phosphate injection system has been installed through a calibrated feed pump. This pump will inject 1 – 5 ppm of phosphates, which will interfere with the crystallization of the minerals in the groundwater as it flows through the system.

Dual Bag Steel Wool Reaction Module:

- The steel wool used in the reduction of hexavalent chromium was previously loaded in trays within the air stripper, a piece of equipment that also helps to eliminate VOCs from the water. The steel wool change outs in this air stripper unit required numerous maintenance steps including electrical lockout/tagout actions. To reduce the maintenance steps and to also increase the contact time between the steel wool and contaminated groundwater, a second set of dual bag filters filled with steel wool has been added to the treatment process in a location before the water reaches the air stripper.

Summary:

- The process improvement actions to install the Phosphate Injection System and the Dual Bag Steel Wool Reaction Module were completed in FY 2015. These systems are fully operational and have resulted in reduced scaling in the CWTS pumps and piping.

8.5 DEMOLITION PROJECTS

8.5.1 LTS Requirements

The scope of demolition projects is the demolition of above-grade structures to slab or to grade. The scope of remediation of the slabs, subsurface structures, and underlying soils is addressed under the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) and the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2).

Interim LTS requirements for slabs following building demolition were the subject of two issues identified in Table 8.14 that have been resolved. The ETTP D&D and RA Project Teams have reached agreement on the management of potentially contaminated slabs, and the process to manage potentially contaminated slabs is contained in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4).

8.5.2 CNF

The CNF was a batch wastewater treatment facility for mixed waste, low-level radioactive waste, RCRA waste, and industrial wastewater. The treatment process included pH adjustment, chemical precipitation, filtration, sludge dewatering, air stripping, and carbon absorption. The facility operated under a permit-by-rule for the treatment of mixed radioactive and hazardous waste. The CNF PCCR (DOE/OR/01-2619&D2) documents the completion of the CNF decommissioning activities to remove all RCRA hazardous waste from the facility and verifies all components of the facility were decontaminated to RCRA clean-closure performance standards. In addition, the PCCR identifies provisional controls, e.g., postings, which were identified using a combination of process knowledge and radiological surveys. Interim LTS requirements, e.g., annual surveys and inspections, were established subsequent to

decommissioning and the final radiological survey of the facility to protect human health and the environment from physical hazards and residual contamination. The provisional controls and LTS requirements are summarized in Table 8.2.

CNF facilities posted and controlled as *Fixed Contamination Areas* include K-1407-H (neutralization tanks F-240-A and F-240-B, and the Sludge Thickener) and K-1407-J (settling basins F-261 and F-262 and dike). Facilities posted and controlled as *Contamination Areas* include Building K-1407-X (annex) and Building K-1419 (centrifuge area). Both the above- and below-grade process piping and the overhead transfer lines of Building K-1419 are posted *Caution Internal Contamination*. The breezeway between office trailers K-1310-BB and K-1310-BC is posted as a *Radioactive Material Area* for storage.

While waiting for demolition and remediation of CNF, provisional LTS activities include the annual inspection of encapsulation of the K-1407-H sludge thickener and K-1407-J settling basins F-261 and F-262, the annual inspection of the steel cover over the K-1407-X annex, and an annual inspection of postings throughout the CNF. In addition, a gross alpha and gross beta survey is conducted annually at CNF facilities K-1310-BB, K-1310-BC, K-1407-H, K-1407-J, and K-1419.

A water sample will be collected at SD-170 once per NPDES reporting period and at Mitchell Branch K-1700 weir annually to identify releases. The sample will be analyzed for gross alpha, gross beta, isotopic uranium, and ^{99}Tc.

The monitoring, survey, and inspection requirements were not approved until FY 2016. However, the annual radiological surveys were performed.

8.6 OTHER WATERSHED MONITORING

This section provides a summary of ETTP sitewide groundwater, surface water, and aquatic biology monitoring.

8.6.1 Groundwater Plumes

Extensive groundwater monitoring at the ETTP site, using SDWA MCLs as groundwater screening values, has identified VOCs as the most significant groundwater contaminant on site. The principal chlorinated hydrocarbon chemicals that were used at ETTP were PCE, TCE, and 1,1,1-TCA.

Figure 8.37 shows the distribution and generalized concentrations of the sum of the primary chlorinated hydrocarbon chemicals and their transformation products, respectively, at ETTP. Specific compounds included in the summation of chlorinated VOCs include chloroethenes (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCA, and VC), chloroethanes (1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,1-DCA, and chloroethane), and chloromethanes (carbon tetrachloride, chloroform, and methylene chloride). Several plume source areas are identified within the regions of the highest VOC concentrations. In these areas, the primary chlorinated hydrocarbons have been present for decades and mature contaminant plumes have evolved. The degree of transformation, or degradation, of the primary chlorinated hydrocarbon compounds is highly variable across the site. In the vicinity of the K-1070-C/D source (Section 8.4.3), a high degree of degradation has occurred, although a strong source of contamination still remains in the vicinity of the “G-Pit,” where approximately 9,000 gal of chlorinated hydrocarbon liquids were disposed in an unlined pit. Other areas where transformation is significant include the K-1401 Acid Line leak site, and the K-1407-B Pond area (Section 8.4.1). Transformation processes are weak or inconsistent at the K-1004 and K-1200 area, K-1035, K-1413, and K-1070-A Burial Ground, and little transformation of TCE is observed in the K-27/K-29 source and plume area.

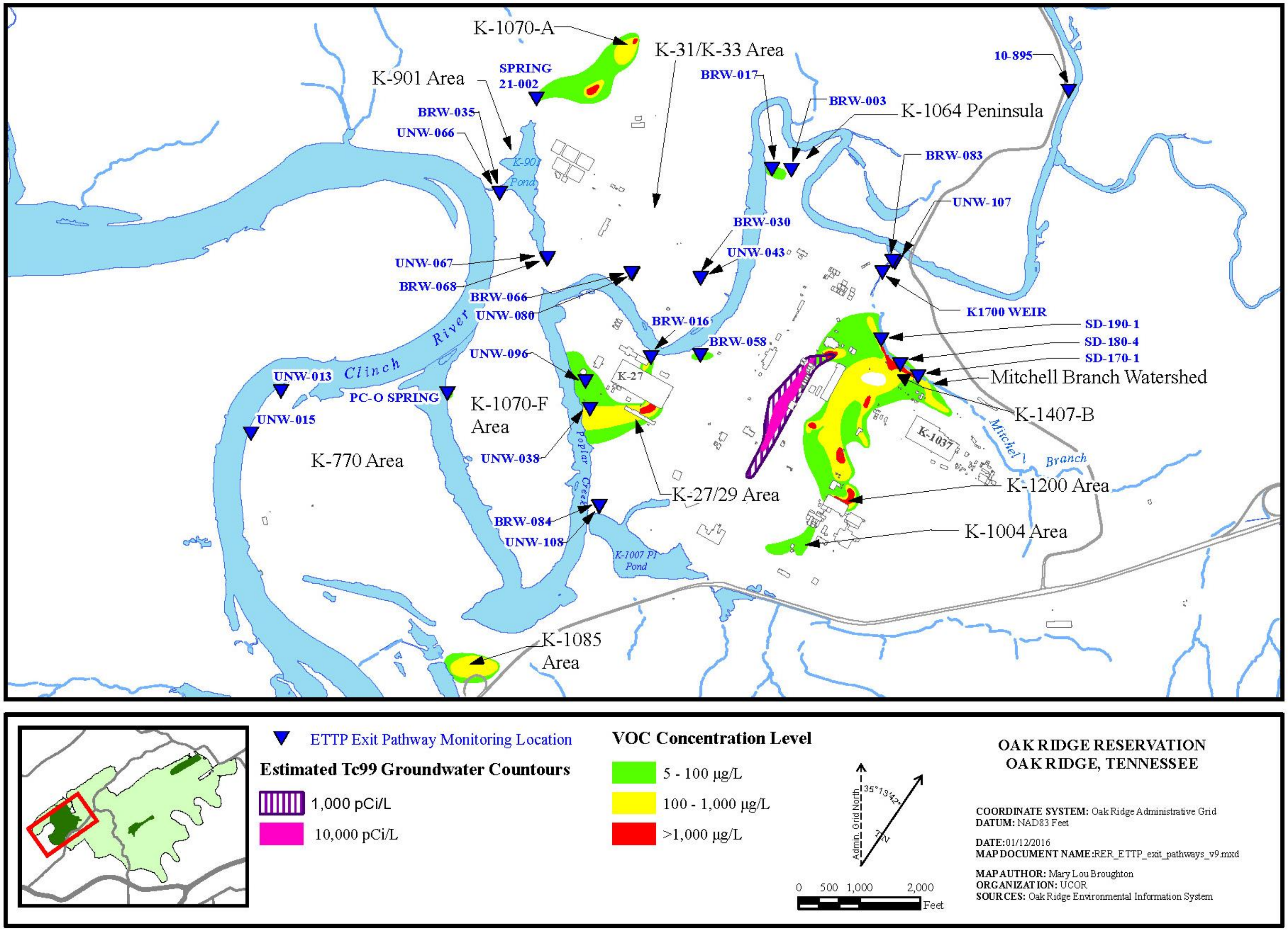

Figure 8.37. ETTP exit pathways monitoring locations.

8.6.2 Groundwater Exit Pathways

Groundwater exit pathway monitoring sites are shown in Figure 8.37. Groundwater monitoring results for the exit pathways are discussed below:

Mitchell Branch – The Mitchell Branch groundwater exit pathway is monitored using surface water data from the K-1700 Weir on Mitchell Branch and wells BRW-083 and UNW-107. Section 8.6.4 includes discussion of the detected concentrations of VOCs in Mitchell Branch.

Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch, have been monitored since 1994. Table 8.6 shows the history and concentrations of detected VOCs in groundwater. Detection of VOCs in groundwater near the mouth of Mitchell Branch is considered an indication of the migration of the Mitchell Branch VOC plume complex. The intermittent detection of VOCs in this exit pathway is thought to be a reflection of variations in groundwater flowpaths that can fluctuate with seasonal hydraulic head conditions which are strongly affected by rainfall. During FY 2015, no chlorinated VOCs were detected in BRW-083 and TCE was detected at an estimated concentration of 0.53 J µg/L in the August sample from UNW-107.

K-1064 Peninsula area – Wells BRW-003 and BRW-017 monitor groundwater at the K-1064 Peninsula burn area. Figure 8.38 shows the history of VOC concentrations in groundwater from FY 1994 through FY 2015. TCE concentrations have declined in both wells over that period of time. TCE was present at concentrations less than the MCL during FY 2015 at well BRW-017 and was detected at an estimated concentration of 0.66 J µg/L in the August sample from well BRW-003. In the August 2015 sample from well BRW-003, 1,1,1-TCA was detected at an estimated concentration of 0.47 J µg/L following several years of non-detect results at the 1 µg/L detection limit. Cis-1,2-DCE was detected at concentrations much less than its MCL in both semiannual samples in well BRW-017.

K-31/K-33 area – Groundwater is monitored in four wells (BRW-066, BRW-030, UNW-080, and UNW-043) that lie between the K-31/K-33 area and Poplar Creek. VOCs are not COCs in this area; however, leaks of recirculated cooling water in the past have left residual subsurface chromium contamination. Figure 8.39 shows the history of chromium detection in wells at K-31/K-33. Well UNW-043 exhibits the highest residual chromium concentrations of any in the area. Chromium concentrations in well UNW-043 correlate with the turbidity of samples, and acidification of unfiltered samples that contain suspended solids often causes detection of high metals content because the addition of acid preservative releases metals that are adsorbed to the solid particles at the normal groundwater pH. During FY 2006, an investigation was conducted to determine if groundwater in the vicinity of the K-31/K-33 buildings contained residual hexavalent chromium from recirculated cooling water leaks. The data indicated the chromium in groundwater near the leak sites was essentially all the less toxic trivalent species. During FY 2008 through FY 2015, field-filtered (i.e., dissolved) and unfiltered samples were collected from UNW-043. Chromium concentrations in the field-filtered samples are consistently much less than the MCL and during FY 2015 the chromium concentration in filtered aliquots was less than the 0.011 mg/L AWQC level for hexavalent chromium. During FY 2015, both field-filtered and unfiltered samples were collected from wells BRW-066, UNW-030 and UNW-080. Chromium was non-detect in all samples from well BRW-066 during FY 2015.

K-27/K-29 area – Several exit pathway wells are monitored in the K-27/K-29 area, as shown on Figure 8.37. Figure 8.40 provides concentrations of detected VOCs in wells both north and south of K-27 and K-29 through FY 2015. The source of VOC contamination in well BRW-058 is not suspected to be from K-27/K-29 area operations but is more likely associated with groundwater contamination that originates in the K-25 area. At well BRW-058, VC continues to slightly exceed the MCL while cis-1,2-

DCE remains at concentrations slightly lower than the MCL. The VOC concentrations in well BRW-016 appear to be gradually decreasing and do not exceed MCLs. TCE levels in well UNW-038 fluctuate between 10 to 20 times the MCL and appear to be in a nearly stable fluctuation range since about 2011 with higher concentrations during the wet season and lower concentrations during the dry season. At BRW-016, cis-1,2-DCE levels show a decreasing trend and VC has decreased to <1 μg/L which is less than the MCL.

Table 8.6. VOCs detected in groundwater in the Mitchell Branch Exit Pathway

Well	Date	cis-1,2-DCE	PCE	TCE	VC
BRW-083	8/29/2002	ND	**5**	**28**	ND
	3/16/2004	0.69	2.2	**9.9**	ND
	8/26/2004	2	4.7	**20**	ND
	3/14/2007	5	**9**	**28**	ND
	3/20/2008	ND	ND	ND	ND
	8/21/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	1.31 J	ND
	8/3/2009	ND	2.66	**14.2**	ND
	3/3/2010	ND	ND	ND	ND
	8/30/2010	3.6	**5.1**	**18**	ND
	3/15/2011	2.8	**6.7**	**22**	ND
	8/10/2011	ND	ND	ND	ND
	3/1/2012	ND	ND	ND	ND
	8/16/2012	ND	ND	ND	ND
	8/6/2013	ND	ND	ND	ND
	3/13/2013	ND	ND	ND	ND
	3/13/2014	ND	ND	ND	ND
	8/7/2014	ND	ND	ND	ND
	3/30/2015	ND	ND	ND	ND
	8/20/2015	ND	ND	ND	ND
UNW-107	8/3/1998	ND	ND	3	ND
	8/26/2004	4.7	ND	3.6	ND
	8/21/2006	3.4	**14**	2	1.2
	3/13/2007	25	2 J	**23**	2[a]
	8/21/2007	17	ND	**30**	0.3 J
	3/5/2008	ND	ND	ND	ND
	8/18/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	ND	ND
	7/30/2009	ND	ND	ND	ND
	3/4/2010	ND	ND	ND	ND
	7/28/2010	ND	ND	ND	ND
	3/16/2011	ND	ND	ND	ND
	8/11/2011	ND	ND	ND	ND
	3/20/2012	ND	ND	ND	ND

Table 8.6. VOCs detected in groundwater in the Mitchell Branch Exit Pathway (cont.)

Well	Date	cis-1,2-DCE	PCE	TCE	VC
	9/12/2012	ND	ND	ND	ND
	8/8/2013	ND	ND	ND	ND
	3/20/2013	ND	ND	ND	ND
	3/18/2014	ND	ND	ND	ND
	8/20/2014	ND	ND	ND	ND
	3/16/2015	ND	ND	ND	ND
	8/25/2015	ND	ND	0.53 J	ND

[a]Detection occurred in a field replicate. Constituent not detected in regular sample.

Bold table entries exceed SDWA MCL screening values (PCE, TCE = 5 µg/L, cis-1,2-DCE = 70 µg/L, VC = 2 µg/L)
All concentrations µg/L.

DCE = dichloroethene
J = estimated value
MCL = maximum contaminant level
ND = Not Detected
PCE = tetrachloroethene
SDWA = Safe Drinking Water Act
TCE = trichloroethene
VC = vinyl chloride
VOC = volatile organic compound

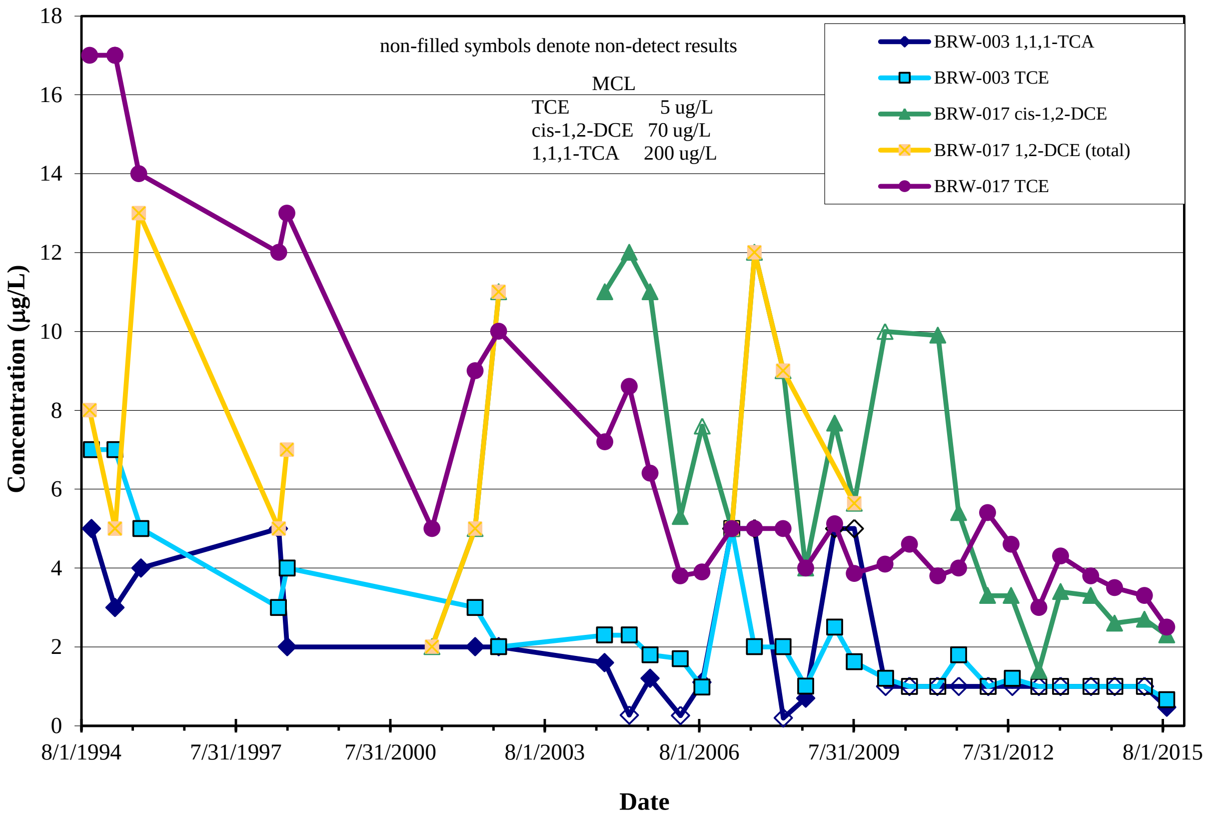

Figure 8.38. VOC concentrations in groundwater at K-1064 Peninsula area.

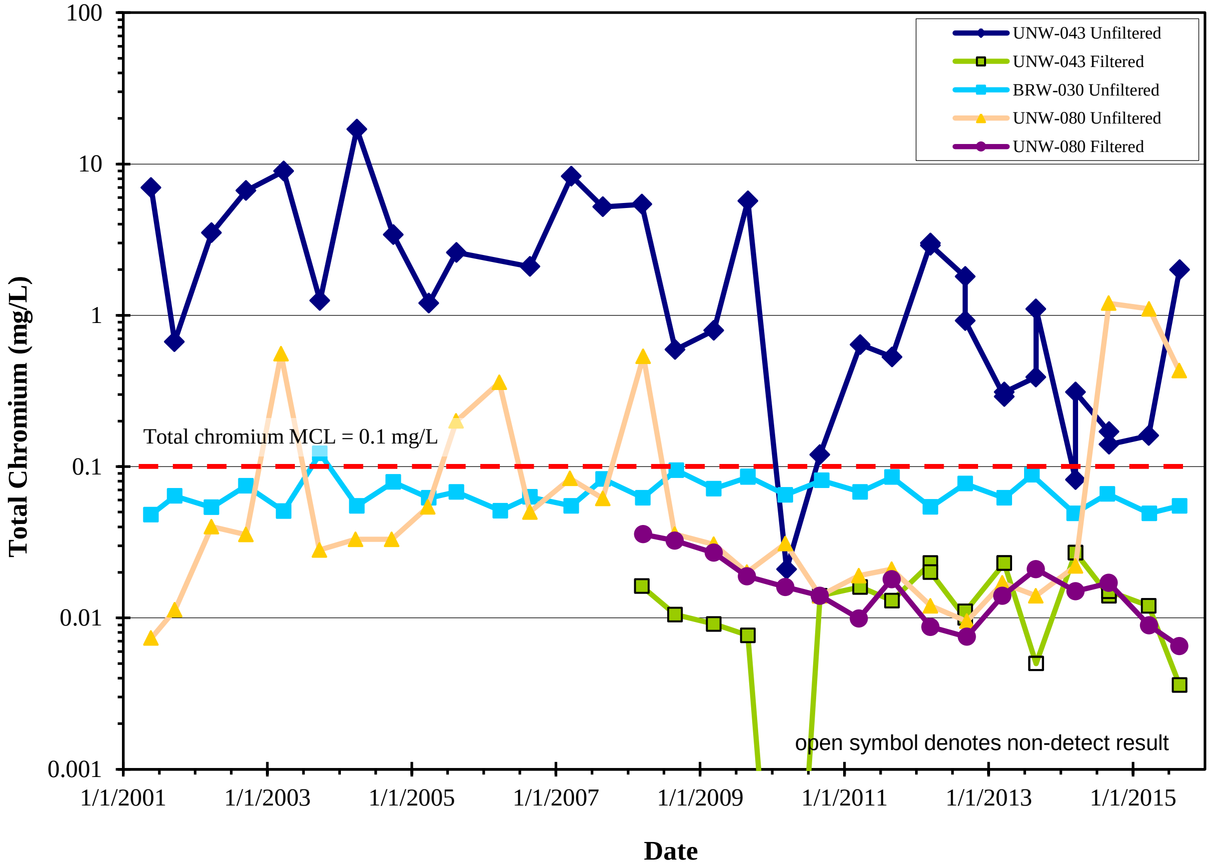

Figure 8.39. Chromium concentrations in groundwater in the K-31/K-33 area.

K-1007-P1 Holding Pond area – Wells BRW-084 and UNW-108 are exit pathway monitoring locations at the northern edge of the K-1007-P1 Holding Pond (Figure 8.37). These wells were monitored intermittently from 1994 through 1998 and semiannually from FY 2001 through FY 2015. The first detections of VOCs in these wells occurred during FY 2006 with detection of low (approximately 10 µg/L or less) concentrations of TCE and cis-1,2-DCE. The source area for these VOCs is not known. During FY 2015 TCE was detected at 7 µg/L and cis-1,2-DCE was detected at 0.83 J µg/L in the August sample from well BRW-084. No VOCs were detected in either sample from well UNW-108. Metals have been detected in the past associated with the presence of turbidity in the samples. Very low concentrations of antimony (0.31 J µg/L in well UNW-108 in March) and selenium (0.46 J µg/L in BRW-084 in March and 0.52 J µg/L in well UNW-108 in September) were detected on filtered samples. Potential sources of these metals in this area are unknown and the detected concentrations are far below any criterion level.

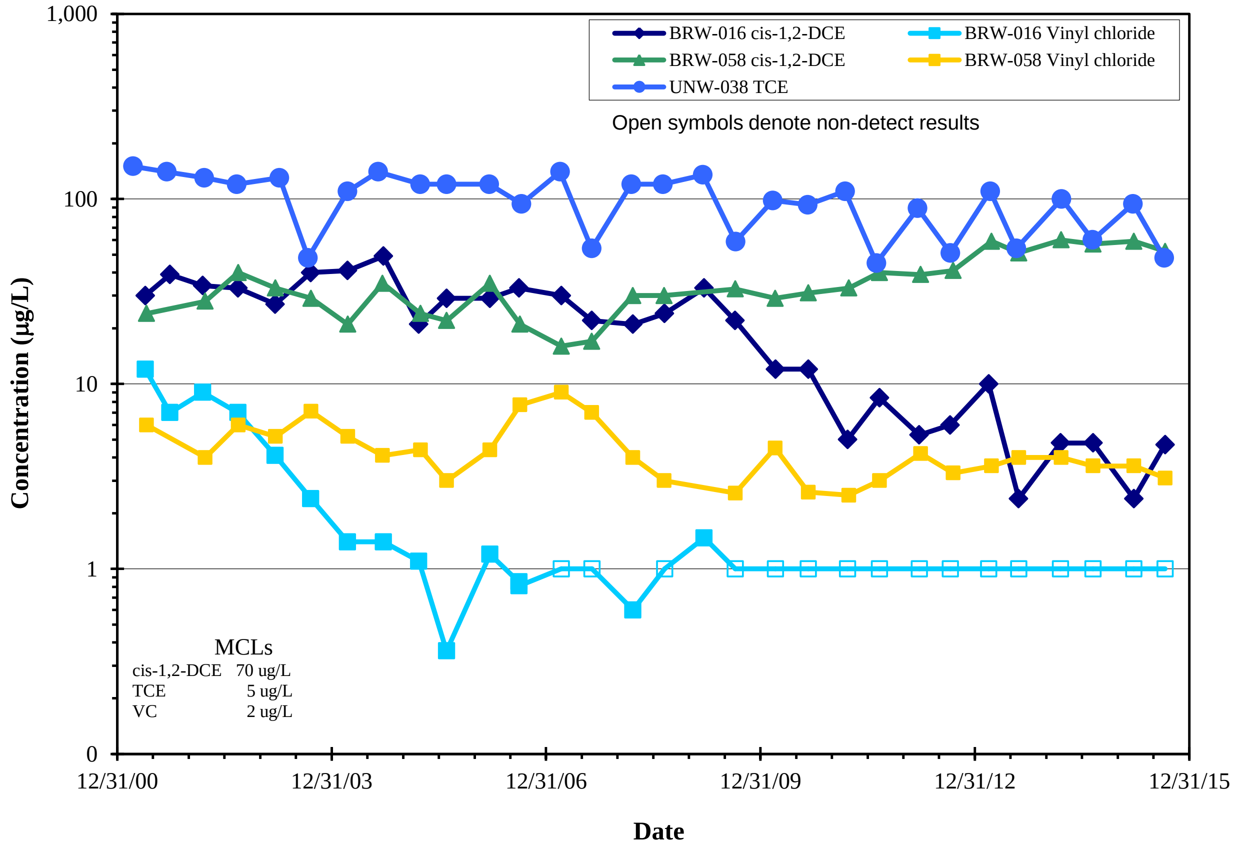

Figure 8.40. Detected VOC concentrations in groundwater exit pathway wells near K-27 and K-29.

K-901-A Holding Pond area – Exit pathway groundwater in the K-901-A Holding Pond area (Figure 8.37) is monitored by four wells (BRW-035, BRW-068, UNW-066, and UNW-067) and two springs (21-002 and PC-0). Very low concentrations (<5 µg/L) of VOCs are occasionally detected in wells adjacent to the K-901-A Holding Pond. However, these contaminants are not persistent in groundwater west and south of the pond. The only VOC detected in the K-901-A Holding Pond exit pathway wells during FY 2015 was cis-1,2-DCE at 0.38 J µg/L in both the March and August samples from well BRW-035. Alpha activity was detected at 28.2 and 68.7 pCi/L in well UNW-066 in the March and August samples, respectively, and at 52.8 pCi/L in the August sample from well UNW-068. Beta activity was detected at 84.1 pCi/L and 81.5 pCi/L in the August samples from well UNW-066 and UNW-067. Based on the increases in detected alpha and beta activity, additional radiological analyses will be conducted in these wells during FY 2016.

TCE is the most significant groundwater contaminant detected in the springs, and the historic TCE concentrations are shown in Figure 8.41. Spring PC-0 was added to the sampling program in 2004. During April through October each year, spring PC-0 is submerged beneath the Watts Bar lake level. In late winter 2012 DOE installed a sampling pump in the spring mouth to allow year-round sampling. The contaminant source for the PC-0 spring is presumed to be disposed waste at the former Construction Spoil Area (K-1070-F) located on Duct Island. The TCE concentrations in PC-0 spring have varied between non-detectable levels and 26 µg/L and have decreased from their highest measured value in 2006 to concentrations less than or several times the drinking water standard. During FY 2015, cis-1,2-DCE was detected at and below about 1 µg/L in PC-0 samples collected in March and June.

Although TCE is the principal contaminant detected at spring 21-002, 1,1-DCE, and carbon tetrachloride, were present at concentrations less than 2 and 3.2 µg/L, respectively. The TCE concentration at spring 21-002 tends to vary between less than 5 and 25 µg/L and this variation appears to be related to variability in rainfall which affects groundwater discharge from the K-1070-A VOC plume. During FY 2015, TCE was detected at its MCL in a January sample and at slightly over three times the MCL in June. Alpha activity was detected at 1.14 pCi/L in the June sample and the highest detected beta activity was 6.45 pCi/L measured in the June sample. Technetium-99 was detected in the sample collected during June 2015, at a measured activity of 8.65 pCi/L, which is much lower than the 900 pCi/L MCL-DC. Uranium-234, ^{235}U, and ^{238}U were detected at less than 1 pCi/L.

TCE concentrations measured in samples from spring 10-895 which is located along Poplar Creek by Blair Road are also shown on Figure 8.41. This spring was added to the ETTP monitoring program during FY 2015. The highest TCE concentration measured was 5.8 µg/L. Carbon tetrachloride was detected at 0.32 J µg/L in the June sample.

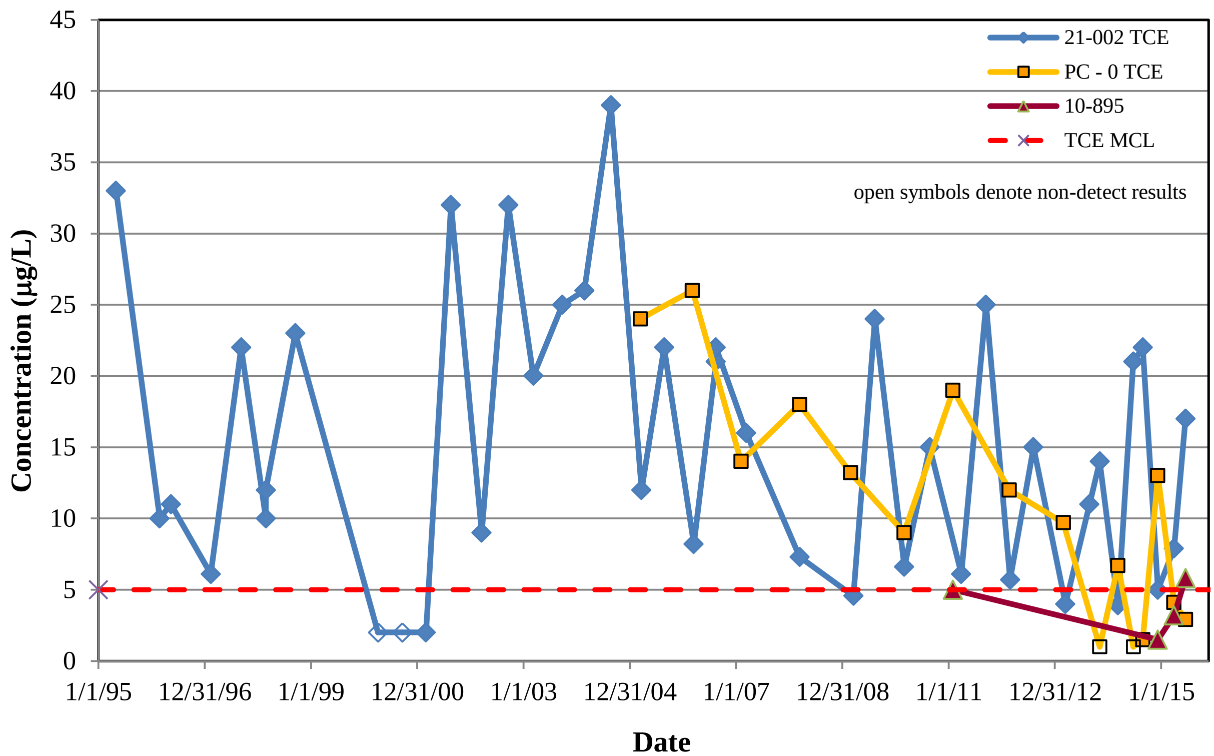

Figure 8.41. TCE concentrations in selected ETTP K-901 area springs.

K-770 area – Exit pathway groundwater monitoring is also conducted at the K-770 area, where wells UNW-013 and UNW-015 are used to assess radiological groundwater contamination along the Clinch River (Figure 8.37). Measured alpha and beta activity levels were below screening levels during FY 2015. Figure 8.42 shows the history of measured alpha and beta activity in this area. Historic analytical results indicate that the alpha activity is largely attributable to uranium isotopes, and well UNW-013 historically contained ^{99}Tc that is a strong beta-emitting radionuclide responsible for the elevated beta activity in that well. Much lower alpha and beta activity levels have been measured in well UNW-015 since sampling was resumed in FY 2013 following an interruption in sampling during site remediation activities.

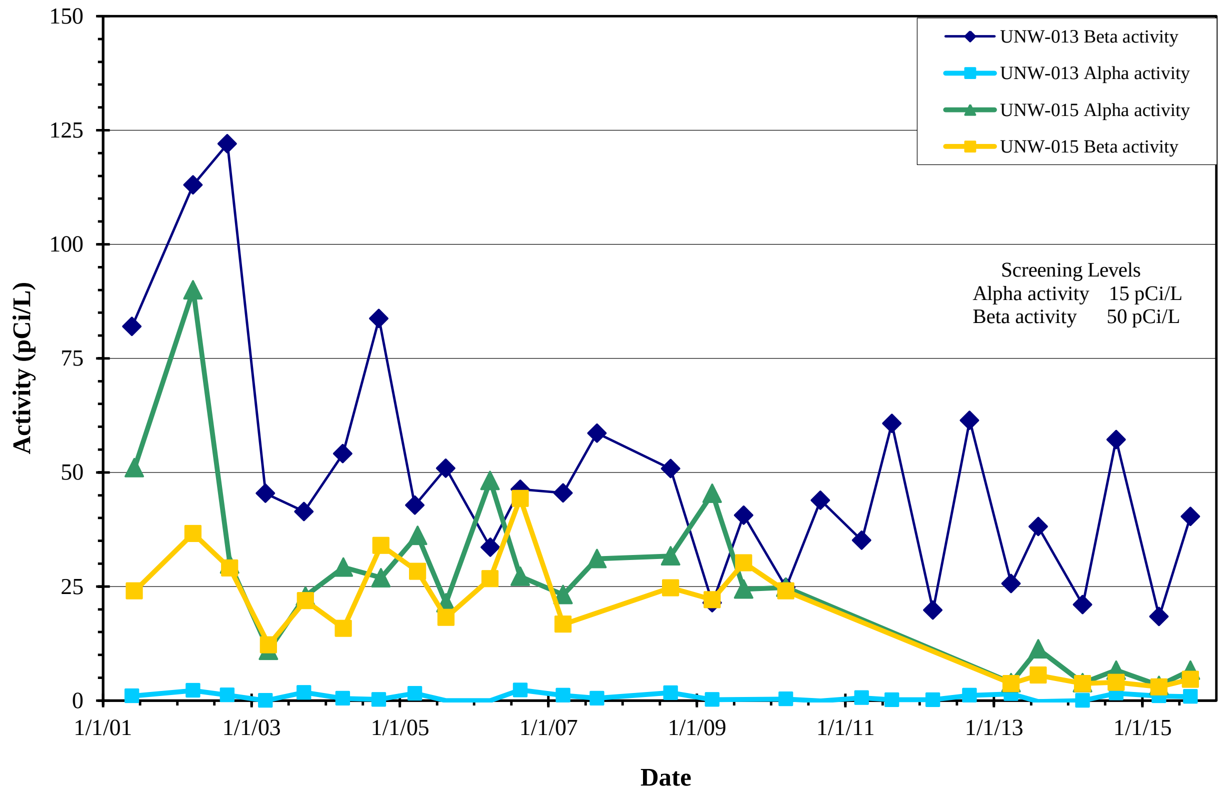

Figure 8.42. History of measured alpha and beta activity in the K-770 area.

8.6.3 Technetium-99 in ETTP Site Groundwater

Technetium-99 is a beta particle-emitting radionuclide. There is not a specific drinking water MCL for ^{99}Tc but its MCL-DC concentration is 900 pCi/L. Technetium-99 has been a known groundwater contaminant at the ETTP site for many years. Past CERCLA investigations have sampled and analyzed for ^{99}Tc in groundwater. In the past, the highest ^{99}Tc activity levels (as high as 6,000+ pCi/L) have been observed beneath the K-1070-A burial ground where concentrations at a couple of wells remain in the 200 – 500 pCi/L range. The area along Mitchell Branch near the former K-1407 Ponds has residual ^{99}Tc contaminated groundwater from the operational era of the ponds, and possibly from K-1420, with much lower activity levels (<100 pCi/L).

8.6.3.1 Background

Environmental fate of some metal contaminants in groundwater is strongly dependent on the pH and redox state of the water. A summary review of the environmental behavior of ^{99}Tc in the environment was published by Pacific Northwest National Laboratory (PNNL; PNNL-15372) related to tank wastes at Hanford. Background information from that report is used in preparation of the following interpretation of potential ^{99}Tc mobility in groundwater at the ETTP site.

Under electrochemically oxidizing conditions technetium forms the negatively charged pertechnetate ion (TcO_4^-) with technetium assuming a valence of 7^+. The pertechnetate ion is quite mobile in aqueous settings since negatively charged ions do not tend to adsorb to mineral surfaces in soil or rock which inherently tend to have negatively charged to neutrally charged surfaces. Under electrochemically reducing conditions the pertechnetate ion is not stable and technetium may assume a 4^+ valence. In the 4^+ valence state technetium may form ionic combinations with oxygen and hydroxyl groups, which may

be amorphous solids with lower solubilities than the pertechnetate ion. In the 4^+ valence, in the absence of complexing ligands, technetium may adsorb to mineral and organic matter surfaces, and may become bound in low solubility technetium oxyhydroxides. In the 4^+ valence, technetium may also form soluble complexes with carbonate/bicarbonate ions as well as sulfate. Thermodynamic and directly measured speciation and solubility relationships for technetium carbonate and sulfate complexes have not been established, although these complexes may be important to technetium mobility in reducing electrochemical environments.

In addition to standard physical chemical conditions, microbial processes are important as potential mediators that can lead to reduction of technetium from the highly soluble and mobile 7^+ valence in the pertechnetate ion to the 4^+ valence in the lower solubility forms. Microbial processes often occur in very localized regions in the subsurface where chemical conditions are favorable. This fact is evident in groundwater at the ETTP site where intrinsic microbial communities are known to slowly degrade chlorinated organic compounds in some areas but not in other areas. Factors that may favor microbial reduction of dissolved compounds include relatively slow groundwater movement, which limits influx of dissolved oxygen via groundwater recharge; presence of organic carbon that can serve as electron donor material; and presence of microbes capable of affecting the required molecular transformations.

8.6.3.2 ETTP Site Groundwater Electrochemistry and General Chemistry

Data from groundwater, spring, and surface water sampling and analyses conducted at the ETTP site as part of the ETTP Water Quality Program (EWQP) during FY 2015 have been reviewed for parameters pertinent to understanding the potential for ^{99}Tc mobility in site groundwater. During collection of all groundwater samples at ETTP, field measurement of pH and redox potential are made and recorded. The field measurements of pH and redox potential from all groundwater, spring, and surface water samples collected in FY 2015 have been plotted and superimposed over the technetium Eh-pH diagram excerpted from the PNNL report (Figure 8.43). Individual data points are posted for samples analyzed for ^{99}Tc and the detection/non-detection status is indicated by symbol color. The data shown on Figure 8.43 suggest that ^{99}Tc is quite mobile under physicochemical conditions present in site groundwater.

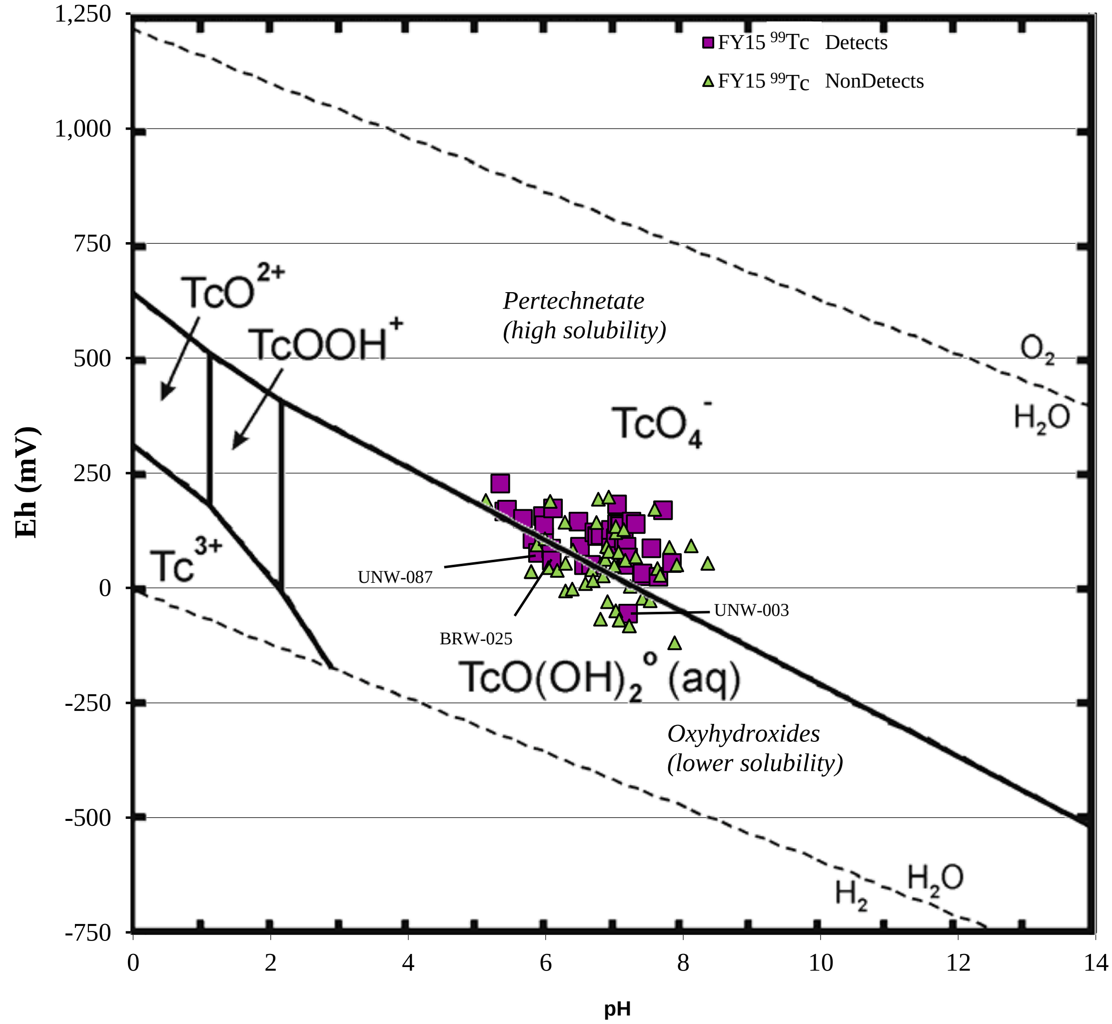

Figure 8.43. Eh – pH region in which ETTP groundwater, spring water, and surface waters lie in relation to the technetium Eh – pH speciation regions at 25° C and 900 pCi/L ^{99}Tc.

In addition to physicochemical data, major dissolved anions including bicarbonate, carbonate, and sulfate are measured on a subset of groundwater samples. Bicarbonate concentrations ranged from a low of 7 mg/L in well UNW-118 which monitors groundwater in the siliceous bedrock of the lower Rome Formation near Highway 58, to a high of 320 mg/L in well BRW-003 which monitors groundwater in the limestone-rich Chickamauga Group within Zone 2. The bicarbonate concentration in site groundwater samples averaged about 110 mg/L. Sulfate concentrations ranged from a low of about 0.6 mg/L at well UNW-121 that monitors groundwater in the soils at the K-1070-A site to a high of 85 mg/L at well BRW-017 that monitors groundwater in bedrock in a portion of the Chickamauga Group. Sulfate concentrations averaged about 12 mg/L in site groundwater. These data indicate that ^{99}Tc could form soluble complexes with bicarbonate and sulfate ions under some conditions that would allow contaminant mobility via groundwater transport.

Much of the ETTP physicochemical data suggests that ^{99}Tc mobility would generally be fairly high. Under this condition, dilution and dispersion processes during groundwater transport would be the only concentration reduction processes that would reduce ^{99}Tc activities since adsorption of pertechnetate ion is negligible. Site groundwater chemical and microbial conditions in some areas may provide attenuation processes that will reduce ^{99}Tc geochemical mobility in the groundwater system. If ^{99}Tc is present where

these conditions occur, these processes would be additive to dilution and dispersion processes expected to reduce contaminant levels with increasing transport distances.

8.6.3.3 FY 2015 Distribution of ^{99}Tc in ETTP Site Groundwater

During demolition of the K-25 East Wing in the winter of 2014, fugitive dust suppression misting and rainfall carried ^{99}Tc off the work area. Contaminated runoff apparently percolated through soil and into subsurface utility lines and probably into backfill surrounding the buried utilities. Groundwater sampling for ^{99}Tc was increased in wells in the general vicinity of the East Wing and where wells were available along potential groundwater transport pathways. During FY 2015, two phases of subsurface investigation work were completed under a Removal Site Evaluation (RmSE; DOE/OR/01-2663&D1/A1) to assess the potential threat to human health and the environment from the elevated ^{99}Tc levels observed in groundwater, storm water, and sanitary sewage during demolition of the K-25 Building. Background information about the behavior of ^{99}Tc in the environment and a summary of groundwater sampling to evaluate levels at ETTP are provided below. Other media sampling results are discussed in Section 8.6.4.6.

The scope of investigations conducted in the ^{99}Tc RmSE focused on understanding the role of site subsurface infrastructure in migration of ^{99}Tc away from the K-25 East Wing source area and the involvement of groundwater. The investigations used push technology to sample soil along and beneath portions of SDs, sanitary sewer pipes, and the abandoned electrical ductbank that formerly carried electrical cables along the east side of the K-25 Building. Continuous soil cores were obtained from the ground surface to target depths of refusal on the bedrock surface. Soils were visually logged and field classified to determine soil types and textures, and all recovered soil cores were field scanned using a photoionization detector (PID) and beta gamma radiation detector. The RmSE Work Plan established criteria for collection of at least two samples per boring for analysis of VOCs and ^{99}Tc. A temporary PVC piezometer was installed in each borehole to allow observation of groundwater levels and to provide groundwater samples for ^{99}Tc and/or VOC analyses. The investigations determined that although ^{99}Tc entered and traveled through the sanitary sewer and the SD that discharges to the K-1007-P1 Pond, the amount of ^{99}Tc transport in backfill outside those pipes was minimal. The investigation found that ^{99}Tc transport through the abandoned underground electrical ductbank was an important transport pathway along the east side of the K-25 Building as far south as ductbank manhole row 21. RAs conducted in Zone 1 included plugging the ductbank manholes with cement grout from row 21 to the south and west to the former steam plant located near the Clinch River in the K-770 Area. VOCs were found to not be significant contaminants in any of the borehole soils. Groundwater was sampled where available in the temporary piezometers in July 2015. The resulting ^{99}Tc contaminated groundwater area is shown on Figure 8.44 along with summer 2015 ^{99}Tc concentration ranges in groundwater throughout the ETTP site.

The area where detected ^{99}Tc is highest is along the eastern side of the K-25 East Wing. The highest concentrations occur in well temporary piezometers near ductbank manholes in row 22 – DB22LD and DB22M (25,900 pCi/L and 19,500 pCi/L, respectively). The second most highly contaminated wells are along the ductbank corridor to the north at wells UNW-137 (9,750 pCi/L) and in wells near the K-1413 facility (UNP-008 = 10,600 pCi/L, BRW-015 = 7,430 pCi/L, and UNW-026 = 3,890 pCi/L). The conceptual model that was advanced in the previous RER was essentially confirmed by the ^{99}Tc RmSE investigations. Percolation water from the contaminated slab area probably entered the backfill around the electrical duct bank that runs north-south along the east side of the building. Rapid transport along this utility corridor carried the high concentrations of ^{99}Tc into the areas where the high concentrations are currently detected.

The plume trajectory for ^{99}Tc is to the south/southwest from the ductbank manhole rows 21 and 22 area and to the northeast from the K-1413 area through well UNW-089 and toward Mitchell Branch. At

well UNW-089, the ^{99}Tc activities apparently reached their maximum during the winter or spring of 2015 since the highest observed result of 428 pCi/L was observed in March and by September the result had decreased to 341 pCi/L. As indicated by the piezometric surface shown on Figure 8.44, there is a trough in the water table surface that is formed in a now filled valley that leads from the K-1413 area northward toward Mitchell Branch. The inset box in Figure 8.44 shows an inferred plume trajectory arrow from the contaminated area near K-1413 toward UNP-005. At well UNP-005 low levels of ^{99}Tc have been detected biannually with previous results of 12.8 pCi/L in August 2010 and 7.6 pCi/L in September 2013 and 8.33 and 12.7 pCi/L in March and September 2015, respectively. Technetium-99 has also been detected intermittently in groundwater in wells UNW-003 and BRW-047 further east along Mitchell Branch. The levels in well UNW-003 have fluctuated in the range of about 10 – 50 pCi/L since reliable ^{99}Tc analytical data became available in 1998 and 2015 results were 13.1 and 21.5 pCi/L in March and August, respectively. A single sample result is available from well BRW-047 which contained about 45 pCi/L of ^{99}Tc. It is also noted that during construction activities in the 1940s and 1950s the culverts for the SD-190 network were laid in the pre-existing valley beneath the contour fill. Infiltration of ^{99}Tc plume water into the SD-190 culvert is expected. Groundwater sampling and analysis for ^{99}Tc in all the wells where it has been detected as shown on Figure 8.44 will continue.

DOE is conducting a third and final phase of investigation under the ^{99}Tc RmSE which includes push probe sampling of areas slightly further east than the currently documented ductbank contamination, further north of the K-1413 area, and two bedrock wells are being installed to the west of the contaminated area to assess potential bedrock contaminant transport. The results of that phase of work will be included in the 2017 RER.

8.6.4 Surface Water

Surface water monitoring is conducted at 12 locations (Figure 8.45) to monitor exit pathway watershed integration points (K-1700 weir, K-1007-B weir, and K-901-A Holding Pond weir); adjacent off-site ambient in-stream conditions (Clinch River kilometer [CRK] 16; CRK 23; K-1710; K-716; K-702-A); and on-site Mitchell Branch in-stream locations MIK 0.4, 0.59, 0.71, and 1.4). Surface water sample collection activities at Mitchell Branch are shown in Figure 8.46.

A summary of the results for radionuclides, VOCs, chromium, mercury, PCBs, and ^{99}Tc follows.

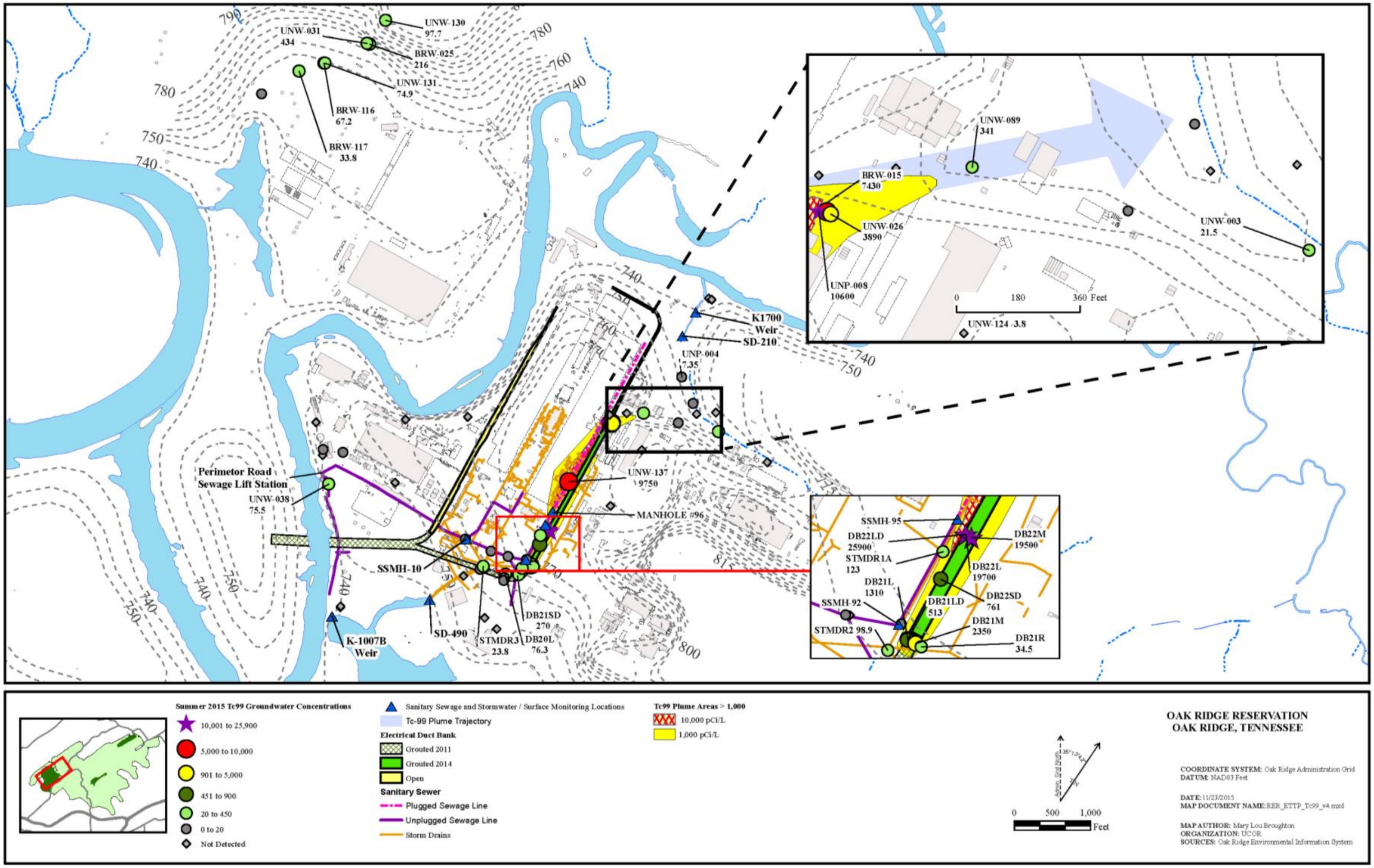

Figure 8.44. Sample locations and maximum detected ^{99}Tc in ETTP groundwater.

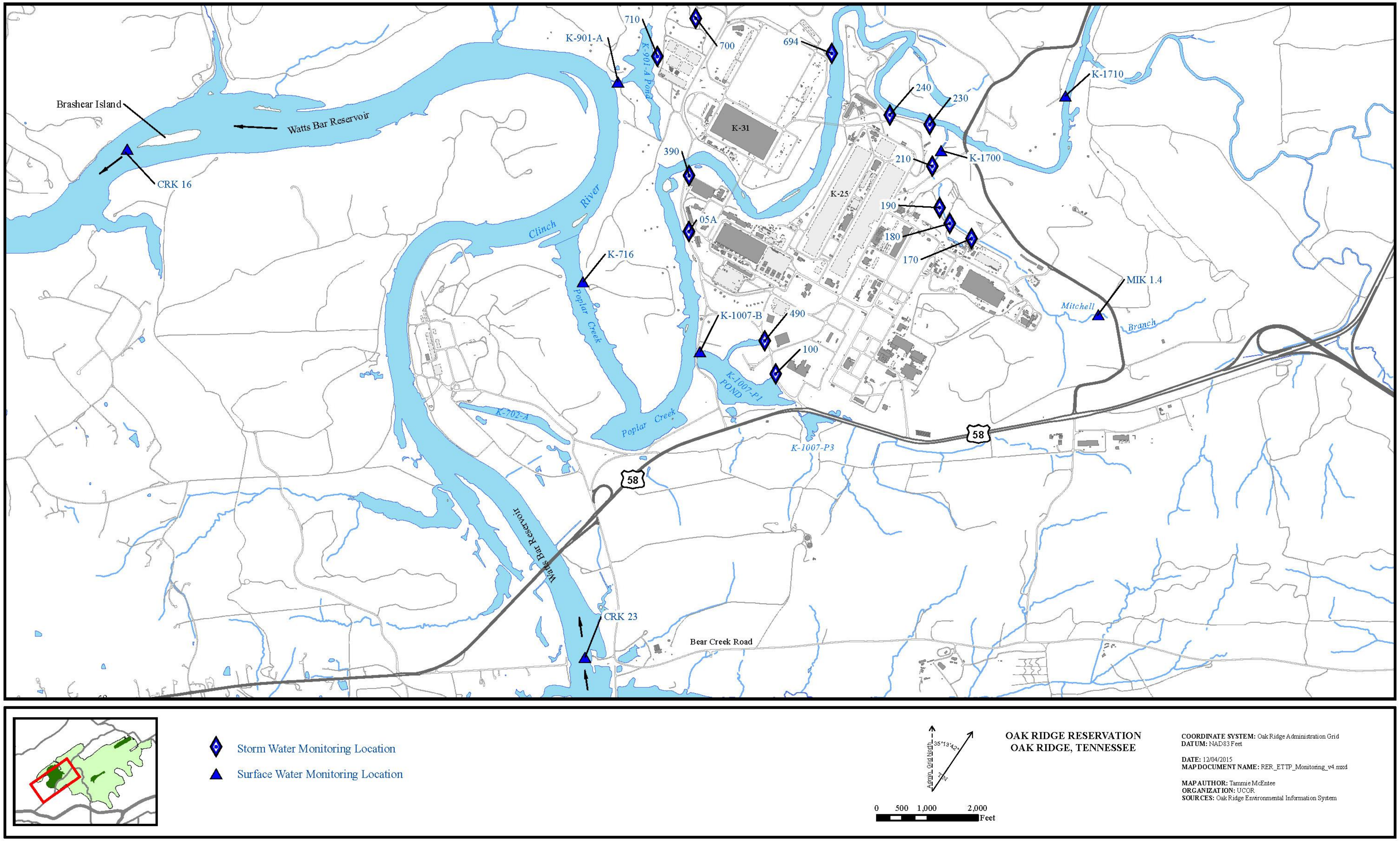

Figure 8.45. Surface water monitoring locations.

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Figure 8.46. Surface water sample collection at Mitchell Branch.

8.6.4.1 Radionuclides

Samples were collected and analyzed for radionuclides either quarterly (K-1700 and MIK 1.4) or semiannually (K-716, K-901-A, K-1007-B, K-1710, CRK 16, and CRK 23), and the results are compared with the DCSs from DOE Standard DOE-STD-1196-2011. Radiological data are reported as fractions of the DCSs. If the sum of DCS fractions for a location exceeds a screening level of 4% of the DCS for the year, a source field investigation is conducted to determine if there are changing conditions within the watershed that are leading to increased radiological discharge levels. The FY 2015 monitoring results are summarized in Figure 8.47. All results were below the 4% of the DCS screening threshold in FY 2015.

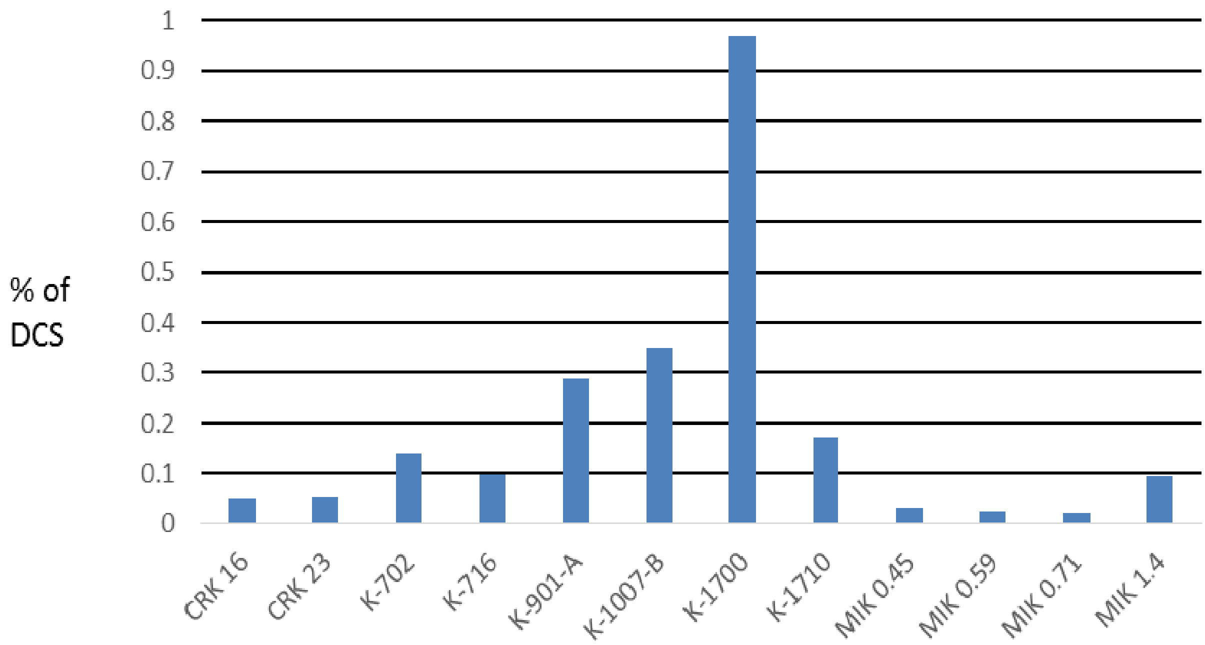


Figure 8.47. Percentage of DCSs at ETTP surface water surveillance locations.

Note: only ^{99}Tc was monitored at MIKs 0.45, 0.59, and 0.71.

8.6.4.2 VOCs

The primary VOC detected in samples from Mitchell Branch is TCE. Figure 8.48 illustrates the concentrations of TCE at the Mitchell Branch monitoring locations, which are the only surface water monitoring locations where VOCs are regularly detected. Concentrations of TCE ranged from less than 1 µg/L to 38.7 µg/L in samples collected in FY 2015. These levels are well below the AWQC for TCE (300 µg/L). Other VOCs such as 1,2-DCE are measured well below the applicable standards. VOCs have been detected in groundwater in the vicinity of Mitchell Branch and in building sumps discharging into storm water outfalls that discharge into the stream. However, SD network monitoring generally has not detected these compounds in the storm water discharges at levels higher than those in the stream. Therefore, it appears that the primary source of these compounds is contaminated groundwater. Concentrations of individual compounds and a mixture of the detected VOCs were well below benchmark values for potential surface water toxicity.

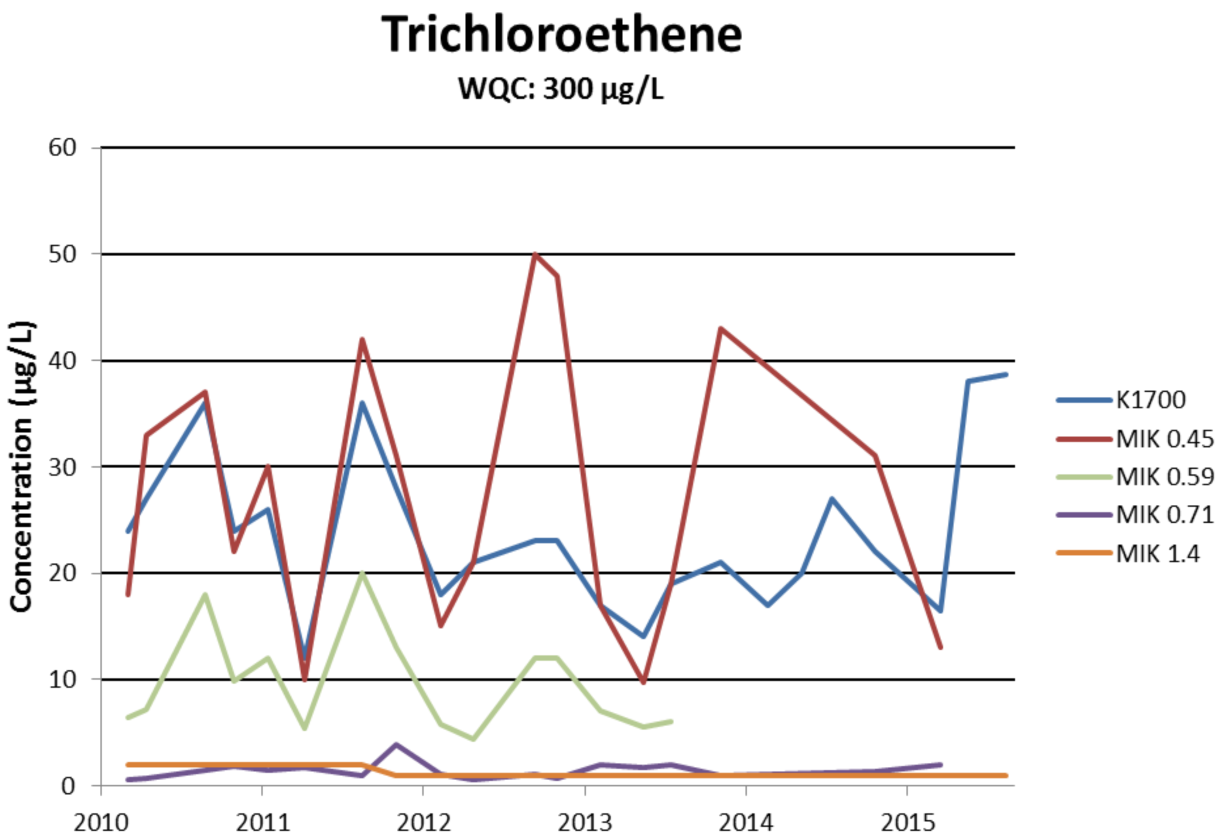


Figure 8.48. TCE trends at Mitchell Branch surface water surveillance locations.

8.6.4.3 Chromium

A detailed review of the Mitchell Branch Chromium Reduction CERCLA action is provided in Section 8.4.4 and includes the time period of FY 2007 and FY 2008 when levels of chromium were above the AWQC for hexavalent chromium (11 µg/L) prior to the groundwater collection system being installed in FY 2008. A summary of the long-term trend measurements of total chromium at the Mitchell Branch K-1700 exit pathway weir over the past five years (Figure 8.49, 2010 through 2015) have been shown to be well below the AWQC for total chromium (74 µg/L) and even well below the more conservative AWQC for hexavalent chromium (11 µg/L). Results from routine surface water monitoring conducted in the spring of 2007 indicated that chromium levels had increased above the AWQC. After an extensive CERCLA investigation (as discussed in previous sections) a chromium groundwater collection system was installed to pump contaminated groundwater from the vicinity of Outfall 170 for treatment. Since this system was installed, chromium levels in Mitchell Branch have dropped dramatically. In FY 2015, levels of total chromium ranged from less than 0.6 µg/L to 2.5 µg/L at the Mitchell Branch monitoring locations and hexavalent chromium was not detected in any of the samples collected in FY 2015.

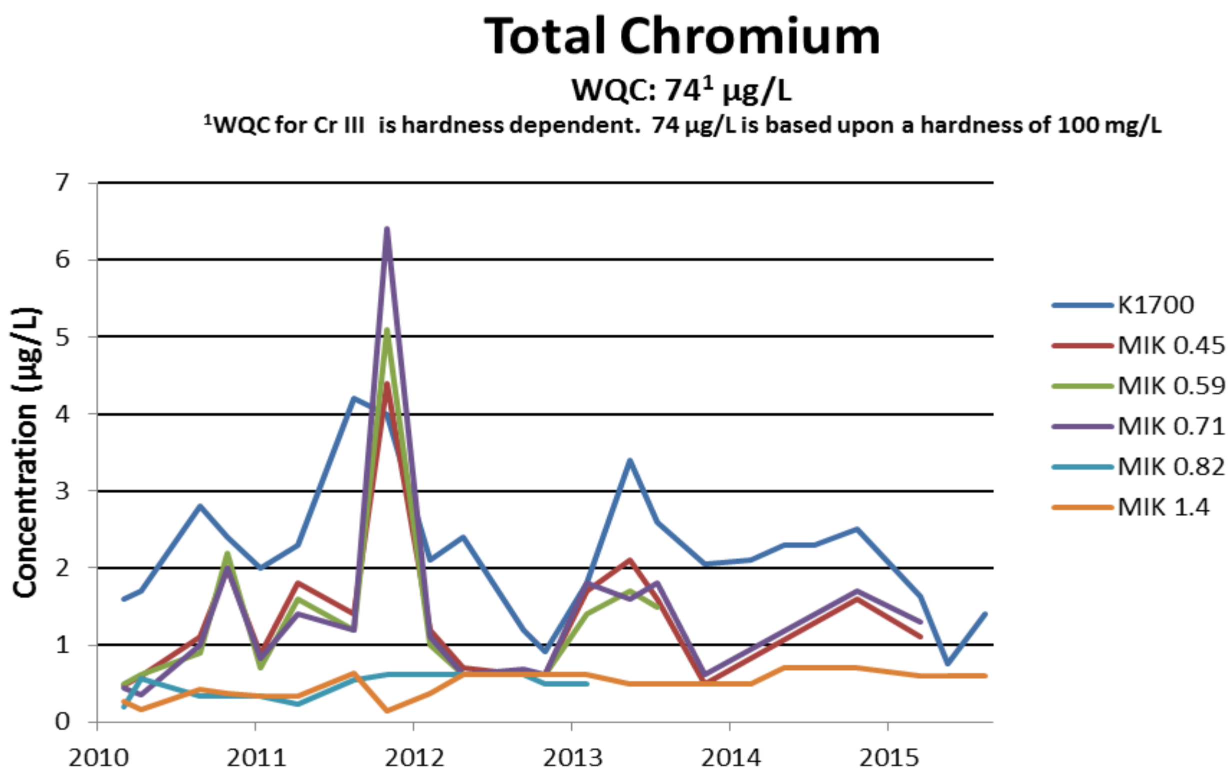


Figure 8.49. Total chromium concentrations at Mitchell Branch monitoring locations.

8.6.4.4 Mercury

Activities involving mercury that were conducted at ETTP included usage, handling, and recovery operations. Mercury usage and handling were common in such equipment as manometers, switches, mass spectrometers, mercury diffusion pumps, mercury traps, and laboratory operations. Large quantities of mercury-bearing wastes from the on-site gaseous diffusion plant operations and support buildings, ORNL, and Y-12, were processed and stored at ETTP. Mercury from soils and spill cleanups was processed on site as well. Mercury recovery operations were conducted in a number of buildings. Many buildings were located in watersheds that discharged primarily to Mitchell Branch.

Mercury levels that exceed the AWQC of 51 ng/L at ETTP have been identified in the Mitchell Branch watershed, as well as in a number of storm water outfalls, surface water locations, and groundwater monitoring wells at ETTP. Improved analytical techniques for mercury have resulted in much lower detection limits than previously possible. In addition, knowledge of known historical mercury processes at the facility has increased substantially. These factors have led to an ongoing facility investigation to more precisely detect and quantify the extent of any mercury contamination that may exist.

As part of the previous NPDES permit compliance program, mercury was sampled on a quarterly basis at Outfalls 05A, 170, 180, and 190. These four locations were selected because information gathered as part of the permit application process indicated that mercury levels at these outfalls occasionally exceeded the AWQC level of 51 ng/L. Outfalls 170, 180, and 190 collect storm water from large areas on the north side of ETTP and discharge to Mitchell Branch (Figure 8.45). Outfall 05A is the discharge point for the former Sewage Treatment Plant (STP) drainage basin into Poplar Creek on the east side of ETTP. The NPDES permit that took effect on April 1, 2015, no longer requires quarterly mercury monitoring. However, in order to continue collecting data for the analysis of trends in mercury discharges from these outfalls,

quarterly mercury sampling is conducted as part of the ETTP Storm Water Pollution Prevention (SWPP) Program. Since mercury has not been detected at Outfall 170 at levels over the AWQC level of 51 ng/L for several years, Outfall 170 will not be sampled as part of this SWPP Program effort.

Table 8.7 contains analytical data from mercury sampling performed at Outfalls 170, 180, 190, and 05A during FY 2015. Samples collected during the first and second quarters of FY 2015 were collected as part of the requirements of the ETTP NPDES permit that was in effect at that time. Mercury samples collected during the third and fourth quarters of FY 2015 were taken as part of the requirements of the ETTP SWPP Program.

Table 8.7. Quarterly NPDES/SWPP Program mercury monitoring results – FY 2015

Sampling location	1st Quarter FY 2015 (ng/L)	2nd Quarter FY 2015 (ng/L)	3rd Quarter FY 2015 (ng/L)	4th Quarter FY 2015 (ng/L)
Outfall 170[a]	5.17	4.1	-----	-----
Outfall 180	**89.6**	**219**	**53.1**	50.8
Outfall 190	19.6	20.3	11.1	16.7
Outfall 05A	**194**	**67.4**	**132**	**148**

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

[a]Quarterly mercury samples were not collected at Outfall 170 after March 2015.

AWQC = ambient water quality criteria
FY = fiscal year
NPDES = National Pollutant Discharge Elimination System
SWPP = Storm Water Pollution Prevention

Comprehensive Mercury Graphs

Figures 8.50 – 8.53 indicate the mercury levels at Outfalls 170, 180, 190, and 05A from CY 2010 to present. These graphs contain mercury information from quarterly sampling performed as part of the quarterly NPDES permit compliance/quarterly SWPP Program sampling, NPDES permit renewal sampling, D&D sampling, and other mercury sampling performed at these outfalls.

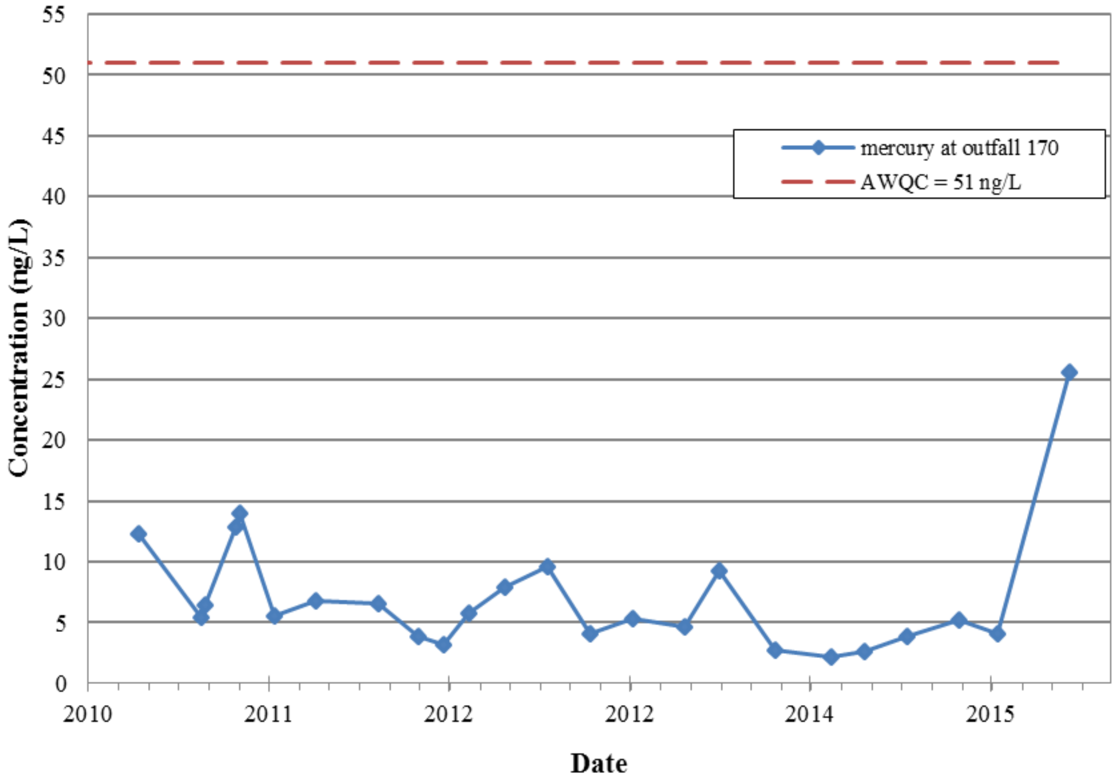


Figure 8.50. Mercury concentrations at Outfall 170.

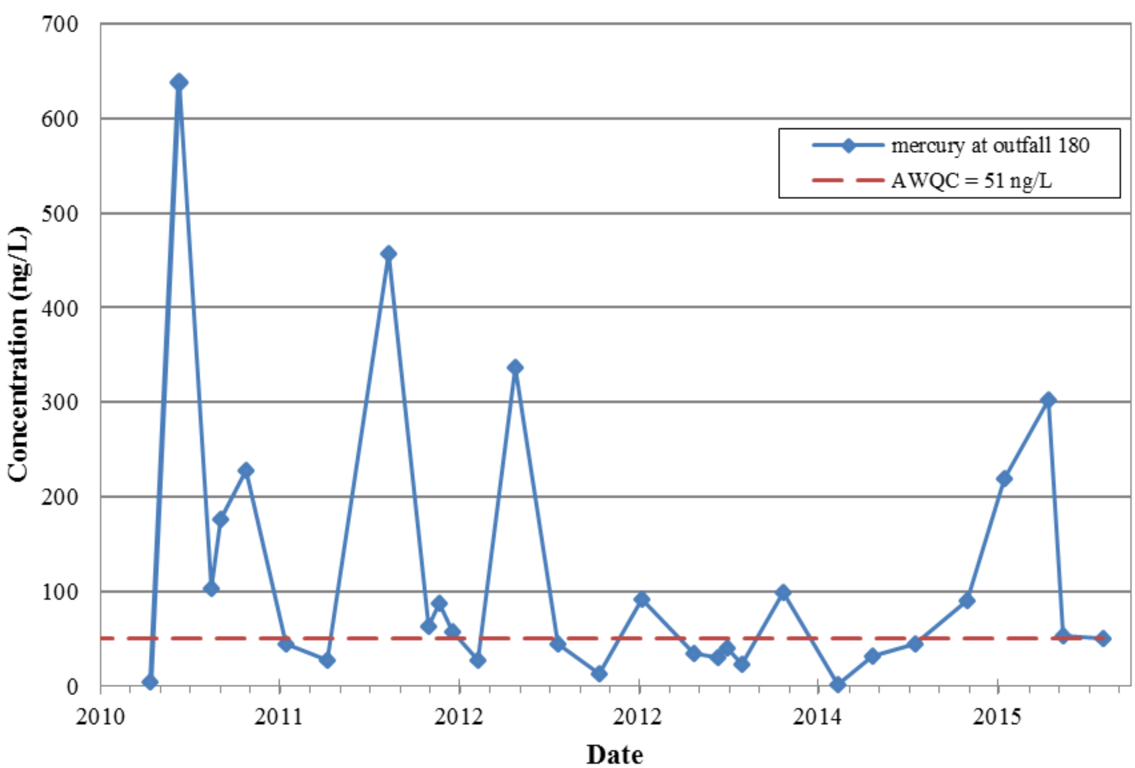


Figure 8.51. Mercury concentrations at Outfall 180.

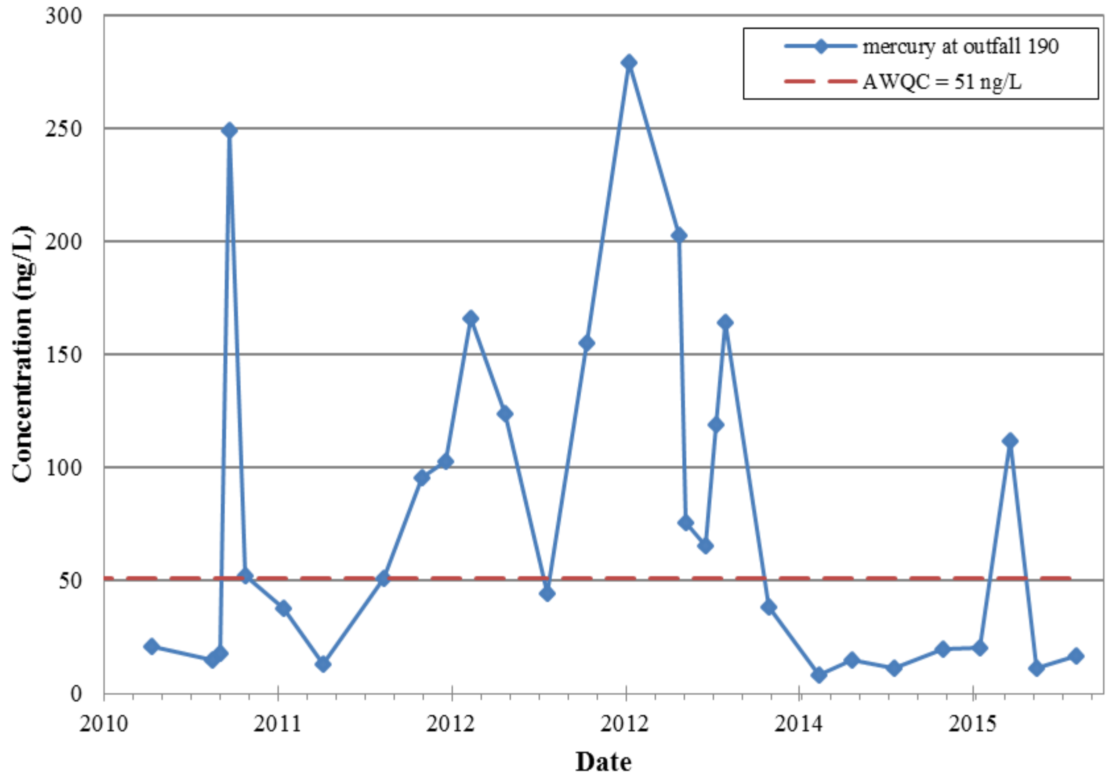


Figure 8.52. Mercury concentrations at Outfall 190.

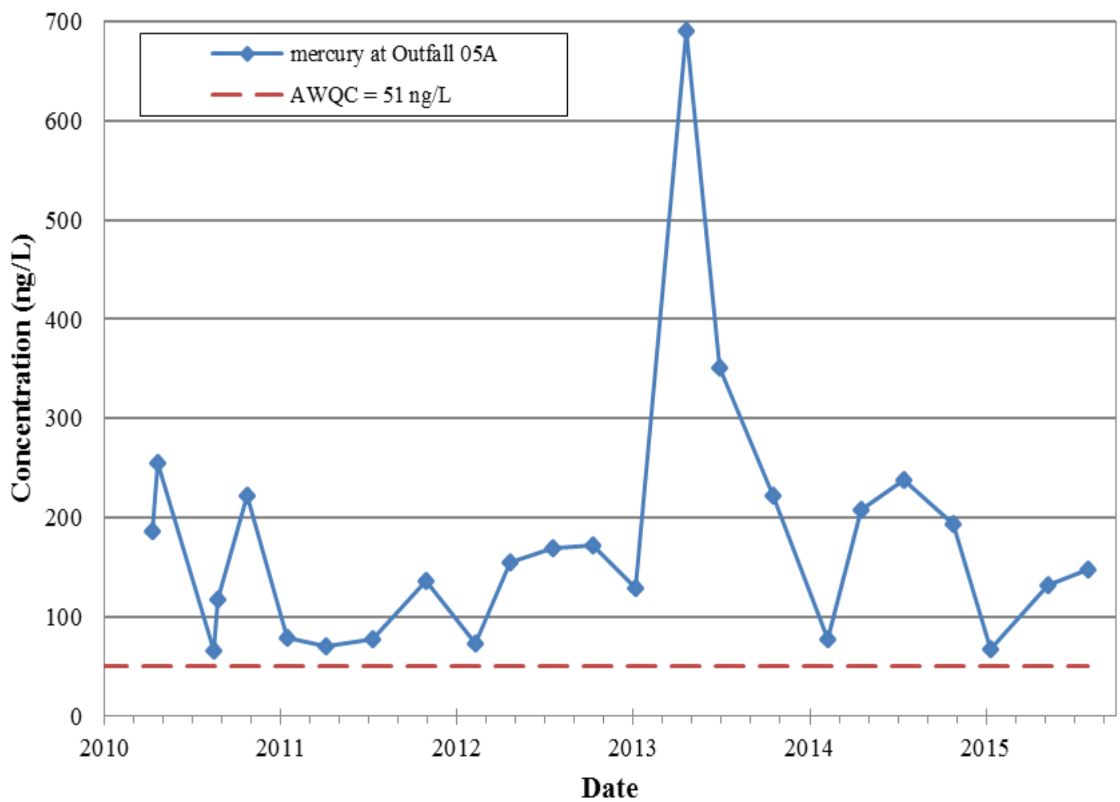


Figure 8.53. Mercury concentrations at Outfall 05A.

Mercury Sampling in the Outfall 230 and 240 Networks

The K-1024 Diluting Pit was used during the K-1024 instrument shop operations (1945 – 1963) and centrifuge development laboratory operations (1970 – 1985) and was located on the northwest corner of the K-1024 Building. During 1946 – 1947, the K-1024 Building operations cleaned mercury from line recorder chemical traps. The electronics shop had a problem with spilled mercury and mercury vapors. The K-1024 Building sanitary flow and acid/solvent flow were each handled by independent drain lines. A 4 in. acid waste line flowed through the dilution pit before discharge into the K-25 Site SD system. The unit was placed in standby in 1985 and in the early 1990s was filled and covered with asphalt.

The SD networks for Outfalls 230 and 240 drain the former K-1024 Building area (Figure 8.45). Therefore, in addition to sampling at the 230 and 240 outfalls, samples were collected from selected SD catchment basins in the Outfall 230 and 240 networks as part of the FY 2015 ETTP SWPP Program. The analytical results from this sampling effort will allow an assessment of the levels of mercury that may be continuing to enter the storm water drainage system.

The total mercury samples were collected during both wet weather and dry weather conditions. Since water samples may inadvertently pick up sediment from the bottom of the SD system, both a filtered and an unfiltered sample were collected for total mercury analysis. The filtering was done in the field utilizing a 0.45 micron filter and a portable peristaltic pump.

Dry weather sampling of Outfall 230 and its associated drainage network was performed in February 2015. As part of the monitoring of the Outfall 230 network, samples were collected at manholes 2003, 3035, 3040, 7011, 7012, 7013, and 7014. Both filtered and unfiltered samples were collected at each location. The results are presented in Table 8.8.

Table 8.8. Mercury results from dry weather sampling at storm water Outfall 230 and associated piping network

Sampling location	Mercury results (ng/L)	
	Unfiltered	Filtered (field)
Outfall 230	2.07	1.54
Manhole 2003	23.1	**69.8**
Manhole 3035	11.9	3.45
Manhole 3040	47.7	17.8
Manhole 7011	2.77	45.6
Manhole 7012	27.3	35.1
Manhole 7013	46.4	31.4
Manhole 7014	**60.1**	39.3

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

AWQC = ambient water quality criteria

Dry weather sampling of Outfall 240 and its associated drainage network was completed on March 26, 2015. At the time of sampling, only manholes 2008 and 2014 were flowing; Outfall 240 and manholes 2050, 7053, 7054, 7056, and 7059 were dry. These results are presented in Table 8.9.

Table 8.9. Mercury results from dry weather sampling at Outfall 240 and associated piping network

Sampling location	Mercury result (ng/L)	
	Unfiltered	Filtered (field)
Manhole 2008	**447**	9.33
Manhole 2014	9.88	7.9

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

AWQC = ambient water quality criteria

Wet weather sampling of Outfall 230 and its associated drainage network was performed on April 20, 2015. As part of the monitoring of the Outfall 230 network, samples were collected at manholes 2003, 3035, 3040, 7011, 7012, 7013, and 7014. Both filtered and unfiltered samples were collected at each location. The results are presented in Table 8.10.

Table 8.10. Mercury results from wet weather sampling at Outfall 230 and associated piping network

Sampling location	Mercury result (ng/L)	
	Unfiltered	Filtered (field)
Outfall 230	36.1	14.2
Manhole 2003	**76.8**	34.7
Manhole 3035	43.2	14.4
Manhole 3040	38.6	16.4
Manhole 7011	**162**	**82.6**
Manhole 7012	**211**	**103**
Manhole 7013	**334**	**160**
Manhole 7014	**963**	**123**

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

AWQC = ambient water quality criteria

Wet weather sampling of Outfall 240 and its associated drainage network has not yet been completed.

Investigation of Mercury in Selected ETTP Storm Water Outfalls

Mercury at levels above the AWQC has been identified at several ETTP storm water outfalls during past sampling events. In order to evaluate whether the discharge of mercury from these outfalls is part of an ongoing trend or whether it is an isolated occurrence, additional sampling at the outfalls shown in Table 8.11 was conducted in FY 2015 to allow for a sufficient number of data points for trend analysis.

Table 8.11. Analytical results for mercury investigation sampling

Sampling location	Mercury result (ng/L)
Outfall 100	8.78
Outfall 195	10.3
Outfall 230	15.6
Outfall 240	22.3
Outfall 250	**89.4**
Outfall 280	19.2

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

AWQC = ambient water quality criteria

A mercury sample was collected at Outfall 250 in October 2014. The results from this sample exceeded AWQC levels for mercury as indicated in Table 8.11. Outfall 250 receives storm water runoff from the K-802 area, which is located northwest of the K-25 building. An investigation into the potential sources of mercury at this outfall was undertaken, but no conclusive results were obtained.

Mercury Investigation at Outfall 694

As part of the site-wide mercury investigation, a mercury sample was collected at Outfall 694 on September 4, 2014. The mercury result from this sample was 910 ng/L. Because the mercury level in this sample was elevated, follow-up samples were collected on July 23, 2015 from Outfall 694 and from catch basin 1B017, which is in the drainage system of the outfall. The mercury results from these samples are indicated in Table 8.12.

Table 8.12. Analytical results for mercury investigation sampling at Outfall 694

Sampling location	Mercury result (ng/L)
Outfall 694 (9/4/14)	**910**
Outfall 694 (7/23/15)	30.5
Catch Basin 1B017 (7/23/15)	15.4

Results in **bold** exceed the AWQC level for mercury (51 ng/L).

AWQC = ambient water quality criteria

It is believed that the elevated mercury result from the September 2014 sample may have been related to sediment that was present in Poplar Creek water that had historically been pumped into the K-892 Pumphouse and may have been discharged through Outfall 694. There is no clear explanation of why the detected mercury level in the follow-up sample differed so greatly from the original sample. Catch basin 1B017 is located upstream of the point where the K-892 pumphouse discharge enters the Outfall 694 network, which may explain why mercury levels in the basin were lower than mercury levels at the outfall.

8.6.4.5 PCB Monitoring at ETTP Storm Water Outfalls

An evaluation of PCB data collected as part of the ETTP SWPP Program from CY 2000 to the present was performed to identify locations where PCBs have been detected at storm water outfall locations. These outfalls will be sampled for PCBs during FY 2015 and FY 2016. Table 8.13 indicates the analytical

results from storm water outfall samples for PCBs collected as part of the FY 2015 SWPP sampling program.

Table 8.13. PCB samples collected as part of the CY 2015 SWPP Program sampling effort

Sampling location	Parameter[a]	Date sampled	Results above detection limit
Outfall 100	Total PCBs and individual PCB aroclors	8/18/15	PCB-1248 – **0.112 µg/L**
Outfall 210	Total PCBs and individual PCB aroclors	9/10/15	No PCBs detected
Outfall 230	Total PCBs and individual PCB aroclors	8/18/15	No PCBs detected
Outfall 240	Total PCBs and individual PCB aroclors	9/10/2015	No PCBs detected
Outfall 390	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected
Outfall 490	Total PCBs and individual PCB aroclors	8/18/15	No PCBs detected
Outfall 700	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected
Outfall 710	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected

Results in **bold** exceed the AWQC level for total PCBs. (0.00064 µg/L).

[a]PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Total PCBs will also be reported as part of the analytical data package.

AWQC = ambient water quality criteria
CY = calendar year
PCB = polychlorinated biphenyl
SWPP = Storm Water Pollution Prevention

Analytical data collected as part of this storm water monitoring effort will be utilized to provide information for evaluating cleanup decisions and to measure the effectiveness of RAs.

8.6.4.6 Technetium-99 Sampling Investigation

The conclusion of the *Technetium-99 Removal Site Evaluation at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2663&D1) indicates the measured levels of ^{99}Tc in site surface water releases are in compliance with applicable regulatory requirements and DOE Orders and do not pose a threat to human health and the environment. A summary of the groundwater sampling to evaluate the ^{99}Tc levels was discussed in Section 8.6.3. The discussion that follows describes the other media sampling results for FY 2015.

Storm Water

Elevated levels of ^{99}Tc were first observed at storm water Outfall 490 in November 2013. Outfall 490 discharges into the K-1007-P1 Pond and is the main storm water discharge point from the purge cascade demolition area. The concentration of ^{99}Tc at this location ranged from 1,300 pCi/L to a maximum value of 59,200 pCi/L. As the storm water controls were modified and the waste was removed from the demolition pad, the measured results declined to 543 pCi/L at Outfall 490 in April 2014. During FY 2015, Outfall 490 results ranged from a high of 687 pCi/L in April 2015 to a low of 59 pCi/L in August 2015. The ^{99}Tc storm water discharges in FY 2015 were orders of magnitude below DOE Order annual sum-of-fraction requirements.

Sanitary Sewer

After the ^{99}Tc release was identified, the sanitary sewer system was sampled at Manhole 96, which is located to the southeast of the demolition area as shown on Figure 8.44. The ^{99}Tc concentrations at this manhole were as high as 269,000 pCi/L. Based on these results, all connections to the sanitary sewer system around the Building K-25 demolition area were isolated, and the sanitary sewer trunk line was plugged at Manhole 96.

After Manhole 96 was plugged, sampling of the City of Oak Ridge sanitary sewer line was then initiated at Manhole 95, which is the next downgradient manhole from the plug that was installed at Manhole 96.

The ^{99}Tc sampling for FY 2015 was performed as follows:

- ^{99}Tc was measured at 133 pCi/L in samples collected at Manhole 95 in August 2015.
- Additional downgradient Manholes 92 and 10 were added as surveillance monitoring locations.
  - The results at Manhole 92 decreased from a high of 3,640 pCi/L down to 296 pCi/L in August 2015.
  - The results at Manhole 10 decreased from a high of 439 pCi/L down to 68 pCi/L in August 2015.
- Concentrations at the Rarity Ridge Lift Station #1 ranged from a high of 897 pCi/L to 120 pCi/L in August 2015.
- Concentrations at the Rarity Ridge Effluent Weir ranged from a high of 690 pCi/L down to 110 pCi/L in August 2015.
- Concentrations at the Rarity Ridge Biological Treatment Aeration Basins ranged from a high of 56,900 pCi/L to 7,850 pCi/L in August 2015.
- Concentrations at the Rarity Ridge Digester ranged from a high of 373,000 pCi/L down to 67,700 pCi/L in August 2015.
- During FY 2015, eight tanker shipments of approximately 5,000 gal per tanker of digester sludge were pumped and shipped off-site for treatment as LLW.

The ^{99}Tc sewage treatment network influent concentrations and STP effluent discharges in FY 2015 were both in compliance with DOE Order annual sum-of-fraction requirements.

8.6.5 Aquatic Biology

Long-term trends in PCB accumulation in fish from the K-901-A Holding Pond, the K-1007-P1 Holding Pond, and the K-720 Slough were presented in Section 8.4.2. Other biological monitoring locations at ETTP are shown in Figure 8.54.

Biological monitoring in Mitchell Branch, conducted by the ETTP Biological Monitoring and Assessment Program (BMAP), includes: (1) contaminant accumulation in fish, (2) fish community surveys, and (3) benthic macroinvertebrate surveys (Figure 8.55). Bioaccumulation monitoring for the ETTP BMAP has historically focused on evaluating the impact of PCB discharges into the environment as a result of past operations at the ETTP complex. It was previously assumed that mercury flux into Poplar Creek and the Clinch River originated largely from the Y-12 discharges into East Fork Poplar Creek. However, recent evidence of elevated mercury concentrations in ETTP SD waters has prompted interest in evaluating the mercury inputs to Poplar Creek deriving from ETTP operations. Total mercury has been monitored in redbreast sunfish fillets at MIK 0.2. Figure 8.56 shows long-term trends in total mercury concentrations (µg/g) in these fish. Mercury concentrations in fish were in the 0.1 to 0.2 µg/g over the 1989 – 1991 time period, but then increased to around 0.25 – 0.4 µg/g range in 1992 – 1993 where they have remained until 2015. Mean mercury concentrations in Mitchell Branch sunfish fillets in 2015 (0.41 µg/g) were comparable to those in 2014, remaining above EPA's fish-based recommended AWQC for mercury (0.3 µg/g).

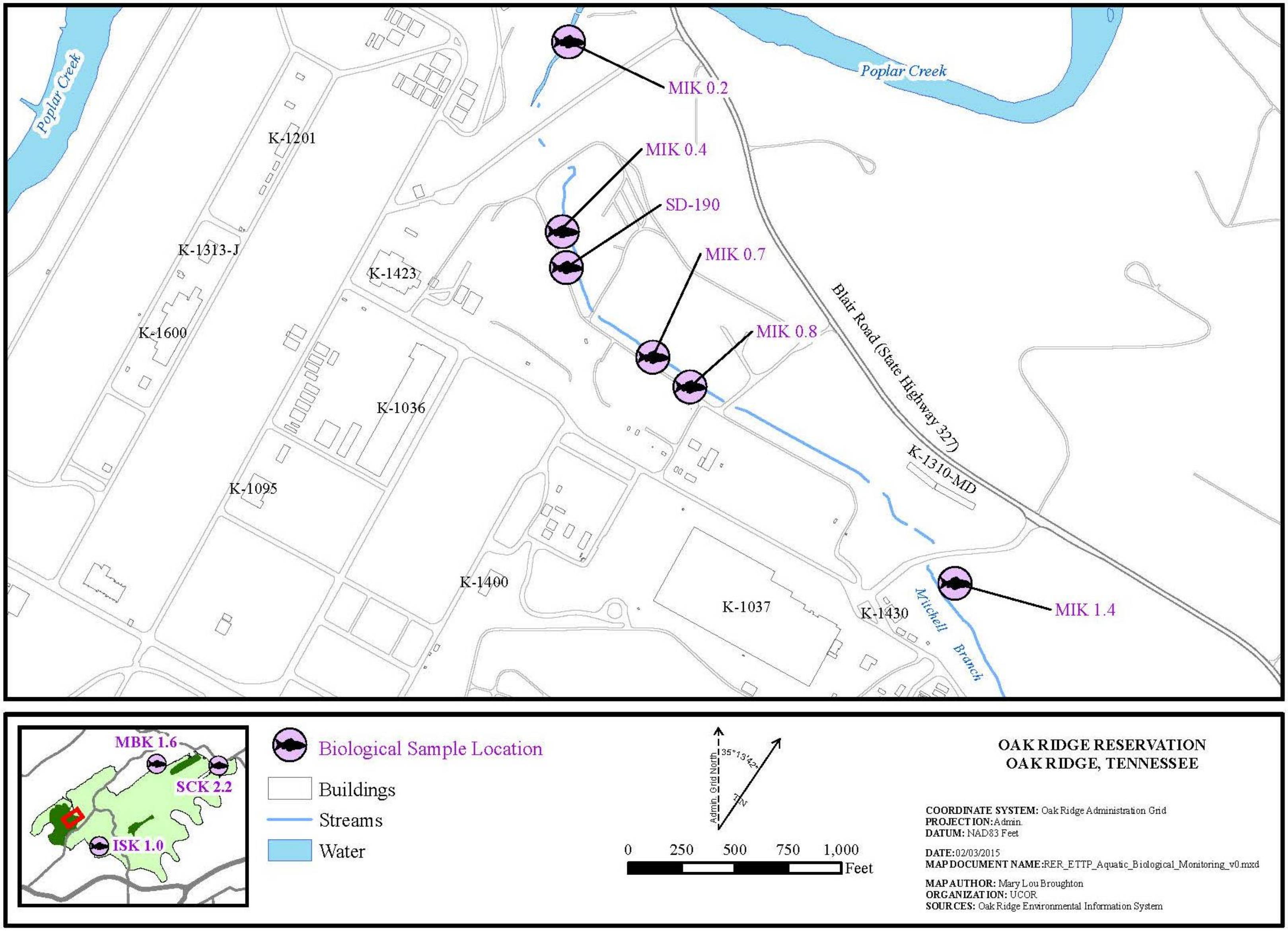


Figure 8.54. Other ETTP biological monitoring

Figure 8.55. Sampling for benthic macroinvertebrates with TDEC protocols.

Mean PCB concentration in redbreast sunfish collected from Mitchell Branch in FY 2015 averaged 2.71 µg/g, significantly higher than in recent years but below historically high levels in the late 1990s and early 2000s when levels in fish were in the 3 to 4 µg/g range (Figure 8.57). Over 2 µg/g range is still a relatively high level of PCBs for sunfish, which are low in lipids and do not accumulate PCBs to the same degree as species such as largemouth bass and channel catfish. Caged Asiatic clams (*Corbicula fluminea*) were placed in Mitchell Branch above and below SD discharges for a four week exposure (May – June 2014) to evaluate the importance of PCB sources to the creek. As has historically been the case, clams placed in Mitchell Branch upstream of SD-190 were relatively low in PCBs (<0.1 µg/g), while clams placed at SD-190 and in the creek downstream of SD-190 were relatively high (range 0.9 to 1.9 µg/g).

The species richness (number of species) of the fish communities in Mitchell Branch (MIK 0.4 and 0.7) has improved since the 1990s (Figure 8.58), and seems to be stabilized at slightly higher levels in samples taken after 2008. This diversity is now only a few values below the range of species richness values of comparable reference streams in the area. Although similar in overall species richness, the fish community at Mitchell Branch still has fewer sensitive species of fish, such as darters and suckers and at much lower densities than at the reference streams indicating that recruitment of these species is being hindered despite the streams proximity to a larger body of water (Poplar Creek) and a source for recruitment. The continued presence of additional sensitive species would be expected to increase as water quality improves and habitat stabilizes within the watershed.

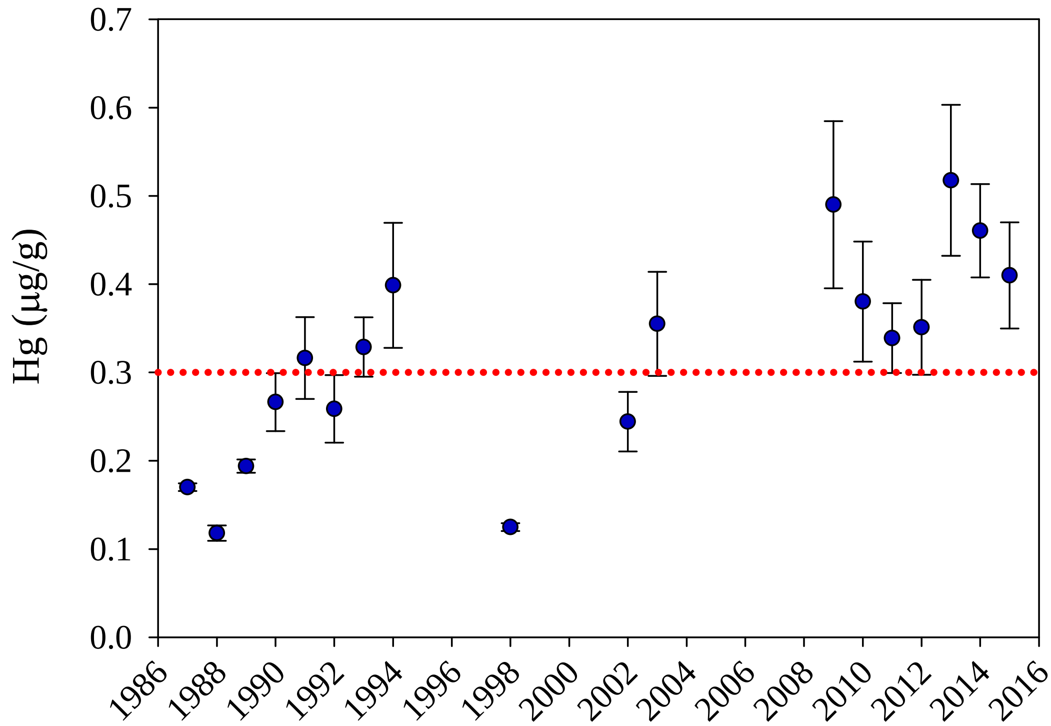


Figure 8.56. Mean mercury concentrations in redbreast sunfish from Mitchell Branch, FY 1993 – 2015.

Red dotted line signifies the EPA recommended AWQC for mercury in fish fillet (0.3 µg/g).

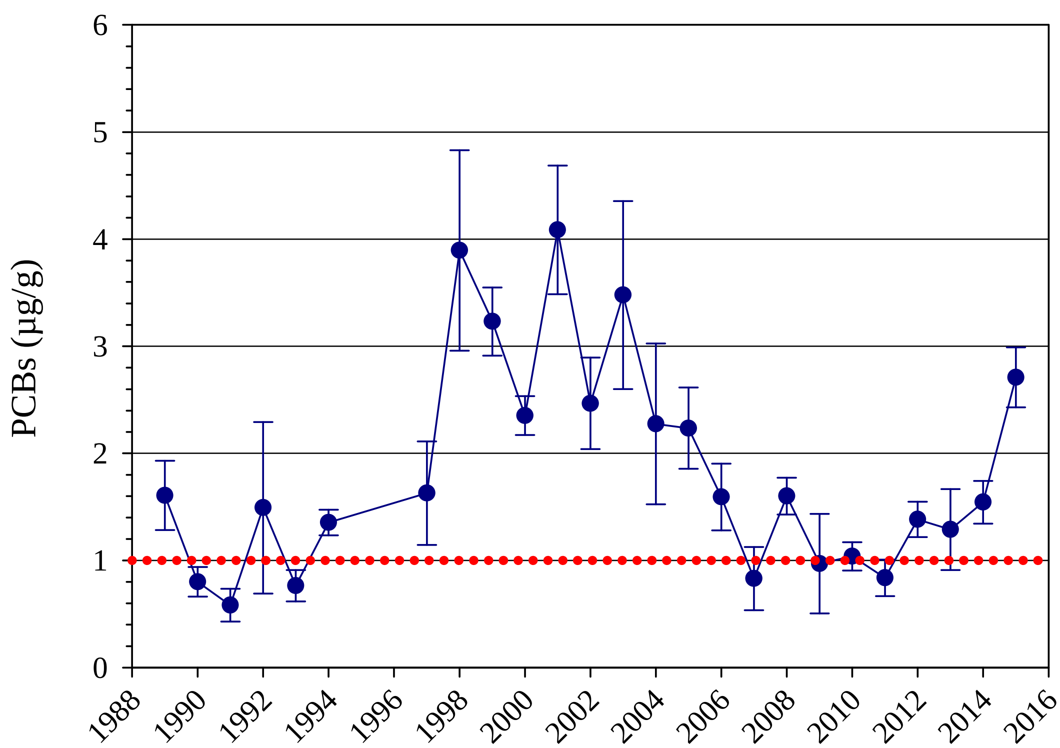


Figure 8.57. Mean PCB concentrations in redbreast sunfish from Mitchell Branch, FY 1993 – 2015.

Red dotted line signifies the remediation goal for K-1007-P1 Pond at ETTP (1 µg/g PCBs in fish fillet).

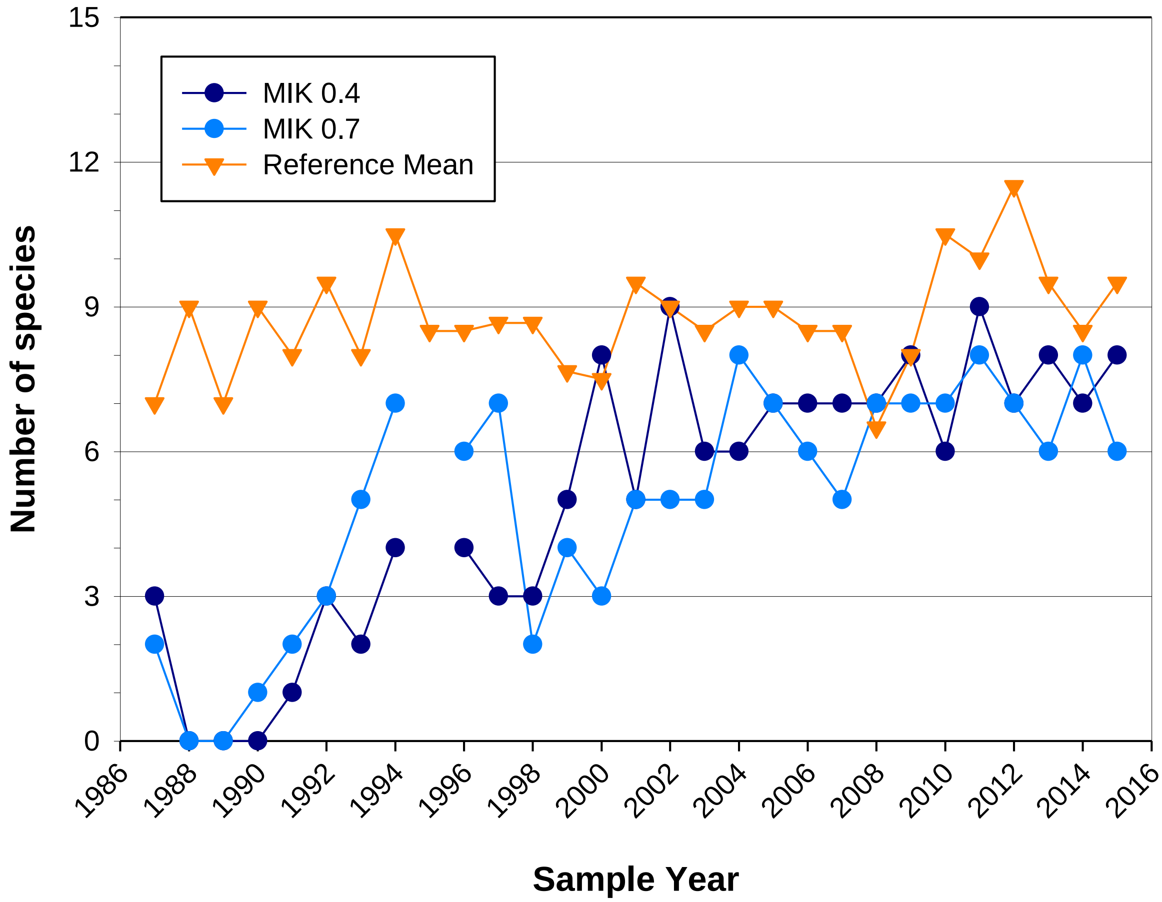
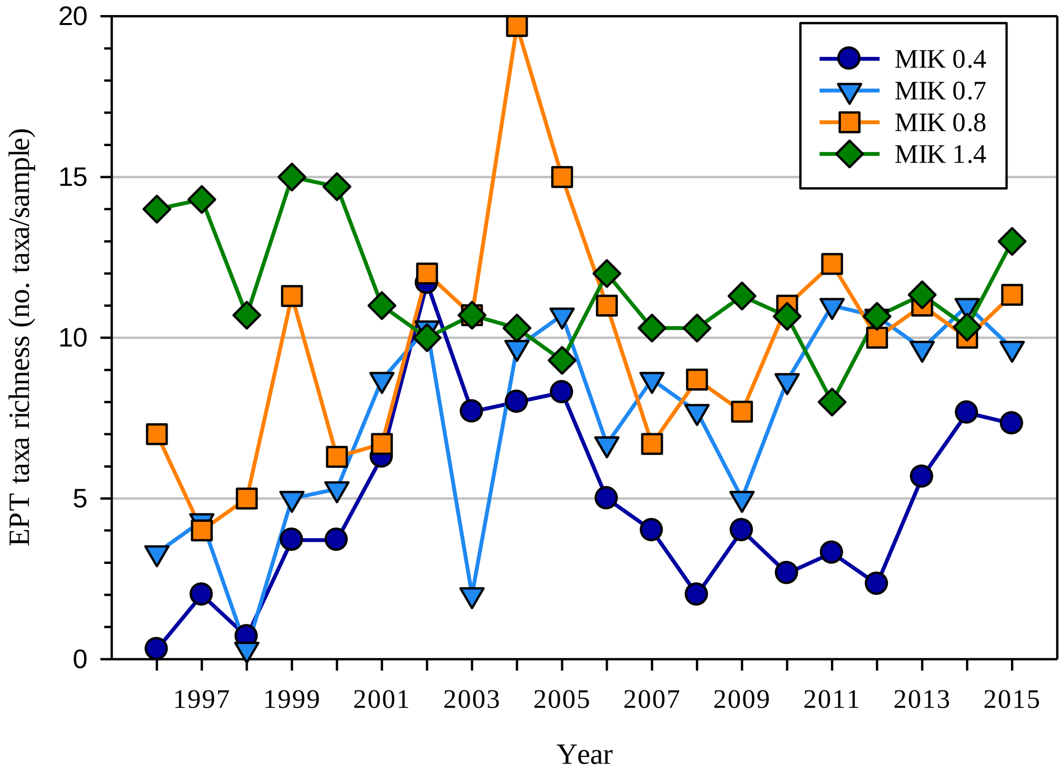


Figure 8.58. Species richness (number of species) in spring samples of the fish community in Mitchell Branch (MIK) and the mean value of three reference streams, Scarboro Creek, Mill Branch, and Ish Creek, 1989 – 2015[a]

[a]Interruptions in data lines indicate missing samples.

There has been a notable increase in the mean number of pollution intolerant taxa (i.e., EPT taxa richness) collected per sample at MIK 0.4 in the past three years, but the number of taxa remains lower than what occurs at the reference site, thus, suggesting that the invertebrate community remains moderately degraded at this site (Figure 8.59). The number of pollution intolerant taxa collected at MIKs 0.7 and 0.8, in contrast, continues to be comparable to the reference site MIK 1.4 (Figure 8.59, top graph). The percent density of the EPT taxa at all three downstream sites continues to be much lower than at the reference site (Figure 8.59, bottom graph). Thus, while improvements are evident at MIK 0.7 and MIK 0.8, evidence of degraded conditions persists.



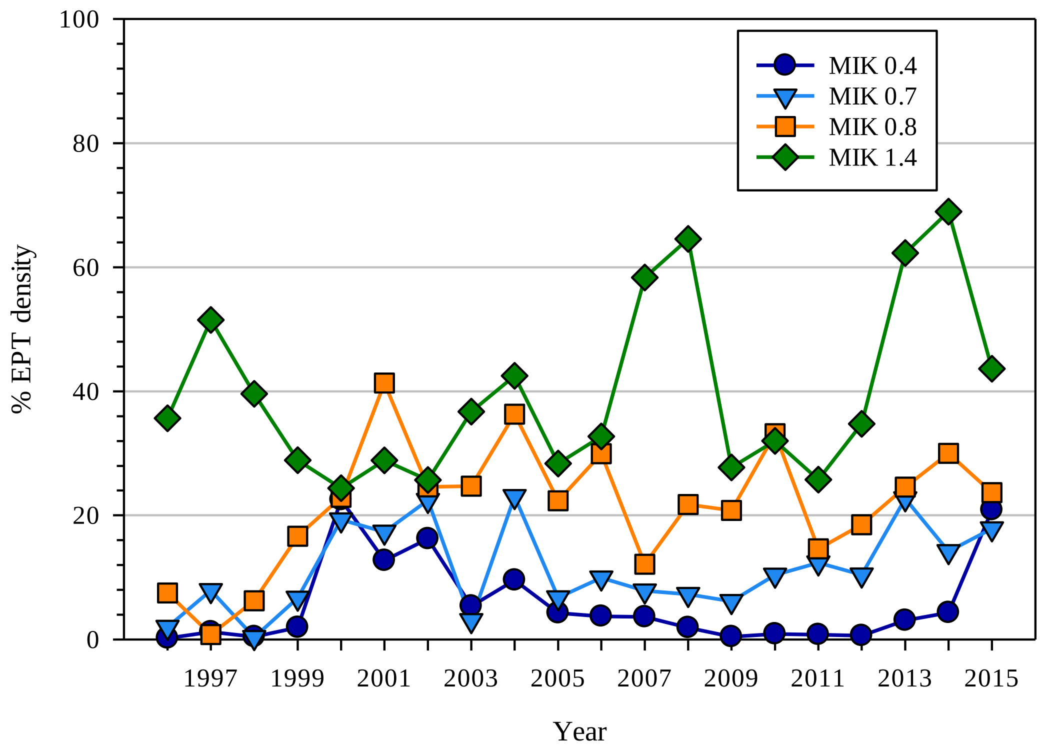


Figure 8.59. Mean (n = 3) taxonomic richness (top) and percent density (bottom) of the pollution-intolerant taxa (EPT taxa) for the benthic macroinvertebrate community at sites in Mitchell Branch, April sampling periods, 1996 – 2015.

EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

8.6.6 Monitoring Summary

During FY 2015, surface water and groundwater monitoring indicates that contaminant levels are generally stable to decreasing in most instances and are consistent with the data from previous years. All surface water radiological data were below the screening level of 4% of the DCS. VOC concentrations at the Mitchell Branch K-1700 weir are well below the applicable AWQC and the benchmark values for potential surface water toxicity. Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell Branch. Total chromium and hexavalent chromium in Mitchell Branch are below AWQC.

In FY 2015, mercury continued periodically to exceed the AWQC in storm water outfalls, surface water locations, and groundwater monitoring wells and exceeds the EPA's recommended criterion in fish tissue. The long-term trend at the K-1700 Mitchell Branch exit pathway location shows a continuing decline from peak levels in FY 2010. Knowledge of historical mercury processes has increased substantially, and these legacy sources of mercury contamination will be addressed under planned CERCLA response actions for D&D and soil remediation.

VOCs are the most significant groundwater contaminant at ETTP. TCE concentrations in wells BRW-003 and BRW-017 in the K-1064 Peninsula area and from the PC-0 spring in the K-901-A Holding Pond area are continuing to decline. At the K-770 area, the alpha and beta activity levels have reached relatively low levels, although seasonal fluctuations are apparent in the data. Measured alpha and beta activity levels in K-770 area groundwater were below drinking water screening levels in FY 2015. At the K-901-A Holding Pond area, there were increases in detected alpha and beta activity in all four wells. Additional radiological analyses will be performed in FY 2016. Chromium concentrations in UNW-043 in the K-31/K-33 area continued to be much lower than the MCLs. In the K-27/K-29 area, VC continues to slightly exceed the MCL in BRW-058, VOCs in BRW-016 are decreasing and are below MCLs, and TCE in UNW-038 fluctuates between 10 – 20 times the MCL.

Following demolition of Building K-25, ^{99}Tc was found in storm water and underground utilities associated with Building K-25. During FY 2015, two phases of a subsurface ^{99}Tc investigation were completed. This investigation confirmed the conceptual model that ^{99}Tc percolated from the Building K-25 slab into the backfill around the electrical duct bank. The ^{99}Tc was transported rapidly along this utility corridor to the areas where the high concentrations are currently detected, along the eastern side of the Building K-25 East Wing. The groundwater plume trajectory is to the south/southwest from the duct bank manholes 21 and 22 and to the northeast from the K-1413 area toward Mitchell Branch. In FY 2015, ^{99}Tc sampling of storm water discharges and in the sanitary sewer system shows both in compliance with the DOE Order annual sum-of-fractions requirement.

Aquatic biological monitoring of Mitchell Branch indicates mercury and PCBs are elevated in fish to concentrations above human health thresholds, and fish and benthic communities remain impaired relative to upstream and reference sites, especially in the lower sections.

8.7 ETTP ISSUES AND RECOMMENDATIONS

The issues and recommendations for the ETTP watershed are in Table 8.14.

Table 8.14. Summary of technical issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issues Carried Forward[b]			
1. The northern section of ETTP Zone 1 has been identified as a conservation easement (BORCE). The BORCE is utilized for recreational use: hiking, bicycling, and select controlled deer hunts. The end use identified in the ETTP Zone 1 ROD is unrestricted industrial, i.e., recreational use was not designated. (2010 RER)	1. DOE acknowledges the land use differences that exist between the BORCE and that which is designated in the Zone 1 ROD. The *Final Proposed Plan for Soils in Zone 1 at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2648&D3) addresses anticipated future industrial and recreational land use in Zone 1. The determination in the Proposed Plan that industrial use goals for Zone 1 are also protective of recreational uses is planned to be included in the Zone 1 Final Soils ROD.	DOE/EPA & TDEC	FY 2016 with Zone 1 Final Soils ROD
Completed/Resolved Issues			
1. An asphalt cover has been placed over the K-29 slab since approval of the CERCLA completion document for building demolition. (2014 RER)	1. Agreement has been reached on the management of potentially contaminated slabs, and this agreement has been documented in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4). The ETTP Project Team has agreed to apply this management approach to the K-29 slab and document it accordingly.	DOE/EPA & TDEC	FY 2015
2. There are several issues associated with the interim management of potentially contaminated slabs at ETTP. Monitoring requirements identified in demolition completion documents have been changed or eliminated following a RA decision for the area without appropriate interaction. The frequency of radiological monitoring by the Radiation Protection Program has changed without notification to the Regulators. Fixatives placed over radiological contamination do not have specified inspection and maintenance requirements. (2013 RER)	2. Agreement has been reached on the management of potentially contaminated slabs, and this agreement has been documented in the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4).	DOE/EPA & TDEC	FY 2015

[a]An issue identified as a "Current Issue" indicates an issue identified during evaluation of current FY 2015 data for inclusion in The 2016 RER. Issues are identified in the table as an "Issue Carried Forward" to indicate that the issue is carried forward from a previous year's RER so as to track the issue through resolution. Any additional discussion will occur at the appropriate CERCLA Project Team level.

[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

BORCE = Black Oak Ridge Conservation Easement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FY = fiscal year
RER = Remediation Effectiveness Report
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation

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9. CERCLA ACTIONS AT OTHER SITES

9.1 INTRODUCTION AND STATUS

9.1.1 Introduction

This chapter presents the remedial effectiveness evaluation for CERCLA actions that are not physically situated within one of the five established watersheds or Chestnut Ridge but are located on the ORR. Table 9.1 lists these CERCLA actions and identifies those with monitoring and other LTS requirements. Figure 9.1 locates the key CERCLA sites and actions. In subsequent sections the effectiveness of each completed action is assessed by discussing performance monitoring objectives and results and other LTS requirements and status. Table 9.2 lists the other LTS requirements for these CERCLA actions. Figure 9.2 shows interim controls requiring LTS.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions not located in the five established watersheds or Chestnut Ridge is provided in Chapter 11 of Volume 1 of the *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2516&D2). This information is updated in the RER and published every fifth year in the CERCLA FYR.

9.1.2 Status Update

During FY 2015, no additional CERCLA actions were implemented or completed at the White Wing Scrap Yard, the Oak Ridge Associated Universities South Campus Facility, or elsewhere on the ORR in the area that falls outside the five established watersheds and Chestnut Ridge. Monitoring in support of performance assessments and evaluations continued.

9.2 WHITE WING SCRAP YARD

The White Wing Scrap Yard is located north of the western end of BCV (Figure 9.3). This RA removed contaminated surface debris retrievable without excavation. Buried material remains at the site.

9.2.1 Other LTS Requirements

White Wing Scrap Yard has LTS requirements (Table 9.2). There are no LTS requirements in the *Interim Record of Decision for the Oak Ridge National Laboratory Waste Area Grouping 11 Surface Debris* (DOE/OR-1055&D4). However, the *Interim Remedial Action Postconstruction Report for Waste Area Grouping 11 at Oak Ridge National Laboratory* (DOE/OR/01-1263&D2) states, *"because the interim remedial action was to remove debris, no operation and maintenance are necessary as a result of the interim action. However, long-term S&M will continue until decisions are made for future and/or final CERCLA remedial actions at the site."*

Table 9.1. CERCLA actions at Other Sites on the ORR

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Other LTS required
White Wing Scrap Yard (WAG 11) Surface Debris	IROD (DOE/OR-1055&D4): 10/06/92	PCR[b] (DOE/OR/01-1263&D2) approved 09/14/94	No/Yes
Oak Ridge Associated Universities South Campus Facility	ROD (DOE/OR/02-1383&D3): 12/28/95	RAR (DOE/OR/02-1474&D2) approved 08/20/96	Yes/Yes

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* (DOE/OR-1014) and is available at <http://www.ucor.com/ettp_ffa_appendices.html>.
[b]This action was completed prior to uniform adherence to the RAR process; hence, no RAR exists for this decision.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
IROD = Interim Record of Decision
LTS = long-term stewardship
ORR = Oak Ridge Reservation
PCR = post construction report
RAR = remedial action report
ROD = Record of Decision
WAG = Waste Area Grouping

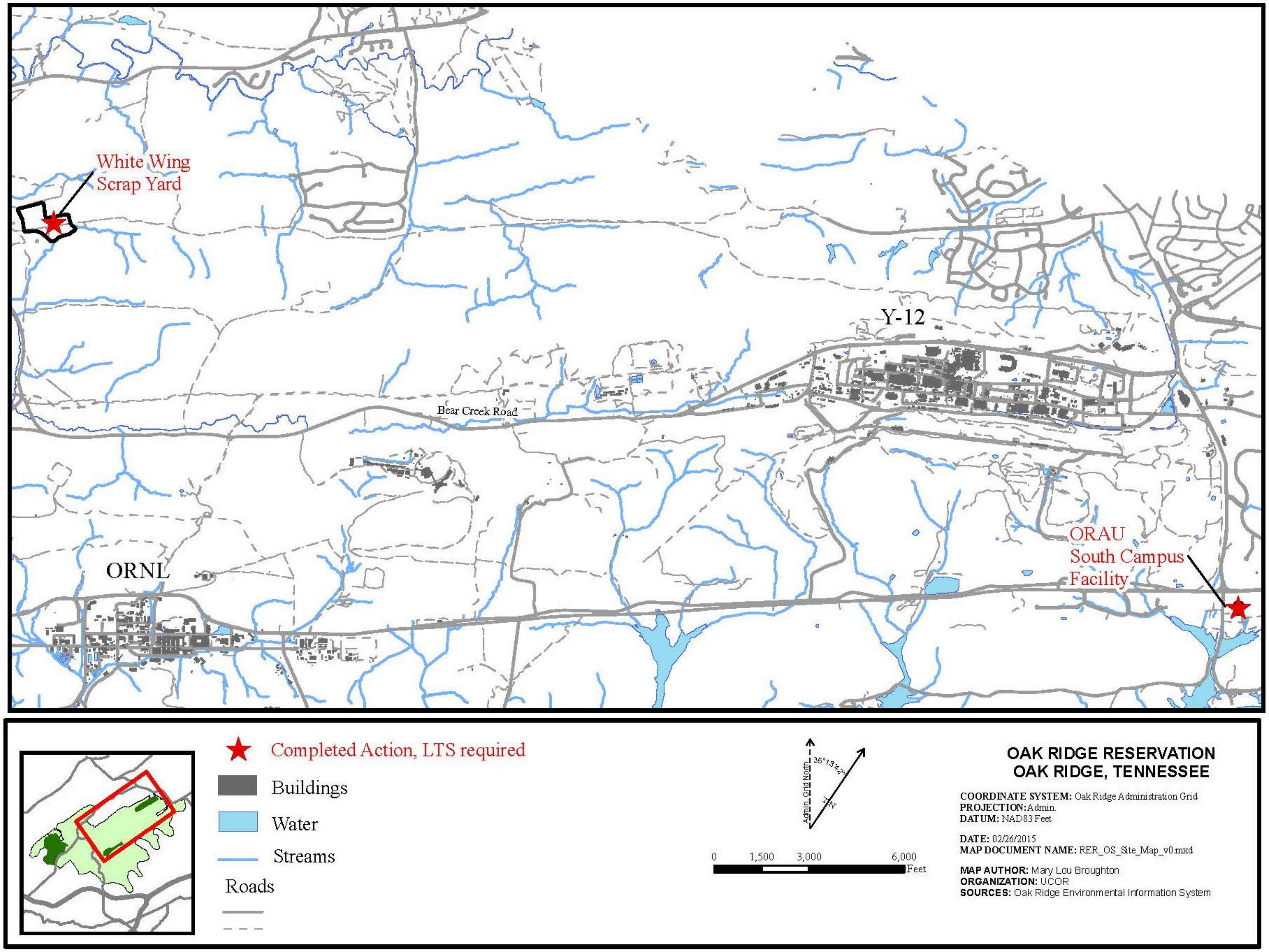

Figure 9.1. Other Sites on the ORR.

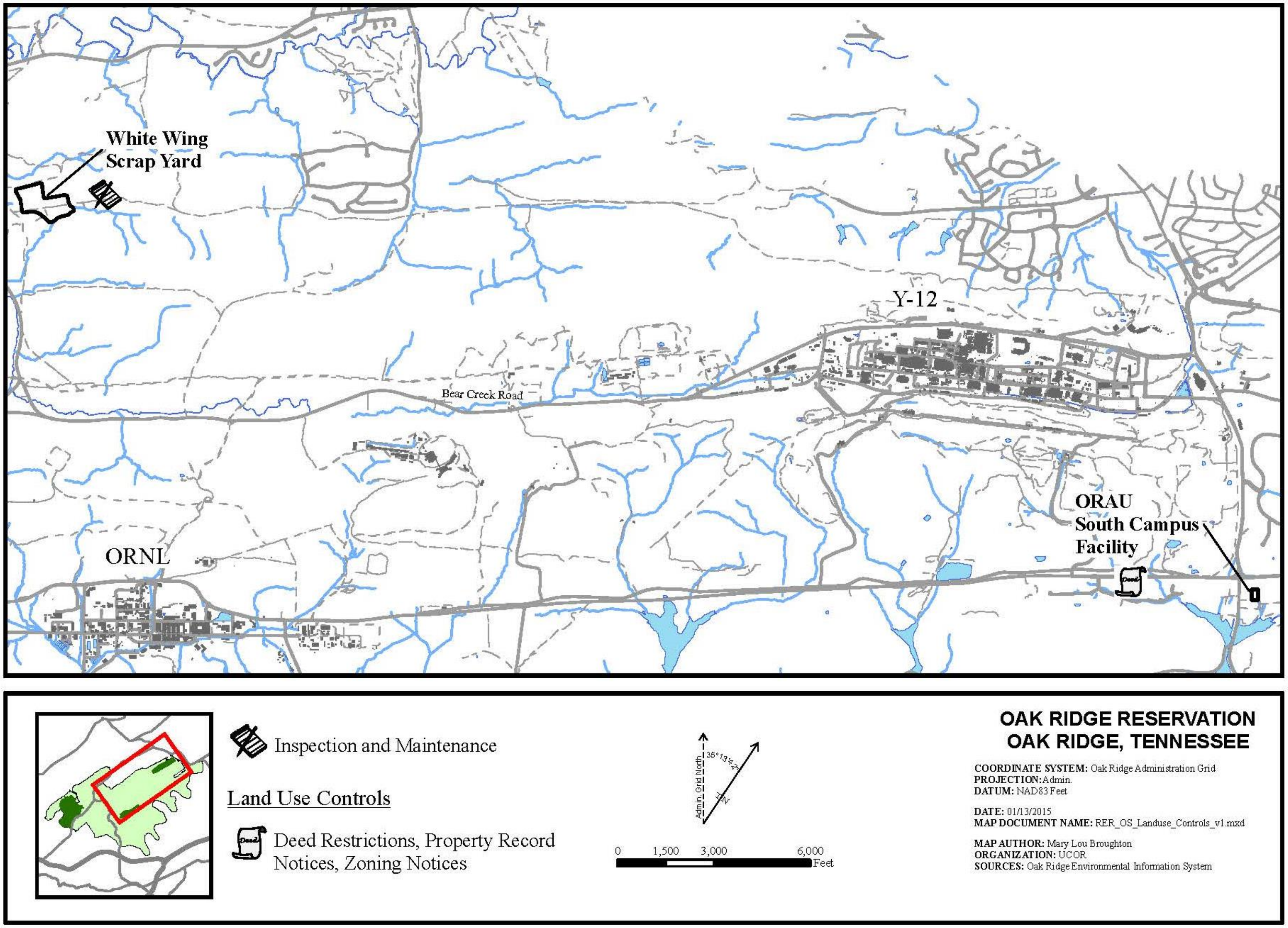

Figure 9.2. Interim controls requiring LTS at Other Sites on the ORR.

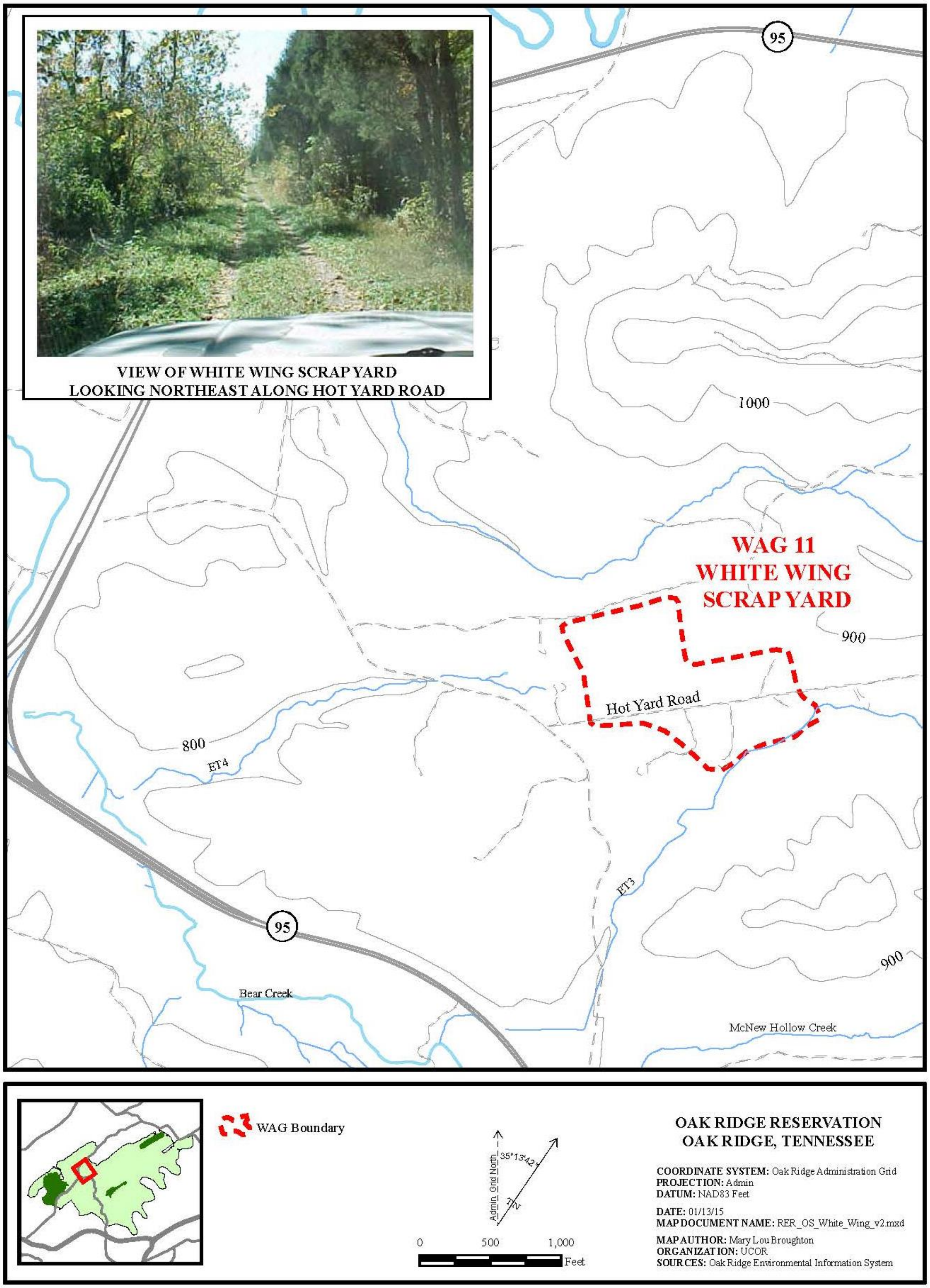

Figure 9.3. Location of White Wing Scrap Yard.

Table 9.2. Other LTS requirements for Other Sites

Other LTS requirements for Completed Actions Other Sites[a]			
Specific Areas	**Project Documents**	**Other LTS Requirements**	**Frequency/Implementation**
White Wing Scrap Yard (WAG 11) Surface Debris	PCR (DOE/OR/01-1263&D2)	• Because the interim RA was to remove the debris, no operation and maintenance are necessary as a result of the interim action. However, long-term S&M will continue until decisions are made for future and/or final CERCLA RAs at the site.	• Long-term S&M will continue until decisions are made for future and/or final CERCLA RAs at the site
Oak Ridge Associated Universities South Campus Facility	ROD (DOE/OR/02-1383&D3) RAR (DOE/OR/02-1474&D2)	• A notification will be added to the Deeds of Records at the Anderson County Courthouse alerting potential owners to the TCE contamination	• FYRs are required until natural attenuation in the zone of contamination decreases TCE concentrations below regulatory levels of concern

[a]LTS for specific areas is determined by each remediation project and listed in the project specific completion report.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
FYR = Five-Year Review
LTS = long-term stewardship
PCR = Post-construction Report
RA = remedial action
RAR = Remedial Action Report
ROD = Record of Decision
S&M = surveillance and maintenance
TCE = trichloroethene
WAG = Waste Area Grouping

9.2.2 Status of Requirements

The Y-12 S&M Program performed monthly inspections in FY 2015 to inspect components including deteriorating access road conditions; damaged or missing gate locks or unlocked gate; debris buildup or blockage at the fence/creek boundaries; unauthorized materials placed within the area; and damage to site perimeter fencing. Additionally, inspections included the separate fenced-in area west of the scrap yard. S&M personnel inspected the fencing by walking the entire perimeter of the site and the west fenced area. Site maintenance in FY 2015 included removing trees that had fallen on the fencing.

9.3 OAK RIDGE ASSOCIATED UNIVERSITIES SOUTH CAMPUS FACILITY

9.3.1 Performance Monitoring

9.3.1.1 Performance Monitoring Goals and Objectives

The South Campus Facility is a former experiment station where the radionuclide effects on animals were studied (Figure 9.4). The *Record of Decision for Oak Ridge Associated Universities South Campus Facility* (DOE/OR/02-1383&D3) specified groundwater monitoring in the vicinity of a VOC contaminated area and LUCs that include a groundwater use restriction.

The *Record of Decision for Oak Ridge Associated Universities South Campus Facility* (DOE/OR/02-1383&D3) did not establish clear goals for groundwater quality; however, it did specify periodic monitoring of groundwater at selected wells and at a surface seep location. The *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2289&D3) recommended continued annual sampling of two wells (GW-841 and GW-842) and two surface water locations (SCF-WS1 and SCF-WS2). The *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation* (DOE/OR/01-2516&D2) recommended that the remedy be continued as monitored natural attenuation for groundwater with the ultimate goal of reaching MCLs for VOCs, that annual sampling be continued, and that the remaining wells (except GW-841 and GW-842) be plugged and abandoned.

9.3.1.2 Evaluation of Performance Monitoring Data

During FY 2015, samples were collected from wells GW-841, GW-842 and surface water locations SCF-WS1 and SCF-WS2 and were analyzed for VOCs. Figure 9.5 shows that the concentrations of detected VOCs in wells GW-841 and GW-842 from FY 1994 through FY 2015 have exhibited a long-term decreasing concentration history with mixed behavior between FY 2013 and FY 2015. The FY 2015 results show that TCE in well GW-841 increased slightly to 12 µg/L which is slightly more than twice the 5 µg/L drinking water standard. TCE in well GW-842 decreased slightly from a concentration of 3.2 µg/L in FY 2014 to 1.7 µg/L in FY 2015, which remains below the drinking water standard. Cis-1,2-DCE was detected in the sample from GW-841 at 20 µg/L compared to a concentration of 18 µg/L in FY 2014. In well GW-842 cis-1,2-DCE decreased from 1.2 µg/L in FY 2014 to 0.5 J µg/L in FY 2015 (J = estimated value). Both of the cis-1,2-DCE levels are much less than the 70 µg/L drinking water standard. VC was not detected in samples from either groundwater monitoring well in FY 2015. No VOCs were detected in surface water at the site during FY 2015.

9.3.2 Other LTS Requirements

Other LTS requirements for the South Campus Facility are listed in Table 9.2.

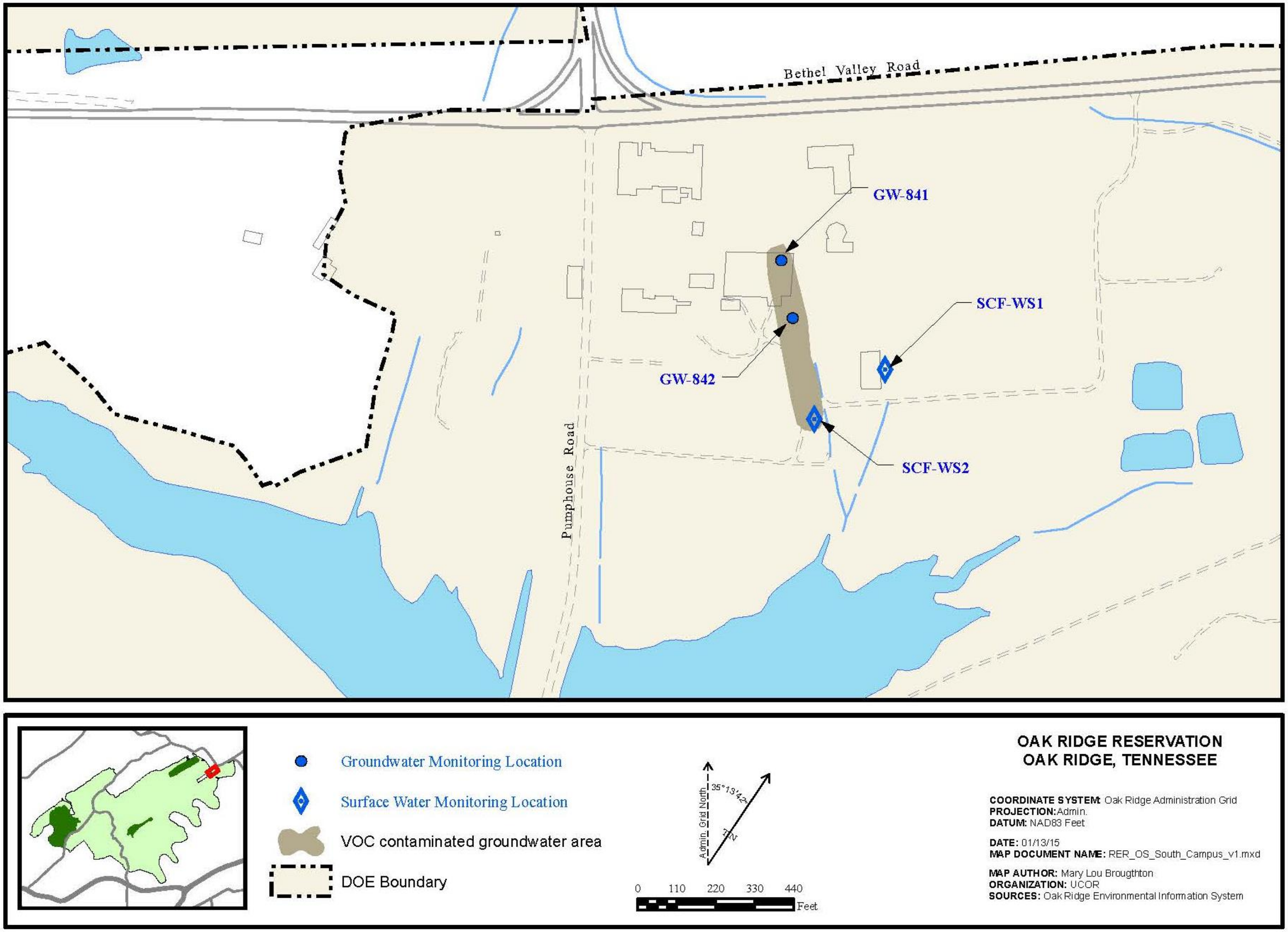

Figure 9.4. South Campus Facility monitoring locations and contaminated groundwater.

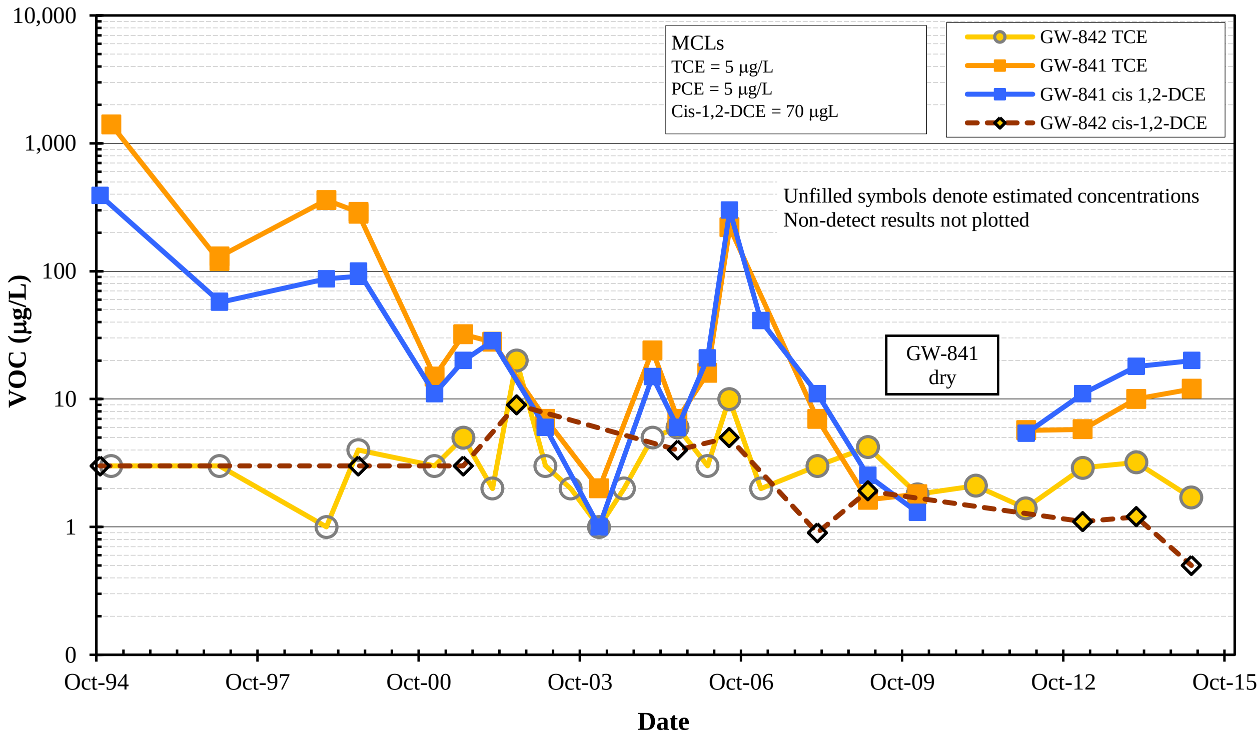

Figure 9.5. Organic compound concentrations in wells GW-841 and GW-842 at Oak Ridge Associated Universities South Campus Facility.

9.3.2.1 Requirements

The *Record of Decision for Oak Ridge Associated Universities South Campus Facility* (DOE/OR/02-1383&D3) requires that a notification of the contamination be placed in the property title to alert potential owners of risk. A notice was filed with the Anderson County Register of Deeds on August 28, 1996.

9.3.2.2 Status of Requirements

The land use restrictions have been maintained and groundwater monitoring has been conducted at the site. An online search of the Anderson County Register of Deeds web site conducted in FY 2015 verified the notice remains filed.

9.4 OTHER SITES ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Other Sites are in Table 9.3.

Table 9.3. Other Sites issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Current Issue			
None			
Issue Carried Forward			
None			
Completed/Resolved Issues[b]			
None			

[a]A "Current Issue" is an issue identified during evaluation of FY 2015 data for inclusion in the 2016 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

9.5 REFERENCES

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DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1383&D3. *Record of Decision for Oak Ridge Associated Universities South Campus Facility, Oak Ridge, Tennessee,* 1995, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1014. *Federal Facility Agreement for the Oak Ridge Reservation*, 1992, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1055&D4. *Interim Record of Decision for Oak Ridge National Laboratory Waste Area Grouping 11 Surface Debris, Oak Ridge, Tennessee*, 1992, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

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APPENDIX A
CERTIFICATION OF LAND USE CONTROL IMPLEMENTATION
FISCAL YEAR 2015

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Certification will be inserted in the D2 version.

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APPENDIX B
SELECTED OAK RIDGE NATIONAL LABORATORY GROUNDWATER DATA

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CONTENTS

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B.1 BETHEL VALLEY SOLID WASTE STORAGE AREA (SWSA) 3 GROUNDWATER HYDROGRAPHS

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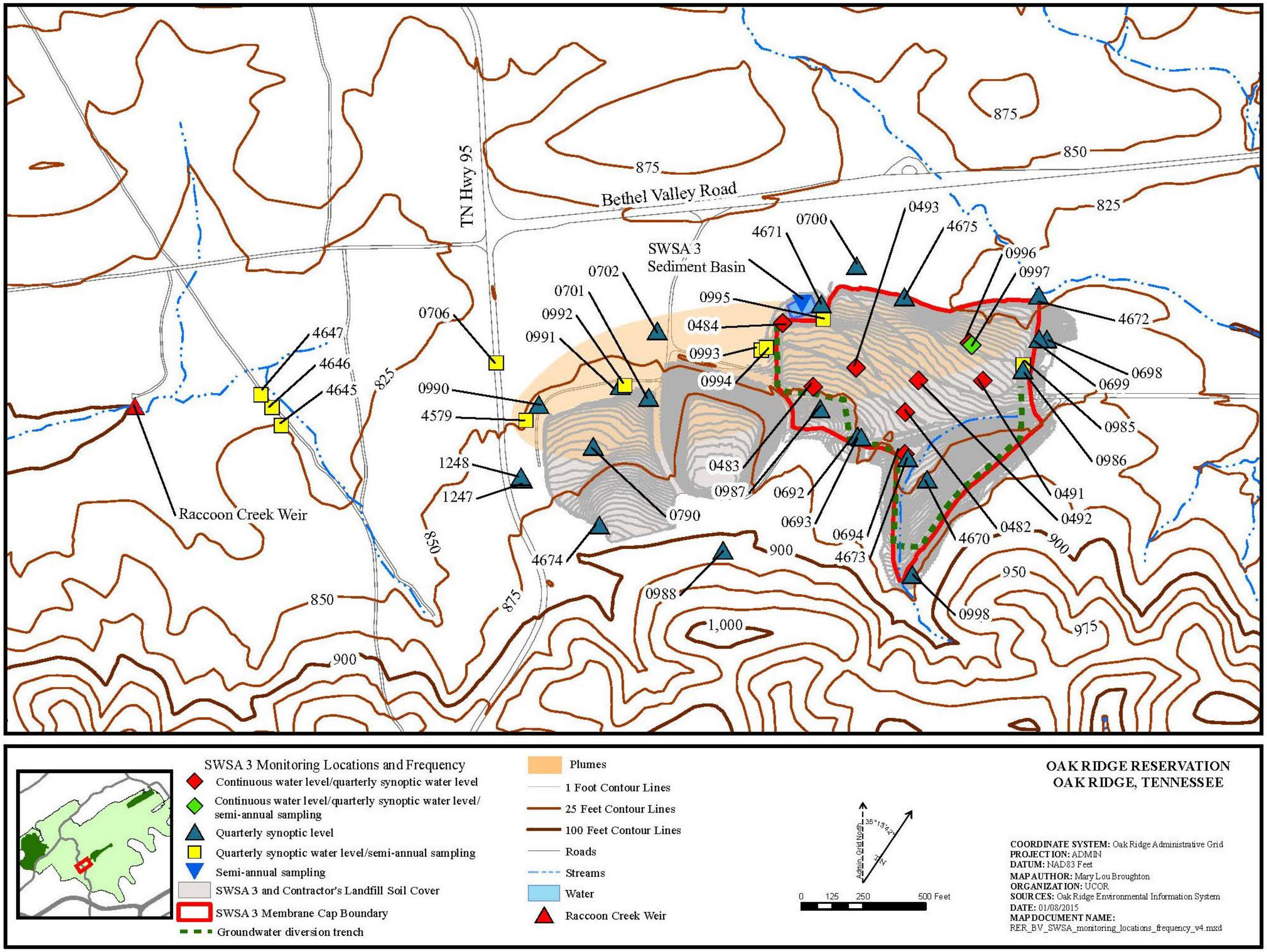

Figure B.1.1. Groundwater monitoring locations at SWSA 3.

Table B.1.1. SWSA 3 Target Groundwater Elevations and FY 2015 Average Levels

Well	Elevation Goal (ft aMSL)	FY 2015 Average Groundwater Elevation (ft aMSL)
0482	823	**826.93**
0483	835	827.88
0484	824	816.15
0491	816	**824.55**
0492	818.5	**823.79**
0493	829	820.99
0694	838.33	836.93
0996	814.31	808.04
0997	818.64	811.83

BOLD values indicate the elevation goal is exceeded.

aMSL = above Mean Sea Level
FY = fiscal year
SWSA = Solid Waste Storage Area

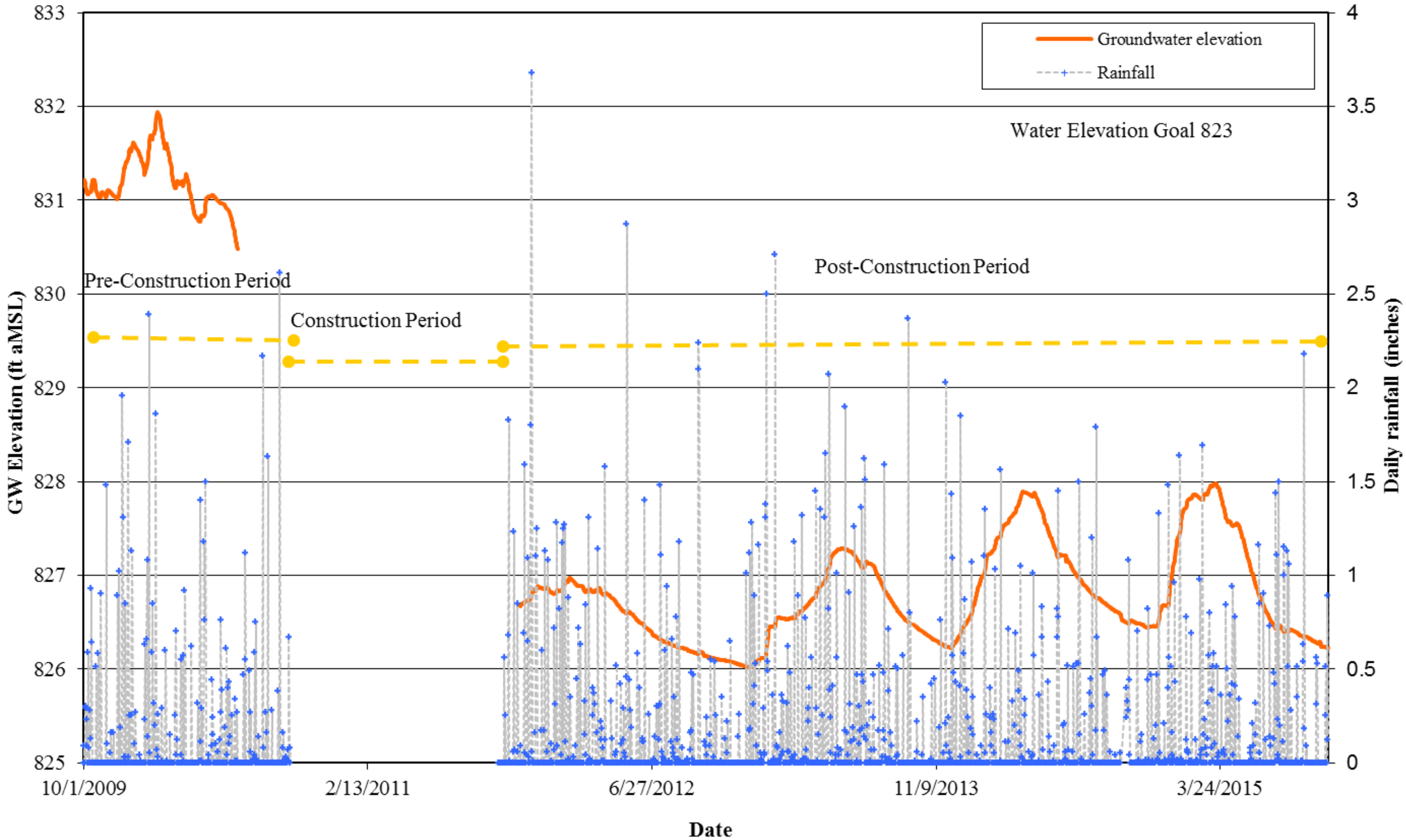

Figure B.1.2. Well 0482 Hydrograph.

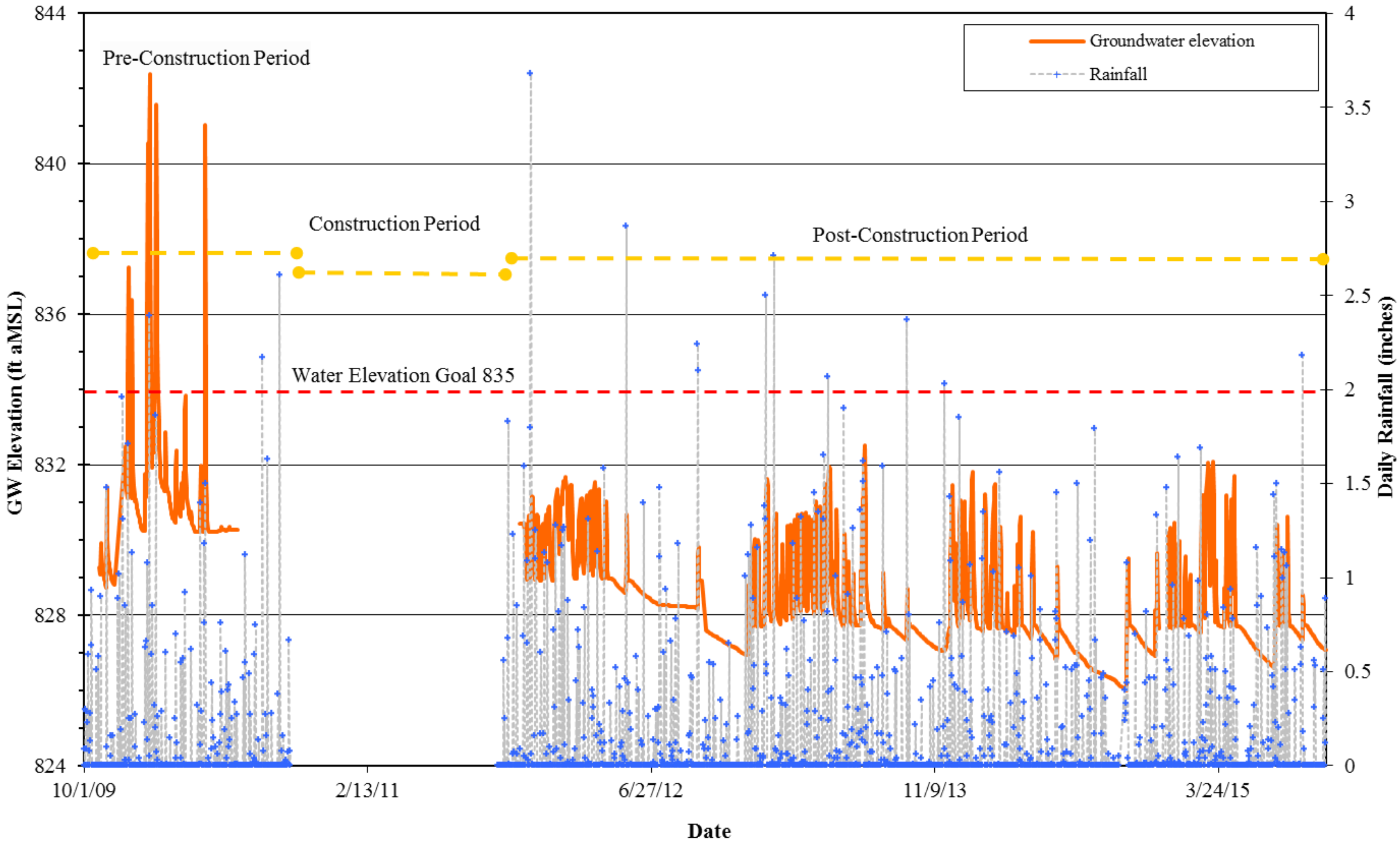

Figure B.1.3. Well 0483 Hydrograph.

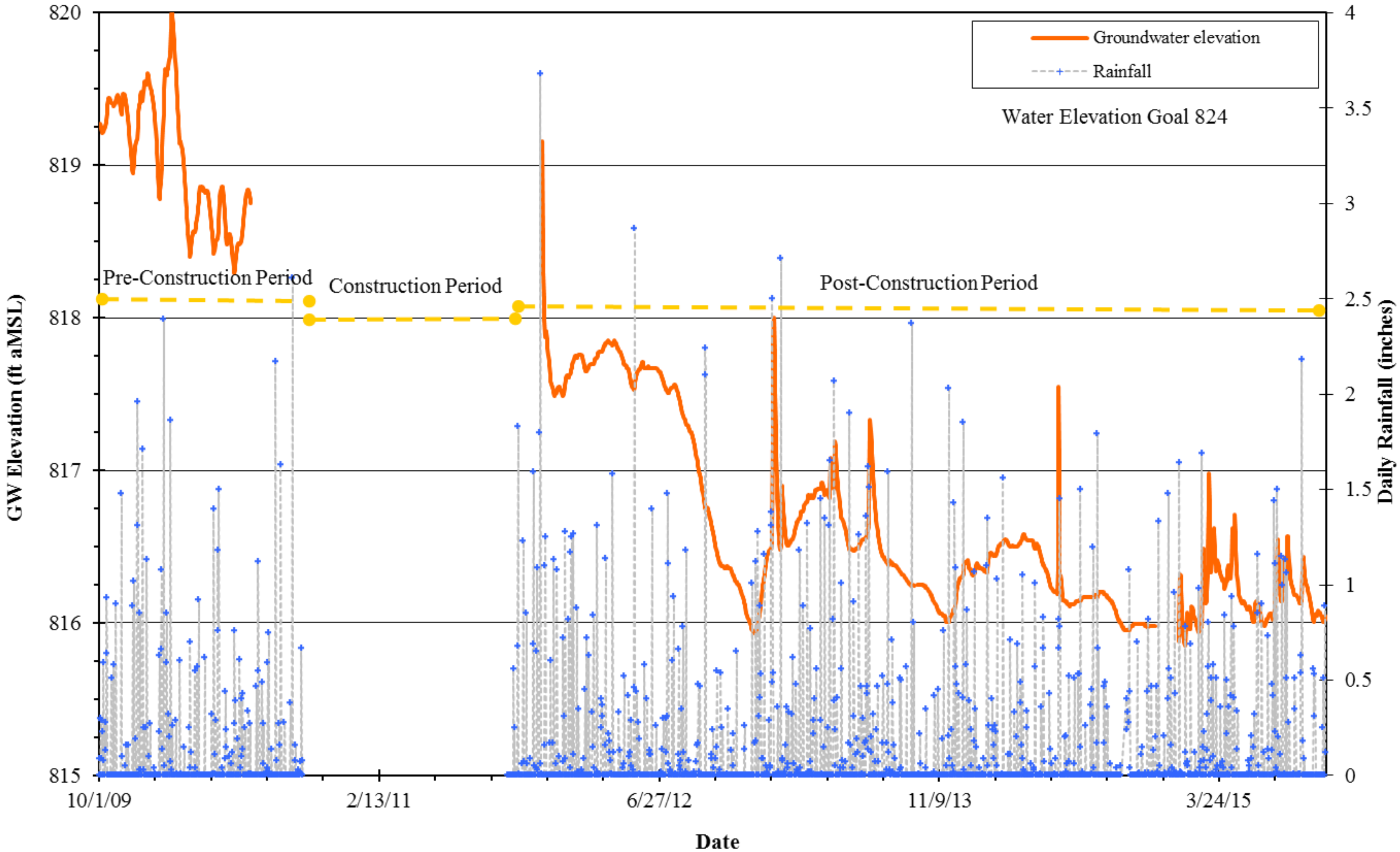

Figure B.1.4. Well 0484 Hydrograph.

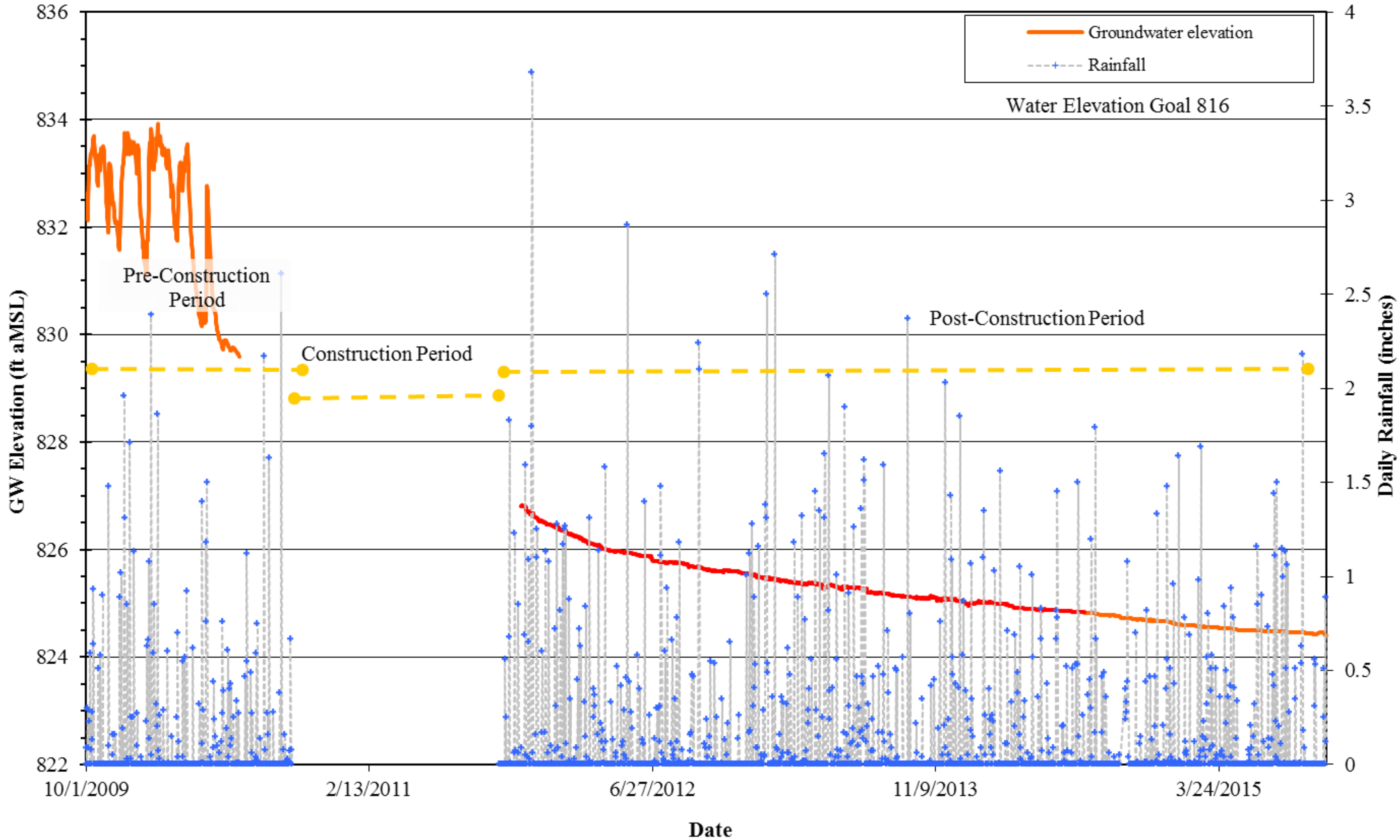

Figure B.1.5. Well 0491 Hydrograph.

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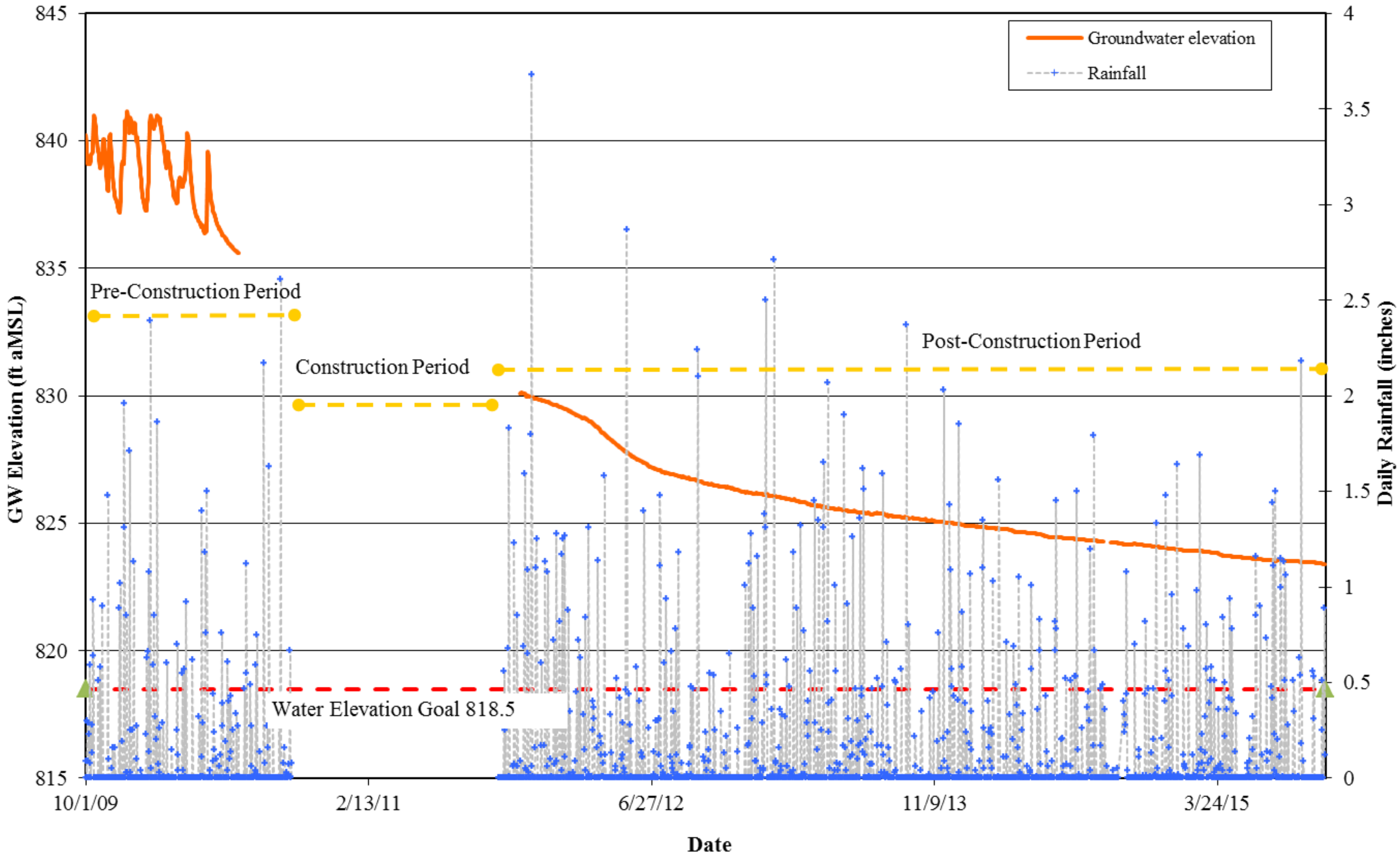

Figure B.1.6. Well 0492 Hydrograph.

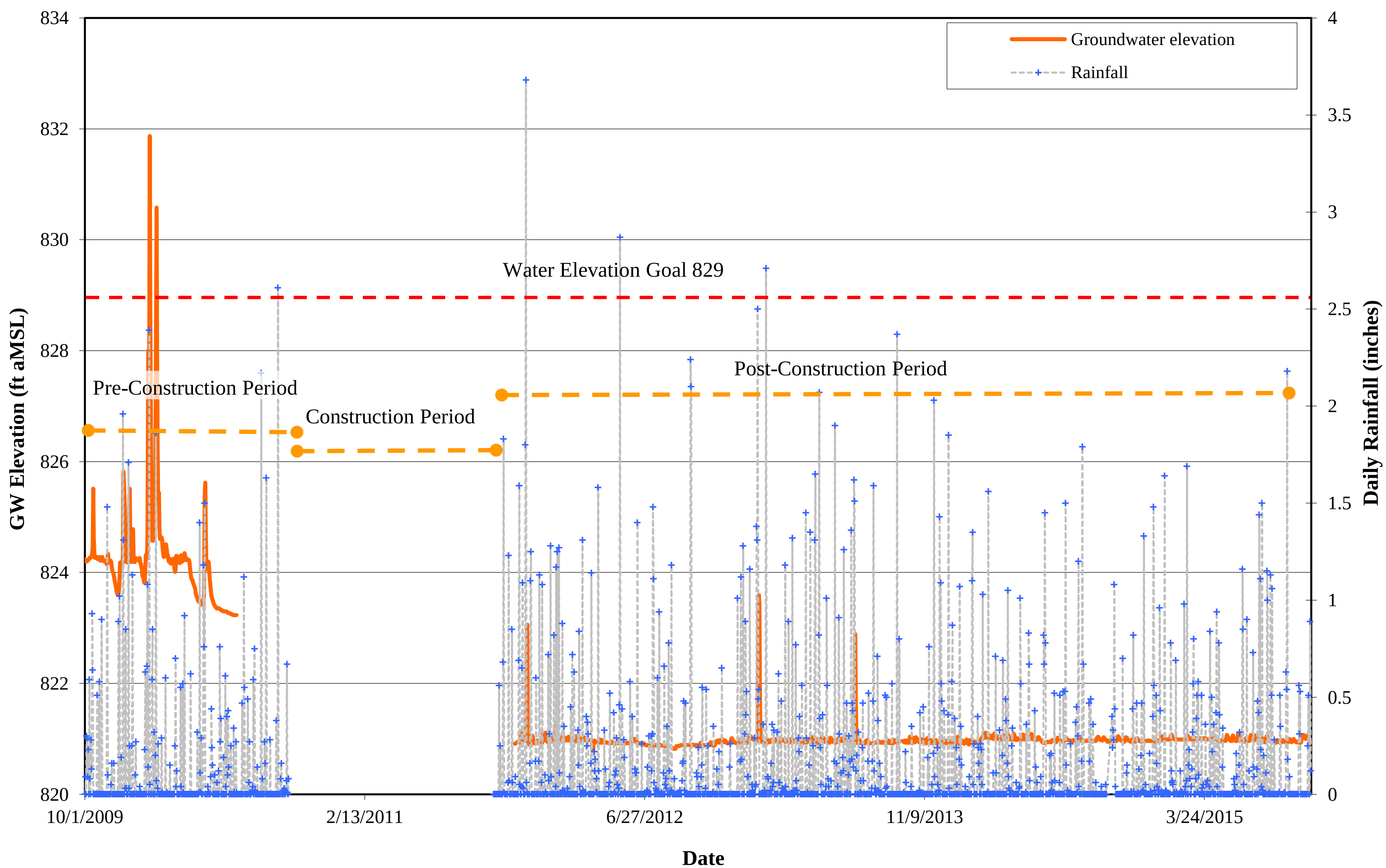

Figure B.1.7. Well 0493 Hydrograph.

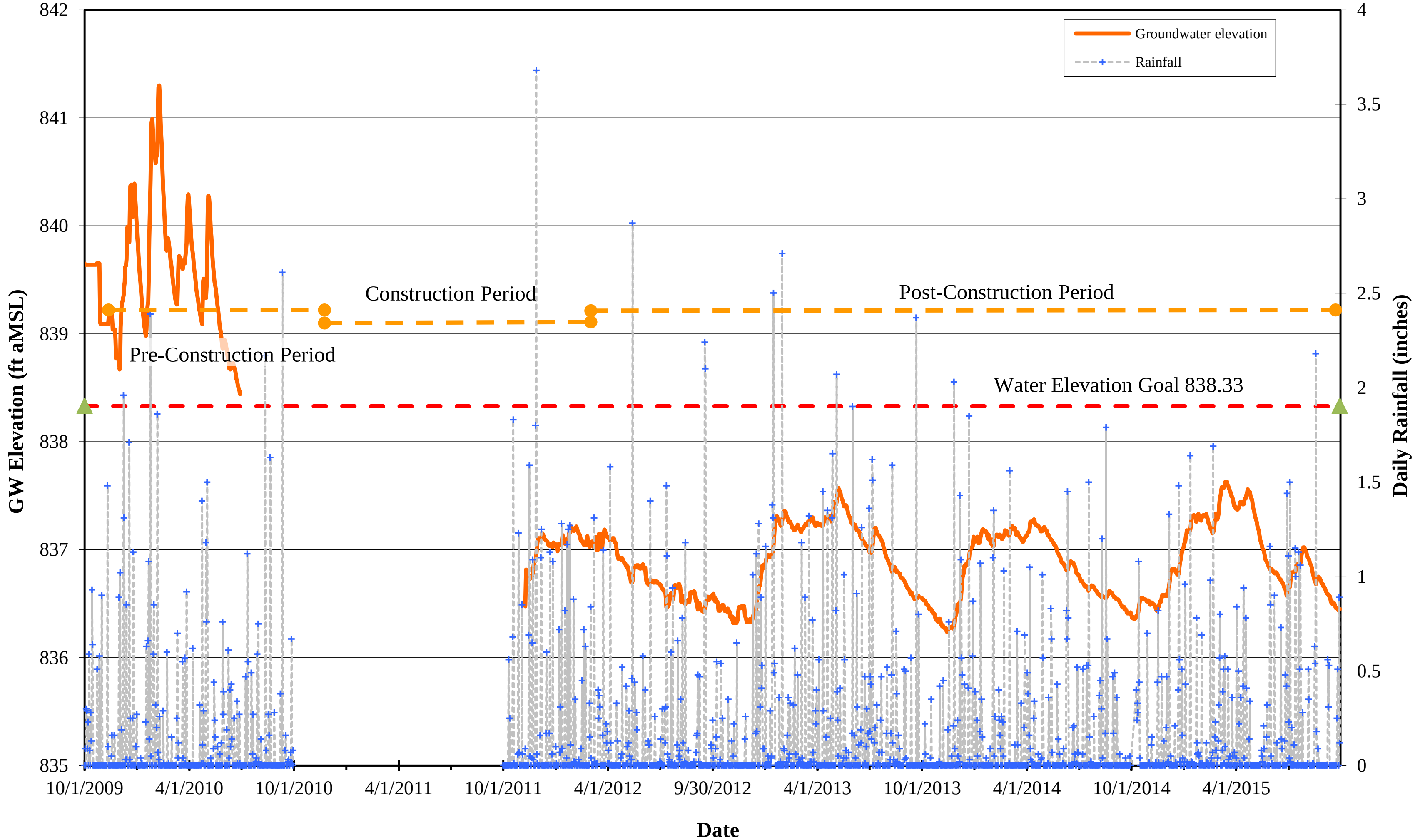

Figure B.1.8. Well 0694 Hydrograph.

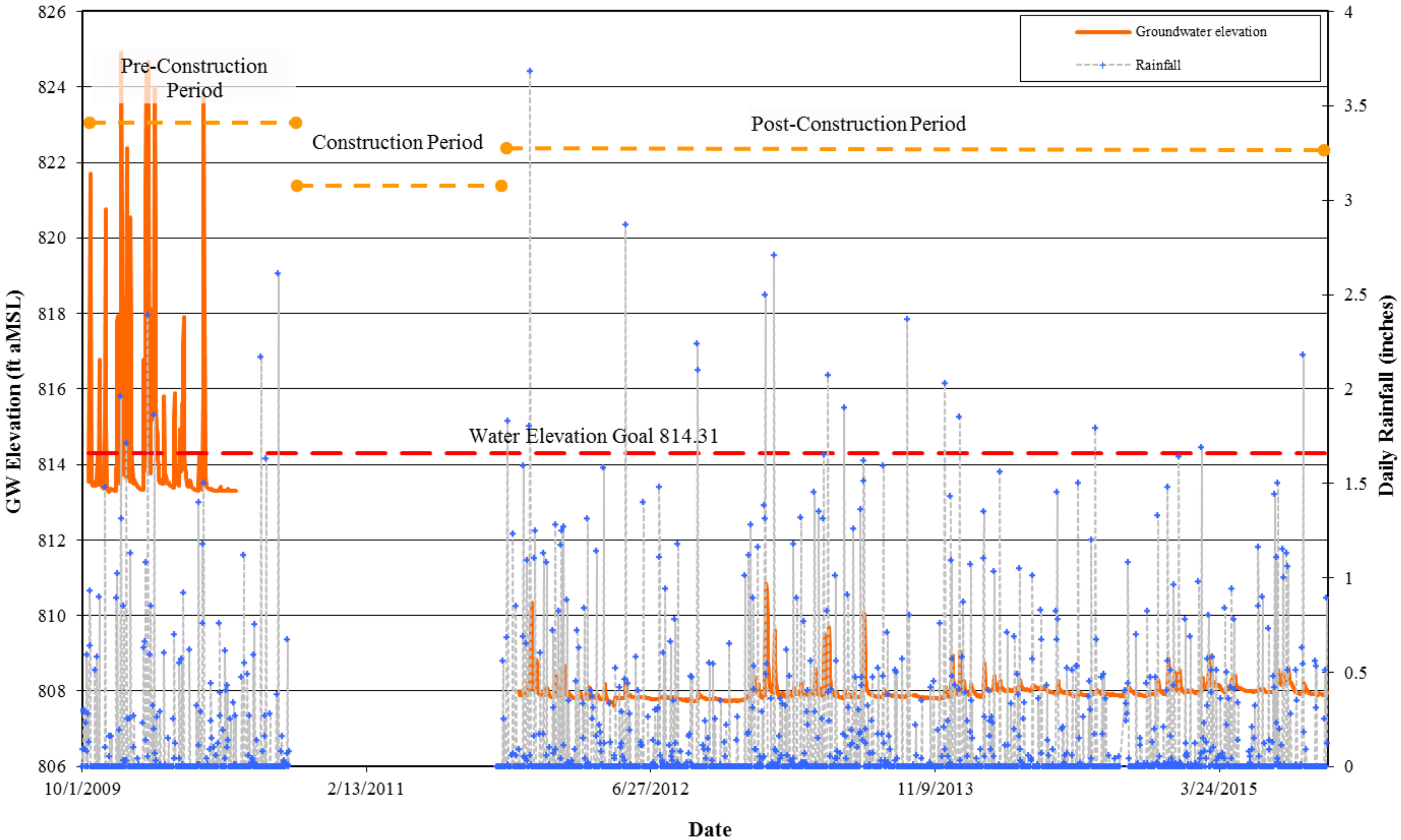

Figure B.1.9. Well 0996 Hydrograph.

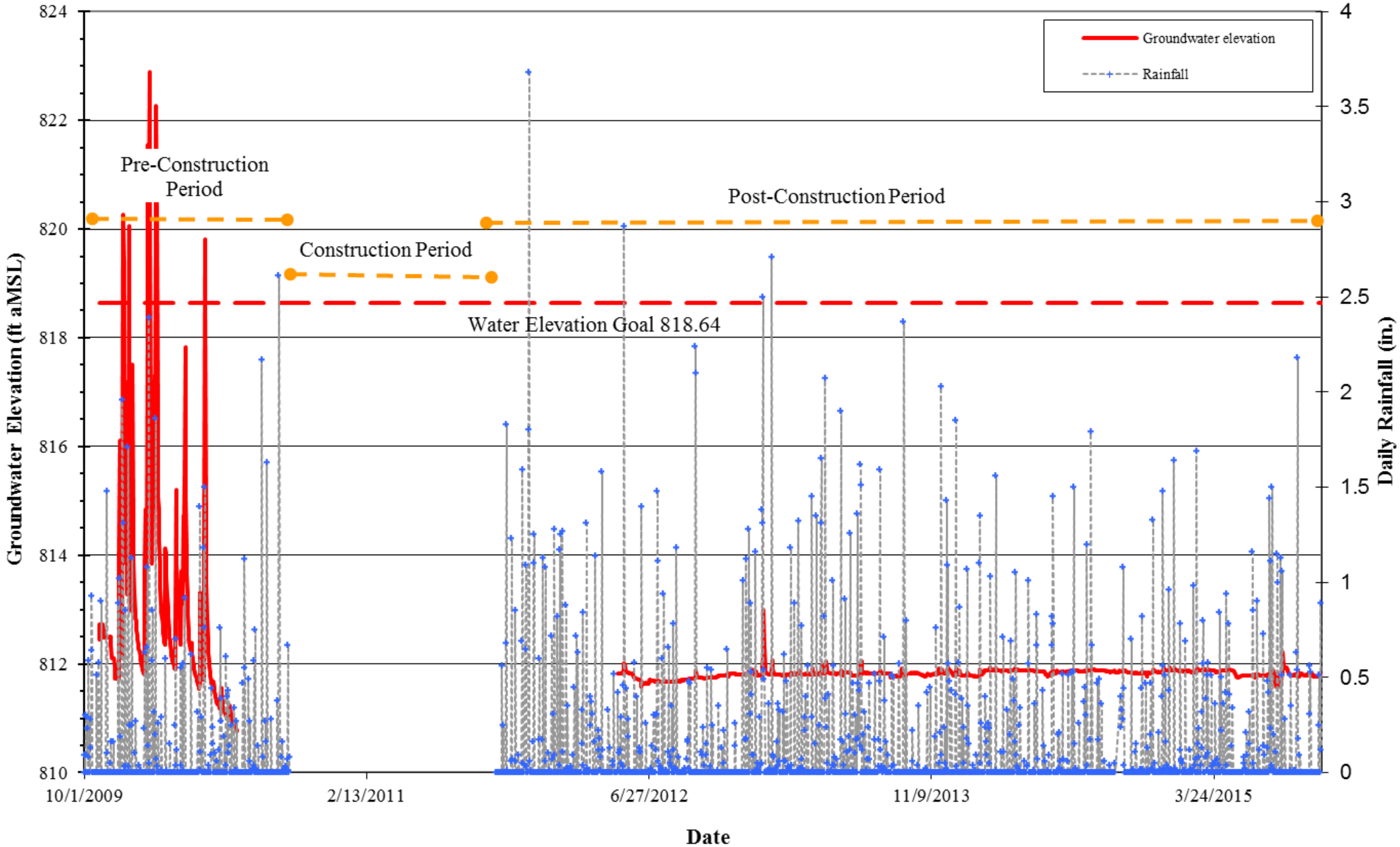

Figure B.1.10. Well 0997 Hydrograph.

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B.2 MELTON VALLEY GROUNDWATER LEVEL PERFORMANCE AND HYDROGRAPHS

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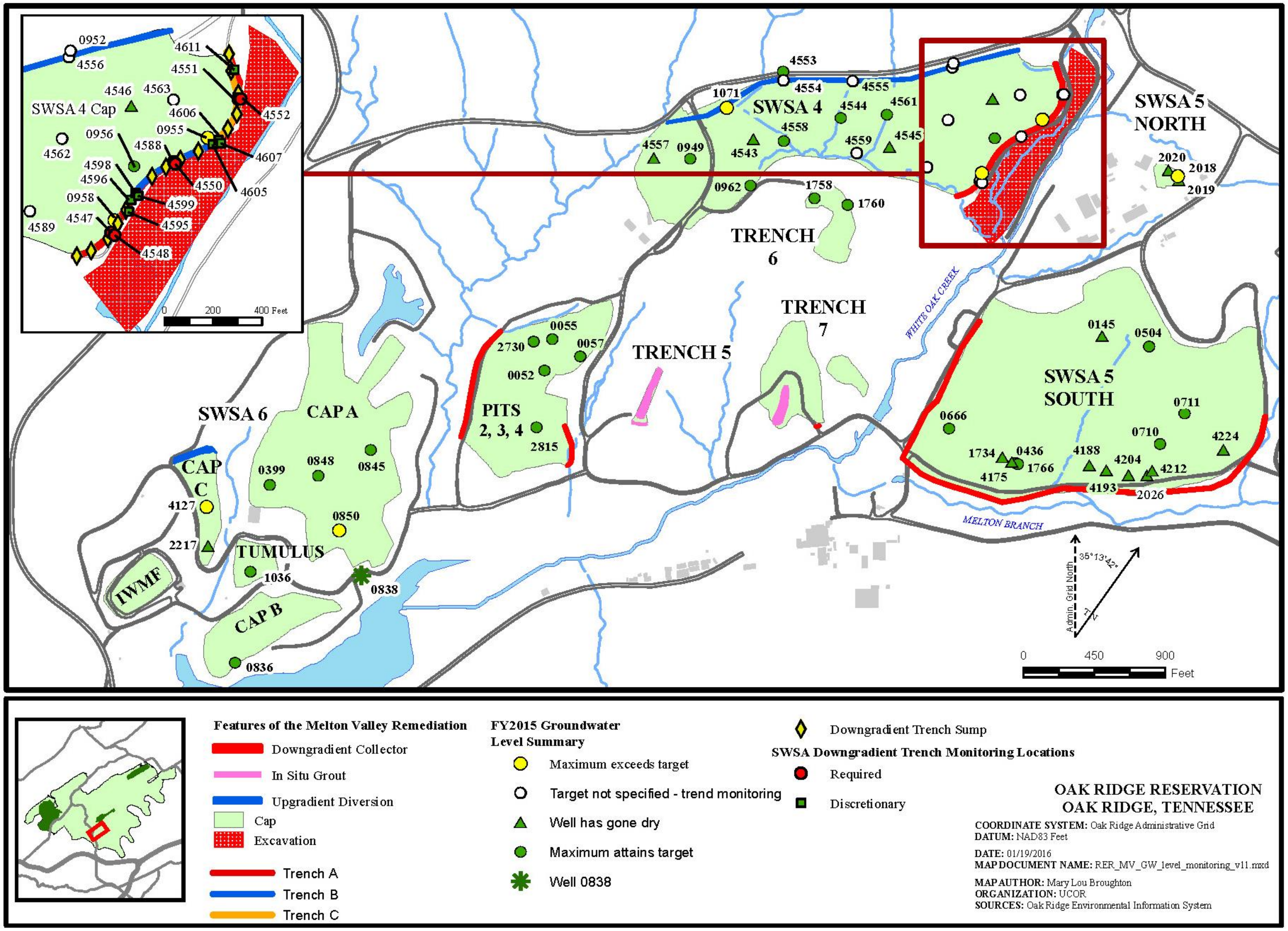


Figure B.2.1. Locations of groundwater elevation monitoring in Melton Valley.

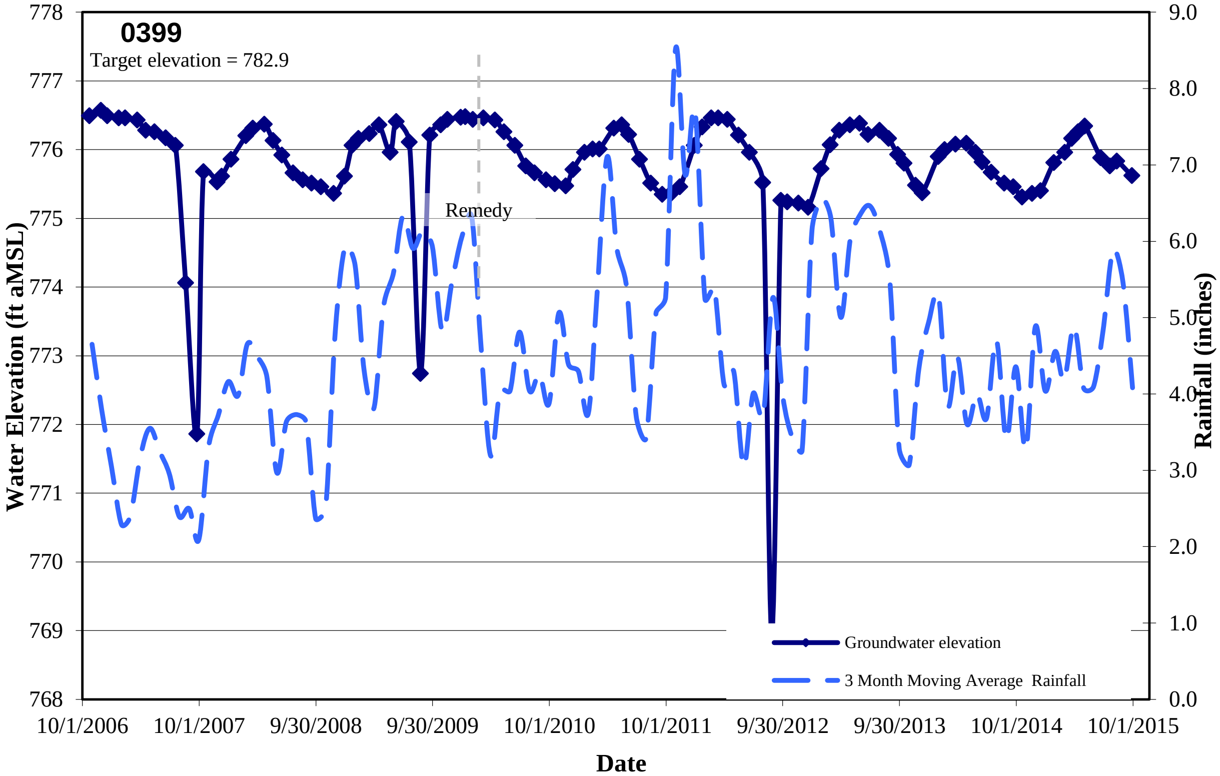
Table B.2.1. FY 2015 Melton Valley Groundwater Level Summary

Well	Area	Meas Freq	Maximum Elevation (ft aMSL)	Observed Range (ft)	TE (ft aMSL)	Target Range (ft)	Meets TE	Meets Fluct
0052	PT-2,3,4	M	781.04	0.56	791.0	--	Y	NA
0055	PT-2,3,4	C	785.25	0.45	795.00	--	Y	NA
0057	PT-2,3,4	M	784.17	3.12	795.00	--	Y	NA
2730	PT-2,3,4	M	778.81	0.7	791.00	--	Y	NA
2815	PT-2,3,4	M	770.16	1.36	789.00	--	Y	NA
1758	PT-Trench 6	M	830.68	4.32	836	4.42	Y	Y
1760	PT-Trench 6	M	821.12	2.86	836	1.00	Y	N
0949	SWSA 4	C	802.33	0.9	813.78	1.48	Y	N
0952	SWSA 4	M	816.21	5.7	810.44	--	--	--
0955	SWSA 4	M	762.15	3.41	759.42	1.03	N	N
0956	SWSA 4	C	767.58	0.3	770.49	0.40	Y	Y
0958	SWSA 4	Q	762.63	2.48	761.25	0.72	N	N
0962	SWSA 4	Q	819.85	2.23	822.85	0.57	Y	N
1071	SWSA 4	C	803.15	0.76	802.44	0.79	N	Y
4543	SWSA 4	C	dry	--	803.31		Y	NA
4544	SWSA 4	C	790.41	1.06	791.89		Y	NA
4545	SWSA 4	M	dry		777.25		Y	NA
4546	SWSA 4	M	dry		--	1.1	Y	NA
4553	SWSA 4	M	819.18	3.78			--	NA
4554	SWSA 4	M	811.04	1.16			--	NA
4555	SWSA 4	C	810.51	1.01	NA	1.25	Y	NA
4556	SWSA 4	C	807.83	2.44	NA		--	NA
4557	SWSA 4	M	dry	--	NA	--	Y	NA
4558	SWSA 4	M	789.97	0.12		0.18	--	Y
4559	SWSA 4	M	777.37	0.25		0.38	--	Y
4561	SWSA 4	C	792.16	0.5				NA
4562	SWSA 4	M	782.03	0.35				NA
4563	SWSA 4	C	777.25	0.36				NA
4589	SWSA 4	C	771.32	0.28	NA	--	--	NA
2018	SWSA 5-N	M	823.06	0.01	822.2	2.5	N	Y
2019	SWSA 5-N	M	dry	--	824.30	1.67	Y	Y
2020	SWSA 5-N	M	dry	--	828.20	0.78	Y	NA
0145	SWSA 5-S	M	dry	--	829.10	1.9	Y	NA

Table B.2.1. FY 2015 Melton Valley Groundwater Level Summary (cont.)

Well	Area	Meas Freq	Maximum Elevation (ft aMSL)	Observed Range (ft)	TE (ft aMSL)	Target Range (ft)	Meets TE	Meets Fluct
0436	SWSA 5-S	M	766.55	1.01	773.90	2.35	Y	Y
0504	SWSA 5-S	M	810.69	0.03	813.10	1.83	Y	Y
0666	SWSA 5-S	M	767.97	0.24	776.10	1.35	Y	Y
0710	SWSA 5-S	M	dry	--	791.50	1.10	Y	Y
0711	SWSA 5-S	M	796.62	0.05	806.1	2.9	Y	Y
1734	SWSA 5-S	M	dry	--	776.70	2.2	Y	NA
1766	SWSA 5-S	M	dry	--	773.9	2.1	Y	NA
2026	SWSA 5-S	M	771.42	1.92	773.3	1.2	Y	N
4175	SWSA 5-S	M	dry	--	775.80	4.10	Y	NA
4188	SWSA 5-S	M	dry	--	772.90	1.63	Y	NA
4193	SWSA 5-S	M	dry	--	775.40	1.32	Y	NA
4204	SWSA 5-S	M	dry	--	773.00	1.40	Y	NA
4212	SWSA 5-S	M	771.65	--	773.7	1.68	Y	NA
4224	SWSA 5-S	M	dry	--	781.6	1.88	Y	NA
0399	SWSA 6	M	776.34	1.03	782.90	1.36	Y	Y
0836	SWSA 6	M	747.33	2.08	753.00	--	Y	NA
0845	SWSA 6	M	784.01	3.47	784.10	0.82	Y	N
0848	SWSA 6	M	777.53	0.53	779.20	0.27	Y	N
0850	SWSA 6	C	767.14	1.74	765.90	2.1	N	Y
1036	SWSA 6	C	764.09	4.38	768.00	--	Y	NA
2217	SWSA 6	M	Dry	--	767.6	2.5	--	NA
4127	SWSA 6	M	774.15	1.11	772.30	2.25	N	Y

C = continuous groundwater level monitoring using pressure transducer and data logger
DGT = down gradient trench
ft = feet
ft aMSL = feet above mean sea level
FY = fiscal year
M = monthly manual groundwater level measurements
N = no
NA = Not applicable
NS = Not specified in the Melton Valley Remedial Action Report
Q = quarterly manual groundwater level measurements
SWSA = Solid Waste Storage Area
TE = target elevation
UGT = up gradient trench
Y = yes



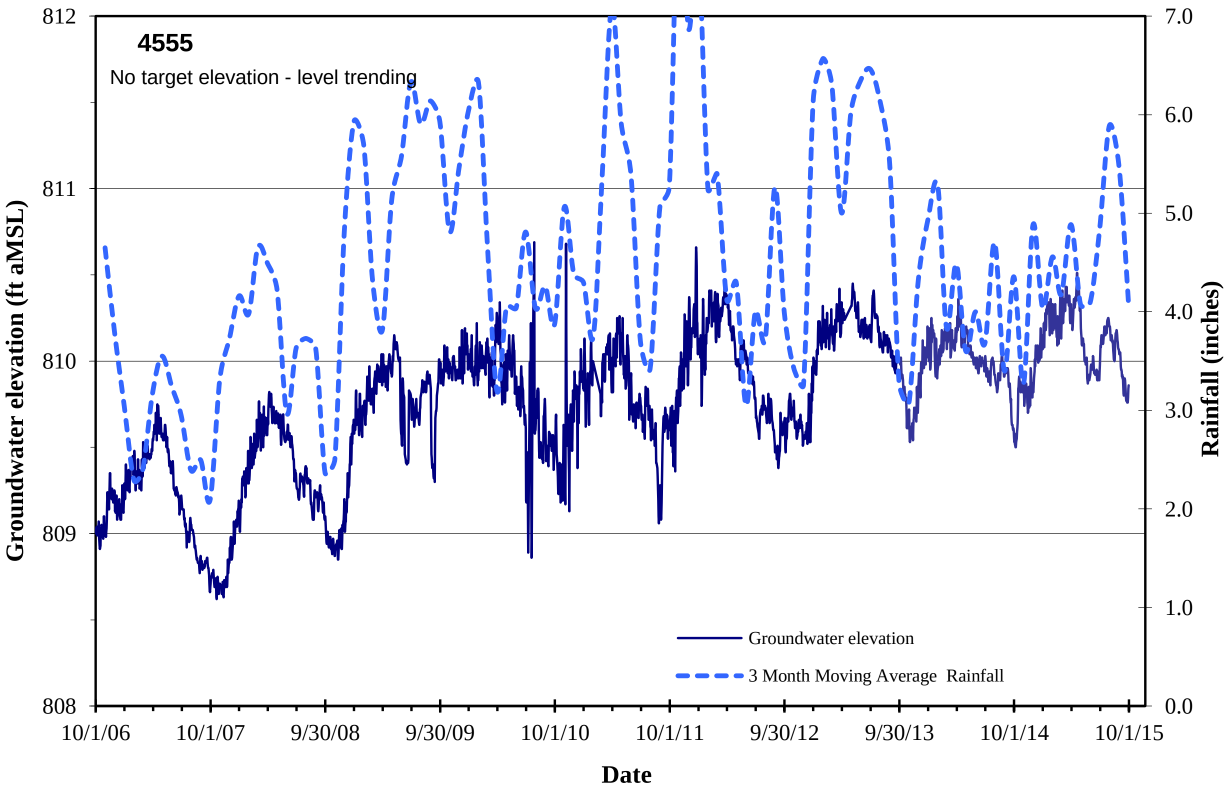
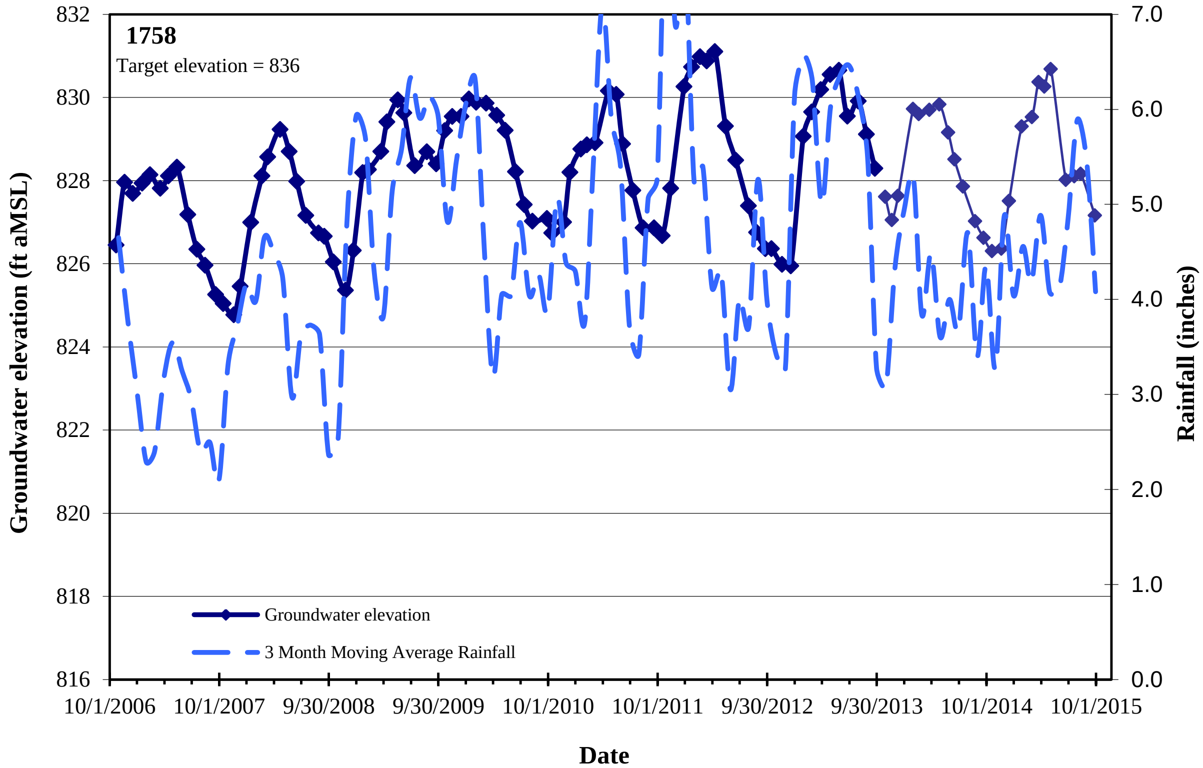


Figure B.2.2. Well hydrographs for wells 0399 and 4555.



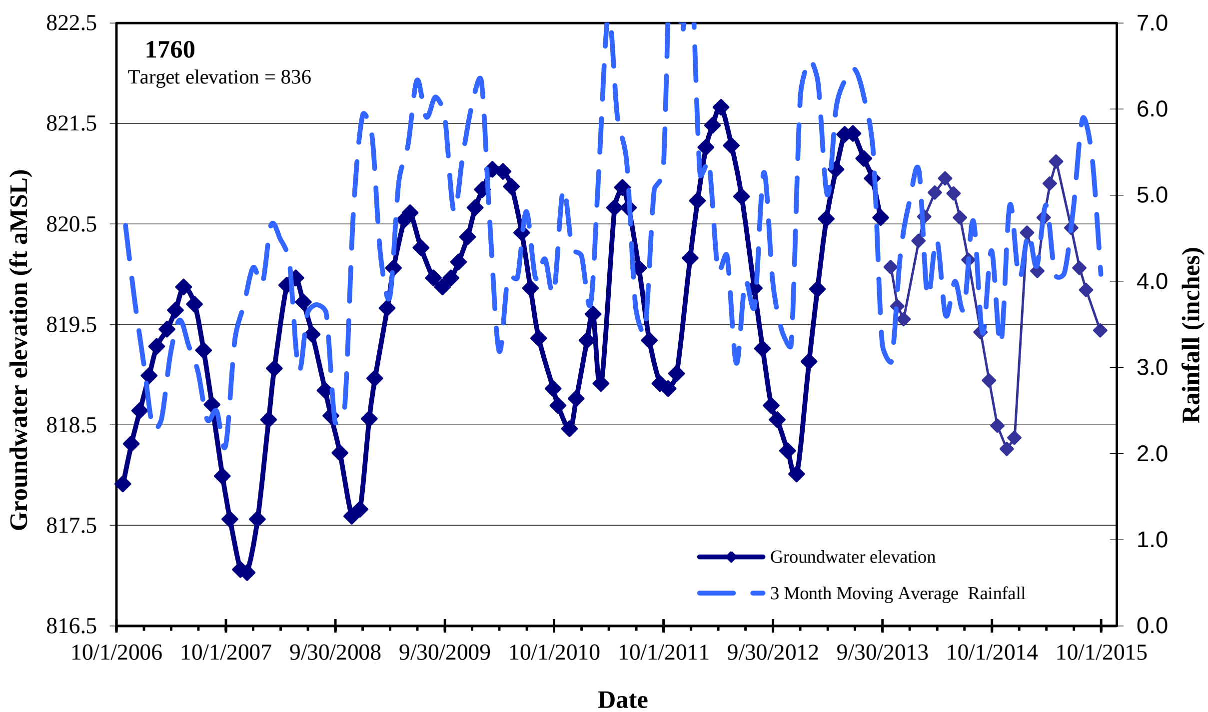
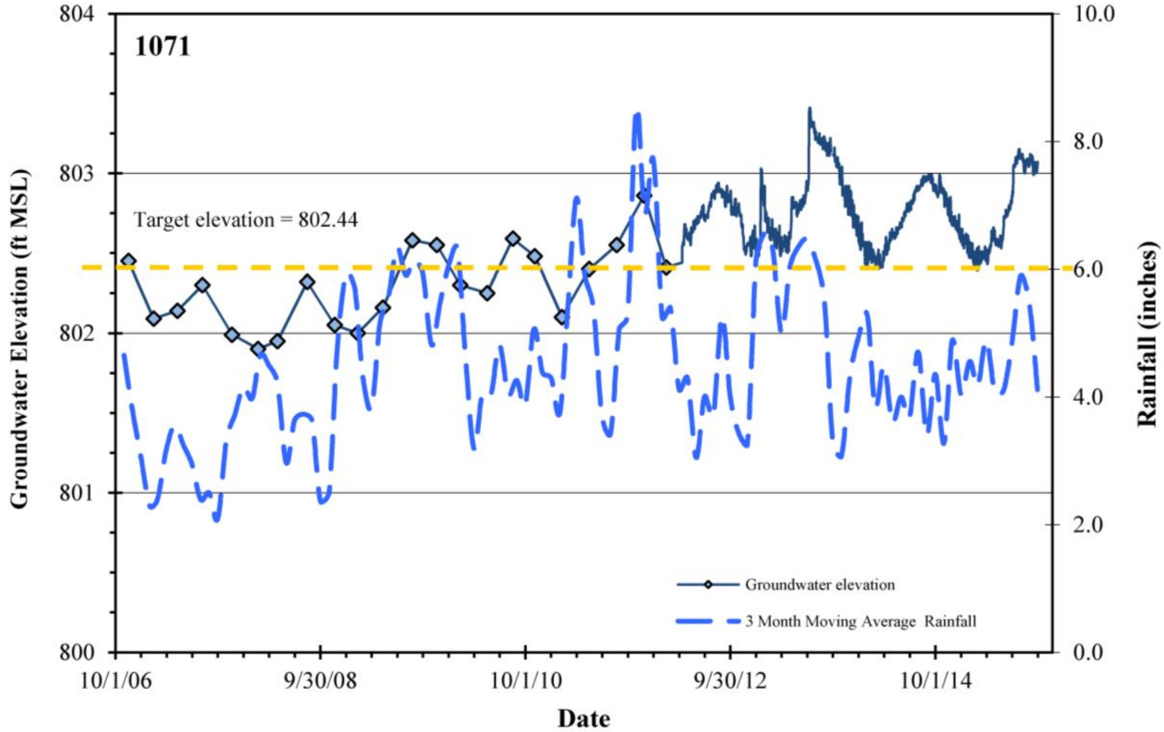


Figure B.2.3. Well hydrographs for wells 1758 and 1760.



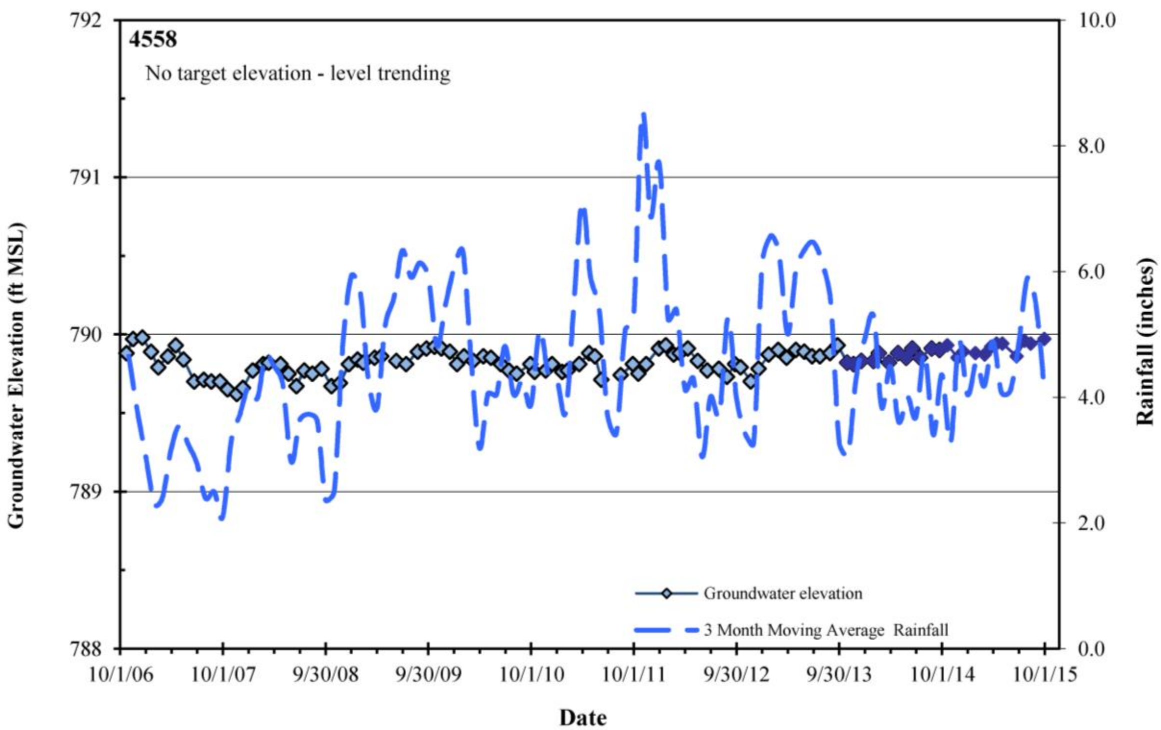
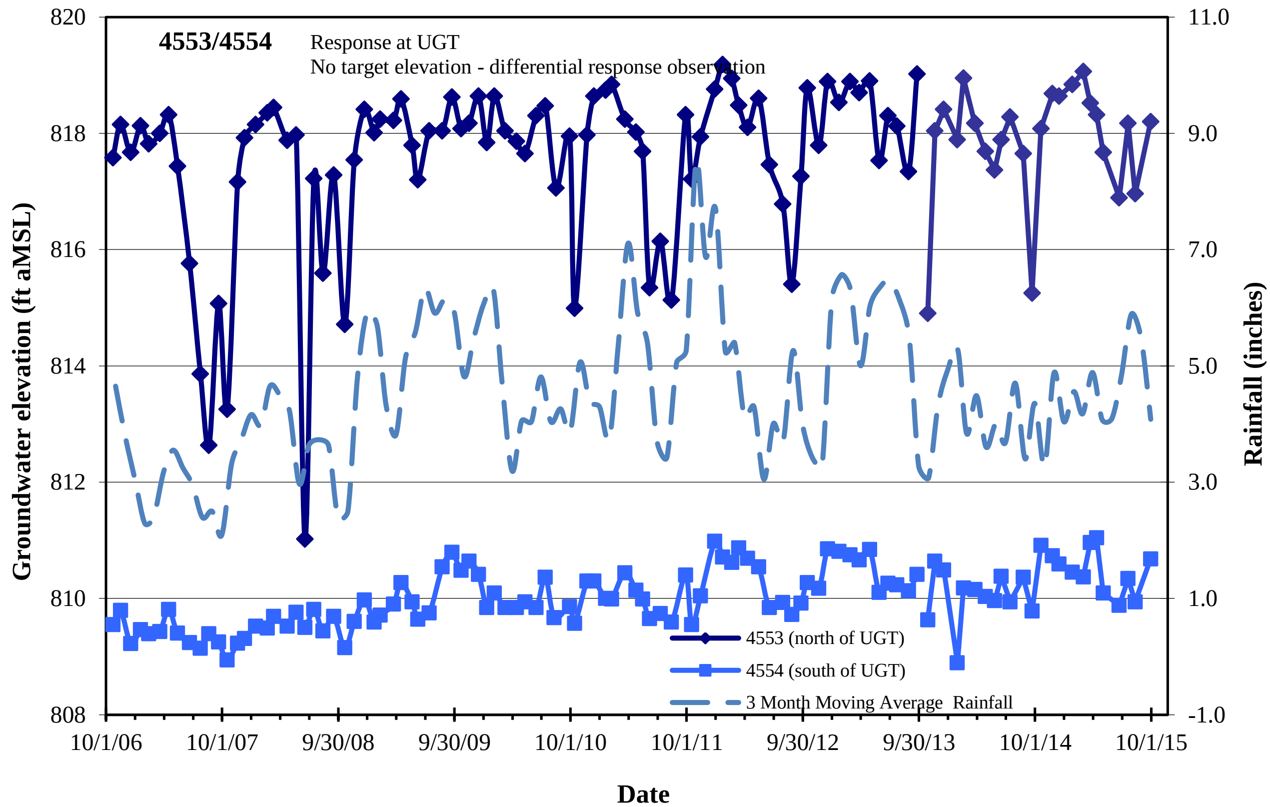


Figure B.2.4. Well hydrographs for wells 1071 and 4558.



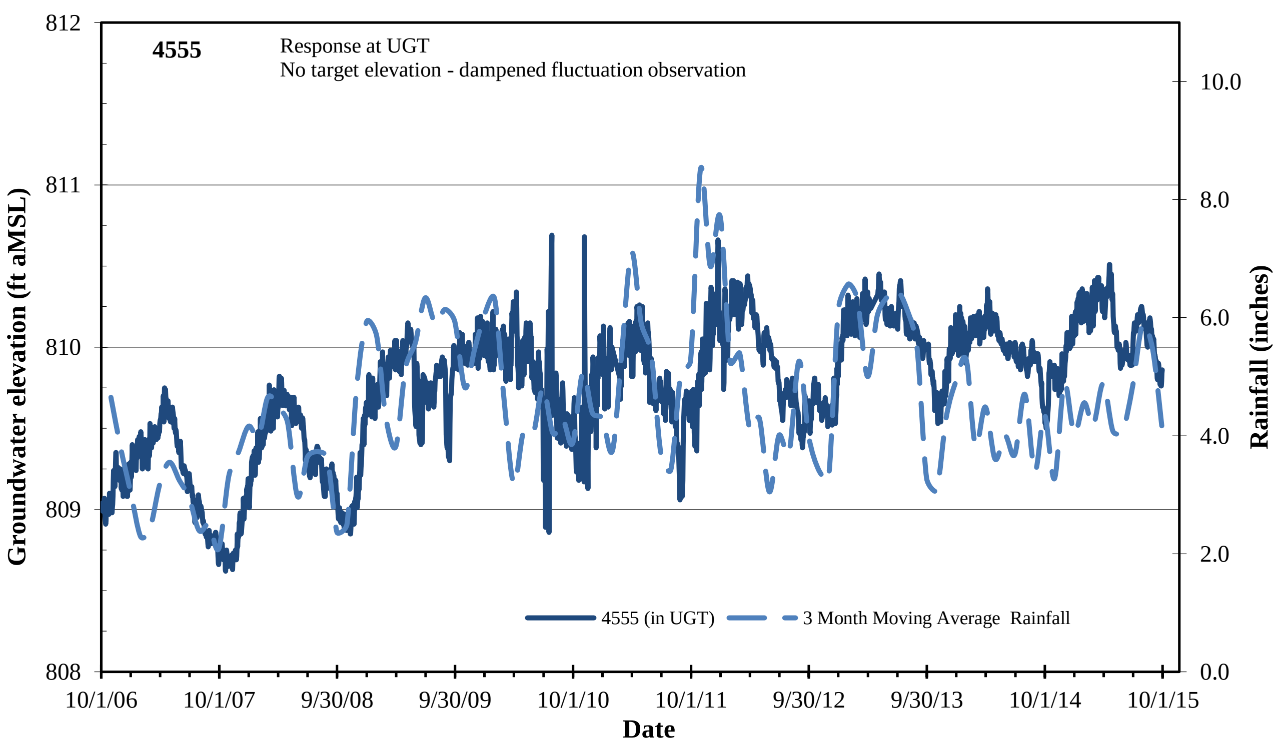


Figure B.2.5. Well hydrographs for wells 4553/4554 and 4555.

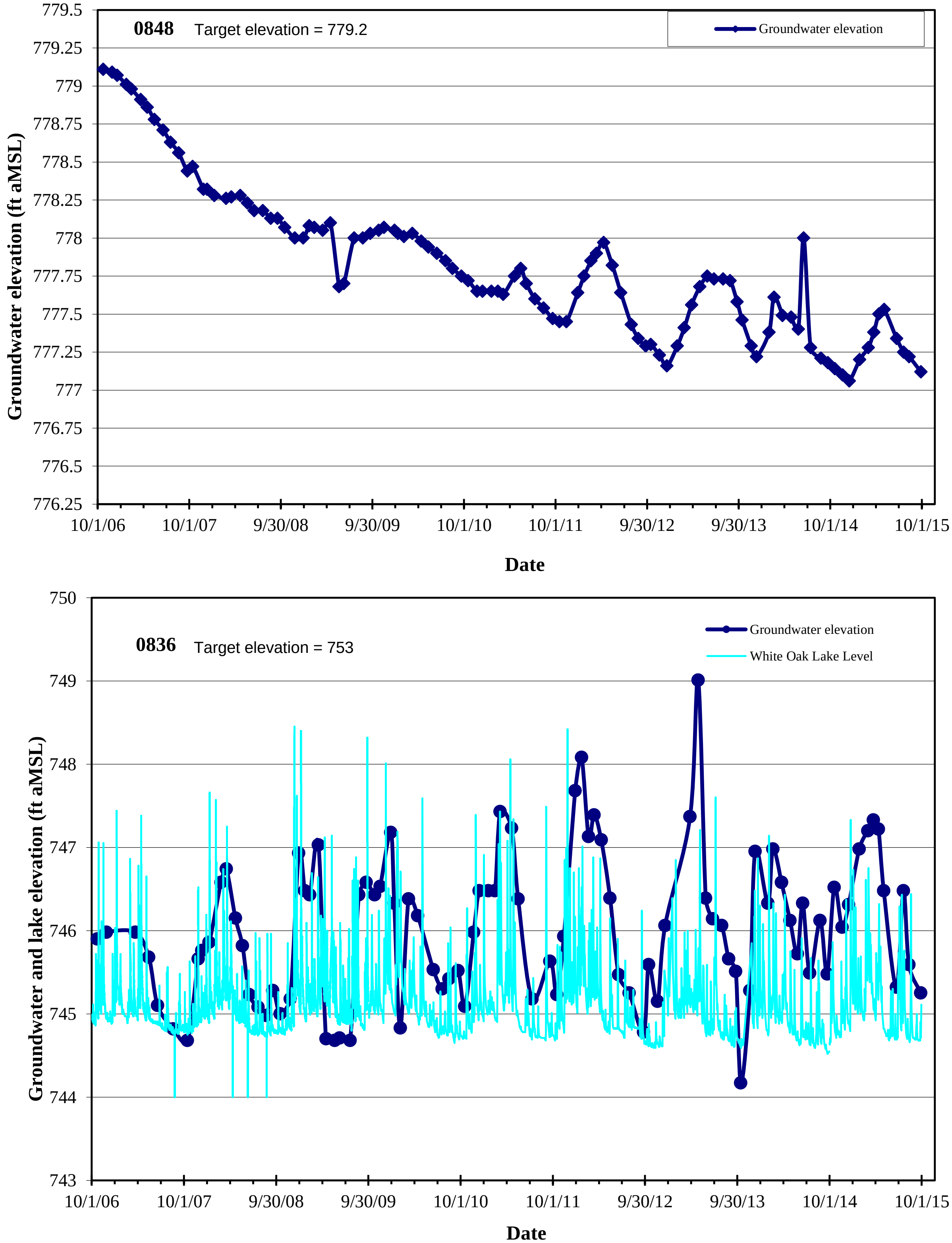
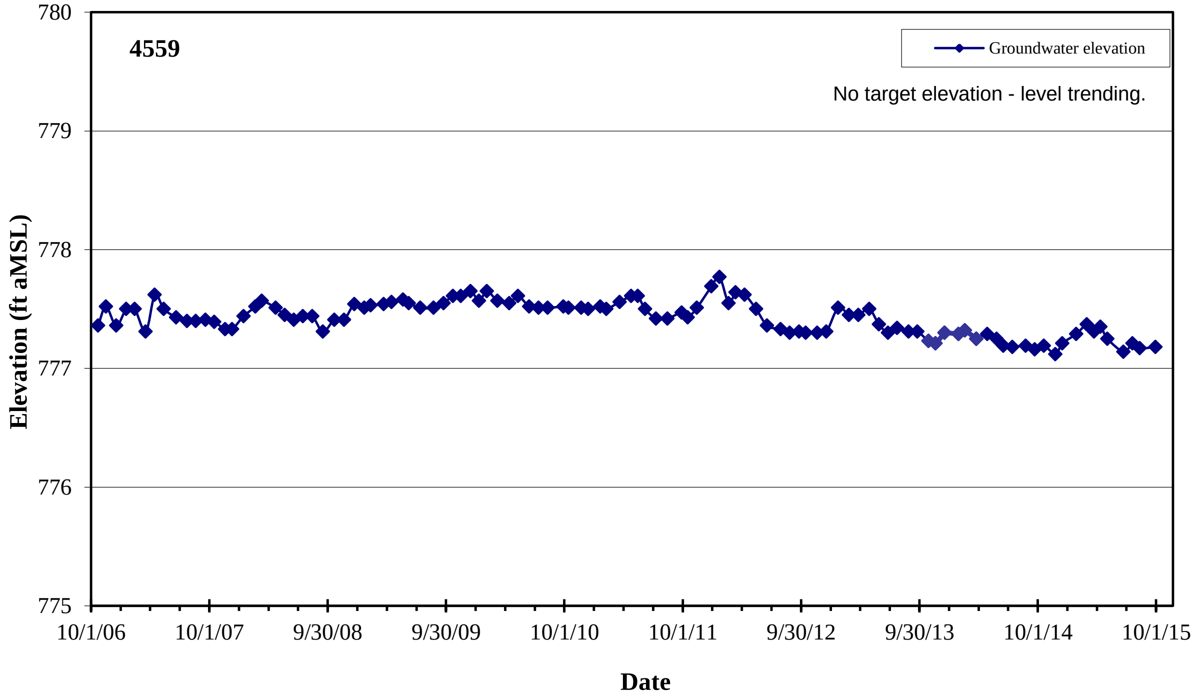


Figure B.2.6. Well hydrographs for wells 0848 and 0836.



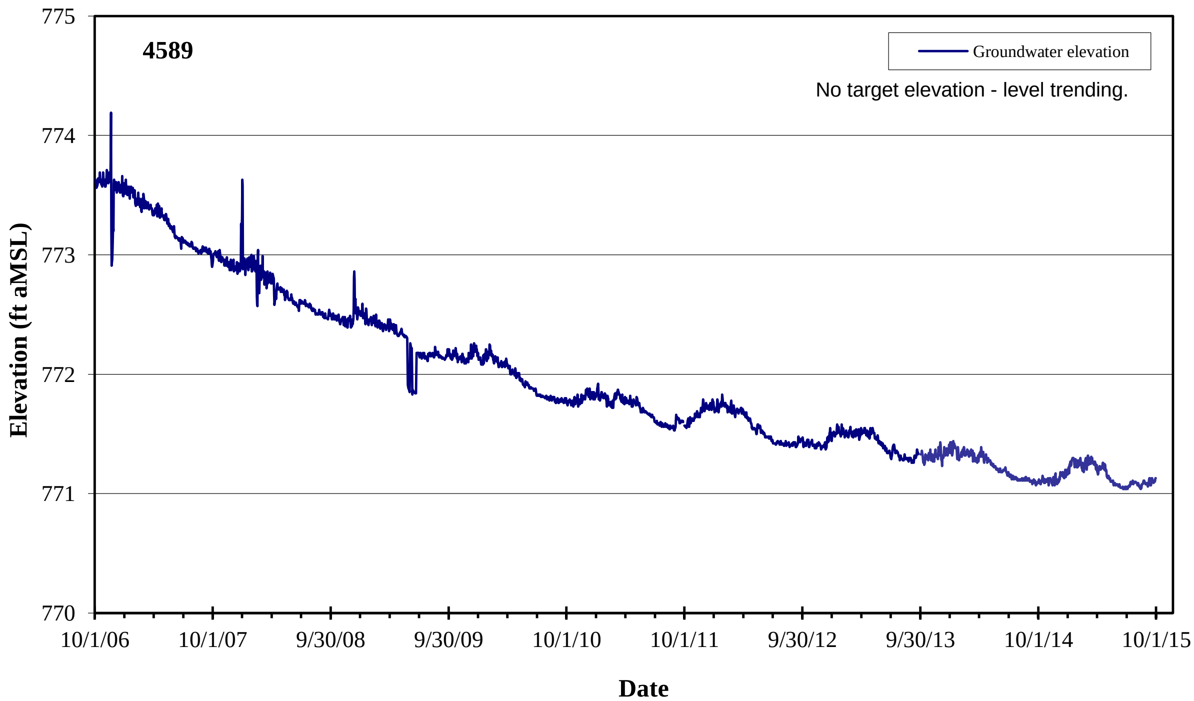
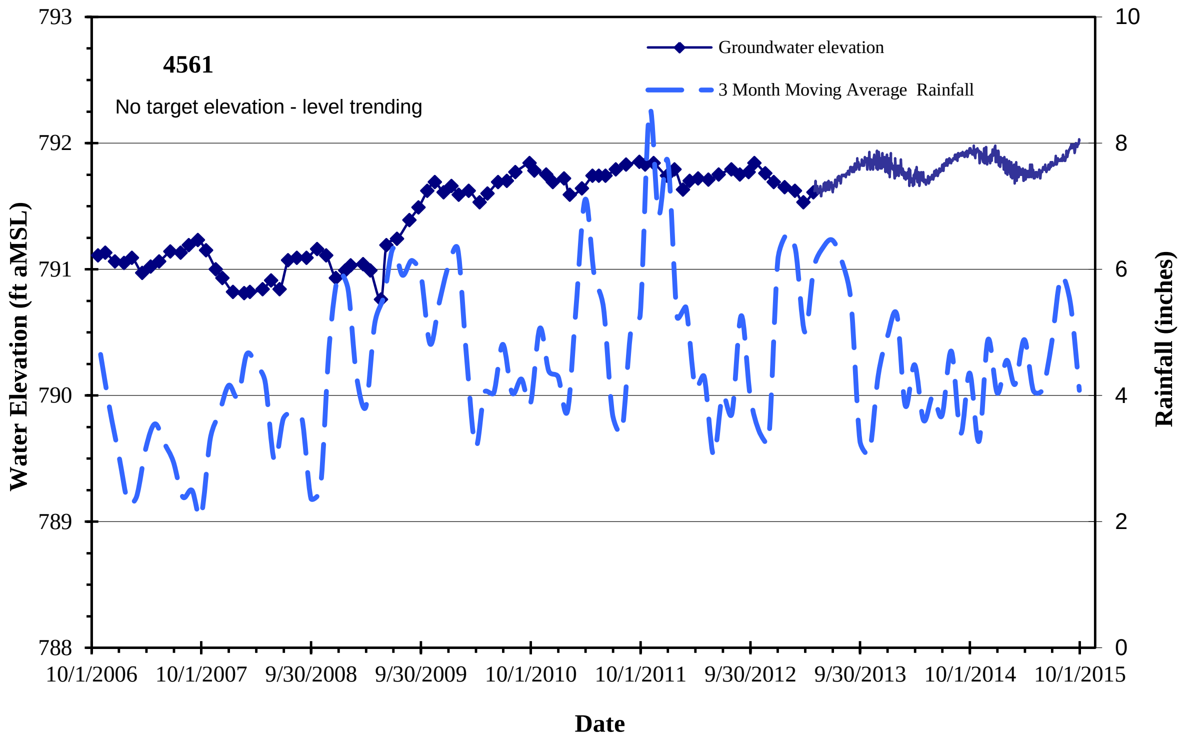


Figure B.2.7. Well hydrographs for wells 4559 and 4589.



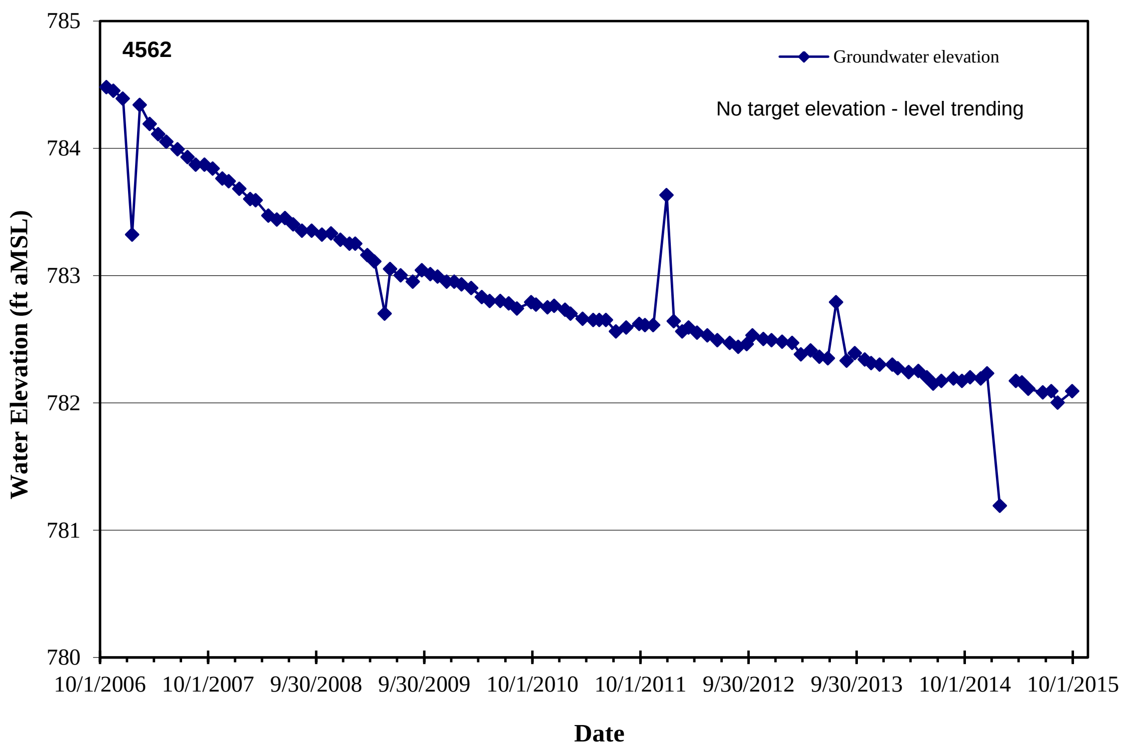
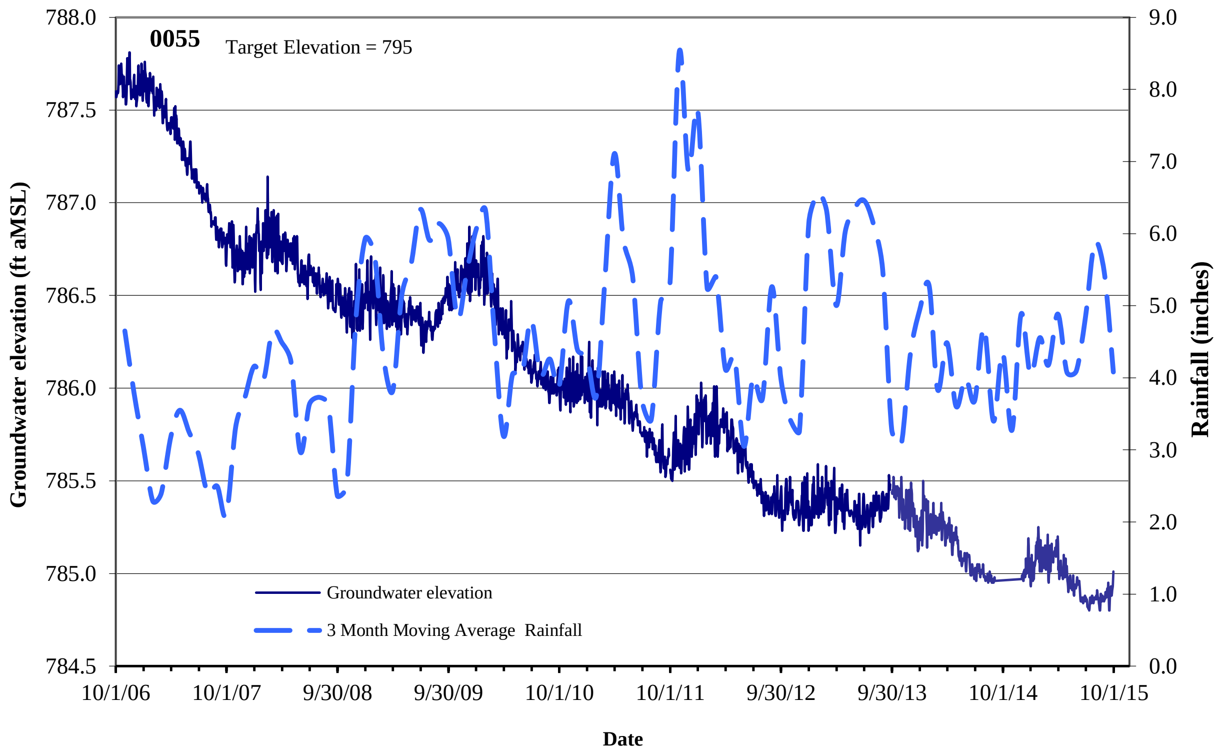


Figure B.2.8. Well hydrographs for wells 4561 and 4562.



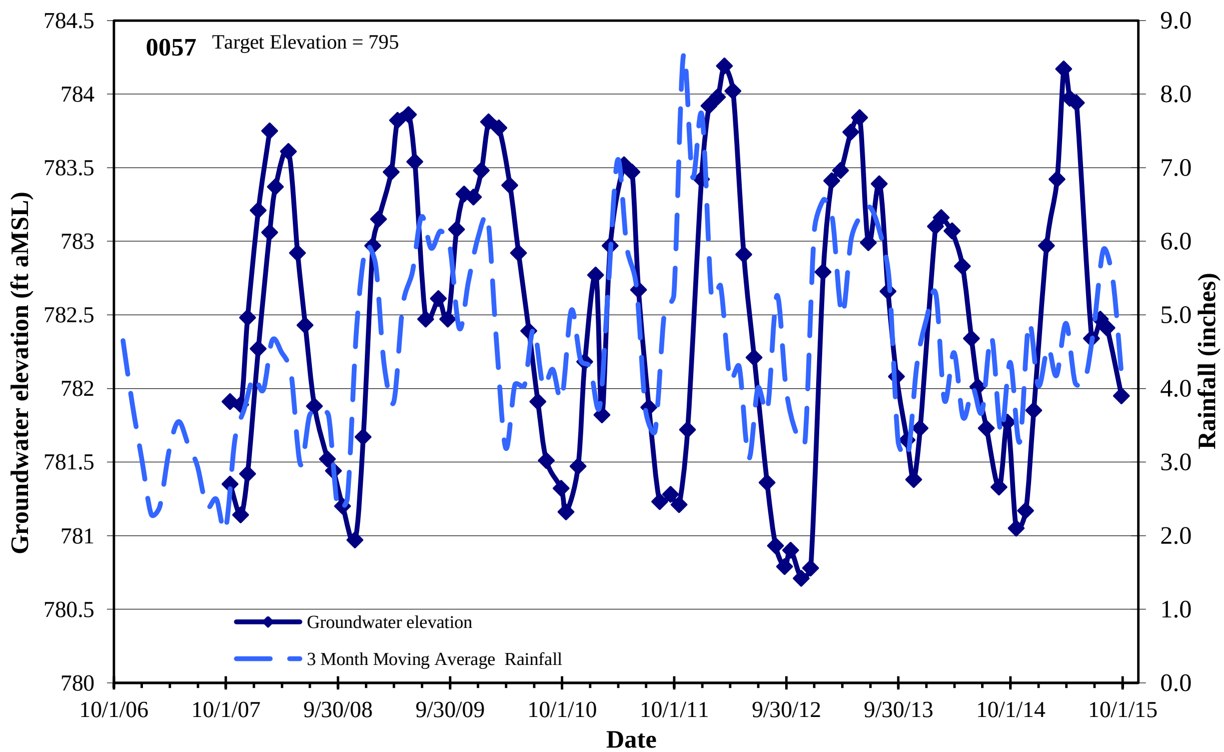
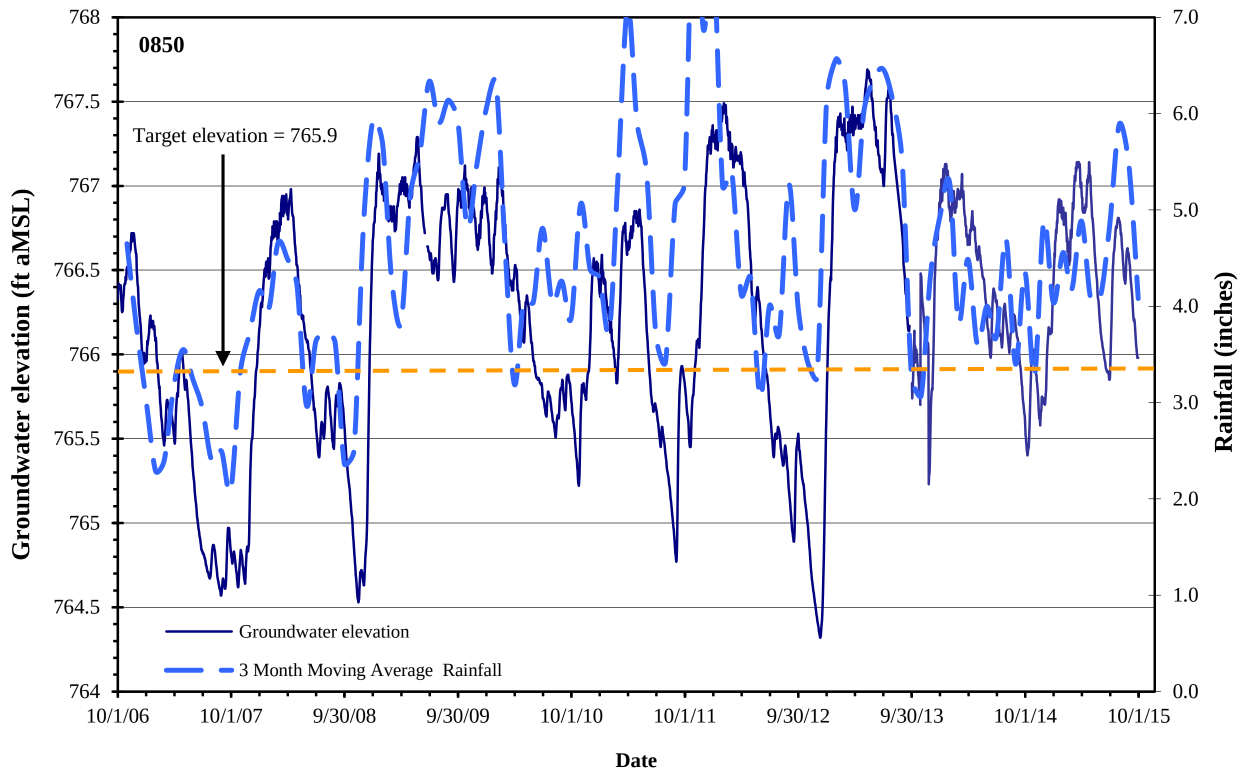


Figure B.2.9. Well hydrographs for wells 0055 and 0057.



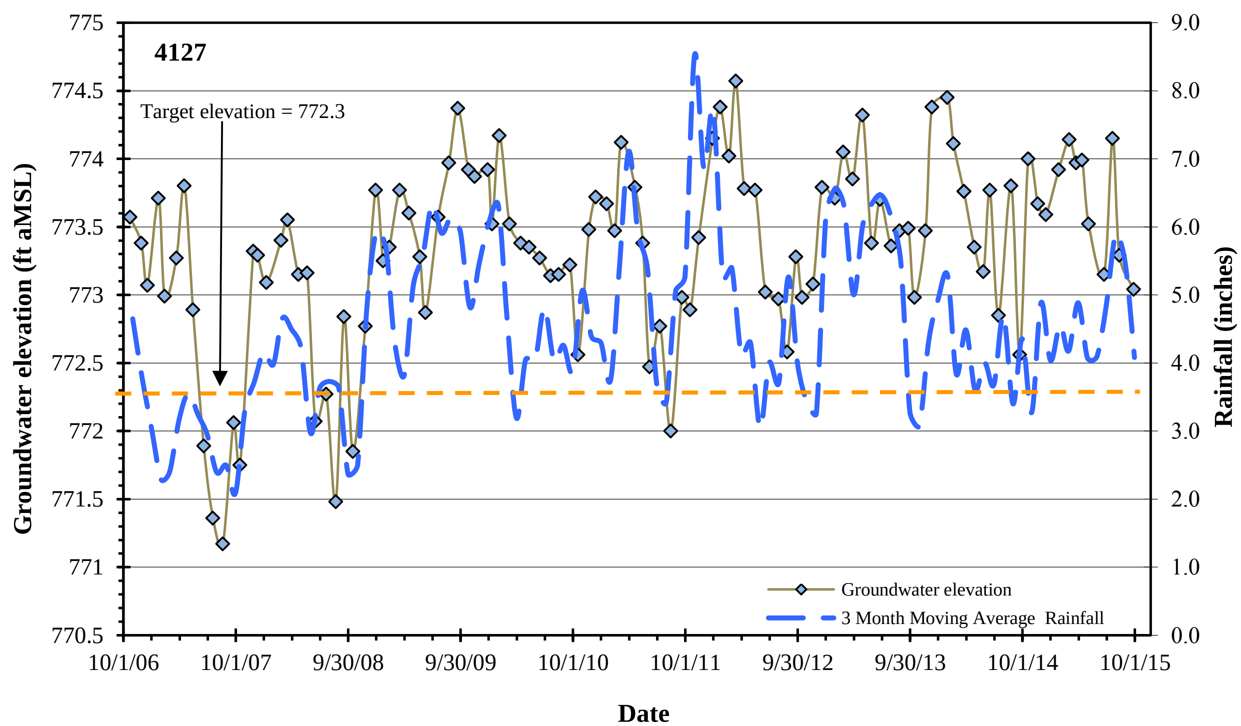
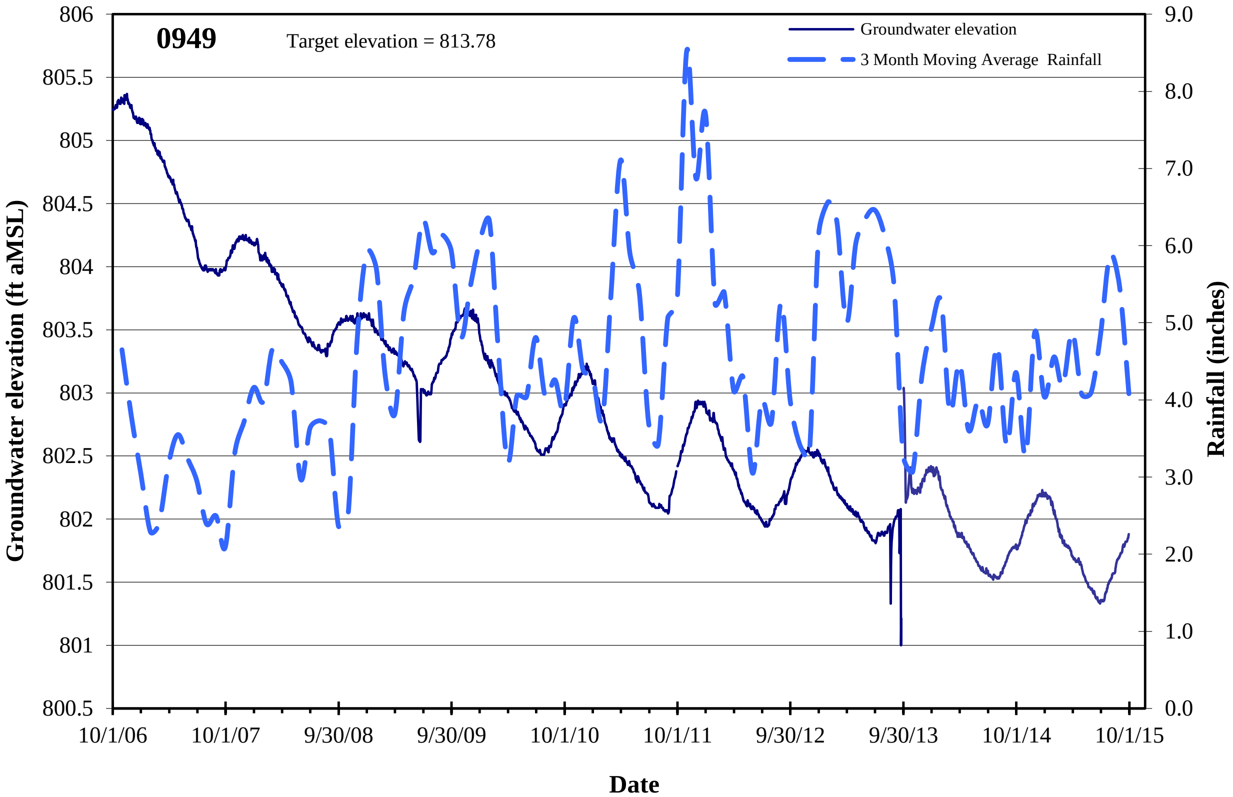


Figure B.2.10. Well hydrographs for wells 0850 and 4127.



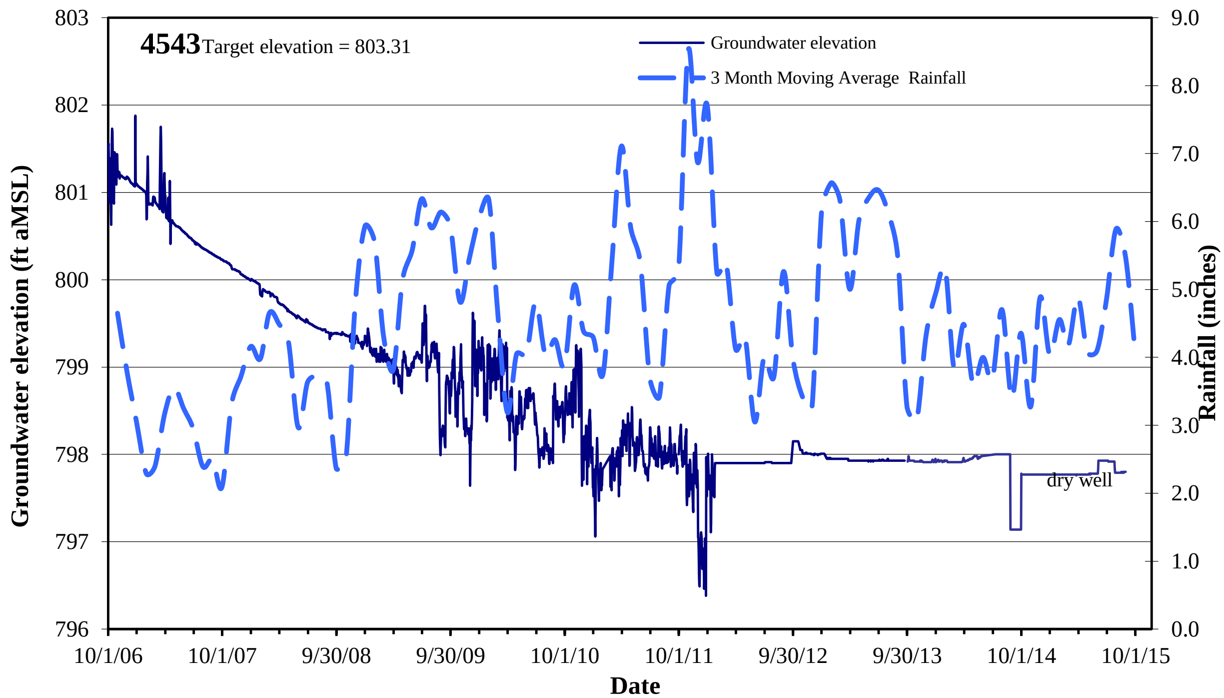
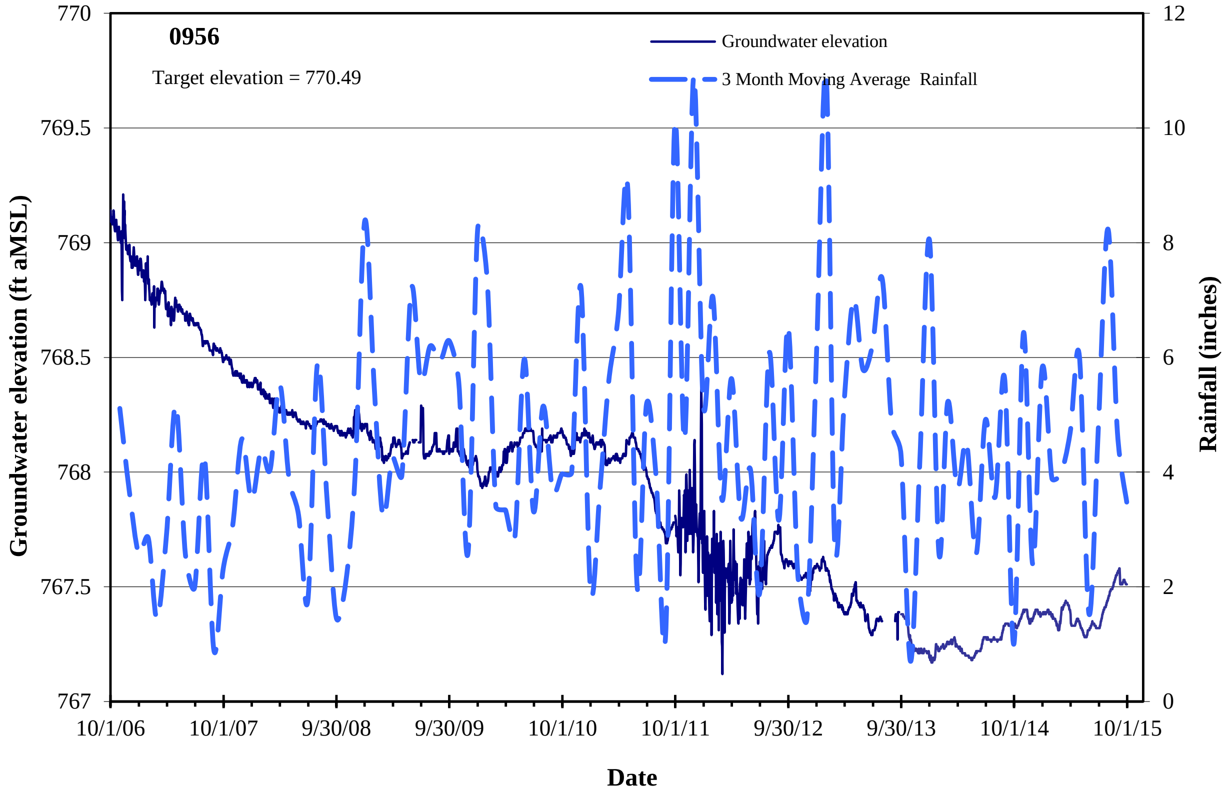


Figure B.2.11. Well hydrographs for wells 0949 and 4543.



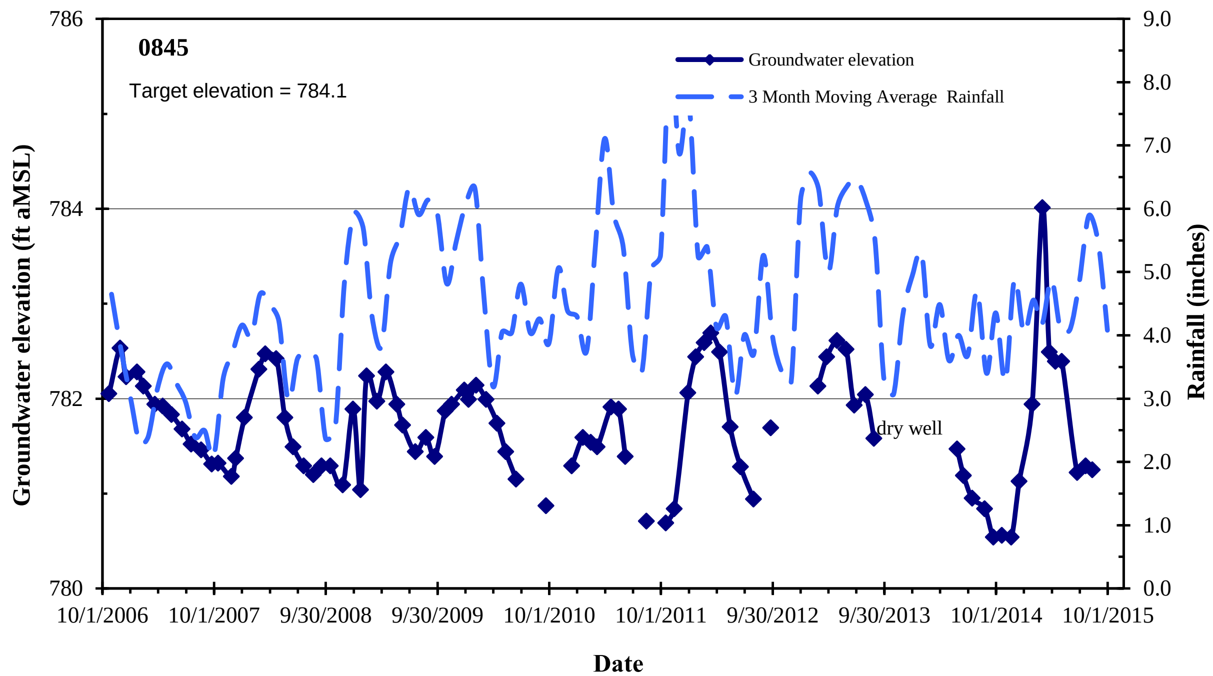
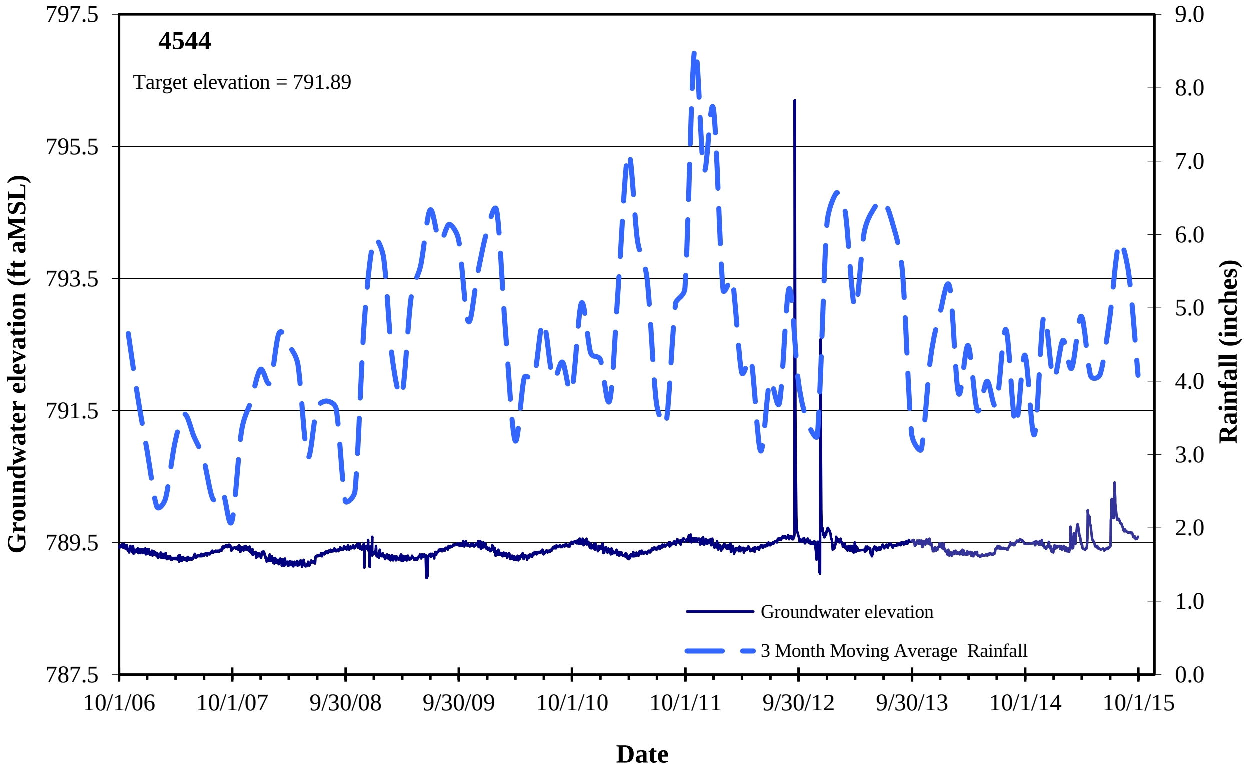


Figure B.2.12. Well hydrographs for well pair 0956 and well 0845.



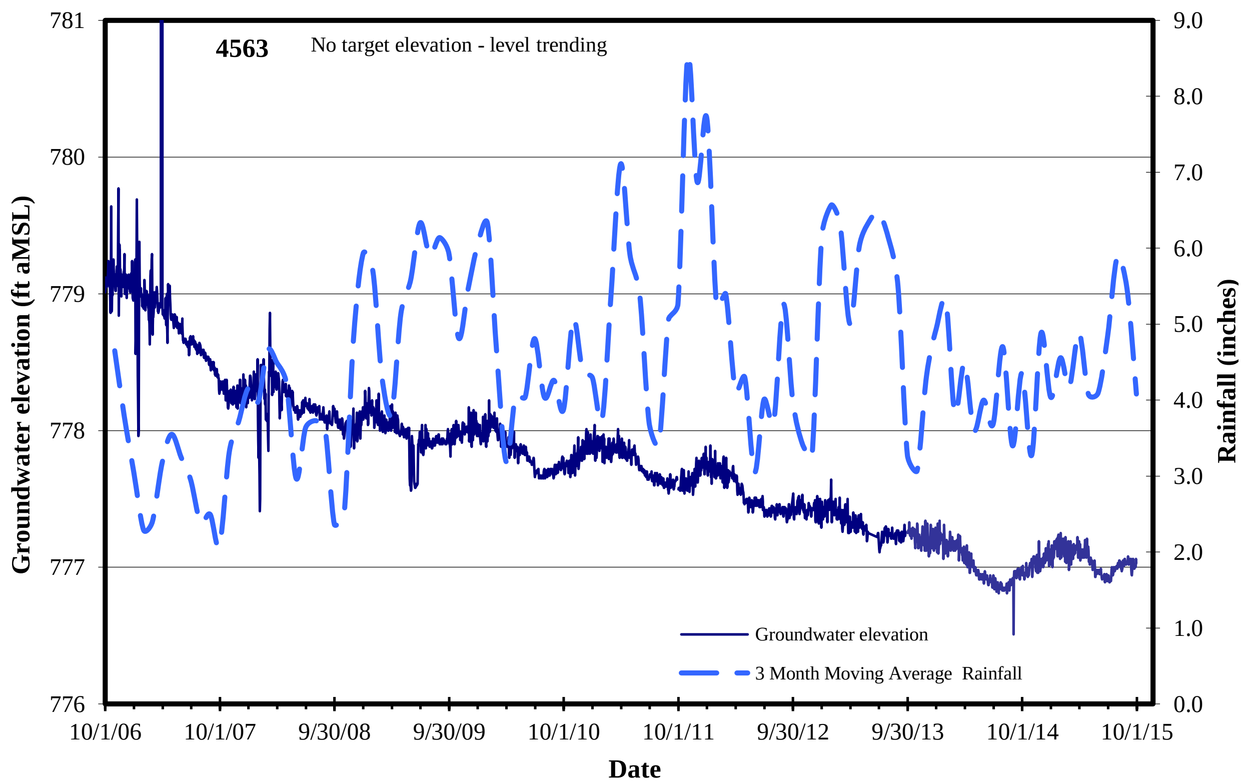
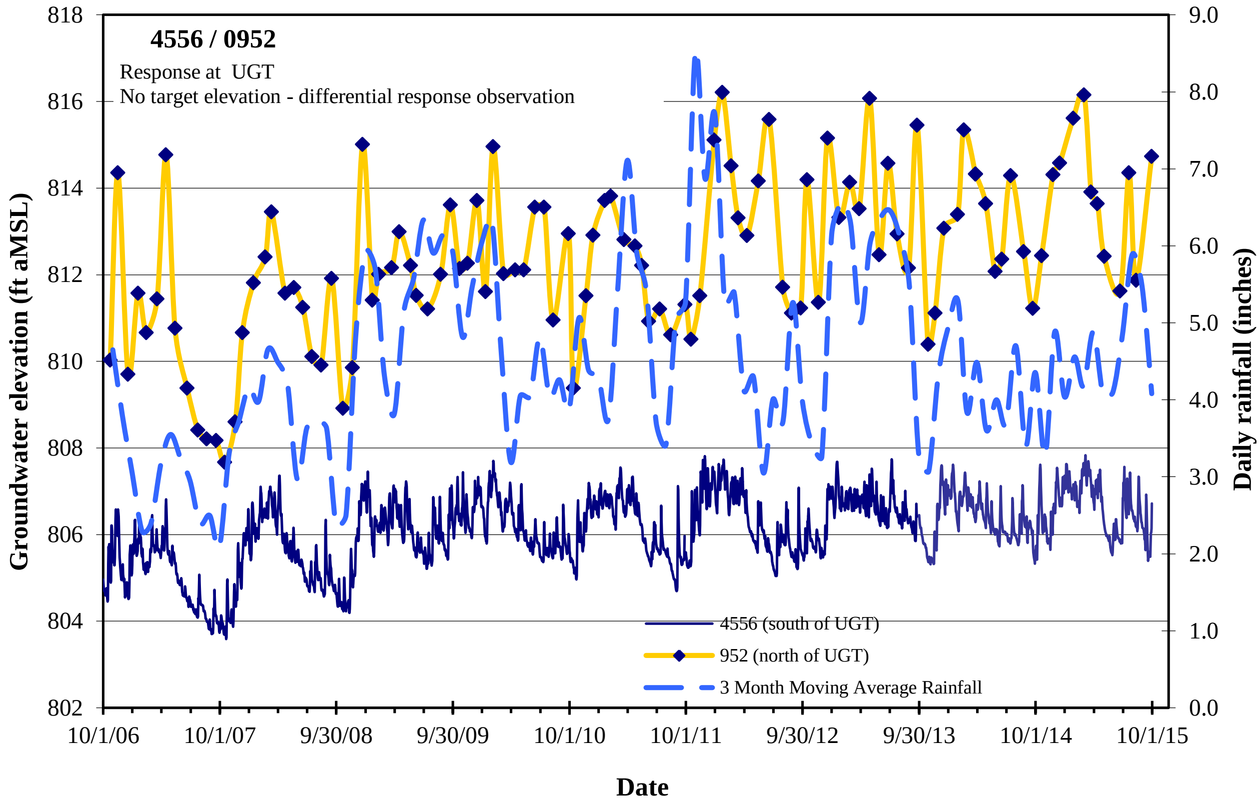


Figure B.2.13. Well hydrographs for wells 4544 and 4563.



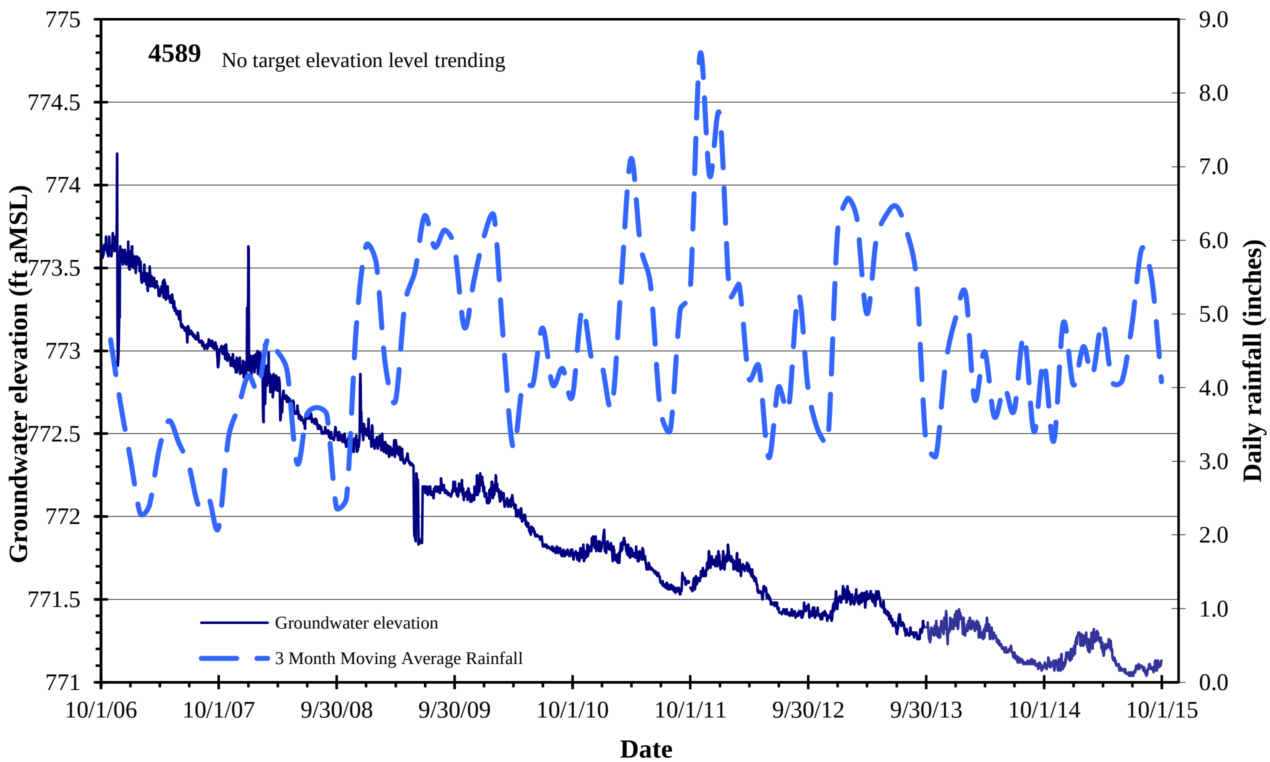


Figure B.2.14. Well hydrographs for wells 4556/0952 and 4589.

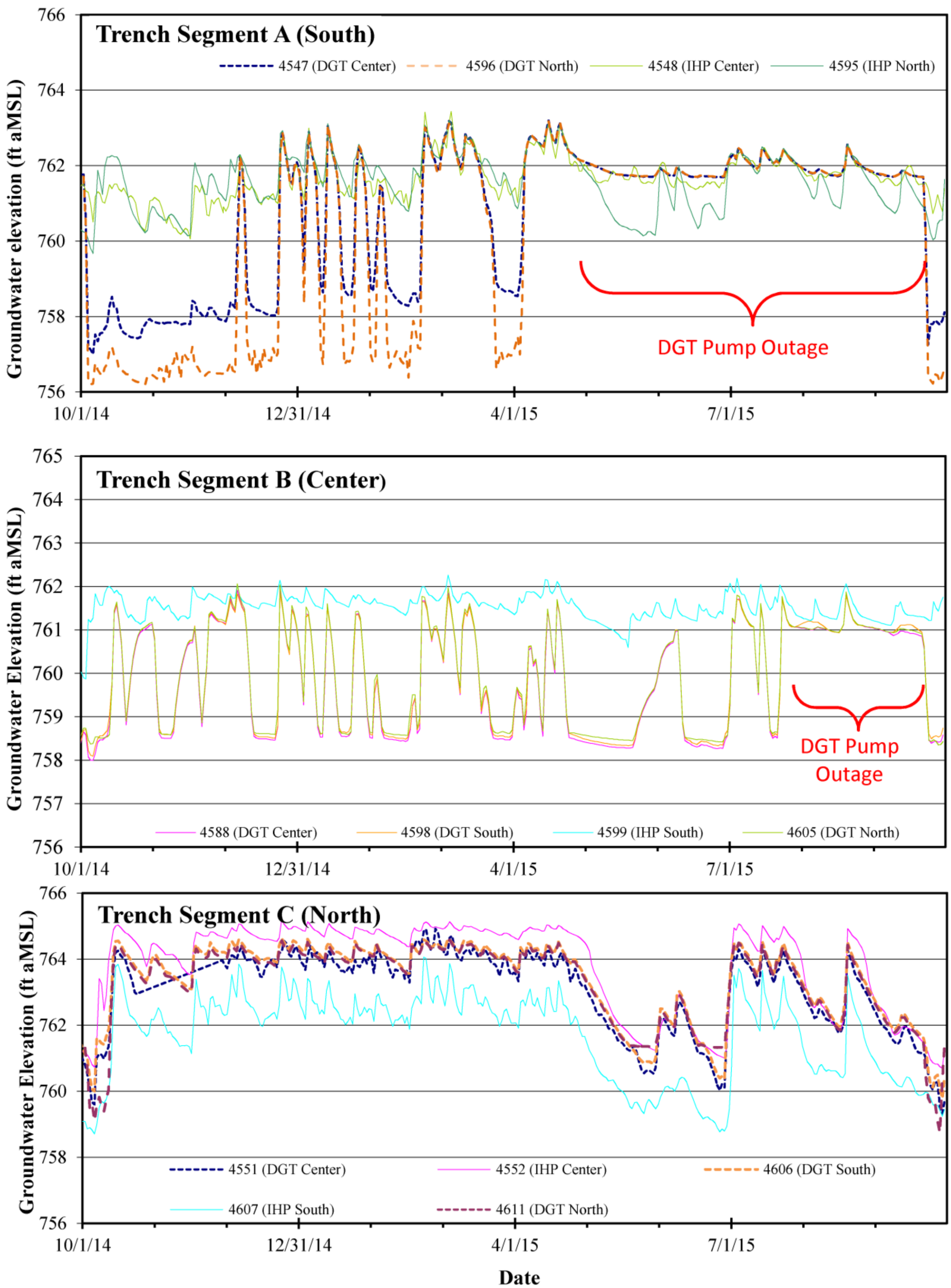


Figure B.2.15. Well hydrographs for wells at the SWSA 4 downgradient trench (FY 2015)

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B.3 SWSA 6 TUMULUS GROUNDWATER TRITIUM CONCENTRATION TIME HISTORY GRAPHS

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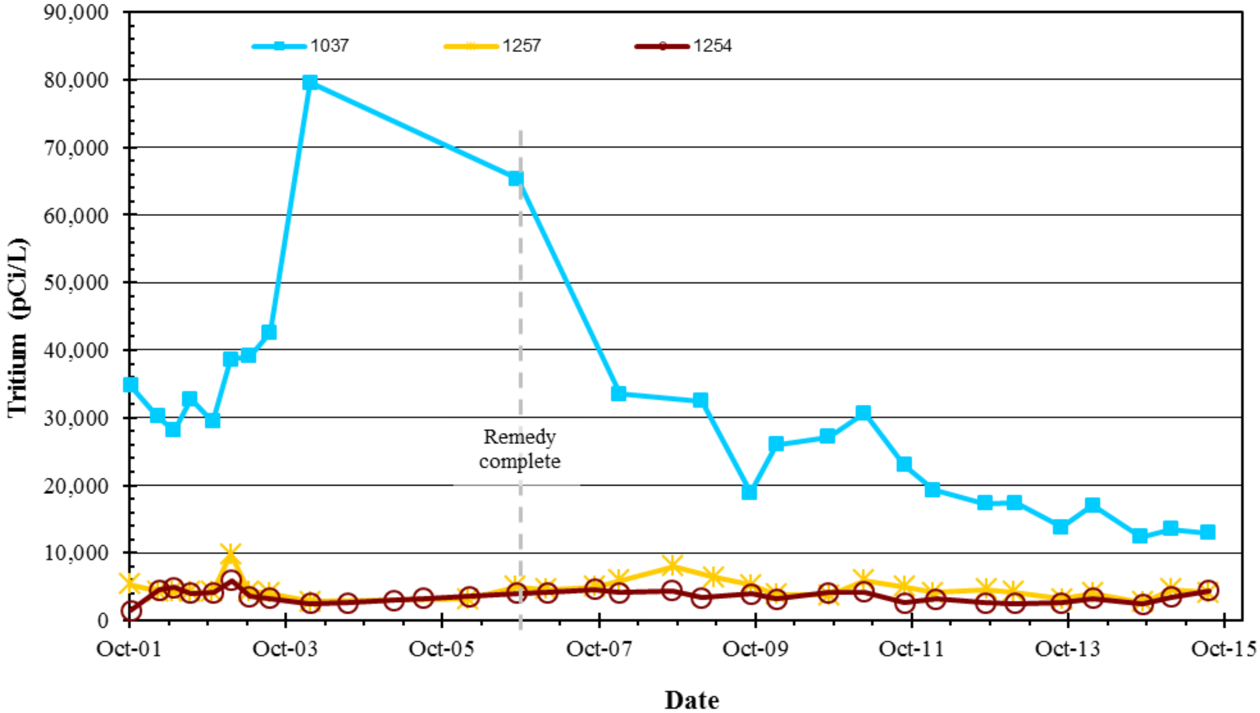

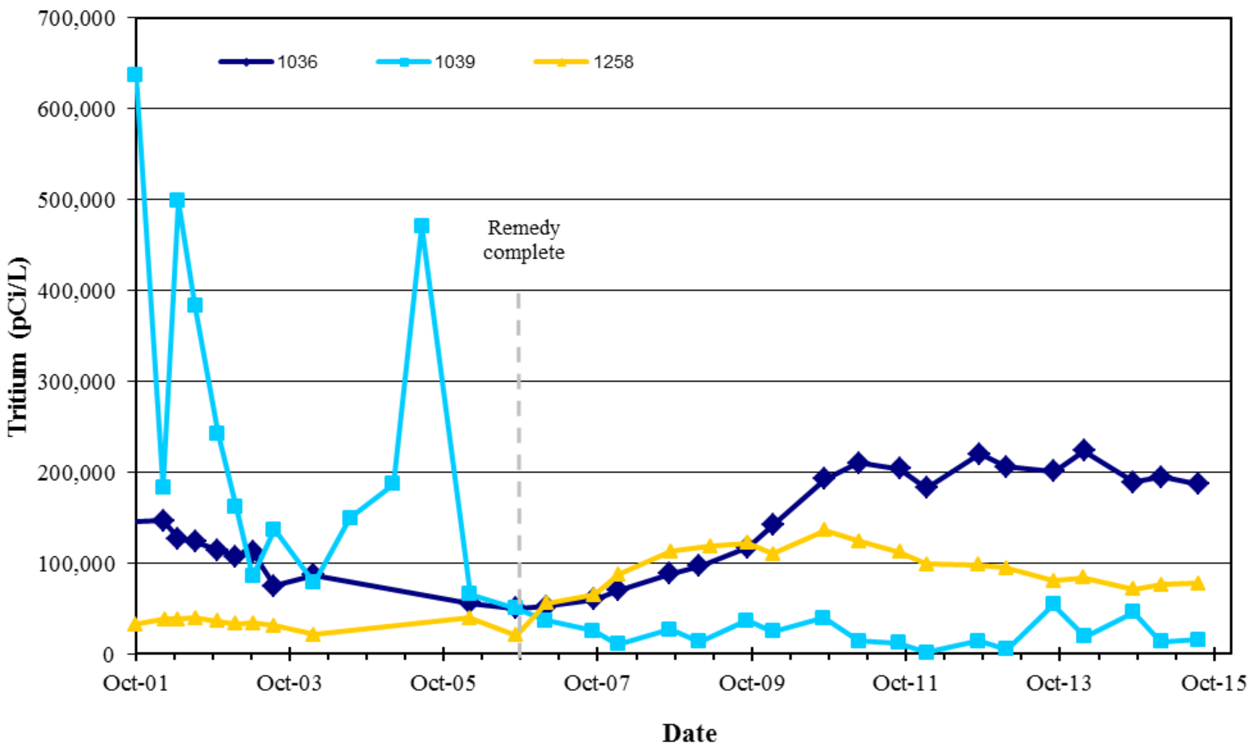

Figure B.3.1. SWSA 6 Tumulus groundwater tritium time histories.

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B.4 MELTON VALLEY OFF-SITE MONITORING WELL HYDROGRAPHS

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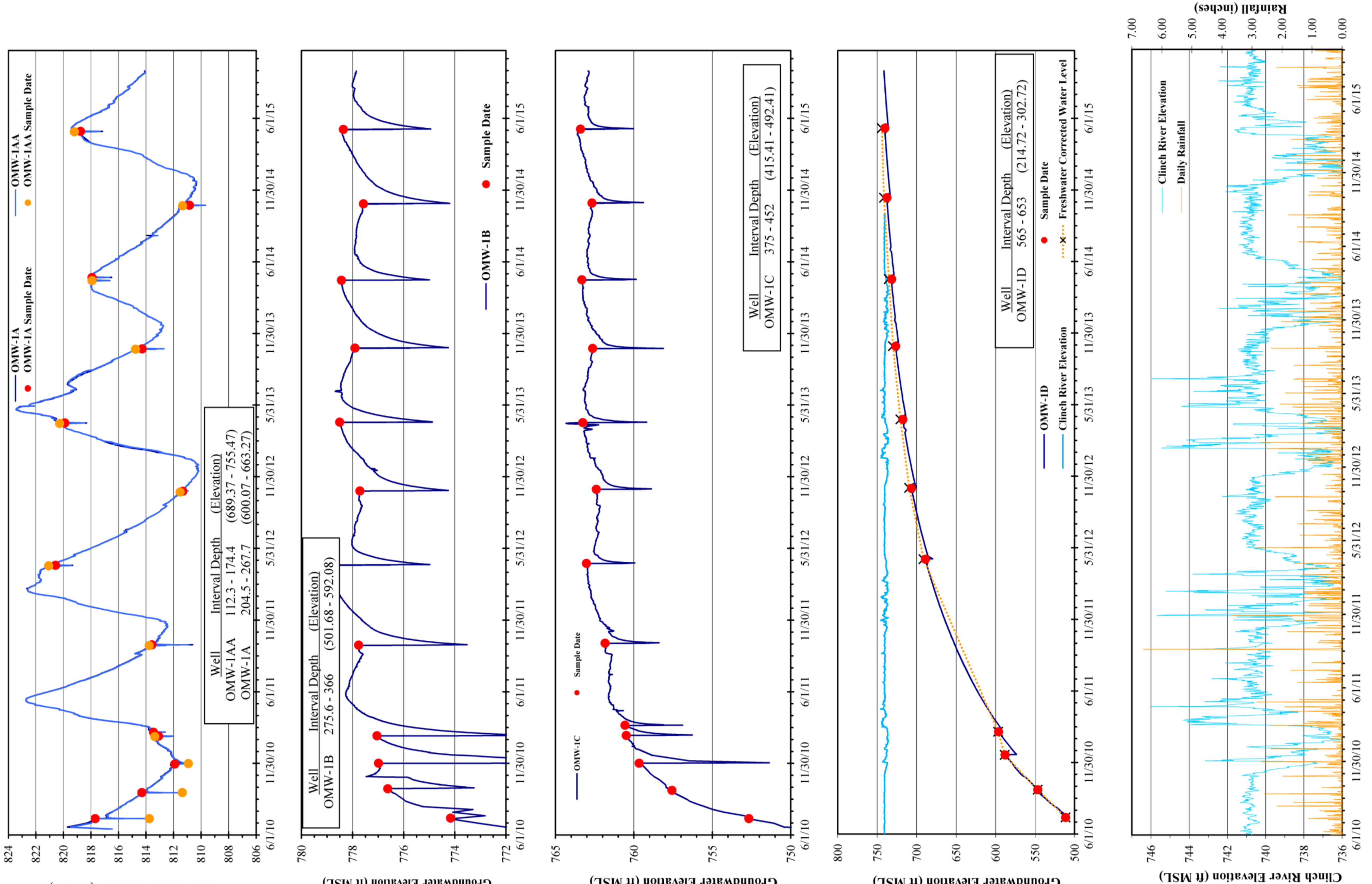

Figure B.4.1. Hydrographs for wells in cluster OMW-1.

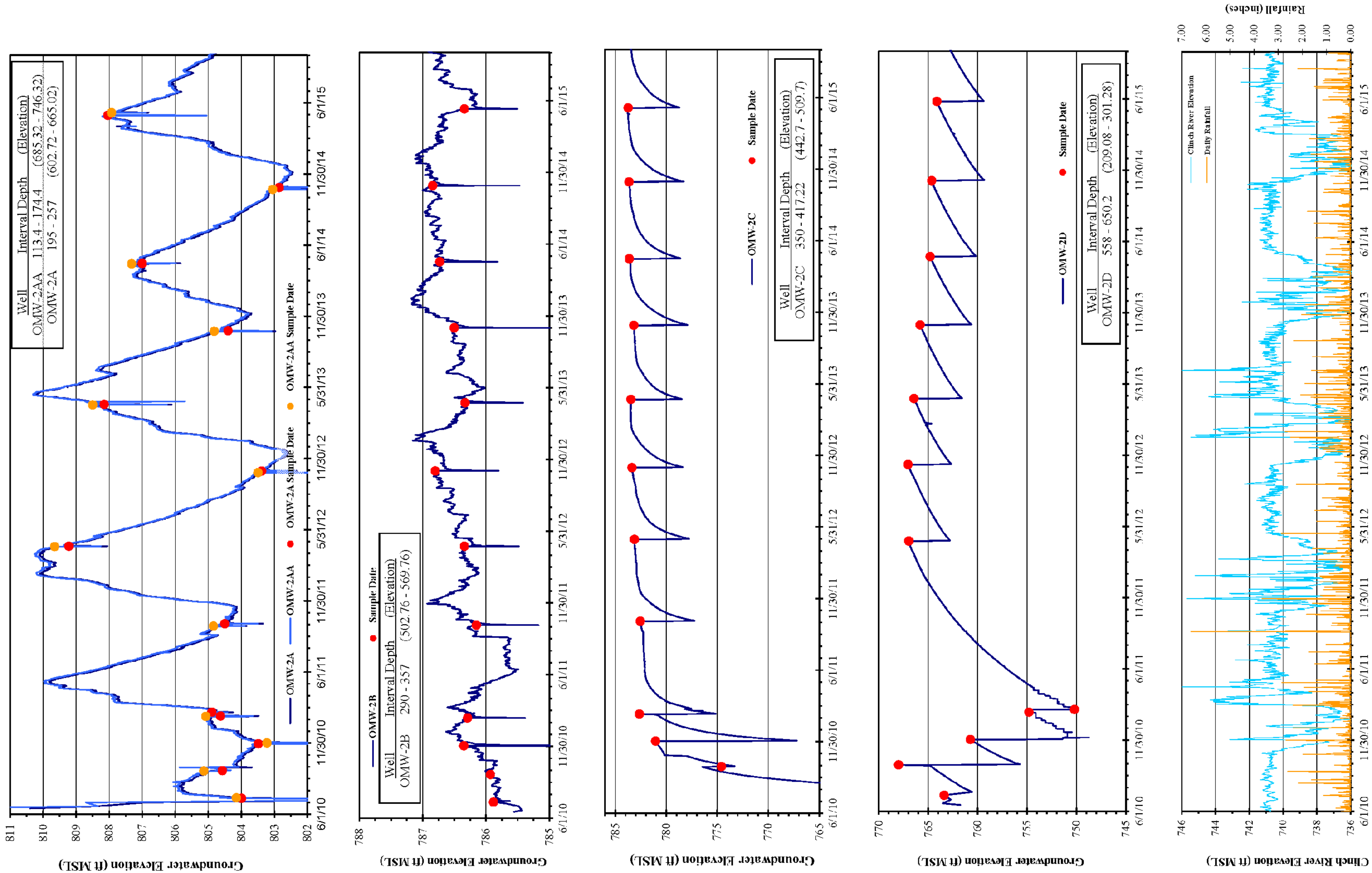

Figure B.4.2. Hydrographs for wells in cluster OMW-2.

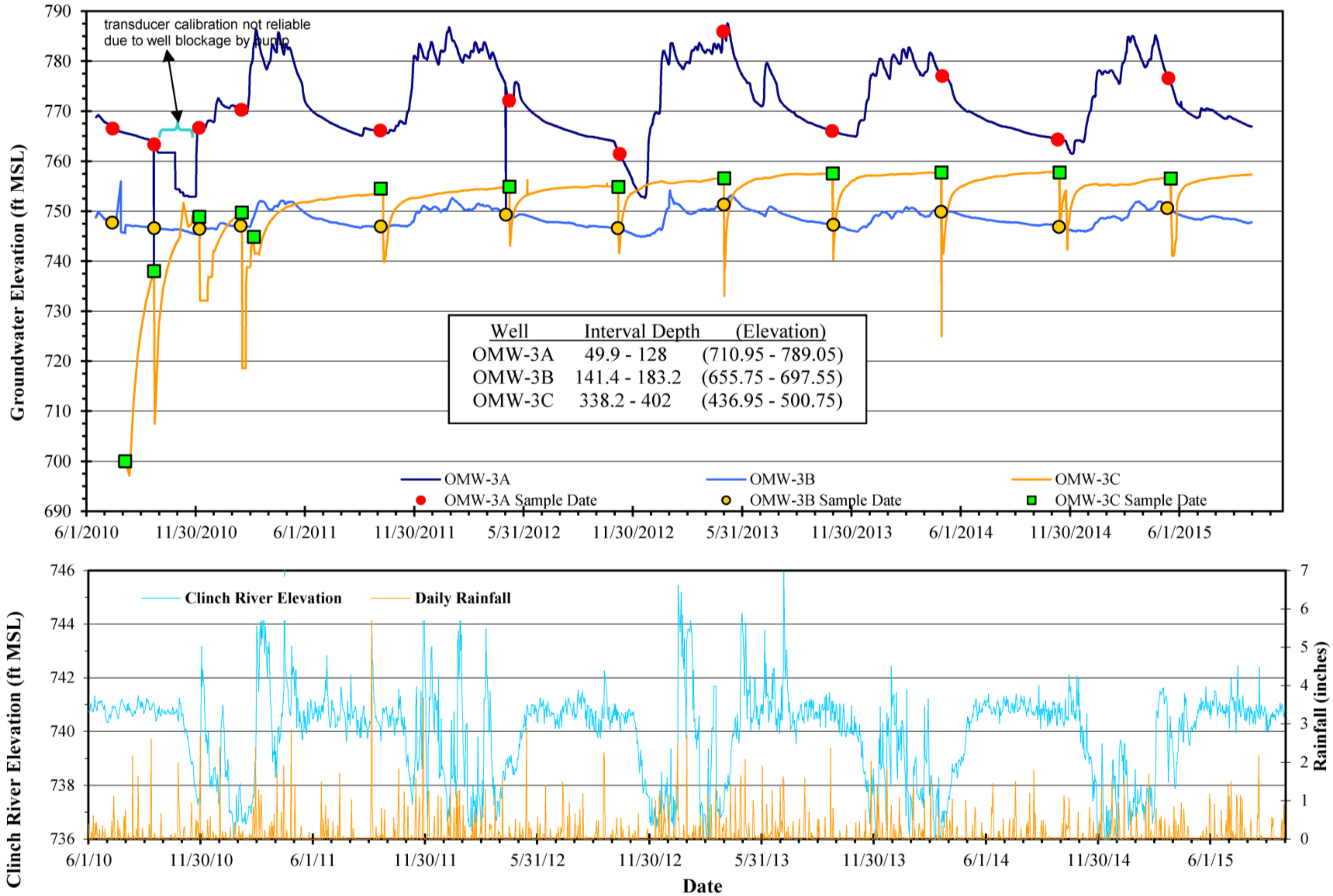

Figure B.4.3. Hydrographs for monitoring zones in OMW-3.

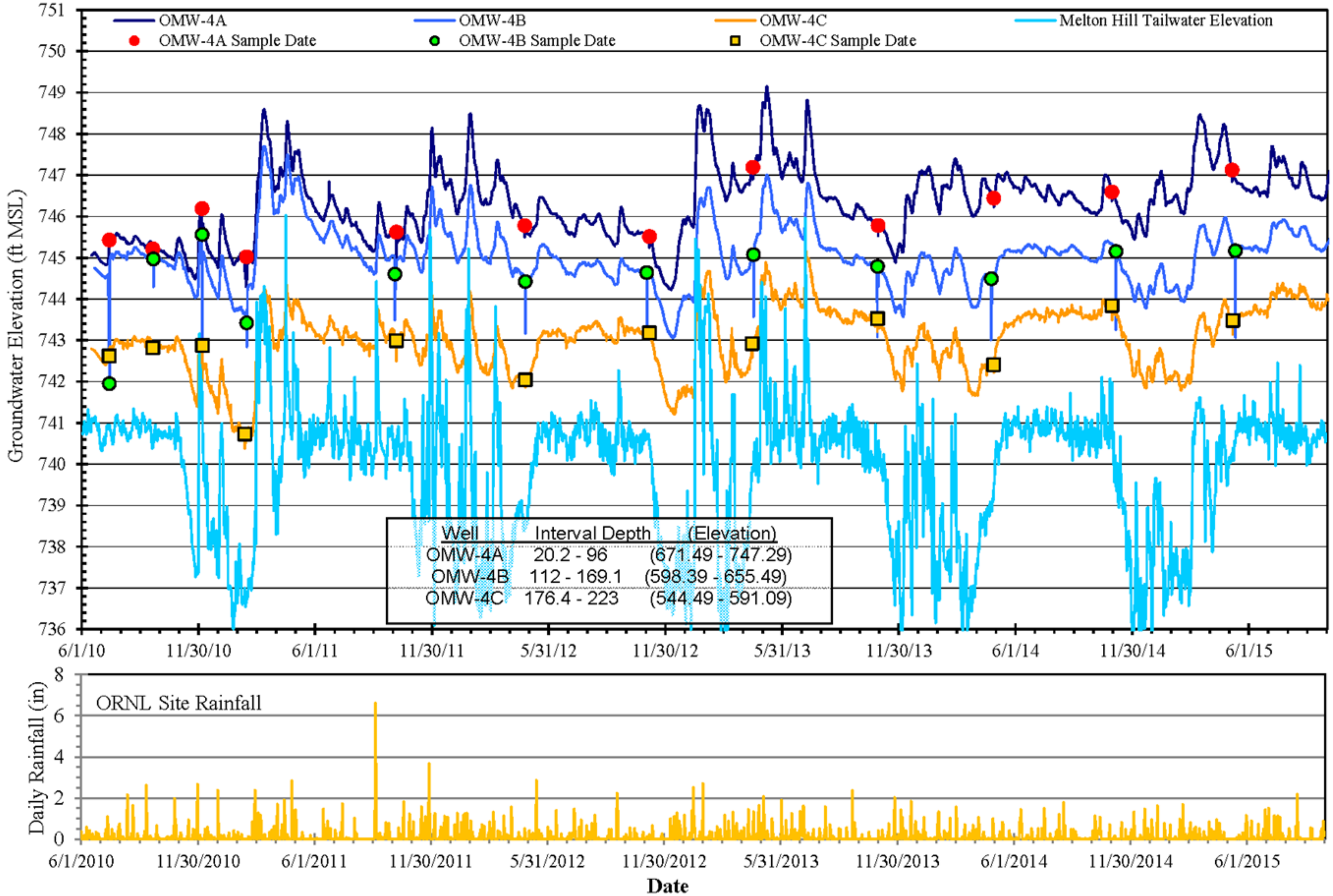

Figure B.4.4. Hydrographs for monitoring zones in well OMW-4.

APPENDIX C
ACTION PLANS IDENTIFIED FROM
2011 THIRD RESERVATION-WIDE CERCLA FIVE-YEAR REVIEW
(DOE/OR/01-2516&D2)

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ACTION PLANS IDENTIFIED FROM 2011 THIRD RESERVATION-WIDE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA) FIVE-YEAR REVIEW (FYR) (DOE/OR/01-2516&D2)

Action Plan Number	Status	Title
1	Open	East Fork Poplar Creek (EFPC) Streambed and Bank Sediments
2	Open	Mercury Bioaccumulation in LEFPC
3	Closed	Review of Cs 137 Action Level
4	Closed	Solid Waste Storage Area (SWSA) 4 Downgradient Trench Performance
5	Closed	Bethel Valley (BV) ROD Goal
6	Closed	Corehole 8 Plume Collection System Upgrade
7	Closed	East End Volatile Organic Compound (EEVOC) Plume Point of Compliance
8	Closed	Bear Creek Valley (BCV) Chemicals of Concern
9	Closed	S3 Pond Pathways 1-3

REFERENCES

DOE/OR/01-2516&D2. *2011 Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

ACTION PLAN 1
East Fork Poplar Creek (EFPC) Streambed and Bank Sediments

STATUS: Open
FIVE-YEAR REVIEW (FYR) ISSUE: OF-2
Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Operable Unit (OU): #28

ISSUE: New information suggests mobilization of mercury from East Fork Poplar Creek (EFPC) streambed and stream banks is a major source of mercury exposure during high-flow conditions. The current Record of Decision (ROD) did not fully consider the entire hydrologic system and did not explicitly address creek bank or creek bed sediments and the role that these sources of mercury could have in contributing to the overall mercury flux and to mercury bioaccumulation in biota in the stream.

BACKGROUND: The role of in-stream and floodplain mercury sources on mercury flux, speciation, and bioavailability in the EFPC system is a complex and not well understood issue. Various studies in Oak Ridge have provided useful information but there remain numerous data gaps and high uncertainty associated with the various mercury source terms. The focus of the U.S. Department of Energy's (DOE's) current and near-future remediation activities to address mercury contamination is in the "upstream areas" near the Y-12 National Security Complex (Y-12), as any potential action downstream will need to be addressed as part of a sequencing approach to the system. Current efforts to address this issue will focus on closing data gaps on the roles of streambed and stream bank soil and sediment and shallow groundwater (GW) beneath the floodplain as sources of mercury and methylmercury to the Lower East Fork Poplar Creek (LEFPC) aquatic ecosystem, and providing information for future remedial decision-making.

PLAN/SCHEDULE: The action plan will involve conducting select field and laboratory investigations to close data gaps and to better define mercury contributions from stream bank and channel sources. Newly collected data will be used to develop conceptual and systems-based models that can be used as tools to refine source estimates. The evaluations will be conducted over a three year period leading to the 2016 Five-Year Review (FYR), and progress reported annually in the Remediation Effectiveness Report (RER).

Update on FY 2015 Action 1 studies

The primary Action Plan 1 effort in FY 2015 included 1) completing field studies of bank soil erosion and shallow groundwater through spring 2015, and 2) generating a model of current mercury flux conditions such that various remedial scenarios can be simulated. The field studies over the last two years of the project have focused on obtaining a better understanding of the role of major source compartments of the watershed (see Figure 1). Generating a working mercury decision-support model and conducting testing and simulations were a major emphasis of the FY 2015 work scope. A final report summarizing field and laboratory studies and modeling work for the Action Plan 1 project will be published in March 2016. A brief update regarding FY2015 progress is provided here.

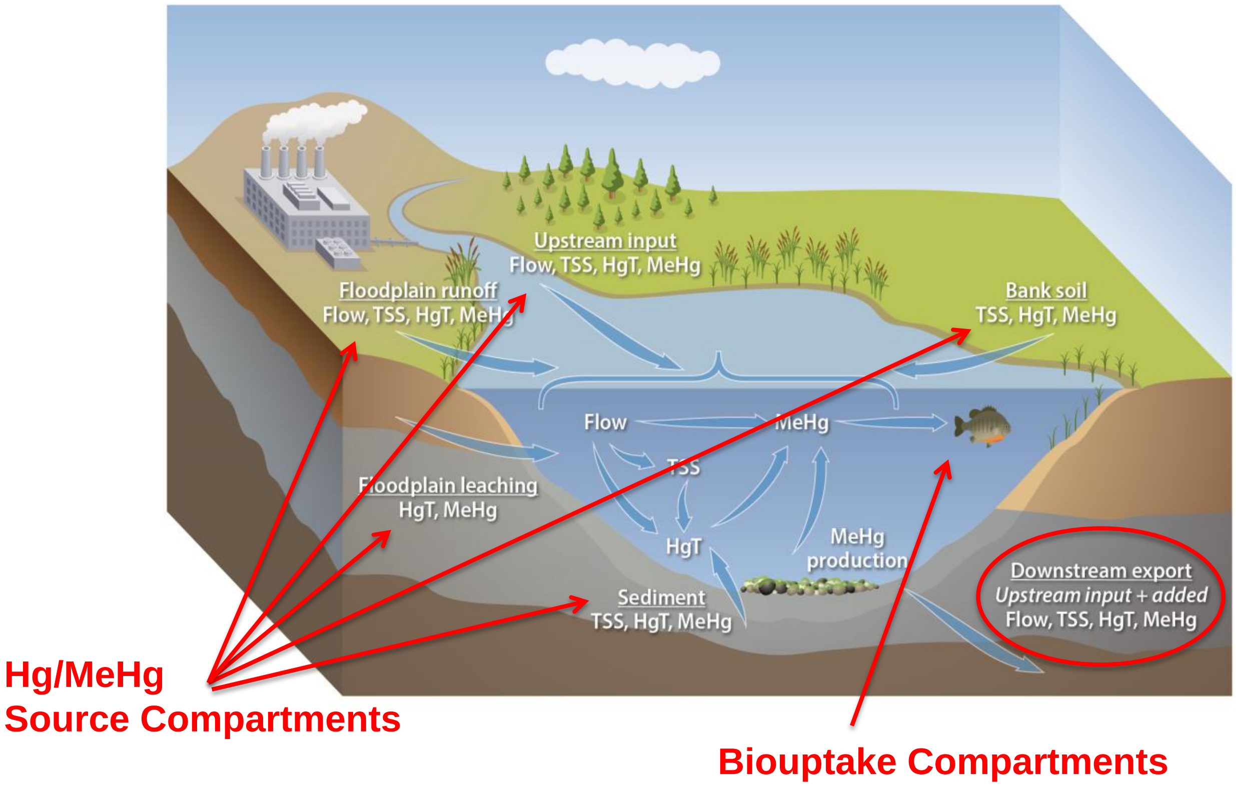

Figure 1. Conceptual model for understanding mercury source contributions and bioaccumulation in Lower East Fork Poplar Creek, where HgT = total mercury, MeHg= methylmercury, and TSS= total suspended solids.

Quantification of Stream Bank Erosion

Eight erosion pin sets were installed at seven sites along the creek in November 2013 and erosion or deposition recorded for 15 of 19 pins over a 531-day deployment (until June 2015) (Figure 2). Much of that erosion occurred during winter and early spring, with little to no erosion recorded from mid-spring to mid-summer. Several factors contribute to enhanced erosion during winter and early spring. There is little to no vegetative cover on stream banks during that time. Freeze–thaw cycles and frost heave are more likely to occur during that time. Wetter soils and lower evapotranspiration during winter through mid-spring favor increased runoff–rainfall ratios, meaning rainfall of similar magnitude will generate higher streamflow in winter than in summer. During the January 2014 sampling campaign, extensive ice lenses were observed beneath a very friable surface of ~5 mm of bank soil. Material slump brought on by frost heave and undercut by the flowing creek also was observed.

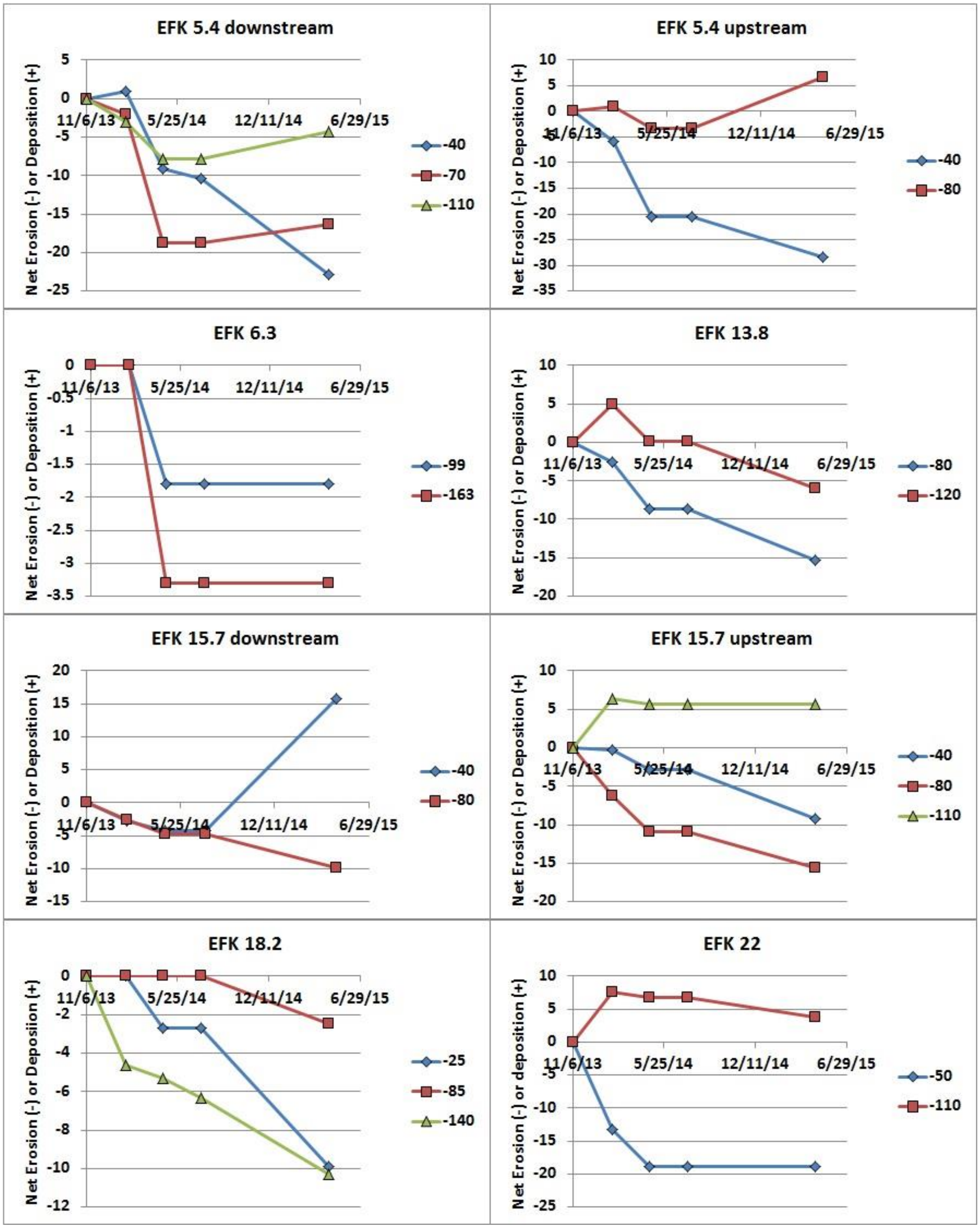

Figure 2. Estimates of net erosion or deposition over time from erosion pin measurements at eight East Fork Poplar creek kilometer (EFK) sites. Numbers in the legend of each plot indicate the distance in centimeters to the erosion pin from the top of the creek bank.

Evaluation of Shallow Groundwater Connections to EFPC

Shallow groundwater wells were established near EFK 15.7, adjacent to where the Mill Branch tributary enters EFPC (Figure 3). Four wells were installed at this location on July 2, 2013. Wells were installed by hand-driving 1 in. PVC casing to the point of refusal. After installation, each well was purged using a peristaltic pump until purge water was clear. Subsequent to well installation and development, groundwater and surface water were sampled for analysis in August 2013 and then monthly beginning in November 2013 to May 2015.

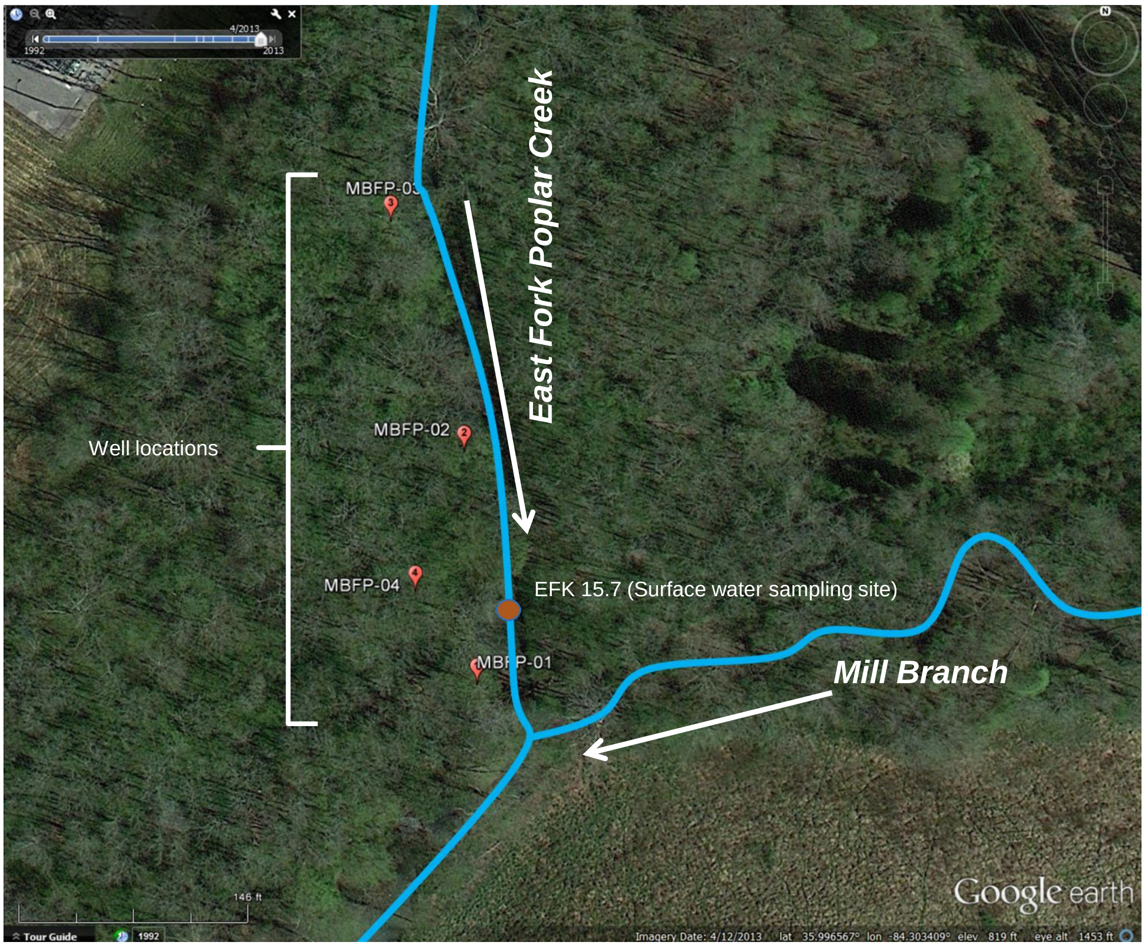

Figure 3. Well and surface water sampling sites near the confluence of East Fork Poplar Creek and Mill Branch.

Results to date demonstrate that the groundwater has a chemical composition that is both distinct from the surface water and consistent with active anaerobic microbial metabolism necessary for methylmercury production. Sampling results strongly suggest that the shallow groundwater at the Mill Branch site supports methylmercury production (Figure 4). Dissolved mercury concentrations were lower in groundwater than in surface water, but dissolved methylmercury (MeHgD) concentrations were comparable to or up to 10 times greater than the surface water. Additionally, two of the wells, MBFP-03 and MBFP-04, showed a strong seasonal pattern in MeHgD concentration, with lower concentrations in winter and higher concentrations in summer, similar to the water temperature pattern. The temporal variability in groundwater chemistry (data not shown here), coupled with groundwater gradients, suggests water exchange with surface water is possible through a combination of lateral flow with the creek water and vertical recharge from precipitation. It is possible that the groundwater is a source of methylmercury

to the surface water, but additional studies are required to establish the likelihood and magnitude of occurrence.

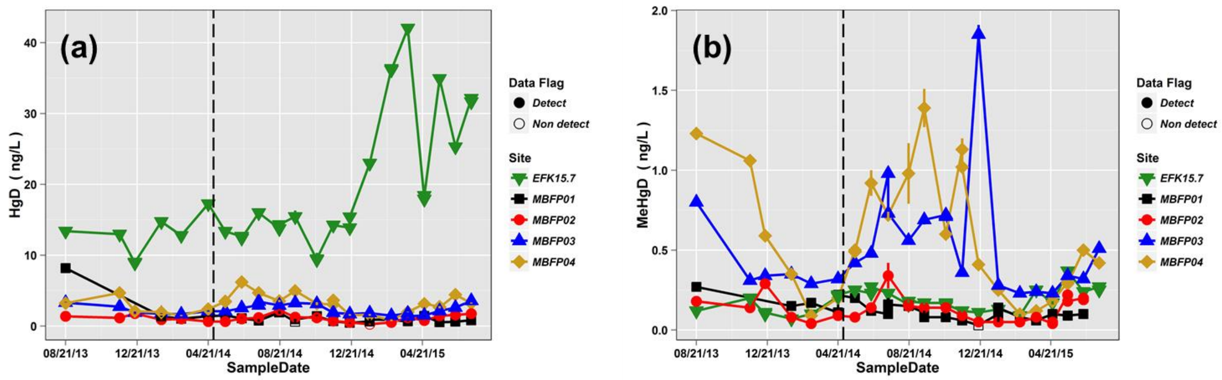

Figure 4. Concentrations of dissolved (a) mercury (HgD) and (b) methylmercury (MeHgD) in surface water (East Fork Poplar Creek kilometer [EFK] 15.7) and groundwater (MBFP-01 to MBFP-04).

The vertical dashed line in panels (a) and (b) indicates the cessation of flow augmentation near Outfall 200 inside the Y-12 National Security Complex.

Error bars indicate ± 1 standard error of the analytical measurement. Error bars not visible are smaller than the symbol size.

Watershed Modeling

Past research has shown a significant disconnect between the amount of total mercury in either sediment or water and the resulting concentrations in aquatic biota, particularly fish. The mercury content in fish and other organisms is primarily methylmercury, which is produced from inorganic mercury mainly in biologically active areas of the surface water and sediment. Mercury contamination in fish is a human health concern throughout the world in all types of aquatic ecosystems because of fish consumption. Because of the poor understanding of methylmercury dynamics in aquatic systems (both production of and accumulation by biota), it is difficult to estimate human health risk or to predict the potential impact of various mitigative measures designed to reduce mercury in the food chain.

To gain a deeper understanding of the complex EFPC ecosystem, a dynamic watershed model has been developed to provide a platform that can be used to integrate the extensive multidisciplinary data from numerous studies into a more holistic understanding of the watershed and to quantify the sources, flux, concentration, transformation, and bioaccumulation of inorganic mercury (IHg) and methylmercury (MeHg). This model can serve as a tool for identifying which components of the LEFPC system are currently generating the greatest mercury fluxes and sustaining the concentration of mercury in the creek. The model also can help target the sources of mercury that could result in the greatest decrease in flux and concentration if remediated. Ultimately, the watershed model can be applied to produce outputs for different remediation scenarios to compare the impact of different source reductions on water quality and to better understand the dynamics of MeHg production and subsequent bioaccumulation and uptake into fish.

The watershed model was developed primarily using the spreadsheet program Excel (Microsoft 2010), although some inputs were derived through analyses conducted in the GIS software ESRI ArcMap 10.1 (Environmental Systems Research Institute 2011). For the purposes of the model, EFPC has been divided into five different reaches (Figure 5), with estimates of average flux and concentration made on a monthly time increment at the downstream end of each reach. The framework of the model is shown in Figure 6. The reaches were selected to maintain similarity of stream type within each reach and to ensure that each reach is represented by a long-standing BMAP fish collection site. The downstream boundary of the first

upstream reach is coincident with Station 17, which has considerable historical data on flows, mercury concentrations, and fluxes. The downstream boundary of the last downstream reach is

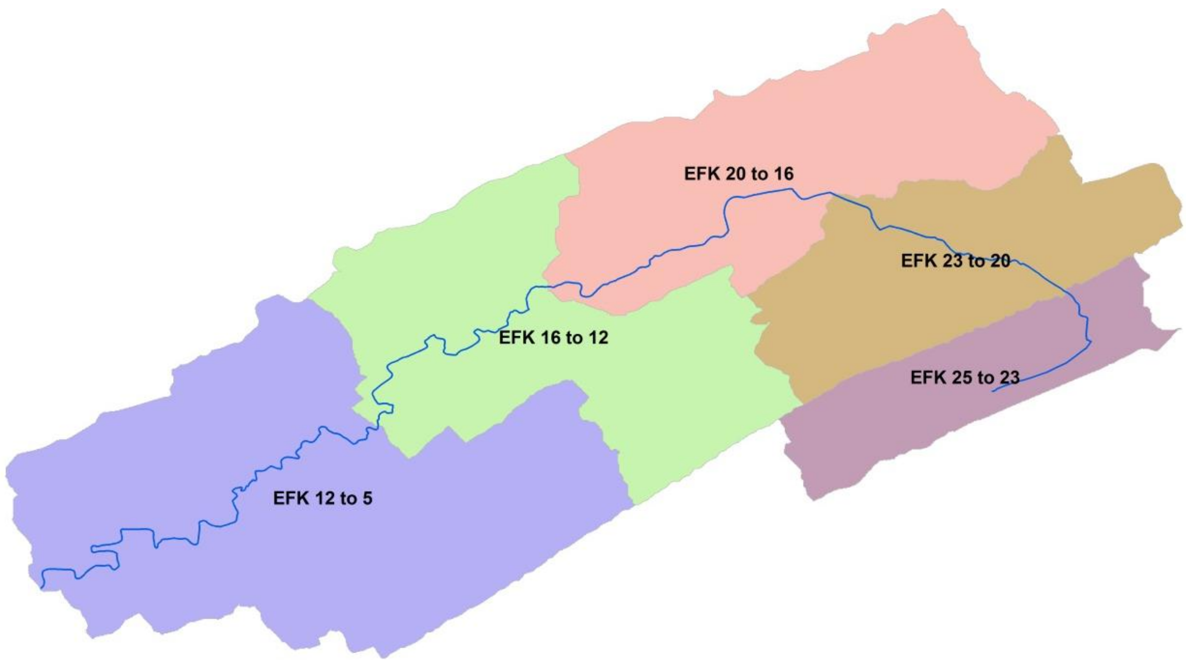

Figure 5. The five modeling reaches along East Fork Poplar Creek. (Note: EFK = East Fork Poplar Creek kilometer.)

coincident with the US Geological Survey (USGS) gauging station near New Horizon (NH), which also has associated historical information as well as recent investigations. The historical data from Station 17 was used to calculate the upstream monthly average flow and mercury inputs coming from Y-12 (UEFPC) to LEFPC; similarly, calculations for NH were made to estimate the monthly average flow and mercury fluxes leaving the model domain. The model is set up to represent typical average monthly flow conditions with flow augmentation in UEFPC turned off because that is the current and likely future condition.

Flow inputs to each of the modeled stream reaches were added incrementally to the Station 17 flow inputs to make the flows add up to the estimated average monthly flows at NH. Calculated average monthly flows from the Oak Ridge Wastewater Treatment Facility (ORWTF) were obtained from the City of Oak Ridge and were added to the EFK 16–12 reach (Figures 5 and 6). The remainder of the flow difference between NH and Station 17 was divided and used as input to each of the reaches based on the proportion of the LEFPC watershed drainage area associated with each reach. LEFPC is flashy, with the magnitude of stream flow increasing considerably during large precipitation events. Some of the mercury processes (e.g., bank erosion) are dependent on these flow conditions, so it was important to estimate the proportion of the monthly average flow that is stormflow versus base flow conditions from the stream hydrographs.

As shown in Figure 6, the model includes estimates of fluxes of IHg and MeHg coming into each of the reaches and the impacts of instream processes occurring in each of the reaches. The influx to each stream reach includes estimates of what is flowing into the reach from the upstream reach, additional inputs from bank erosion, and overland flow and infiltration from the floodplain. Estimates of the inflow of clean water and clean total suspended solids (TSS) that enter the system within each of the reaches and its impact on IHg and MeHg concentrations also are included in the model. Instream processes considered

include sediment deposition and mobilization (IHg and MeHg), MeHg production primarily by periphyton, and partitioning. The model is configured so that the watershed impacts of a reduction in flux

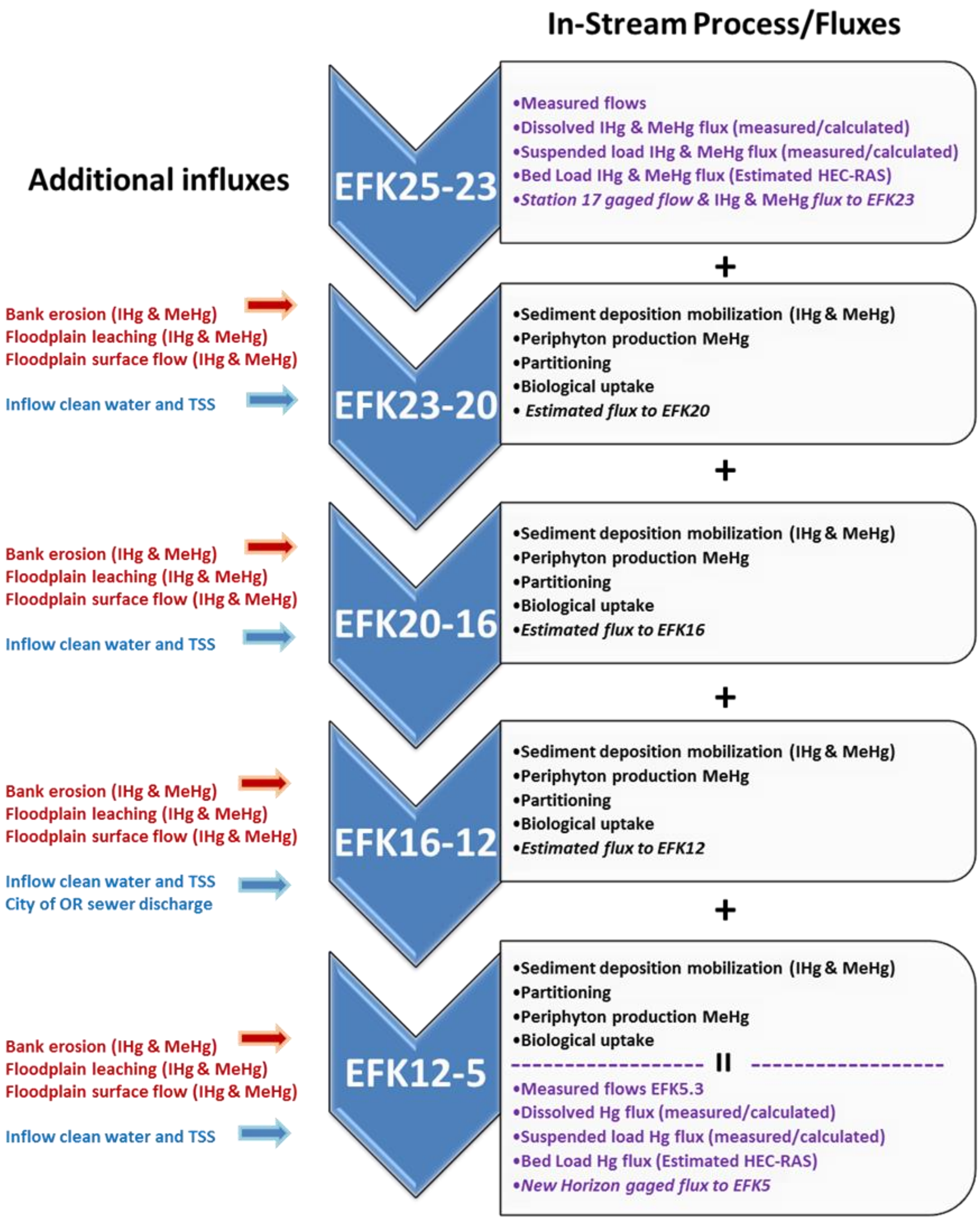

Figure 6. Watershed model framework showing stream reaches, IHg and MeHg inflow and outflow, and instream processes considered in the model.

in one or more of the mercury inputs can be assessed. More detailed descriptions of the major components of the watershed model and the methodology used to estimate the magnitude of flow and HgT and MeHg fluxes and concentrations will be provided in a final report to be completed in March 2016.

Output from the watershed dynamics portion of the model will be input to the biotic or bioaccumulation portion of the model. The bioaccumulation component of the model uses STELLA software. The general operation of the model tracks the feeding, growth, and mercury assimilation in representative individual fish (one for each species) through their typical life span (up to 6 years). The amount of food and, therefore, mercury that is consumed and assimilated during the simulated period varies as a function of fish size, water temperature, and diet. Ultimately the approach includes development of a predictive model based on present conditions, future changes in those conditions, and an understanding of system-wide transformation and transport mechanisms.

ACTION PLAN 2
MERCURY BIOACCUMULATION IN LEFPC

STATUS: Open
FYR ISSUE: OF-3
CERCLIS OU: #10

ISSUE: New mercury bioaccumulation studies show mercury uptake in spiders along LEFPC.

BACKGROUND: Questions regarding mercury bioaccumulation in plant and animal species along LEFPC have been documented as a decision uncertainty and information gap in the conceptual site model for the creek in the Remedial Investigation (RI) (DOE/OR/02-1119&D2)/Feasibility Study (FS) (DOE/OR/02-1185&D2&V2), Proposed Plan (PP)/ROD, and 2006 FYR. The 2011 FYR included additional information from studies along LEFPC indicating mercury uptake by spiders. Based upon the new spider information, uncertainty, and data gaps, the 2011 FYR deferred the protectiveness determination for LEFPC.

PLAN/SCHEDULE: The plan in FY 2012 was to conduct a literature evaluation that would provide data for a revised ecological risk evaluation for the LEFPC floodplain, which would inform the protectiveness determination. A comprehensive analysis of these new (spider) data along with an analysis of new toxicity information in the literature (e.g., Bergeron et al., [2011] and Albers et al., [2007]) and new information on methylmercury uptake in spiders near the South River in Virginia were completed in early FY 2013.

The schedule for this effort was to complete this Action Plan report in the 2014 RER. Additionally, it was believed that the findings would result in a protectiveness statement for LEFPC. However, after results were attained, it was determined that more conclusive site-specific floodplain information was needed that would decrease the uncertainty.

Therefore, DOE agreed to complete a Data Quality Objectives (DQOs) workshop and LEFPC Sampling and Analysis Plan in FY 2014. In FY 2015 sampling would take place and an evaluation will be completed in time for the FYR in 2016 at which time a LEFPC protectiveness statement will be made.

Update on FY 2015 studies

In FY 2015, invertebrate samples were collected at selected plots with soil mercury data from FY 2014 (Figure 1). The plots were selected based on the need for appropriate habitat for the target invertebrate taxa and that would be representative of high, medium, and low mercury (defined for this project as >100 ppm, 20–100 ppm, and <20 ppm, dry weight, respectively) exposure to invertebrates. The study was designed such that there would be a range of exposure conditions to calculate bioconcentration factors for invertebrates that could then be used in risk calculations.

Invertebrate collections started in spring of 2015 and were completed in September. There was generally sufficient biomass collected from the four target taxa (i.e., worms, detritivores, spiders, and herbivores) from all sites and areas, including the reference site; however, the biomass of herbivores in 14 samples (at least one plot from each site) and detritivores in one sample (Brushy Fork Plot BF-45) was slightly below the desired weight. See Table 1 for a sample summary.

While the biomass for several samples of herbivores was below the minimum desired by the laboratory, this group was represented by species from a single family of herbivores (i.e., Cicadellidae or leaf hoppers). The decision to include only one family of herbivores was being made in order to reduce

potential variation in the results for this taxon. Appropriate provisions for ultra-low sample mass were made by the analytical laboratory to account for the low biomass of some samples from associated sample plots.

All samples for each of the four taxa groups were freeze dried and shipped to the analytical laboratory. Verified results are pending. A final report summarizing Action Plan 2 studies will be completed in spring 2016.

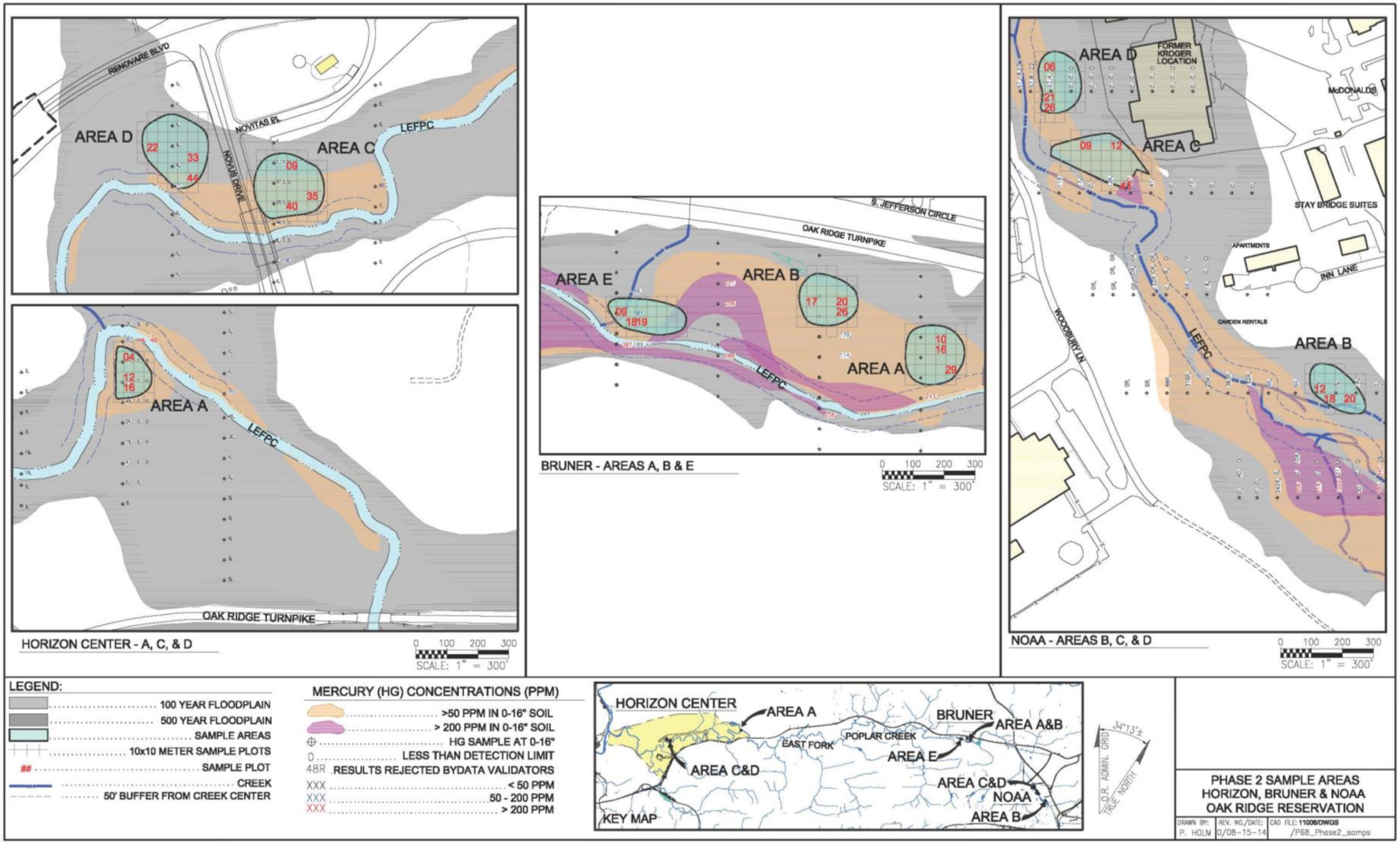

Figure 1. Soil sampling areas at Horizon Center, Bruner, and NOAA.

Table 1: Summary of invertebrate biomass collected in spring and summer 2015

Sample Area	Target Taxa	Number of Plots with biomass well above desired mass (>2 g)	Number of Plots with biomass above desired mass (1.2 – 2 g)	Number of Plots at minimum biomass (0.12 – 1.1999 g)
Upstream – NOAA	Worms	4/9	4/9	1/9
	Detritivores		1/9	8/9
	Wolf Spiders	3/9	1/9	8/9
	Herbivores	-	-	1/9 (8/9 below min.)
Midstream – Bruner	Worms		9/9	-
	Detritivores	-	7/9	2/9
	Wolf Spiders	-	3/9	6/9
	Herbivores	-	-	9/9
Downstream – Horizon Center	Worms	1/9	8/9	-
	Detritivores	-	6/9	3/9
	Wolf Spiders	-	-	9/9
	Herbivores	-	-	3/9 (6/9 below min.)
Reference Site – Brushy Fork	Worms	-	3/3	-
	Detritivores	-	-	2/3 (1/6 below min.)
	Wolf spiders	-	1/3	2/3
	Herbivores	-	-	3/3

g = gram
NOAA – National Oceanic and Atmospheric Administration

ACTION PLAN 3
Review of Cs 137 Action Level

STATUS: Closed
FYR ISSUE: OF-4
CERCLIS OU: #24

ISSUE: The ^{137}Cs action level used by the Watts Bar Interagency Working Group (WBIWG) should be reviewed in light of the various changes in the risk assessment process and cancer slope factors.

BACKGROUND: The ROD for the Lower Watts Bar Reservoir (LWBR) requires institutional controls to prevent exposure to lake sediments that are contaminated with ^{137}Cs. The WBIWG, established by the Watts Bar Reservoir Permit Coordination Interagency Agreement in 1991, established a procedure for interagency coordination and review of permitting and other activities that could result in the disturbance, resuspension, removal, and/or disposal of contaminated sediments in the Watts Bar Reservoir. This agreement identified the cooperative efforts of DOE, EPA, U.S. Army Corps of Engineers (USACE), Nashville District, the Tennessee Valley Authority (TVA), and Tennessee Department of Environment and Conservation (TDEC). Any requests for sediment-disturbing activities by the public and government agencies are submitted to the WBIWG for approval, which involves a review of sediment sampling results to determine that the ^{137}Cs concentration is at or below the risk-based action level of 11 pCi/g.

The 11 pCi/g action level was developed outside of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) documentation (ORNL 1994) in 1991. The 2011 FYR recommended that, given the changes in risk methods and ^{137}Cs toxicity data, the WBIWG action level should be reviewed to insure that it is protective of human health.

PLAN/SCHEDULE: The 11 pCi/g ^{137}Cs action level has been in place for a long period of time and has been used to make many decisions about sediment dredging. Review of this action level was completed with this in mind, and therefore a conservative CERCLA Reasonable Maximum Exposure (RME) approach that utilized a single set of conservative risk factors is not appropriate for this stage of the process. Instead, DOE used a stochastic approach making use of the range of potential exposure and risk factor values. The steps involved with this approach included:

1. Review the current action level;
2. Develop a “simple” Monte Carlo run for the ^{137}Cs action level using the new models and new toxicity information;
3. Reporting results in the 2013 RER Action Plan #3.

The steps have been completed and the reporting of results is provided below. This Action Plan #3 from the *2011 Third Reservation-wide CERCLA Five-year Review* is now closed.

<u>Reporting of Results</u>

Executive Summary

The new model, new toxicity information, and real data and information on typical dredging activities in the LWBR over the past 20 years were used to develop a Monte Carlo statistical analysis of the range of potential protective action levels. The analysis shows that the range of safe levels is 5.5 to 22.3 pCi/g, suggesting the 11 pCi/g action level is sufficient for reviewing typical residential dock dredge permit requests. The analysis does suggest that additional review steps should be taken for larger industrial dredge requests. In these cases where the WBIWG receives requests for larger commercial dredges

(> 1000 m^3 or approximately 1300 yd^3), additional steps should be taken to review these requests, particularly related to review and input on the issue of where and how dredge materials will be disposed of in these cases. Reuse of these dredge materials in areas where land use is not residential, e.g. recreational areas, may be acceptable. Higher action levels would be protective for these recreational uses since many of the conservative exposure assumptions other than slab size used to develop the 11 pCi/g level (e.g., the exposure frequency of 350 days/year) would not be applicable to recreational use.

Findings

Changes to the Risk Model Used to Identify the ^{137}Cs Action Level

The ^{137}Cs plus daughters (+D) action level for dredged sediments (11 pCi/g) used by the WBIWG was developed outside of the official CERCLA documentation in 1991 (ORNL 1994). The action level was calculated using the available risk models in 1991 and was based on a residential land use scenario and a target cancer risk of 1E-4. Given the changes in risk methods and ^{137}Cs +D toxicity data, the WBIWG action level was evaluated to ensure that it is still protective under CERCLA. The current EPA Radionuclide PRG Model and ^{137}Cs +D toxicity data were used in a Monte-Carlo simulation to determine the range of likely protective levels. The current evaluation also used a residential land use scenario and a target cancer risk of 1E-4.

EPA Radionuclide PRG Model

The EPA publishes generic PRGs or action levels for radiological constituents that are risk-based activity concentrations (in pCi/g) that can be used to screen potentially contaminated media. Radiological PRGs combine current EPA toxicity values with standard exposure equations and factors that represent reasonable maximum exposure (RME) conditions to estimate contaminant activities in soil that the agency considers protective of humans over a lifetime. The activity concentrations are based on direct exposure pathways (ingestion, inhalation, external exposure, and produce consumption) for which generally accepted methods, models, and assumptions have been developed. The drawback with the generic PRGs for radionuclides is that the parameters used do not account for any site-specific characteristics. Two parameters for which site-specific parameter values are key in estimating a ^{137}Cs action level for soil include the extent of contamination (e.g., area and thickness of contamination in the soil) and the indoor gamma shielding factor (which accounts for attenuation of gamma radiation by building materials).

As a result, the EPA publishes a radionuclide PRG calculator function at the *EPA Preliminary Remediation Goals for Radionuclides* website (EPA 2012) that allows for site-specific input parameters to be used in order to calculate site-specific action levels. The radionuclide PRG calculator and the associated equations are the source of the PRG model used in this assessment; however, instead of using the online PRG calculator, the EPA equations were entered into Crystal Ball, a Monte-Carlo simulation program, to perform a stochastic evaluation of potential ^{137}Cs +D action levels. A range of site-specific input parameters for the area and thickness of the contaminated soil and the indoor gamma shielding factor were used in this evaluation. In addition to these two parameters, the “area correction factor” and “particulate emission factor” are dependent on the area of contamination; therefore, these parameters are also site-specific. The original target cancer risk of 1E-4 was used. All other input parameters used in the evaluation are the standard exposure factors typically used in the PRG calculator.

Monte-Carlo Simulation

For this assessment, a Monte-Carlo simulation was run to calculate the PRG for ^{137}Cs +D using Decisioneering Crystal Ball Risk Assessment software. Crystal Ball works with data in MS Excel spreadsheets and expands the analysis capability beyond the traditional point estimates, range estimates, and "what if" scenarios, by helping to define the variables that contribute most to uncertainty – referred to as the sensitive parameters. Using a range of values and the likely shape of the probability distribution curve for a given parameter, Crystal Ball can run thousands of simulations to determine the probability that a certain forecast value will fall within a specified range. Therefore, the probability that the action level of 11 pCi/g will fall within the range of likely protective levels can be determined.

Monte-Carlo simulation is appropriate for managing uncertainty in complex situations because it accounts for the variability of key factors. For this assessment, only the area of soil contamination (slab size) and the gamma shielding factor parameters were given a range of values and probability distribution. Site-specific, constituent-specific, and standard parameters used in the Monte-Carlo simulation are described below. The area correction factor and particulate emission factor are automatically calculated based on the area of soil contamination (slab size) and therefore are also shown as a range of values.

Evaluation of Risk Parameters used to Identify the ^{137}Cs Action Level

Site-Specific Parameters

Site-specific parameters used in this evaluation include the area and thickness of soil contamination (and related area correction factor and particulate emission factor), and the indoor gamma shielding factor.

The area of soil contamination or slab size is based on reported dredge volumes listed on dredge permit applications received by the TVA for the Watts Bar Reservoir between 2010 and 2012. On most of the permit applications, the expected volume of dredged sediment is provided. A majority of the dredge requests are related to installation of small, residential/recreational docks. Many of the applications indicated that the dredged material would be placed within the applicants' yard. Based on the reported volume of dredged sediment, and an assumed land application thickness of 15 cm (5.9 in.), the range in the soil contamination area or slab size was determined to be 30.6 m^2 to 765 m^2 (329.4 ft^2 to 8234 ft^2), with an estimated average area of soil contamination or slab size of 522 m^2 (5618 ft^2). For the Monte-Carlo simulation, a triangular distribution for the area was assumed with the average area selected as the most likely result. The range in the soil contamination area (slab size) was used as the minimum and maximum values. This soil contamination area also factors into the calculated area correction factor and the area used to calculate the particulate emission factor. While the area correction factor and the area used to calculate the particulate emission factor varied for each simulation based on the area selected during the Monte-Carlo simulation, neither of these parameters had distributions defined in Crystal Ball. The particulate emission factor was also dependent on the climatic zone selected for the calculation. For this assessment, the climatic zone of Atlanta, Georgia was selected as recommended by the online EPA radionuclide PRG calculator.

On an infrequent basis, the WBIWG is approached with a commercial dredge request. These types of requests are rare, and as expected, address larger dredge volumes. Review of these requests showed potential dredge volumes resulted in slab areas ranging from 7,650 m^2 (3011 ft^2) to 10,900 m^2 (4291 ft^2), with a likely value of 9,258 m^2 (3644 ft^2).

The indoor gamma shielding factor accounts for attenuation of gamma radiation by building materials and the resulting reduction in dose to a potential receptor while indoors. The shielding factor is one of the most important parameter values impacting the calculation of the ^{137}Cs +D PRG because the external dose

pathway dominates the risk for this constituent. The default indoor gamma shielding factor used in the EPA radionuclide PRG calculator is 0.4; however, residual radioactivity computer code (RESRAD) uses a default gamma shielding factor of 0.7 and historically gamma shielding factors as high as 0.8 were used. Gamma shielding factors are also reported to be as low as 0.2 for heavily constructed (block and brick) homes (EPA 1981). A study titled *Development of Site-Specific Shielding Factors for Use in Radiological Risk Assessments* conducted by the Nuclear Regulatory Commission (NRC) calculated many site-specific gamma shielding factors for various building types and exposure scenarios (NRC 2010). Building types included slab on grade with wood siding, slab on grade with brick siding, basement foundation, crawlspace foundation. Exposure scenarios included general contamination (house is located in the center of a 10,000 m^2 [107639 ft^2] area of contamination) and an elevated area of contamination (a 100 m^2 [1076 ft^2] elevated area directly under the house). The weighted mean gamma shielding factors for various composites of these scenarios were below 0.4. For the Monte-Carlo simulation, a triangular distribution for the gamma shielding factor was assumed with 0.4 selected as the most likely result. The minimum and maximum gamma shielding factors used for the triangular distribution were 0.2 and 0.8, respectively.

Site-specific parameter values for slab size and gamma shielding are summarized in Table 1.

Table 1. Summary of site-specific parameters

Parameter	Unit	Minimum value	Maximum value	Most likely value
Slab Size – typical residential dredge (area of contamination)	m^2	30.6	765	522
Slab Size – typical residential dredge (area of contamination)	ft^2	329.4	8234	5619
Gamma Shield Factor – indoor	unitless	0.2	0.8	0.4

Radionuclide-Specific Parameters

Radionuclide-specific parameters including the decay constant, wet soil to plant transfer factor, and slope factors used in this assessment are provided on Table 2. With the exception of the external slope factor, each of these radionuclide-specific parameters is the default values used in the EPA Radionuclide PRG calculator. The external slope factor used in this evaluation is the value from the EPA PRGs for Radionuclides website (EPA 2012) that is based on an assumed thickness of 15-cm (5.9 in.) throughout the entire area of contamination. Neither range estimates nor distributions were identified for these radionuclide-specific parameters for the Monte-Carlo simulation.

For this investigation, ^{137}Cs +D slope factors were used to account for the daughter products of ^{137}Cs. Select radionuclides and radioactive decay chain products are designated in the generic PRG table with the suffix "+D" (plus daughters) to indicate that the cancer risk estimates for these radionuclides include contributions from their short-lived decay products, assuming equal activity concentrations (i.e., secular equilibrium) with the principal or parent nuclide in the environment. The "+D" indicates that associated decay products with half-lives less than 6 months are included in the PRG. In the case of ^{137}Cs, the short-lived daughter radionuclide, ^{137}Bismuth, emits the majority of gamma radiation associated with ^{137}Cs, hence the use of the +D slope factor is essential.

Table 2. Constituent-specific Parameters for ^{137}Cs +D

Parameter	Value	Unit
λ (decay constant)	2.31E-02	1/yr
SFext (slope factor external) – 15 cm	2.27E-06	(risk/yr)/(pCi/g)
SFs (slope factor ingestion)	4.33E-11	risk/pCi
SFi (slope factor inhalation)	1.19E-11	risk/pCi
SFf (food slope factor)	3.74E-11	risk/pCi
TFp (wet soil to plant transfer factor)	0.04	unitless

Standard Exposure Factors/Parameters

Standard exposure factors/parameters used in this assessment are provided on Table 3. Each of these exposure factors/parameters are default values in the EPA Radionuclide PRG calculator. Neither range estimates nor distributions were identified for these standard exposure factors/parameters for the Monte-Carlo simulation.

Table 3. Standard Parameters

Parameter	Value	Unit
t_r (time - resident)	30	yr
ED_r (exposure duration - resident)	30	yr
ET_r (exposure time - resident)	24	hr/day
ET_{r-o} (exposure time - outdoor resident)	0.073	hr/hr
ET_{r-i} (exposure time - indoor resident)	0.684	hr/hr
ED_{r-c} (exposure duration - resident child)	6	yr
ED_{r-a} (exposure duration - resident adult)	24	yr
EF_r (exposure frequency - resident)	350	day/yr
IRS_{r-a} (soil intake rate - resident adult)	100	mg/day
IRS_{r-c} (soil intake rate - resident child)	200	mg/day
IRF_{r-a} (fruit consumption rate - resident adult)	20.5	mg/day
IRF_{r-c} (fruit consumption rate - resident child)	5.4	mg/day
IRV_{r-a} (vegetable consumption rate - resident adult)	10.4	kg/yr
IRV_{r-c} (vegetable consumption rate - resident child)	3.8	kg/yr
IRA_{r-a} (inhalation rate - resident adult)	20	m^3/day
IRA_{r-c} (inhalation rate - resident child)	10	m^3/day
IFF_{r-adj} (age-adjusted fruit ingestion factor - resident)	17.48	kg/yr
IFV_{r-adj} (age-adjusted vegetable ingestion factor - resident)	9.08	kg/yr
IFS_{r-adj} (age-adjusted soil ingestion factor - resident)	120	mg/day
IFA_{r-adj} (age-adjusted soil inhalation factor - resident)	18	m^3/day
CPF_r (contaminated plant fraction)	0.25	unitless

Results of Monte-Carlo Simulations

- Based on the results of the Monte-Carlo simulation, the range of the potential PRG is 5.49 to 22.27 pCi/g with an average of 9.88 pCi/g (Table 4).

Table 4. Monte-Carlo Statistics

Statistics	Value	Unit
Trials	10000	---
Mean	9.88	pCi/g
Median	9.61	pCi/g
Mode	---	---
Standard Deviation	2.34	---
Variance	5.49	---
Skewness	0.74	---
Kurtosis	3.53	---
Coeff. of Variability	0.24	---
Range Minimum	5.49	pCi/g
Range Maximum	22.27	pCi/g
Range Width	16.78	---
Mean Std. Error	0.02	---

Figure 1 shows the distribution of potential PRGs calculated in the Monte Carlo simulation. There is a 28% chance that the action level is greater than 11 pCi/g. Therefore the action level of 11 pCi/g falls within the range of likely protective levels.

- There is an 80% chance the potential PRG falls between 7 and 13 pCi/g.
- There is a 66% chance the potential PRG falls between 8 and 13 pCi/g.
- There is a 50% chance the total PRG is between 9 and 13 pCi/g.

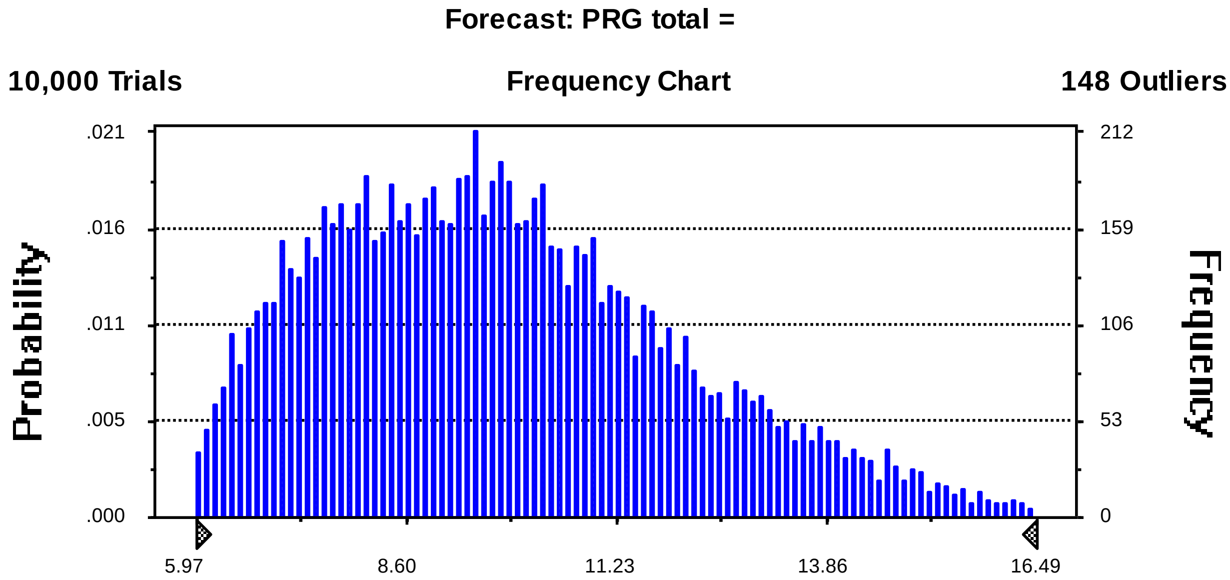

Figure 1. Distribution in the Total PRG

A single model run was performed using the larger commercial dredge volumes. When these volumes are used to define slab size in the model, the potential action levels are less (e.g., < 11 pCi/g).

Conclusions

The current 11 pCi/g action level used by the WBIWG to review residential dredge permit requests continues to be protective of human health. The WBIWG should continue to compare this value with available historical data (and new data as deemed necessary) to insure dredging activities are safe. However, in cases where the WBIWG receives requests for larger commercial dredges (> 1000 m^3 or approximately 1300 yd^3), additional steps should be taken to review these requests, particularly related to review and input on the issue of where and how dredge materials will be disposed of in these cases. Reuse of these dredge materials in areas where land use is not residential, e.g., recreational areas, may be acceptable. Higher action levels would be protective for these recreational uses since many of the conservative exposure assumptions other than slab size used to develop the 11 pCi/g level (e.g., the exposure frequency of 350 days/yr) would not be applicable to recreational use.

References

EPA 1981. *Population Exposure to External Radiation Background in the United States*, ORP/SEPD-80-12, Environmental Protection Agency, Office of Radiation Programs, Washington, D.C., April.

EPA 2012. *USEPA Preliminary Remediation Goals for Radionuclides*, Available at: <http://epa-prgs.ornl.gov/radionuclides/>.

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ACTION PLAN 4
Solid Waste Storage Area (SWSA) 4 Downgradient Trench Performance

STATUS: Closed
FYR ISSUE: MV-1
CERCLIS OU: #29

ISSUE: During FY 2009 and FY 2010, the GW level control in the Solid Waste Storage Area (SWSA) 4 downgradient trench in Melton Valley (MV) showed short-term problems following significant rainfall events. This indicates the possibility that contaminated GW may be discharged to the Intermediate Holding Pond for periods of time when water level control in the trench is inadequate. There are currently three wells not attaining their target level concentrations as stipulated in *The Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) (Section 3.2.2.2).

BACKGROUND: The SWSA 4 downgradient GW collection trench was designed and built to capture GW seepage from beneath the SWSA 4 cap. The design did not utilize a seepage barrier outside the capped area but rather relied upon maintaining a gradient control between the in-trench water level and water levels outside the unit beneath the former Intermediate Holding Pond. Siltation of the gravel backfill in the downgradient trench reduces the efficiency of the downgradient trench extraction wells, therefore not attaining the target concentrations.

PLAN/SCHEDULE: A project has been implemented to redevelop all the GW extraction wells in the SWSA 4 downgradient trench and to replace failed pumps to improve remedy performance. The project was completed in February 2013. Monitoring of GW levels in and around the trench will continue to determine the effectiveness of the remedy at containing contaminated GW beneath the downgradient cap edge. This Action Plan #4 from the *2011 Third Reservation-wide CERCLA Five-Year Review* is now closed.

ACTION PLAN 5
Bethel Valley (BV) ROD Goal

STATUS: Closed
FYR ISSUE: BV-1
CERCLIS OU: #30

ISSUE: The Bethel Valley (BV) ROD (DOE 2002) goal for SW of "achieve at least 45% risk reduction at 7500 Bridge" is difficult to use as a quantitative measure of performance due to:

(1) uncertainty related to the exact baseline risk values against which to measure this reduction, and

(2) lack of clarity in the ROD on sampling and statistical approach for measuring changes.

BACKGROUND: One of the remediation goals in the BV ROD is:

> *The selected remedy will also reduce risk in surface water at the 7500 Bridge by at least 45% relative to 1994 levels. The 7500 Bridge is the point at which surface water exits Bethel Valley and enters Melton Valley. Based on the anticipated effectiveness of the Melton Valley remedy, the 45% risk reduction is necessary to meet the Melton Valley watershed ROD goal of protecting the off-site resident user of surface water at the confluence of White Oak Creek with the Clinch River."*

PLAN/SCHEDULE: DOE will review the intent of the goal in the ROD and clarify the approach that will be used in future RERs and FYRs. Possible outcomes of the review could include:

- Definitive 1994 baseline contaminant masses and/or concentrations;
- A more clear definition of the quantitative approach for measuring the 45% risk reduction;
- A target concentration level for each contaminant detected at 7500 Bridge, along with clarity on the type of SW sample needed to confirm compliance;
- A target annual contaminant mass release for each contaminant detected at 7500 Bridge,
- Etc.

<u>History of the Issue</u>

The BV ROD (DOE 2002) identified several remedial action objectives (RAOs) for protection of SW bodies. Only the RAO relevant to this Action Plan will be discussed; "Achieve at least 45% risk reduction at the 7500 Bridge" (DOE 2002).

At stated in the BV ROD:

> *"This goal is a direct result of a goal in the Melton Valley watershed ROD to protect an off-site residential user of surface water at the confluence of White Oak Creek and the Clinch River. The Melton Valley watershed ROD established a remediation level of 1x10-4 ELCR (annual average) at the confluence. Because White Oak Creek receives water from Bethel Valley and Melton Valley watersheds, risk contribution from both watersheds are taken into account. Assuming 1994 baseline conditions, and assuming the*

Melton Valley remedy achieves at least an 82% reduction of the Melton Valley contribution to the residential risk at the confluence, then the Bethel Valley remedy must achieve a 45% risk reduction in surface water exiting Bethel Valley in order for the Melton Valley ROD goal of protection of the off-site resident to be met."

Additionally the BV ROD states:

"*The 45% risk reduction will be based on the combined risk from ^{90}Sr and ^{137}Cs*".

FINDINGS

Findings are discussed below under headings that correspond to the "possible outcomes of the review" identified under "**PLAN/SCHEDULE**" on p. 1 of this Action Plan.

Definitive 1994 baseline contaminant masses and/or concentrations. The FY 1994 data shown in Table 1 were first published in an Environmental Restoration Monitoring and Assessment report (DOE 1995), a precursor to the RER, and represent "1994 baseline conditions".

Table 1. Contaminant concentrations and flux at 7500 Bridge and White Oak Dam, 1994[a]

Parameter	Units	1994	
		7500 Bridge	**White Oak Dam**
Strontium-90 concentration/total contaminant mass flux	pCi/L/(Ci)	67/(0.75)	180/(3.37)
Cesium-137 concentration/total contaminant mass flux	pCi/L/(Ci)	59/(0.66)	33/(0.62)

[a]**Source:** Table 3.3 in DOE 1995.

WOD = White Oak Dam

Although conditions in BV relative to MV have changed since 1994, the ultimate purpose of setting the 45% risk reduction goal at the 7500 Bridge in BV was to ensure that the downstream MV ROD goal of protection the off-site resident is met. As shown in Table 2 below from Chapter 3 of the 2013 RER, regardless of the risk reduction realized at the 7500 Bridge, the goal to protect an off-site resident at the confluence of White Oak Creek (WOC) and the Clinch River (as measured at White Oak Dam [WOD]) has been achieved. This goal is evaluated based on an evaluation of average annual concentrations for ^{90}Sr, ^{137}Cs, and ^{3}H.

Table 2. Summary of FY 2012 radiological contaminant levels at White Oak Dam integration point in Melton Valley

WHITE OAK DAM			
Monthly composite date	^{90}Sr	^{3}H	^{137}Cs
27-Oct-11	61	25,000	17.8
30-Nov-11	59	32,000	26.7
29-Dec-11	52	16,000	9.6
26-Jan-12	37	5,500	32.5
29-Feb-12	41	4,600	12.4
29-Mar-12	30	7,000	20.7
26-Apr-12	44	13,000	9.6
31-May-12	38	16,000	27.9
28-Jun-12	48	39,000	31.5
26-Jul-12	49	53,000	24.1
30-Aug-12	47	**61,000**	13.9
27-Sep-12	42	**60,000**	30.0
Average concentration (pCi/L)	46.7	27,000	28.2
ROD Goal	85	58,000	150

Activity values are pCi/L measured in monthly continuous flow composite samples.
Bold value indicates sample concentration exceeds *Melton Valley ROD goal.*

^{137}Cs = cesium-137
^{3}H = tritium
^{90}Sr = strontium-90

A more clear definition of the quantitative approach for measuring the 45% risk reduction. Table 3 shows the concentration comparison provided in Chapter 2 of the FY 2013 RER. As risk is driven by contaminant concentration, evaluation of the 45% risk reduction goal by evaluation of reduction in average (arithmetic mean) annual contaminant concentration is appropriate. Other SW within the BV Watershed allows tracking of contaminant discharges from various source areas. This quantitative approach for measuring the 45% risk reduction has been used annually and is the recommended approach for evaluation in future RERs and the next FYR.

Table 3. 7500 Bridge risk-reduction goal evaluation

Year	Average strontium-90 (Goal = 37 pCi/L)[b]	Average cesium-137 (Goal = 33 pCi/L)[b]
1994[a]	67	59
2001	37	**219**
2002	37	**116**
2003	37	**41**
2004	**78**	**47**
2005	**70**	**78**
2006	35	33
2007	27	17
2008	27	<6
2009	**40**	12
2010	**42**	10
2011	**54**	< 16
2012	33	<15

Bold values indicate years during which annual average concentration exceeded the record of decision risk-based goal.

[a]*Record of Decision for Interim Actions in Bethel Valley Watershed* (DOE 2002) baseline year.
[b]Goal = 45% reduction in average concentrations measured during baseline year.

A target concentration level for each contaminant detected at 7500 Bridge, along with clarity on the type of SW sample needed to confirm compliance. The target concentration levels (pCi/L) for ^{90}Sr and ^{137}Cs (37 pCi/L and 33 pCi/L, respectively) to meet the 45% risk reduction goal are shown in Table 3. These values represent a 45% reduction of the 1994 contaminant concentrations (see Table 1). For ^{90}Sr the value is 67 pCi/L x .55 = 37 pCi/L and for ^{137}Cs the value is 59 pCi/L X .55 = 33 pCi/L.

With regard to the type of SW sample needed, the following is stated in the BV ROD (DOE 2002, p. 2-162):

> *"Samples to demonstrate compliance with the 45% risk reduction will be taken at the 7500 Bridge or equivalent integration point. If the continuous samples are used at the 7500 Bridge, as expected, averages of the measured concentrations rather than the UCL_{95} will be used for the average concentration parameter in the risk calculation."*

The current sampling approach, a monthly flow-paced composite sample at the 7500 Bridge, will continue to be used to measure compliance. This sampling approach produces an average constituent concentration result that inherently accounts for impacts of flow rate on concentrations over time. The sampling approach is also conservatively reflective of how a SW intake system for a public water supply would be sampled.

A target annual contaminant mass release for each contaminant detected at 7500 Bridge. Development of a target annual contaminant mass release for ^{90}Sr and ^{137}Cs is neither necessary or appropriate. It is recommended the 45% risk reduction goal continue to be evaluated in the RER and FYR as shown in Table 3 by comparing concentration data from monthly flow-paced composite sampling to target concentrations of ^{90}Sr and ^{137}Cs.

RECOMMENDATION

It is recommended that the 45% risk reduction goal in the BV ROD continue to be evaluated in future annual RERs and FYRs using the current approach documented in Table 3 above. The FY 1994 data shown in Table 1 will continue to be used to represent "1994 baseline conditions". The target concentration levels (pCi/L) for ^{90}Sr and ^{137}Cs (37 pCi/L and 33 pCi/L, respectively) to meet the 45% risk reduction goal will continue to be used for comparison evaluation.

It is also recommended that the current sampling approach, a monthly flow-paced composite sample at the 7500 Bridge, continue to be used to measure compliance. The approach is consistent with ROD language, produces an average constituent concentration result that inherently accounts for impacts of flow rate on concentrations over time, and is conservatively reflective of how a SW intake system for a public water supply would be sampled. Development of a target annual contaminant mass release for ^{90}Sr and ^{137}Cs is neither necessary or appropriate.

Although conditions in BV relative to MV have changed since 1994, the ultimate purpose of setting the 45% risk reduction goal at the 7500 Bridge in BV was to ensure that the downstream MV ROD goal of protection the off-site resident was met. As shown in Table 2 above, regardless of the risk reduction realized at the 7500 Bridge, the goal to protect an off-site resident at the confluence of WOC and the Clinch River (as measured at WOD) has been achieved based on an evaluation of average annual concentrations for ^{90}Sr, ^{137}Cs, and ^{3}H. This Action Plan #5 from the *2011 Third Reservation-wide CERCLA Five-Year Review* is now closed.

REFERENCES

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ACTION PLAN 6
Corehole 8 Plume Collection System Upgrade

STATUS: Closed
FYR ISSUE: BV-2
CERCLIS OU: #35

ISSUE: Corehole 8 Plume collection system operation and maintenance issues are preventing it from currently meeting the Removal Action Report (RmAR) performance goals.

BACKGROUND: For several years leading up to the 2011 Third Reservation-wide CERCLA FYR for the DOE ORR a deterioration in performance of the Corehole 8 plume collection system was observed and reported in annual RERs. System performance deteriorated to the extent that the BV ROD goal for risk reduction at the 7500 Bridge was not met due to releases attributable to ^{90}Sr originating from Corehole 8 plume discharges into First Creek.

PLAN/SCHEDULE: During FY 2011 and 2012 DOE conducted a large scale upgrade to the Corehole 8 plume collection system. The upgrade included installing 2 bedrock plume extraction wells, and replacing all of the system's electrical, mechanical and control components. The upgraded and refurbished system was brought into full operation in mid-March 2012. Ongoing monitoring of contaminant discharges into First Creek shows that the ^{90}Sr discharges have been reduced to levels measured prior to the onset of system performance deterioration. Strontium-90 concentrations at the 7500 Bridge now meet the risk-based performance goals for 45% reduction. This Action Plan #6 from the *2011 Third Reservation-wide CERCLA Five-Year Review* is now closed.

Monitoring of system performance and contaminant discharges to First Creek will continue and will be reported annually in the RER.

ACTION PLAN 7
East End Volatile Organic Compound (EEVOC) Plume Point of Compliance

STATUS: Closed
FYR ISSUE: UEF-2
CERCLIS OU: #42

ISSUE: The East End Volatile Organic Compound (EEVOC) Plume Action Memorandum (AM) does not clearly indicate the intended point of compliance (POC) for measuring compliance with ambient water quality criteria (AWQC).

BACKGROUND: There is no location clearly indicated in the EEVOC Plume AM as the POC for monitoring compliance with the carbon tetrachloride AWQC that is established as an ARAR in the AM. Under Tennessee law, compliance with AWQC for effluent discharges is typically measured beyond the edge of a designated mixing zone. Although the EEVOC Plume engineering evaluation/cost analysis (EE/CA) clearly indicated that compliance with the carbon tetrachloride AWQC would be attained instream downstream from the discharge point, this language was not carried through to the AM.

In March 2013, DOE issued a Non-Significant Change (NSC) to the EEVOC Plume AM to clarify that, pursuant to TDEC 1200-04-03-.05(2), the POC for monitoring compliance with the AWQC will be at Lake Reality Bypass (LRBP) 1 ["EEVOC Effluent (Mixing Zone)"], which is downstream from the EEVOC Plume treatment system and beyond the edge of a mixing zone in the concrete-lined portion of UEFPC. An erratum to the RmAR was also issued in March 2013 to clarify POC language in that document.

Although carbon tetrachloride concentrations exceeded the Tennessee recreational (organisms only) water quality standard (16 μg/L) nine out of twelve months in 2010 in the EEVOC plume treatment system effluent as measured where it is collected directly from the treatment system prior to discharge, the instream concentration as measured at LRBP-1 is below the carbon tetrachloride AWQC.

PLAN/SCHEDULE: DOE has issued a NSC to the EEVOC plume AM and an erratum to the RmAR that specify an in-stream POC for monitoring compliance with the AWQC. Monitoring of the POC will be reported on in the annual RER. This Action Plan #7 from the *2011 Third Reservation-wide CERCLA Five-Year Review* is now closed.

ACTION PLAN 8
Bear Creek Valley (BCV) Chemicals of Concern

STATUS: Closed
FYR ISSUE: BCV-1
CERCLIS OU: #32

ISSUE: The Bear Creek Valley (BCV) Phase I ROD does not provide a comprehensive list of contaminants of concern (COCs) and related remediation levels (RLs) to evaluate compliance with ROD goals. This was the first "watershed" ROD and did not include these levels.

BACKGROUND: In the process of developing both the 2006 and 2001 FYRs, risk assessors found it difficult to assess progress towards protectiveness because the BCV Phase I ROD does not clearly identify the full list of COCs in BCV. The situation is confounded by BCV being divided into three zones.

The MV, BV, and East Tennessee Technology Park (ETTP) RODs clearly identify the COCs for each media in tables within the RODs. The BCV Phase I ROD does not.

Because the strategy for closure of BCV is long-term, this issue does not impact current activities. However the review of the BCV Phase I ROD is difficult to complete and it will be an issue as planning for future RODs and actions occur in BCV.

PLAN/SCHEDULE: The DOE will develop a list of COCs for BCV media to be used in the next FYR for the BCV Phase I ROD. This list will be valley-wide—not by zone—and will be available prior to planning for the next FYR and for planning future events. This effort will entail the following:

1. Review the RI and FS COC lists for BCV.

2. Review (compiled/reported) environmental data for SW and GW, including Environmental Management Waste Management Facility (EMWMF) data, collected since 1995. (Note: The project team will not review raw data in the Oak Ridge Environmental Information System [OREIS].)

3. Develop the following BCV COC lists:

   - SW;
   - GW; and
   - Soil

4. Report on status in the 2013 RER.

At the same time, DOE will identify activities that will need to occur in the development of final RODs for BCV.

HISTORY OF THE ISSUE

Initially, in the BCV cleanup approach under the CERCLA effort, it was assumed that the BCV ROD would address all the findings of the original watershed-scale RI and FS. As such, a broad range of RAOs was developed to evaluate remedial alternatives. However, as discussions progressed among the Federal Facility Agreement (FFA) parties, it was determined that a first Bear Creek ROD would address "Phase I"

remedial actions (RAs) including the S-3 Ponds and the Boneyard/Burnyard (BYBY), but remediation decisions at the Bear Creek Burial Grounds (BCBG) and final remediation goals for GW would be deferred.

The legacy of the early watershed-scale work and a desire to perform the initial source actions in the context of broad watershed-scale goals resulted in the Phase I ROD containing:

1. Specific performance measures for the Phase I source actions (Table 1),
2. General references toward meeting generic watershed-scale goals in SW and GW throughout the valley (Table 2), and
3. Expected outcomes of the selected remedy with some cleanup levels identified for GW and SW by Zone and source area (Table 3).

The primary goal of each of the actions under the Phase I ROD was to reduce the worst off-site contaminant migration, which was identified to be uranium releases to SW in Bear Creek from the S-3 Ponds and BYBY (Table 1). The Phase I ROD identified both source-specific areas (North Tributary [NT]-1, NT-3) and a watershed-scale POC (Bear Creek kilometer [BCK] 9.2). Three additional COCs (cadmium, nitrate, and mercury) were found to be present either as a human health or ecological risk via the same flowpaths as uranium and, hence, also received specific RLs.

Table 1. Site-specific goals for BCV Phase I ROD remedial actions at the S-3 Site Pathway 3 and the BYBY

Remedial action goals for S-3 Site Pathway 3	Remedial action goals for BYBY
Prevent expansion of the nitrate plume into Zone 1.	Reduce flux of uranium in NT-3 at confluence with Bear Creek to 4.3 kg/year.
Reduce concentration of cadmium in NT-1 and upper Bear Creek to meet AWQC (0.25 µg/L).[a]	Reduce concentration of mercury in NT-3 to meet AWQC (51 ng/L).[b]
Prevent future increase in release of uranium to Bear Creek to maintain annual flux below 27.2 kg total U at BCK 12.34.	
Reduce seasonal nitrate flux at NT-1/Bear Creek confluence by 40%. The seasonal nitrate flux benchmark will be defined by the FFA parties in remedial design.	

[a]The *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4), originally established the cadmium concentration performance standard as the criterion maximum concentration of 3.9 µg/L and criterion continuous concentration of 1.1 µg/L. This standard changed to the continuous criterion concentration of 0.25 µg/L due to changes in the promulgated AWQC.

[b] The Phase I ROD originally established the mercury concentration performance standard as the recreation water organisms criterion of 12 ng/L. This standard changed to 51 ng/L due to changes in the promulgated AWQC.

AWQC = ambient water quality criteria
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
FFA = Federal Facility Agreement
NT = North Tributary
U = uranium

Table 2. Watershed groundwater and surface water goals for the BCV Phase I ROD[a]

Area of the valley	Current situation	Goal
Zone 1 – western half of BCV	No unacceptable risk posed to a resident or a recreational user. AWQC and groundwater MCLs are not exceeded.	Maintain clean groundwater and surface water so that this area continues to be acceptable for unrestricted use. Land use: unrestricted
Zone 2 – a 1-mile-wide buffer zone between zones 1 and 3	No unacceptable risk posed to a recreational user. Risk to a resident is within the acceptable risk range except for a small area of groundwater contamination. Groundwater MCLs are exceeded, but AWQC are not.	Improve groundwater and surface water quality in this zone consistent with eventually achieving conditions compatible with unrestricted use. Land use: recreational (short-term); unrestricted (long-term)
Zone 3 – eastern half of BCV	Contains all the disposal areas that pose considerable risk. Groundwater MCLs and AWQC are exceeded.	Conduct source control actions to (1) achieve AWQC in all surface water, (2) improve conditions in groundwater to allow Zones 1 and 2 to achieve the intended goals, and (3) reduce risk from direct contact to create conditions compatible with future industrial use. Land use: controlled industrial

[a]Source: Table 2.1 of *Record of Decision for the Phase 1 Activities in Bear Creek Valley* [(DOE 2000) page 2-13].

AWQC = ambient water quality criteria
BCV = Bear Creek Valley
MCLs = maximum contaminant levels
ROD = Record of Decision
SDWA = Safe Drinking Water Act

Table 3. Expected outcome of the selected remedy, BCV watershed[a]

	Zone 1	Zone 2	Zone 3		
			S-3 Site/Pathway 3	BYBY/OLF Area	BCBGs
Cleanup levels, residual risk	- MCLs in groundwater - AWQC in surface water - risk to residential receptor below RAO of 1E-5	- TBD for groundwater - AWQC in surface water - risk to residential receptor below RAO of 1E-5	- TBD for groundwater - AWQC in surface water - direct exposure risk to industrial/terrestrial receptors eliminated - risk to industrial receptor below RAO of 1E-5 - Reduce seasonal nitrate flux at the NT-1/Bear Creek confluence by 40%	- TBD for groundwater - AWQC in surface water - risk to industrial receptor below RAO of 1E-5	N/A

[a]Source: from *Record of Decision for the Phase 1 Activities in Bear Creek Valley* [(DOE 2000) Table 2.22].

AWQC = ambient water quality criteria
BCBG = Bear Creek Burial Ground
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
MCLs = maximum contaminant levels
N/A = not applicable
NT = North Tributary
OLF = Oil Landfarm
RAO = remedial action objectives
SDWA = Safe Drinking Water Act
TBD = to be determined

As shown in Table 2, the BCV Phase I ROD identifies broad GW quality goals. Table 3 shows expected outcomes of the BCV Phase I ROD in terms of cleanup levels and residual risk in Zones 1 and 2 and the S-3 Site and BYBY source areas in Zone 3. Despite the ROD language that states final GW remediation goals are deferred, the ROD identifies maximum contaminant levels (MCLs) for GW in Zone 1 as an expected outcome for cleanup. The ROD also identifies AWQC in SW in Zones 1 and 2 and at the S-3 Site and BYBY in Zone 3, as expected outcomes for cleanup, The ROD does not provide the specific requirements for achieving goals and expected outcomes that are usually identified in RODs, (e.g. there are no specific COCs or compliance points for the Phase I actions related to the MCLs, AWQC, and residual risk levels).

The ambiguity related to the broad GW and SW goals listed in Table 2 and expected outcomes listed in Table 3 leads to the question – what type of analysis against these goals and expected outcomes should be performed during the Phase I ROD FYR?

FINDINGS

Historical, pre-decision CERCLA documents and more recent studies were reviewed for further insight on this issue.

Review of COC lists from BCV CERCLA documents

The RI for BCV (DOE 1997a) contains a fairly comprehensive list of BCV COCs. These COCs are identified by source area/environmental media/land use receptors so there are numerous lists identified in Appendix F Tables and Exhibits F.1 through F.4 of the RI (the Baseline Risk Assessment). These tables indicate the following:

- There are three separate zones in BCV: Zone 1 residential, Zone 2 recreational, and Zone 3 industrial.

- All of the sites/soils interim actions are in Zone 3, the industrial zone where the source units are located. Most of the performance monitoring for the interim ROD addresses a limited set of COCs in SW in Zone 3 and at the interface between Zones 2 and 3 (the BCK 9.2 monitoring location).

- Zone 2 is slated for future recreational use (short-term) and future residential use (long-term) and based on review of the RI appears to only have COCs based on protection of fish. Currently, limited SW sampling occurs for comparison to AWQC.

- Zone 1 is designated for residential use, but it is very difficult to tell from the RI appendices what COC identification work was done for Zone 1.

- There are no soil COCs listed in the ROD. Soil COCs, as depicted in the RI, vary by land use and by areas within Zone 3 (Table 4). This list appears to be incomplete for Zones 1 and 2, possibly due to lack of soil data in those areas. In order to guide a final status closure survey in Zones 1 and 2, soil COCs would need to be identified in a final ROD.

- GW and SW COCs were developed in the RI using available data. For this review, using the GW and SW COC lists from the RI, contaminant data from the RI were re-evaluated using multiple screens (various risk levels and MCLs). Attachment 1 provides these lists and the subsequent reanalysis. The variations on the lists depending on which screen is performed show the importance of identifying final endpoints (target risk levels and/or MCLs) and the final COC list in BCV.

Although some GW modeling was performed in the RI, modeling of potential plume migration downgradient in the Maynardville from Zone 3 to Zones 1 and 2 was limited to use of a water balance model to predict mixing and dilution. A better understanding of future plume migration is necessary to identify final GW COCs in Zones 1 and 2.

Table 4. Summary of soil COCs listed in the BCV RI

Site	Zone 1 – Unrestricted residential	Zone 2 – Recreational	Zone 3 – Industrial
S-3	NA	NA	Be, PCB, Cs, Np, Pu, Ru, Tc, Th-228/230, U-234/235/238
OLF	NA	NA	As, Co, Rb, Thallium-208
SL-1	NA	NA	None
BYBY	NA	NA	Sb, As, Be, Hg, SVOCs (see below), PCB, U-234/235/238
BG	NA	NA	U-234/235/238, Be, U-total, benzene, Benzidine, PCB, TCE
DARA	NA	NA	Dioxins, PCBs, U

Semivolatile organic compounds (SVOCs) = benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)flouranthene, dibenzo(*a,h*)anthracene, indeno(1,2,3)pyrene; Be = beryllium; PCB = polychlorinated biphenyl; Cs = cesium; Np = neptunium; Ru = ruthenium; Tc = technetium; Th = thorium; U = uranium; As = arsenic; Co = cobalt; Rb = rubidium; Sb = antimony; Hg = mercury; and NA = not applicable in remedial investigation.

BCV = Bear Creek Valley
BG = Burial Ground
BYBY = Boneyard/Burnyard
COC = chemical of concern
DARA = Disposal Area Remedial Action
TCE = trichloroethene

The RI was also reviewed to ascertain if the COC issue was further refined through the CERCLA process. The FS acknowledged the variety of the COC lists from the RI and developed short lists of "indicator COCs" for human health (p. 2-9 of the FS, DOE 1997b). Again, these lists were developed for the FS; however, since the ROD focused on a small subset of the potential actions for the valley, these short-list COCs were not carried into the ROD.

Although these COCs were not adopted in the Phase I ROD, they serve as a good list of indicator chemicals for the valley:

- Groundwater: ^{238}U, ^{234}U, 1,1-dichloroethene (DCE), 1,2-DCE, tetrachloroethene, vinyl chloride, barium, cadmium, and nitrate, plus trichloroethene (TCE) and ^{99}Tc.
- Soil: ^{238}U and polychlorinated biphenyls (PCBs).
- SW: Same as GW, minus barium
- Sediment: ^{238}U and PCBs.
- Fish: PCBs and mercury.

This FS indicator COC list and the reanalysis of the RI COC lists in Attachment 1 indicate that the FS did not include several chemicals that have been detected in BCV above their respective MCLs. Additional chemicals that were detected above their MCL include:

- Beryllium, mercury, bis(2-ethyhexyl) phthalate, methylene chloride, radium (as compared to the total alpha MCL), benzene, chloroform, 1,1,1-trichloroethane (TCA), 1,1,2-TCA, and 1,2-dichloroethane (DCA).

<u>Review (Compiled/Reported) Environmental Data for SW and GW</u>

In addition to the RI and FS, additional documents were consulted to determine if more recent sampling efforts confirm the RI and FS COC list. Data from the Y-12 Groundwater Protection Program (GWPP) Annual Reports in 2009, 2010, and 2011 (B&W Y-12 2009, B&W Y-12 2011, B&W Y-12 2012) and from the EMWMF Annual Reports for Detection Monitoring from 2001 through 2009 (BJC 2004, BJC 2006, BJC 2007, BJC 2008, BJC 2009, and BJC 2010) were reviewed.

The GWPP reports have a large amount of GW data analysis (e.g., the 2009 report contains over 2000 pages of statistical analysis and trend charts) that is focused on trends for a limited analyte list, primarily nitrate, uranium, gross alpha, gross beta, and volatile organic compounds (VOCs). Analytes evaluated in the GWPP are included in the Bear Creek RI COC list.

The EMWMF detection monitoring process has a very different definition for "COC" (e.g., a COC is a chemical identified in the waste streams accepted at the facility [along with constituents detected in leachate samples]). Over the years the EMWMF COC list has grown to a very large list of chemicals and radionuclides that have or may have been disposed in the facility. In addition, because detection monitoring is designed to identify detections "above background baseline" monitoring, chemicals identified in this analysis are chemicals that exceed their background threshold limit value (TLV) or project quantitation limit, not chemicals that pose a potential risk as defined by CERCLA. In 2003 to 2004, there were sporadic exceedances of TLVs (^{129}I, ^{228}Ra, ^{230}Th, ^{232}Th, tritium, TCE, and inorganics), but they were not confirmed in following years. SW data collected by the EMWMF show the following chemicals have exceeded their respective AWQC at least once over the years: lead, zinc, copper, pesticides and PCBs, alpha, beta, ^{90}Sr, and tritium. These chemicals are monitored under the EMWMF ROD and will need to be considered during the development of the final ROD for BCV but should not be included in the review of the Phase I ROD.

CONCLUSIONS

The exercise of identifying COCs for the Phase I ROD partially turned into an exercise in better understanding the scope of the Phase I ROD. The RI and FS attempted to address all containment sources, all environmental media, and all zones of the valley in the first ORR watershed-scale ROD. However, the specific Phase I ROD scope addressed a small subset of sources (S-3 and BYBY), COCs (uranium, nitrate, cadmium, and mercury), and environmental media (SW). The whole process resulted in a hybrid set of specific source action COCs and RLs along with more general, less-defined COCs for other media and areas and generic goals or "expected outcomes."

Recommended Approach for 2016 FYR

Based on the above, it is recommended that the following approach be used to evaluate the status and effectiveness of the Phase I ROD in the 2016 FYR:

1. To evaluate protectiveness of the Phase I ROD, the 2016 analysis should use the specific performance goals selected for the S-3 Site and BYBY RAs for uranium, nitrate, cadmium, and mercury in SW.

2. To address progress toward meeting the RLs yet to be established in the Final ROD and the expected outcomes of the BCV Phase I ROD shown in Table 3, it is recommended that the following list of COCs be monitored in SW and GW the year before the FYR at a minimum and compared to MCLs, AWQC, and risk-based levels. This comparison should take place for each of Zones 1, 2, and 3 to provide updated baselines indicating where drinking water levels, AWQC, and risk-based levels have and have not been achieved:

   - Radionuclides: ^{238}U, ^{234}U, ^{99}Tc, and radium (as compared to the total alpha MCL).

   - Organics: 1,1-DCE, 1,2-DCE, TCE, tetrachloroethylene, VC, methylene chloride, 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, benzene, chloroform, and bis(2-ethyhexyl) phthalate.

   - Inorganics: barium, cadmium, and nitrate, plus beryllium, mercury, and nitrate.

   There is a great deal of interaction between shallow GW and SW in BCV, resulting in gaining and losing reaches along streams. As a result, the same list of COCs is recommended for GW and SW monitoring. It is also recommended that the COC list be reevaluated over time, as appropriate, depending on monitoring results and actions in the area.

The following items are missing from the Phase I ROD and will need to be developed for the Final ROD:

- A list of soil COCs and related industrial-based RLs for Zone 3, and RLs for Zones 1 and 2. The basis for these levels will be defined as part of the final ROD.

- A list of sediment COCs and related RLs for the Bear Creek floodplain and creek banks. The basis for these levels will be defined as part of the final ROD.

- A final list of valley-wide GW COCs and RLs in the various zones in BCV. Although it is suggested by the Phase I ROD that MCLs will apply to GW in Zone 1 (Picket A), the ROD will need to confirm this and will also need to specify what levels are acceptable in Zones 2 and 3 (Pickets B and C), based either on potential for migration or on limited uses other than residential.

- A final list of valley-wide SW COCs, RLs, and points of compliance. As suggested by the Phase I ROD, these levels will likely reflect AWQC.

This Action Plan #8 from the 2011 Third Reservation-wide CERCLA Five-Year Review is now closed.

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ATTACHMENT 1

Table 1. S-3 Ponds Groundwater COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Barium	1.56E+02	Barium	Barium	--	2.00E+00	Barium
Beryllium	1.92E-02	Beryllium	--	--	4.00E-03	Beryllium
Boron	3.63E-01	--	--	--	NA	--
Cadmium	2.69E-01	Cadmium	Cadmium	--	5.00E-03	Cadmium
Chromium	2.40E-02	Chromium	Chromium	Chromium	1.00E-01	--
Fluoride	2.99E+00	Fluoride	--	--	NA	--
Manganese	1.01E+01	Manganese	Manganese	--	NA	--
Mercury	5.20E-03	Mercury	--	--	2.00E-03	Mercury
Nickel	3.29E+00	Nickel	Nickel	--	NA	--
Nitrate (as N)	2.11E+03	Nitrate (as N)	Nitrate (as N)	--	1.00E+01	Nitrate (as N)
Nitrite (as N)	6.70E+00	Nitrite (as N)	--	--	1.00E+00	Nitrite (as N)
Strontium	8.80E+01	Strontium	--	--	NA	--
Total Uranium	2.56E+00	Total Uranium	Total Uranium	--	3.00E-02	Total Uranium
1,1-Dichloroethene	2.63E-03	--	--	--	7.00E-03	--
2,4-Dinitrophenol	3.20E-02	2,4-Dinitrophenol	--	--	NA	--
Benzene	2.61E-03	Benzene	--	--	5.00E-03	--
Bis(2-ethylhexyl)phthalate	1.83E-02	Bis(2-ethylhexyl)phthalate	--	--	6.00E-03	Bis(2-ethylhexyl)phthalate
Chloroform	6.20E-03	Chloroform	Chloroform	--	8.00E-03	--
Di-n-octylphthalate	2.79E-03	--	--	--	NA	--
Methylene Chloride	2.42E-02	Methylene Chloride	--	--	5.00E-03	Methylene Chloride
Tetrachloroethene	4.21E-01	Tetrachloroethene	Tetrachloroethene	--	5.00E-03	Tetrachloroethene
Trichloroethene	5.28E-03	Trichloroethene	Trichloroethene	--	5.00E-03	Trichloroethene
Vinyl Chloride	5.04E-03	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	2.00E-03	Vinyl Chloride
Americium-241	3.14E+01	Americium-241	Americium-241	--	NA	--
Cesium-137	6.00E+00	Cesium-137	--	--	NA	--
Neptunium-237	5.87E+02	Neptunium-237	Neptunium-237	Neptunium-237	NA	--
Radium (total alpha)	3.51E+01	--	--	--	5.00E+00	Radium (total alpha)
Strontium-90	1.92E+02	Strontium-90	Strontium-90	Strontium-90	NA	--
Technetium-99	6.94E+04	Technetium-99	Technetium-99	Technetium-99	NA	--
Thorium-228	3.20E+00	Thorium-228	--	--	NA	--
Tritium	4.10E+03	Tritium	Tritium	--	NA	--
Uranium-234	3.14E+03	Uranium-234	Uranium-234	Uranium-234	NA	--
Uranium-235	3.53E+02	Uranium-235	Uranium-235	Uranium-235	NA	--
Uranium-238	7.48E+03	Uranium-238	Uranium-238	Uranium-238	NA	--

NA = Not Available

Table 2. S-3 Ponds Surface Water COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Barium	3.08E-01	--	--	--	2.00E+00	--
Beryllium	2.25E-04	--	--	--	4.00E-03	--
Cadmium	9.78E-03	Cadmium	--	--	5.00E-03	Cadmium
Fluoride	6.15E-01	--	--	--	NA	--
Manganese	1.15E+00	Manganese	--	--	NA	--
Nitrate (as N)	9.74E+01	Nitrate (as N)	--	--	1.00E+01	Nitrate (as N)
Total Uranium	6.10E-02	Total Uranium	--	--	3.00E-02	Total Uranium
Tetrachloroethene	2.85E-03	--	--	--	5.00E-03	--
Strontium-90	1.39E+00	Strontium-90	--	--	NA	--
Technetium-99	3.27E+02	Technetium-99	Technetium-99	--	NA	--
Uranium-233/234	2.83E+01	Uranium-233/234	Uranium-233/234	--	NA	--
Uranium-235	1.60E+00	Uranium-235	--	--	NA	--
Uranium-238	5.87E+01	Uranium-238	Uranium-238	--	NA	--

NA = Not Available

Table 3. Oil Landfarm, Boneyard/Burnyard, and Sanitary Landfill Groundwater COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Barium	3.45E-01	--	--	--	2.00E+00	--
Beryllium	4.40E-04	--	--	--	4.00E-03	--
Boron	3.55E-01	--	--	--	NA	--
Cadmium	3.29E-03	--	--	--	5.00E-03	--
Chromium	3.00E-02	Chromium	Chromium	Chromium	1.00E-01	--
Fluoride	4.00E-01	--	--	--	NA	--
Manganese	1.09E+00	Manganese	--	--	NA	--
Mercury	3.12E-03	Mercury	--	--	2.00E-03	Mercury
1,1-Dichloroethene	2.97E-02	--	--	--	7.00E-03	1,1-Dichloroethene
1,2-Dichloroethane	4.90E-03	1,2-Dichloroethane	1,2-Dichloroethane	--	5.00E-03	--
Benzene	6.91E-03	Benzene	Benzene	--	5.00E-03	Benzene
Carbon Tetrachloride	3.26E-03	Carbon Tetrachloride	--	--	5.00E-03	--
Chloroform	1.01E-02	Chloroform	Chloroform	--	8.00E-03	Chloroform
Methylene Chloride	8.21E-02	Methylene Chloride	--	--	5.00E-03	Methylene Chloride
PCB-1254	4.50E-04	PCB-1254	PCB-1254	--	5.00E-04	--
Tetrachloroethene	1.01E-01	Tetrachloroethene	Tetrachloroethene	--	5.00E-03	Tetrachloroethene
Trans-1,2-Dichloroethene	1.37E-01	Trans-1,2-Dichloroethene	--	--	1.00E-01	Trans-1,2-Dichloroethene
Trichloroethene	1.29E-01	Trichloroethene	Trichloroethene	Trichloroethene	5.00E-03	Trichloroethene
Vinyl Chloride	9.69E-03	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	2.00E-03	Vinyl Chloride
Cesium-137	4.60E+00	Cesium-137	--	--	NA	--
Lead-212	1.56E+01	Lead-212	--	--	NA	--
Neptunium-237	2.40E-01	--	--	--	NA	--
Potassium-40	1.51E+02	Potassium-40	Potassium-40	--	NA	--
Thorium-228	1.29E+00	Thorium-228	--	--	NA	--
Thorium-230	2.14E+00	Thorium-230	--	--	NA	--
Uranium-234	1.30E+03	Uranium-234	Uranium-234	Uranium-234	NA	--
Uranium-235	2.89E+01	Uranium-235	Uranium-235	--	NA	--
Uranium-238	7.21E+02	Uranium-238	Uranium-238	Uranium-238	NA	--

NA = Not Available

Table 4. Oil Landfarm, Boneyard/Burnyard, and Sanitary Landfill Surface Water COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Arsenic	8.16E-04	Arsenic	Arsenic	--	0.01	--
Barium	2.75E-01	--	--	--	2	--
Cadmium	7.52E-03	Cadmium	--	--	0.005	Cadmium
Fluoride	1.16E+00	Fluoride	--	--	NA	--
Nitrate (as N)	4.93E+01	Nitrate (as N)	--	--	10	Nitrate (as N)
Total Uranium	2.24E-01	Total Uranium	--	--	0.03	Total Uranium
Strontium-90	9.30E-01	Strontium-90	--	--	NA	--
Technetium-99	8.41E+01	Technetium-99	--	--	NA	--
Uranium-233/234	5.62E+01	Uranium-233/234	Uranium-233/234	--	NA	--
Uranium-235	5.26E+00	Uranium-235	--	--	NA	--
Uranium-238	1.11E+02	Uranium-238	Uranium-238	Uranium-238	NA	--

NA = Not Available

Table 5. Bear Creek Burial Grounds Groundwater COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Barium	2.83E-01	--	--	--	2.00E+00	--
Beryllium	3.45E-04	--	--	--	4.00E-03	--
Cadmium	3.74E-03	--	--	--	5.00E-03	--
Chromium	3.48E-02	Chromium	Chromium	Chromium	1.00E-01	--
Fluoride	1.14E+00	Fluoride	--	--	NA	--
1,1,1-Trichloroethane	5.68E-01	--	--	--	2.00E-01	1,1,1-Trichloroethane
1,1,2-Trichloroethane	2.27E-02	1,1,2-Trichloroethane	1,1,2-Trichloroethane	--	5.00E-03	1,1,2-Trichloroethane
1,1-Dichloroethane	6.46E-01	1,1-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethane	NA	--
1,1-Dichloroethene	5.41E-01	1,1-Dichloroethene	--	--	7.00E-03	1,1-Dichloroethene
1,2-Dichloroethane	1.85E-02	1,2-Dichloroethane	1,2-Dichloroethane	1,2-Dichloroethane	5.00E-03	1,2-Dichloroethane
1,2-Dichloroethene	1.47E-01	1,2-Dichloroethene	--	--	7.00E-02	1,2-Dichloroethene
Benzene	4.38E-02	Benzene	Benzene	Benzene	5.00E-03	Benzene
Chloroform	3.92E-02	Chloroform	Chloroform	Chloroform	8.00E-03	Chloroform
Methylene Chloride	2.63E-02	Methylene Chloride	--	--	5.00E-03	Methylene Chloride
Tetrachloroethene	3.15E+00	Tetrachloroethene	Tetrachloroethene	Tetrachloroethene	5.00E-03	Tetrachloroethene
Trans-1,2-Dichloroethene	4.24E+00	Trans-1,2-Dichloroethene	Trans-1,2-Dichloroethene	--	1.00E-01	Trans-1,2-Dichloroethene
Trichloroethene	1.66E+00	Trichloroethene	Trichloroethene	Trichloroethene	5.00E-03	Trichloroethene
Trichlorofluoromethane	8.19E-01	--	--	--	NA	--
Vinyl Chloride	2.71E-01	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	2.00E-03	Vinyl Chloride
Cesium-137	5.77E+00	Cesium-137	--	--	NA	--
Potassium-40	1.29E+02	Potassium-40	Potassium-40	--	NA	--
Thorium-228	1.20E+00	Thorium-228	--	--	NA	--
Uranium-238	9.31E-01	Uranium-238	--	--	NA	--

NA = Not Available

Table 6. Bear Creek Burial Grounds Surface Water COCs

COC	95% UCL (mg/L or pCi/L)	95% UCL >1x10-6 RSL?	95% UCL >1x10-5 RSL?	95% UCL >1x10-4 RSL?	MCL (mg/L or pCi/L)	95% UCL >MCL?
Beryllium	2.28E-04	--	--	--	0.004	--
1,1,2-Trichloroethane	2.00E-03	1,1,2-Trichloroethane	--	--	0.005	--
1,1-Dichloroethene	8.72E-03	--	--	--	0.007	1,1-Dichloroethene
1,2-Dichloroethane	2.95E-03	1,2-Dichloroethane	1,2-Dichloroethane	--	0.005	--
1,2-Dichloroethene	2.11E-01	1,2-Dichloroethene	--	--	0.07	1,2-Dichloroethene
Benzene	2.58E-03	Benzene	--	--	0.005	--
Chloroform	4.39E-03	Chloroform	Chloroform	--	0.008	--
Tetrachloroethene	6.17E-02	Tetrachloroethene	--	--	0.005	Tetrachloroethene
Trichloroethene	4.84E-02	Trichloroethene	Trichloroethene	Trichloroethene	0.005	Trichloroethene
Vinyl Chloride	1.70E-02	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	0.002	Vinyl Chloride
Potassium-40	1.30E+02	Potassium-40	Potassium-40	--	NA	--
Thorium-228	3.09E-01	--	--	--	NA	--
Uranium-233/234	1.34E+01	Uranium-233/234	Uranium-233/234	--	NA	--
Uranium-238	3.77E+01	Uranium-238	Uranium-238	--	NA	--

NA = Not Available

ACTION PLAN 9
S3 POND PATHWAYS 1-3

STATUS: Closed
FYR ISSUE: BCV-2
CERCLIS OU: #32

ISSUE: Bear Creek NT-1 currently exceeds the AWQC of 0.25 µg/l for cadmium, which is an applicable or relevant and appropriate requirement in the *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant* (Phase I ROD), and the operable unit is not protective of ecological receptors. Uranium activity at Bear Creek Kilometer (BCK) 9.2 remains above acceptable levels for residential and industrial human receptors; however, there currently is no unacceptable human exposure.

BACKGROUND: Under the *Action Memorandum for the Bear Creek Valley Tributary Interception Trenches for the S-3 Uranium Plume* GW from pathways 1 and 2 from the S-3 Pond were collected and treated. Due to the low quantity of uranium removed and the indiscernible reduction of uranium flux at BCK 12.34, the system was shut-down. Consequently, cadmium exceeds the AWQC, and uranium activity remains above acceptable levels. The Phase I ROD includes a RA for S-3 Pond and monitoring at BCK 12.34. Approximately 51% of the uranium appears to come from NT-8 that drains the BCBGs, for which there is no remedial decision. A significant amount of uranium comes from the S-3 Ponds. In order to develop a comprehensive remediation strategy, pathways 1 and 2 will be combined with pathway 3 as a RA under the Phase I ROD.

PLAN/SCHEDULE: Monitoring for uranium and cadmium at BCK 12.34 will continue, and the results will be reported in annual RERs. The S-3 Pond RA and future decisions for an NT-8 early action are currently scheduled in FFA Appendix J for FY 2022 and the BCV Burial Grounds RA is currently scheduled in FFA Appendix J for FY 2024. These projects will be considered and prioritized annually in accordance with the *Federal Facility Agreement*. This Action Plan #9 from the *2011 Third Reservation-wide CERCLA Five-Year Review* is now closed.

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