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2012 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee

Data and Evaluations

This document is approved for public release per review by:

George E. Roettger (Signature on file) 3/8/12

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2012 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
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ACRONYMS

ALARA	as low as reasonably achievable
AWQC	ambient water quality criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
DCA	dichloroethane
DOE	U. S. Department of Energy
EMWMF	Environmental Management Waste Management Facility
ETTP	East Tennessee Technology Park
EU	exposure unit
FFA	Federal Facility Agreement
FY	fiscal year
LEFPC	Lower East Fork Poplar Creek
MBWEIR	Melton Branch Weir
MCK	McCoy Branch kilometer
MCL	Safe Drinking Water Act maximum contaminant level
NT	North Tributary
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
psig	pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act of 1976
TDEC	Tennessee Department of Environment and Conservation
Tl	Thallium
UEFPC	Upper East Fork Poplar Creek
VOC	volatile organic compound
WCK	White Oak Creek kilometer
WCWEIR	White Oak Creek Weir
Y-12	Y-12 National Nuclear Security Administrative Site

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EXECUTIVE SUMMARY

Under the requirements of the *Federal Facility Agreement* (DOE 1992) established between the DOE, the U.S. Environmental Protection Agency, and the Tennessee Department of Environment and Conservation, all environmental restoration activities on the Oak Ridge Reservation are performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This *2012 Remediation Effectiveness Report*:

- assesses and documents the performance of engineering and land use controls for each completed CERCLA action on and around the U. S. Department of Energy (DOE) Oak Ridge Reservation

- evaluates the effectiveness of and compliance with the long-term stewardship requirements for each of the completed actions

- summarizes watershed monitoring results

First issued in 1997, the Remediation Effectiveness Report has been reissued annually to update the performance of completed actions and to add descriptions of new CERCLA actions. With the exception of some ecological sampling data, all data reported in the *2012 Remediation Effectiveness Report* was collected prior to or in Fiscal Year (FY) 2011.

Remedial decision on the Oak Ridge Reservation have been made at the watershed scale in recognition of surface water being the major pathway for offsite contaminant transport and to ensure that the evaluation considers the cumulative resources needed for cleanup and the resource implications for alternate end uses. The watershed records of decision contain performance goals to be met and a series of remedial actions designed to achieve them. Since the implementation of these watershed-scale Records of Decision can take many years to complete, evaluation of performance must consider completed actions, actions not implemented, and actions which are in progress.

Monitoring information used to assess performance was compiled by the Water Resources Restoration Program that was established to implement a comprehensive, integrated environmental monitoring and assessment program for the Oak Ridge Reservation 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.

Since most of the remediation decisions do not allow unrestricted end use, these sites will require long-term stewardship. Long-term stewardship is the set of activities necessary to protect human health and the environment from physical hazards, residual contamination, and wastes remaining following remediation and includes activities such as facility operations, monitoring, and land use controls. The Remediation Effectiveness Report evaluates the performance of engineering controls and land use controls 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 comprise several individual sub-watersheds but are treated as a single unit for decision-making and performance assessment purposes. Each chapter identifies completed single-project actions and completed watershed-scale actions with long-term stewardship requirements.

A summary of the effectiveness evaluation follows. Issues and recommendations are summarized in Chapter 1, and more detailed discussion of the issues and recommendations is in each chapter.

Bethel Valley

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

- Mercury concentrations at the Bethel Valley watershed integration point (7500 Bridge) continue to decrease. The mercury concentrations measured at the 7500 Bridge integration point were below the ambient water quality criteria (AWQC) of 51 ng/L in all 12 monthly grab samples. One of two samples collected from White Oak Creek near the former mercury discharge outfall exceeded the AWQC.

- ^{90}Sr concentrations at the Bethel Valley watershed integration point (7500 Bridge) do not meet the risk reduction goal and continue to increase. Higher than average rainfall during 2009 through 2011 compounded with problems associated with the Corehole 8 plume extraction system are responsible for the increase in ^{90}Sr during the past few years. The plume collection system is expected to resume operation during the second or third quarter of FY 2012, after which ^{90}Sr concentrations are expected to decrease.

- The risk reduction goal for ^{137}Cs was met at the Bethel Valley watershed integration point (7500 Bridge).

- Biological monitoring of the Bethel Valley watershed continues to indicate moderate ecological recovery. Decreased mercury concentrations in fish at the site closest to the Oak Ridge National Laboratory facilities to levels below the Environmental Protection Agency-recommended fish-based AWQC for mercury is encouraging.

Melton Valley

Following is a summary of the 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). Concentration trends for these contaminants were stable or decreasing during FY 2011. Principal contaminant 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 2000). Although a slight increase in the ^{90}Sr was observed, the contaminant fluxes from Melton Valley remained low relative to the responses observed during wet years prior to remediation.

- Groundwater contaminant concentrations around the shallow land burial sites are generally decreasing or stable compared to concentrations measured before completion of the Melton Valley remedy.

- Groundwater level monitoring of the hydrologic isolation areas in Melton Valley showed that performance criteria were met at 38 of 44 locations. Three of the wells not meeting the performance criteria are located in Solid Waste Storage Area 4. Two of those are located near the downgradient trench which, based on these wells performance, show evidence of deteriorated performance during FY 2011. An evaluation of the options to enhance system performance is planned.

- Monitoring of wells in the Melton Valley groundwater exit pathway and offsite monitoring wells shows that groundwater flow paths converge toward the Clinch River from both the DOE side and offsite. Disturbance of this natural flow condition by groundwater pumping offsite has the potential to draw DOE contaminants to offsite pumping locations. Because of this vulnerability, DOE provided funds for installation of utility water supply to offsite residents near the Clinch River.

- Groundwater analyses conducted on samples from the sentinel wells since their construction in 2004 have resulted in a number of radionuclides and volatile organic compounds (VOCs) being detected periodically in different monitoring locations. Sampling and analysis of groundwater from offsite wells showed detection of low concentrations of VOCs in samples from one sample at one well. This detection occurred coincident with detection of similar VOCs in one of the DOE sentinel wells. The offsite detection occurred early in the sampling history and is suspected to have occurred because of pumping stresses in the offsite well during construction. This detection is considered to exemplify the vulnerability of offsite wells in close proximity to areas of ground contamination. Two detections of very low levels of ^{90}Sr and one detection of very low level ^{99}Tc occurred in offsite monitoring wells during the year and these were either not detectable in duplicate samples or were not detected in subsequent samples.

- The biological monitoring results indicate that Melton Branch stream communities are impaired relative to reference sites, but continue to improve.

Bear Creek Valley

Following is a summary of the Bear Creek Valley watershed performance monitoring:

- Surface water monitoring at the integration point (BCK 9.2) showed that the Record of Decision goal of ≤34 kg/yr of uranium was not attained. The measured uranium flux at the integration point was about 109 kg. About 29% of the uranium flux is attributed to surface water discharged from the S-3 Ponds plume and about 51% of the uranium flux originated in the Bear Creek Burial Grounds. Other contributors to the total uranium flux include deeper groundwater flows in the S-3 plume that discharge to Bear Creek via springs SS-4 and SS-5 and diffuse bed seepage, as well as smaller contributions from NT-3, NT-5, and NT-7. During FY 2011, the risk level associated with uranium at the integration point remained about twice the goal.

- In FY 2011 samples were collected within the NT-8 drainage at several locations to identify points of entry of contaminants into the stream. The analytical results confirm that the eastern branch of NT-8 that originates in Burial Ground D-West was the principal source of uranium and was a significant source of polychlorinated biphenyls (PCBs). Additionally, the highest source of VOCs is attributed to a discharge of plume water that evolves from beneath Burial Ground A and extending westward beneath NT-7.

- Both nitrate and cadmium concentrations meet AWQC requirements at the watershed integration point (BCK 9.2).

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

- Groundwater contaminant trends are relatively stable, and changes from FY 2010 levels are minor. Increases in some VOC constituents were observed in groundwater at the Bear Creek Burial Grounds.

Chestnut Ridge

- **United Nuclear Corporation** — As discussed in previous Remediation Effectiveness Reports (DOE 2010 and DOE 2011), elevated gross beta activity continues to be observed in downgradient well GW-205 and in FY 2011 at UNC SW-1, suggesting a potential contaminant release from the site. The gross beta activity does not appear to be caused by ^{90}Sr, but does track closely to ^{40}K. The downgradient spring (UNC SW-1), added to the monitoring network in FY 2008 to assess the potential impacts of groundwater seepage on surface water quality, exhibits data consistent with results from other downgradient monitoring wells at the site that do not detect any contaminants of concern above an action limit. However, because of detected gross beta in the United Nuclear Corporation SW-1 in FY 2011, it is recommended that ^{90}Sr be added to the analytical suite for that location.

- **Kerr Hollow Quarry** — Results of statistical evaluations of FY 2011 groundwater analytical data for Kerr Hollow Quarry do not indicate a contaminant release for the uppermost aquifer and do not warrant any response action specified in the Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime (TDEC 2006).

- **Filled Coal Ash Pond —** The monitoring results since the remedial action indicate that the remedy is successfully lowering the concentration of contaminants of concern in surface water as it exits the wetland. Arsenic concentrations, however, generally exceed AWQC in both the upgradient and downgradient locations at the Filled Coal Ash Pond wetland, although concentrations have decreased since implementation of the remedial action. Arsenic levels in Rogers Quarry fish have been near background. However, selenium and mercury concentrations are substantially higher in fish relative to concentrations found in reference stream fish. Stream community measures show that McCoy Branch is improving but remains below the values observed in reference streams.

Upper East Fork Poplar Creek

Following is a summary of the Upper East Fork Poplar Creek watershed performance monitoring:

- The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) goal at Station 17 is 200 ng/L. The average flow-paced composite mercury concentration during FY 2011 was 817 ng/L. Although significant reductions in mercury concentration were observed following startup of the Big Spring Water Treatment System, and in response to drought conditions during 2007 and 2008, the interim goal for mercury concentrations has not yet been attained on an annual average basis. The increased concentrations measured during FY 2011 are related to sediment disturbances that occurred during the West End Mercury Area storm drain cleanout process.

- Surface water contaminant discharge conditions were adversely affected by disturbances related to the West End Mercury Area storm drain sediment removal project. High concentrations and high fluxes of mercury were measured throughout the watershed.

- The Big Spring Water Treatment System was fully operational during FY 2011 and although no significant downtime or operational problems occurred, inflow volumes exceeded treatment capacity which caused bypass of untreated water to discharge via Outfall 51 and at the Big Spring Water Treatment System equalization tank overflow. Based on available data it is estimated that 0.3 to 0.5 kg of mercury may have been discharged via Outfall 51. During FY 2012, a sampling system was installed on the equalization tank overflow to measure the amount of water and mercury that is discharged without treatment. The average effluent concentration for Big Spring Water Treatment

System was 0.029 µg/L, which is slightly greater than the past two years but is less than the performance standard of 0.2 µg/L. In addition to continued monitoring of the mercury concentrations during high flows at Outfall 51, the equalization tank overflow water will be monitored.

- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux at Station 17 in FY 2011 remains elevated relative to levels observed in drought years. Uranium concentration and fluxes originate from groundwater seepage and storm water transport of surface contamination at Y-12. Groundwater contamination in the West End Mercury Area is a source of uranium flux at Outfall 200A6. In addition to groundwater plume discharges to surface water, another source of the increased uranium flux observed at Station 17 may be the former Oil Skimmer Basin.

- Aquatic biological monitoring shows that mercury concentrations remain stable in fish tissue at EFK 23.4 near the watershed integration point. PCB concentrations in fish increased to 0.64 µg/g in 2011 but remained much lower than peak levels. The lack of a response in fish to decreased mercury concentrations in water is an ongoing issue. Additionally, remedial measures required by the *Record of Decision for Phase I Interim Source Control Actions* (DOE 2002), including the clean up and repair of storm sewers in the West End Mercury Area, are expected to reduce mercury concentrations at Station 17. Although fish and benthic communities are relatively stable, they continue to show impairment compared to the reference streams.

Off-Site Actions

- **Lower East Fork Poplar Creek -** Monitoring at Station 17 is conducted to measure the concentration and mass flux of mercury that is discharged from the Upper East Fork Poplar Creek watershed into Lower East Fork Poplar Creek. During FY 2011, the flow-paced continuous monitoring detected an average concentration of 817 ng/L and a mass flux of about 43.2 kg mercury. The levels of mercury in fish tissue have remained elevated.

- **Clinch River/Poplar Creek -** Performance monitoring of the Clinch River and Poplar Creek continues to indicate a downward trend in fish polychlorinated biphenyl concentrations since the late 1980s. PCBs in channel catfish are below the fish advisory levels in most years in the Clinch River, but have been at or near the advisory limits in the last couple of years in Poplar Creek. Striped bass are routinely above 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 the highest levels in fish in Poplar Creek and lower levels with distance downstream. Overall, the performance monitoring has been successful in addressing the record of decision goal of evaluating changes in fish contaminant levels and how those levels compare to fish advisory limits.

- **Lower Watts Bar Reservoir -** Performance monitoring results from Lower Watts Bar Reservoir obtained during FY 2011 continue to indicate that mercury and PCB levels in fish are below commonly-used fish advisory levels.

East Tennessee Technology Park

During FY 2011, monitoring results for the principal surface water and groundwater locations indicate that contaminant levels are generally stable to decreasing in most instances. Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell

Branch. Mercury detections at storm drain outfalls and the K-1700 Weir indicate the need for additional investigation to identify potential mercury sources.

Performance monitoring at the K-1007-P1 Holding Pond began in FY 2010. The baseline trends show PCBs in largemouth bass around 15 µg/g as a long-term average. The current sunfish average in fillet is around 2 µg/g, resulting in a decrease in potential human health risks associated with the change in species alone. Bluegill concentrations have decreased from around 3 µg/g prior to the actions to 2 µg/g currently. Clam studies continue to indicate that storm drains are a source of PCBs to the K-1007-P1 Holding Pond, but resuspension of contaminated sediments in the pond are a more likely important source of PCBs to fish. The removal action at the K-1007-P1 Holding Pond was designed to reduce sediment mobilization and subsequent bioaccumulation in fish. It will take some time for the fish, plant, wildlife, and water quality conditions in the pond to stabilize, allowing a better assessment of whether PCB exposure in the pond has sufficiently decreased.

<u>CERCLA Actions at Other Sites</u>

- **Oak Ridge Associated Universities South Campus Facility -** During FY 2011, samples were collected from well GW-842 and surface water locations SCF-WS1 and SCF-WS2 and were analyzed for VOCs. Well GW-841 was dry at the time of sampling. The FY 2011 results, which were below drinking water standard concentrations, show continuing decreased concentrations compared to the short-term increase observed during 2006 and 2007. No site-related VOCs were detected in the two surface water samples collected during FY 2011.

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1. INTRODUCTION

1.1 PURPOSE

The purposes of the annual Remediation Effectiveness Report are to:

- Evaluate the performance of each completed action 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

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

- summarize watershed monitoring results

With the exception of some ecological sampling data, all data reported in the *2012 Remediation Effectiveness Report* was collected prior to or in Fiscal Year (FY) 2011.

1.2 REMEDIATION STRATEGY

In Oak Ridge, DOE and its predecessor agencies have had a mission over the past sixty 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 Oak Ridge Reservation. The Oak Ridge Reservation was placed on the CERCLA National Priorities List in 1989. The *Federal Facility Agreement* (DOE 1992), signed by DOE, the Environmental Protection Agency, and the Tennessee Department of Environment and Conservation in 1991, describes how remediation under CERCLA will be performed.

The remediation strategy for the contaminated sites on the Oak Ridge Reservation is based on a watershed management approach. The Clinch River bounds the Oak Ridge Reservation on three sides, and there are active creeks that flow down the valleys to the Clinch River. 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 and shallow soil, which contains most of the contaminated sites, before discharging to nearby surface water. Consequently, the primary pathway for offsite contaminant migration is through shallow groundwater to surface water. Because of abundant rainfall, 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. This conceptual site model is illustrated in Figure 1.1.

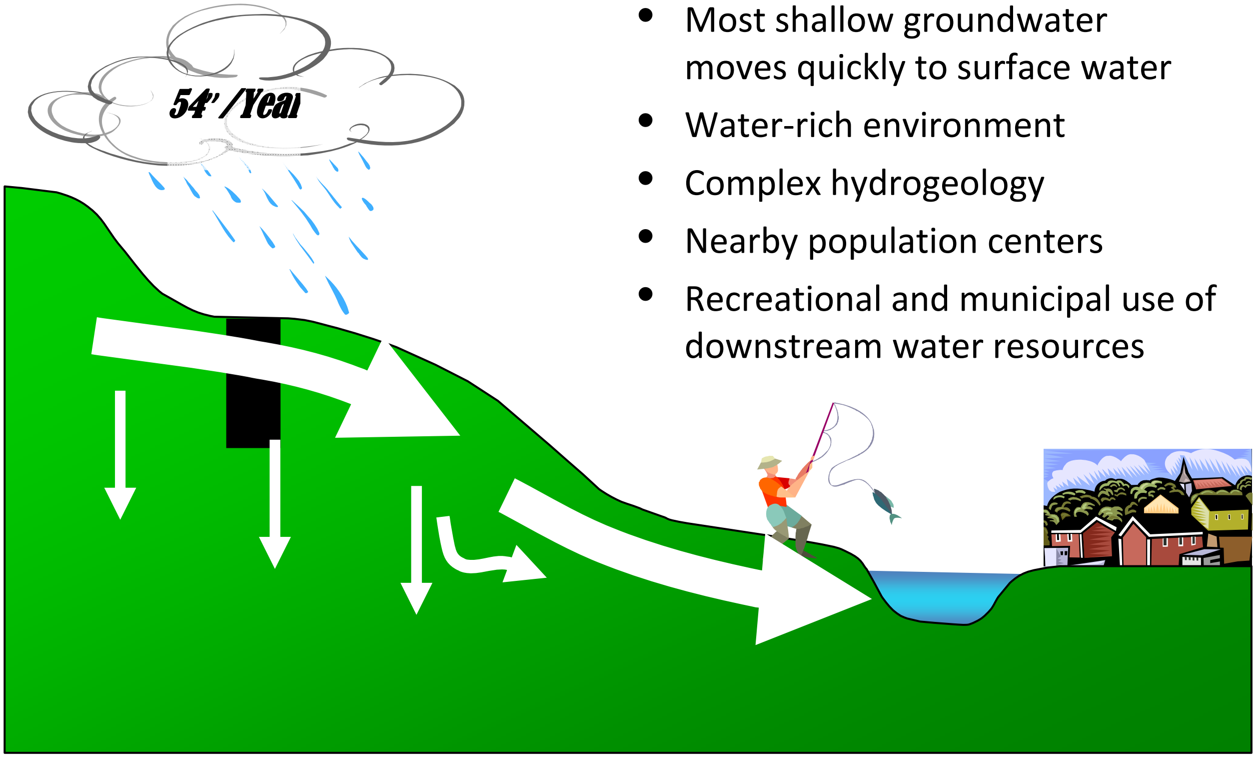

Figure 1.1. Conceptual site model.

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 Oak Ridge Reservation by grouping contaminated sites into the following five watersheds (Figure 1.2):

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

Additionally, decisions have been made and actions taken off-site (Lower East Fork Poplar Creek, Clinch River/Poplar Creek, and Lower Watts Bar Reservoir), 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

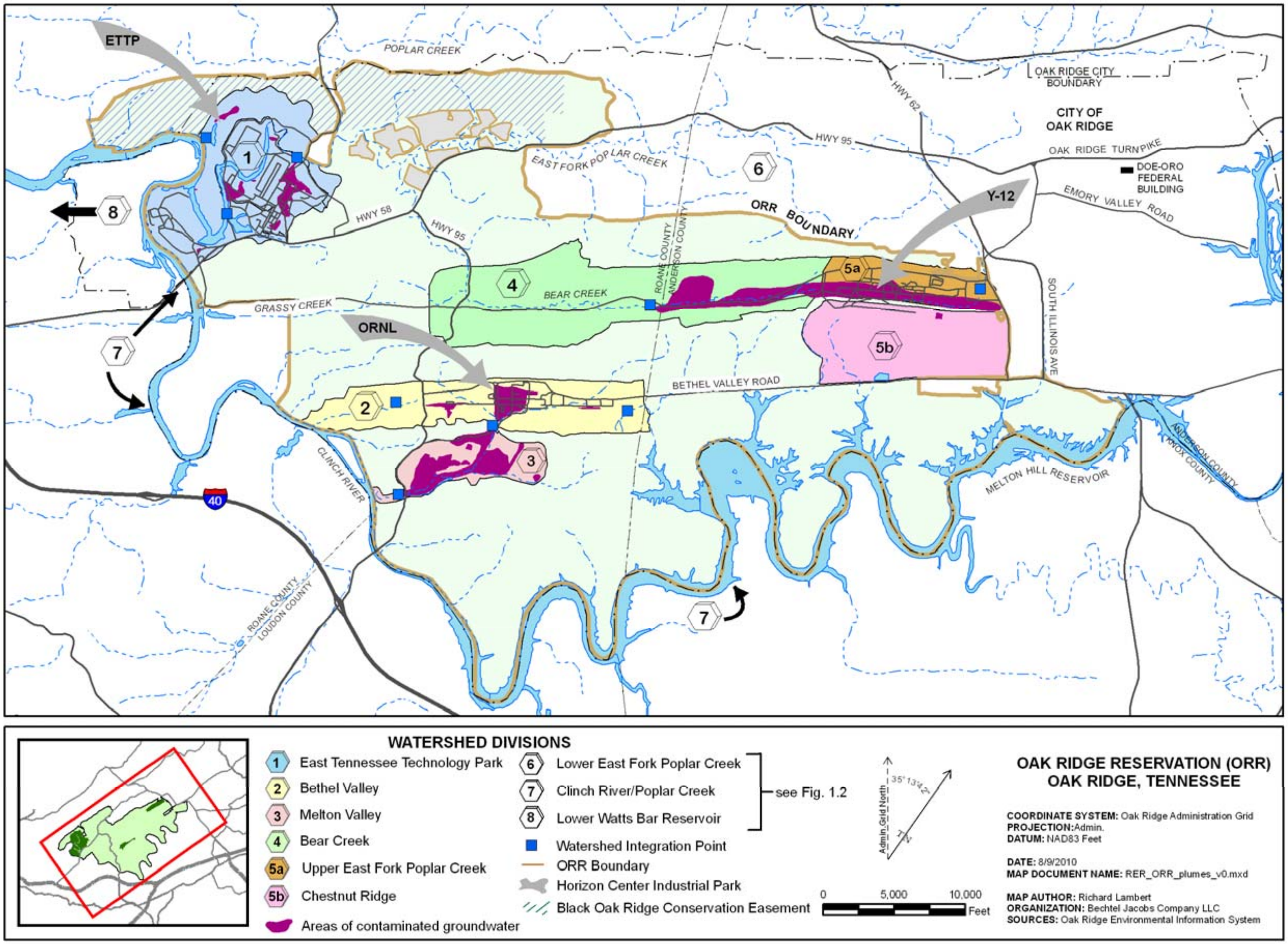

Figure 1.2. Watersheds on the Oak Ridge Reservation.

- make remedial decisions
- evaluate remedial 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 offsite to the Clinch River. Therefore, the surface water acts as an integrator of contaminant flux, and integration points (Figure 1.2) are identified in each watershed at which contaminant releases can be tracked, assessed, and prioritized. Once the baseline monitoring and characterization are completed and the cleanup objectives are defined, the contribution of each remedial action 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.

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

- mitigate immediate onsite and offsite risks
- reduce further migration of contaminants offsite
- address sources of offsite surface water and groundwater contamination
- address remaining onsite contamination
- address decontamination and demolition of facilities

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 Oak Ridge Reservation 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 contain performance goals to be met and a series of remedial actions designed to achieve them.

While waiting for the watershed decisions to be made with the associated series of remedial actions, single-project actions were performed primarily to mitigate immediate risks and to reduce further migration of contaminants offsite.

1.3 LONG-TERM STEWARDSHIP

Various CERCLA decision documents are used to make remediation decisions on the Oak Ridge Reservation. Typically, either a Record of Decision for a remedial action or Action Memorandum for a removal action defines the selected remedy. These decision documents contain the statutory decision for remediation activities and may also specify long-term stewardship requirements. However, because most decision documents generally lack specifics, additional details typically are found in post-Record of

Decision documents, such as remedial action work plans, post-construction reports, remedial action reports, removal action reports, phased-construction completion reports, or monitoring plans.

The decision documents contain engineering controls and land use controls:

- 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.

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

Since most of the remediation decisions do not allow unrestricted end use, these sites will require long-term stewardship. Long-term stewardship 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 long-term stewardship are:

- Stewards – Stewards are responsible for developing, implementing, and overseeing long-term stewardship activities.

- Operations – Operations are those activities necessary to ensure the integrity of the engineering and land use controls and include facility operations, inspection, verification, surveillance, monitoring, enforcement, maintenance, modification, replacement, and evaluation.

- Information Systems – Information systems maintain records of residual contamination, associated risks, required long-term stewardship activities, and performance of the engineering and land use controls.

- 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 long-term stewardship 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 long-term stewardship activities.

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

- Funding – Adequate and sustained funding is necessary to develop and maintain long-term stewardship activities.

Long-term stewardship ensures that the engineering controls and land use controls remain effective for an extended, or possibly indefinite, period of time until residual hazards are reduced sufficiently to permit unrestricted use and unlimited access (DOE 2003). Long-term stewardship is designed to:

- Prevent the residual hazard from migrating to the receptor (generally through engineering controls), and

- Prevent the receptor from encountering the residual hazard (generally through land use controls).

The Remediation Effectiveness Report evaluates the performance of engineering controls and land use controls that are required by CERCLA documents, e.g., Records of Decision, Action Memoranda, Remedial Action Work Plans, Removal Action Work Plans, Phased Construction Completion Reports, Remedial Action Reports, and Removal Action Reports, to protect human health and the environment. The definitions encompassing long-term stewardship have evolved over time, and earlier decision documents used the term "institutional controls" instead of land use controls and engineering controls. This term "institutional controls" is used throughout this document when using citations directly from these earlier decision documents.

Long-term stewardship information used in this document was collected and/or compiled by the Water Resources Restoration Program in conjunction with the Surveillance and Maintenance Program, the Radiation Protection Program, and Environmental Compliance. Site-specific inspections to assess the condition of engineering controls, as well as physical land use controls, i.e., access controls, signs, and security patrols, are performed by the Surveillance and Maintenance Program in accordance with site-specific surveillance and maintenance plans. Inspection check sheets are completed for each location and linked to any needed maintenance request forms. This documentation is maintained by the Project Document Control Center and ultimately filed in the Document Management Center. The Water Resources Restoration Program routinely obtains copies of these check sheets to monitor effectiveness and to summarize compliance with the long-term stewardship requirements annually in the Remediation Effectiveness Report. Long-term stewardship requirements at the ETTP also include radiological surveys, Contamination Area postings, storm drain sampling, and surface water monitoring for areas with remaining contamination. Radiological monitoring information is maintained by the Radiation Protection Program, and a summary of the survey results are incorporated into the Remediation Effectiveness Report. Storm drain sampling and surface water monitoring is performed by ETTP Environmental Compliance.

Documentation verifying the implementation of administrative land use controls, i.e., property record restrictions, property record notices, zoning notices, and excavation/penetration permit 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 excavation/penetration permit program. Copies of this documentation are obtained by the Water Resources Restoration Program 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 1999a) requires that the Manager, DOE Oak Ridge Operations, annually verify in the Remediation Effectiveness Report that Land Use Controls Implementation Plans are being implemented on the Oak Ridge Reservation. Only select land use controls for Melton Valley require an annual certification, and this annual certification for Melton Valley is in Appendix A.

Monitoring information is an instrumental component of long-term stewardship, it is used to assess the performance of completed CERCLA actions where residual contamination is left that does not allow for unrestricted use. On the Oak Ridge Reservation for CERCLA sites this information is compiled by the Water Resources Restoration Program. The Water Resources Restoration Program was established to implement a comprehensive, integrated environmental monitoring and assessment program for the Oak Ridge Reservation 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 Remediation Effectiveness Report are collected in accordance with the watershed-specific monitoring plans and the *Quality Assurance Project Plan for the Water Resources Restoration Program* (UCOR 2012, in preparation). Baseline data will be reported in future Remediation Effectiveness Reports, as required, once the respective actions are completed.

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

Figure 1.2 shows areas of known groundwater contamination in each of the watersheds. No final groundwater decisions have been made on the Oak Ridge Reservation to date, although several groundwater remedial actions 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 remedial actions were implemented using *in situ* media to capture or degrade contaminants. None of these remedial actions met with long-term success, and all were terminated. Remedial actions 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 offsite plume migration at the Y-12 east-end volatile organic compound (VOC) plume in Upper East Fork Poplar Creek (UEFPC) and at the hexavalent chromium plume at the East Tennessee Technology Park (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. Dense non-aqueous phase liquids containing chlorinated VOCs in fractured bedrock are known to exist at ETTP and in Bear Creek Valley and may be present in other areas of the Oak Ridge Reservation. Such contaminant problems are extremely difficult and in some instances have been determined to be technically impracticable to remediate. Groundwater treatability studies are being conducted at two chlorinated VOC sites – ETTP and the Oak Ridge National Laboratory – to evaluate the feasibility of remediating these contaminants in the Oak Ridge Reservation groundwater setting. Groundwater also is monitored to establish a baseline and to identify trends. Groundwater wells have been identified to monitor exit pathways from the Oak Ridge Reservation and to monitor the performance of specific actions.

In summary, as illustrated in Figure 1.3, the decision documents describe the remedy in terms of engineering controls and land use controls. Through the Operations element of long-term stewardship engineering controls must be operated, maintained, and monitored, and land use controls must be inspected and verified so protectiveness and performance can be evaluated. Then, the performance is assessed and reported in the Remedial Effectiveness Report and Five-Year Review.

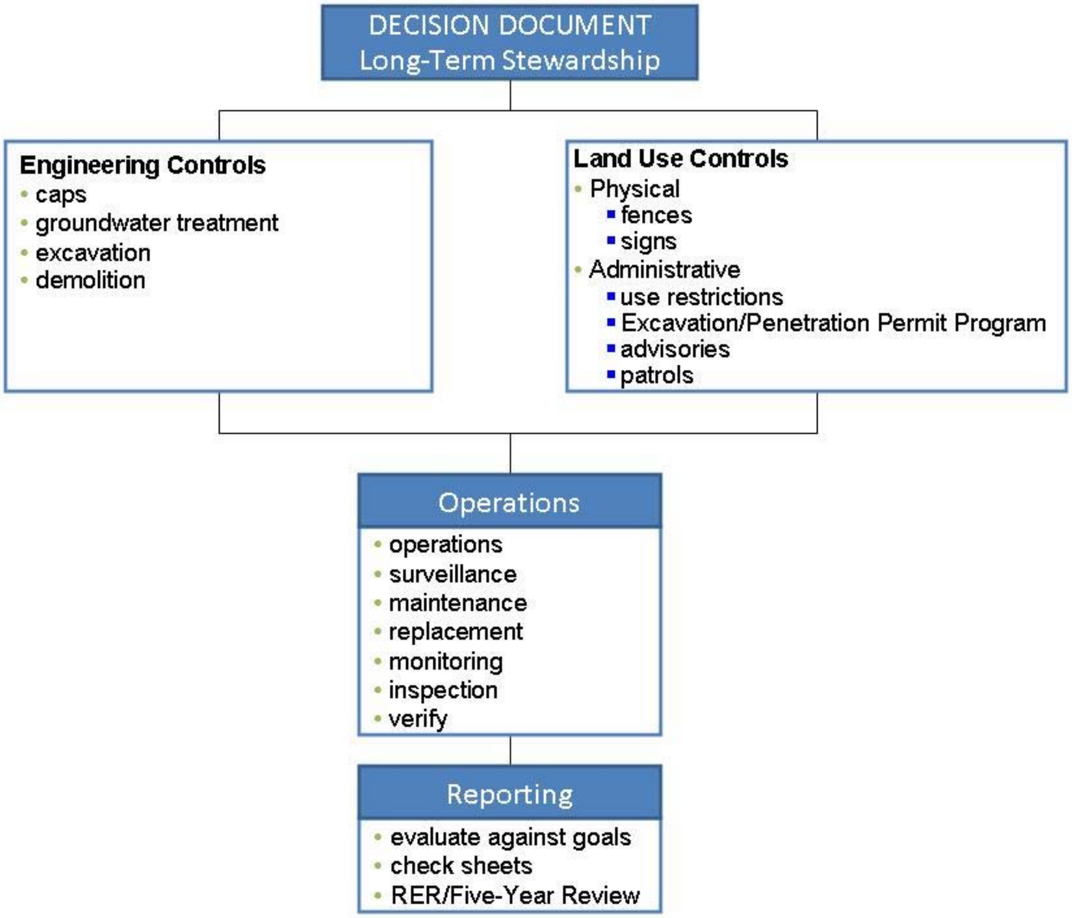

Figure 1.3. Hierarchy for assessing performance.

1.4 OAK RIDGE RESERVATION RAINFALL

The quantity, duration, and intensity of rainfall affect contaminant concentrations in groundwater and surface water across the Oak Ridge Reservation. Because of this, general rainfall trends for FY 2011 are summarized to provide a general context for the remainder of this document.

Details of rainfall distribution for FY 2011 are illustrated in Figure 1.4. Mean monthly rainfall values for FY 2011 vary from ~1.2 inches/month to approximately 10 inches/month. During FY 2011, the greatest monthly rainfall occurred in September when a tropical storm system passed over East Tennessee over a 3 day period, and the lowest monthly rainfall occurred during August. During FY 2011, rainfall distribution was uneven with the months of December, May, and August experiencing about 50% or less of typical monthly average levels and November, April, and September experiencing much greater than normal rainfall levels.

Total rainfall on the Oak Ridge Reservation during FY 2011 measured over 60 inches based on a composite of six rain-gauge stations located throughout the Oak Ridge Reservation (Figure 1.5). The total rainfall during FY 2011 was greater than the long-term mean of 54 inches/year.

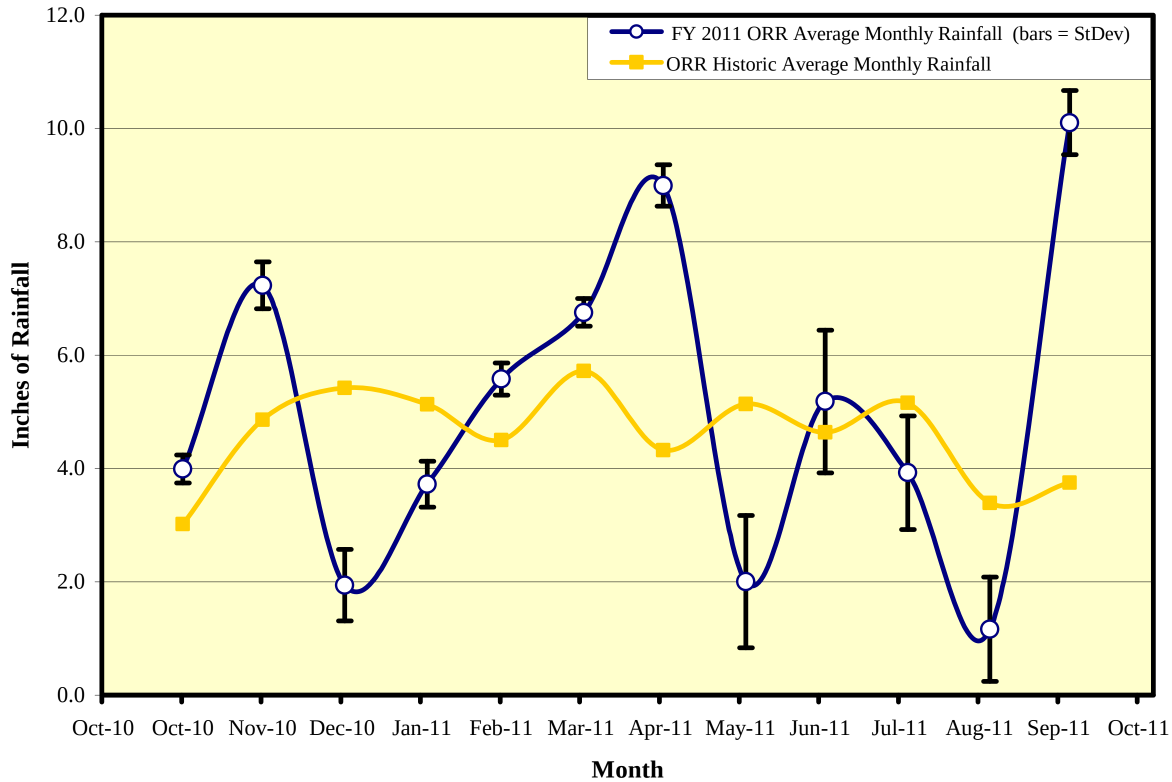

Figure 1.4. Fiscal Year 2011 monthly average rainfall from six rain gauges on the Oak Ridge Reservation.

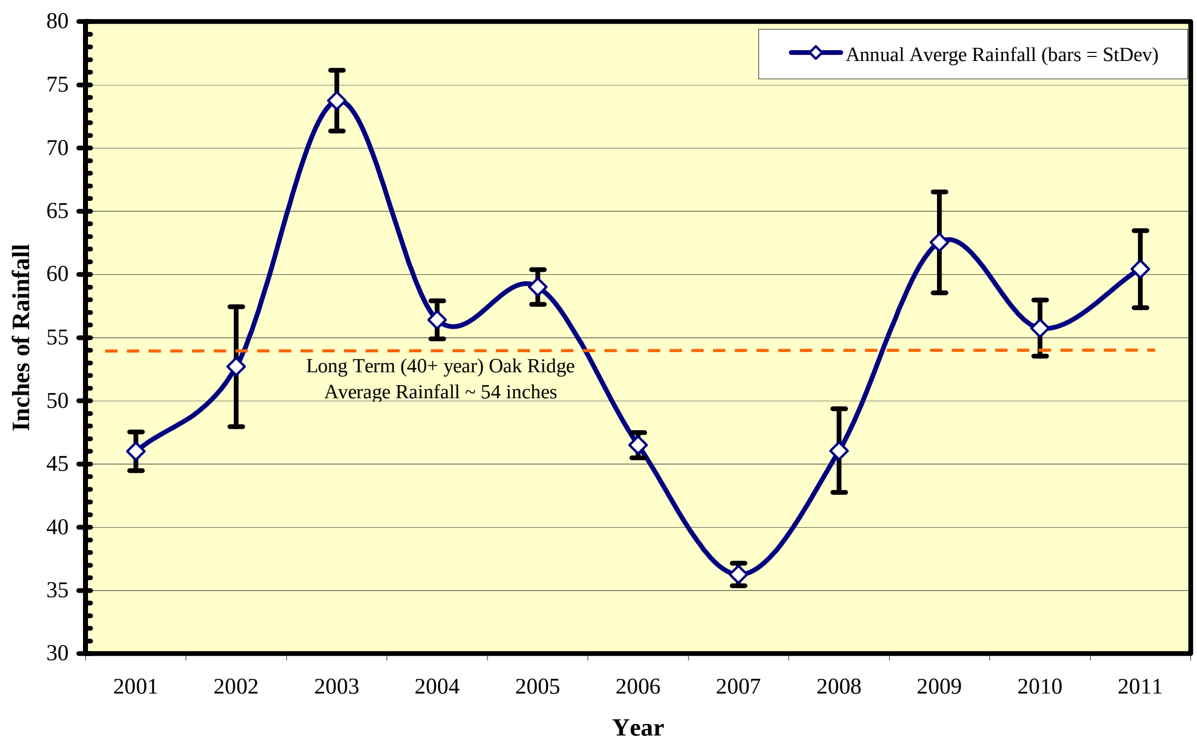

Figure 1.5. Mean annual rainfall from six rain gauges on the Oak Ridge Reservation, 2001-2011.

1.5 DOCUMENT ORGANIZATION

The Remediation Effectiveness Report 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
- Chapter 7 – Off-Site
- Chapter 8 – East Tennessee Technology Park
- Chapter 9 – Other Sites
- Appendix A – the applicable compliance certification for the approved Melton Valley land use controls
- Appendix B – Graphical presentation of data that support discussions of Melton Valley performance assessments

Figure 1.2 shows the watersheds on the Oak Ridge Reservation, and Figure 1.6 shows the boundaries of the impacted watersheds downstream of the Oak Ridge Reservation. Implementation of the watershed records of decision can take many years to complete. Therefore, watershed maps in each chapter use different symbols to identify completed actions, actions not implemented, and actions which are in progress.

A chapter is devoted to each of the watersheds (Figure 1.2), 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 single-project actions and completed watershed-scale actions with long-term stewardship requirements. For each chapter, the following information is provided:

- Description of the completed actions
- Long-term stewardship requirements, e.g., monitoring, land use controls, and facility operations, for completed actions

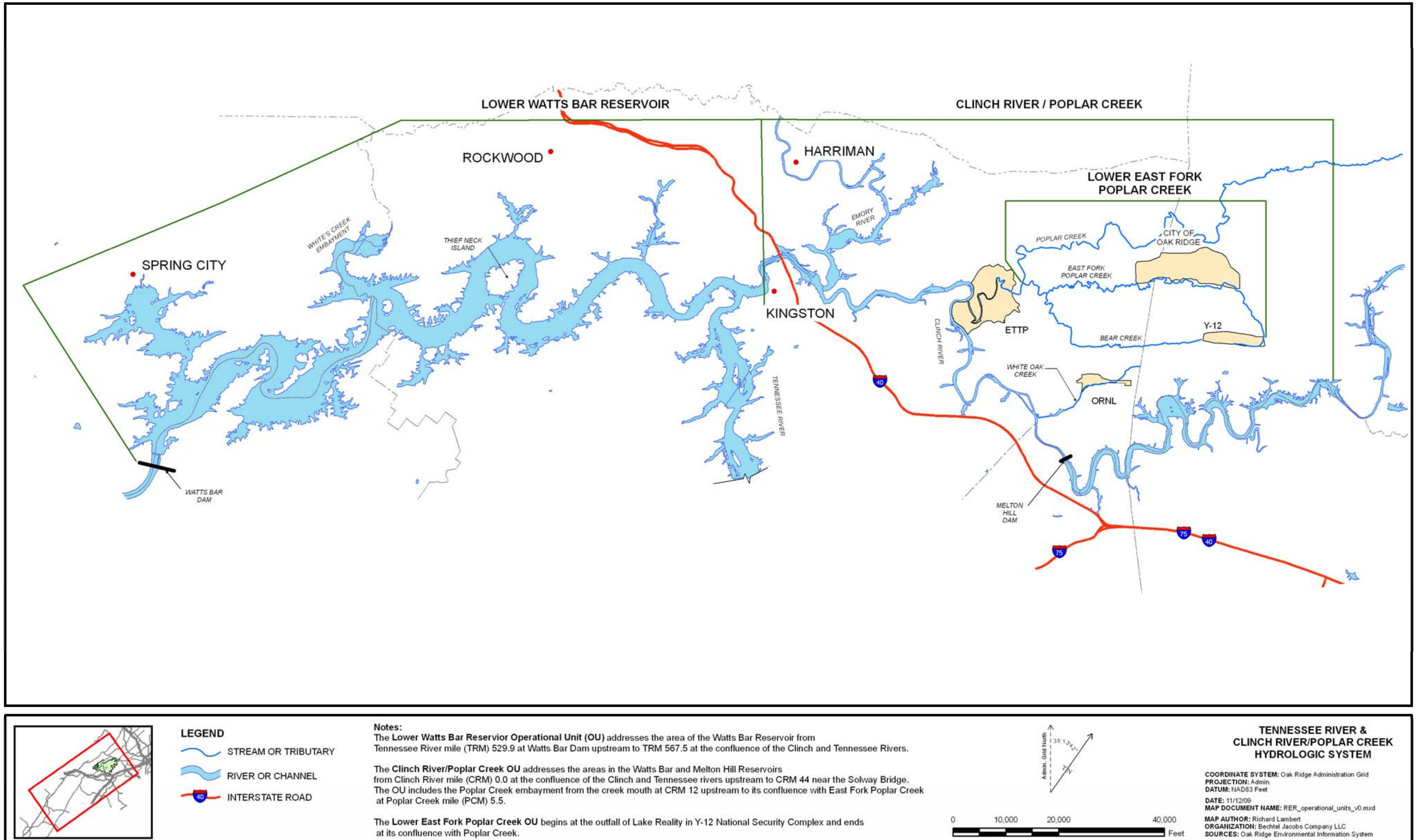

Figure 1.6. Lower Watts Bar, Clinch River/Poplar Creek, and Lower East Fork Operational Units.

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- Evaluation of compliance with long-term stewardship 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 record of decision 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, issues and recommendations

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

1.6 ISSUES AND RECOMMENDATIONS

Table 1.1 summarizes issues and recommendations identified through evaluation of long-term stewardship requirements. To track issues through their resolution, Table 1.1 is a compilation of the issues identified in subsequent chapters of this Remediation Effectiveness Report and unresolved issues carried forward from a previous Remediation Effectiveness Report. Table 1.2 identifies those issues that are closed out in this Remediation Effectiveness Report and will no longer be tracked in future Remediation Effectiveness Reports or Five-Year Reviews. Table 1.3 and Table 1.4 are reserved at this time in this document, these tables usually contain issues from the *CERCLA Five-Year Reviews* (e.g., DOE 2011). However, the most recent Five-Year Review (i.e., 2011 Five-Year Review) is in the D1 version and comments are being resolved with EPA/TDEC at the time of this printing.

An issue that is carried forward from a previous years' Remediation Effectiveness Report is only discussed in the respective chapter of the text if FY 2011 assessment clarifies, modifies, or otherwise impacts the issue in any way. For example, because many of the issues in Table 1.1 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 1.1. 2012 issues and recommendations
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation	Responsible parties Primary/Support	Target response date
Bethel Valley			
1. Corehole 8 Plume collection system performance does not meet RmAR performance goals. (2010 RER)[a]	1. Line leaks in the potable water system were identified and fixed by UT-Battelle in FY 2010. Additionally, new wells were drilled for the Bethel Valley Corehole 8 Extraction System in FY 2010 and FY 2011 and are currently being hooked up to the extraction system. After the extraction system is fully operational, the ^{90}Sr concentrations are expected to decrease.	DOE/ EPA & TDEC	FY 2012
Melton Valley			
1. Initial sampling of new offsite wells (2 events) yielded indication of the presence of VOCs and some metal contaminants. (2011 RER) [a]	1. Comprehensive picket well and offsite well sampling was completed in the first quarter of FY 2012. The presence of site contaminants, trends, and on-site vs off-site hydrologic head relationship was discussed with the Core Team in January 2012. New sampling is being agreed upon with DOE/EPA/TDEC for the Melton Valley Exit Pathway and is being documented in the MV Monitoring Plan.	DOE/ EPA & TDEC	FY 2012
2. During FY 2010 groundwater level control at the SWSA 4 downgradient trench deteriorated as indicated by water level measurements in the trench, within the nearby portion of SWSA 4, and the former IHP area. (2011 RER)[b]	2. (a) closed out in Table 1.2 (b) DOE will evaluate options to enhance the performance of the SWSA 4 downgradient extraction trench. In 2011 it was determined that contaminants from SWSA 4 were seeping to surface water.	DOE/ EPA & TDEC	FY 2012
Bear Creek Valley			
1. Documented discharge of contaminants from upstream sources in NT-8. (2011 RER)[a]	1. (a) Closed out in Table 1.2. (b) Engineering design and operational records for the non-CERCLA groundwater seepage collection system in the NT-8 headwaters associated with BCBG D-West will be reviewed and the system performance will be evaluated.	DOE/ EPA & TDEC	NT-8 Surface Water Early Action: refer to FFA Appendix E and J for planned implementation schedule.
2. A scarcity of groundwater monitoring wells in Zone 2 makes it impossible to precisely map and track groundwater contaminant transport pathways from a DNAPL area in the BCBGs and potentially into Zone 1. (2011 RER)[a]	2. Evaluation of potential pathways and installation of additional wells will be included in the work plan associated with the future BCV Groundwater ROD.	DOE/ EPA & TDEC	BCV Groundwater ROD; refer to FFA Appendix E and J for planned implementation schedule.

Table 1.1. 2012 issues and recommendations (cont.)
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation	Responsible parties Primary/Support	Target response date
3. Five years of monitoring has been completed at the Bear Creek restoration site (BCK 4.6). The site is in excellent condition and is well on its way to recovery. (2011 RER)[a]	3. DOE recommends that stream habitat, riparian vegetation and wetland monitoring be discontinued. DOE submitted an Appendix I-12 letter.	DOE/ EPA & TDEC	FY 2012 when Appendix I-12 letter is concurred to by EPA/TDEC.
4. In addition to surface water monitoring at the BYBY, the PCCR (DOE 2003d) specifies stream-stability monitoring, riparian vegetation monitoring, and in-stream biological monitoring of the restored NT-3 channel. (2008 RER)[b]	4. DOE recommended that riparian vegetation monitoring be discontinued because of improved habitat. DOE submitted an Appendix I-12 letter to discontinue the monitoring for EPA/TDEC approval.	DOE/ EPA & TDEC	FY 2012 when Appendix I-12 letter is concurred to by EPA/TDEC.
Chestnut Ridge			
1. Gross beta detected in UNC SW-1 in fourth quarter sample.	1. Add ^{90}Sr to the analytical suite for that location. DOE will submit an Appendix I-12 letter for EPA/TDEC approval with changed pages from the UEFPC Monitoring Plan.	DOE EPA & TDEC	FY 2012/2013 when Appendix I-12 letter is concurred to by EPA/TDEC.
East Tennessee Technology Park			
1. Sampling of the SW-31 Spring is no longer required, but the decision and completion document still requires monitoring.	1. Revise *Addendum to the Remedial Action/Effectiveness Report for the K-1070 Operable Unit SW31 Spring Phase 2 Remedial Action at the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE 2007).	DOE/ EPA & TDEC	FY 2012
2. 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)[b]	2. DOE acknowledges the land use differences that exist between the BORCE use and that which is in the Zone 1. The end use of the portion of Zone 1 that is also identified as part of the BORCE will be changed from industrial to recreational in an amendment to the Zone 1 Interim ROD (DOE 2002a) with the appropriate level of public participation. The *Addendum to the Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2010g) includes the risk assessment to support this change.	DOE/ EPA & TDEC	FY 2012 with amendment to Zone 1 Interim ROD

[a] The year of the Remediation Effectiveness Report or the Five Year Review in which the issue originated is provided in parentheses, e.g., (*2008 Remediation Effectiveness Report*).

AWQC = ambient water quality criteria
BCK = Bear Creek kilometer
BCBG = Bear Creek Burial Grounds
NNSA = National Nuclear Security Administration
NT = North Tributary
PCB = polychlorinated biphenyl

Table 1.1. 2012 issues and recommendations (cont.)

(New issues identified in this RER are in blue text.)

BORCE = Black Oak Ridge Conversation Easement
BYBY = Boneyard/Burnyard
BSWTS = Big Spring Water Treatment System
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
EFPC = East Fork Poplar Creek
EM = Environmental Management
EPA = Environmental Protection Agency
ESD = Explanation of Significant Difference
IHP = Intermediate Holding Pond
RDR/RAWP = Remedial Design Report/Remedial Work Plan
RMPE = Reduction of Mercury in Plant Effluents
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
TM = Technical Memorandum
UNC = United Nuclear Corporation
VOA = volatile organic analysis
VOCs = volatile organic compound

Table 1.2. Closed-out issues in 2011

Issue[a]	Recommendation/Resolution	Responsible parties Primary/Support	Target response date
Melton Valley			
1. During FY 2010 groundwater level control at the SWSA 4 downgradient trench deteriorated as indicated by water level measurements in the trench, within the nearby portion of SWSA 4, and the former IHP area. (2011 RER)[b]	1. (a) During winter of 2011 DOE will collect seepage samples from the IHP adjacent to the SWSA 4 downgradient trench during or soon after large rainfall events to determine if SWSA 4 contaminants are being discharged to surface water in the IHP. In 2011 it was determined that contaminants from SWSA 4 were seeping to surface water, results included in the 2011 RER. (b) Included as an open issue in Table 1.1.	DOE/ EPA & TDEC	FY 2011 with submission of the 2012 D2 RER
2. Monitoring results for some zones in the MV exit pathway wells yield elevated alpha and beta activity results that are apparently the result of elevated suspended and/or dissolved solids. These results raise concern over possible migration of contamination across the DOE property boundary in western MV. (2008 RER)[a]	2. Monitoring of the picket wells in accordance with the MV Monitoring Plan continued through December 2011. Additionally in 2010, DOE established an offsite monitoring system to confirm the presence of contaminants including two clusters of newly drilled wells and two reconfigured wells. Monitoring of the new system was agreed upon for four quarters, after which the Core Team discussed the monitoring results. The Core Team discussed the result of the sampling in December 2011. This issued is closed out. Issue #1 in Table 1.1 concerns the follow on sampling documentation in a revision to the Melton Valley Monitoring Plan.	DOE/ EPA & TDEC	FY 2011 with submission of the 2012 D2 RER
Bear Creek			
1. Documented discharge of contaminants from upstream sources in NT-8. (2011 RER)[b]	1. (a) Surface water samples were collected along a transect from the NT-8 flume upstream to the BCBG fence identifying the inputs of uranium, VOCs, and PCBs to NT-8 in FY 2011, results are included in the 2012 RER. (b) Included as an open issue in Table 1.1.	DOE/ EPA & TDEC	FY 2011 with submission of 2012 D2 RER
2. Monitoring results for Zone 1 of BCV exhibit trace-to-low contaminant concentrations in groundwater, thereby compromising the Phase I ROD goal to maintain clean groundwater acceptable for unrestricted use. (2010 RER)[b]	2. The contaminant concentrations have remained low and are observed intermittently at various monitoring locations. In FY 2010, concentrations continued to trend downward or were not observed at all. The intermittent plume in the Maynardville Limestone were monitored during FY 2011 and no MCLs were exceeded.	DOE/ EPA & TDEC	FY 2011 with submission of 2012 D2 RER
3. Results for BCK 9.2 show an increase in the proportion of ungauged uranium flux beginning in FY 2002. Increasing uranium trends are not observed at gauged monitoring stations, or in	3. Uranium flux mass balance in the Bear Creek watershed is complicated by the karst groundwater system. However, during FY 2010 the mass balance between source area contribution and the BCK 9.2 total matched within an 1% (<1 kg). DOE submitted an Appendix I-12 letter (and included the revised pages from the BCV Watershed Monitoring Plan) to the regulators	DOE/ EPA & TDEC	BCV Monitoring Plan Addenda and I-12 letter concurred on by acceptance of the regulators in

Table 1.2. Closed-out issues in 2011 (cont.)

Issue[a]	Recommendation/Resolution	Responsible parties Primary/Support	Target response date
principal groundwater exit points contributing to Bear Creek surface flow. (2006 FYR)[b]	recommending re-instatement of flow paced monitoring at NT-3 and NT-5 and the creation of an additional flux monitoring station at BCK 10.15 (downstream of SS-4 but upstream of NT-7) to attempt to determine inputs to the stream channel from karst discharge. The Appendix I-12 letter was accepted by both TDEC and EPA. Flow calibration at BCK 10.15 is on-going in FY 2011. Sources of uranium flux have been identified.		January 2012.
UEFPC			
1. During FY 2010 inflow to BSWTS exceeded system design treatment capacity necessitating bypass flow to occur during significant periods of time.	1. Recommend additional data collection at Outfall 51 to better quantify water volume and total mercury discharges, which is necessary to support any modification to BSWTS capacity. Flow meter and sampling system were installed on 8-inch overflow pipe.	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER
2. Mercury concentrations in fish within the UEFPC system remain elevated, despite decreasing concentrations in aqueous mercury levels. (2007 RER)[b]	2. A team consisting of DOE EM, NNSA, and Office of Science continue working together to develop a conceptual model(s) for mercury fate and transport relevant to methyl mercury concentrations in the UEFPC ecosystem. Two recent reports focused on mercury sources, transport, and fate have been drafted or published (Southworth *et al*. 2010, Peterson *et al* 2011).	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER
3. FY 2005 pre-action mercury concentrations at Station 17 are above the 200-ppt performance goal. Hg concentrations in fish in UEFPC have yet to respond to commensurate reductions of Hg from historical RMPE actions. Biota monitoring in UEFPC shows impaired diversity and density of pollution-intolerant species. (2006 FYR)[b]	3. Remedial measures including the recent clean up and repair of storm sewers in the West End Mercury Area required by the UEFPC Phase I ROD are expected to reduce Hg concentrations at Station 17. FY 2010 mercury levels in UEFPC fish remain above federal AWQC, but are less than peak levels observed in 2001-2002. Issue will continue to be monitored and discussed in future RERs.	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER UEFPC Phase I ROD, refer to the FFA Appendix E and Appendix J for planned implementation schedules.
East Tennessee Technology Park			
1. Fish barrier in K-1007-P1 Holding Pond was damaged during storm events allowing reintroduction of undesirable fish species into the pond.	1. Fish barrier was repaired and undesirable fish were removed to the extent practicable in FY 2010. Performance monitoring initiated, and PCB concentrations in fish will continue to be evaluated.	DOE/ EPA & TDEC	2011 FYR with submission of 2012 D2 RER.

Table 1.2. Closed-out issues in 2011 (cont.)

[a] The year of the RER or the FYR in which the issue originated is provided in parentheses, e.g., (2008 RER). Only issues that are closed out in this RER (2011) are included. Similarly, prior RERs have identified issues which were closed out in that year.

EPA = Environmental Protection Agency
MCL = Safe Drinking Water Act maximum contaminant level
NT = North Tributary
TDEC = Tennessee Department of Environment and Conservation

Table 1.3. Summary of unresolved issues, recommendations, and follow-up actions from the Five-Year Review (Reserved)

This table is reserved because the 2011 Five-Year Review is going through comment resolution at this time.

Table 1.4. Summary of completed technical issues and recommendations from the Five-Year Review (Reserved)

This table is reserved because the 2011 Five-Year Review is going through comment resolution at this time.

1.7 REFERENCES

DOE 1999a. *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation.* Attachment: *Land Use Control Assurance Plan for the Oak Ridge Reservation,* Oak Ridge, TN, DOE/OR/01-1824&D1/A1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1992. Federal Facility Agreement, DOE/OR-1014, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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

DOE 2003. *Department of Energy Oak Ridge Operations Environmental Management Program Long-Term Stewardship Strategic Plan,* Office of Environmental Management, U.S. Department of Energy, Oak Ridge, TN.

DOE 2005. *Addendum to the Remedial Design Report/Remedial Action Work Plan for the Solid Waste Storage Area 4 Burial Grounds and Intermediate Holding Pond Remediation Project, Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1915&D2/A2/R1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007. *Addendum to the Remedial Action/Effectiveness Report for the K-1070 Operable Unit SW31 Spring Phase 2 Remedial Action at the Oak Ridge K-25 Site, Oak Ridge, Tennessee,* DOE/OR/01-1520&D1/R1/A1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010. Addendum to *Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1 East Tennessee Technology Park, Oak Ridge, Tennessee*, DOE/OR/01-2261&D2/A1/R1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011. *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&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN

Peterson, MJ, RA Efroymson, and SM Adams. 2011. *Long-Term Biological Monitoring of an Impaired Stream: Synthesis and Environmental Management Implications*. Environmental Management 47:6: 1125-1140.

Southworth, G., M. Greeley, M. Peterson, K. Lowe, and R. Ketelle, 2010. *Sources of Mercury to East Fork Poplar Creek Downstream from the Y-12 National Security Complex: Inventories and Export Rates,* ORNL/TM-2009/231, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

UCOR 2012 (in preparation). *Quality Assurance Project Plan for the Water Resources Restoration Program, U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee,* UCOR-4049, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

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2. CERCLA ACTIONS IN 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 the Oak Ridge National Laboratory. Table 2.1 lists the CERCLA actions within the watershed, and Figure 2.1 locates the key CERCLA sites and actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. Only sites that have monitoring and long-term stewardship requirements (Table 2.1) are included in these performance evaluations. Remedial Action Objectives that form the basis for the interim remedial actions are based on the end uses depicted in Figure 2.2. These end uses require certain restrictions regarding site access and allowable activities as listed in Table 2.2.

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 provides 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 2011e). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

2.1.2 Status

<u>Watershed-Scale Actions</u>

The *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) establishes protectiveness and cleanup levels for the watershed and specifies the following remedial actions for soil and sediment -- capping at two large waste sites, Solid Waste Storage Area 1 and the Solid Waste Storage Area 3 area; removing soil in actions that vary in size from limited extent to large areas; and removing stream sediments from seven stream-reach exposure units. The status follows:

- The *Remedial Design Report/Remedial Action Work Plan for Soils, Sediments and Dynamic Characterization Strategy for Bethel Valley* (DOE 2009a) defines the scope of remediation to be performed, describes the method of accomplishment for remediation, and presents statistically-based soil characterization strategy to verify that the Remedial Action Objectives (DOE 2002) are met following remedial action. The cleanup strategy includes a series of workshops to identify sampling needs in specific portions of Bethel Valley. More than 15 workshops were conducted in FY 2010 and field activities, focused on the Raccoon Creek drainage and the western end of Bethel Valley including the northwest corner of the Oak Ridge National Laboratory main campus, have been completed. With the exception of groundwater and of areas adjacent to Raccoon Creek, 487 acres west of the Contractors Landfill were identified No Further Action under the *Record of Decision for Interim Actions at Bethel Valley* by the end of FY 2010. Activities were ongoing as of September 30, 2011.

Table 2.1. CERCLA actions in Bethel Valley Watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Facility Operations/ Land Use Controls required	section
Watershed-scale actions				
Bethel Valley Interim Actions	ROD (DOE/OR/01-1862&D4): 05/2/02 NSC (05/2/04) NSC (DOE/OR/01-2152&D1), addition of Hot Storage Garden (3597), 07/12/04 NSC (12/3/04) ESD (DOE/OR/01-2446&D2): 10/05/10 NSC (errata pages submitted 10/26/09; no approval required)	Actions complete		2.2
		PCCR for the Tanks T-1, T-2, and High Flux Isotope Reactor (DOE/OR/01-2238&D1) 11/16/05.	No/No/No[b]	
		PCCR for the Bethel Valley Mercury Sumps Groundwater Action (DOE/OR/01-2472&D1) approved 08/27/10.	Yes/Yes/Yes	2.2.2.1.2
		Actions in progress		
		RDR/RAWP for Oak Ridge National Laboratory soils and sediments (DOE/OR/01-2378&D4), approved 12/07/09.		
		RDR/RAWP for the Bethel Valley Burial Grounds (DOE/OR/01-2427&D2/A2), approved 11/03/10.		
		Treatability Study Work Plan (7000 Area) (DOE/OR/01-2475&D2), approved 12/28/10.		
		PCCR (BV Burial Grounds) (DOE/OR/01-2533&D1) submitted 09/14/11.		
Single-project actions				
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.	Yes/No/No	2.3.1
		RDR/RAWP for Bethel Valley Corehole 8 Extraction System (DOE/OR/01-2469&D2) approved 11/04/10.	Yes/Yes/Yes	
		Phase I Operations Report (DOE/OR/01-1832&D1)		
		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/No[c]	--
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/No/Yes	2.3.3
		RAR for Impoundments C and D (DOE/OR/01-1784&D2) approved 04/19/99.		
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/Yes	2.3.4
		PCCR (Hot Storage Garden) (DOE/OR/01-2265&D1) approved 01/10/06.		

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

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status[a]	Monitoring/ Facility Operations/ Land Use Controls required	section
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/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/No	--
Waste Evaporator Facility Removal Action	AM (DOE/OR/02-1381&D2): 07/28/95	RmAR (DOE/OR/01-1460&D1) approved 12/12/96.	No/No/No	--
Gunite and Associated Tanks Operable Unit	ROD (DOE/OR/02-1591&D3): 09/2/97	RAR (DOE/OR-01-1955&D1) approved 10/2/01.	No/No/No	--
Inactive Liquid Low-Level Waste 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/No	--
		RmAR II Addendum (DOE/OR/01-1953&02/A2) submitted 09/26/01		
Gunite and Associated Tanks Stabilization (Shells/Risers)	AM (DOE/OR/01-1957&D2): 07/13/01	RmAR (DOE/OR/01-2010&D1) approved 08/21/02.	No/No/No	--
Single-project action; pending additional action				
Corehole 8 Plume Source (Tank W-1A)	AM (DOE/OR/01-1749&D1): 09/18/98 Amended in 1999	RmAR (DOE/OR/01-1969&D2) issued February 2002.d	No/Yes/Yes	2.3.2
Demolition projects				
Non-Reactor Facilities D&D	TC AM (DOE/OR/01-2412&D1): 09/30/09 TC AM (DOE/OR/01-2407&D1): 04/09/09	RDR/RAWP for the D&D of Non-Reactor Facilities (DOE/OR/01-2428&D2), issued December 2009.		
		Addendum to the RDR/RAWP for the D&D for the Non-Reactor Facilities (DOE/OR/01-2428&D2/A2), approved 02/03/10.		
		RmAR for 2000 Complex (DOE/OR/01-2501&D1) submitted 03/31/11.		
Bethel Valley Isotopes Facilities D&D	TC AM (DOE/OR/01-2402&D2) approved 05/04/09	RmAR (Wooden Superstructure) (DOE/OR/01-2470&D1) submitted 03/22/11.		

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* and is available at <http://www.ucor.com/ettp_ffa_appendices.htm>.

[b]The *Phased Construction Completion Report for the Remediation of Tanks T-1, T-2, and HFIR* (DOE 2005c) 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 2009b) which omits any long-term stewardship requirements for these sites. The long-term stewardship of these sites is no longer reported in the Remediation Effectiveness Report. The T-1 and T-2 Tanks are located on the Bethel Valley Watershed map (Figure 2.1) and High Flux Isotope Reactor Tank is located on the Melton Valley Watershed map (Figure 3.1).

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

[c]The *Removal Action Report on the Building 3001 Canal* (DOE 1997) 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 Remediation Effectiveness Report.

[d]In FY 2006, sampling and characterization were completed and delineated the extent of remaining contamination. The project completed planning, mobilization and readiness and started excavation in September 2011. The removal of the remaining soil, tank and concrete tank saddle is expected in 2012.

AM = action memorandum
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
ESD = Explanation of Significant Difference
NSC = Non-Significant Change
PCCR = phased construction completion report
RAR = remedial action report
RAWP = remedial action work plan
RDR = remedial design report
RmAR = removal action report
ROD = record of decision
TC = time-critical
WAG = Waste Area Grouping

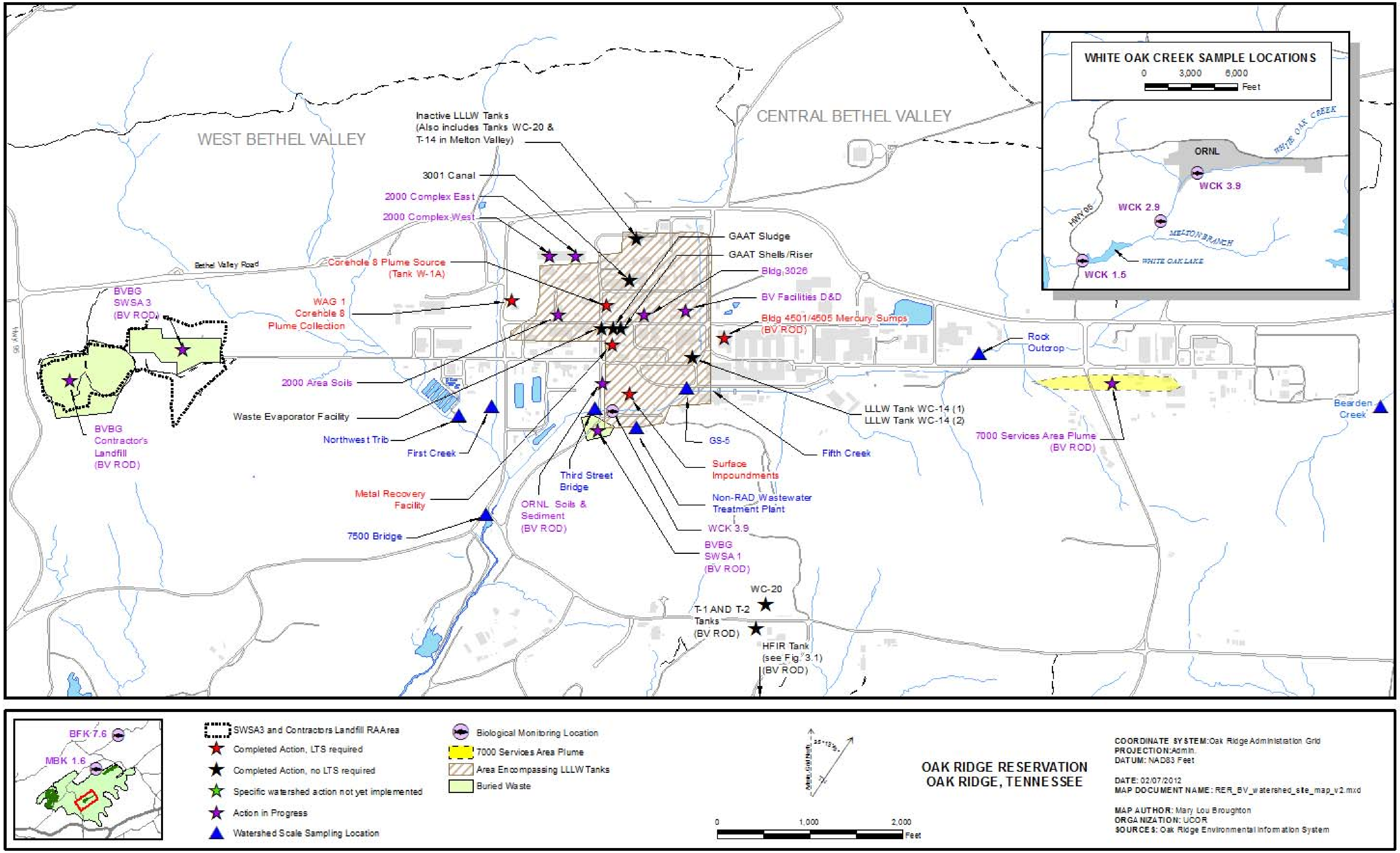

Figure 2.1. Bethel Valley Watershed.

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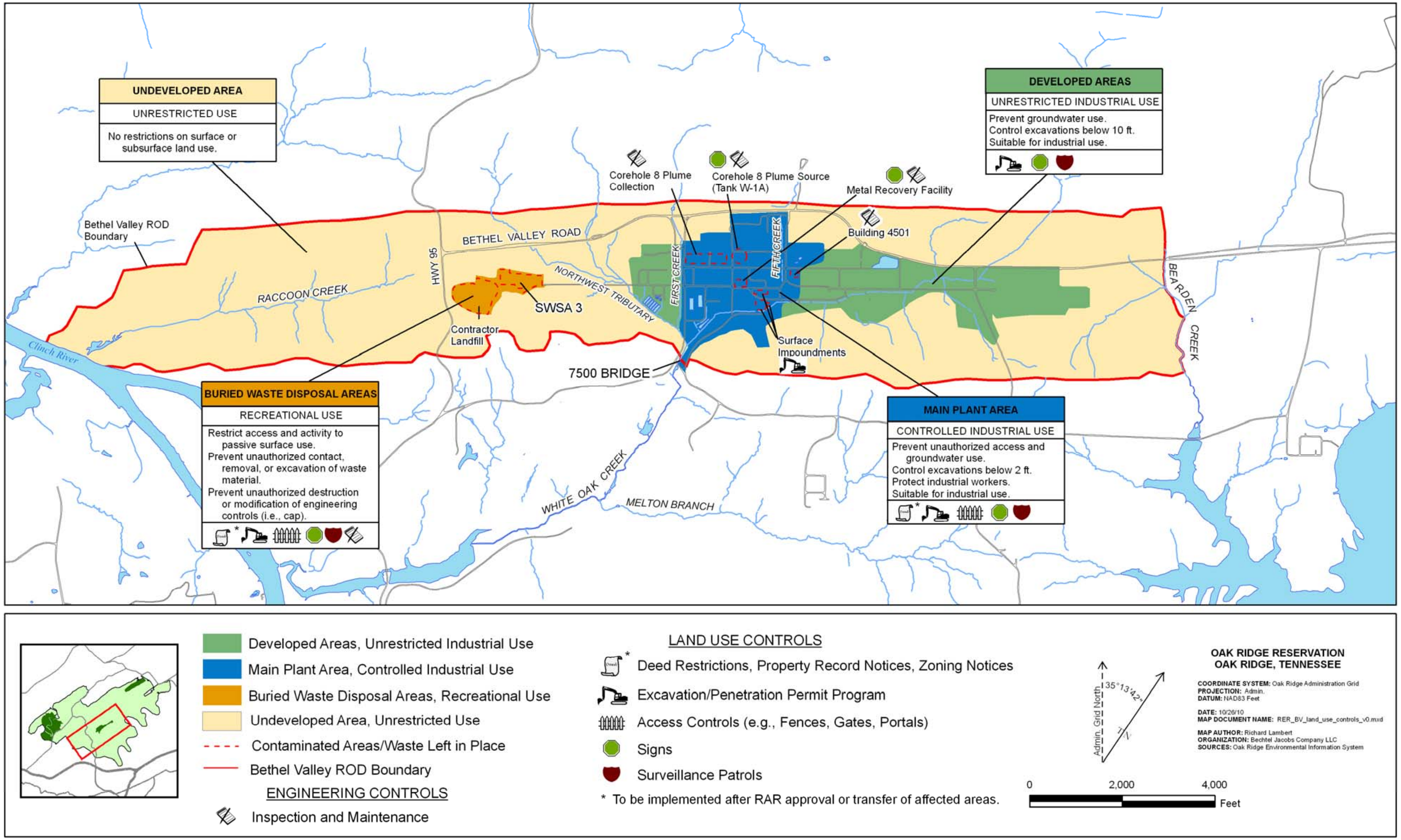

Figure 2.2. Bethel Valley Record of Decision-designated end uses and interim land use controls.

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Table 2.2. Long-term stewardship requirements in Bethel Valley Watershed

<table>
<tr><th rowspan="2">Site/Project</th><th colspan="2">Long-term stewardship requirements</th><th rowspan="2">Status</th><th rowspan="2">Section</th></tr>
<tr><th>LUCs</th><th>Engineering controls</th></tr>
<tr><td colspan="5">Watershed-scale actions</td></tr>
<tr><td>Record of Decision for Interim Actions in Bethel Valley[a]
Bethel Valley Mercury Sumps Groundwater Action Phased Construction Completion Report (Building 4501)</td><td><u>Watershed LUCs</u>
Administrative:
▪ land use and groundwater deed restrictions
▪ property record notices
▪ zoning notices
▪ excavation/penetration permits program

Physical:
▪ access controls
▪ signs
▪ security patrols</td><td>Maintain caps
Operations and maintenance of pretreatment system</td><td><u>LUCs in place</u>
▪ Physical LUCs in place.
▪ Administrative LUCs required at completion of actions.

Engineering controls remain protective.</td><td>2.2.4</td></tr>
<tr><td colspan="5">Completed single project actions</td></tr>
<tr><td>Waste Area Grouping 1 Corehole 8 (Plume Collection)[b]</td><td>None specified</td><td></td><td>NA</td><td>2.3.1</td></tr>
<tr><td>Surface Impoundment Operable Unit</td><td>Maintain existing EPP program</td><td></td><td>LUCs in place.</td><td>2.3.3</td></tr>
<tr><td>Metal Recovery Facility</td><td>Signs</td><td>Maintain gravel cover</td><td>LUCs in place.

Engineering controls remain protective.</td><td>2.3.4</td></tr>
<tr><td colspan="5">Completed single project actions—pending additional action</td></tr>
<tr><td>CoCorehole 8 Plume Source (Tank W-1A)</td><td>Signs</td><td>Maintain backfill</td><td>LUCs in place.

Engineering controls remain protective.</td><td>2.3.2</td></tr>
</table>

[a] Remaining actions requiring LTS have not been implemented.
[b] Extraction system is maintained.

LUC = land use controls
NA = not applicable

- The *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley Burial Grounds* (DOE 2010a) contains the design for hydrologic isolation of buried waste at two former waste sites that are sources of contaminant release: Solid Waste Storage Area 1 in Central Bethel Valley and Solid Waste Storage Area 3 in West Bethel Valley, as well as contaminated areas in the vicinity of Solid Waste Storage Area 1 and Solid Waste Storage Area 3. This project was completed in FY 2011, and the phased construction completion report was submitted to the regulators on September 14, 2011 (DOE 2011a).

- The treatability study of the 7000 Area groundwater plume (DOE 2010b) to determine the feasibility of bioremediation technologies to remove VOCs from groundwater in the area continued in FY 2011.

Single-Project Actions

- **Tank W-1A and Associated Soils Excavation**. Remediation of Tank W-1A includes excavating, packaging, and transporting waste for disposal; removing, size-reducing, containerizing, and transporting the concrete pad and tank supports and tank shell to the Nevada Test Site; and performing soil sampling and characterization along a Tank W-1A feed pipeline to delineate the extent, type, and concentration of contamination for excavation. In FY 2011 project planning and readiness reviews were completed, and soil excavation was initiated.

- **Core Hole 8 Plume Extraction Wells Installation**. As reported in the *2010 Remedial Effectiveness Report* (DOE 2010c), large increases in ^{90}Sr and uranium discharges were observed in First Creek. Because of these increased discharges, a project was initiated to install additional plume groundwater extraction wells to improve plume collection and treatment. The purpose for the additional extraction wells is to increase plume water removal from the bedrock zone to prevent it from seeping upward into the shallow soils where the contamination can seep into storm drains that discharge into the stream. The *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley (Corehole 8) Extraction System* (DOE 2010d) was submitted in FY 2010. Well installation was initiated in August 2010, with completion of extraction well construction in November 2011. Activities that followed installation of the new extraction wells included pressure testing of existing transfer piping from existing lift stations in the system, installation of new transfer piping to connect the new extraction wells, installation of new electrical supply circuitry to the new and existing pumps, and installation of a new Process Logic Control system to coordinate the operation of all 5 pumps that operate in the western end of the plume extraction system. Operation of the existing plume extraction operations were terminated in mid-May when a leak was identified in an existing transfer pipeline. The system upgrade was essentially completed by the end of July 2011. Delays in funding authorization prevented further work to complete the upgrade process and re-start the remedy operation during FY 2011. Since the Corehole 8 plume project was initiated in 1995 as a single-action project, the ongoing system performance monitoring has been reported in the single-action project section of the Remedial Effectiveness Report. Upon signature of the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) the groundwater/surface water protection aspects of this action became elements of the ROD effectiveness. Beginning in this Remediation Effectiveness Report, the Corehole 8 plume collection system will be reported in the *Record of Decision for Interim Actions at Bethel Valley* performance evaluation and will no longer be reported as a single project action.

Demolition Projects

- The *Addendum to the Remedial Design Report/Remedial Action Work Plan for the Decontamination and Decommissioning of Non-Reactor Facilities in Bethel Valley* (DOE 2009c) addresses demolition of approximately 180 facilities and the removal of legacy material planned for implementation over a period of more than 20 years. Key components are site preparation, removal of legacy material, building demolition to slab or grade, waste management, and site restoration. Field activities were initiated in July 2010. Remediation of building slabs and soils, demolition of reactor facilities, and other remedial actions identified in the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) will be addressed in separate CERCLA documents.

- Demolition was initiated in FY 2009 on one of the highest hazard excess facilities at the Oak Ridge National Laboratory, the Facility 3026 C&D Radioisotope Development Laboratory as a time-critical removal action (DOE 2009d). A roof failure in 2007 damaged the fire suppression sprinkler system, requiring it to be deactivated. The resulting risks from this deactivation warranted removing the Facility 3026 C&D wooden structure. The demolition of the wooden structure was completed on February 26, 2010. The remaining hot cell structures and the slab were coated with a polyurea-type coating to stabilize the surfaces. The *Removal Action Report for Building 3026 C&D Wooden Structure* (DOE 2011b) was submitted on March 22, 2011, and the 3026 C&D area was transitioned to the DOE hot-cell demolition contractor on September 23, 2010.

- The time-critical *Action Memorandum for the 2000 Complex Facilities Demolition* (DOE 2009e) was a two phase process. The first phase (2000 Complex East) was completed in FY 2010 with the demolition of six buildings (2001, 2019, 2024, 2087, 2088, and 2092). The second phase demolition (2000 Complex West, Buildings 2000 and 2034) was completed in FY 2011. The *Removal Action Report for the 2000 Complex Facilities* (DOE 2011c) was submitted on March 31, 2011.

- The time-critical *Action Memorandum for Buildings 3074 and 3136, and the 3020 Stack* (DOE 2009f) includes the dismantlement of buildings 3074 and 3136, which was completed in FY 2010 to allow for the dismantlement of the 3020 Stack.

2.2 RECORD OF DECISION FOR INTERIM ACTIONS FOR THE BETHEL VALLEY WATERSHED

2.2.1 Performance Goals and Monitoring Objectives

The remedy in the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) includes actions to address contaminated buildings and other facilities designated for demolition, buried waste, underground liquid low-level waste tanks, accessible underground process and liquid low-level waste 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., Bldg. 4500N) and infrastructure that have ongoing missions, 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. Areas of groundwater contamination in the Central Bethel Valley area are shown on Figure 2.3, and areas of groundwater contamination in West Bethel Valley and the Raccoon Creek headwaters are shown on Figure 2.4.

The *Record of Decision for Interim Actions at Bethel Valley* specified surface water quality, surface water risk goals, and groundwater controls to be achieved within specified periods after completion of the remedial actions. The ROD also included specific performance objectives that will be used as the metrics to evaluate the effectiveness of the remediation. These goals and metrics are presented below. The evaluation of performance during FY 2011 is presented in Sect. 2.2.2.

Remedial Action Objectives were developed separately for the Central and East Bethel Valley and the West Bethel Valley and Raccoon Creek areas. This was done because contamination in West Bethel Valley/Raccoon Creek is limited to discrete areas (i.e., Solid Waste Storage Area 3, the Contractor's Landfill, the Closed Scrap Metal Area, and a few small areas of potential surface soil contamination), while the Central/East Bethel Valley area contains widespread contamination resulting from its use as a nuclear research laboratory. Thus, end use options that were considered in the feasibility study for the West Bethel Valley/Raccoon Creek area were different from those considered for the Central/East Bethel Valley area. Additional information concerning the Remedial Action Objectives for the *Record of Decision for Interim Actions at Bethel Valley* are in Chap. 2 of Vol. 1 of the *2007 Remedial Effectiveness Report* (DOE 2007a).

The *Record of Decision for Interim Actions at Bethel Valley* stipulated Remedial Action Objectives for Bethel Valley based on future end use including controlled industrial use (the main Oak Ridge National Laboratory 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 2.3). Highlighted Remedial Action Objectives in Table 2.3 are supported by ongoing monitoring and are discussed in detail in subsequent sections.

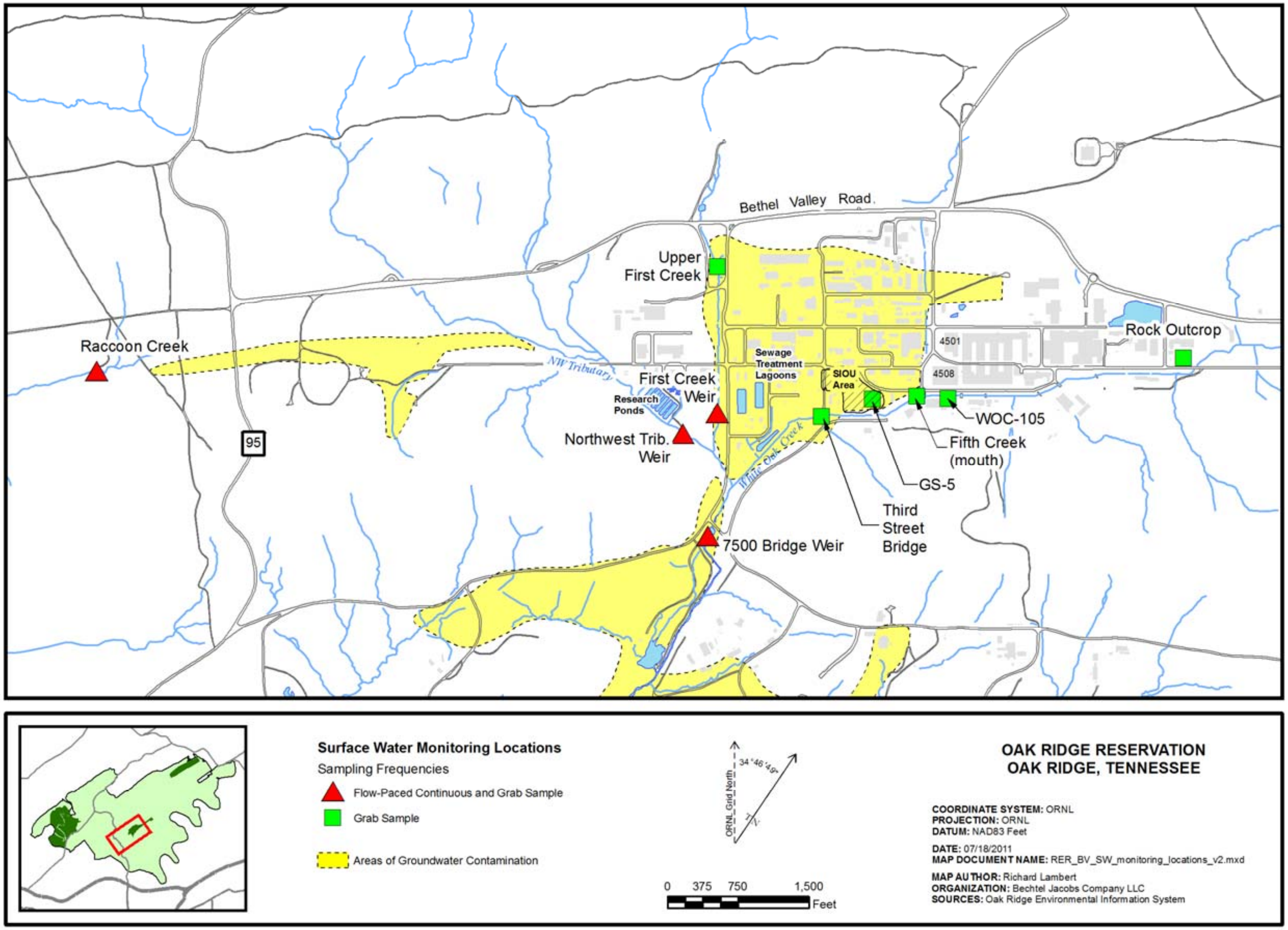

Figure 2.3. CERCLA surface water monitoring locations in Oak Ridge National Laboratory main plant area.

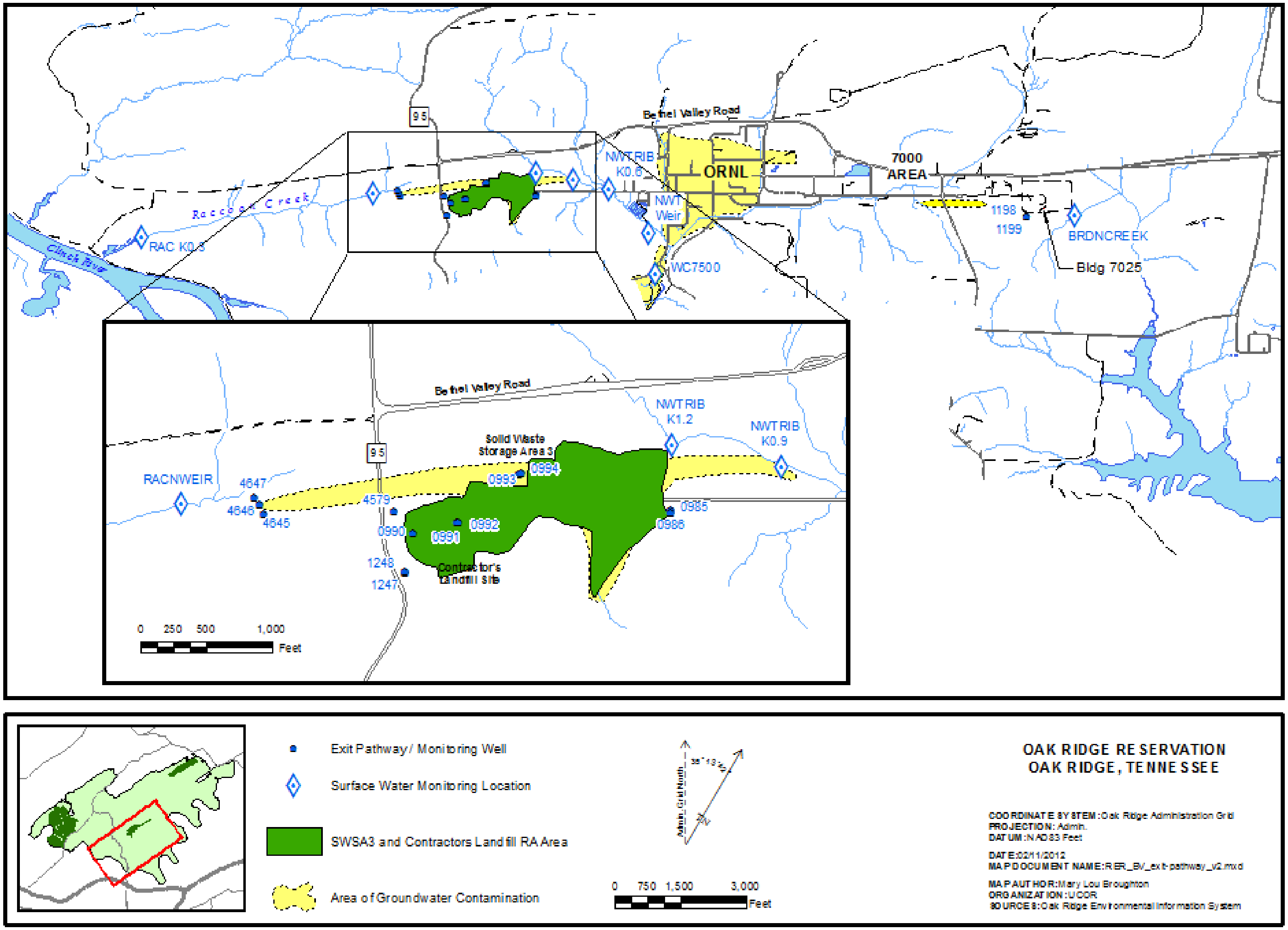

Figure 2.4. Bethel Valley exit pathway monitoring locations.

Table 2.3. Remedial action objectives for Bethel Valley*

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*

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
SWSA = solid waste storage area
[a]*Record of Decision for Interim Actions at Bethel Valley* (DOE 2002)

Remedial Action Objectives for surface water include attainment of a 45% risk reduction from baseline levels of 1994 at the 7500 Bridge and attainment of ambient water quality criteria (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 specifies the attainment and maintenance of water quality and sediment contaminant levels of 1 x 10^{-4} for a hypothetical recreational end use scenario. The Remedial Action Objective for groundwater is to prevent further degradation of water quality by remediation of soils that contribute to groundwater contamination above a 1 x 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 also 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 long-term stewardship requirements will be developed in the phased construction completion report for each element of the remedy.

The *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) 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. Table 2.4 lists the performance objectives and performance measures for the defined remedial actions.

Table 2.4. 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*
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 cm (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)*

Table 2.4. Performance measures for major actions in Bethel Valley[a] (cont.)

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
	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-basked 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*
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)]; continue to treat to remove ^{90}Sr*	*Prevent groundwater from causing surface water exceedances (recreational risk-based levels and at least 45% risk reduction at 7500 Bridge)*	*Streams meet surface water goals (recreational risk and at least 45% risk reduction at 7500 Bridge); 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(6)[b]]*

[a]Table 2.37 of *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002).
[b] 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 1200-4-9-.16.

AWQC = ambient water quality criteria
HFIR = high flux isotope reactor
LLLW = liquid low-level (radioactive) waste
NPDES = National Pollutant Discharge Elimination System
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
P & A = plugging and abandonment
RCRA = Resource Conservation and Recovery Act of 1976
Sr = strontium
SWSA = solid waste storage area
VOC = volatile organic compound

2.2.2 Evaluation of Performance Monitoring Data

2.2.2.1 Surface Water Monitoring Data

This section presents the results of remedy effectiveness evaluation of surface water monitoring in Bethel Valley. Section 2.2.2.1.1 summarizes the remediation goals for surface water; Sect. 2.2.2.1.2 presents information concerning major radionuclide concentrations and fluxes at the surface water integration points; Sect. 2.2.2.1.3 presents data obtained at tributary sampling locations.

2.2.2.1.1 Surface Water Quality Goals and Monitoring Requirements

Surface water goals are protection of the Clinch River to meet its stream use classification (e.g., as a domestic water supply) and to achieve AWQC. The *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) includes specific surface water remediation levels, as outlined in Table 2.5. Locations where surface water monitoring occurs to evaluate the remedy performance are shown on Figure 2.3. The following excerpts from the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002), Section 2.12.7.3 Remediation Levels for Surface Water, include the specific concentration goals for the principal surface water contaminants of concern.

Table 2.5. Surface water remediation levels for 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 2.3)	*See Fig. 2.36 (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 at Bethel Valley* (DOE 2002).

[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

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. 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 the off-site resident.*

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 2.3 *(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 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 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 2.3 *(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.*

Samples to demonstrate compliance with the 45% risk reduction will be taken at the 7500 Bridge or equivalent integration point. If the continuous samplers 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.

Sampling locations, schedules and analytical parameters to provide data to meet surface water performance metrics are shown in Table 2.6.

Table 2.6. Watershed-scale CERCLA monitoring requirements and performance standards for Bethel Valley Watershed[a]

Media	Monitoring location	Schedule	Parameters	Performance standard
Surface water	7500 Bridge weir	Continuous flow-proportional monthly composite sample	^{90}Sr, ^{3}H, gamma[b] (flux)	Achieve 45% risk reduction from 1994 levels at 7500 Bridge (based on combined risk from ^{90}Sr and ^{137}Cs); achieve AWQC for all designated stream uses in all waters of the state.
		Semiannual grab sample	Metals (including Hg), gross alpha, gross beta, gamma, ^{90}Sr, ^{3}H	Baseline
		Annual grab sample (year prior to FYR)	AWQC	AWQC
		Monthly grab sample	Hg	Integration Point Hg assessment
	First Creek weir	Continuous flow-proportional monthly composite sample	gross alpha, gamma, ^{90}Sr (flux)	^{90}Sr and ^{137}Cs (flux)
		Semiannual grab sample	gross alpha, gross beta, gamma, ^{90}Sr, ^{3}H	Baseline
		Annual grab sample (year prior to FYR)	AWQC	AWQC
	Northwest tributary weir	Continuous flow-proportional monthly composite sample	gamma, ^{90}Sr, ^{3}H (flux)	gamma, ^{90}Sr, ^{3}H (flux)
		Semiannual grab sample	Metals, gross alpha, gross beta, gamma	Baseline
		Annual grab sample (year prior to FYR)	AWQC	AWQC
	Raccoon Creek weir	Continuous flow-proportional monthly composite sample	^{90}Sr, ^{3}H (flux)	^{90}Sr, ^{3}H (flux)
		Semiannual grab sample	Metals, gross alpha, gross beta, gamma	Baseline
		Annual grab sample (year prior to FYR)	AWQC	AWQC
	Bearden Creek	Semiannual grab sample	^{3}H	Baseline
Groundwater	West Bethel Valley/Raccoon Creek area exit pathway wells	Semiannual[c] grab samples	gross alpha, gross beta, ^{90}Sr	Exit pathway monitoring to determine if contaminants are leaving known contaminated areas.
	East Bethel Valley exit pathway wells	Semiannual grab samples	^{3}H, volatile organic compounds	

[a]This table represents current requirements for monitoring included in the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002), post-decision primary documents, or any subsequent addenda that have received concurrence/approval from the U.S. Environmental Protection Agency and Tennessee Department of Environment and Conservation.

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

[c]Per the *Engineering Study Report for Groundwater Actions in Bethel Valley* (DOE 2005), 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 concentration trend is clearly demonstrated. Note: monitoring has not been reduced due to presence of contamination.

AWQC = ambient water quality criteria FYR = five year review

2.2.2.1.2 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 and groundwater monitoring provides baseline data against which to determine the effectiveness of remedial actions as well as verifying reduction of offsite releases of contaminants.

Surface water monitoring in Bethel Valley includes both continuous, flow-paced monitoring at key locations and routine collection of grab samples. Figure 2.3 shows the locations of CERCLA surface water monitoring sites in Central Bethel Valley. The Raccoon Creek surface water and exit pathway groundwater monitoring locations and Bearden Creek surface water and exit pathway groundwater monitoring locations are shown in Figure 2.4.

2.2.2.1.2.1 Watershed-scale Surface Water Monitoring Results

Radiological Discharges to White Oak Creek

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 at Bethel Valley* (DOE 2002). Tritium discharges in White Oak Creek originate primarily from sources outside of Bethel Valley:

- groundwater collected in Melton Valley and transferred to the Process Water Treatment Complex via the groundwater collection and treatment system

- wastewaters generated by Office of Science operating facilities High Flux Isotope Reactor and Spallation Neutron Source that are discharged via the Process Water Treatment Complex and sanitary sewage system

Figure 2.3 shows locations in the Oak Ridge National Laboratory main plant area in Bethel Valley where contaminant concentrations and flows are measured to estimate the discharge fluxes from various contributing areas or outfalls. ^{90}Sr is the principal radiological contaminant of concern in surface water in Bethel Valley because it is a fairly widely distributed contaminant in buried waste, in contaminated soils related to liquid low-level waste pipeline leaks, and in groundwater. ^{137}Cs is a significant surface water contaminant in White Oak Creek, and its sources include discharges from the Process Water Treatment Complex and soils on the White Oak Creek 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. However, three CERCLA actions included in the *Record of Decision for Interim Actions at Bethel Valley* are currently in progress that are expected to reduce ^{90}Sr discharges to surface water – the Bethel Valley Burial Grounds remedial action at Solid Waste Storage Areas 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.

Table 2.7 lists the average annual ^{90}Sr and ^{137}Cs activities calculated from the flow-paced composite samples collected at the 7500 Bridge for FY 1994 and FY 2001 through FY 2011 and the concentration goals for ^{90}Sr and ^{137}Cs based on the 45% risk-reduction requirement. As shown in Table 2.7, ^{90}Sr activities exceeded the risk-based goal in 2004, 2005, 2009, 2010, and 2011 while ^{137}Cs activities exceeded the goal in each year except 2006 through 2011. The elevated ^{90}Sr activities of 2004 and 2005 have been noted in previous Remedial Effectiveness Reports and were the consequence of prolonged above normal rainfall patterns. Higher than average rainfall during 2009 through 2011 compounded with problems associated with the Corehole 8 plume extraction system are responsible for the increase in ^{90}Sr during the past two years. Figure 2.5 shows the annual average activities and the average plus one standard deviation activities of ^{137}Cs, ^{90}Sr, and tritium at the 7500 Bridge. The risk-based goals calculated based on the 45% reduction of ^{137}Cs and ^{90}Sr are also shown.

Table 2.7. 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

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.

Although the average ^{90}Sr activity at 7500 Bridge increased slightly during FY 2011 compared to FY 2009 and FY 2010, the amount of ^{90}Sr discharged remained stable at 0.33Ci. During FY 2011, ungauged ^{90}Sr sources contributed about 31% of the total in comparison to the approximate 35% that originated from Corehole 8 plume discharges measured in First Creek.

Tritium concentrations in surface water in the Bethel Valley portion of White Oak Creek have increased as a result of collection and transfer of former groundwater discharges from Melton Valley to the wastewater treatment system in Bethel Valley. This activity is conducted as a condition of the remedial action taken in Melton Valley. However, tritium concentrations in surface water throughout White Oak Creek are still below the DOE-derived concentration guide and below remedy human health risk goals.

Radiological Discharges to Raccoon Creek and Bearden Creek

Raccoon Creek and Northwest Tributary (Solid Waste Storage Area 3 Area). Surface water in the western end of Bethel Valley is monitored to determine if contaminants discharge to Raccoon Creek and the Clinch River via a western exit pathway. Figure 2.4 shows locations where Bethel Valley exit pathway sampling is conducted. Contaminated groundwater originating in Solid Waste Storage Area 3 seeps to the headwaters of Raccoon Creek, a short distance to the west of Tennessee Highway 95. The

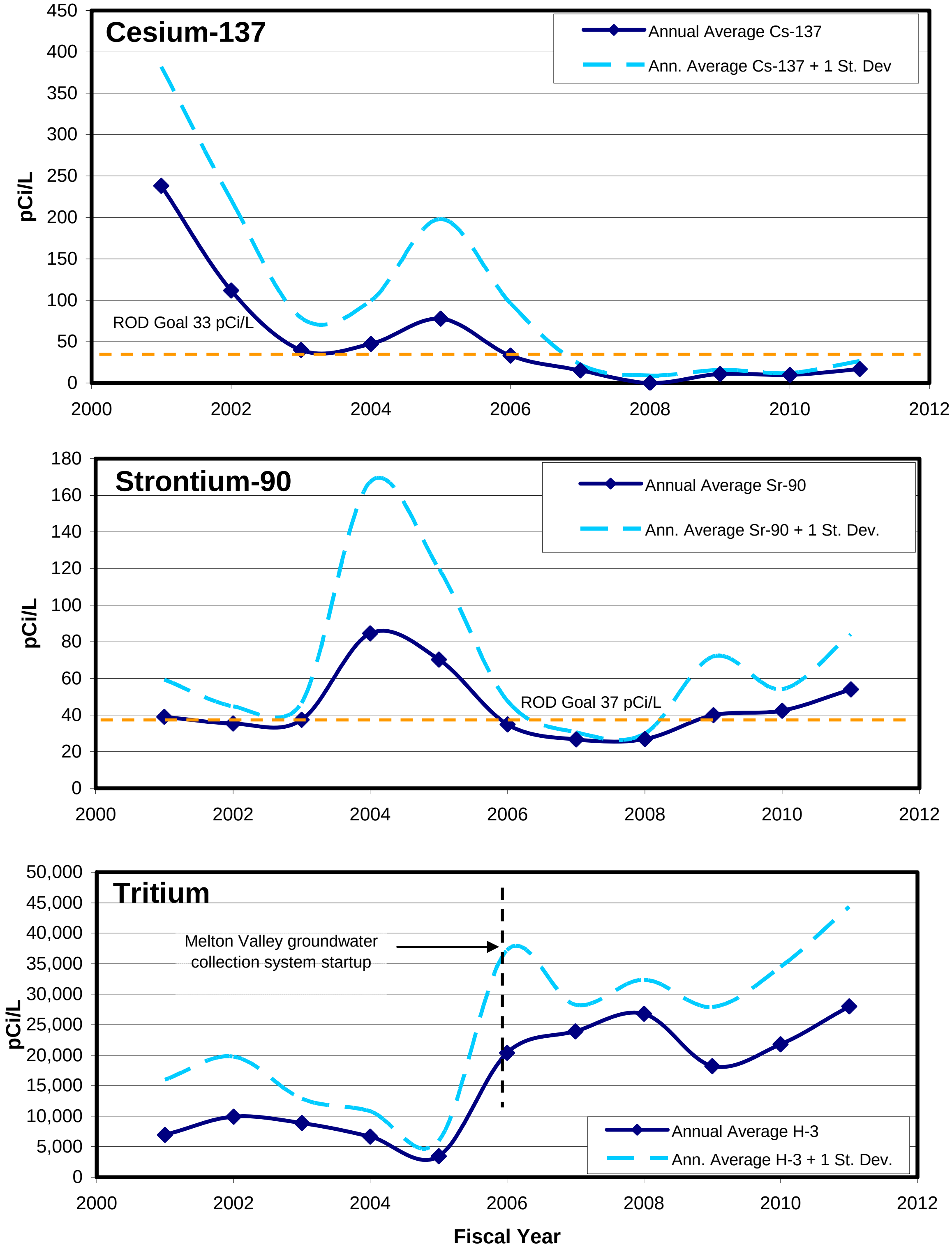

Figure 2.5. Annual average activities of ^{137}Cs, ^{90}Sr, and tritium at 7500 Bridge.

seepage pathway from Solid Waste Storage Area 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 the ability to estimate flux. Surface water and groundwater monitoring to obtain pre-remediation baseline data for the remediation of Solid Waste Storage Area 3 was started in FY 2010 and continued during FY 2011 to the extent that monitoring locations were accessible during site construction activities.

Table 2.8 summarizes detection frequency and maximum value; total flow volume from samples containing detectable ^{90}Sr; average ^{90}Sr activity data from continuous flow samples collected 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. The ^{90}Sr activities at the weir have historically fluctuated inversely to the amount of flow at the station because the seepage pathway from the source is in bedrock and groundwater seepage constitutes a higher proportion of baseflow during dry seasons than it does during wet seasons. During above-normal rainfall periods, such as those experienced in 2003 and 2004, the flux of ^{90}Sr discharged via Raccoon Creek increases. Historically, during 1998, the highest ^{90}Sr activities measured at Raccoon Creek were nearly 100 pCi/L.

Table 2.8. ^{90}Sr data from Raccoon Creek Weir

Year	Detection frequency and maximum value (No. detects/No. samples) (Max 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	20.9a	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 (Feb. – Sept.)	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	11.52[a]	1.9E-04
FY 2011	11 / 12 18.3	277,034,731	5.178	6.4E-04

[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.

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 Bethel Valley Burial Grounds Solid Waste Storage Area 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 contaminant of concern 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. Semiannual grab samples are collected at the Northwest Tributary K0.3, K0.6, K0.9, and K1.2 stations, as well as at

Raccoon Creek K0.3 station. Instantaneous flow measurements are made in the stream channels at the time samples are collected to provide an estimate of flux (Table 2.9).

Table 2.9. Daily ^{90}Sr flux grab sample activity

Station	Instantaneous ^{90}Sr flux (mCi/day)			
	10/26/2009	3/16/2010	10/11/2010	5/17/2011
NWTRIB K1.2	no flow	6.2E-05	no flow	no flow
NWTRIB K0.9	no flow	no flow	no flow	no flow
NWTRIB K0.6	1.4E-01	1.9E-01	3.9E-03	2.6E-02
NWTWeir	6.7E-02	4.7E-02	8.8E-04	1.1E-02
RACNWEIR	1.2E-03	2.8E-03	1.9E-03	4.8E-04
RAC K0.3	< 9.1E-03[a]	<2.2E-02[a]	no flow	no flow

[a]^{90}Sr activity below MDA - MDA value used to calculate a maximum value for flux

MDA = minimum detectable activity
NWTRIB = Northwest Tributary
NWTWeir = Northwest Tributary weir
RACNWEIR = Raccoon Creek weir
RAC = Raccoon Creek

The long-term flux monitoring of both the Northwest Tributary and the Raccoon Creek weir show that the amount of ^{90}Sr leaving Solid Waste Storage Area 3 via Raccoon Creek is on average less than 5% of the surface water flux for both streams combined. During FY 2011 the ^{90}Sr activity levels in Raccoon Creek increased over measurements of FY 2010 and the ^{90}Sr flux in Raccoon Creek increased compared to FY 2009 and 2010. This condition is thought to be associated with construction-related disturbances in Solid Waste Storage Area 3 during remedial action. Figure 2.6 shows the monthly percentage that Raccoon Creek comprises of the combined Raccoon Creek and Northwest Tributary ^{90}Sr discharge as well as the measured ^{90}Sr activity in each monthly composite sample for FY 2006 through FY 2011.

Bearden Creek (7000 area). Surface water is sampled in a tributary of Bearden Creek at the eastern end of Bethel Valley to evaluate contaminant discharges to surface water eastward from the 7000 Services Area. The principal contaminant source that affects this area is the former tritium handling facility at Bldg. 7025 (Figure 2.4). 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 VOC plume in groundwater (Figure 2.4) that migrates westward from its source toward White Oak Creek.

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 limit; however, these results are considered suspect because of possible laboratory problems. During the period 2000 through 2005, 7 of 10 samples analyzed contained detectable tritium at activities ranging from 417 pCi/L to 949 pCi/L, all of which were less than 5% of the drinking water effective dose equivalent limit of 20,000 pCi/L. During FY 2011, the Bearden Creek was sampled twice and tritium was not detectable in either sample.

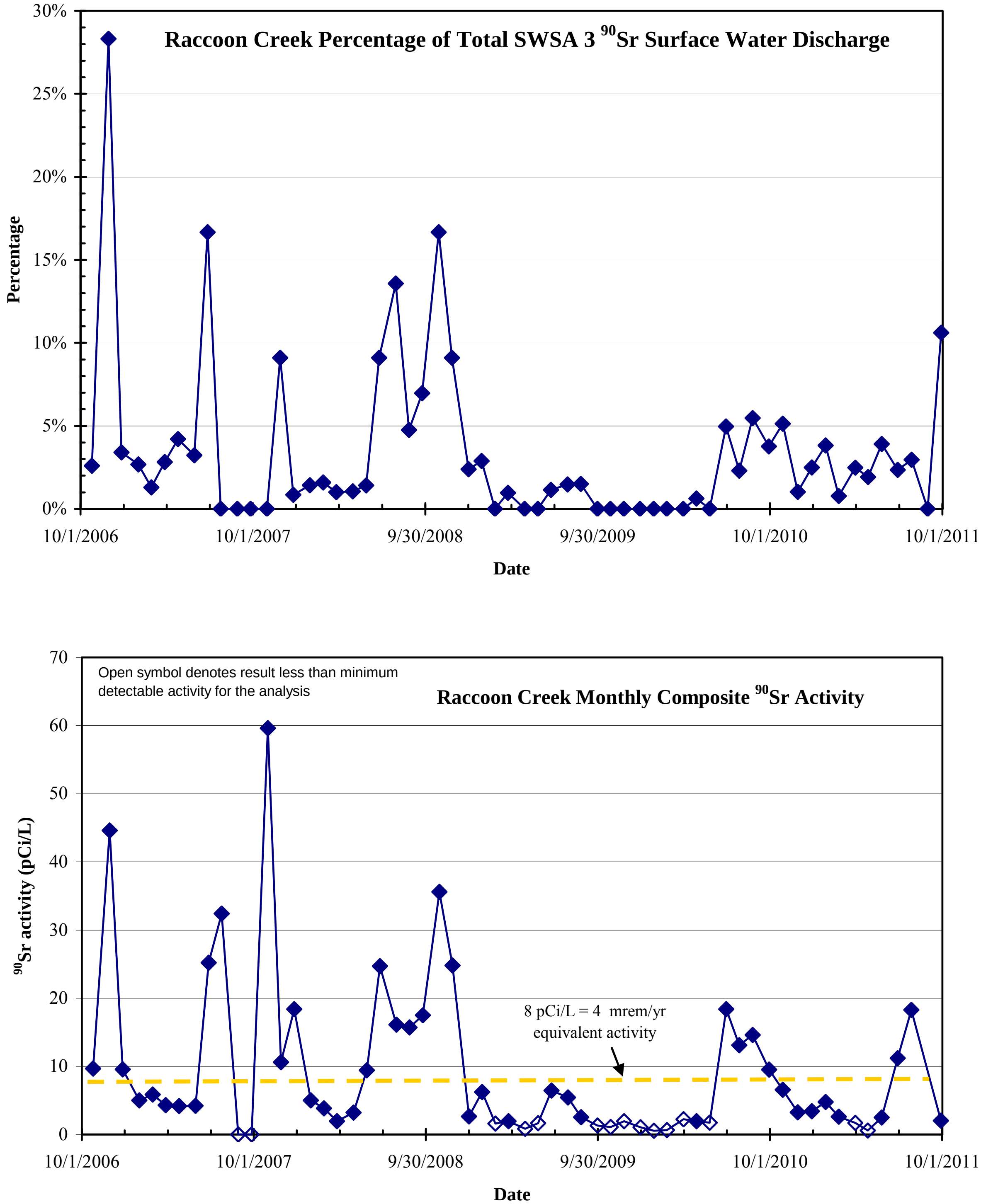

Figure 2.6. Raccoon Creek Percentage of combined Solid Waste Storage Area 3 surface water ^{90}Sr discharge.

Surface Water Mercury Monitoring

Mercury is a contaminant of concern in surface water because of its strong bioaccumulation tendency in fish. Mercury sampling has been conducted for many years at the 7500 Bridge. Since winter of 2008, following diversion of the Building 4501 basement sump discharges, semiannual sampling of mercury has been conducted at First Creek, Northwest Tributary, Raccoon Creek, and Fifth Creek. Those monitoring results indicate that Raccoon Creek, First Creek, and Northwest Tributary are not significant contributors of mercury, as each of these sites has routinely contained less than 5 ng/L of total mercury. The current 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 FY 2011, four samples were collected in Fifth Creek for mercury analysis and average concentration was about 63 ng/L with a maximum value of 94.5 ng/L. These concentrations are somewhat higher than those measured during FY 2010 and may be a reflection of the fact that FY 2011 was the third consecutive year that experienced above-average rainfall. The mercury in Fifth Creek originates from the Building 4501 area and enters the stream via storm drains. Additional mercury monitoring results related to the remedial action for mercury discharges from Building 4501 are discussed below.

Building 4501 Mercury Contaminated Sump Discharges

In December 2007, the first remedial action specified in the *Record of Decision for Interim Actions at Bethel Valley* was partially completed by re-routing mercury-contaminated basement sump water at Building 4501 to treatment at the Process Water Treatment Complex. Prior to the action, mercury-contaminated groundwater collected in building basement sumps at Building 4501 was discharged to White Oak Creek via storm drain Outfall 211. In October 2009, the Building 4501 sump system was completed with the installation of an ion exchange system for the collected groundwater to remove particle-associated mercury and dissolved mercury from the wastewater stream prior to its treatment at the Process Water Treatment Complex. This system installation includes a pre-filter and ion exchange and is located in the basement of Building 4501. It serves to pre-treat the sump water which is then routed to the Process Water Treatment Complex for final treatment and discharge.

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 instream sampling location (WOC-105) that is located downstream of the Outfall 211 storm drain (Figure 2.3). Prior to the 2007 remedial action in the Building 4501 basement, some of the mercury contaminated basement sump discharges were routed to the storm drain that discharges at Outfall 211. Residual mercury contamination, including elemental mercury, remains in sediment accumulations in the upper portion of the storm drain. This residual mercury contamination is the source of ongoing mercury discharges to White Oak Creek at Outfall 211. Figure 2.7 shows the mercury concentration history for the WOC-105 and 7500 Bridge locations. As shown on Figure 2.7, after 4501 basement sump water was routed to the Process Waste Treatment Complex the frequency of AWQC exceedance for total mercury at 7500 Bridge decreased and one sample result at WOC-105 exceeded the AWQC.

During FY 2011, the mercury concentrations at 7500 Bridge were below the AWQC value of 51 ng/L. One of four samples collected at WOC-105 during FY 2011 had a mercury concentration of 52.5 ng/L and the remaining three samples had concentrations in the range of 20 – 30 ng/L.

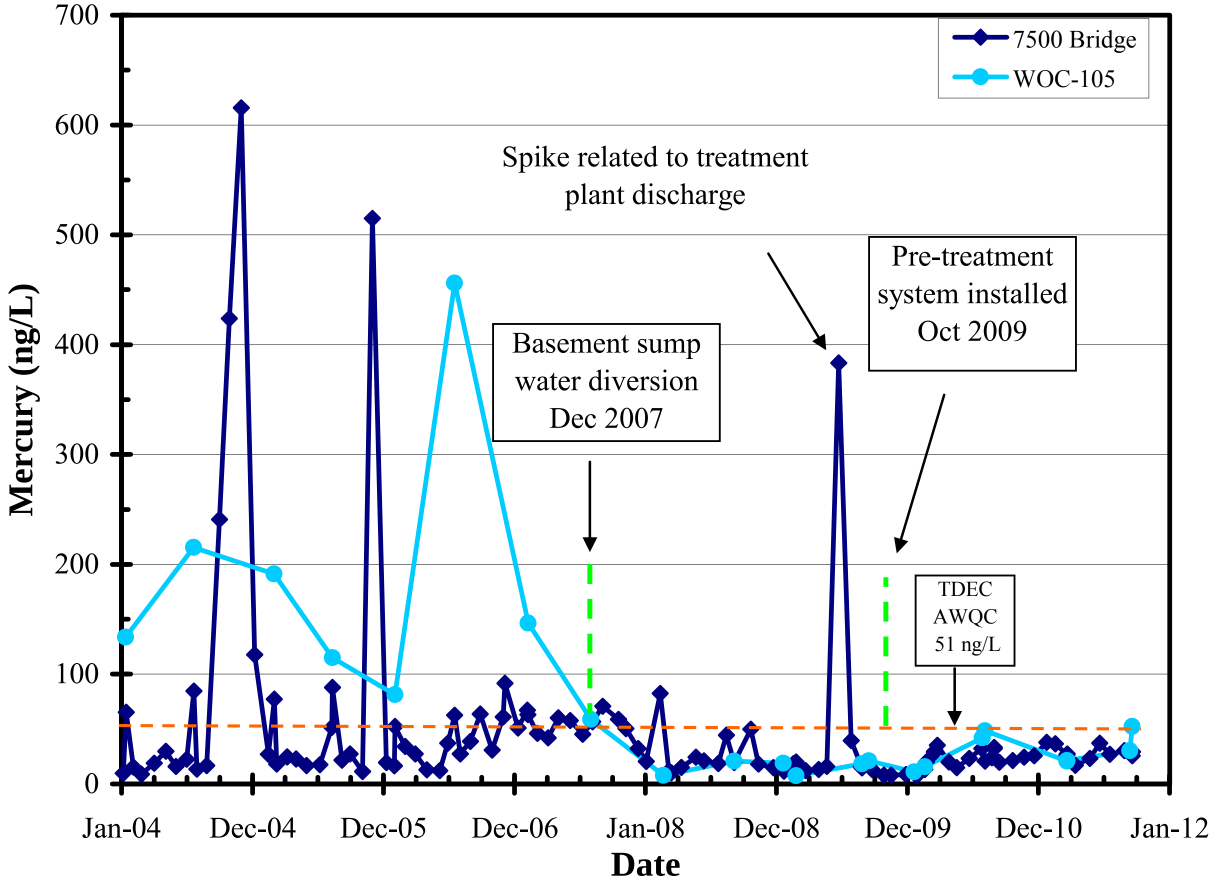

Figure 2.7. Mercury concentration history at 7500 Bridge and White Oak Creek-105 monitoring locations.

2.2.2.1.2.2 Single Project Monitoring Results

Waste Area Grouping 1 Corehole 8 Removal Action (Plume Collection)

In 1991, CERCLA characterization efforts identified a plume of ^{90}Sr-contaminated groundwater, referred to as the Corehole 8 plume (Figure 2.8). Note that the Corehole 8 plume source (Tank W-1A) is addressed as a separate action and is included in Section 2.3.2. A removal site evaluation performed in 1994 concluded that contaminated groundwater seeping into the storm drain system was being discharged into First Creek at storm drain Outfall 342. First Creek is a tributary to White Oak Creek 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 the Oak Ridge National Laboratory.

Figure 2.9 is a conceptual block diagram of the Corehole 8 plume that shows the plume confined within a dipping limestone bed that is approximately 10 feet thick. Contaminants seep into the weathered limestone bed beneath the North Tank Farm in the vicinity of Tank W-1A. Groundwater seepage within the dipping bed carries contamination downward and westward, as shown by the seepage arrows in Figure 2.9. The flow rises to discharge into the base of the soil profile near the western edge of the Oak Ridge National Laboratory central campus near First Street, where the plume collection system was installed during implementation of the removal action. Contaminant concentrations are attenuated along

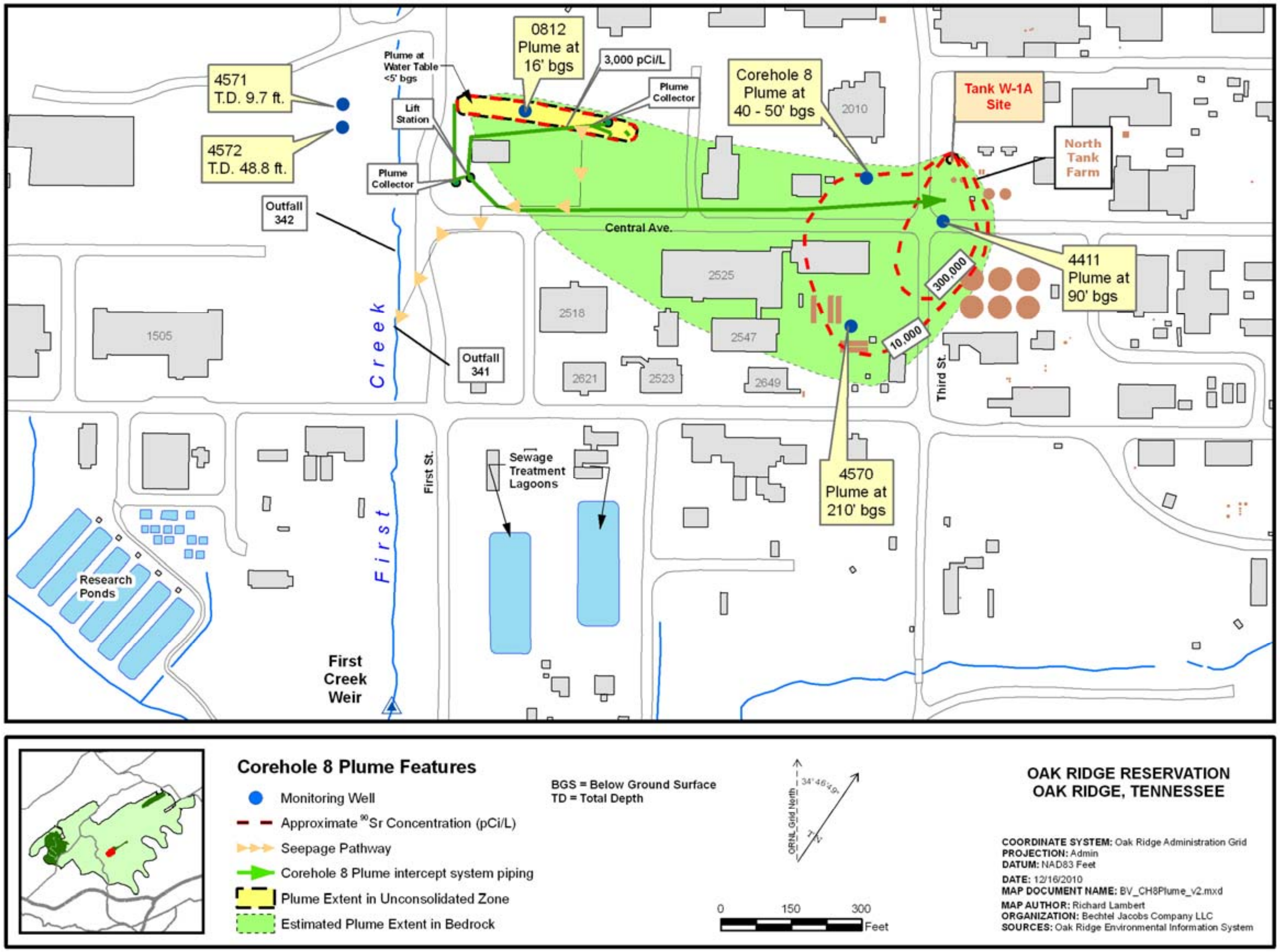

Figure 2.8. **Location and features of the Corehole 8 Plume.**

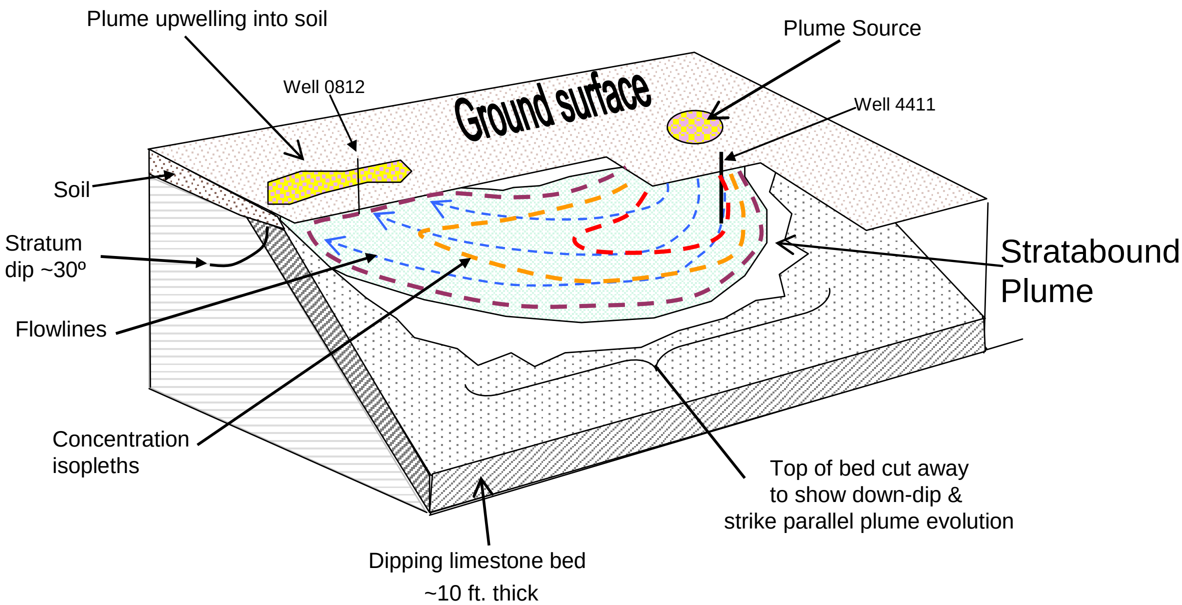

Figure 2.9. Conceptual block diagram of the Corehole 8 Plume.

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.

Evaluation of Plume Collection Performance Monitoring Data

During FY 2011, the Corehole 8 plume interceptor system did not achieve the performance goal for reduction of ^{90}Sr discharge to First Creek as discussed below. During FY 2011, the system was operational from October through March when operation ceased to allow testing and upgrade of system components.

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 2.10 includes the FY 2011 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 2011 was approximately 95% of the flux measured during calendar year 1994 prior to startup of the Corehole 8 groundwater collection system. Table 2.11 shows the history of ^{90}Sr fluxes and flux reduction factors in First Creek from calendar year 1993 through FY 2011.

Performance evaluation data summarized in Table 2.11 show that the Waste Area Grouping 1 Corehole 8 removal action 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.

Table 2.10. First Creek ^{90}Sr fluxes pre-action and in FY 2011

Month	Calendar year 1994 (pre-action)			Month	Fiscal year 2011		
	^{90}Sr (pCi/L)	Flow volume (liters)	^{90}Sr flux (Ci)		^{90}Sr (pCi/L)	Flow volume (liters)	^{90}Sr flux (Ci)
January 1994	124.4	102,893,891	0.0128	October 2010	144	31,713,955	0.0046
February 1994	95.6	126,569,038	0.0121	November 2010	109	54,801,706	0.0060
March 1994	89.2	228,699,552	0.0204	December 2010	97	58,509,518	0.0057
April 1994	105.4	166,982,922	0.0176	January 2011	128	70,544,477	0.0090
May 1994	236.5	41,437,632	0.0098	February 2011	100	33,609,485	0.0034
June 1994	297.3	32,963,337	0.0098	March 2011	71	205,383,586	0.0146
July 1994	324.4	25,585,697	0.0083	April 2011	63.2	158,151,226	0.0100
August 1994	378.4	30,919,662	0.0117	May 2011	79.1	78,902,942	0.0062
September 1994	364.9	26,586,673	0.0097	June 2011	620	27,933,206	0.0173
October 1994	133.6	24,700,599	0.0033	July 2011	767	22,844,131	0.0175
November 1994	260.9	37,178,996	0.0097	August 2011	589	18,094,133	0.0107
December 1994	179.8	66,740,823	0.012	September 2011	183	62,018,971	0.0113
Total		911,258,822	0.137	Total		822,507,336	0.1163

Table 2.11. ^{90}Sr flux changes at First Creek Weir, 1993–2011

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

[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 2.10 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 feet below ground surface in a location approximately 120 feet south of Tank W-1A, where leakage from a broken liquid low-level waste 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 Process Water Treatment Complex for treatment. Corehole 8 is a 50 feet 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 feet below ground surface. 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 2.10 show that during FY 2011 at Corehole 8, ^{90}Sr and $^{233/234}U$ activities remained high. Well 4411 was not operational during FY 2011 because of pump failure.

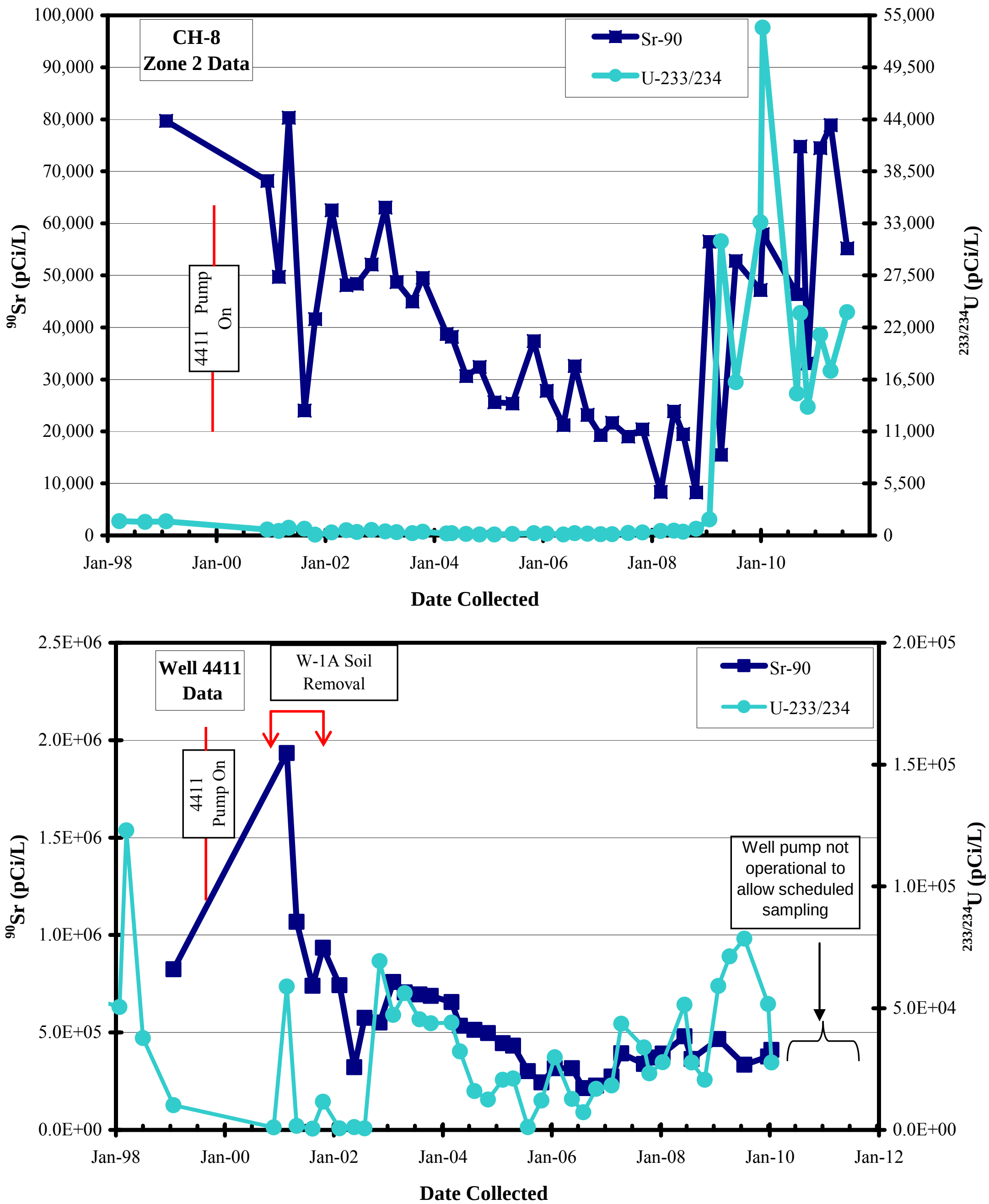

Figure 2.10. Contaminant activities in well 4411 and Corehole 8 Zone 2.

Figure 2.11 shows the Corehole 8 groundwater collection sump ^{90}Sr and alpha activity data from system startup in 1995 through FY 2011. 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 2.12 includes Corehole 8 collection system monthly and year-end total flow volumes collected and ^{90}Sr flux captured and sent to the Process Water Treatment Complex for FY 1997 and FY 2011. Figure 2.12 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 inches per year. As shown on Figure 2.12, FY 2003–FY 2005, and FY 2009 through 2011 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.

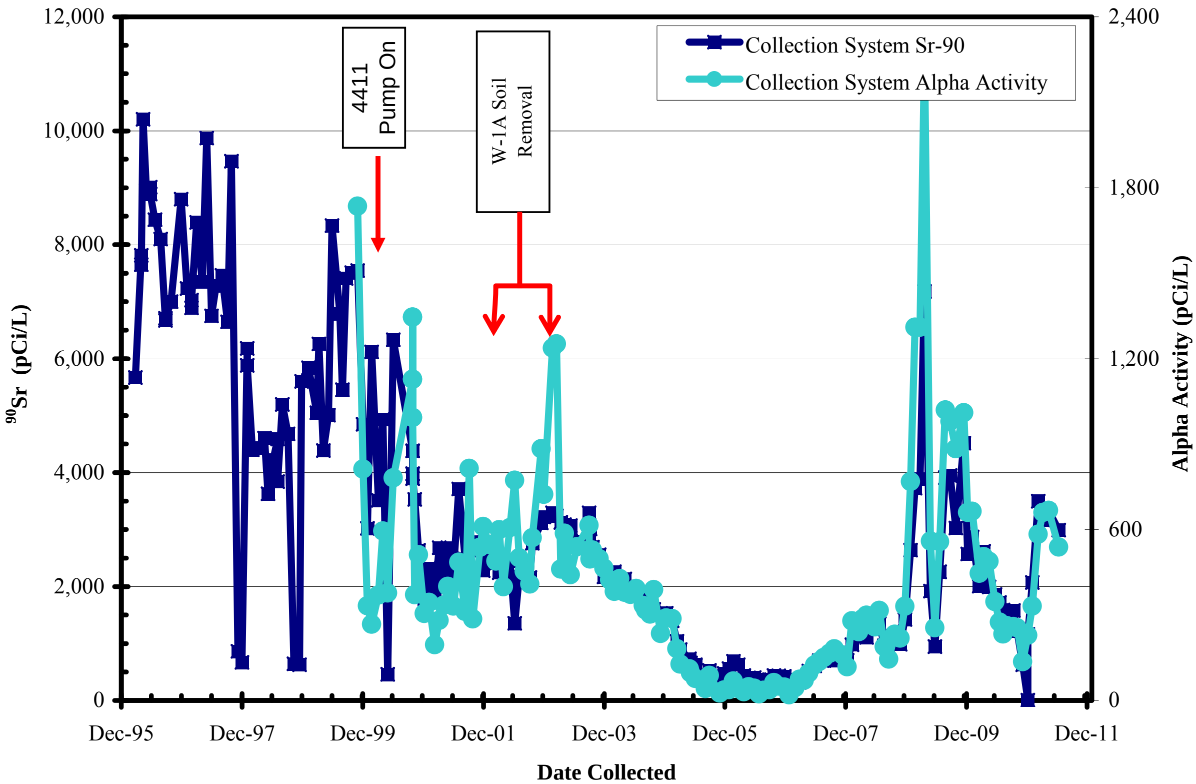

Figure 2.11. ^{90}Sr and alpha activity in collected Corehole 8 Plume groundwater.

Table 2.12. Corehole 8 groundwater collection system ^{90}Sr flux

Month	FY 1997			Month	FY 2011		
	^{90}Sr (pCi/L)	Flow volume (liters)	^{90}Sr flux (Ci)		^{90}Sr (pCi/L)	Flow volume (liters)	^{90}Sr flux (Ci)
October 1996	8700	933,000	0.0081	October 2010	625	2,309,587	0.001
November 1996	8800	1,845,000	0.0162	November 2010	1380	2,853,331	0.004
December 1996	7230	2,595,000	0.0188	December 2010	2070	2,176,920	0.005
January 1997	6890	1,711,000	0.0118	January 2011	3500	221,674	0.001
February 1997	8390	1,858,000	0.0156	February 2011	3170	147,125	0.0005
March 1997	7350	2,162,000	0.0159	March 2011	667	551,030	0.0004
April 1997	9870	1,946,000	0.0192	April 2011	—	0	—
May 1997	6750	1,697,000	0.0115	May 2011	—	0	—
June 1997	7280	2,631,000	0.0192	June 2011	—	0	—
July 1997	7463	1,705,000	0.0127	July 2011	—	0	—
August 1997	6647	1,131,000	0.0075	August 2011	—	0	—
September 1997	9465	953,000	0.009	September 2011	—	0	—
Total		21,167,000	0.1655	Total		8,259,667	0.011

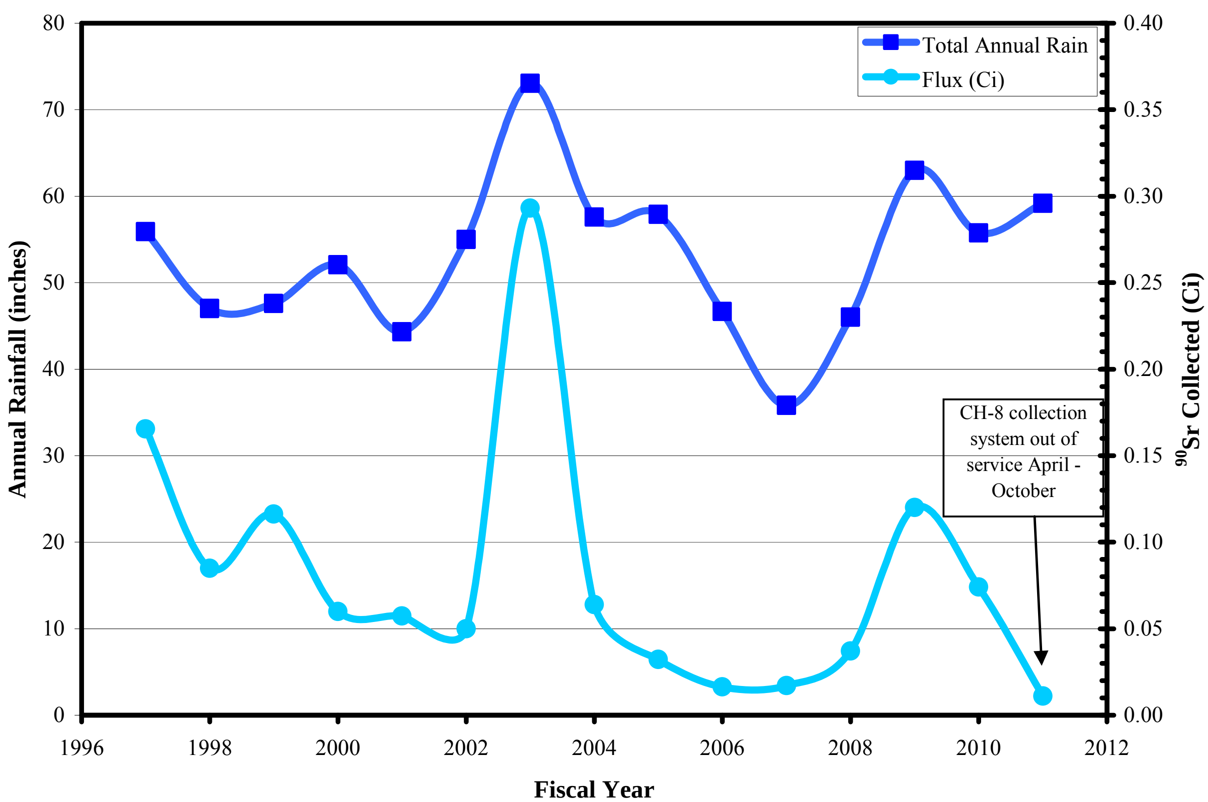

Figure 2.12. Corehole 8 Plume groundwater collector annual intercepted ^{90}Sr flux and rainfall.

Figure 2.13 shows ^{90}Sr and $^{233/234}U$ activities measured at well 4570 (see Figure 2.8) since its installation as recommended in the *Engineering Study Report for Groundwater Actions in Bethel Valley* (DOE 2005). Contaminant activities have generally declined since the beginning of monitoring this well. Wells 4571 and 4572 (Figure 2.8) are also monitored to evaluate the potential extension of the plume west of First

Creek. Strontium-90 was not detected in well 4571 (9.7 feet deep) in either of two sampling events during FY 2011 and has not been detected since the start of monitoring in 2005. Strontium-90 was detected in well 4572 (48.8 feet deep) at 2.47 pCi/L in the January 2011 sample but was not detected in the August sample. The January 2011 detection of ^{90}Sr in well 4571 was the first unqualified detection since monitoring started in 2005.

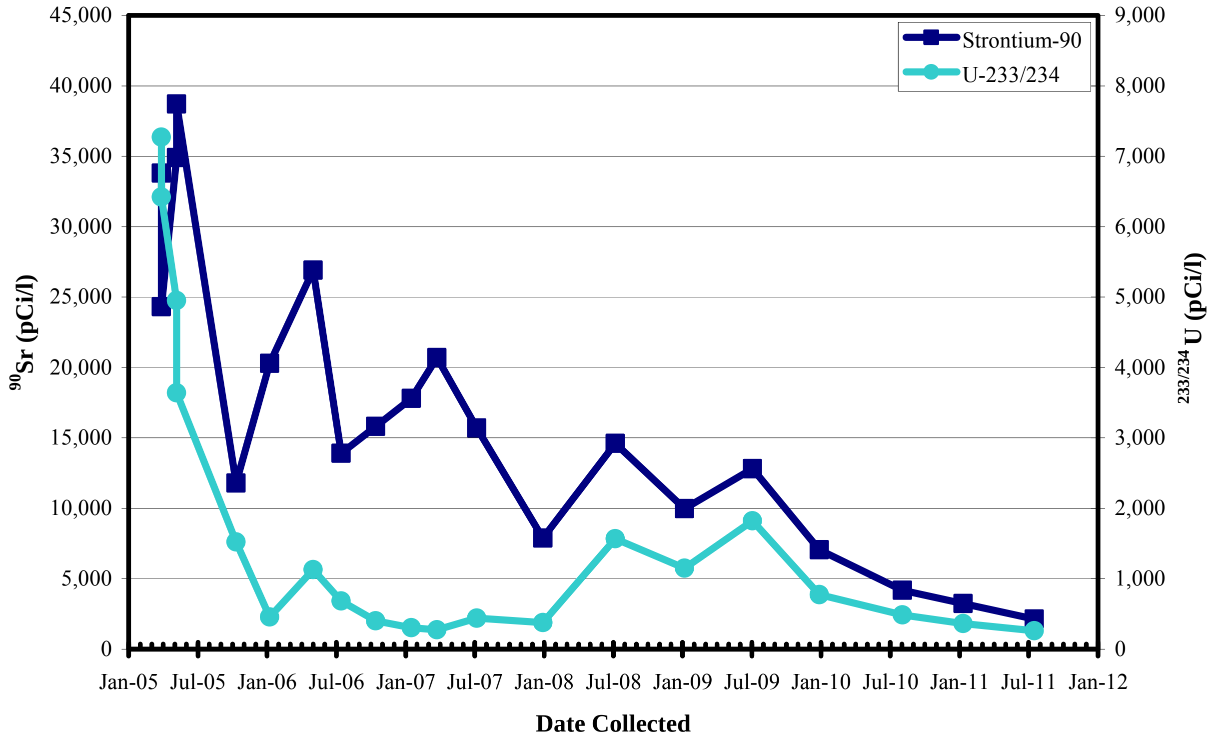

Figure 2.13. ^{90}Sr and ^{234}U activities in well 4570.

Plume Collection Performance Summary. The Corehole 8 plume collection system did not meet its performance goal during FY 2011. Due to construction activities, the plume collection system was not operational after March 2011. During FY 2011, the increase in contaminant mass transport that started during FY 2009 continued.

The problems with the Corehole 8 Plume collection system were identified as an issue in the *2010 Remediation Effectiveness Report* (DOE 2010c). In response to the deficiencies with the plume collection system, additional plume extraction wells were installed to allow more robust hydrologic control of the plume in its bedrock seepage pathway. In addition, the mechanical system in the existing shallow lift stations has been upgraded and replaced to be compatible with the new controls system. This work was conducted as a groundwater action under the authority of the *Record of Decision for Interim Actions at Bethel Valley* and the project design is documented in the *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley (Corehole 8) Extraction System* (DOE 2010d).

Status of Requirements for FY 2011. During FY 2011, the system was under construction and refurbishment. An issue identifying that the Corehole 8 collection system did not meet system performance goals has been carried forward from the *2010 Remediation Effectiveness Report* as indicated on Table 2.14. The plume collection system is expected to resume operation during the second or third quarter of FY 2012, after which ^{90}Sr concentrations are expected to decrease.

2.2.2.2 Groundwater Monitoring

CERCLA groundwater monitoring in Bethel Valley includes exit pathway well monitoring, well monitoring related to the Corehole 8 plume and well monitoring related to the Solid Waste Storage Area 3 remedial action. Exit pathway wells in the eastern and western ends of Bethel Valley are monitored to determine if contaminants discharge to Raccoon Creek and Bearden Creek. Results of surface water monitoring in these two watersheds was discussed in Sect. 2.2.2.1.2. Figure 2.4 shows locations where Bethel Valley exit pathway sampling is conducted. Additionally, groundwater monitoring is conducted at Solid Waste Storage Area 3 to provide additional baseline groundwater data that will be used to evaluate the effectiveness of the Bethel Valley Burial Ground remedial action. The Solid Waste Storage Area 3 Burial Ground hydrologic isolation construction was completed in September 2011. Post-remediation remedy effectiveness data evaluations will occur starting in the 2013 Remediation Effectiveness Report. The Solid Waste Storage Area 3 and Raccoon Creek exit pathway and Bearden Creek exit pathway groundwater monitoring results for FY 2011 are discussed below.

Based upon the Remedial Action Objective of unrestricted land use in the area surrounding Solid Waste Storage Area 3 and the closed Contractors Landfill and in the Raccoon Creek area and in the immediate vicinity of Bearden Creek (Figure 2.2), drinking water maximum contaminant levels are considered appropriate criteria for screening of groundwater monitoring results.

Solid Waste Storage Area 3 and Raccoon Creek Exit Pathway

The Solid Waste Storage Area 3 area groundwater sampling was conducted in the dry season of October 2010 and in the wet season of May 2011. Groundwater sampling was conducted at all the wells shown on Figure 2.4 (inset) at least once. The three sampling zones in Well 4579, the Westbay® well, were sampled four times during FY 2011 in the combined Bethel Valley Burial Ground and Water Resources Restoration Program sampling activities. Exit pathway wells 4645, 4646, and 4647 in the headwaters of Raccoon Creek were constructed in FY 2010 and were sampled twice during FY 2011 in conjunction with the Solid Waste Storage Area 3 area sampling.

Analytical parameters included metals, anions and alkalinity, VOCs, and a suite of radionuclides that included ^{90}Sr, tritium, gross alpha and beta activities, and gamma-emitting radionuclides. Table 2.13 includes a screening summary of results of analyses compared to maximum contaminant levels or to the 8 pCi/L (4 mrem/yr activity equivalent) level for ^{90}Sr.

- Radionuclides: Beta activity exceeded the 50 pCi/L screening level in groundwater at wells 0994, and 1248. Strontium is the source of the elevated beta activity in well 0994 (maximum value of 560 pCi/L), and ^{90}Sr exceeded the 8 pCi/L activity level in 10 of 40 groundwater samples including those from five in the vicinity of Solid Waste Storage Area 3. Strontium-90 was detected at about 2.5 pCi/L or less in well 4547, which is the shallowest of the three new Raccoon Creek exit pathway wells. Its detection is not surprising since the well samples groundwater at the top of bedrock adjacent to the stream where a seep has been known to discharge contaminated groundwater for several decades. Tritium was detected in six of the 40 samples analyzed. None of the tritium concentrations approached maximum contaminant levels. The highest tritium activity (3540 pCi/L) was measured in well 0994 at the western end of Solid Waste Storage Area 3.

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Table 2.13. Groundwater sampling summary for Solid Waste Storage Area 3 area -- FY 2011

Analyte	Number of locations	Number of samples	Number of detects	MCL	Number of MCL exceedances	Locations exceeding MCL (maximum detection presented)
Alpha activity	17	40	9	15 pCi/L	0	
Antimony	17	40	0	6 µg/L	0	
Arsenic	17	40	2	10 µg/L	2	Well **1248 (15 µg/L)**
Barium	17	40	39	2 mg/L	0	
Beryllium	17	40	0	4 µg/L	0	
Cadmium	17	40	1	5µg/L	0	
Chromium	17	40	5	100 µg/L	0	
Copper	17	40	8	1.3 mg/L[e]	0	
Fluoride	17	40	18	2[a], 4[b] mg/L	6	Well **4579-01 (11 mg/L),** Well **1248**
Lead	17	40	3	15µg/L[e]	0	
Mercury	14	26	24	2 µg/L	0	
Selenium	17	40	0	50 µg/L	0	
Thallium	17	40	2	2µg/L	0	
Benzene	17	41	9	5 µg/L	6	Well **4579-01** (**12 µg/L**), Well **4579-02**
Carbon tetrachloride	17	41	1	5 µg/L	0	
Cis-1,2-DCE	17	41	2	70µg/L	0	
Ethylbenzene	17	41	6	700 µg/L	0	
Toluene	17	57	9	1 mg/L	0	
Total xylenes	17	47	6	10 mg/L	0	
Trichloroethene	17	41	1	5µg/L	1	Well **0985 (7 ug/L)**
Vinyl chloride	17	41	2	2 µg/L	1	Well **0986 (2.4 µg/L)**
Strontium-90	17	40	17	8 pCi/L[c]	10	Wells **0705, 0992**, **0993**, **0994(560 pCi/L) , 4579-03**
Tritium	17	40	6	20,000 pCi/L[d]	0	

Table 2.13. Groundwater sampling summary for Solid Waste Storage Area 3 area -- FY 2011 (cont.)

Analyte	Number of locations	Number of samples	Number of detects	MCL	Number of MCL exceedances	Locations exceeding MCL (maximum detection presented)
pH	17	38	49	6.5 – 8.5[a]	13	Low [**0705, 4546, 4579-03(5.97)**] High [**4579-01, 4579-02**, **1248 (12.5)**]

MCL = Safe Drinking Water Act maximum contaminant level. MCLs are primary drinking water criteria unless otherwise noted.
Number of samples exceeding criterion shown. Maximum detected values exceeding criteria denoted in bold text.

[a]concentration is a secondary drinking water criterion.
[b]concentration is a primary drinking water criterion.
[c]8 pCi/L for 90Sr is the 4 mrem/yr effective dose equivalent activity.
[d]20,000 pCi/L for tritium is the 4 mrem/yr effective dose equivalent activity.
[e]Action level for concentration reduction of copper and lead in public water supplies.

- VOCs: Trichloroethene was detected in only 1 sample during FY 2011 and the detection exceeded maximum contaminant levels in Well 0985 on the eastern edge of Solid Waste Storage Area 3. Cis-1,2-DCE was also detected in well 0985 but did not exceed its maximum contaminant level. Vinyl chloride was detected in one sample from well 0985 at less than the MCL. Vinyl chloride was detected at 2.4 µg/L which exceeds the 2 µg/L MCL in one sample from well 0986.

  Benzene/toluene/ethylbenzene and xylene compounds were detected in the two deeper Westbay sampling zones in well 4579. Its appearance in only these two bedrock zones and its absence elsewhere in the area suggests the possibility that it is derived from a natural petroleum source in bedrock. Natural petroleum has been encountered in relatively shallow bedrock elsewhere in Bethel Valley.

- Metals: Fluoride exceeded maximum contaminant levels at wells 1248 and in the two deeper zones of well 4579. These wells had pH levels greater than 9.5. Three of the wells, including new well 4546, had pH values less than 6.5, and four wells had pH greater than 8.5. Arsenic exceeded maximum contaminant levels in the two samples from well 1248. Thallium was detected at levels much below its maximum contaminant levels in the October samples from two of the new Raccoon Creek exit pathway wells but was not detected in any wells during the May sampling event.

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 2.4). Well 1198 is a shallow well, screened from about 28 – 43 feet below ground surface and well 1199 is a deeper well screened from about 53 to 73 feet below ground surface. 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 2011, tritium was detected in well 1198 in January at 524 pCi/L but was not detected in September. In well 1199, tritium activity was measured at 1,500 pCi/L in Januarey and 965 pCi/L in September. Site investigations conducted by the Office of Science for a new facility to be constructed near the Bearden Creek exit pathway (and to the northeast of the Building 7025 facility) encountered tritium in groundwater in the area. All lab results on groundwater samples in the area were less than the drinking water 20,000 pCi/L maximum contaminant level effective dose equivalent. Analyses for VOCs has been conducted throughout the monitoring history at both wells. VOCs are occasionally detected in well 1199. In the January 2010 sampling event, TCE and cis-1,2-DCE were detected at 56 µg/L and 3.4 µg/L, respectively. Neither constituent was detected in the dry season sample collected in September 2010. In September 2011, TCE was detected at 66 µg/L, cis-1,2-DCE was detected at 3.2 µg/L, and vinyl chloride was detected at 1.7 µg/L. Of these detections, only TCE has been measured above the 5 µg/L maximum contaminant level to date. The origin of the detected VOCs is presumed to be 7000 Area TCE plume that is the subject of an ongoing plume treatability study.

2.2.2.3 Aquatic Biological Monitoring in White Oak Creek

Biological monitoring data are available for several locations in Bethel Valley, including a location in White Oak Creek near the watershed's exit point (Figure 2.14). This information is useful in evaluating watershed trends and the effectiveness of watershed-scale decisions defined in the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002). Biological monitoring data for the White Oak Creek watershed includes contaminant accumulation in fish, fish community surveys, and benthic macroinvertebrate surveys. Fish bioaccumulation results for mercury and PCBs (Figure 2.15 and Figure 2.16, respectively) from all of White Oak Creek, including stream sections downstream of the Melton Branch confluence, are presented in this chapter.

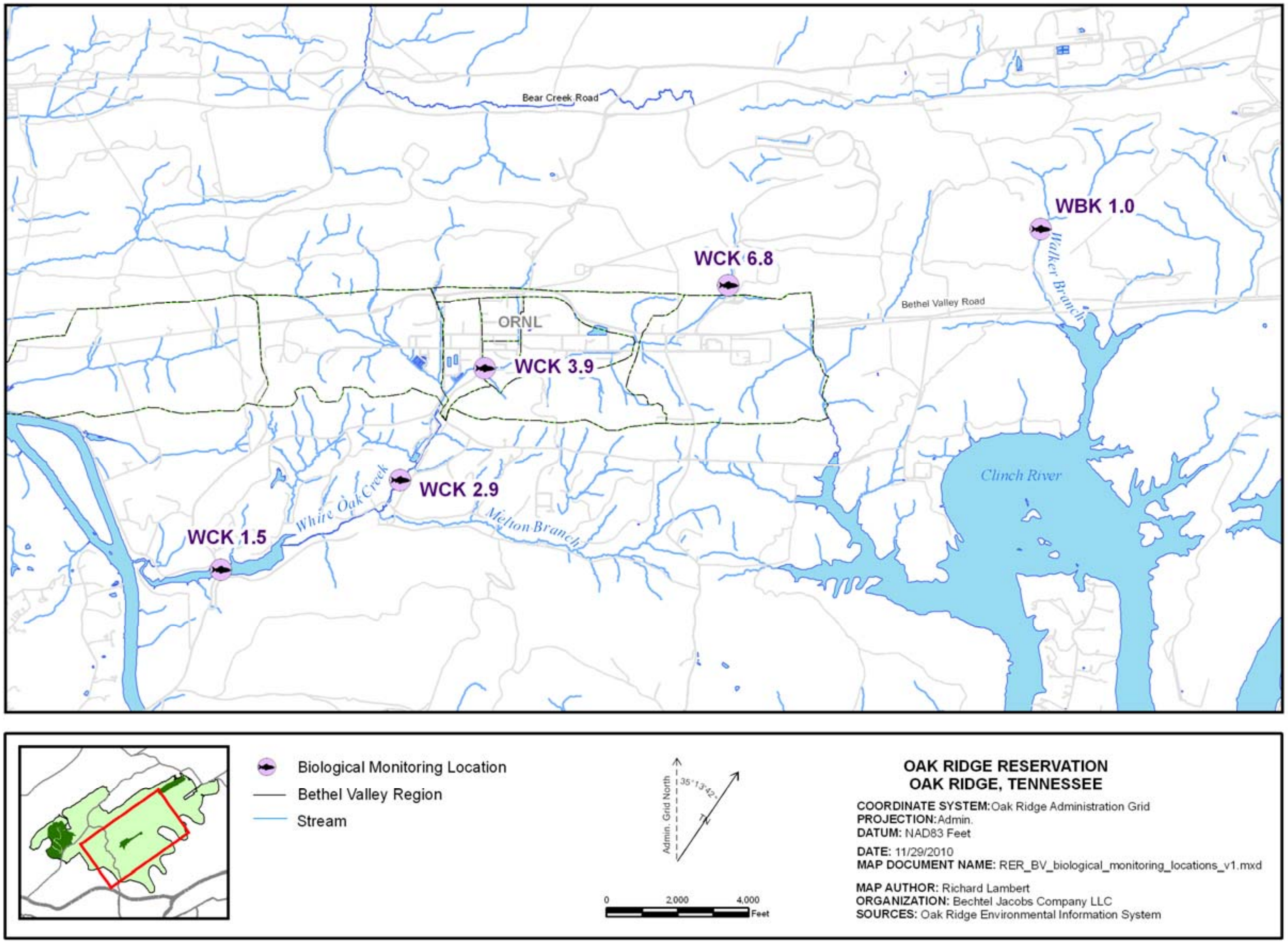

Figure 2.14. Biological monitoring locations at the Oak Ridge National Laboratory.

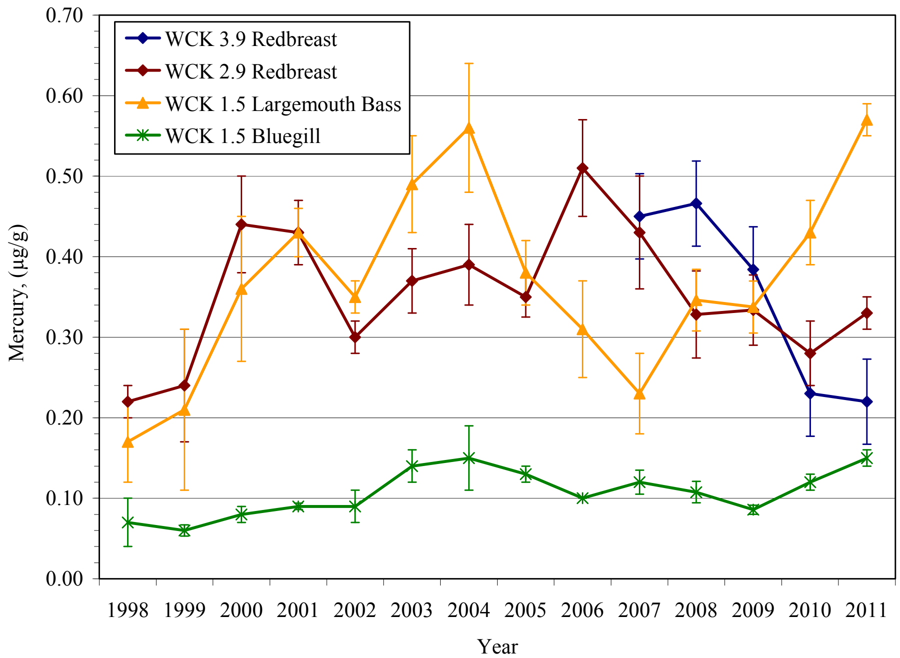

Figure 2.15. Mean concentrations of mercury (µg/g, ± SE, N = 6) in muscle tissue of sunfish and bass from White Oak Creek (WCK 2.9 and WCK 3.9) and White Oak Lake (WCK 1.5), 1998–2011.

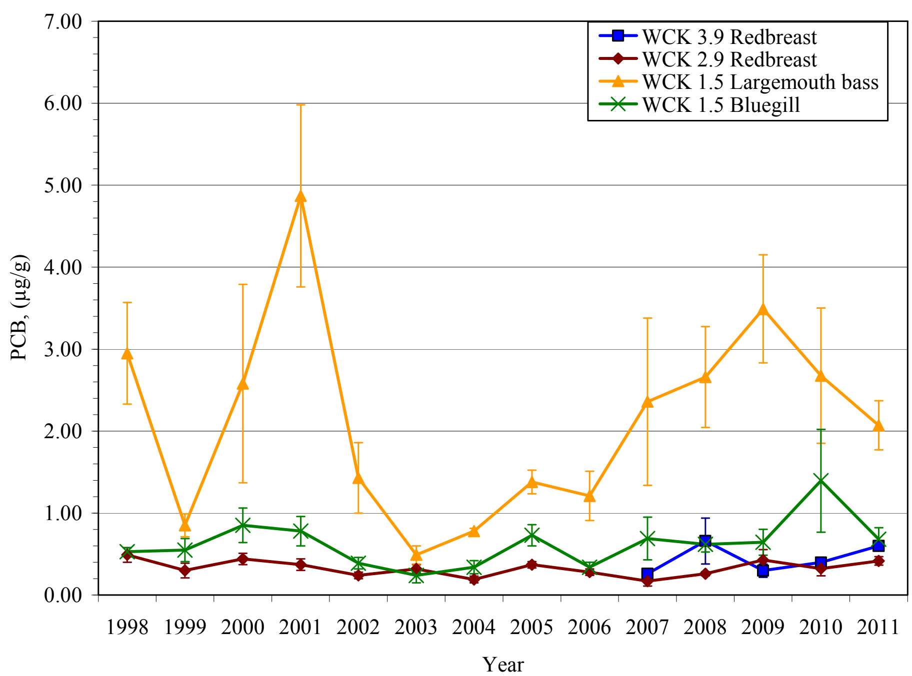

Figure 2.16. PCB concentrations (µg/g, ± SE, N = 6) in fish fillet collected from the White Oak Creek Watershed, 1998–2011.

Mercury concentrations in fish collected in 2011 at White Oak Creek kilometer (WCK) 3.9 averaged 0.22 µg/g (Figure 2.15), remaining below the Environmental Protection Agency fish-based mercury AWQC of 0.3 µg/g. This is consistent with the decreasing trend in fish tissue mercury concentrations at this site in recent years. This decrease in fish tissue mercury concentrations is likely due to the decreases in aqueous mercury concentrations as a result of the *Bethel Valley Mercury Sumps Groundwater Action* in 2008 (DOE 2010e). While average mercury concentrations in fish collected from WCK 2.9 dropped below the AWQC in 2010, concentrations in 2011 increased slightly to 0.33 µg/g. Future monitoring efforts will show whether mercury concentrations continue to decrease and remain below the AWQC throughout the creek. In contrast to the decreases in mercury concentrations seen in fish collected from upper White Oak Creek, mercury concentrations in fish collected in White Oak Lake (WCK 1.5) have been increasing in recent years. Concentrations in bass collected at this site increased significantly from 0.43 µg/g in 2010 to 0.57 µg/g in 2011. Average mercury concentrations in bluegill collected from White Oak Lake also increased, from 0.12 µg/g in 2010 to 0.15 µg/g in 2011. These are the highest mercury concentrations in fish monitored in White Oak Lake for the past 13 years (Figure. 2.15).

Mean total polychlorinated biphenyl (PCB) concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in redbreast sunfish from the White Oak Creek watershed remained within historical ranges (Figure 2.16). PCB levels in redbreast collected from WCK 3.9 appeared to increase in 2011. Investigatory studies done in 2009-2010 by the Oak Ridge National Laboratory's Water Quality Protection Program identified First Creek as a major source of PCBs to White Oak Creek. For this reason, redbreast sunfish collected from the WCK 3.9 site in 2011 were divided into two groups: those collected upstream of First Creek (n=6), and those collected below First Creek (n=6). The average total PCB concentrations in all fish was 0.60 ± 0.17 µg/g, higher than the average PCB concentration in fish collected at this site in 2010 (0.40 µg/g). The six fish collected above First Creek had higher mean concentrations (0.75 µg/g) than those collected below First Creek (0.45 µg/g), though this difference was not statistically significant because of high PCB variation in individual fish results. PCB concentrations in redbreast at WCK 2.9 increased slightly (average 0.42 ± 0.05 µg/g) in 2011. Mean PCB values for bluegill sunfish collected at WCK 1.5 were 0.68 µg/g in 2011, significantly lower than concentrations seen in 2010, but comparable to previous years. Largemouth bass PCB concentrations were lower than in 2010, but were within the range of values found in recent years (average 2.07 ± 0.30 µg/g) (Figure 2.16).

Fish and benthic communities are negatively impacted relative to reference sites, although improvements have occurred since the mid-1980s. The fish communities in White Oak Creek in 2011 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 7.6). The number of species in White Oak Creek was similar or greater than the number of fish found at the smaller Mill Branch reference site (Mill Branch Kilometer 1.6) (Figure 2.17). Recent introductions of fish species into White Oak Creek watershed have been very successful with reproduction observed in all five species and expanded distributions for two species. The introduced species fill in missing groups of fish, including sensitive species such as darters and suckers, and should help the overall richness of the fish fauna in White Oak Creek be more comparable to area reference streams. The fish introductions are a management tool to compensate for the isolation of White Oak Creek watershed by dams and weirs that prevent natural upstream fish passage, with fish being placed in the White Oak Creek watershed beginning in 2009 through 2011. Benthic macroinvertebrate community results from 2010 continue to show that the modest recovery that occurred at WCK 3.9 after 1996 continues to persist, and the invertebrate community at WCK 6.8 is comparable to that of the Walker Branch Kilometer 1.0 reference site (Figure 2.18).

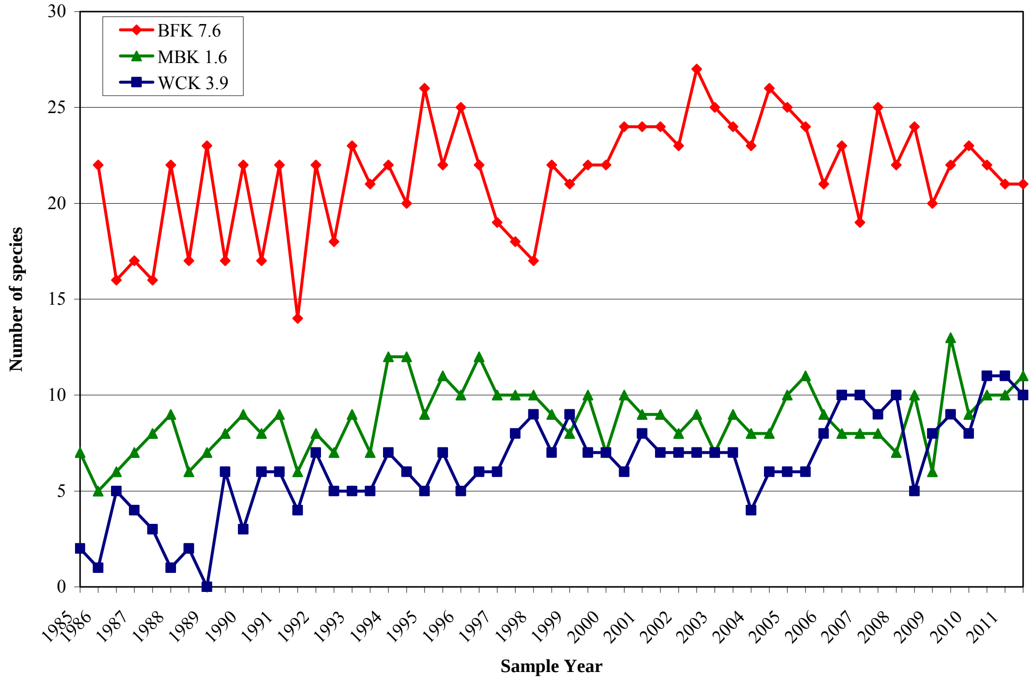

Figure 2.17. Species richness (number of species) in samples of the fish community in White Oak Creek (WCK 3.9) and reference streams, Brushy Fork kilometer (BFK) and Mill Branch kilometer (MBK), 1985–2011.

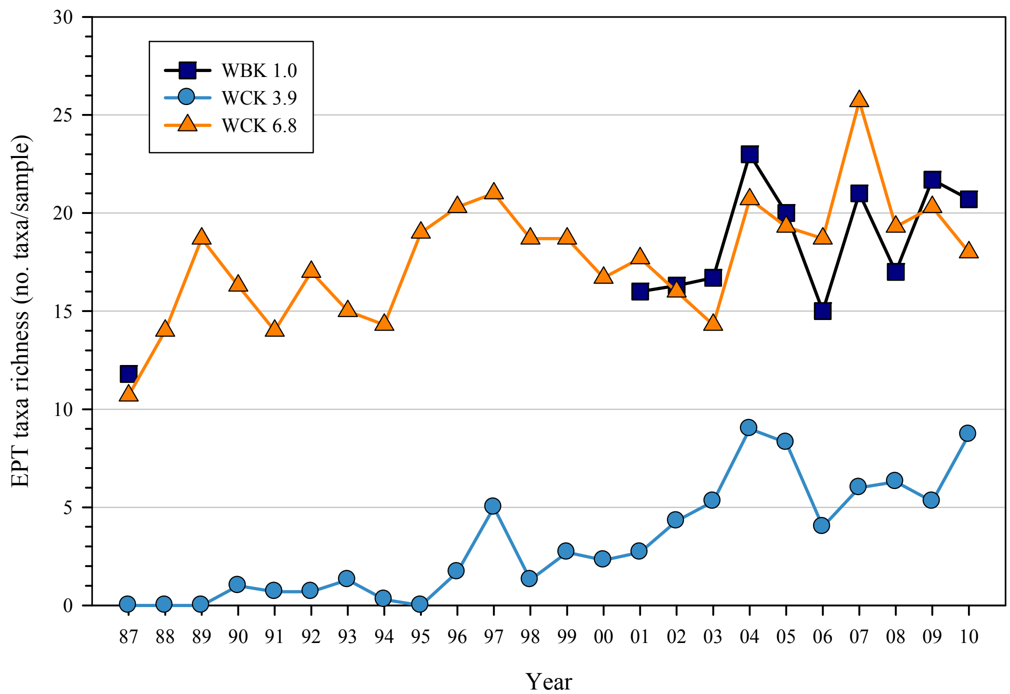

Figure 2.18. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in upper White Oak Creek and Walker Branch, April sampling periods, 1987–2010. [a,b]

[a]WBK = Walker Branch kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, caddisflies, and stoneflies.
[b]Samples collected in 2011 have not yet been processed. Data were not available for Walker Branch from 1988-2000.

2.2.3 Performance Summary

Following is a summary of the FY 2011 Bethel Valley watershed performance monitoring;

- Mercury concentrations at the Bethel Valley watershed integration point (7500 Bridge) continue to decrease as a result of treating the Building 4501 basement foundation sump water prior to discharging to the creek. In October 2009 a pre-filter and ion exchange water treatment system were installed in the basement of Building 4501. Following pre-treatment, the sump water is routed to the Process Water Treatment Complex for final treatment and discharge to White Oak Creek. The mercury concentrations measured at the 7500 Bridge integration point were below the AWQC of 51 ng/L in all 12 monthly grab samples. One of two samples collected from White Oak Creek near the former mercury discharge outfall exceeded the AWQC.

- ^{90}Sr concentrations at the Bethel Valley watershed integration point (7500 Bridge) do not meet the risk reduction goal and continue to increase. Higher than average rainfall during 2009 through 2011 compounded with problems associated with the Corehole 8 plume extraction system are responsible for the increase in ^{90}Sr during the past few years. During FY 2011, the Corehole 8 plume extraction system was under construction and refurbishment. An issue identifying that the Corehole 8 collection system did not meet its system performance goals has been carried forward from the *2010 Remediation Effectiveness Report* as indicated on Table 2.14. The plume collection system is expected to resume operation during the second or third quarter of FY 2012, after which ^{90}Sr concentrations are expected to decrease.

- The risk reduction goal for ^{137}Cs was met at the Bethel Valley watershed integration point (7500 Bridge).

- Biological monitoring of the Bethel Valley watershed continues to indicate moderate ecological recovery. Decreased mercury concentrations in fish at the site closest to the Oak Ridge National Laboratory facilities to levels below the Environmental Protection Agency-recommended fish-based AWQC for mercury is encouraging.

2.2.4 Compliance with Long-Term Stewardship Requirements

2.2.4.1 Requirements

Watershed-scale Requirements

The *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002) includes interim land use controls to protect against unacceptable exposures to contamination during and after remediation.. These interim land use controls will remain in effect until permanent land use controls are established in a future, final remedial decision. Objectives of the interim land use controls are:

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

- <u>Controlled industrial area</u>. Restrict excavations or penetrations deeper than 0.6 meters (2 feet) and prevent uses of the land more intrusive than industrial above 0.6 meters (2 feet).

- <u>Unrestricted industrial area</u>. No restrictions on excavations or penetrations shallower than 3 meters (10 feet) and prevent uses of the land more intrusive than industrial deeper than 3 meters (10 feet).

- Recreational area (as applied to the Solid Waste Storage Area 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.

Under the *Explanation of Significant Differences from the Record of Decision for Interim Actions in Bethel Valley* (DOE 2010f) the Solid Waste Storage Area 3 cap was extended to cover Contaminated Soil Area No. 2 and Contaminated Soil Area No. 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 at Bethel Valley* (after excavation). Now that they are under the Solid Waste Storage Area 3 cap, the end use for these areas is recreational. This project was completed in FY 2011, and the phased construction completion report was submitted to the regulators on September 14, 2011 (DOE 2011a). Once approved, the long-term stewardship requirements for this action will include cap and soil cover inspections and maintenance, radiological surveys, and access controls.

Single Project-scale Requirements

The long-term stewardship requirement specified in the *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action* (DOE 2010e) 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.

2.2.4.2 Status of Requirements for FY 2011

Interim land-use controls were maintained for the specified end use areas identified in the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002). Signs were maintained to control access, and surveillance patrols conducted as part of routine surveillance and maintenance inspections were effective in preventing access by unauthorized personnel. The Excavation and Penetration Permit Program functioned according to established procedures and plans.

Inspections of the Building 4501 pretreatment system were conducted weekly in FY 2011 by the UT-Battelle Facility Manager in accordance with the operating manual. Monthly system status updates were submitted to the Water Resources Restoration Program documenting system operations, monthly pumped/treated volume, and influent/effluent concentrations. Routine maintenance included monthly inlet filter changes and replacement of the resin column in March. Operational problems and downtime for two days occurred in May while the original pump was replaced. It had stopped working due to failed seals. Additional operational problems and downtime for five days occurred in August because of a wide-scale power surge and outage that destroyed the power supply for the control system. A replacement power supply was obtained and installed.

2.3 COMPLETED SINGLE ACTIONS IN BETHEL VALLEY WATERSHED WITH MONITORING AND/OR LONG-TERM STEWARDSHIP REQUIREMENTS

2.3.1 Corehole 8 (Plume Collection)

2.3.1.1 Long-Term Stewardship Requirements

Long-term stewardship requirements were not specified in the *Action Memorandum for the Waste Area Grouping 1 Corehole 8 Removal Action* (DOE 1999b). However, the Phased Construction Completion Report for the extraction system is being prepared, and it includes long-term stewardship requirements. Upon approval long-term stewardship requirement will be maintenance of the extraction system. Specifically, the requirements will be 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 thunderstorm activities.

2.3.1.2 Status of Requirements for FY 2011

There are no requirements.

2.3.2 Tank W-1A

2.3.2.1 Long-Term Stewardship Requirements

The location of Tank W-1A (the Corehole 8 plume source) is on Figure 2.1. The scope of this removal action included removal of contaminated soils, along with associated piping, valve pits, and appurtenances within the area of excavation; backfilling; and site restoration. Some soils and the tank have been left in place due to potential transuranic waste that requires special handling and disposition. The tank interior was cleaned; however, excavation of the contaminated soil from around the tank and tank removal require completion. In FY 2006, sampling and characterization were completed and delineated the extent of remaining contamination. The project completed planning, mobilization and readiness and started excavation in September 2011. The removal of the remaining soil, tank and concrete tank saddle is expected in 2012.

This site has only long-term stewardship 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.

Presently, the site has been prepared to complete the removal action, and the perimeter of the site has been posted as a Radiological Area. Once the removal action is complete, the long-term stewardship requirements will be specified in the Removal Action Report. These requirements will include the routine surveillance and maintenance activities to be performed to ensure that the clean backfill is not undergoing excessive subsidence or erosion and that the area be posted as “Soil Contamination Area–Contact Radiation Protection before disturbing surfaces.”

2.3.2.2 Status of Requirements for FY 2011

The site has been prepared to complete the removal action. A Documented Safety Analysis along with other project documents have been prepared and site controls implemented through Work Packages and Procedures. In FY 2011 the site access controls and signs were revised to reflect the start of the removal action. Additional access controls were implemented and chain link fencing has been installed around the site.

2.3.3 Surface Impoundments Operable Unit

2.3.3.1 Long-Term Stewardship Requirements

The location of the Surface Impoundments is on Figure 2.1. This action removed contaminated water, sediment, and the upper 0.1 to 0.2 feet 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.

The *Remedial Action Report on the Surface Impoundments Operable Unit* (DOE 2003a) 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.

No post-action performance monitoring of groundwater or surface water was specified.

2.3.3.2 Status of Requirements for FY 2011

The site underwent an annual inspection in FY 2011 by the Oak Ridge National Laboratory Surveillance and Maintenance Program to check for evidence of unauthorized excavation/penetration without a valid permit. No unacceptable activity was noted.

In addition an Excavation and Penetration Permit Program with procedures in in place that does not allow unauthorized excavations/penetrations in this area.

2.3.4 Metal Recovery Facility

2.3.4.1 Long-Term Stewardship Requirements

The location of the Metal Recovery Facility is 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 two inches of gravel. Final disposition of the slab and subsurface structures has been deferred to the *Record of Decision for Interim Actions at Bethel Valley* (DOE 2002).

The *Removal Action Report for the Metal Recovery Facility* (DOE 2003b) requires surveillance and maintenance and posting as an underground contamination area. Surveillance and maintenance 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 two inches gravel protective cover over the epoxy barrier coating must be restored.

No surface water or groundwater monitoring is required to verify the effectiveness of the removal action.

2.3.4.2 Status of Requirements for FY 2011

The site underwent an annual inspection in FY 2011 performed by the Oak Ridge National Laboratory Surveillance and Maintenance 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 MONITORING CHANGES AND RECOMMENDATIONS

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

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Table 2.14. Bethel Valley watershed issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
Issue Carried Forward			
1. Corehole 8 Plume collection system performance does not meet RmAR performance goals (Remedial Actions Report for the Corehole 8 Removal Action at Oak Ridge National Laboratory (DOE 1995). (2010 RER)[b]	1. Line leaks in the potable water system were identified and fixed by UT-Battelle in FY 2010. Additionally, new wells were drilled for the Bethel Valley Corehole 8 Extraction System in FY 2010 and FY 2011 and are currently being hooked up to the extraction system. After the extraction system is fully operational, the ^{90}Sr concentrations are expected to decrease.	DOE/ EPA & TDEC	FY 2012
Completed/Resolved Issues[b]			
None.			

[a] A 2012 "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remediation Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remediation Effectiveness Report for Five Year Review 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., (2006 FYR).

DOE = Department of Energy
EPA = Environmental Protection Agency
RDR/RAWP = remedial design report/remedial action work plan
RER = remediation effectiveness report
TDEC = Tennessee Department of Environment and Conservation

2.5 REFERENCES

DOE 1995. *Remedial Action Report for the Corehole 8 Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1380&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1997. *Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1599&D2, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1998. *Feasibility Study for Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/02-1629&D2**,** U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1999a. *Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1748&D2/V1&V2, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1999b. *Action Memorandum Addendum for the Waste Area Grouping 1 Corehole 8 Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1831&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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

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

DOE 2003a. *Remedial Action Report on the Surface Impoundments Operable Unit at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2086&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2003b. *Removal Action Report for the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2000&D2/R1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2005. *Engineering Study Report for Groundwater Actions in Bethel Valley, Oak Ridge Tennessee*, DOE/OR/01-2219&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007a. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007b. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2289&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009a. *Remedial Design Report/Remedial Action Work Plan for Soils, Sediments and Dynamic Characterization Strategy for Bethel Valley, Oak Ridge, Tennessee,* DOE/OR/01-2378&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009b. *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-2343&D1/A1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009c. *Addendum to the Remedial Design Report/Remedial Action Work Plan for the Decontamination and Decommissioning of Non-Reactor Facilities in Bethel Valley at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2428&D2/A2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009d. *Time-Critical Removal Action Memorandum for the Facility 3026 C&D Wooden Superstructure at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-2402&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009e. *Time-Critical Removal Action Memorandum for the 2000 Complex Facilities Demolition at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-2412&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009f. *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, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010a. *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, Addendum 1, Wetlands and Streams Impacts,* DOE/OR/01-2427&D2/A1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010b. *Treatability Study Work Plan for the 7000 Area in Bethel Valley, Oak Ridge, Tennessee, Oak Ridge, Tennessee*, DOE/OR/01-2475&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010c. *2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2437&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010d. *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, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010e. *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2472&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010f. *Explanation of Significant Differences from the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee, Bethel Valley Burial Grounds*, DOE/OR/01-2446&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011a. *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory*, DOE/OR/01-2533 &D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011b. *Removal Action Report for the 3026 C&D Wooden Superstructure at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE.OR/01-2470&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011c. *Removal Action Report for the 2000 Complex Facilities Complex Demolition at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2501&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011d. *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2505&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011e. *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&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

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3. CERCLA ACTIONS IN 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 Figure 3.1 locates the key CERCLA sites and actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. Only sites that have long-term stewardship requirements (Table 3.1) are included in these performance evaluations. Remedial action objectives that form the basis for the interim remedial actions are based on the end uses depicted in Figure 3.2. These end uses require certain restrictions regarding site access and allowable activities as listed in Table 3.2.

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 Remedial Effectiveness Report* (DOE 2011d). The information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

3.1.2 Status

Watershed-Scale Actions

- The actions in the Record of Decision for Interim Actions for the Melton Valley Watershed (DOE 2000) have been completed and documented in the Remedial Action Report for the Melton Valley Watershed (DOE 2009a; DOE 2009b). Performance monitoring continued in FY 2011.

- In FY 2010, a series of offsite monitoring wells were installed across the Clinch River to the west of Melton Valley. The purpose of the offsite wells is to evaluate potential groundwater communication beneath the Clinch River between the Oak Ridge Reservation and an area of offsite groundwater use. Initial sampling was conducted at all new sampling points and from additional nearby residential wells in FY 2010 and FY 2011, and the results are being discussed with the Environmental Protection Agency and the TDEC in FY 2012. Based on the discussions the regulators, a new Melton Valley exit pathway monitoring strategy for both the Melton Valley sentinel wells and the off-site wells across the Clinch River will be developed in FY 2012. The revised monitoring strategy will be documented in the *Addendum to the Melton Valley Monitoring Plan* (DOE 2010b).

Single-Project Actions

- The *Action Memorandum for Corrective Actions at White Oak Dam* (DOE 2010a) to mitigate the potential failure of White Oak Dam and the potential for future releases of contaminants to the environment and potential human exposure to these contaminants was completed in FY 2011

Table 3.1. CERCLA actions in Melton Valley Watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations/ Land Use Controls required	Section
Watershed-scale actions				
Melton Valley Interim Actions	ROD (DOE/OR/01-1826&D3): 09/21/00 ROD Amendment (DOE/OR/01-2170&D1): 09/07/04 Amendment to change remediation approach for Trenches 5 & 7 to *in situ* grouting. ESD (DOE/OR/01-2040&D2): 03/12/04 Add 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 Modify requirements for 11 waste units. ESD (DOE/OR/01-2249&D1): 09/13/05 Remove seven facilities from MSRE D&D. ESD: DOE/OR/01-2333&D1): 12/27/06 Remove five shielded transfer tanks from D&D scope. LUCIP (DOE/OR/01-1977&D6): 05/24/06	RAR (DOE/OR/01-2343&D1) 09/05/07	Yes/Yes/Yes	3.2
		o (DOE/OR/01-2343&D1/A1) 06/25/09		
		o (DOE/OR/01-2343&D1/A2) submitted 08/05/09.		
		o Melton Valley Monitoring Plan Addendum (DOE/OR/01-1982&D1/R4/A1/R2), approved 05/12/10.		
		Hydrofracture Well Plugging & Abandonment (DOE/OR/01-2138&D1) approved 07/14/06.		
		New Hydrofracture Facility D&D (DOE/OR/01-2306&D1) approved 07/31/06.		
		Trenches 5 and 7 and Homogeneous Reactor Experiment Fuel Wells In Situ		
		Grouting (DOE/OR/01-2302&D1) approved 08/14/06.		
		Hydrologic Isolation at Solid Waste Storage Area 6 (DOE/OR/01-2285&D1) approved 09/06/06.		
		Solid Waste Storage Area 4 and Intermediate Holding Pond (DOE/OR/01-2300&D1) approved 09/11/06.		
		Old Hydrofracture Facility D&D (DOE/OR/01-2014&D2) approved 09/26/06.		
		Hydrologic Isolation at Seepage Pits and Trenches (DOE/OR/01-2310&D1) approved 10/02/06.		
		Soils and Sediments (DOE/OR/01-2315&D1) approved 10/02/06.		
		Homogeneous Reactor Experiment 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 Solid Waste Storage Area 5 (DOE/OR/01-2286&D1) approved 11/06/06.		

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

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations/ Land Use Controls required	Section
Single-project actions				
White Oak Creek Embayment	AM (Letter): 11/9/90	RmAR (ORNL/ER/Sub/91-KA931/4) approved 09/30/92.	No/Yes/Yes	3.2.5.2.1
Waste Area Grouping 13 Cesium Plots	IROD (DOE/OR/01-1059&D4): 10/06/92	RAR Postconstruction report (DOE/OR/01-1218&D2) approved 08/25/94.	No/Yes/Yes	3.2.5.2.2
Waste Area Grouping 5 Seep C	AM (DOE/OR/02-1235&D2): 03/30/94	RmAR Postconstruction Report (DOE/OR/01-1334&D2) approved 06/22/95. o System shutdown prior to capping.	Discontinued	--
Waste Area Grouping 5 Seep D[b]	AM (DOE/OR/02-1283&D2): 07/26/94	RmAR Postconstruction Report (DOE/OR/01-1334&D2) approved 06/22/95. o Collection of contaminated groundwater ongoing.	Superseded	--
Waste Area Grouping 4 Seep Control	AM (DOE/OR/02-1440&D2): 02/12//96	RmAR (DOE/OR/01-1544&D2) approved 03/05/98.	Discontinued	--
Molten Salt Reactor Experiment D&D Reactive Gas	AM (Letter): 06/12/95	RmAR (DOE/OR/01-1623&D2) approved 02/12/98.	No/No/No	--
Molten Salt Reactor Experiment 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/No	3.2.5.2.3
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/No	--
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.	Discontinued	--
Molten Salt Reactor Experiment D&D Fuel Salt Removal	ROD (DOE/OR/02-1671&D2): 07/07/98 ESD (DOE/OR/01-2088&D2) approved: 01/19/07 Delete 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/NoNo	--
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) submitted 03-31-11.		

[a] Detailed information on the status of actions is from Appendix E of the FFA. The most up-to-date status of schedule information is available at <**http://www.ucor.com/ettp_ffa_appendices.html**>.

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

[b] The Seep D treatment system was dismantled during MV ROD RAs. The groundwater collection sump was incorporated into the MV ROD groundwater collection system.

AM = action memorandum
ESD = Explanation of Significant Difference
IROD = Interim Record of Decision
LUCIP = land use control implementation plan
OHF = Old Hydrofracture Facility
PCCR = phased construction completion report
RAR = remedial action report
RmAR = removal action report
ROD = record of decision
TBD = to be determined
WOCE = White Oak Creek Embayment

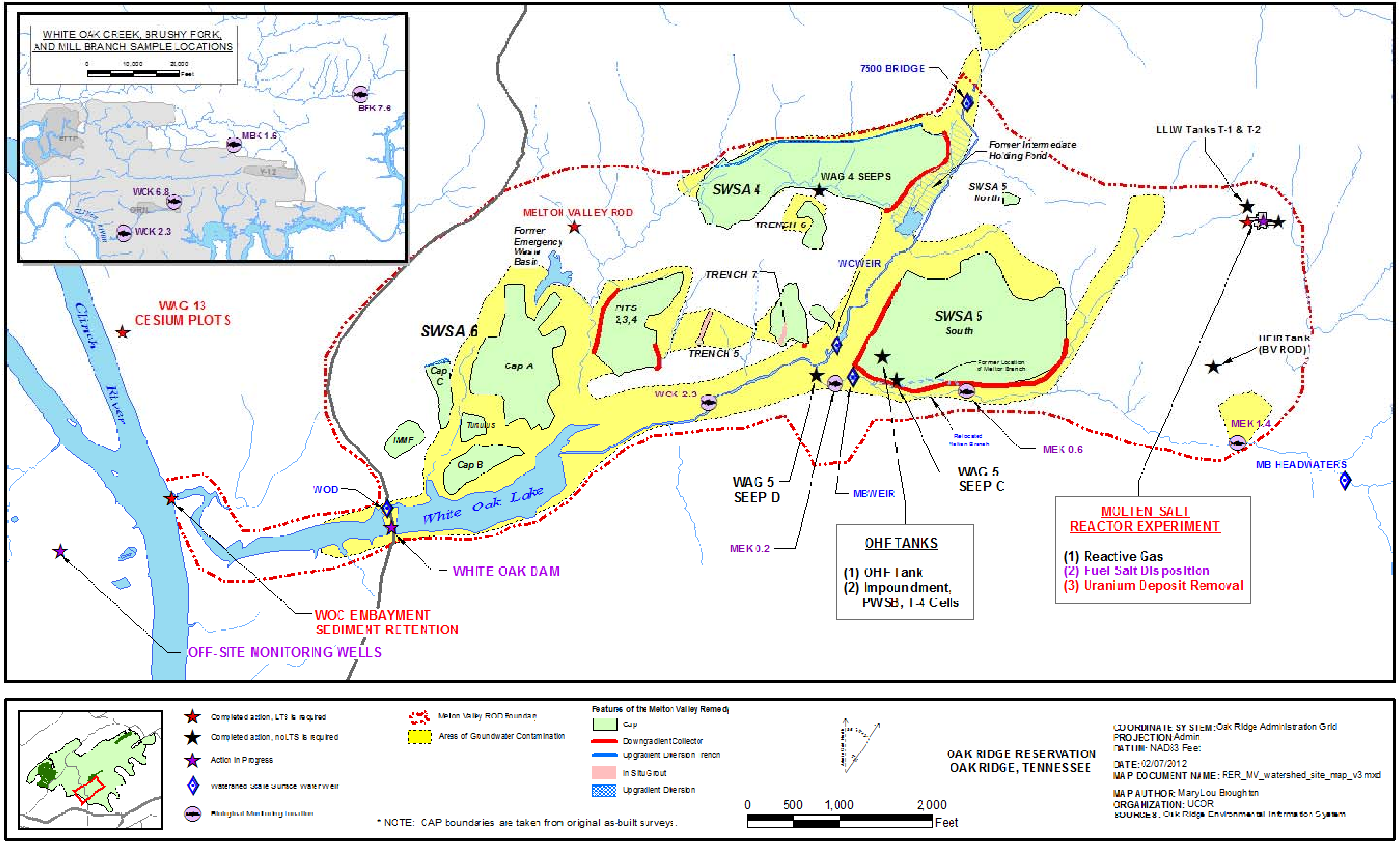

Figure 3.1 Melton Valley Watershed.

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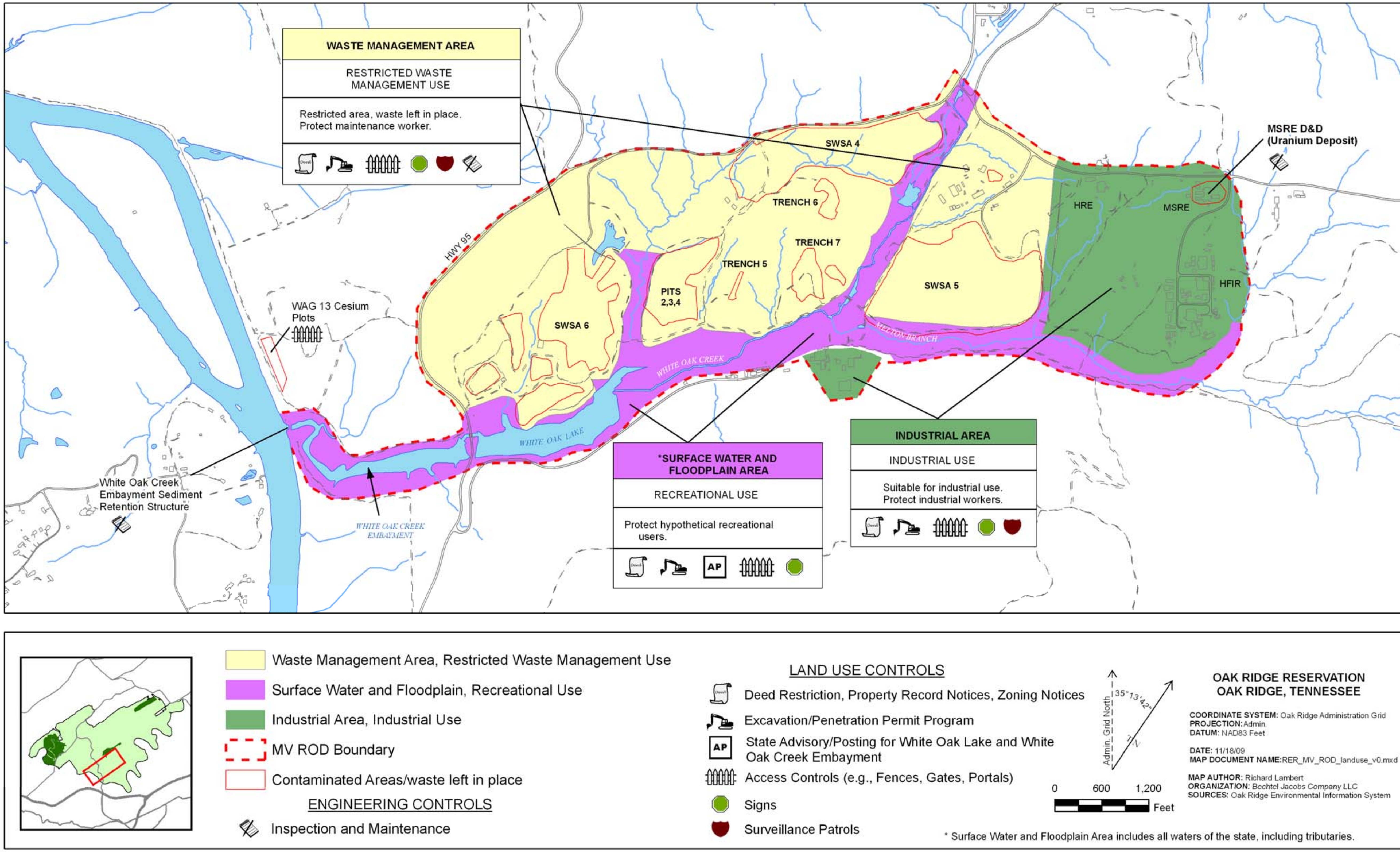

Figure 3.2. Melton Valley Record of Decision-designated end use and interim land use controls.

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Table 3.2. Long-term stewardship requirements in Melton Valley Watershed

<table>
<tr><th rowspan="2">Site/Project</th><th colspan="2">Long-Term Stewardship Requirements</th><th rowspan="2">Status</th><th rowspan="2">Section</th></tr>
<tr><th>Land Use Controls</th><th>Engineering controls</th></tr>
<tr><td colspan="5">Watershed-scale actions</td></tr>
<tr><td>ROD for Interim Actions for the Melton Valley Watershed
▪ SWSA 4 and IHP PCCR
▪ SWSA 5 PCCR
▪ SWSA 6 PCCR
▪ Seepage Pits and Trenches PCCR
▪ Trenches 5 and 7 PCCR
▪ Soils and Sediments PCCR
▪ Hydrofracture Well P&A PCCR
▪ NHF D&D PCCR
▪ OHF D&D PCCR
▪ HRE Ancillary Facilities D&D PCCR
▪ 7841 Equipment Storage Area and 7802F Storage Shed D&D PCCR</td><td>Watershed Land Use Controls
Administrative:
▪ land use and groundwater deed restrictions
▪ property record notices
▪ zoning notices
▪ permits program

Physical:
▪ state advisory / postings
▪ access controls
▪ signs
▪ security patrols</td><td>Hydrologic Isolation Projects[a] PCCRs specific:
▪ Maintain caps
▪ Operations and Maintenance of groundwater collection systems</td><td>Watershed Land Use Controls implemented under LUCIP:
▪ Physical land use controls in place.
▪ Administrative land use controls in place.[b]
▪ RCRA required notices complete.

Hydrologic Isolation Projects[a,b] PCCRs specific:
▪ Engineering controls remain protective.</td><td>3.2.5</td></tr>
<tr><td colspan="5">Completed single project actions</td></tr>
<tr><td>White Oak Creek Embayment Sediment Retention Structure</td><td></td><td>▪ Inspection and maintenance of SRS</td><td>▪ Engineering controls remain protective.</td><td>3.2.5.2.1</td></tr>
<tr><td>WAG 13 Cesium Plots Interim Remedial Action</td><td>▪ Long-term S&M of the fenced enclosure</td><td></td><td>▪ Land use controls in place.</td><td>3.2.5.2.2</td></tr>
<tr><td>MSRE D&D (Uranium Deposit) Removal Action</td><td></td><td>▪ Ongoing S&M</td><td>▪ Engineering controls remain protective.</td><td>3.2.5.2.3</td></tr>
</table>

[a]Hydrologic Isolation Projects include SWSA 4, SWSA 5, SWSA 6, and Seepage Pits and Trenches area.
[b]Zoning notices will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.

HRE = Homogeneous Reactor Experiment
IHP = Intermediate Holding Pond
LUCIP = land use controls implementation plan
MSRE = Molten Salt Reactor Experiment
NHF = New Hydrofracture Facility
OHF = Old Hydrofracture Facility
P&A = plugging and abandonment
PCCR = phased construction completion report
RCRA = Resource Conservation and Recovery Act
ROD = record of decision
S&M = surveillance & maintenance
SRS = Sediment Retention Structure
SWSA = solid waste storage area

(DOE 2011a). This removal action included grout-fill of the existing box culvert; fill, extend and armor the downstream slope of the dam; and fill and armor upstream of the dam.

- The Phased Construction Completion Report for the Removal and Transfer of the Uranium from the Molten Salt Reactor Experiment (DOE 2008) documenting the completion of the Fuel Salt Disposition project conducted at the Molten Salt Reactor Experiment facility was approved in October 2008. This action included the sequential processing of each of the three drain tanks to: (1) melt and chemically treat the salts, (2) fluorinate the salt to remove uranium, (3) trap the uranium on cold traps and transfer the uranium to chemical traps, and (4) ship the uranium loaded traps to Oak Ridge National Laboratory Bldg. 3019A for storage. Per agreement with the Environmental Protection Agency and the Tennessee Department of Environment and Conservation, the Record of Decision for Molten Salt Reactor Experiment Fuel Salt Removal (DOE 1998) requirements relative to uranium were considered completed when the uranium was delivered to Building 3019A. The commitment (DOE 1998) to transfer the residual transuranic salts to shielded canisters and interim storage at the Oak Ridge National Laboratory Solid Waste Storage Area 5 has been delayed. An Engineering Evaluation of Options for the Molten Salt Reactor Experiment Defueled Coolant Salts (DOE 2011b) evaluates the following six alternatives for addressing the remaining radioactive salts in the Fuel Flush Tanks and Fuel Salt Drain Tank:

  – maintain as-is for 50 years,

  – entomb salt tanks in place,

  – remove the “intact tanks”,

  – remove salt mechanically and disposit at the Waste Isolation Pilot Plant,

  – remove salt thermally and disposit at the Waste Isolation Pilot Plant, and

  – store salt on-site in an approved type-B container using one of the previously-listed removal methods.

  Non-destructive assay measurements for the defueled salts was completed in FY 2011 (DOE 2011c), and a Remediation Strategy Plan is scheduled for submittal in late September 2012.

3.2 RECORD OF DECISION FOR INTERIM ACTIONS FOR MELTON VALLEY WATERSHED

3.2.1 Performance Goals and Monitoring Objectives

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000):

- includes actions for the hydrologic isolation of burial grounds, removal of impoundments, grouting of Homogenous Reactor Experiment 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 land use controls;

- specifies surface water quality, surface water risk goals, and groundwater controls to be achieved within specified periods after completion of the remediation. The Record of Decision also includes specific performance objectives to be used as the metrics to evaluate the effectiveness of the remediation;

- stipulates a remedial action objective for Melton Valley based on the industrial use area (east of Solid Waste Storage Area 5), the Waste Management Area, the Surface Water and Floodplain Area, and for human receptors and ecological populations (Table 3.3). Yellow highlighted portions of the remedial action objectives are supported by ongoing monitoring and are discussed in detail in subsequent sections. Pink highlighted portions of the remedial action objectives are supported by long-term stewardship requirements;

- includes 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 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. Table 3.4 includes the performance objectives and performance measures for those elements of the remedy that specified post-remediation monitoring. Also, included in Table 3.4 are goal attainment dates and references to sections in this Remedial Effectiveness Report 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 13 wells in the vicinity of those two units for water quality evaluation. Results of that sampling and analyses are included in Sect. 3.2.2.2.3.

Groundwater emanating from capped waste areas is collected by downgradient interceptor trenches at Solid Waste Storage Area 5; along the eastern edge of Solid Waste Storage Area 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 Solid Waste Storage Area 4 before transfer to the Process Waste Treatment Complex in Bethel Valley. Water at the equalization tank is sampled to verify that the wastewater meets the facility waste acceptance criteria.

Table 3.3. Remedial action objectives 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 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 2000), Table 1.1.

[b]A future CERCLA decision will be prepared to determine whether additional actions are required for floodplain soil <2500 μR/hour.

[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 remedial actions including land use controls. 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 valleywide 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
HI = hazard index
SWSA = solid waste storage area

Table 3.4. 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 Sect. 3.2.2.1.3] ▪ *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 Sect. 3.2.2.1.2] ▪ *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 Sect. 3.2.2.2]
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 Sect. 3.2.2.1.3] • *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 Sect. 3.2.2.1.2] • *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 Sect. 3.2.2.2]
• ***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 Sect. 3.2.2.2]
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 Sect. 3.2.2.1.3] • *Comply with RCRA postclosure requirements for designated RCRA areas* (Ongoing). [See Sect. 3.2.5.1] • *Reduce groundwater throughflow in buried waste units by >75% as measured by >75% decrease in water*

Table 3.4. 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]**
		level fluctuations in selected monitoring locations inside the contained area. [See Sect. 3.2.2.2]
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 Sect. 3.2.2.1.3] • *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 Sect. 3.2.2.2]
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 Sect. 3.2.2.1.3] • *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 Sect. 3.2.2.1.3] • *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 Sect. 3.2.2.1.2]

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000), Table 2.17. NOTE: Non-italicized text within table references sections in the current document.

[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.

AWQC = ambient water quality criteria
HRE = Homogeneous Reactor Experiment
ISV = *in situ* vitrification
OHF = Old Hydrofracture Facility
RCRA = Resource Conservation and Recovery Act
RER = remedial effectiveness report
ROD = record of decision
SWSA = solid waste storage area

Table 3.4. Performance measures for major actions in the Melton Valley Watershed[a] (cont.)

P&A = plugging and abandonment
RAO = remedial action objective
TDEC = Tennessee Department of Environment and Conservation

3.2.2 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 2000). Performance monitoring includes surface water monitoring, groundwater monitoring, and biological monitoring. Monitoring locations are shown on Figures 3.1 and 3.2.

3.2.2.1 Surface Water Monitoring Data

This section presents the results of remedy effectiveness evaluation of surface water monitoring in the Melton Valley watershed. Section 3.2.2.1.1 summarizes the remediation goals for surface water; Section 3.2.2.1.2 presents information concerning major radionuclide concentrations and fluxes at the surface water integration point monitoring stations; and Section 3.2.2.1.3 presents data obtained at the tributary sampling locations.

3.2.2.1.1 Surface Water Quality Goals and Monitoring Requirements

Surface water goals include protection of the Clinch River to meet its stream use classification (e.g., 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 2000) includes specific surface water remediation levels (Table 3.5). Locations where surface water monitoring occurs to evaluate the remedy performance are shown on Figure 3.3. The following excerpts from the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) include the specific concentration goals for the principal surface water contaminants of concern in Melton Valley.

Table 3.5. 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 3.3 of RER	See Figure 3.3 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 3.7 of RER	See Table 3.6 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 2000), Table 2.18. NOTE: Non-italicized text within table is referencing figures and tables in the current document.

Table 3.5. Surface water remediation levels for the Melton Valley watershed[a] (cont.)

AWQC = ambient water quality criteria
N/A = not applicable
RER = remediation effectiveness report
TDEC = Tennessee Department of Environment and Conservation

Protect Clinch River to meet its stream use classification

This goal protects the Clinch River as a domestic water supply [i.e., meets Safe Drinking Water Act of 1974 maximum contaminant levels*] from contaminated surface water coming from Melton Valley. This goal provides residential risk-based limits for surface water at the confluence of White Oak Creek with the Clinch River. This goal will be met within ten years from completion of actions in Melton Valley and Bethel Valley. Remediation levels at the confluence of White Oak Creek with Clinch River will achieve an annual average excess lifetime cancer risk less than 1×10^{-4} and a hazard index 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 and/or White Oak Dam. Table 3.6 lists the remediation levels for the contaminants contributing to residential risk at White Oak Dam.

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. 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 1×10^{-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.

* MCLs refer to the Safe Water Drinking Act of 1974 maximum contaminant levels for drinking water.

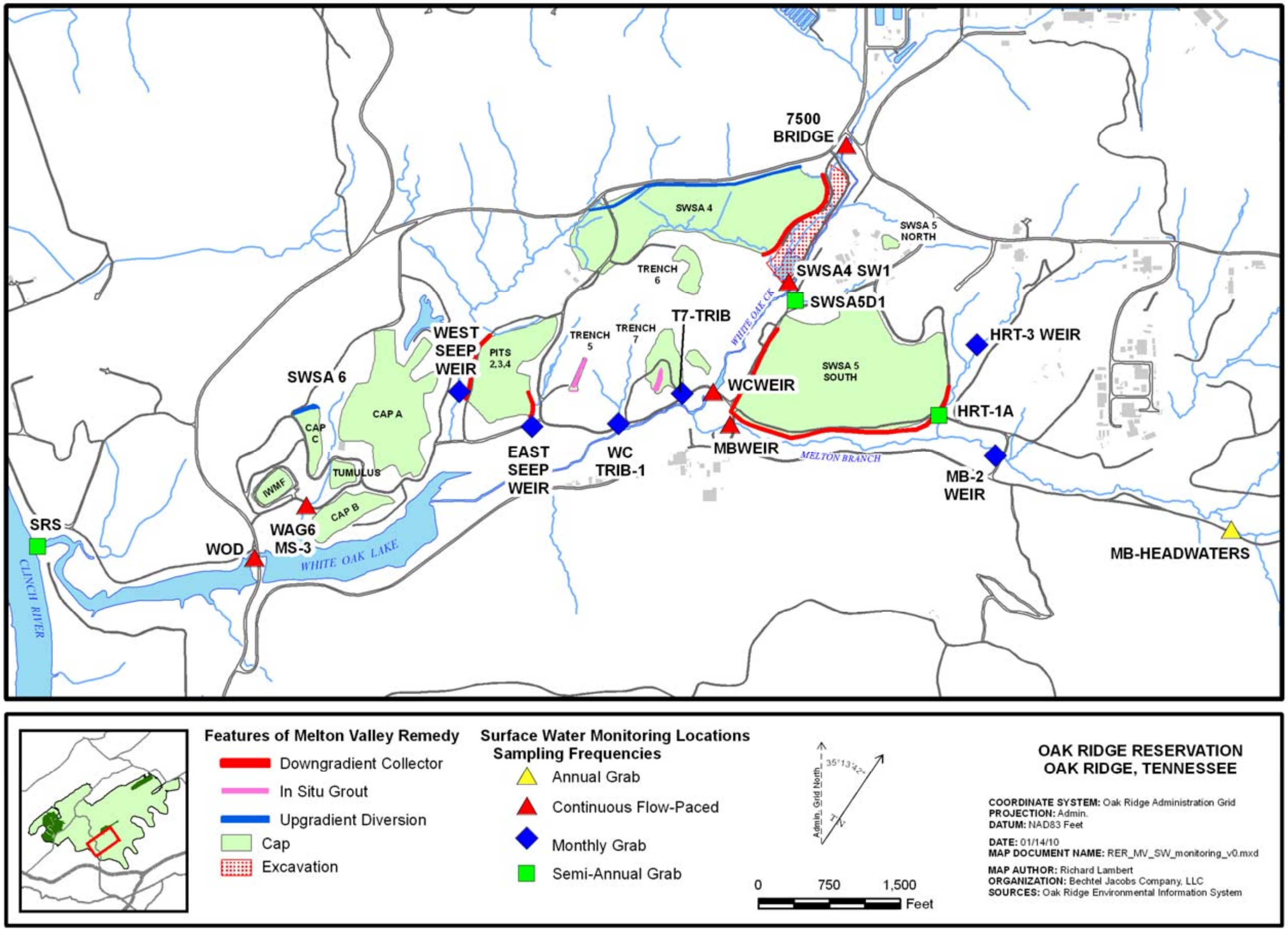


Figure 3.3. Melton Valley surface water monitoring locations.

Table 3.6. 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 White Oak Creek Embayment 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 X 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 2000), 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 2000 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

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}.

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 3.7 *[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 3.7. 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 White Oak Creek Embayment)*	*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 1×10^{-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 2000), 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 2000) 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.*

D = daughter products
NA = not applicable
ND = not detected or analyzed

3.2.2.1.2 Integration Point Monitoring Results

This section provides an evaluation of the surface water quality data collected at surface water integration points on White Oak Creek and Melton Branch during FY 2011 compared to the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) goals and performance metrics. Surface water monitoring locations are shown on Figure 3.3.

The principal surface water integration point monitoring station in Melton Valley is at White Oak Dam where White Oak Creek discharges from White Oak Lake. 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 at the 7500 BRIDGE. Table 3.8 displays the activities of ^{137}Cs, ^{90}Sr, and ^{3}H from the monthly flow-paced composite samples obtained at these main stem integration points.

Comparison of ^{137}Cs, ^{90}Sr, and ^{3}H activities measured at White Oak Dam (Table 3.8) with the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) goal (Table 3.6) is the basis for remedy effectiveness evaluation for protection of the Clinch River.

Figure 3.4 shows the annual average and average-plus-one standard deviation activities of ^{137}Cs, ^{90}Sr, and ^{3}H at White Oak Dam for FY 2001 through FY 2011. Total annual rainfall at the Oak Ridge National Laboratory is provided to enable long-term comparison of contaminant activities response to rainfall. Record of Decision 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, thus providing a reliable measure of the time-averaged contaminant activity. During FY 2011, all analytical results from flow-paced composite samples collected at White Oak Dam were below the risk-based activity goals.

Comparison of ^{137}Cs, ^{90}Sr, and ^{3}H activities (Table 3.8) measured at 7500 Bridge, WCWEIR, and MBWEIR, which are upstream integration monitoring locations, with the Record of Decision goal for a recreational scenario (Table 3.7) indicates that all results for FY 2011 are well below the risk-based goals for these constituents. 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 (DOE 2002).

Figure 3.5 shows the annual radionuclide flux for ^{137}Cs, ^{90}Sr, and ^{3}H measured at White Oak Dam and the Oak Ridge National Laboratory site total annual rainfall from FY 2001 through FY 2011. During FY 2011, rainfall was approximately 10% greater than the long term average of 54 inches. The total fluxes of ^{137}Cs, ^{90}Sr, and ^{3}H remained low and comparable to the FY 2007 through FY 2010 values.

Table 3.8. Summary of Fiscal Year 2011 radiological contaminant levels at surface water integration points in Melton Valley

	7500 BRIDGE			WHITE OAK CREEK WEIR			MELTON BRANCH WEIR			WHITE OAK DAM		
Monthly composite date	^{90}Sr	^{3}H	^{137}Cs	^{90}Sr	^{3}H	^{137}Cs	^{90}Sr	^{3}H	^{137}Cs	^{90}Sr	^{3}H	^{137}Cs
27-Oct-10	53.2	46,400	8.13	40	31,000	110	26	7,600	3.7(U)	57	38,000	16
24-Nov-10	47.5	29,200	9.24 (U)	50	33,000	5 (U)	60	7,900	4(U)	62	33,000	37
29-Dec-10	42.8	33,600	7.58(U)	37	21,000	11	49	8,100	4.2(U)	58	24,000	8.4
26-Jan-11	51.5	10,500	0 (U)	43	21,000	70	38	7,000	4.4(U)	59	11,000	7.1
23-Feb-11	34.4	22,000	21.2	43	25,000	9.1	34	7,200	3.9(U)	61	19,000	14
30-Mar-11	22.5	12,400	9.19	50	15,000	5.6	30	3,100	0.1(U)	43	12,000	6.8
27-Apr-11	30.2	10,100	12.4	31	9,300	7.9	32	2,700	3.5(U)	42	7,700	10
25-May-11	25	5,640	-2.82	58	27,000	5.7	35	3,100	0.9(U)	63	17,000	13
29-Jun-11	90.2	31,300	10.2	79	26,000	28	34	4,300	-0.21(U)	82	26,000	25
27-Jul-11	121	48,900	7.06 (U)	88	20,000	59	14	2,500	3.9(U)	**92**	26,000	9.5
31-Aug-11	83.7	54,200	33.5	68	54,000	53	20	3,500	4.2(U)	84	46,000	63
28-Sep-11	44.2	32,800	17.9	52	37,000	10	38	14,000	0.1(U)	65	40,000	9.4
Average concentration (pCi/L)	53.9	28,000	< 11.1	53	27,000	31	83	5,900	< 2.8	64	25,000	18
ROD Goal[a]	*1.33E+05*	*1.04E+08*	*2.37E+05*	*1.33E+05*	*1.04E+08*	*2.37E+05*	*1.33E+05*	*1.04E+08*	*2.37E+05*	85	58,000	150

ROD goals per Table 3.6 and 3.7.
Activity values are pCi/L.

U = reported activity was below the minimum detectable activity – analyte was not detected.

Bold value indicates sample concentration exceeds *Melton Valley ROD goal.*

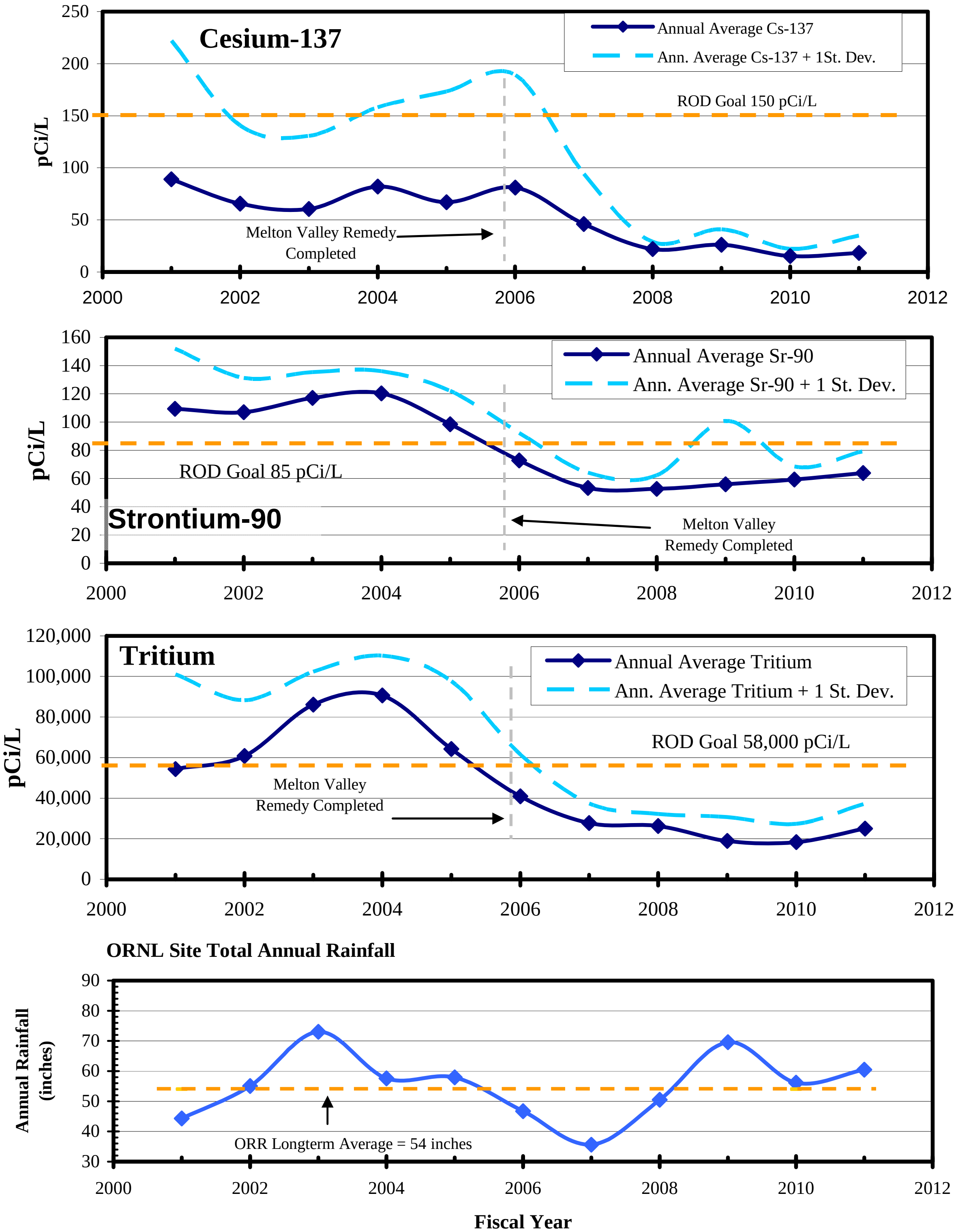


Figure 3.4. Annual average surface water activities of ^{137}Cs, ^{90}Sr, and ^{3}H at White Oak Dam.

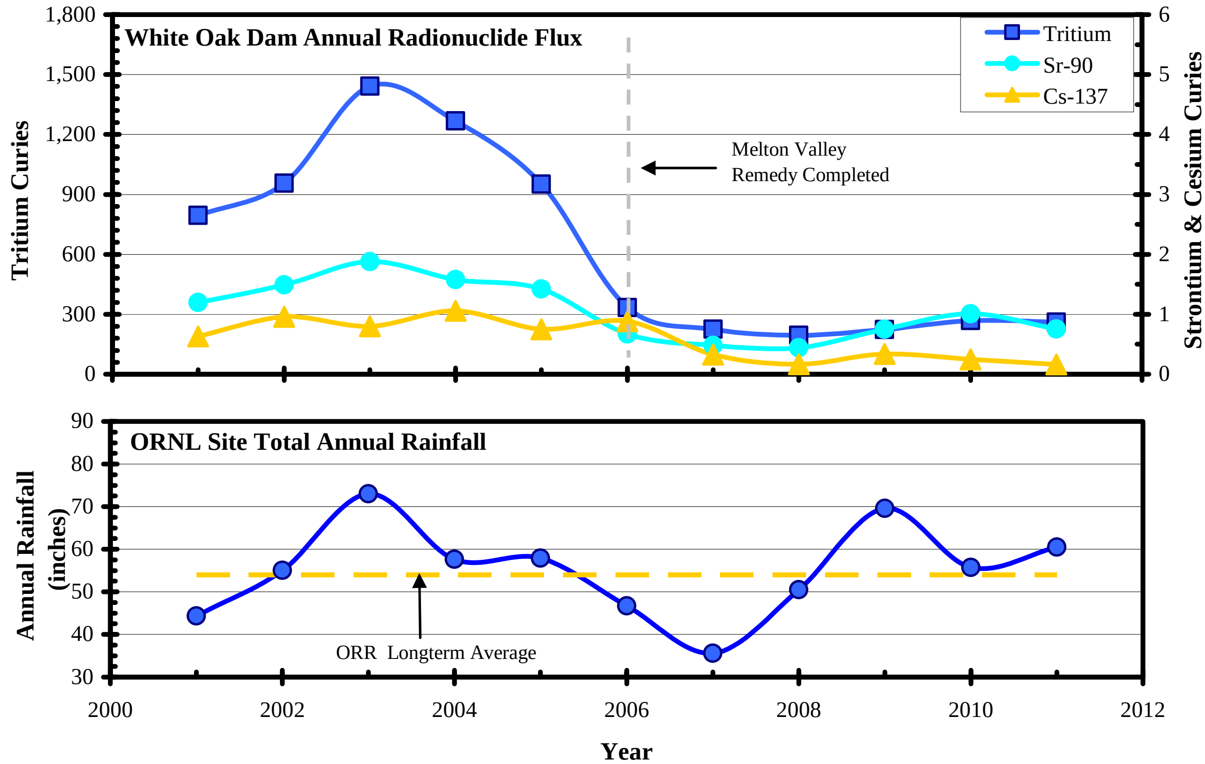


Figure 3.5. Annual radionuclide fluxes at White Oak Dam and annual rainfall at the Oak Ridge National Laboratory.

3.2.2.1.3 Tributary Surface Water Monitoring Results

Tributary monitoring locations (Figure 3.3) are sampled to evaluate the effect of remediation on water quality in tributaries to White Oak Creek and Melton Branch. Samples are obtained by the grab method, except at Waste Area Grouping 6 MS-3 and Solid Waste Storage Area 4 SW1 where flow-paced composite sampling is performed. Radiological remediation levels for surface water in the Melton Valley tributaries are in Table 3.7. Results of annual average radionuclide concentrations are in Appendix B. All results are well below the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) recreational goals for surface water. Graphs showing trends of the major radionuclides at key tributary monitoring locations are in Figures 3.6 and 3.7. 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. ^{3}H and ^{90}Sr activities increased at the Solid Waste Storage Area 4 SW1 location during FY 2011. This increase is attributed to Solid Waste Storage Area 4 downgradient trench performance issues noted in the *2010 Remediation Effectiveness Report* (DOE 2010c) and in the *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE 2011). During FY 2012, the downgradient extraction wells at Solid Waste Storage Area 4 will be redeveloped, which is expected to improve remedy performance in that area. This issue is carried forward in this document in Table 3.12.

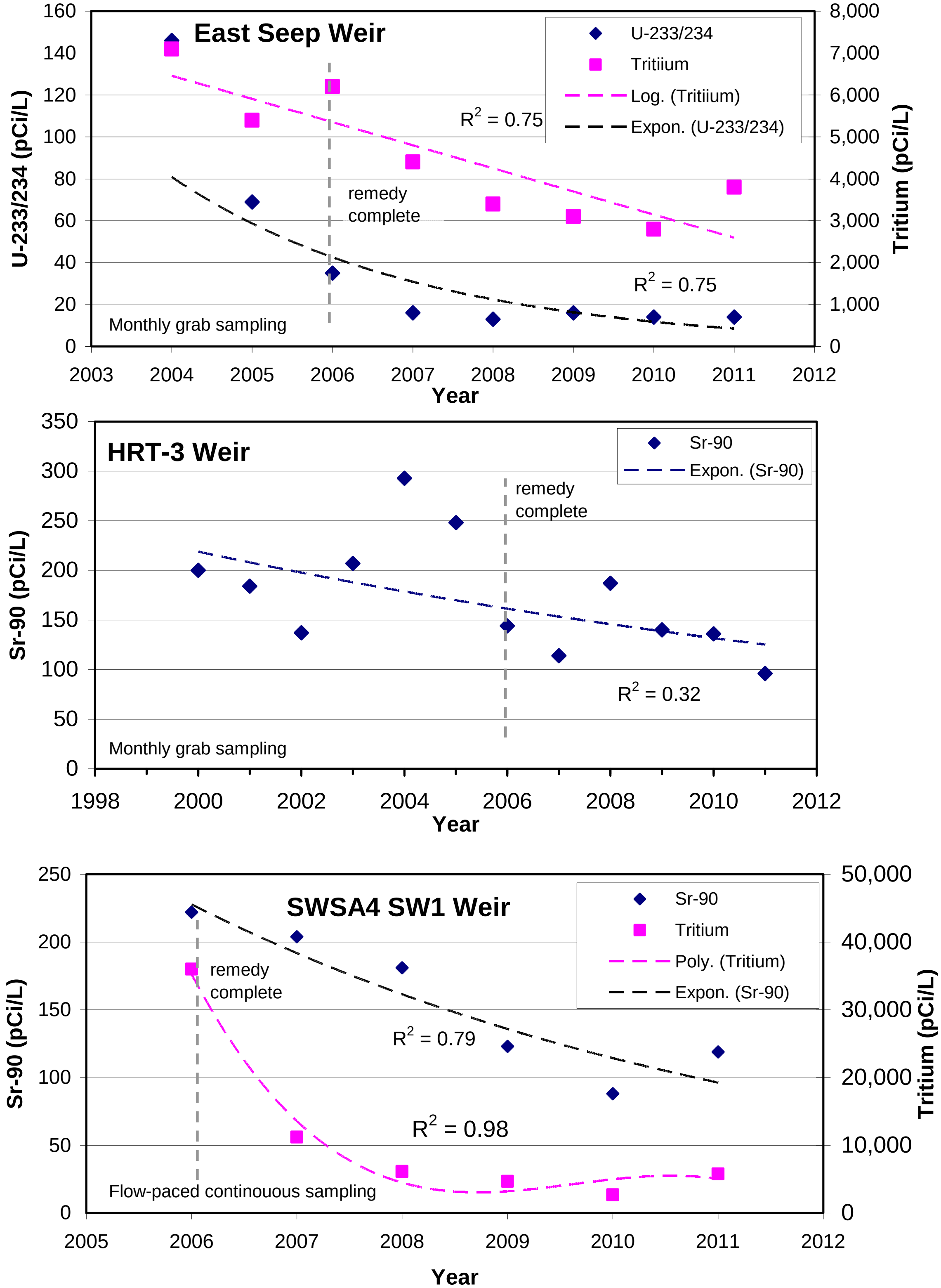


Figure 3.6. Tributary surface water average annual radionuclide activities at East Seep Weir, HRT-3 Weir, and Solid Waste Storage Area 4 SW1 Weir.

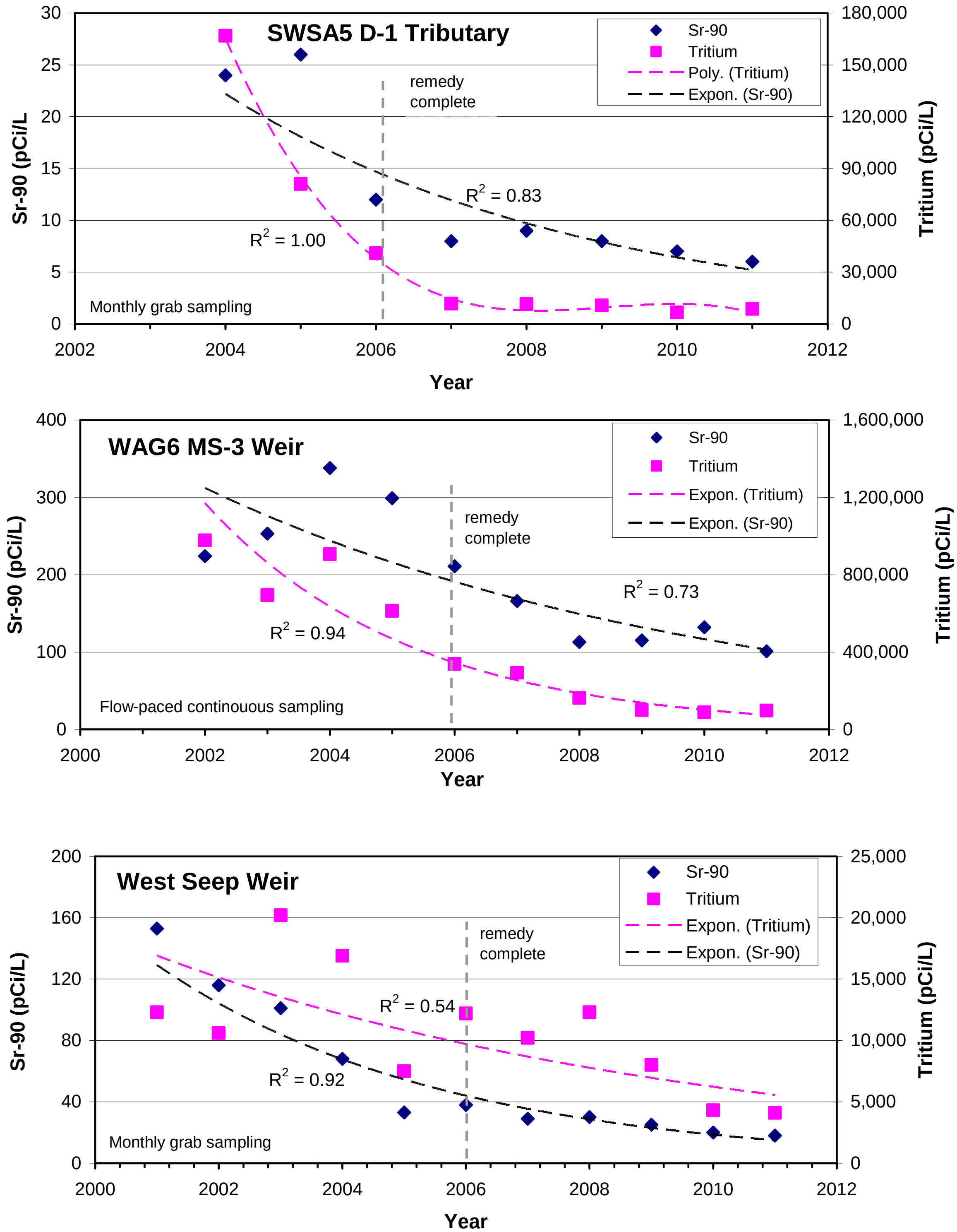


Figure 3.7. Tributary surface water average annual radionuclide activities at Solid Waste Storage Area 5 D1-Tributary, Waste Area Grouping 6 MS-3 Weir, and West Seep Weir.

3.2.2.2 Groundwater Monitoring Data

3.2.2.2.1 Groundwater Quality Goals and Monitoring Requirements

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) Remedial Action Objective for groundwater is to mitigate further impact to groundwater in the waste management and industrial land use areas (Table 3.3). 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. 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 3.4). Groundwater level control in hydrologic isolation areas is discussed in Sect. 3.2.2.2.2.

The Record of Decision 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 of groundwater at Solid Waste Storage Area 6 is conducted under the requirements of the Solid Waste Storage Area 6 Post-Closure Permit Application (pending approval by TDEC–Division of Solid Waste Management). Data obtained from the Solid Waste Storage Area 6 Resource Conservation and Recovery Act monitoring is used to evaluate the post-remediation groundwater quality conditions at the site perimeter. Monitoring results obtained to date in these areas are discussed in Sect. 3.2.2.2.3.

3.2.2.2.2 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. Contact of this water with buried waste materials was the source of contaminated leachate that subsequently seeped downward 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 Oak Ridge National Laboratory Process Waste Treatment Complex for treatment prior to discharge to White Oak Creek in Bethel Valley.

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) includes the performance goal of reducing groundwater-level fluctuations within hydrologically isolated areas by >75% from preconstruction fluctuation ranges (Table 3.4). 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. Existing 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.

Fifty four wells lie within hydrologic isolation areas and are used to evaluate groundwater fluctuations beneath caps. During FY 2011 over 90% of the 54 wells used to monitor hydrologic isolation effectiveness met their target groundwater elevations and six wells did not. Figure 3.8 shows the locations where groundwater-level monitoring is conducted to evaluate hydrologic isolation performance. Symbol shape and color 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. The reasons for these wells not attaining the design target elevations are related to the well construction characteristics, location very near edges of caps, location with respect to pre-remediation topography, or location near a downgradient trench. Wells that did not meet their target elevations during FY 2011 have attained essentially stable hydrologic response patterns and the same wells have been identified for several years.

Some shallow wells inside the hydrologically isolated areas have gone dry as a result of area capping and water level decline. Some shallow wells inside hydrologically isolated areas exhibit continuing water level declines as gradual drainage of groundwater toward collector trenches or adjacent surface water bodies occurs. Bedrock wells are observed to respond to head changes from areas outside hydrologic isolation structures which can cause target groundwater level exceedances. This condition is observed at Solid Waste Storage Area 6.

Appendix B 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 2011 are also included in Appendix B.

During FY 2011, the maximum measured groundwater elevation in six wells inside hydrologically isolated areas of Melton Valley exceeded the design target groundwater elevation (Figure 3.8). This number decreased from seven wells that exceeded target groundwater elevations during FY 2010.

Two wells in the Solid Waste Storage Area 6 area did not meet their target groundwater elevations during FY 2011. Well 4127 in western Solid Waste Storage Area 6 is a bedrock well that extends more than 20 feet below waste burial trench floor elevations in the adjacent capped area. Groundwater elevation is measured monthly and the hydrograph for well 4127 is shown in Figure 3.9. This well monitors groundwater level fluctuation beneath a fairly narrow cap that lies between two surface water drainages. The groundwater elevation measured in well 4127 shows a strong seasonal fluctuation signature and wet season levels are similar to the ground surface elevations in the adjacent ravines where wet-weather streams exist. The groundwater levels measured in well 4127 are probably controlled by the shallow groundwater levels in areas adjacent to the cap. A well (2217) further downslope beneath the same cap monitors groundwater levels in a shallow waste burial trench and that well was dry during all measurements during FY 2008 through 2011, indicating that the cap is preventing trench flooding.

Well 0850 is located in the central portion of Solid Waste Storage Area 6 in a former ravine area. The well extends approximately 13 feet below the estimated floor elevations of nearby waste burial trenches beneath the adjacent capped area. Water-level monitoring data indicate that during the wet season the groundwater level in the well rises above the target groundwater elevation. The hydrograph response for well 0850 (Figure 3.9) shows a muted response to rainfall events and a strong seasonal fluctuation signature suggesting that the well is responding to groundwater level variations caused by recharge to areas outside the capped area. As shown in Figure 3.9, the water level in well 0850 remained high through the summer of 2009 and into the summer of 2010 when levels again declined. Water quality data from well 0838, which is located downgradient from well 0850, was reviewed to determine if contaminant levels from that portion of Solid Waste Storage Area 6 are adversely affected by the groundwater levels near well 0850. VOCs are not detected at well 0838, nor are alpha and beta activity. ^{3}H is detected in well 0838, as it was in surface water from the area prior to remediation, and since FY 2004 the ^{3}H

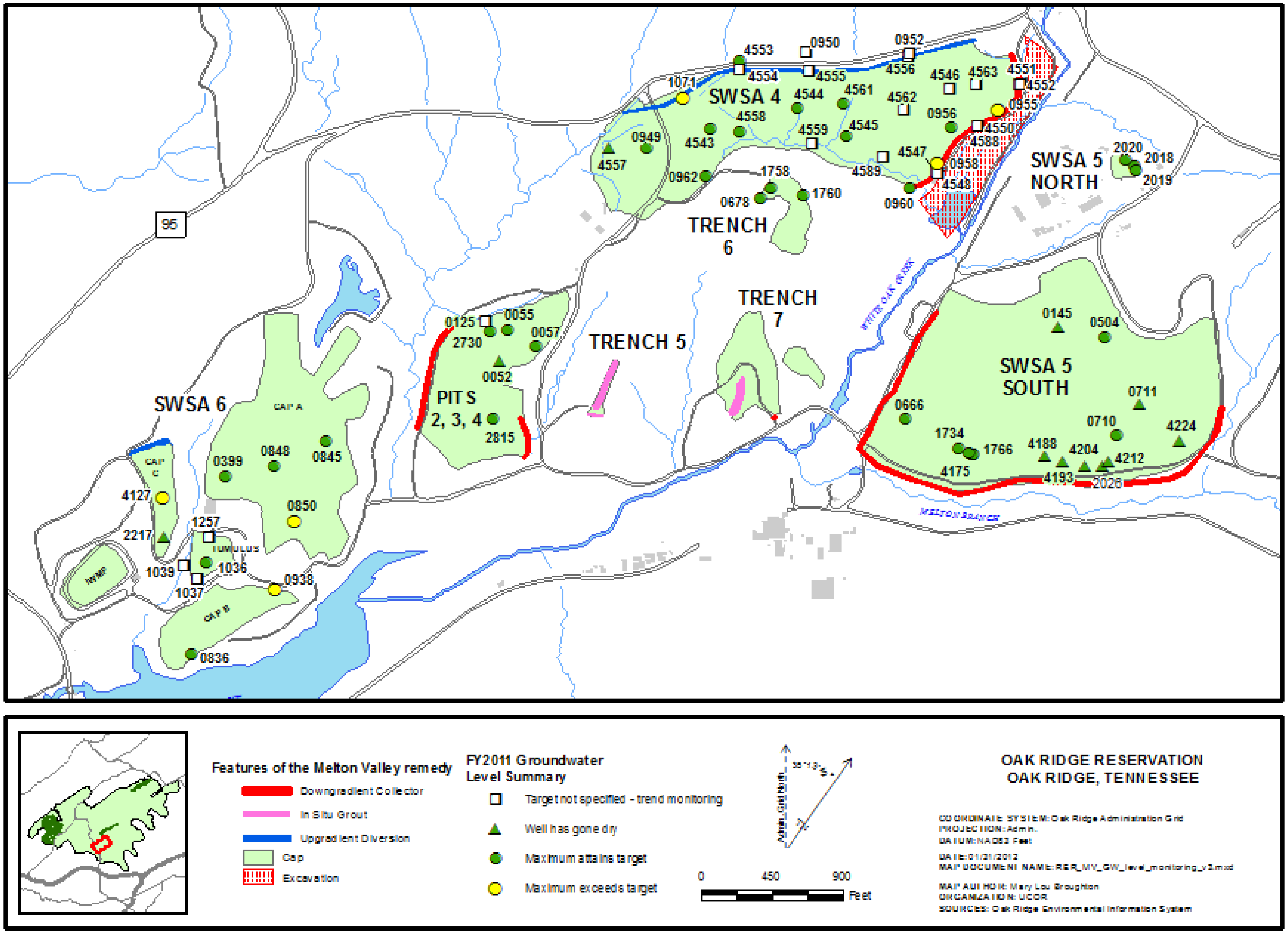


Figure 3.8. Summary of groundwater-level monitoring results for FY 2011.

concentrations have decreased exponentially from more than 200,000 pCi/L to less than 10,000 pCi/L. This decrease in ^{3}H concentration in this area is a continuation of tritium concentration reduction observed since about FY 2003 and suggests that the groundwater levels observed at well 0850 are not causing mobilization of contaminants from the area.

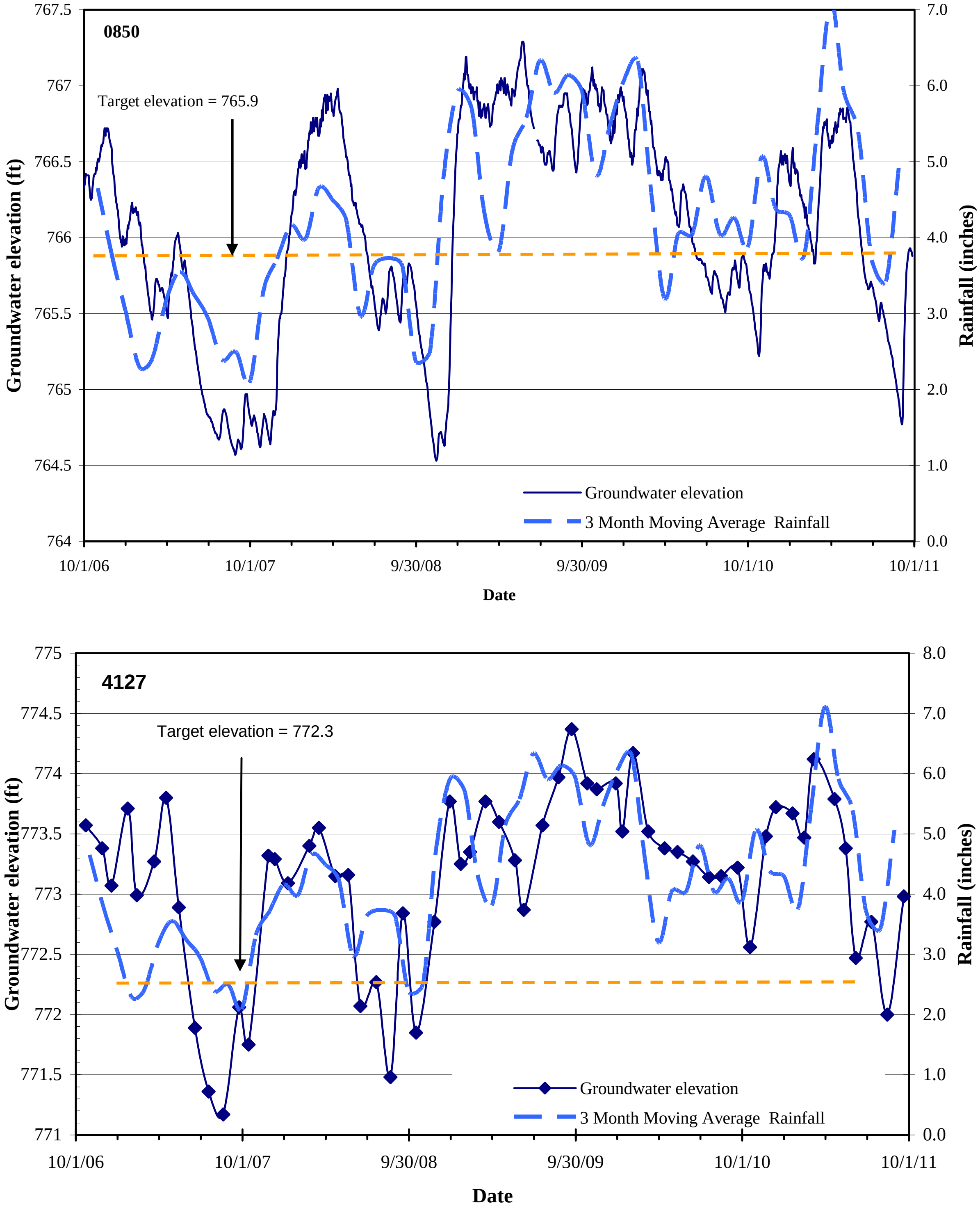


Figure 3.9. Hydrographs for wells 4127 and 0850 for FY 2007 through FY 2011.

Three wells in Solid Waste Storage Area 4 did not attain their target elevations in FY 2011 – well 1071 in the western part of the burial ground and wells 0955 and 0958 located near the Solid Waste Storage Area 4 downgradient trench (Figure 3.8). Well 1071 is located near a former surface water drainage feature that crossed Solid Waste Storage Area 4 from northwest to southeast. This area formerly carried runoff from an upslope area of about 16.5 acres. During construction of the Solid Waste Storage Area 4 Upgradient Diversion Trench, a clay plug was constructed across the mouth of the upslope valley in conjunction with the installation of the Solid Waste Storage Area 4 Upgradient Diversion Trench to prevent continued seepage into the hydrologically isolated burial ground. The well 1071 hydrograph (Figure 3.10) shows that groundwater levels fluctuate within a range of slightly greater than one foot. During dry seasons, the groundwater tends to drop below the target elevation; however, during wet seasons the level exceeds the target elevation. The groundwater-level behavior of other wells within the former Solid Waste Storage Area 4 tributary area to the east and downgradient of well 1071 (wells 4558 and 4559) do not indicate that a large amount of water is moving through the former surface drainage features because their water levels are stable or continuing to decrease gradually.

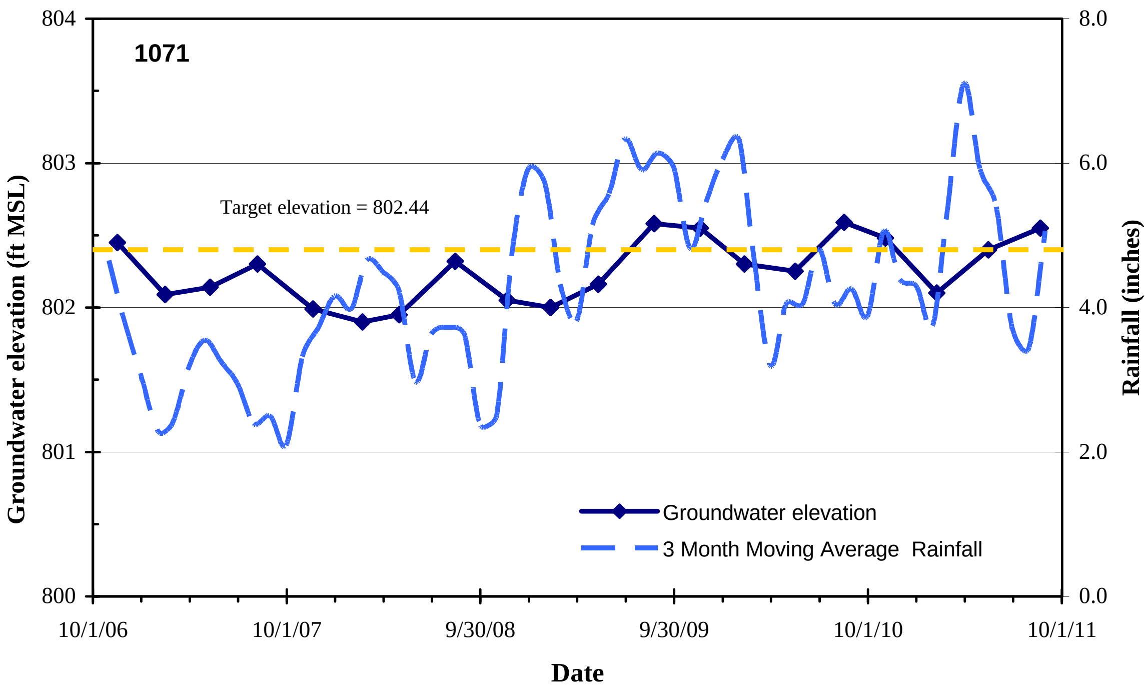
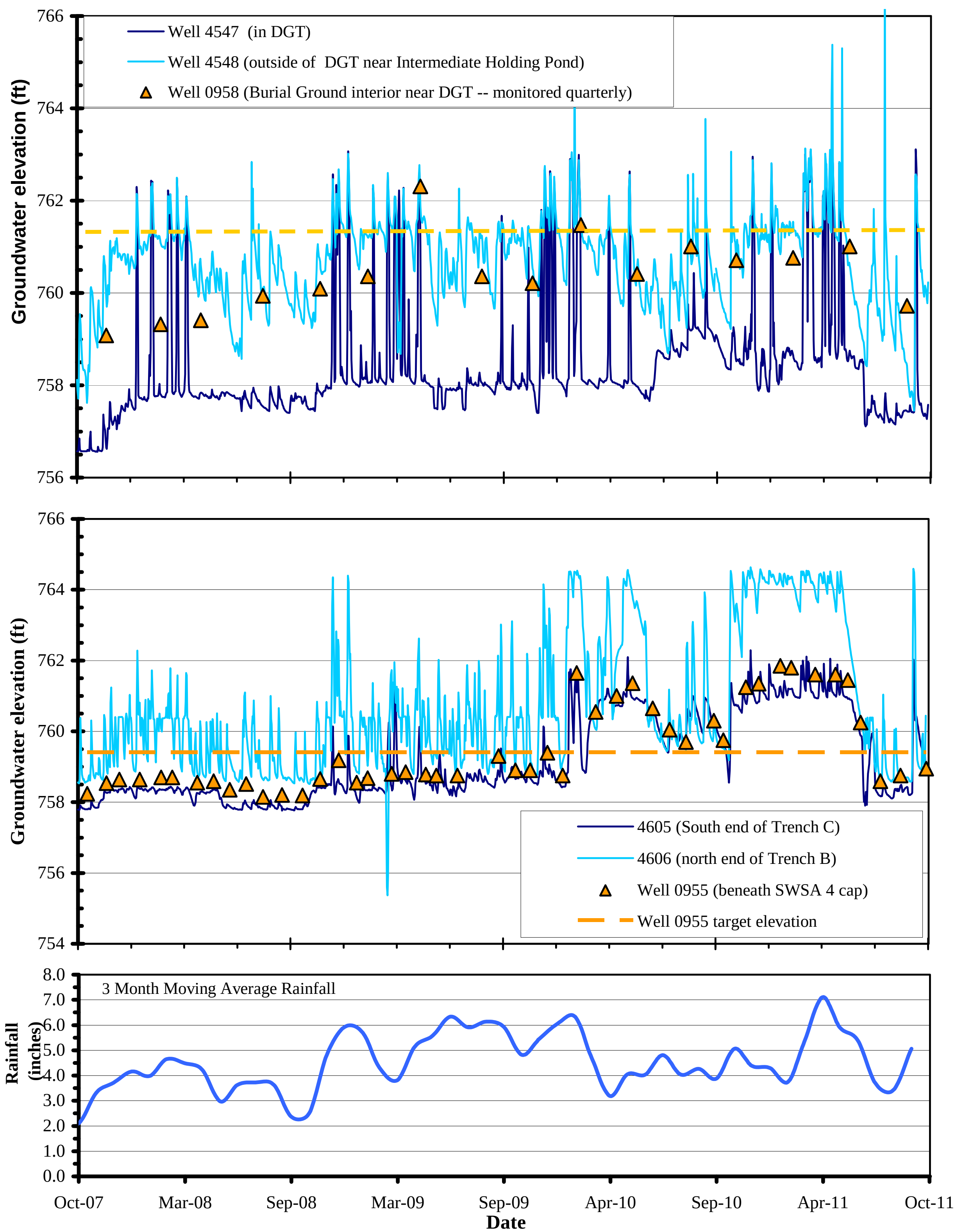


Figure 3.10. Hydrograph for well 1071.

MSL = mean sea level

The other well in Solid Waste Storage Area 4 that did not meet target groundwater levels during FY 2011 was Well 0955, which is located near the downgradient groundwater collection trench inside the hydrologically isolated area. Figure 3.11 includes hydrographs of wells 0955 and 0958 and nearby wells in the downgradient trench and former Intermediate Holding Pond area. The Solid Waste Storage Area 4 downgradient trench was excavated in three segments of nearly equal length with short (about 10 ft) unexcavated soil breaks separating the southern (A segment) and northern (C segment) from the mid section (the B segment). Water levels are monitored continuously in piezometers installed in each trench segment and in the former Intermediate Holding Pond area to measure the head gradient imposed by pumping in the trench segments. The water-level measurements at well 0955 (monthly) and 0958 (quarterly) are made manually.



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

Figure 3.11. Hydrographs of wells in Solid Waste Storage Area 4, the downgradient trench, in the former Intermediate Holding Pond area.

Well 0955 is located at the boundary between the mid-section (B segment) and northern (C segment). The hydrograph of well 0955 (Figure 3.11) indicates periodic conditions when the northern (C segment) pumps have difficulty maintaining drawdown in the trench and the pumps in the mid segment (B segment) have experienced more chronic difficulty maintaining drawdown. These data are indicative of deterioration in performance of the Solid Waste Storage Area 4 downgradient system that started during FY 2010 and continued until summer 2011. Figure 3.12 shows the hydrographs for the water level monitoring of the downgradient trench from the beginning of FY 2007 through FY 2011. The trace of the 3-month moving average rainfall shown on the hydrographs corresponds fairly well to periods when water levels in the trenches rise and gradient control is impaired. Intense rainfall causes water levels outside the hydrologically isolated area (in the Intermediate Holding Pond) to rise, which can cause water to flow into the downgradient trench more rapidly than the pumping system can remove. Data through FY 2009 showed that this condition was observed to occur for periods of 3 to 4 days, after which the storm runoff subsided and the downgradient trench pumps would draw the trench groundwater levels back down. However, during FY 2010 and 2011, the hydrograph for the B segment shows that conditions appear to have changed and the pumps are drawing down head less than during previous years. A similar condition appears to affect the A trench segment as well.

Additional monitoring was conducted during winter of 2011 that confirmed that contaminated water is discharged to surface water outside of the Solid Waste Storage Area 4 containment system following wet season storms after surface water inundates the downgradient trench. Similar conditions are not observed at the other downgradient collection trenches in Melton Valley because a different design was used that prevents groundwater in-leakage from outside the collection trench. Winter months are the season during which most groundwater recharge occurs because the dormant vegetation cannot lower soil moisture levels through evapotranspiration. This sampling, confirming the seepage to surface water from Solid Waste Storage Area 4, closes out an issue that was identified in the 2011 Remediation Effectiveness Report as indicated on Table 3.12. The Solid Waste Storage Area 4 downgradient trench extraction system will be evaluated to determine options to enhance system performance. This is an issue carried forward on Table 3.12. Monitoring will continue to determine the trench effectiveness.

An important element of the Solid Waste Storage Area 4 hydrologic isolation system is the upgradient diversion trench that prevents shallow storm flow water from entering the burial ground from the upslope side (Figure 3.8). The diversion trench is a narrow trench with a horizontal pipe in its base and sand backfill that captures seepage in near surface soil and weathered bedrock. This seepage water is discharged to the ground surface and is drained away from the burial ground at the eastern and western ends. Three well pairs exist along the diversion trench to measure the difference in groundwater level fluctuations upgradient vs. inside the burial ground where hydrologic isolation prevents direct infiltration of rainfall into the buried waste unit. Figure 3.13 shows hydrographs for wells 0950 (upslope) and 4555 (within hydrologic isolation). The fluctuations measured upslope versus downslope of the upgradient diversion trench demonstrate a ~90% damping of the hydrologic stresses in that area.

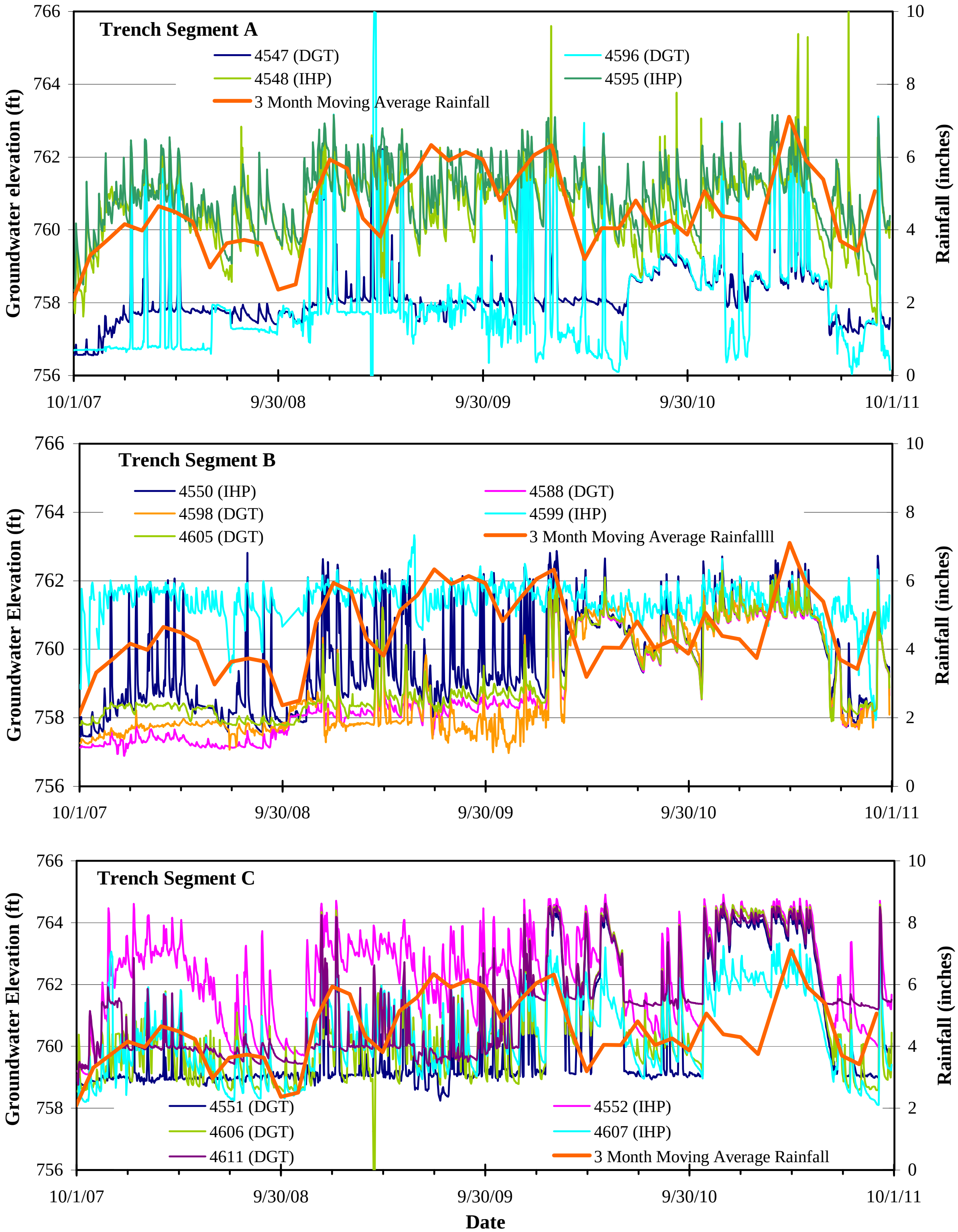
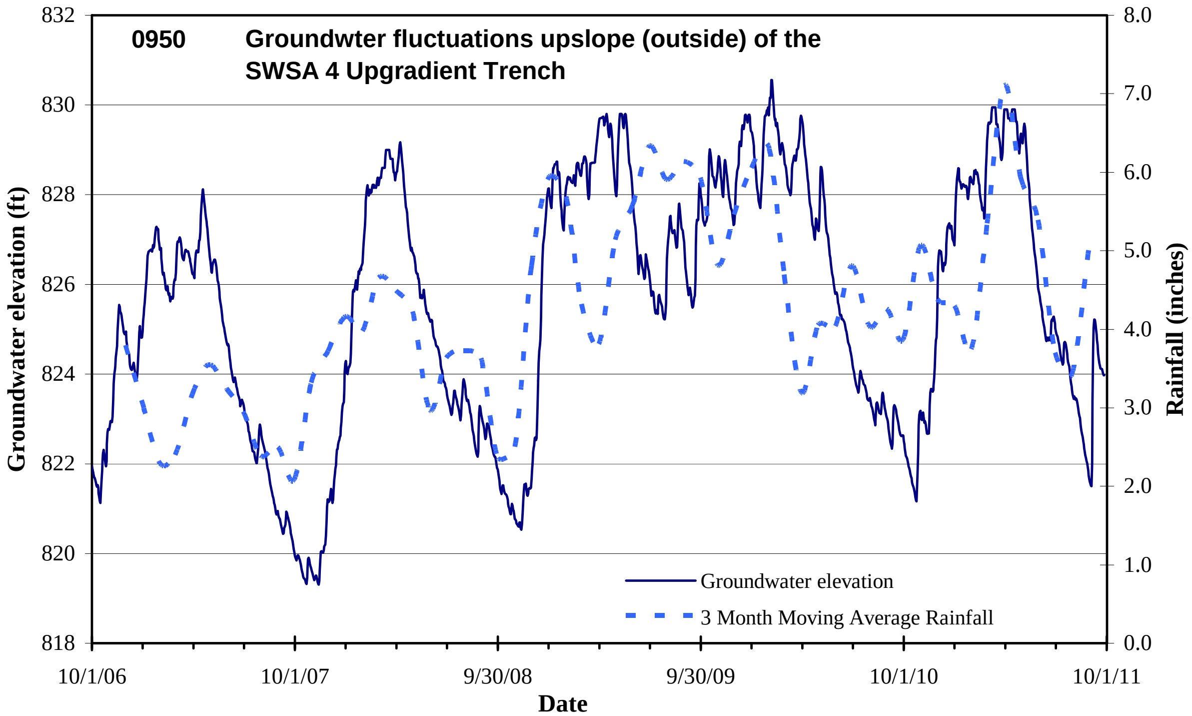


Figure 3.12. Hydrographs from piezometers monitoring the SWSA 4 downgradient trench performance.



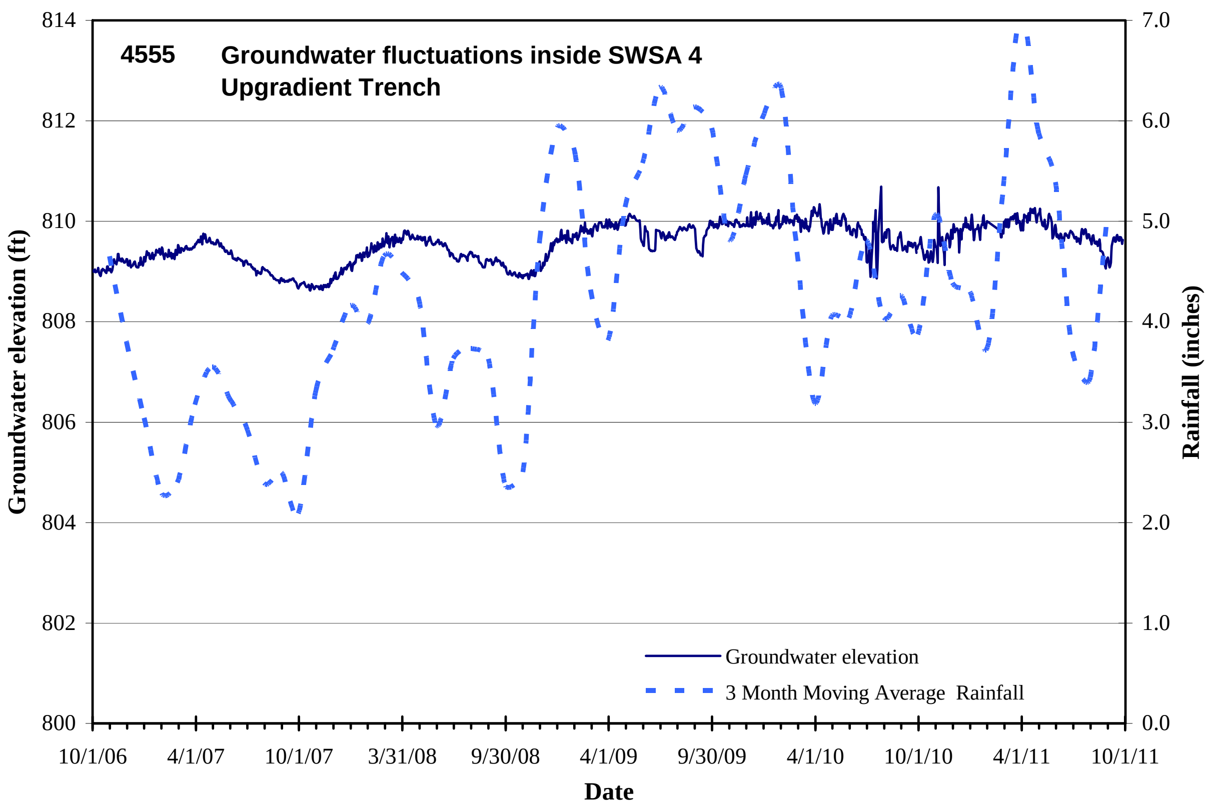


Figure 3.13. Comparison of groundwater fluctuations upslope and within Solid Waste Storage Area 4 hydrologic isolation near the upgradient diversion trench.

3.2.2.2.3 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 Solid Waste Storage Area 6. Additionally, groundwater monitoring is conducted at Solid Waste Storage Area 6 in compliance with the proposed Resource Conservation and Recovery Act permit requirements. The results are reported annually to the Tennessee Department of Environment and Conservation (TDEC) Division of Solid Waste Management and are summarized in this section.

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 Waste Area Grouping 7), as well as in the immediate proximity to Liquid Low-Level Waste Seepage Trenches 5 and 7.

Figure 3.14 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 2000) remedial actions. 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 radiolonuclides detected at the Seepage Pits and Trenches include ^{14}C, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{3}H, ^{232}U, $^{233/234}$U, and ^{238}U. ^{14}C was a constituent of the Liquid Low-Level Waste disposed in the seepage trenches, and because the chemical treatment used to immobilize strontium and cesium had little affect 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 3.9 includes a summary of radiological contaminants for 15 wells in the 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 2011 activity level, and the ratio of FY 2011 activity to pre-remediation activity (which indicates the factor by which contaminant levels have changes since remediation). Table 3.9 identifies the trend of radionuclide activity levels over a four-year post-remediation time period (January 2008 through September 2011) 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 except ^{232}U at well 1712. The method provides a 90% confidence level that the trend is significant.

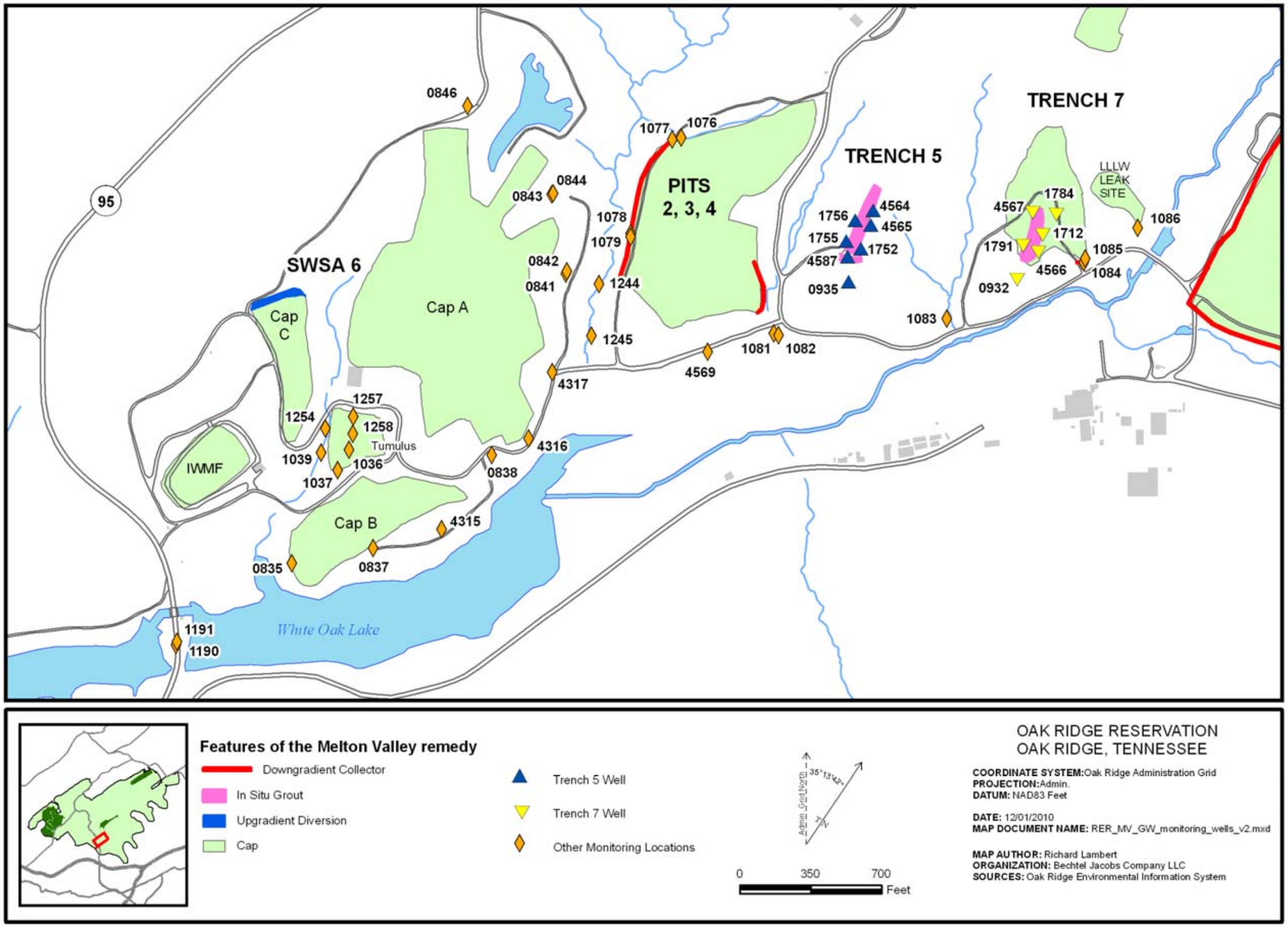


Figure 3.14. Locations of wells monitored in the vicinity of the Seepage Pits and Trenches and Solid Waste Storage Area (SWSA) 6.

Table 3.9. Summary of radiological groundwater contaminants detected at Seepage Pits and Trenches

Area	Well	Contaminant	Average Activity (pCi/L)		Ratio (FY11/Pre -Remedy)	Exceeds Screening Level	Mann Kendall Post-Remedy Trend
			Pre-Remedy	FY 2011			
Pits 2, 3, 4	1076	Strontium-90	14.23	9.65	0.7	MCL - EDE	Decreasing
	1079	Alpha activity	478	239	0.5	MCL	Decreasing
		Tritium	130,333	98,950	0.8	MCL - EDE	Decreasing
		Uranium-233/234	264	241	0.9	Industrial	Decreasing
Trench 5	1752	Alpha activity	932	335	0.4	MCL	Stable
		Carbon-14	246,667	66,800	0.3	Industrial	Stable
		Technetium-99	28,100	5,855	0.2	MCL - EDE	Decreasing
		Uranium-232	66.7	61.3	0.9	Industrial	Stable
		Uranium-233/234	593	364	0.6	Industrial	Stable
	1755	Alpha activity	1,687	1,048	0.6	MCL	Stable
		Carbon-14	109,700	34,400	0.3	Industrial	Decreasing
		Technetium-99	4,177	2,005	0.5	MCL - EDE	Stable
		Uranium-232	150	184	1.2	Industrial	Stable
		Uranium-233/234	884	1070	1.2	Industrial	Stable
		Uranium-238	111	86.6	0.8	Residential	Stable
	1756	Alpha activity	2,464	314	0.1	MCL	Stable
		Carbon-14	59,700	15,800	0.3	Industrial	Stable
		Technetium-99	4,403	1,250	0.3	MCL - EDE	Decreasing
		Uranium-232	189	41.8	0.2	Residential	Stable
		Uranium-233/234	1,416	307	0.2	Industrial	Stable
	4564	Alpha activity	73.53	44.4	0.6	MCL	Stable
		Carbon-14	33,467	8,560	0.3	Residential	**Increasing**
	4565	Carbon-14	57,600	10,025	0.2	Residential	Decreasing
		Technetium-99	3,664	1,266	0.3	MCL – EDE	Decreasing
		Tritium	56,050	28,150	0.5	MCL	Stable
	4587	Alpha activity	55.40	91.65	1.7	MCL	**Increasing**
		Carbon-14	34,700	35,550	1	Industrial	Stable
		Technetium-99	8,150	2,815	0.3	MCL - EDE	Decreasing
	0935	Tritium	38,000	30,650	0.8	MCL	Decreasing
Trench 7	1084	Carbon-14	38,400	8,110	0.2	Residential	Decreasing
	1712	Alpha activity	290	320	1.1	MCL	**Increasing**
		Carbon-14	59,500	32,100	0.5	Industrial	Stable

Table 3.9. Summary of radiological groundwater contaminants detected at Seepage Pits and Trenches (cont.)

Area	Well	Contaminant	Average Activity (pCi/L)		Ratio (FY11/Pre -Remedy)	Exceeds Screening Level	Mann Kendall Post-Remedy Trend
			Pre-Remedy	FY 2011			
		Uranium-232	35	64.1	1.8	Industrial	N/A[a]
		Uranium-233/234	215	257	1.2	Industrial	**Increasing**
	1784	Alpha activity	53.53	22.3	0.4	MCL	**Increasing**
		Carbon-14	16,400	7,015	0.4	Residential	Stable
	1784	Strontium-90	202	10.6	0.1	MCL – EDE	Decreasing
Trench 7	1791	Alpha activity	7	48.05	7.2	MCL	Stable
		Carbon-14	27,300	15,800	0.6	Industrial	Decreasing
		Technetium-99	898	12,900	14.4	MCL - EDE	**Increasing**
	4566	Alpha activity	51.00	20.35	0.4	SDWA	Stable
		Carbon-14	148,467	49,050	0.3	Industrial	Stable
		Cobalt-60	2,743	1,260	0.5	Industrial	Decreasing
		Technetium-99	1,250	1,760	1.4	MCL - EDE	Stable

[a]N/A = an insufficient number of uranium-232 detections have occurred to conduct a Mann-Kendall trend evaluation.

EDE = effective dose equivalent
MCL = Safe Drinking Water Act maximum contaminant level
Industrial = industrial scenario 1 x 10-4 risk-based activity
Residential = residential scenario 1 x 10-4 risk-based activity
MCL-EDE = (tritium MCL EDE = 20,000 pCi/L, 99Tc MCL EDE = 900 pCi/L, and 90Sr MCL EDE = 8 pCi/L).
SDWA = Safe Drinking Water Act

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) did not specify target groundwater contaminant levels but stated that the remedy should "Mitigate further impact to groundwater" (Sect. 3.2.1, Table 3.3). To provide a sense of risk levels associated with the detected radionuclides, FY 2011 contaminant levels are compared to 4 screening criteria: Safe Drinking Water Act Maximum Contaminant Levels (MCL) (as applicable), individual effective dose equivalents to the 4 mrem/yr MCL for beta particle and photon activity (8 pCi/L for ^{90}Sr, 900 pCi/L for ^{99}Tc , and 20,000 pCi/L for ^{3}H), 1 X 10^{-4} risk equivalent activities for industrial (based on RAIS risk calculator) or residential (based on Environmental Protection Agency 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 3.9, 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 3.9, 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 2011 to pre-remediation levels was 0.5 indicating that the median reduction observed is about a factor of 2. In most instances the trend evaluations show that post-remediation radionuclide levels are stable or decreasing. Exceptions are observed, particularly in the vicinity of Trench 7 where ratios of FY 2011 to pre-remediation levels are positive and increasing trends are also observed. The cause of these increases is not known. Possible factors may include changes in groundwater flow patterns beneath the capped area covering Trench 7 and/or affects of fluids displaced during the grouting process at that trench.

Three tributaries to White Oak Creek originate in, or receive water from the Seepage Pits and Trenches, as shown on Figure 3.3. Review of the surface water tributary monitoring (Sect. 3.2.2.1.3, Figures 3.6 and 3.7) 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 3.3 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 White Oak Creek. Although data from the White Oak Creek TRIB-1 location is not summarized in Sect. 3.2.2.1.3, contaminant levels there have also diminished since site closure.

Solid Waste Storage Area 6 Groundwater Monitoring Results

The Resource Conservation and Recovery Act (RCRA) monitoring program samples 10 wells around the perimeter of Solid Waste Storage Area 6 (Figure 3.14). Well 0846 is the designated upgradient well. 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-DCA. These constituents are detected regularly in wells 0841 and 0842, located on the eastern boundary of Solid Waste Storage Area 6. Monitoring data indicate that the concentrations of regulated hazardous constituents in groundwater are generally stable to gradually decreasing. CERCLA radiological monitoring of groundwater is also conducted in these wells. The principal and most mobile radionuclide detected in groundwater is ^{3}H. The highest ^{3}H activities in the Resource Conservation and Recovery Act well network are measured in wells 0841, 0842, 0843, 0844, and 4316 along the eastern site boundary. Tritium activity trends are decreasing in wells 0841, 0842, and 0843. However, tritium in well 0844 continues to follow a long-term increasing trend. Tritium activity in well 4316 increased significantly between 2003 and 2008 but has been on a decreasing trend since 2008. The groundwater contaminant trends along the eastern edge of Solid Waste Storage Area 6 suggest that contamination in bedrock wells is susceptible to trends that started long before Melton Valley closure and those trends are slow to respond to the burial ground capping. Trend graphs of the contaminants noted above are included in Appendix B.

^{3}H is also monitored in groundwater around the Tumulus low-level solid waste disposal facility where historic discharges from containerized waste created a groundwater ^{3}H plume. Six wells (Figure 3.14) at the Tumulus are sampled to measure the groundwater tritium trends. Trend plots for ^{3}H in these wells are included in Appendix B. Wells 1036 and 1258 exhibit the highest ^{3}H levels. Gradually increasing trends at observed at wells 1036 and 1258 between 2006 and 2009 appear to have reached maximum levels and may be starting to decrease. The ^{3}H level in Well 1039 has shown a significant decline in ^{3}H activity subsequent to the 2006 remedy completion and ^{3}H levels in the well were below the MCL in FY 2011.

The reduction in ^{3}H discharges from the Tumulus is a significant component of the decrease in ^{3}H measured in surface water at Waste Area Grouping 6 MS3, which is located nearby (Figure 3.3). The reader is referred back to Sect. 3.2.2.1.3 and Appendix B for the surface water data presentation.

Melton Valley Exit Pathway and Offsite Groundwater Monitoring Results

Exit pathway groundwater monitoring includes monitoring of wells 1190 and 1191 that are located on White Oak Dam (Figure 3.14), monitoring of six deep groundwater wells between the Clinch River and the western edge of Solid Waste Storage Area 6, and monitoring of offsite wells located southwest of the Clinch River. This section also includes hydrofracture well monitoring.

Wells 1190 and 1191 (Figure 3.14) 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 feet mean sea level, which is approximately equivalent to the bed of the Clinch River located about 2,500 feet to the west. Well 1191 samples water from the interface between the bedrock surface and the sediment/soil fill beneath the dam at elevations from 724 – 743 feet mean sea level, which is approximately equivalent to elevations of the White Oak Creek embayment and the channel of the Clinch River. ^{3}H and ^{90}Sr are the principal contaminants detected in these wells and Figure 3.15 shows the activity histories from about 1990 through FY 2011. Contaminant levels are greater in the shallow well (1191) than in the bedrock well and both contaminants continue a long-term decline in activity. In well 1191, both ^{90}Sr and ^{3}H experienced small increases in concentration during FY 2011. During FY 2011, ^{90}Sr levels were below detection limits (< 2 pCi/L) in well 1190.

As part of the *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000), in 2004 six groundwater monitoring wells were installed in the western end of Melton Valley to serve as sentinel 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 White Oak Creek Embayment near White Oak Dam. Locations of these wells are shown on Figure 3.16. Three wells (Wells 1008, 1009, and 1010) in a previously constructed well cluster near the southern end of the line of sentinel wells are also shown.

The deep groundwater monitoring data are discussed in terms of sample zone elevation because the local area has surface topographic relief of 200 – 300 feet 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 feet above mean sea level. 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 feet above mean sea level beneath Melton Valley (450 - 500 feet 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-feet elevation to 100,000 mg/L or more at about the 200-feet 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 exit pathway wells and offsite monitoring wells were designed and installed to sample groundwater above the non-potable brine zone.

Sentinel wells near the Clinch River on the Oak Ridge Reservation side were drilled to bottom elevations of about 250 feet above mean sea level. Based on test results, a total of 37 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 2006, baseline samples were collected and analyzed to evaluate the stabilization of groundwater quality in the sampled zones.

In 2010 offsite 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 sentinel well monitoring zones in 2007 through 2009 and because of concern that groundwater withdrawals on the western side of the Clinch River could potentially pull groundwater affected by DOE's waste disposal activities beneath the river. As a precaution to minimize groundwater

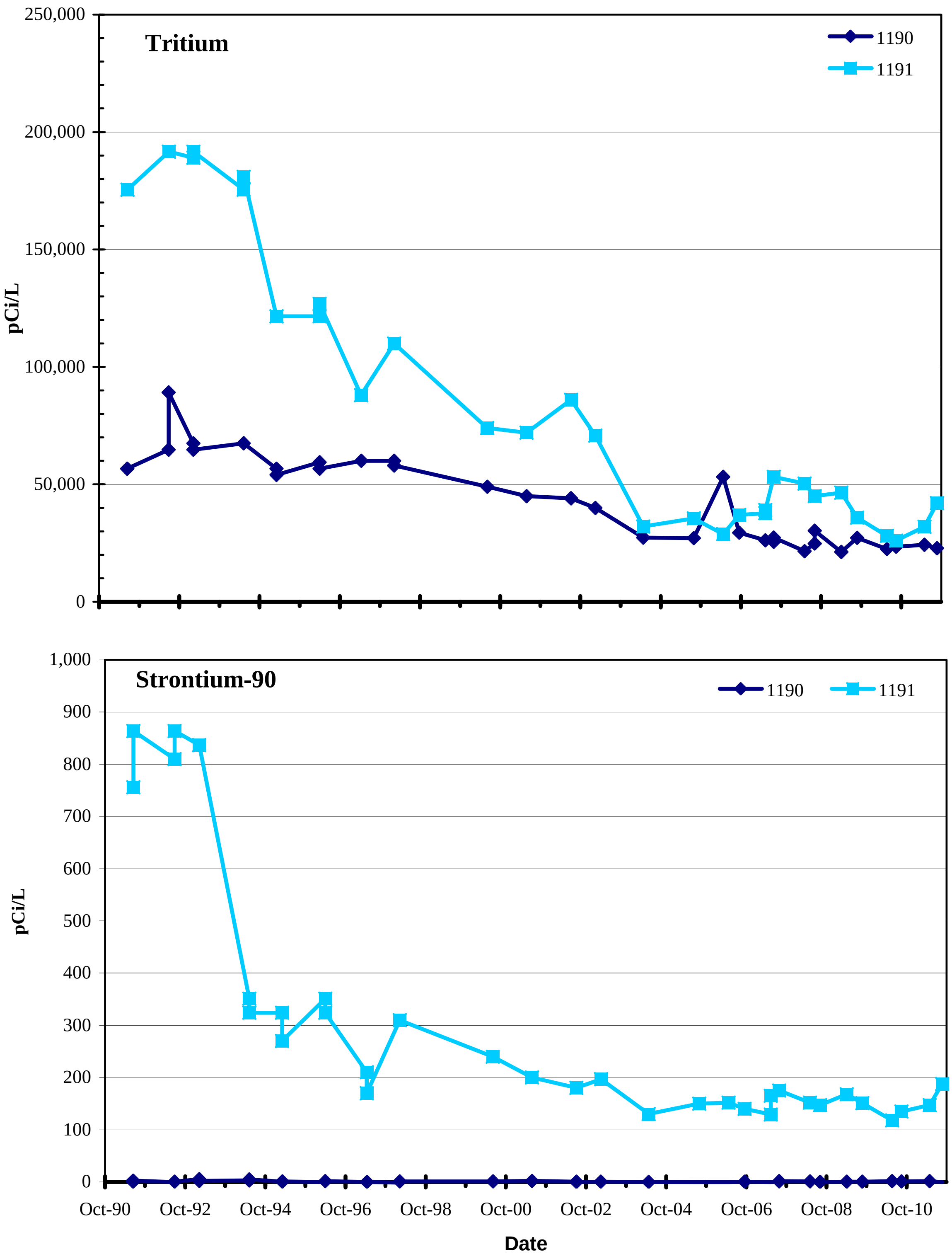


Figure 3.15. White Oak Dam groundwater tritium and ^{90}Sr activity histories.

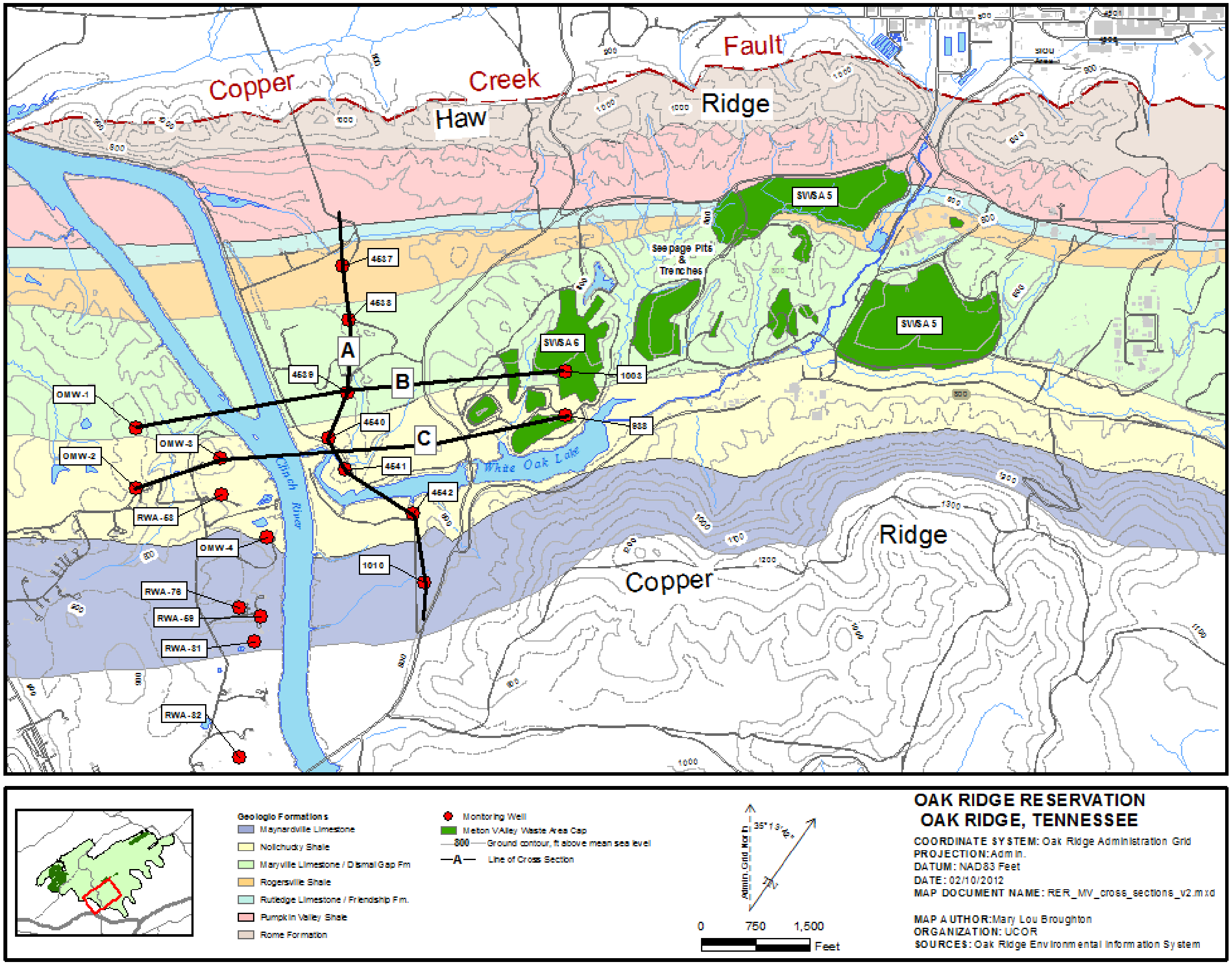


Figure 3.16. Locations of Melton Valley exit pathway wells and deep groundwater monitoring wells.

withdrawals near the Clinch River, DOE provided funding for extension of utility water supplies through the residential area along Jones Road and has provided water to residents in the area.

The offsite groundwater monitoring project has included installation of two well clusters (OMW-1 and OMW-2) containing 5 wells each on a ridgecrest west of the river, modification of two existing residential water wells (OMW-3 and OMW-4) near the river to create 3 sampling intervals within each borehole, and sampling of 5 existing residential wells in the vicinity. Locations of the offsite monitoring wells are shown on Figure 3.16. Goals of the installation of the 16 new sampling zones included in the two ridgecrest well clusters and the two modified existing wells near the river are: 1) to allow measurement of groundwater levels to determine the 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 contamination has been detected in multizone wells on the DOE side of the river. In addition to constructing the offsite wells to sample groundwater from elevations correlative to those on the DOE side of the river, to the extent feasible, the offsite wells were constructed in locations where sample intervals would be in approximately correlative geologic strata on both sides of the river. For example, well 4539 on the DOE side of the river and offsite well cluster OMW-1 intersect the upper portion of the Maryville Limestone stratigraphic unit. Similarly, wells 4540 and 4541 intersect strata also sampled in offsite well cluster OMW-2. In the offsite monitoring network the deepest wells in the two ridgecrest clusters were drilled to allow sampling in the elevation range between 200 – 300 feet above mean sea level, 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 feet above mean sea level ranges. Residential wells near the Clinch River that were converted to 3-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 feet above Mean Sea Level ranges. The 5 existing residential wells that are monitored are typical open borehole water wells and groundwater from long bedrock intervals is included in the monitoring.

Groundwater level monitoring has been conducted continuously in all except one of the wells (discussed later) in well clusters OMW-1 and OMW-2, and in all zones in wells OMW-3 and OMW-4. 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 semi-confined bedrock zones that have either preferential fracturing (including bedding plane partings), preferential weathering because of bedrock type, or both.

The location of 3 hydraulic head cross sections are shown on Figure 3.16. Figure 3.17 shows the winter 2011 hydraulic head in the Melton Valley picket 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 White Oak Creek 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 White Oak Creek aligns with the lowest part of Melton Valley where White Oak Creek and White Oak Lake 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 Oak Ridge National Laboratory 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 flow is actually perpendicular to this cross section toward the Clinch River.

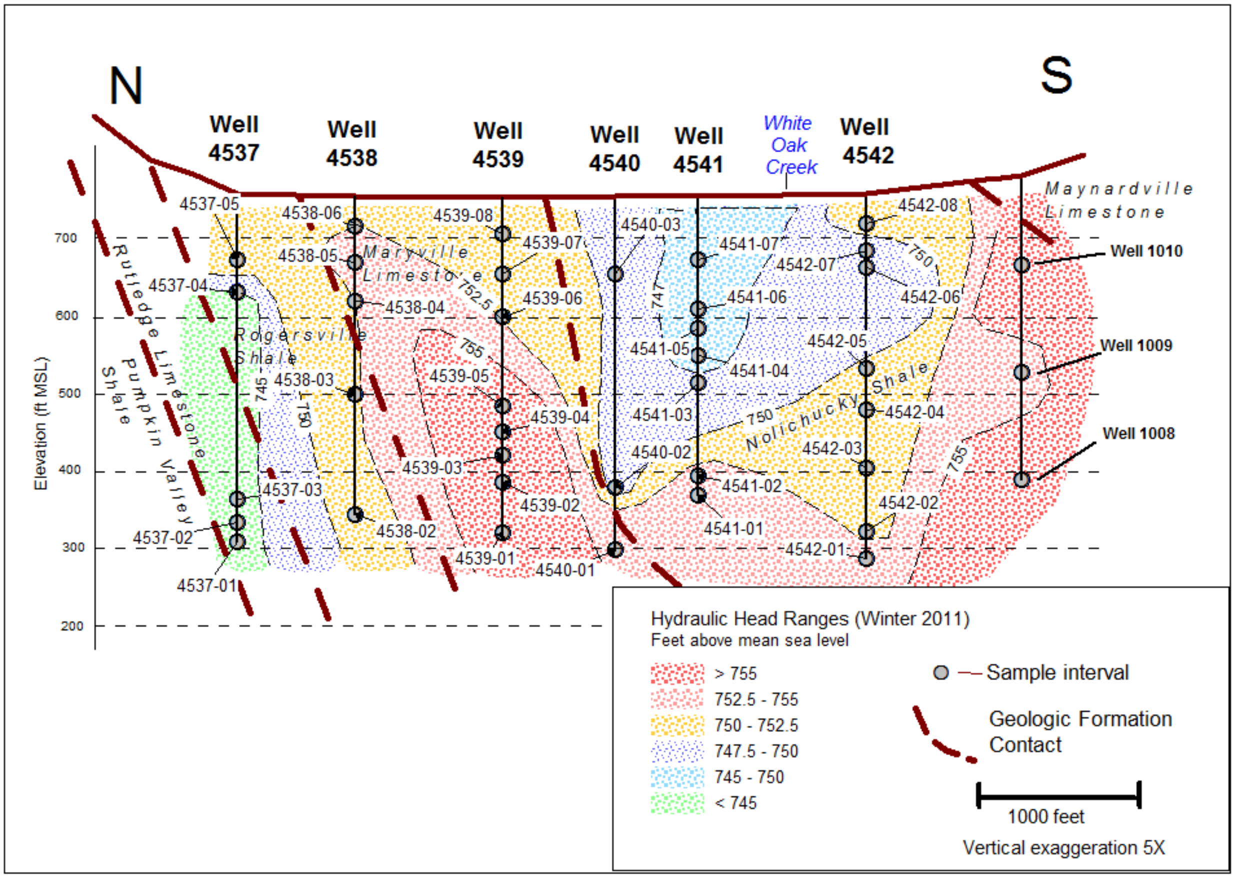


Figure 3.17. Hydraulic head cross section A.

Figure 3.18 shows the winter 2011 hydraulic head in the Melton Valley picket wells along Cross Section B that has its western end on the ridgecrest at OMW-1 and its eastern end near the center of Solid Waste Storage Area 6. This section is drawn essentially parallel to geologic strike in the Maryville Limestone as shown on Figure 3.16. The hydraulic head variations along Cross Section B show that a region of head ranging from 775 to > 800 feet above mean sea level 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 feet above mean sea level. 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 Solid Waste Storage Area 6 area where the profile terminates. Head levels measured at the eastern end of Cross Section B are lower than those beneath the offsite 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-feet hydraulic head contour which has higher head areas on both east and west sides.

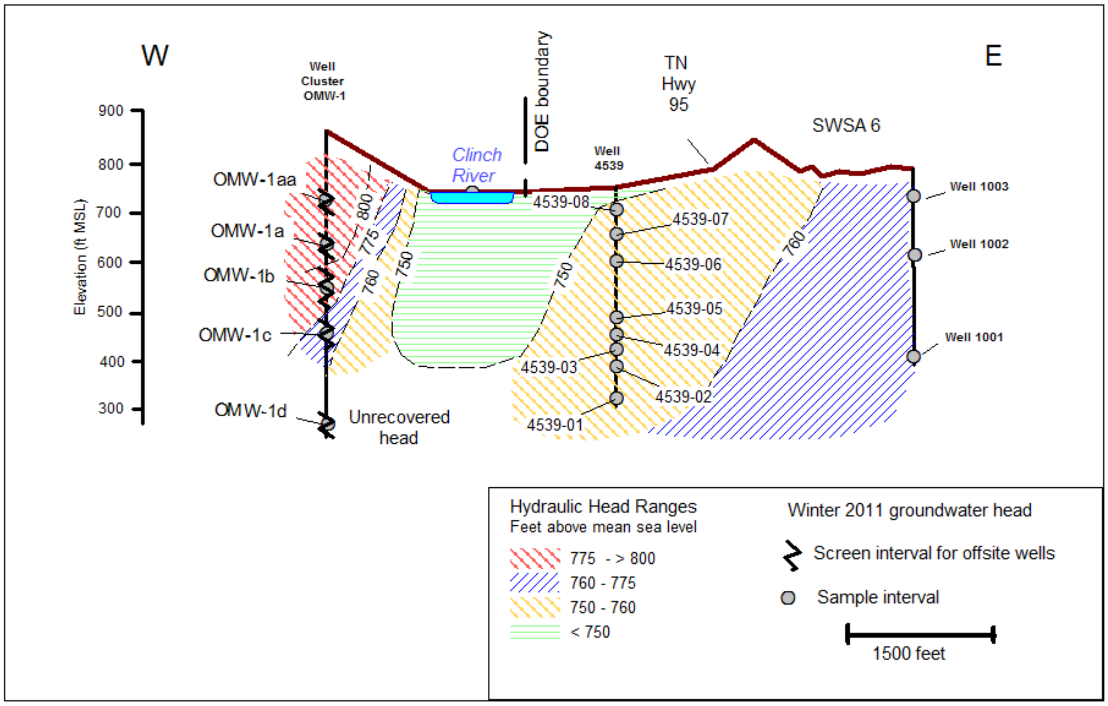


Figure 3.18. Hydraulic head cross section B.

The deepest well in offsite cluster OMW-1 (OMW-1A) is constructed in a very low-yield bedrock zone and, although the screened interval is about 100 feet in length, the well has not fully recovered over a nearly 1.5 year period. Because of the slow recovery a continuous monitoring device was not installed in the well; however, groundwater level is measured manually on a weekly frequency. The groundwater level continues to rise steadily with a recovery rate of about 0.2 ft/day. The well has recovered from an initial water level of about 510 feet above mean sea level after construction and development in July of 2010 to approximately 660 feet above mean sea level as of November 2011. 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. 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 3.19 shows the hydraulic head profile along Cross Section C (Figure 3.16) which has its western terminus at offsite well cluster OMW-2 and its eastern terminus at wells on a knoll in the southern part of Solid Waste Storage Area 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 feet above mean sea level 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. Again, the lowest hydraulic head is observed beneath the Clinch River. This section is drawn to coincide with the low groundwater region that underlies White Oak Creek and White Oak Lake 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.

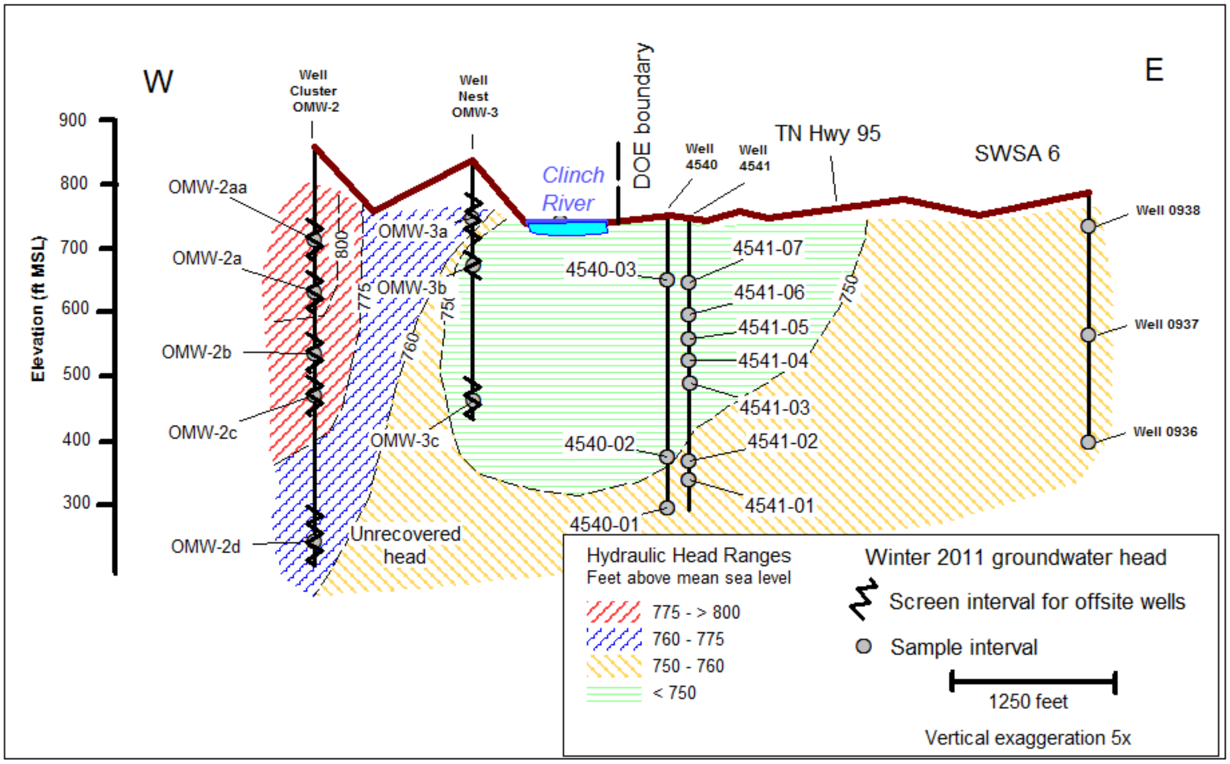


Figure 3.19. Hydraulic head cross section C.

Hydraulic head data summarized in Figures 3.18 and 3.19 show that the pressure gradients within the groundwater system are consistent with groundwater flow toward the Clinch River from both eastern and western sides of the river. The head data profiles 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. During the 15 months of groundwater level monitoring conducted between well completion and the end of FY 2011, all except two of the wells have reached full head recovery and show that groundwater head levels are higher than the Clinch River water elevation. The two wells that are still recovering are OMW-1D and OMW-2D, the deepest wells in the offsite well clusters. Although head in well OMW-2D is not fully recovered, the heads at the end of FY 2011 were nearly 20 feet higher than the Clinch River water level which indicates underflow of the ridgecrest in that area is very unlikely.

Groundwater quality monitoring has been conducted in the Melton Valley sentinel wells since 2006 and four rounds of samples were collected in the offsite monitoring wells between July 2010 and the end of FY 2011. The analytical results for unfiltered samples from all the wells, both the Melton Valley sentinel wells and the offsite wells, have been compared to the Environmental Protection Agency MCLs. Table 3.10 is a summary of the data screening results for primary MCLs.

Well construction activities in the new offsite well clusters at OMW-1 and OMW-2 introduced a large amount of cement grout into the boreholes as grout to seal the well casings into the bedrock. This grout has created a pH affect that shows itself as very high pH in the groundwater samples from most of the wells in those two well clusters. Similar affects are not observed at the OMW-3 and OMW-4 wells or in the other monitored residential 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 Maximum Contaminant Levels, barium and thallium are common constituents of geologic brines. A brine sample from a deep monitoring well approximately 6 miles away in Bear Creek Valley contained higher concentrations of these two elements than the levels reported in Table 3.10. 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 solids since concentrations in the 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 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 offsite groundwater has detected low levels of 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 Oak Ridge National Laboratory is ^{90}Sr. Strontium-90 is frequently detected in one of the Melton Valley sentinel wells (4537-02) and has exceeded the 8 pCi/L screening level on two occasions. Two very low ^{90}Sr detections occurred in offsite wells, OMW-1D and OMW-3C. In the OMW-1D sampling event the detected result was less than 2 pCi/L and ^{90}Sr was not detectable in a duplicate sample collected at the same time. One sample from well OMW-3C had an estimated ^{90}Sr result of 1.22 pCi/L in a December 2010 sample. ^{90}Sr was not detectable in a subsequent sampling conducted in February 2011. Although much less widespread than ^{90}Sr, ^{99}Tc is present in groundwater in the Seepage Pits and Trenches area. ^{99}Tc has not been detected in the Melton Valley sentinel wells; however, one low

Table 3.10. Results of data screen compared to Environmental Protection Agency Primary National Drinking Water Criteria

Analyte	Screening Level[a]	Units	Station[b]	Number of Analyses[c]	Number Detected[d]	Number > MCL[e]	Results Minimum	Results Mean	Results Maximum
Fluoride	4	mg/L	1008	1	1	1	5.93	5.93	5.93
			1009	2	2	2	9.5	9.70	9.89
			1010	2	2	1	0.16	3.18	6.2
			4537-05	9	9	6	2.3	4.01	5.29
			4538-03	11	11	1	1.5	3.67	19.7
			4538-04	9	9	4	2.9	3.88	4.58
			4538-05	8	8	2	2.1	3.40	4.52
			4539-02	13	13	11	3	4.71	5.6
			4539-03	10	10	9	3.3	5.03	6
			4539-04	12	12	11	3.5	5.22	5.9
			4539-05	10	10	9	3.5	10.74	21.3
			4539-06	10	10	9	3.5	5.42	6.6
			4540-02	10	10	8	2	4.43	5.5
			4540-03	10	10	8	2.6	5.60	6.9
			4541-01	9	9	7	2.3	4.23	5
			4541-02	11	11	7	2.7	4.03	4.4
			4541-03	10	10	8	2.4	5.00	5.9
			4542-03	9	9	8	3.2	6.17	9.4
			4542-04	12	12	12	5.2	7.63	9.62
			4542-05	10	10	6	1.6	5.54	9.7
			4542-07	9	9	1	0.3	1.58	9.76
			OMW-1B	4	4	4	5.63	5.89	6.11
			OMW-2B	4	4	4	5.63	6.1	6.42
Antimony	0.006	mg/L	OMW-1D	6	4	4	0.00623	0.0095	0.0159
Arsenic	0.01	mg/L	4537-02	6	4	1	0.0069	0.011	0.015
Barium	2	mg/L	4540-01	13	7	7	7.91	15.8	21.7
			4542-01	9	5	5	4.28	14.96	41.7
			4542-02	10	5	5	6.94	12.51	16.3
			OMW-2D	6	4	1	0.273	1.3695	3.43
Beryllium	0.004	mg/L	OMW-1C	6	1	1	0.00416	0.0042	0.00416
			OMW-1D	6	1	1	0.0152	0.0152	0.0152
Cadmium	0.005	mg/L	OMW-1D	6	1	1	0.0158	0.0158	0.0158
Chromium	0.1	mg/L	4538-02	8	5	1	0.0347	0.067	0.125
			4538-03	10	5	1	0.00709	0.03	0.108
			4540-02	13	7	1	0.0214	0.0627	0.128
Lead	0.015[f]	mg/L	4538-02	8	5	1	0.0051	0.0093	0.0175
			4538-03	10	4	1	0.000575	0.0047	0.0153
			4540-02	13	7	1	0.00429	0.0118	0.0234
			OMW-1C	6	1	1	0.0231	0.0231	0.0231
			OMW-1D	6	4	1	0.000635	0.026	0.1
Thallium	0.002	mg/L	4538-02	8	3	1	0.00072	0.0014	0.00253
			4542-03	7	1	1	0.011	0.011	0.011
			OMW-1C	6	1	1	0.0028	0.0028	0.0028
			OMW-1D	6	1	1	0.0104	0.0104	0.0104
Uranium	0.03	mg/L	OMW-1D	6	3	1	0.000069	0.0667	0.2

Table 3.10. Results of data screen compared to Environmental Protection Agency Primary National Drinking Water Criteria (cont.)

Analyte	Screening Level[a]	Units	Station[b]	Number of Analyses[c]	Number Detected[d]	Number > MCL[e]	Results Minimum	Results Mean	Results Maximum
Alpha activity	15	pCi/L	4538-02	9	5	4	9.2	33.5	53
			4538-03	11	7	4	3.11	18.5	41.7
			4539-02	13	11	5	5.16	41.0	221
			4539-04	12	5	2	6.78	23.1	61.7
			4539-05	10	4	1	1.62	12.3	37.1
			4540-01	12	4	4	21.3	35.2	53.5
			4540-02	12	7	3	7.52	39.0	171
			4541-01	9	3	2	5.65	16.2	25.7
			4541-02	11	2	1	9.18	19.0	28.8
			4541-04	12	5	2	8.02	211.1	1010
			4541-05	12	7	3	4.02	13.9	22.4
			4541-06	12	7	2	5.56	11.0	24.4
			4542-01	10	2	2	17.8	20.4	22.9
			4542-02	10	2	2	20.8	25.3	29.7
			4542-04	12	7	3	4.17	10.9	19.1
Beta activity	50	pCi/L	4537-02	11	7	1	5.53	19.2	63.5
			4538-02	9	6	1	7.66	71.2	275
			4538-03	11	7	5	8.94	268.8	1330
			4539-02	13	10	5	6.78	124.9	534
			4539-04	12	8	2	4.63	25.3	75
			4540-01	12	8	3	6.06	61.0	166
			4540-02	12	10	2	7.02	57.1	355
			4541-02	11	4	2	4.4	262.1	982
			4541-04	12	9	5	5.61	128.9	873
			4541-05	12	10	5	4.87	43.4	95.6
			4541-06	12	9	4	6.38	40.7	81.2
			4542-01	10	2	1	40.8	97.9	155
			4542-02	10	3	1	21.7	41.9	54.9
			4542-04	12	9	2	4.66	30.9	87.4
			OMW-1D	4	4	3	19.2	64.2	101
Strontium-90	8[g]	pCi/L	4537-02	7	5	2	2.4	22.0	83.2
cis-1,2-Dichloroethene	70	µg/L	OMW-1B	4	1	1	80.8	80.8	80.8
Methylene chloride	5	µg/L	4538-02	8	3	2	3.4	9.5	15
			4542-04	12	2	1	0.2	4.1	8
			4542-05	10	1	1	8	8	8
Trichloroethene	5	µg/L	4537-03	8	1	1	113	113	113
			4539-02	12	2	1	0.88	3.95	7.02
			4539-08	10	1	1	30.9	30.9	30.9
			4541-02	11	2	1	2	21.1	40.2
			OMW-1B	4	1	1	81.1	81.1	81.1
Vinyl chloride	2	µg/L	4537-03	8	1	1	7.49	7.49	7.49
			4541-02	11	3	1	0.24	1.3	2.92
			OMW-1B	4	1	1	2.63	2.63	2.63

[a]Screening levels are Environmental Protection Agency Primary National Drinking Water Standards except beta activity, for which 50 pCi/L was used.

[b]See Figure 3.17 for zone locations.

Table 3.10. Results of data screen compared to Environmental Protection Agency Primary National Drinking Water Criteria (cont.)

[c]Number of Analyses = total number of analyses for analyte from each location
[d]Number Detected = number of analyses in which analyte was detectable
[e]Number > MCL = number of results that were greater than the Safe Drinking Water Act maximum contaminant level (MCL)
[f]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 limit.
[g]8 pCi/L is an effective does equivalent to the 4 mrem/yr MCL for beta particle and photon activity.

concentration was detected in a sample from well OMW-1C. The Primary Drinking Water Standard 4 mrem/yr beta activity effective dose equivalent activity for ^{99}Tc is 900 pCi/L and the detection occurred in December 2010 at an activity of 25 pCi/L. ^{99}Tc was not detected in a duplicate sample collected at the same time, and the radionuclide was not detected in two samples collected from the well in February 2011.

Detected VOCs that exceed the screening levels include TCE, cis-1,2-DCE, vinyl choride, and methylene chloride. Methylene chloride is a common laboratory chemical in analytical labs and this compound is commonly detected at low levels because of lab atmosphere affects. TCE is a common industrial cleaning solvent that can degrade to DCE, and vinyl chloride. These compounds are known groundwater contaminants at the Melton Valley burial grounds, including at Solid Waste Storage Area 6 where they are monitored as required by the RCRA. Detections of these compounds in the Melton Valley exit pathway wells has been infrequent and concentrations have usually been low with the exception of one event in September 2010. Sampling in September 2010 detected TCE, cis-1,2-DCE, and vinyl chloride at elevated concentrations in well 4539 and in well OMW-1B. The simultaneous detections on both sides of the river is thought to have been caused by groundwater removals during construction of the cluster OMW-1 wells. The groundwater withdrawals are thought to have pulled water from beneath the Clinch River through interconnected fractures. These contaminants have not been detected in the offsite wells subsequent to September 2010.

Table 3.11 is a summary of trend evaluations for analytes that have shown MCL exceedances and for selected uranium isotopes detected in onsite and offsite groundwater. The trend evaluation used was the Mann-Kendall non-parametric trend analysis. This approach to trend evaluation analyzes the cumulative direction (increasing, decreasing, or stable) of concentration change of an analyte through time. The data used to begin the Mann-Kendall trend analysis on this dataset was that a minimum of 4 detected results for the analyte of interest had to be available. Analytes with fewer than 4 detected results were excluded from trend analysis. The method provides a 90% confidence level that the trend is significant. The "No Trend" entries indicate the data have a high variability and a trend cannot be confidently shown. The raw data for onsite 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 four of the available offsite sampling episodes for the offsite wells were included in trend evaluation. For metals analyses, when both filtered and unfiltered sample results were available, the unfiltered results were used for trend evaluation. 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.

As shown in Table 3.11, most of the trends of analytes that have exceeded screening levels are stable to decreasing. Increasing trends for fluoride and barium in offsite wells OMW-1B and OMW-1D are consistent with ongoing changes on water quality in the new wells as conditions equilibrate from disturbances to the rock formation and groundwater caused by well construction. Barium is considered a

Table 3.11. Trend evaluations for analytes having screening level exceedances in Melton Valley Exit Pathway and Offsite groundwater

Well – Sampling Port[a]	Analyte	Screening Level [b]	Time Series Concentration Trend					
			Number of Samples	Sampling Date Range			Numbear of Samples > Screening Level	M-K[c] Trend Evaluation
4537-02	Arsenic	0.010 mg/L	4	Jan-07	-	Feb-09	1	Stable
	^{90}Sr	8 pCi/L	7	Nov-05	-	Feb-11	2	No Trend
4537-05	Fluoride	4 mg/L	6	Apr-06	-	Aug-11	6	Increasing
4538-02	Alpha	15 pCi/L	9	May-05	-	Feb-11	4	Increasing
	Beta	50 pCi/L	8				0	Increasing
	Chromium	0.1 mg/L	5	Feb-07	-		1	Stable
	Lead	0.015 mg/L	5	Jan-07	-		1	Stable
4538-03	Alpha	15 pCi/L	10	Feb-05	-	Feb-11	4	Decreasing
	Beta	50 pCi/L	9				3	Decreasing
4538-04	Fluoride	4 mg/L	5	Feb-06	-	Aug-11	5	Increasing
4538-05	Fluoride	4 mg/L	5	Feb-06	-	Sep-10	2	Stable
4539-02	Fluoride	4 mg/L	8	Feb-07	-	Mar-11	8	Stable
4539-02	Alpha	15 pCi/L	10	Feb-06	-	Aug-11	5	Decreasing
4539-03	Fluoride	4 mg/L	6	Feb-06	-	Aug-11	6	Stable
4539-04	Fluoride	4 mg/L	9	Feb-06	-	Mar-11	9	Stable
4539-05	Fluoride	4 mg/L	9	Feb-05	-	Mar-11	9	Stable
4539-06	Fluoride	4 mg/L	8	Feb-06	-	Mar-11	8	Stable
4540-01	Alpha	15 pCi/L	10	May-05	-	Aug-11	4	Decreasing
	Barium	2 mg/L	7	Feb-07	-		7	Stable
	Beta	50 pCi/L	10	May-05	-		3	Decreasing
4540-02	Alpha	15 pCi/L	9	Feb-05	-	Aug-11	3	Stable
	Beta	50 pCi/L	10	Feb-05	-		2	No Trend
	Chromium	0.1 mg/L	7	Jan-07	-		1	Decreasing
	Fluoride	4 mg/L	6	Aug-08	-		6	Stable
	Lead	0.015 mg/L	7	Feb-07	-		1	Decreasing
4540-03	Fluoride	4 mg/L	6	Feb-06	-	Mar-11	6	Stable
4541-01	Fluoride	4 mg/L	5	Feb-06	-	Aug-11	5	Stable
4541-02	Fluoride	4 mg/L	8	Feb-06	-	Aug-11	6	Decreasing
4541-03	Fluoride	4 mg/L	6	Feb-06	-	Mar-11	6	Stable
4541-04	Alpha	15 pCi/L	10	Nov-05	-	Aug-11	2	Decreasing
	Beta	50 pCi/L	10				5	Decreasing
4541-05	Alpha	15 pCi/L	10	Nov-05	-	Aug-11	3	Decreasing
	Beta	50 pCi/L	10				5	Decreasing
4541-06	Alpha	15 pCi/L	10	Feb-06	-	Aug-11	2	Decreasing
	Beta	50 pCi/L	10				4	Decreasing
4542-01	Barium	2 mg/L	5	Feb-07		Mar-22	5	No Trend
4542-02	Barium	2 mg/L	5	Feb-08		Mar-11	5	Stable
4542-03	Fluoride	4 mg/L	5	Feb-06	-	Aug-11	5	Decreasing

Table 3.11. Trend evaluations for analytes having screening level exceedances in Melton Valley Exit Pathway and Offsite groundwater (cont.)

Well – Sampling Port[a]	Analyte	Screening Level [b]	Time Series Concentration Trend: Number of Samples	Sampling Date Range			Numbear of Samples > Screening Level	M-K[c] Trend Evaluation
4542-04	Alpha	15 pCi/L	10	Nov-05	-	Aug-11	3	Decreasing
	Beta	50 pCi/L	10				2	Decreasing
	Fluoride	4 mg/L	9	Feb-06	-	Aug-01	9	Stable
OMW-1B	Fluoride	4 mg/L	4	Jul-10	-	Feb-11	4	Stable
OMW-1D	Antimony	0.006 mg/L	4	Jul-10	-	Feb-11	4	Decreasing
	Beta	50 pCi/L	4				3	Decreasing
	Lead	0.015 mg/L	4				1	No Trend
OMW-2B	Fluoride	4 mg/L	4	Jul-10	-	Feb-11	4	Increasing
OMW-2D	Barium	2 mg/L	4	Jul-10	-	Feb-11	1	Increasing

[a]See Figures 3.16 through 3.18 for zone locations.

[b]Screening levels are Environmental Protection Agency Primary National Drinking Water Standards except 8 pCi/L for ^{90}Sr which is the effective dose equivalent to the 4 mrem/yr MCL for beta particle and photon activity, and beta activity for which 50 pCi/L was used.

[c] M-K = Mann-Kendall trend evaluation

natural groundwater constituent in deep groundwater because it is very abundant in the natural brines. Fluoride has natural and potential man-made sources in the Melton Valley area.

Exit Pathway Summary

Groundwater analyses conducted on samples from the Melton Valley picket wells since their construction in 2004 have resulted in a number of radionuclides and VOCs being detected periodically in different monitoring zones. In response to this observation, DOE has undertaken an offsite groundwater monitoring program that includes construction of monitoring wells and sampling and analysis of water from the newly constructed wells and selected offsite residential wells. Monitoring results obtained during FY 2010 and 2011 show that natural head gradients indicate groundwater movement toward the Clinch River from both east and west sides of the river. Alteration of the natural gradients caused by pumping can induce flow through interconnected fractures. This type of gradient alteration has the potential to induce contaminant movement from areas beneath the river to offsite wells. During FY 2010 DOE funded installation of potable water lines to the residential area near Jones Road on the west side of the Clinch River to provide utility water to residents in the area. This measure was taken to minimize offsite groundwater pumping that could have drawn DOE contaminants offsite.

Groundwater analytical results for the Melton Valley onsite picket wells and for the offsite monitoring wells were compared to Environmental Protection Agency MCLs. Constituents that exceeded screening levels in the offsite groundwater included fluoride (2 wells), antimony (1 well), barium (1 well), beryllium (2 wells), cadmium (1 well), lead (2 wells), thallium (2 wells), uranium (1 well), cis-1,2-DCE (1 well), TCE (1 well), and vinyl chloride (1 well). Constituents that have exceeded MCLs in the DOE onsite wells include fluoride, arsenic, barium, chromium, lead, thallium, alpha activity, ^{90}Sr, TCE, and vinyl chloride. 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. Barium and thallium were detected above MCLs in some of the samples from near the saline groundwater zone in both offsite and DOE onsite wells; however, these are considered to be natural constituents of the deep brine because of their abundance in deep groundwater remote from Melton Valley. Trend evaluation shows that for those constituents that show Environmental Protection Agency MCL exceedances having a sufficient number of detections to conduct trend evaluation, the trends are predominantly decreasing or stable. An issue identified from the 2008 Remediation Effectiveness Report concerning the elevated levels of some zones in the Melton Valley exit pathway wells is being closed out in this Remediation Effectiveness Report. As discussed in the aforementioned section, additional wells were drilled and offsite wells were reconfigured for sampling. Four quarters of exit pathway and offsite sampling were completed, evaluated and discussed with the Core Team. A separate issue which identified elevated levels of VOCs in the new offsite wells is being carried forward. This issue has been discussed with the Core Team (January 2012) in addition to the presence of site related contaminants, trends, and on-site and off-site hydrologic head relationships. New sampling is being agreed upon with the DOE/EPA/TDEC for the Melton Valley Exit Pathway which will be documented in the MeltonValley Monitoring Plan. Issues are included in Table 3.12.

3.2.2.2.4 Process Waste Treatment Complex Waste Acceptance Criteria Compliance for Collected Groundwater

Groundwater collected in the downgradient seepage interceptor systems at Seepage Pits and Trenches, Solid Waste Storage Area 4, and Solid Waste Storage Area 5 is pumped to the equalization tank located at Solid Waste Storage Area 4 prior to being pumped via pipeline to the Process Waste Treatment Complex in Bethel Valley for treatment. Samples of the collected groundwater are obtained monthly at the equalization tank and analyses include metals, radionuclides, and VOCs. Waste acceptance criteria for the Process Waste Treatment Complex have been developed for radionuclides and metals. The only constituent detected near or above the Process Waste Treatment Complex waste acceptance criteria was ^{3}H. The Process Waste Treatment Complex waste acceptance criteria for tritium is 2×10^{6} pCi/L and the average and maximum ^{3}H concentrations measured in FY 2011 in the collected groundwater were about 1.4×10^{6} and 3.25×10^{6}, respectively, which are both slightly lower than the values measured during FY 2010. During FY 2011, three of the monthly samples contained ^{3}H at concentrations greater than the waste acceptance criteria compared to three during FY 2009 and six during FY 2008 that contained ^{3}H above the waste acceptance criteria. Although the maximum ^{3}H concentrations in the collected groundwater were greater than the waste acceptance criteria, the Process Waste Treatment Complex discharge was compliant with the required discharge limit for ^{3}H in all of the continuous, flow-paced samples collected and analyzed at the point of discharge.

3.2.3 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 2000) 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 3.1. 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 White Oak Creek just downstream of the Melton Branch confluence (WCK 2.3; Figure 3.1).

Redbreast sunfish were collected in FY 2011 from lower Melton Branch (MEK 0.2) and fillets analyzed for mercury, PCBs, metals, and ^{137}Cs. Mean (± SE) mercury concentrations in these fish remained similar to those seen in FY 2010 (average 0.15 ± 0.02 µg/g), approximately two-fold higher than typical of reference site concentrations in this species. PCB concentrations were near background levels and in most cases below detection limits, averaging 0.03 ± 0.005 µg/g in the six redbreast sunfish analyzed. As expected, most metals (As, Se, 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. ^{137}Cs was not detected in sunfish samples from MEK 0.2.

The monitoring results for Melton Branch and White Oak Creek 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 3.20 and 3.21). After a period of mostly stable numbers of fish species, in 2009-2011 some improvement in number of species has occurred at the downstream sites as a result of a fish introduction program. Two darter species are now commonly found at MEK 0.6, and at WCK 2.3 three introduced fish species are common. In the most recent samples at both WCK 2.3 and Melton Branch, fish species richness values were the highest or next to highest ever seen. 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 White Oak Creek (WCK 2.3), as measured by the number of intolerant taxa, remains below comparable reference sites (MBK 1.6 and WCK 6.8) (Figure 3.22). However, there has been substantial improvement over the years at this site, with the current number of sensitive taxa 5-fold higher than the late 1980s. The greatest improvement appears to be between 2001 and 2002 (Figure 3.22). The number of pollution intolerant macroinvertebrate taxa collected per sample in lower Melton Branch (MEK 0.6) in 2011, were similar to the numbers collected at reference sites (Figure 3.22). While taxonomic richness of the pollution-intolerant taxa is a relatively sensitive metric, other community metrics such as density (number of individuals/unit area; not shown) continue to indicate that nutrient concentrations in Melton Branch may be elevated (i.e., higher than expected).

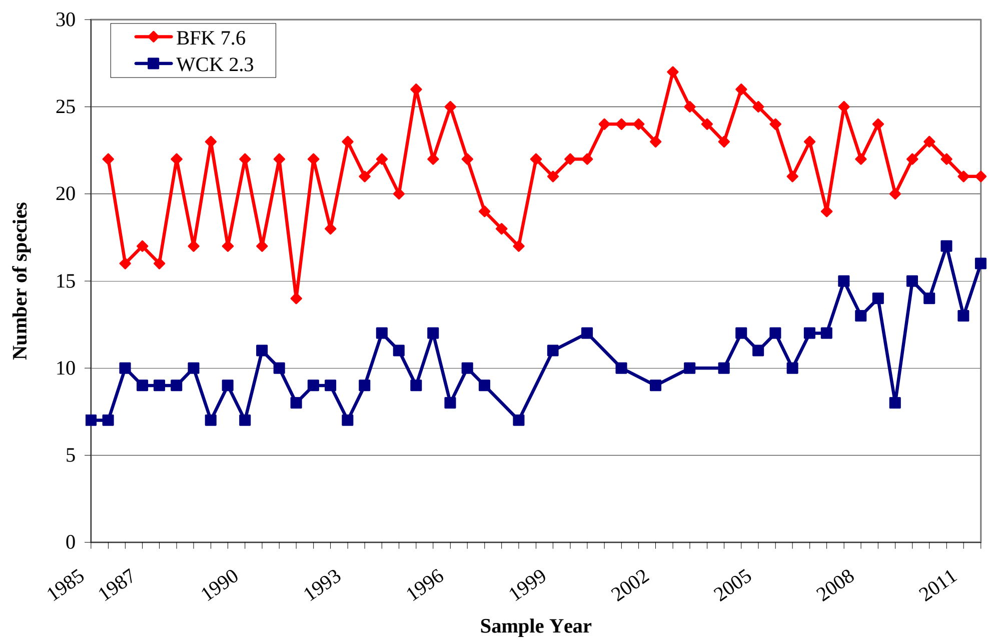


Figure 3.20. Species richness (number of species) in samples of the fish community in lower White Oak Creek (WCK 2.3) and a reference stream, Brushy Fork (BFK), 1985–2011[a].
[a]Reduction of sampling frequency at WCK 2.3 from biannual to annual between 1998 and 2005 is indicated by the discontinuation of the line for this period.

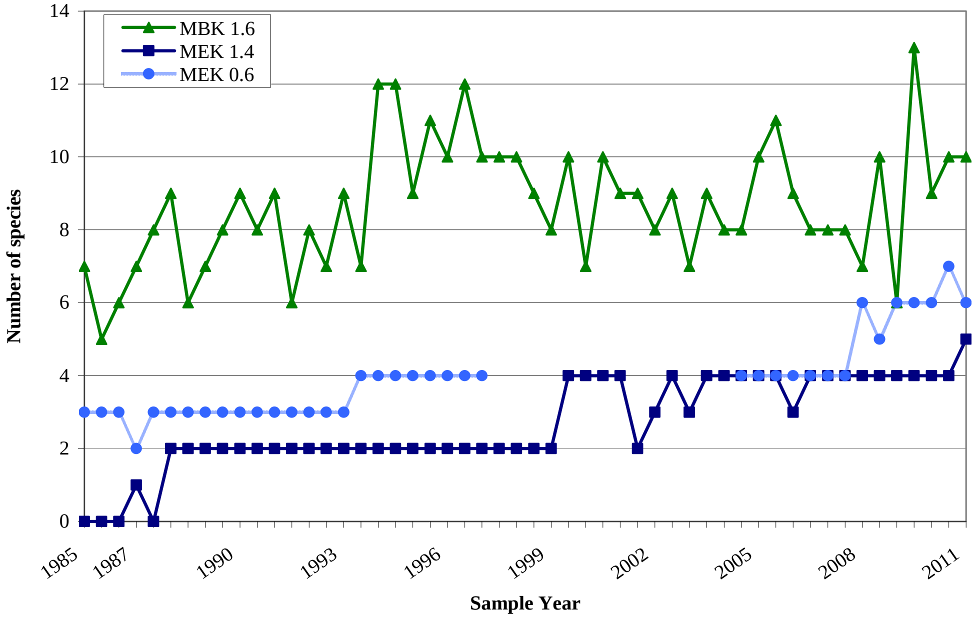


Figure 3.21. Species richness (number of species) in samples of the fish community in Melton Branch (MEK) and a reference stream, Mill Branch (MBK), 1985–2011.[a]
[a]Symbols not joined by lines show periods when samples were not collected.

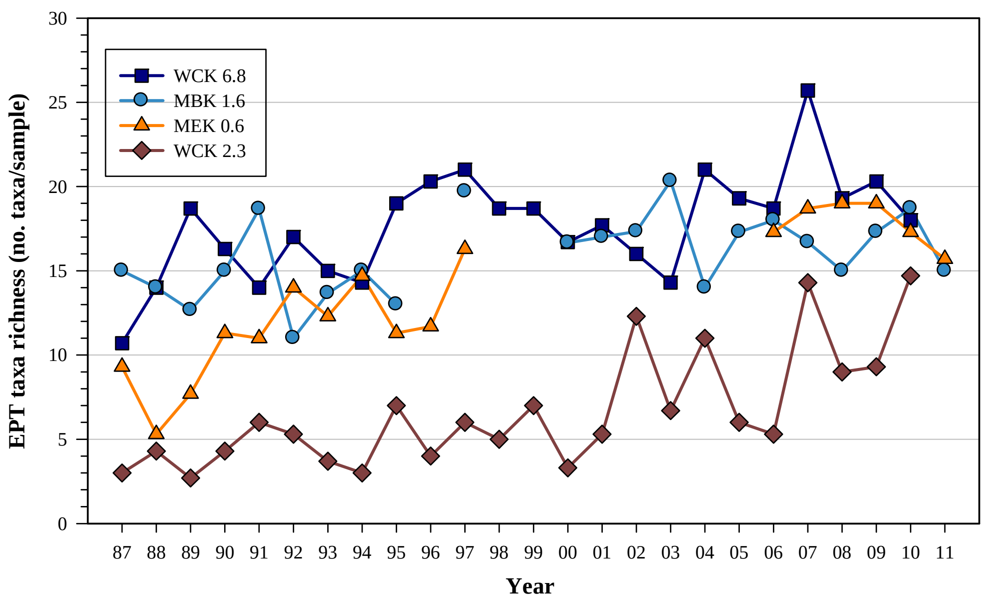


Figure 3.22. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrates communities in lower WOC (WCK 2.3), lower Melton Branch (MEK 0.6), and reference sites in upper WOC (WCK 6.8) and Mill Branch (MBK 1.6), April sampling periods, 1987–2011.[a, b]

[a]Samples collected from WCK 2.3 and WCK 6.8 in 2011 have not yet been processed.
[b]Symbols not joined by lines show periods when samples were not collected.

3.2.4 Performance Summary

Following is a summary of the FY 2011 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). Concentration trends for these contaminants were stable or decreasing during FY 2011. Principal contaminant 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 2000). Although a slight increase in the ^{90}Sr was observed, the contaminant fluxes from Melton Valley remained low relative to the responses observed during wet years prior to remediation.

- Groundwater contaminant concentrations around the shallow land burial sites are generally decreasing or stable compared to concentrations measured before completion of the Melton Valley remedy.

- Groundwater level monitoring of the hydrologic isolation areas in Melton Valley showed that performance criteria were met at 38 of 44 locations. Three of the wells not meeting the performance criteria are located in Solid Waste Storage Area 4. Two of those are located near the downgradient trench which, based on these wells performance, show evidence of deteriorated performance during FY 2011. This is identified as an issue in Table 3.12. Additional seepage sampling will be instituted in FY 2011 to determine if well maintenance will enhance performance.

- Monitoring of wells in the Melton Valley groundwater Exit Pathway and offsite monitoring wells shows that groundwater flow paths converge toward the Clinch River from both the DOE side and offsite. Disturbance of this natural flow condition by groundwater pumping offsite has the potential to draw DOE contaminants to offsite pumping locations. Because of this vulnerability, DOE provided funds for installation of utility water supply to offsite residents near the Clinch River.

- Groundwater analyses conducted on samples from the sentinel wells since their construction in 2004 have resulted in a number of radionuclides and VOCs being detected periodically in different monitoring locations. Sampling and analysis of groundwater from offsite wells showed detection of low concentrations of VOCs in samples from one sample at one well. This detection occurred coincident with detection of similar VOCs in one of the DOE sentinel wells. The offsite detection occurred early in the sampling history and is suspected to have occurred because of pumping stresses in the offsite well during construction. This detection is considered to exemplify the vulnerability of offsite wells in close proximity to areas of ground contamination. Two detections of very low levels of ^{90}Sr and one detecton of very low level ^{99}Tc occurred in offsite monitoring wells during the year and these were either not detectable in duplicate samples or were not detected in subsequent samples. Continued monitoring of the exit pathway wells and the offsite wells will be conducted consistent with the *Addendum to the Melton Valley Monitoring Plan* (DOE 2010b).

- The biological monitoring results indicate that Melton Branch stream communities are impaired relative to reference sites, but continue to improve.

3.2.5 Facility Operations and Land Use Controls

3.2.5.1 Watershed-Scale Actions

Requirements

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires interim land use controls to protect against unacceptable exposures to contamination during and after remediation (Table 3.2). During remediation, interim land use controls were imposed that will remain in effect until final land use controls are established in future, final remedial decisions. The land use control objectives (DOE 2000) 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 land use controls.
- ***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 land use controls.

The implementation and maintenance of these land use controls are specified in the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006; 2009a; 2009b) Because of the similarity in interim land use control objectives among the three remediation areas, most of the land use controls apply throughout the watershed. Thus, the land use controls are defined as follows:

- DOE land notation (property record restrictions) on land use and groundwater use in areas where waste is left in place.

- Property record notices to provide records about existence and location of areas where wastes are left in place.

- Zoning notices to provide notice to the city of Oak Ridge of existence and locations where wastes are left in place.

- Excavation and penetration permit program.

- State advisories/postings (e.g., no fishing or contact advisories at White Oak Lake and White Oak Creek Embayment).

- Access controls (fences, gates, portals).

- Signs at designated locations throughout the valley to provide warning to prevent unauthorized access.

- Surveillance patrols.

These land use controls are grouped into administrative controls (land use and groundwater deed restrictions, property record notices, zoning notices, permits program) and physical controls (state advisories/postings, access controls, signs, and security patrols), as shown in Table 3.2.

The requirements of the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) are in Appendix A, along with the required certification. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires individual remediation projects within the Melton Valley watershed to identify applicable land use controls in the project completion document. None of the Melton Valley completion documents contain project-specific land use controls.

While the completion documents do not require additional land use controls, the hydrologic isolation projects include engineering controls that are to be maintained at the 13 separate waste caps. Maintenance of the engineering controls at the caps is addressed in the *Melton Valley Surveillance and Maintenance Plan* (DOE2007b) that is attached to the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009a; DOE 2009b). This plan covers the surveillance and maintenance required for all remediation completed in Melton Valley; however, only the caps constructed at Solid Waste Storage Area 5, Solid Waste Storage Area 4, Seepage Pits and Trenches, and Solid Waste Storage Area 6 and the groundwater collection system at Seepage Pits, Trench 7, Seep D, Solid Waste Storage Areas 4 and 5 require long-term maintenance. No other remediation performed in Melton Valley requires long-term surveillance and maintenance. Inspections and maintenance of the engineering controls began immediately upon completion and were implemented in accordance with the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC 2006).

Status

Appendix A contains the Certification of Land Use Controls for FY 2011. The Land Use Control Assurance Plan 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 1999a) requires that the Manager, DOE - Oak Ridge Operations, annually verify in the Remedial Effectiveness Report that land use control implementation plans are being implemented on the Oak Ridge Reservation. A summary of the implementation verification and status of the Melton Valley watershed land use controls follows:

- **DOE Land Notation (Property Record Restrictions).** The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires that deed restrictions, e.g., land and groundwater use, be implemented for all waste management areas and other areas where hazardous substances are left in place to restrict use of property by imposing limitations and prohibiting uses of groundwater. The land notation is to be recorded by DOE in accordance with state law at the County Register's of Deeds office upon completion of remediation and/or transfer of affected areas.

  The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires DOE to file the Land Notation in the applicable county records. The Land Notation must include a survey plat executed by a registered land surveyor that depicts the relevant restricted areas subject to land use controls, including contamination/waste disposal areas. The *Land Use Control Implementation Plan* requires that a DOE official (or its contractor) verify annually that the information is properly recorded at the County Register of Deeds office in the event of a records search.

  The Department of Energy 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 Books 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 2011, this information was verified to be properly filed electronically at the Roane County Register's of Deeds office.

- **Property Record Notices**. The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires that a deed notice/Resource Conservation and Recovery Act postclosure notice be recorded for all waste management areas and other areas where hazardous substances are left in place to provide notice to anyone searching records about the existence and location of a hazardous waste landfill(s). This deed notice is to be recorded by the Department of Energy in accordance with state law at the County Register's of Deeds office upon completion of remediation and/or transfer of affected areas.

  The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) calls this land use control a property record notice and states that the Department of Energy will prepare a property record notice that will include the purpose of the notice, a brief summary of the main contaminants of concern, a listing of the land use controls and objectives, available maps and figures, an explanation of assumptions of future use of the property, and the land use control and Department of Energy contacts. The applicable land use control information, including the available figures and maps identified, will be posted on the Department of Energy web home page, will be placed at the publicly accessible Department of Energy Information Center as a hardcopy, and will be added to Appendix A of the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006). At the completion of remediation, this property record notice will be replaced within the Department of Energy web page and at the Department of Energy Information Center by the above Department of Energy-prepared land notation and survey plat described in the previous section. Both the land notice and survey plat will also be filed by the Department of Energy in the Register's of Deeds records of the pertinent county. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires that a Department of Energy official (or its contractor) verify annually that the information is properly recorded at the County Register's of Deeds office in the event of a records search.

  The Department of Energy placed the Melton Valley property record notice, officially titled, "Notice of Land Use Restrictions in Melton Valley Area Department of Energy – Oak Ridge Reservation," in the Roane County News (December 10, 2007), Oak Ridger (December 11, 2007), Knoxville News Sentinel (December 11, 2007), Loudon County News Herald (December 13, 2007), and the Oak Ridge Observer (December 13, 2007). This same notice was also placed on the Department of Energy website and filed at the Department of Energy Information Center. The notice includes the predominant contaminants of concern; future use limitations of the areas within Melton Valley; the required land use controls; additional contact information; and a figure depicting the three land use zones. For FY 2011, this information was verified to be posted electronically on the web site and to be placed at the Department of Energy Information Center. In addition to the Melton Valley property record notice, the Department of Energy land notation and survey plat were also filed on the web page and at the Information Center. It also was verified that the land notation was properly recorded at the Roane County Register's of Deeds office (see previous section).

- **Zoning Notices**. Requirements for Zoning Notices were changed through an erratum to the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) that replaced Chapter 7 (land use controls) and added them to Appendix A of the the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006). These changes represent how the City of Oak Ridge is to handle zoning information provided by the Department of Energy for land on the Oak Ridge Reservation. The *Remedial Action Report for the Melton Valley Watershed* now states that the Oak Ridge Reservation, including Melton Valley, is currently zoned as a federal controlled industrial/research area 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 transferred out of federal control. Resource Conservation and Recovery Act Subtitle C hazardous waste landfill(s) Property Record notice(s) will be filed according to Tennessee Department of Environment and Conservation Chapter 1200-1-11.05 and/or 1200-1-11.06 with the City Planning Commission. This replaces the requirement from the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) that the Department of Energy will file a zoning notice with the City Planning Commission upon completion of all remediation.

The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires that a zoning notice be recorded by the Department of Energy for all waste management areas and other areas where hazardous substances are left in place to provide notice to the city about the existence and location of a hazardous waste landfill(s) for zoning/planning purposes. A survey plat of Solid Waste Storage Area 6 Interim Corrective Measure Areas/Hillcut Test Facility is to be filed by the Department of Energy with the City Planning Commission.

The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) states that the Department of Energy will submit to the City Planning Commission a survey plat (at least four copies) indicating the location and dimensions of landfill cells or other disposal units, i.e., the Solid Waste Storage Area 6 Interim Corrective Measures Areas and the Hillcut Test Facility) with respect to permanently surveyed benchmarks as well as a record of the type, location, and quantity of hazardous wastes disposed to the best of the Department of Energy's knowledge based upon any kept records. This zoning notice information is similar to the property record notices discussed above. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires that a Department of Energy official (or its contractor) verify annually that the information is properly maintained and assessable at the City Planning Commission.

- **Excavation/Penetration Permit Program.** The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires that an excavation/penetration permit 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 excavation/penetration activity, as appropriate. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires a DOE official (or its contractor) to verify no less than annually the functioning of the permit program against existing procedures.

  Verification was provided by the Melton Valley Project Engineer stating that the excavation/penetration permit program was functioning during FY 2011 in accordance with Appendix B of the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) and Procedure OR-1010, *Excavation/Penetration Permit for ORNL Site*. Excavations conducted by UT-Battelle when operating as the prime workgroup were performed in accordance with the UT-Battelle procedure, *Initiating and Issuing an Excavation or Penetration Permit*, which requires the Melton Valley Project Engineer signature on every excavation permit before work can begin. The UT-Battelle excavation permit form (ORNL-211) also requires that the Melton Valley Project Environmental Compliance Lead review the area to determine if any CERCLA land use control implementation plans are established, and if so, specify the relevant details. In FY 2011, there were no UT-Battelle excavation permits requested for Melton Valley remediation areas.

  Excavations conducted at Melton Valley were performed in accordance with Procedure OR-1010, *Excavation/Penetration Permit for ORNL Site* which requires that an excavation/penetration permit log be maintained and that all excavation/penetration permits at the Oak Ridge National Laboratory be entered into the log and maintained by one person. The procedure also requires that an Environmental Compliance Review Form (BJCF-147b) be completed by Melton Valley

Environmental Compliance for all excavations and that Environmental Compliance review existing information sources to determine if the area is covered by a land use control implementation plan to ensure that the activity will not unknowingly violate CERCLA land use controls. In FY 2011, there were no excavation permits requested for Melton Valley remediation areas.

- **State Advisories/Postings**. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires that advisories established by the TDEC Division of Water Pollution Control that provide notice to potential resource users of contamination and prohibit fishing/swimming in White Oak Creek Embayment and White Oak Lake on signs and in the fishing regulations published by the Tennessee Wildlife Resources Agency will be effective immediately upon approval of the *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006). Although adequate warning signs have been established and maintained on the White Oak Lake and White Oak Creek Embayment, current state advisories and published fishing regulations do not address the White Oak Lake and White Oak Creek Embayment. Changes made through the FY 2010 addendum to the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) state that DOE will continue to place appropriate signs at the White Oak Lake and White Oak Creek Embayment. These changes do not prevent future postings of these waters by the State of Tennessee but allow the Department of Energy to fully meet the intent of this requirement.

  Per the *Land Use Control Implementation Plan for the Melton Valley Watershed*, the purpose of the advisories/postings is to provide the public with important warnings that seek to limit/restrict incompatible uses and prevent unsafe exposure to contaminants. There are Department of Energy established signs posted along the White Oak Dam access areas at Highway 95 and at the access gate and on fencing along the White Oak Creek Embayment that state, "Warning, No Fishing, No Water Contact, Area Contaminated."

  These signs have been added to the Melton Valley Access Controls and Signs map in the *Remedial Action Report for the Melton Valley Watershed* through an addendum (DOE 2009b) that replaced Chapter 7 (Land Use Controls). The changes incorporated the additional signs around the White Oak Lake and the White Oak Creek Embayment at six of the twenty major access points in Melton Valley to provide notice to potential resource users of contamination and prohibit fishing/contact. These changes allow the Department of Energy to meet the intent of the State Advisories/Postings requirements with the continued placement of appropriate signs at White Oak Lake and White Oak Creek Embayment to prevent the unauthorized use of these waters.

  The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) also requires that a Department of Energy official (or its contractor) verify the information in the fishing regulations with a Tennessee Wildlife Resources Agency official to ensure that fishing regulations accurately describe impacted streams. The Tennessee Wildlife Resources Agency receives guidance from the Tennessee Department of Environment and Conservation on publishing these advisories in their annual fishing regulations. Currently, there are no Tennessee Department of Environment and Conservation-established advisories on White Oak Lake and White Oak Creek Embayment because the Department of Energy Oak Ridge Reservation property does not afford public access and, therefore, no information has been published in the Tennessee Wildlife Resources Agency fishing regulations for these areas.

- **Access Controls**. The *Record of Decision for Interim Actions for the Melton Valley Watershed* (DOE 2000) requires that access controls (e.g., fences, gates, portals) be maintained throughout the Melton Valley remediation areas to control and restrict access to workers and the public to prevent unauthorized uses. A map depicting the location of access controls that are necessary to ensure protectiveness of the remedy is included in the *Remedial Action Report for the Melton Valley*

Watershed (DOE 2009b). This map was revised through an addendum (DOE 2009b) that replaced Chapter 7 (land use controls) The revision increased the number of access control locations from 16 to 20 to better cover the White Oak Dam while also removing interior Melton Valley access control locations that are no longer necessary.

The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires that any access controls will be monitored and maintained by DOE indefinitely or for as long as needed. The *Land Use Control Implementation Plan for the Melton Valley Watershed* requires that a DOE official (or its contractor) conduct a field survey no less than annually of all controls to assess their condition and ensure fences are erect or intact and gates/portals are functioning properly. In addition to routine site inspections conducted in accordance with the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC 2006), a field survey was conducted by the Water Resources Restoration Program and the surveillance and maintenance program to verify access controls designated in the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) (with errata sheets incorporated) were in place, in good condition and functioning properly. All major access points remain guarded or locked at all times, and interior gates are selectively locked. Specifically, access is restricted by the Oak Ridge Reservation perimeter fence and security portals at the east and west ends of Bethel Valley Road. There also is a locked gate at the junction of the haul road and the Melton Valley Access Road. Perimeter roads around Melton Valley have gates that allow access for maintenance activities.

- **Signs**. The *Record of Decision for Interim Actions for the Melton Valley Watershed* requires that signs be maintained by DOE at select locations throughout Melton Valley to provide notice or warning to prevent unauthorized access. A map depicting the location of the signs that apply to the Melton Valley watershed is included in the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b). This map was revised through an addendum that replaced Chapter 7 (land use controls). The revision increased the number of sign locations from 13 to 20 to better cover White Oak Dam while also removing interior Melton Valley sign locations that are no longer necessary. In addition to location changes, wording of the signs was updated to more appropriately represent the current site conditions and restrictions. This revision allows the intent of the State Advisories/Postings requirements to be met with the continued placement of appropriate signs at White Oak Lake and White Oak Creek Embayment to prevent the unauthorized use of these waters.

  The *Land Use Control Implementation Plan for the Melton Valley Watershed* (2006) requires that, within six months of approval, signs will be in place at designated locations throughout the Melton Valley watershed near major access points to provide notice or warning to prevent unauthorized access. Any signs that are land use controls will be monitored and maintained, until the concentration of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure or as long as needed. The *Land Use Control Implementation Plan for the Melton Valley Watershed* requires that a DOE official (or its contractor) conduct a field survey no less than annually of all signs to assess their condition and ensure they remain erect, intact, and legible. In addition to routine site inspections conducted by the Melton Valley Surveillance and Maintenance Program according to the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC 2006) of all remediated areas in Melton Valley, a field survey was conducted by the Water Resources Restoration Program and the surveillance and maintenance program to verify signs designated in the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) were in place, in good condition and legible. All signs as identified in the *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) were in place and meeting their intended purpose. Specifically, 20 signs were in place around the Melton Valley watershed and at the White Oak Lake and White Oak Creek Embayment to provide notice of contamination or warning to prevent unauthorized access. There were also six additional signs posted at locations around White Oak Lake and White Oak Creek Embayment and on the Sediment Retention Structure to provide notice to potential resource users of contamination and prohibit fishing/swimming.

- **Surveillance Patrols**. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires that surveillance patrols of selected areas in Melton Valley be effective immediately and be conducted no less frequently than once a quarter as part of the required, routine surveillance and maintenance site inspections. The *Land Use Control Implementation Plan for the Melton Valley Watershed* (DOE 2006) requires a DOE official (or its contractors) to verify no less than annually against approved procedures/plans that routine patrols are conducted to ensure that incompatible uses have not occurred for units/areas requiring land use restrictions. In FY 2011, surveillance patrols were performed by the Oak Ridge National Laboratory Surveillance and Maintenance Program as part of routine site inspections in accordance with the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC 2006). Inspections of the capped areas within Melton Valley were performed on a quarterly basis. In addition, security personnel also perform required daily patrols of various areas within Melton Valley.

In addition to implementing the physical land use controls, i.e., access controls, signs, and surveillance patrols, as detailed above, the Surveillance and Maintenance 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, fences, gates, and signs.

The *Remedial Action Report for the Melton Valley Watershed* (DOE 2009b) requires that for the first two years after installation of a hydrologic isolation cap, an engineer familiar with the cap design shall inspect each cap and associated features quarterly and after any precipitation that is greater than or equal to a five-year, 24-hour storm event (4.1 inches in a 24-hour period). After a minimum two-year period or until the hydrologic isolation cap and surface drainage features remain stable, the inspection schedule will revert to twice per year and after any precipitation that is greater than or equal to a 25-year, 24-hour storm event (5.5 inches in a 24-hour period).

In FY 2011, engineering controls were inspected quarterly by the Surveillance and Maintenance Program according to the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC 2006) at the following sites:

- Solid Waste Storage Area 4,
- Solid Waste Storage Area 5 North 4-Trench Area,
- Solid Waste Storage Area 5 South,
- Solid Waste Storage Area 6 Capped Area – CAP A,
- Solid Waste Storage Area 6 Capped Area – CAP B,
- Solid Waste Storage Area 6 Capped Area – CAP C,
- Solid Waste Storage Area 6 Capped Area – CAP D,
- Solid Waste Storage Area 6 Capped Area – CAP E,
- Solid Waste Storage Area 6 Capped Area – HTF,
- 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 2011 included repairing a disconnected gas vent at Trench 6 and Trench 6 Leak Sites; reseeding four acres at Solid Waste Storage Area 4 and four acres at Solid Waste Storage Area 5 South; and adding dirt and reseeding 3 acres at Pit 2, Pit 3, and Pit 4. All caps were mowed a minimum of once during the year. A 25-year, 24-hour intensity rainfall event occurred on September 6, 2011 and inspections were performed at all sites. No major erosion issues were identified.

3.2.5.2 Single-Project Actions

3.2.5.2.1 White Oak Creek Embayment Sediment Retention Structure

Requirements

Location of the White Oak Creek 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 White Oak Creek to contain the sediments in lower White Oak Creek Embayment 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 White Oak Creek flow and fluctuation of Watts Bar Reservoir levels.

Long-term stewardship requirements are in Table 3.2 and include only inspection and maintenance of the sediment retention structure.

No surface water or groundwater monitoring is required to verify the effectiveness of the removal action.

Status

The site was inspected monthly in FY 2011 by the Surveillance and Maintenance 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. No maintenance was required.

3.2.5.2.2 Waste Area Grouping 13 Cesium Plots Interim Remedial Action

Requirements

The location of the Waste Area Grouping 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.

Long-term stewardship requirements are in Table 3.2. and include only long-term surveillance and maintenance of the fenced enclosure.

No surface water or groundwater monitoring is required to verify the effectiveness of the removal action.

Status

The site underwent quarterly inspections in FY 2011 conducted by the Surveillance and Maintenance 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-contact signs were in place, and the site was clear of unauthorized materials. No maintenance was required, and routine mowing was performed.

3.2.5.2.3 Molten Salt Reactor Experiment Uranium Deposit Removal

Requirements

The location of the Molten Salt Reactor Experiment 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.

Long-term stewardship requirements in Table 3.2) are specified in the *Removal Action Report for Uranium Deposit Removal at the Molten Salt Reactor Experiment* (DOE 2001) and include surveillance and maintenance for the interim storage of the collector canister holding the uranium-laden charcoal removed from the auxiliary charcoal bead. 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.

No surface water or groundwater monitoring is required to verify the effectiveness of the removal action.

Status

Inspections were conducted daily of the uranium-laden charcoal canister, in accordance with Molten Salt Reactor Experiment procedures. These inspections included periodic pressure measurements and periodic venting of the canister to reduce pressure when needed. The only maintenance required in FY 2011 was to perform calibrations on the PT-15 monitor. No other maintenance was performed on the canister itself.

3.3 MELTON VALLEY WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Melton Valley watershed are in Table 3.12.

Table 3.12. Melton Valley Watershed issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
None.			
Issue Carried Forward			
1. Initial sampling of new offsite wells (2 events) yielded indication of the presence of VOCs and some metal contaminants. (2011 RER)b	1. Comprehensive picket well and offsite well sampling was completed in the first quarter of FY 2012. The presence of site contaminants, trends, and on-site vs off-site hydrologic head relationship was discussed with the Core Team in January 2012. New sampling is being agreed upon with DOE/EPA/TDEC for the Melton Valley Exit Pathway and is being documented in the MV Monitoring Plan.	DOE/ EPA & TDEC	FY 2012
2. During FY 2010 groundwater level control at the SWSA 4 downgradient trench deteriorated as indicated by water level measurements in the trench, within the nearby portion of SWSA 4, and the former IHP area. (2011 RER)[b]	2. (a) Item was closed out. See Completed/Resolved Issues below. (b) DOE will evaluate the performance of SWSA 4 downgradient extraction trench. In 2011 it was determined that contaminants from SWSA 4 were seeping to surface water.	DOE/EPA & TDEC	FY 2012
Completed/Resolved Issues			
1. During FY 2010 groundwater level control at the SWSA 4 downgradient trench deteriorated as indicated by water level measurements in the trench, within the nearby portion of SWSA 4, and the former IHP area. (2011 RER)[b]	1. (a) During winter of 2011 DOE will collect seepage samples from the IHP adjacent to the SWSA 4 downgradient trench during or soon after large rainfall events to determine if SWSA 4 contaminants are being discharged to surface water in the IHP. In 2011 it was determined that contaminants from SWSA 4 were seeping to surface water, results included in the 2011 RER. (b) Included as an Issue Carried Forward, see above.	DOE/ EPA & TDEC	FY 2011 with submission of the 2012 D2 RER
2. Monitoring results for some zones in the MV exit pathway wells yield elevated alpha and beta activity results that are apparently the result of elevated suspended and/or dissolved solids. These results raise concern over possible migration of contamination across the DOE property boundary in western MV. (2008 RER)[b]	2. Monitoring of the picket wells in accordance with the MV Monitoring Plan continued through December 2011. Additionally in 2010, DOE established an offsite monitoring system to confirm the presence of contaminants including two clusters of newly drilled wells and two reconfigured wells. Monitoring of the new system was agreed upon for four quarters, after which the Core Team will discuss the monitoring results. The Core Team discussed the result of the sampling in December 2011. This issued is closed out. Issue #1 in Table 1.1 concerns the follow on sampling documentation in a revision to the Melton Valley Monitoring Plan.	DOE/ EPA & TDEC	FY 2011 with submission of the 2012 D2 RER

Table 3.12. Melton Valley Watershed issues and recommendations (cont.)

[a] A "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remediation Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remediation Effectiveness Report for Five-Year Review 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., (2006 FYR).

DOE = Department of Energy
EPA = Environmental Protection Agency
IHP = Intermediate Holding Pond
MV = Melton Valley
RDR/RAWP = remedial design report/remedial action work plan
RER = remedial effectiveness report
SWSA = solid waste storage area
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound

3.4 REFERENCES

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DOE 1997. *Remedial Investigation Report on the Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1546&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1998. *Feasibility Study for Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/02-1629&D2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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

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

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

DOE 2006. *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1977&D6, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007a. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE2007b. *Melton Valley Surveillance and Maintenance Plan, Oak Ridge, Tennessee,* DOE/OR/01-2342&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007c. *Melton Valley Monitoring Plan*, DOE/OR/01-1982&D1/R4, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2008. *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, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009a. *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2343&D1/A1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2009b. *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2343&D1/A2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010a. *Action Memorandum for Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2460&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010b. *Addendum to the Melton Valley Monitoring Plan, Oak Ridge, Tennessee, Appendix E*, DOE/OR/01-1982&D1/R4/A1/R2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010c. *2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2437&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011a. *Removal Action Report for the Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-2509&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011b. *Engineering Evaluation of Options for the Molten Salt Reactor Experiment Defueled Coolant Salts*, DOE/OR/01-2496&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011c. *NDA Measurements for Defueled Salts Completion for the Molten Salt Reactor Experiment*, DOE/OR/01-2513&D1, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011d. *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&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

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4. CERCLA ACTIONS IN BEAR CREEK VALLEY WATERSHED

4.1 INTRODUCTION AND STATUS

4.1.1 Introduction

The Bear Creek Valley watershed contains waste disposal facilities. Table 4.1 lists the CERCLA actions within the watershed, and Figure 4.1 locates the key CERCLA sites and actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of effectiveness of each completed action are discussed. Only sites that have long-term stewardship requirements (Table 4.1) are included in these performance evaluations. Remedial action objectives that form the basis for the remedial actions are based on the end uses depicted in Figure 4.2. These end uses require certain restrictions regarding site access and allowable activities as listed in Table 4.2.

Completed CERCLA actions in the Bear Creek 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 provides a preliminary evaluation of the early indicators of effectiveness at the watershed scale.

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 2011b). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

4.1.2 STATUS

<u>Bear Creek Valley Watershed-scale Actions</u>

- The *Record of Decision for the Phase I Activities in Bear Creek Valley* (DOE 2000) establishes protectiveness and cleanup levels for the watershed and specifies remedial actions for the S-3 Site, the Oil Landfarm Area (Oil Landfarm Soil Containment Pad, Boneyard/Burnyard, and North Tributary-3), and the Disposal Area Remedial Action Facility.

- The *Focused Feasibility Study for the Bear Creek Burial Grounds* (DOE 2008a) and *Proposed Plan for the Bear Creek Burial Grounds* (DOE 2008b) for remediation of the Bear Creek Burial Grounds were submitted to the regulators in FY 2008. Review was suspended in FY 2009 due to issues related to funding for long-term land-use controls and DOE's proposed schedule to defer implementation of the selected remedy. Issues remain unresolved as of September 30, 2011. Future decision documents and their respective implementation have not been formalized at this time.

Table 4.1. CERCLA actions in Bear Creek Valley watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations/ Land Use Controls required	Section
Watershed-scale actions				
Bear Creek Valley Phase I ROD	ROD (DOE/OR/01-1750&D4): 06/16/00 LUCIP (DOE/OR/01-2320&D1) submitted 09/29/06	Actions complete		
		• Boneyard/Burnyard PCCR (DOE/OR/01-2077&D2) approved 01/12/04.	Yes/Yes/Yes	4.2
		• Oil Landfarm Soils Containment Pad RAR (DOE/OR/01-1937&D2) approved 07/16/01.	No/No/No	
		Actions not yet implemented		
		• S-3 Site Pathway 3	No/Yes/Yes	
		• Disposal Area Remedial Action	No/Yes/Yes	
Bear Creek Valley Phase II ROD	ROD: TBD[b]			
Single-project actions				
Bear Creek Valley Operable Unit 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/Yes	4.2.4.2
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).		
Bear Creek Burial Ground Unit D-East	AM (DOE/OR/01-2036&D1): 08/12/02	RmAR (DOE/OR/01-2048&D2): approved 05/09/03.	No/No/No	--
Environmental Management Waste Management Facility	ROD (DOE/OR/01-1791&D3): 110/2/99 ESD (DOE/OR/01-1905&D2): 10/05/01 ESD (DOE/OR/01-2194&D2): 01/11/05 ESD (DOE/OR/01-2426&D2): 06/29/10	PCCR (DOE/OR/01-2255&D1): approved 07/15/05.		
		PCCR (DOE/OR/01-2296&D1): approved 04/26/06 (Haul Road).		
		Construction Completion Report (DOE/OR/01-2022&D1): approved 05/20/02.		

[a]Detailed information of the status of actions is from Appendix E of the Federal Facility Agreement and is available at <http://www.ucor.com/ettp_ffa_appendices.htm>.
[b]D1 Focused Feasibility Study and Proposed Plan for remediation of the Bear Creek Burial Grounds submitted in FY 2009. Future decision documents and their respective implementation have not been formalized at this time.

Table. 4.1. CERCLA actions in Bear Creek Valley watershed (cont.)

AM = Action Memorandum
DARA = Disposal Area Remedial Action
ESD = Explanation of Significant Differences
LTS = long-term stewardship
LUCIP = Land Use Control Implementation Plan
PCCR = Phased Construction Completion Report
RER = Remediation Effectiveness Report
RAR = Remedial Action Report
ROD = record or decision
RmAR = Removal Action Report
S&M = surveillance and maintenance
TBD = to be determined

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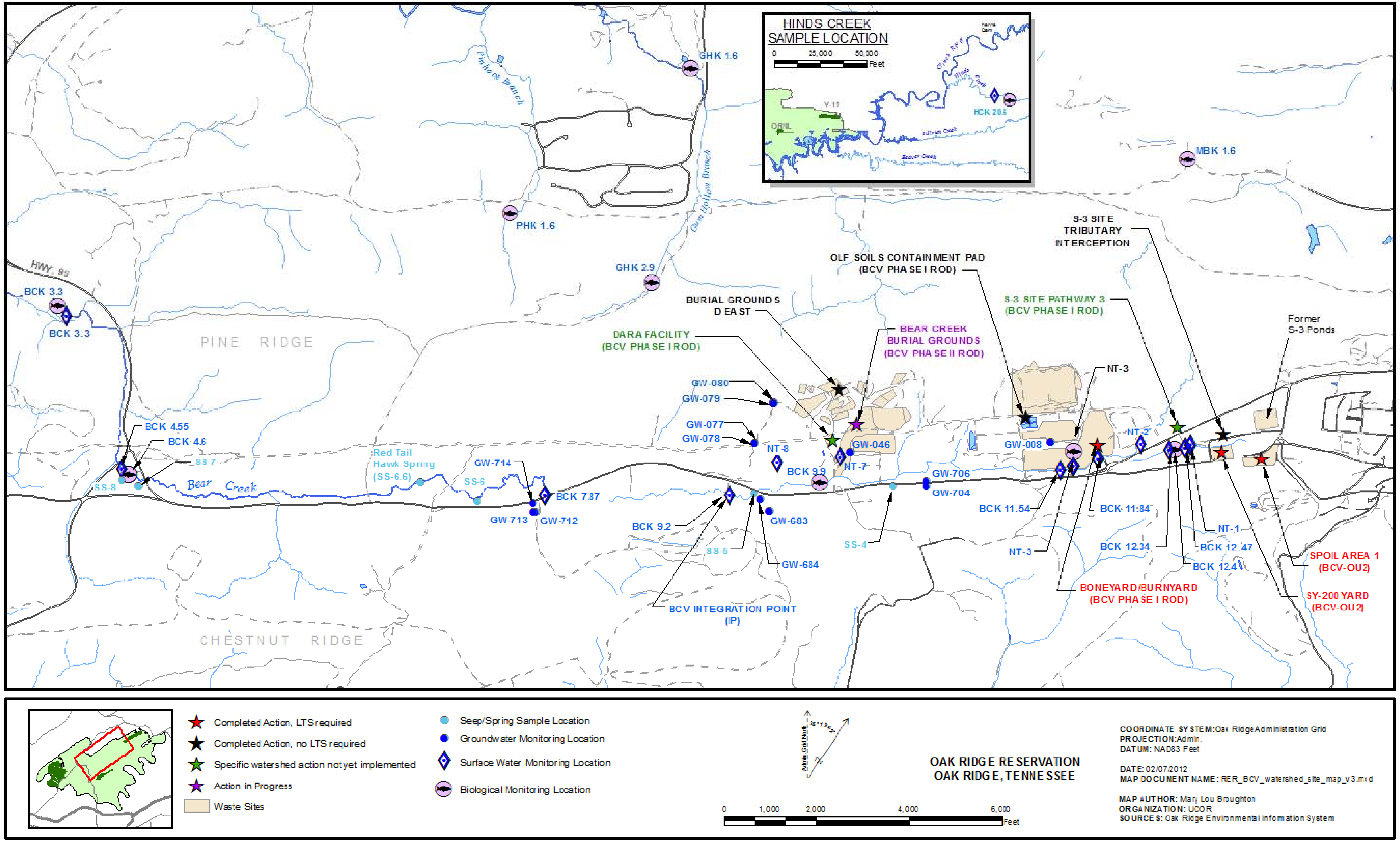

Figure 4.1. Bear Creek Valley Watershed.

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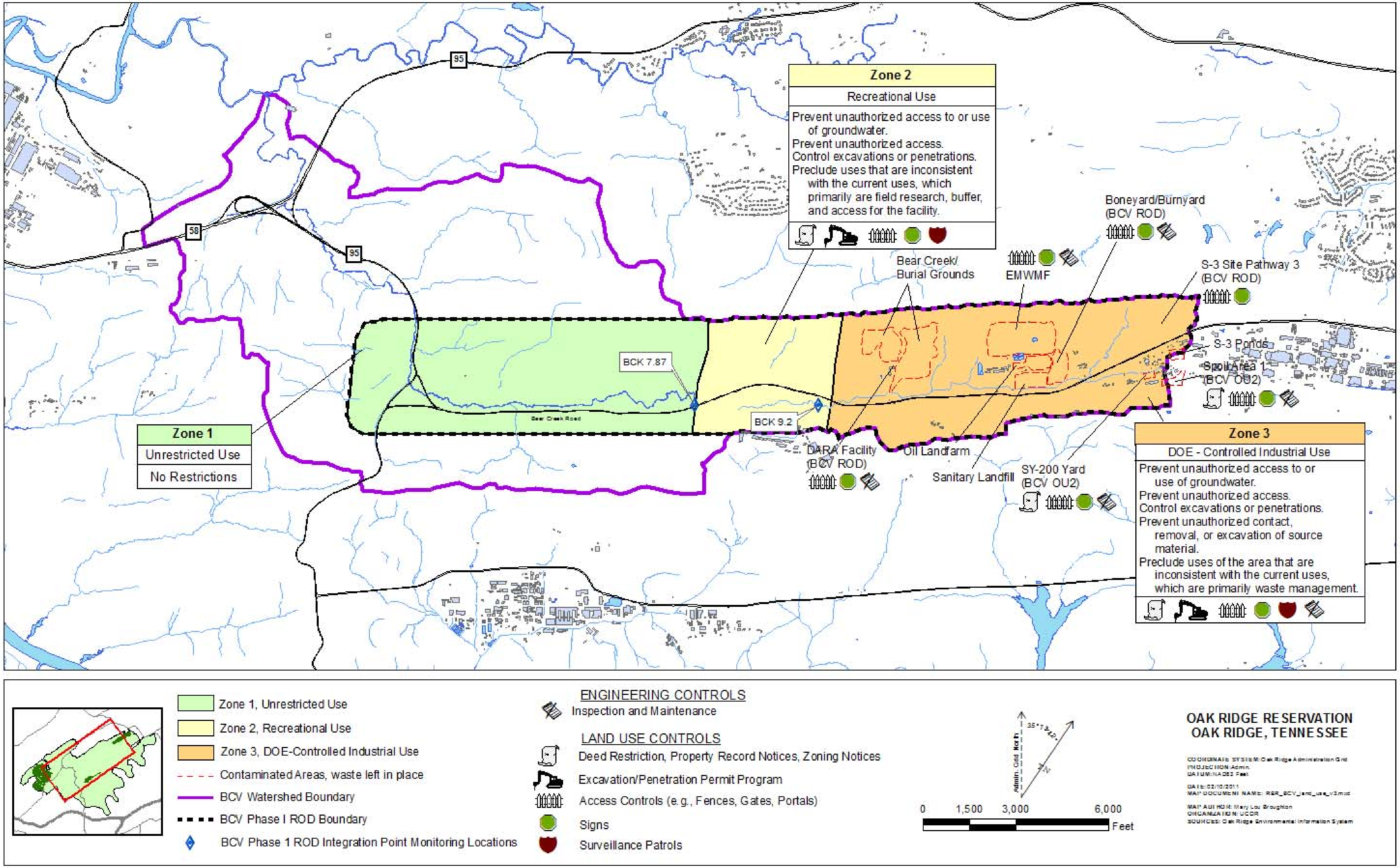

Figure 4.2. Bear Creek Valley Phase I Record of Decision-designated end use and interim land use controls.

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Table 4.2. Long-term stewardship requirements for CERCLA actions in Bear Creek Valley watershed

Site/Project	Long-Term Stewardship Requirements: Land Use Controls	Long-Term Stewardship Requirements: Engineering controls	Status	Section
Watershed-scale actions				
BCV Phase I ROD[a] ▪ BYBY PCCR	Watershed Land Use Controls Administrative: ▪ land use and groundwater deed restrictions[b] ▪ property record notices ▪ zoning notices ▪ permits program Physical: ▪ access controls ▪ signs ▪ security patrols BYBY PCCR specific: ▪ Access controls ▪ Signs	BYBY PCCR specific: ▪ Maintain cap at BYBY	Watershed Land Use Controls ▪ Physical Land Use Controls in place. ▪ Administrative Land Use Controls required at completion of actions. BYBY PCCR specific: ▪ Land Use Contnrols in place. ▪ Engineering controls remain protective.	4.2.4
Completed single- project actions				
BCV OU2 (Spoil Area 1, SY-200 Yard)	Deed restrictions Access controls (fencing) Signs	Maintain vegetated soil cover	Land use controls in place. Engineering controls remain protective.	4.2.4.2

[a]Remaining actions have not been implemented but require interim access controls (e.g., S-3 Site Pathway 3 and Disposal Area Remedial Action Facility).
[b]Includes restrictions on surface water use.

BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
OU = operable unit
PCCR = Phased Construction Completion Report
RER = Remediation Effectiveness Report
ROD = record of decision

4.2 BEAR CREEK VALLEY PHASE I RECORD OF DECISION

4.2.1 Performance Goals and Monitoring Objectives

The remedy in the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) 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 Bear Creek Valley watershed predate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley*. 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*, 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* 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* 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 Bear Creek Watershed. Annual performance measurements obtained during FY 2011 are presented along with historic monitoring results.

The remedial action objectives for the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) 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 Bear Creek Valley watershed were identified previously on Figure 4.2. Consistent with the remedial action objectives, water quality goals are also established (DOE 2000) for each zone as stated in Table 4.3. In addition to the watershed-wide water quality goals, the Record of Decision provides site-specific water quality goals for the S-3 Site Pathway 3 and the Boneyard/Burnyard actions (Table 4.4).

Table 4.3. Groundwater and surface water goals, Bear Creek Valley 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 2000) (page 2-13).

AWQC = ambient water quality criteria
MCLs = Safe Drinking Water Act maximum contaminants level

Table 4.4. Site-specific goals for remedial actions at the S-3 Site Pathway 3 and the Boneyard/Burnyard[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 2000) (page 2-14).
[b]The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) originally established the cadmium concentration performance standard as 3.9 µg/L. This standard changed to 0.25 µg/L due to change in the promulgated AWQC.

AWQC = ambient water quality criteria
BYBY = Boneyard/Burnyard
BCK = Bear Creek Kilometer
FFA = Federal Facility Agreement
NT = north tributary

The source removal actions related to principal threat source materials and groundwater control actions specified in the Record of Decision were intended to attain the stated water quality goals. The following components of the selected remedy are listed in the Record of Decision (DOE 2000):

- **S-3 Site**. Install trench at Pathway 3 for passive *in situ* treatment of shallow groundwater (DOE 2001).

- **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 Boneyard/Burnyard and contaminated floodplain soils and sediments. Excavated materials meeting the Environmental Management Waste Management Facility (EMWMF) waste acceptance criteria will be disposed on-site; materials exceeding EMWMF waste acceptance criteria will be disposed off-site. Install clay cap over uncapped disposal areas at Boneyard/Burnyard, and maintain existing caps.

  - Implement hydraulic isolation measures at Boneyard/Burnyard, including reconstruction of North Tributary-3, elimination of stagnation points, and installation of drains or well points.

- **Other Sites**. Remove waste stored in the Disposal Area Remedial Action 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* was initiated in FY 2000. Remedial actions in the Oil Landfarm Area are complete (Boneyard/Burnyard and Oil Landfarm Soil Containment Pad). Other key components of the remedy (S-3 Pathway 3 and Disposal Area Remedial Area) have not yet been implemented.

The Record of Decision included expected outcomes, target risk levels, and timeframes for attainment of goals for each of the Bear Creek Valley watershed end uses (Table 4.5).

Table 4.5. Expected outcome of the selected remedy, Bear Creek Valley 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 x* 10^{-5}	- *TBD for groundwater* - *AWQC in surface water* - *risk to residential receptor below RAO of 1 x* 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 x* 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 x* 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 onsite 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 2000, 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
BCBG = Bear Creek Burial Ground
BYBY = Boneyard/Burnyard
MCLs = Safe Drinking Water Act maximum contaminants level
N/A = not applicable
NT = North Tributary
OLF = Oil Landfarm
RAO = remedial action objectives
S-3 = Pathway 3
TBD = to be determined

4.2.2 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 2000). Performance monitoring includes surface water monitoring, groundwater monitoring, and biological monitoring. Monitoring locations are shown on Figure 4.1 and Figure 4.2. The performance metrics and monitoring parameters for each location are outlined in Table 4.6.

4.2.2.1 Surface Water Monitoring

This section presents the results of remedy effectiveness evaluation of surface water monitoring in the Bear Creek watershed. Section 3.2.2.1.1 summarizes the remediation goals for surface water;, and Section 3.2.2.1.2 presents information concerning major radionuclide concentrations and fluxes at the surface water integration point monitoring stations.

4.2.2.1.1 Surface Water Quality Metrics and Monitoring Requirements

The goals of the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) include AWQC compliance, annual mass (flux) reductions for nitrate and uranium at several locations throughout the watershed, and carcinogenic risk to a receptor of 1×10^{-5} at the integration point. AWQC sampling is conducted in the year prior to each CERCLA Five-Year Review. The most recent presentation and evaluation of progress toward meeting AWQC in Bear Creek Valley was reported in the *2011 RER (*DOE 2011a*) and the 2011 Third Reservation-Wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2011b). Monitoring is keyed to the boundaries between the three zones defined in the Record of Decision. Key surface water monitoring locations include Bear Creek kilometer (BCK) 9.2, BCK 12.34, North Tributary (NT)-3, SS-5, and NT-8 (Figure 4.1). BCK 9.2 is the integration point which lies between 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 Boneyard/Burnyard which has been remediated. NT-8 carries runoff and contaminants from the western end of the Bear Creek Burial Grounds to Bear Creek just a short distance near the western end of Zone 3 and above the integration point at BCK 9.2.

Zone 1

Zone 1 of Bear Creek Valley watershed constitutes the valley area west of BCK 7.87 (Figure 4.2). Surface water quality is monitored at BCK 7.87. For Zone 1 surface water, results are compared to AWQC in each CERCLA Five-Year Review, consistent with the unrestricted use goal. In addition, risk-based concentrations for residential exposure to surface water (1×10^{-5}) are included as part of the evaluation. The AWQC comparison includes quarterly grab samples for metals and anions during the year prior to each Five-Year Review.

Zone 2

Zone 2 of Bear Creek Valley watershed constitutes the section of the valley located between BCK 7.87 and BCK 9.2 (Figure 4.2). The goal for Zone 2 is to improve groundwater and surface water quality consistent with eventually achieving unrestricted use in 50 years. The monitoring location for Zone 2 surface water is at BCK 9.2, which lies between Zones 2 and 3. BCK 9.2 has continuous flow monitoring and is sampled for ^{234}U, ^{235}U, and ^{238}U, with quarterly samples for metals, VOCs and nitrate in the year prior to each CERCLA Five-Year Review. Zone 2 surface water results at BCK 9.2 are compared to a

Table 4.6. Bear Creek Valley watershed CERCLA performance monitoring[a]

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
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	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 and isotopic uranium, and mercury; VOCs; and nitrate[f]	AWQC, risk-based[e]
			Continuous flow-proportional monitoring	Uranium (isotopic)	U flux ≤ 34 kg/yr
	Groundwater	GW-683, GW-684 (Picket A) SS-5 Spring	Semiannual grab samples	Metals, including uranium; nitrate	TBD[b] trend monitoring
			Continuous flow-proportional monitoring and semiannual grab samples	Uranium (isotopic), mercury, methylmercury	
Zone 3	Surface water	BCK 12.34	Quarterly grab samples (in year prior to FYR)	Metals, including Cd, Hg, and isotopic and total U (with an MDL of 0.004 mg/L); VOCs, nitrates[f]	AWQC, risk-based[e] – within five yrs, U ≤27kg/yr, Cd ≤0.25µg/L, Nitrates – 40% seasonal reduction, Nitrate trend
		NT-1	Quarterly grab samples (in year prior to FYR)	Metals, including total and isotopic uranium, and Cd; VOCs, and nitrate[f]	AWQC, risk-based[e]
		NT-2	Quarterly grab samples (in year prior to FYR)	Metals, VOCs, and nitrate[f]	AWQC, risk-based[e]
		NT-3	Quarterly grab samples (in year prior to FYR)	Metals, including mercury; VOCs[f]	AWQC, risk-based[e] – within five yrs; Hg ≤51 ng/L
		BCK 11.54	Quarterly grab samples (in year prior to FYR)	Metals, including total and isotopic uranium, and mercury; and nitrate[f]	AWQC, risk-based[e]
			Continuous flow-proportional monitoring	Uranium (isotopic)	Uranium trend

Table 4.6. Bear Creek Valley watershed CERCLA performance monitoring (cont.)

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
		NT-8	Continuous flow-proportional monitoring	Uranium (isotopic)	Determine relative contribution of the BCBGs to uranium flux at BCK 9.2
Boneyard/Burnyard	Surface water	NT-3	Monthly grab samples with instantaneous flow measurement	Uranium (isotopic)	Uranium flux ≤ 4.3 kg/yr
			Quarterly grab samples (in year prior to FYR)	Metals, including mercury; VOCs	AWQC Hg ≤ 51 ng/L
	Biota	NT-3	Annually (until recovery complete)	In-stream sampling of fish and benthic macroinvertebrate communities	Aquatic community data compared to data available for similar reference streams on the Oak Ridge Reservation
	Vegetation[h]	NT-3	Annually (until recovery complete)	Riparian 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.
	Stream channel stability	NT-3	Recovery complete. Survey terminated 2009	Stream channel stability	Qualitative field measurements
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
			Quarterly grab samples (in year prior to FYR)	Metals, including Cd	Cd ≤ 0.25 µg/L; AWQC – within five years
		NT-1	Quarterly grab samples	Metals, including Cd	Cd ≤ 0.25 µg/L
		NT-2	Weekly flow-proportional composite samples	Nitrate (flux)	Nitrate – 40% seasonal reduction in flux

Table 4.6. Bear Creek Valley watershed CERCLA performance monitoring (cont.)

Area/Site	Media	Monitoring location	Schedule	Parameters	Performance standard
S-3 Pathways 1 and 2[g]	Monitoring to evaluate the effectiveness of the treatment systems is discontinued.				
	Surface water	BCK 12.34	Weekly flow-proportional composite samples	Nitrate, uranium isotopes	No additional performance measures imposed with documentation of the treatment system shutdown.
		BCK 12.34	Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and Hg	
		BCK 9.2	Continue weekly flow-proportional composite samples	Uranium isotopes	
	Biota	BCK 3.3 BCK 9.9 BCK 12.4	Continue biological monitoring as before P1 and P2 treatment system shutdown	Hg and PCBs[d]	Measure changes in quality of aquatic habitat as compared to reference sites.

[a]This table represents current requirements for monitoring that have been agreed upon by all Federal Facility Agreement parties at the Bear Creek Valley Core Team Meeting held November 18, 2008. Currently, recommended monitoring per this Remediation Effectiveness Report is not included on this table.

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

[c]Remedial actions 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 2007b) 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 include mercury and PCBs. The correct parameters will be approved in the Sampling and Analysis Plan/Quality Assurance Program Plan that will be submitted to the regulators for review and approval.

[e]Risk-based concentrations of 1x10-5 residential receptor for Zones 1 and 2 and industrial for Zone 3.

[f]Sampling will be conducted for contaminants of concern identified from the Bear Creek Valley Remedial Investigation for risk-based comparisons.

[g]Correspondence from regulators (DOE 2007b) 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.

[h]Vegetation riparian survey has been recommended to be discontinued (see Table 4.14).

AWQC = ambient water quality criteria
BCBG = Bear Creek Burial Ground
BCK = Bear Creek kilometer
FYR = Five-Year Review
GW = groundwater
IP = integration point
MCLs = Safe Drinking Water Act maximum contaminants level
NT = North Tributary
VOCs = volatile organic compounds

flux goal annually and to AWQC during the Five Year Review. In addition, risk-based concentrations for residential exposure to surface water (1 x 10^{-5}) are included as part of the evaluation.

Zone 3

Zone 3 of Bear Creek watershed is the section of the valley east of BCK 9.2 (Figure 4.2) 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. These locations include BCK 11.54 and BCK 12.34 with weekly continuous-flow monitoring and samples analyzed for ^{234}U, ^{235}U, and ^{238}U and surface water grab samples analyzed for nitrates.. There are also quarterly grab samples for metals including mercury at BCK 12.34 and NT-1, with semiannual grab samples at NT-2 and NT-3 during the year prior to each CERCLA Five-Year Review.

The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) 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
- ≤4.3 kg/yr at the mouth of NT-3

Effectiveness of remediation at the Boneyard/Burnyard is measured by water quality in the NT-3 stream. Monitoring at Bear Creek main stream station BCK 11.54, downstream of NT-3 (Table 4.6 and Figure 4.1), now performs as an upstream integration point for the Bear Creek Burial Grounds.

The *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) requires Boneyard/Burnyard to meet AWQC in surface water at NT-3 and that surface water risk to an industrial receptor is below 1 x 10^{-5}. During years prior to each CERCLA Five Year Review, grab samples are collected, at a minimum, monthly from NT-3 and analyzed for mercury and uranium with semiannual grab samples for metals analysis.

4.2.2.1.2 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 Bear Creek Valley watershed-scale long-term CERCLA decision making is provided in Figure 1.5 of the *2007 Remediation Effectiveness Report* (DOE 2007a).

Zone 1

Surface water monitoring results are compared to AWQC, and evaluated against the risk-based concentrations for residential exposure to surface water (1 x 10^{-5}) consistent with the unrestricted land use goals. Zone 1 surface water sampling and data evaluations are presented in the CERCLA Five Year Review documents. The *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE 2011b) presented the most recent results and determined that no chemicals exceeded AWQCs in Zone 1 surface water and that, although detectable, uranium concentrations were less than the primary drinking water standard and ^{99}Tc was present at levels of approximately 1% of the maximum contaminant level effective dose equivalent (900 pCi/L).

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 human health protection goals established in the Record of Decision. 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. The FY 2011 average activities of ^{234}U, ^{235}U, and ^{238}U were **7.6**, 0.7, and **17.6** pCi/L, respectively. The values for ^{234}U and ^{238}U exceeded the risk-based activities of 6.7 and 5.5 pCi/L <http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search>, respectively. These risk-based goals are equivalent to the Record of Decision hypothetical residential exposure goal of a 1×10^{-5} excess lifetime cancer risk attributable to the uranium isotopes. Table 4.7 and Figure 4.3 present the historic average activity of isotopes of uranium and concentration of nitrate since the Record of Decision was implemented. Over the period of monitoring, ^{235}U has been less than the 6.6 pCi/L risk-based activity in Zone 2. Additional discussion of contaminant transport from Zone 3 into Zone 2 is presented below.

Table 4.7. Historic average activity of uranium isotopes and concentration of nitrate at the integration point (BCK 9.2)

Fiscal Year	Uranium 234 pCi/L	Uranium 235 pCi/L	Uranium 238 pCi/L	Nitrate mg/L	Average Oak Ridge Reservation rainfall[a]
Risk-based concentration[b]	6.7	6.6	5.5	58	-
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	59.17

Bold values indicate the risk-based concentration is exceeded.

[a]Average rainfall in inches for rain gauges at Y-12, ETTP, Oak Ridge National Laboratory, and DOE town site.

[b]Risk-based concentrations from EPA, regional screening tables <**http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm**>, <http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search>.

BCK = Bear Creek kilometer

Nitrate concentrations measured at BCK 9.2 since Record of Decision approval are compared to the risk-based concentrations. Since FY 2000 the 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 residential drinking water non-carcinogenic hazard index of 58 mg/L <http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm>. Since FY 2003, the average nitrate concentrations measured at BCK 9.2 have been below the 10 mg/L maximum contaminant level. The principal source of nitrate contamination is legacy disposal of acid liquids in the S-3 Ponds in the headwaters of Bear Creek. Nitrate has been monitored historically at a number of locations in Bear Creek Valley. Concentrations are highest near the S-3 source and decrease with distance downstream to the west. Table 4.7 shows the average concentration of nitrate at BCK 9.2 for years since the Record of Decision was implemented. Figure 4.3 shows the average nitrate concentration in surface water at BCK 9.2 along with the annual average rainfall.

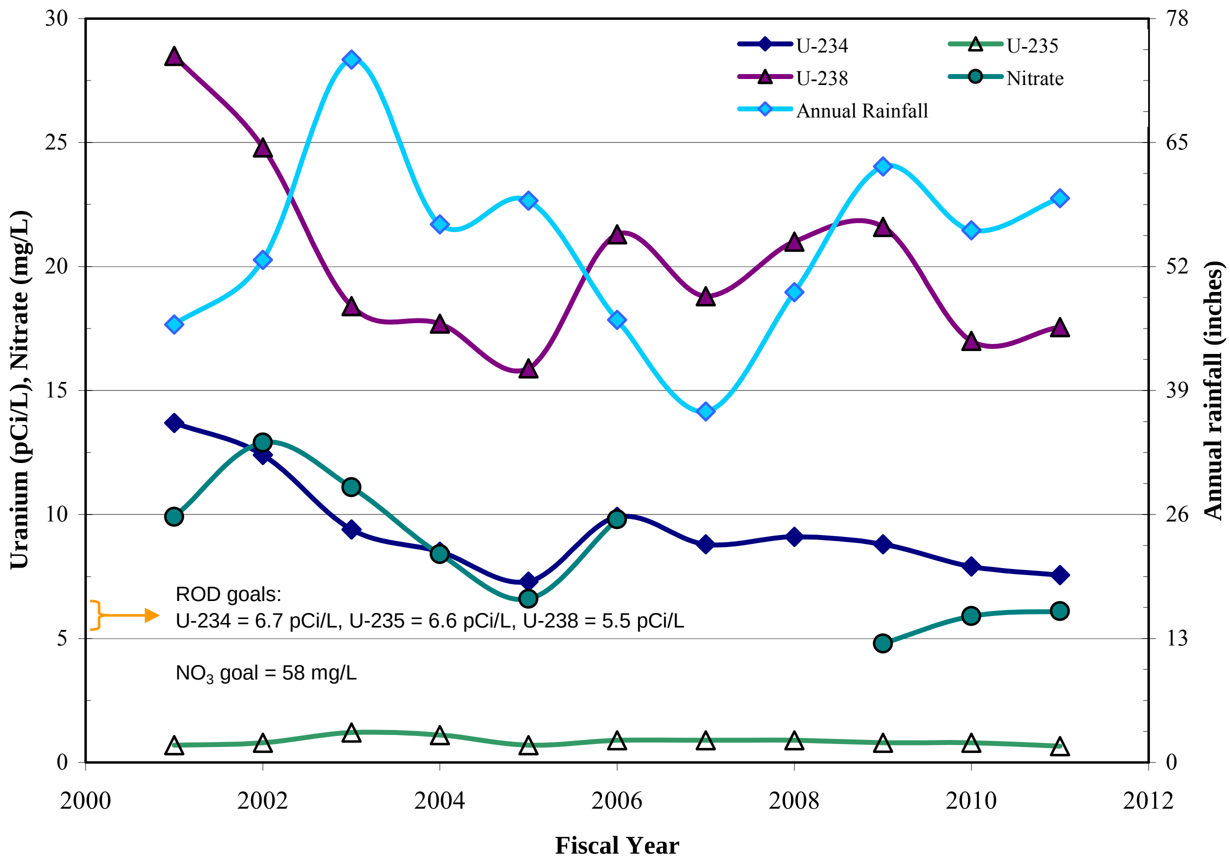

Figure 4.3. Average annual uranium isotope activity, nitrate concentration at Bear Creek kilometer 9.2, and annual rainfall.

ROD = record of decision

Zone 3

During FY 2011, 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 remedial action areas. Two key metrics were identified in the Record of Decision 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, ^{234}U and ^{238}U activities at BCK 9.2 consistently exceed the risk-based concentration.

The post-Record of Decision history of measured uranium fluxes at BCK 9.2 and BCK 12.34, along with annual rainfall, are summarized in Table 4.8 and Figure 4.4. The watershed flux goal (≤34 kg/yr) for the

Zone 3 integration point was not met in FY 2011 based on the 108.7 kg of uranium computed at BCK 9.2. The FY 2011 uranium flux at BCK 12.34 was 37.8 kg which is more 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 2011, a uranium flux of 16.3 kg was measured at the mouth of NT-3. This uranium discharge exceeds the 4.3 kg/yr flux goal for the stream following remediation of the Boneyard/Burnyard. Additional discussion of the NT-3 uranium discharge is provided later in this section.

Table 4.8. Uranium flux[a] at flow-paced monitoring locations in Bear Creek Valley watershed

Fiscal Year	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

Bold values indicate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000) goal for uranium flux has not been met**.**

[a]All flux values are kilograms of uranium/year.

[b]Average rainfall in inches 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.

Review of Figure 4.4 shows the relationship between 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, higher groundwater levels, and more contaminant transport from buried/below-grade 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 monitoring period, as demonstrated in Figure 4.5. 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 2011 monitoring of NT-8 documented that about 40 kg of uranium was discharged directly to Bear Creek (Table 4.8).

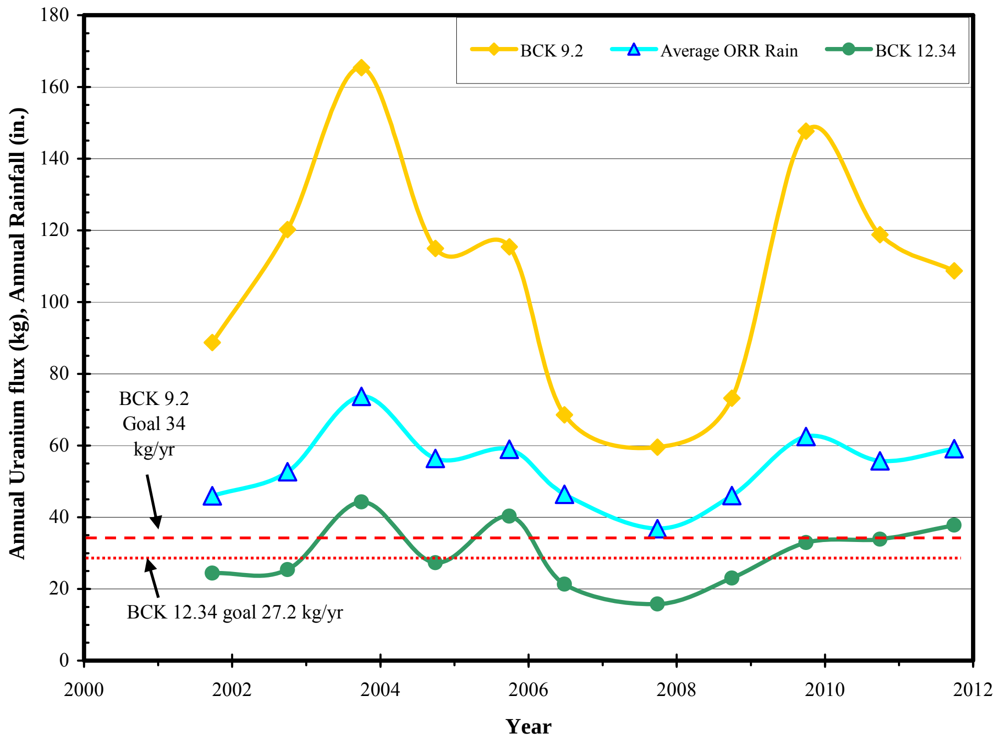

Figure 4.4. Post-Record of Decision uranium flux at BCK 9.2 and BCK 12.34 and annual rainfall.

BCK = Bear Creek kilometer ORR = Oak Ridge Reservation

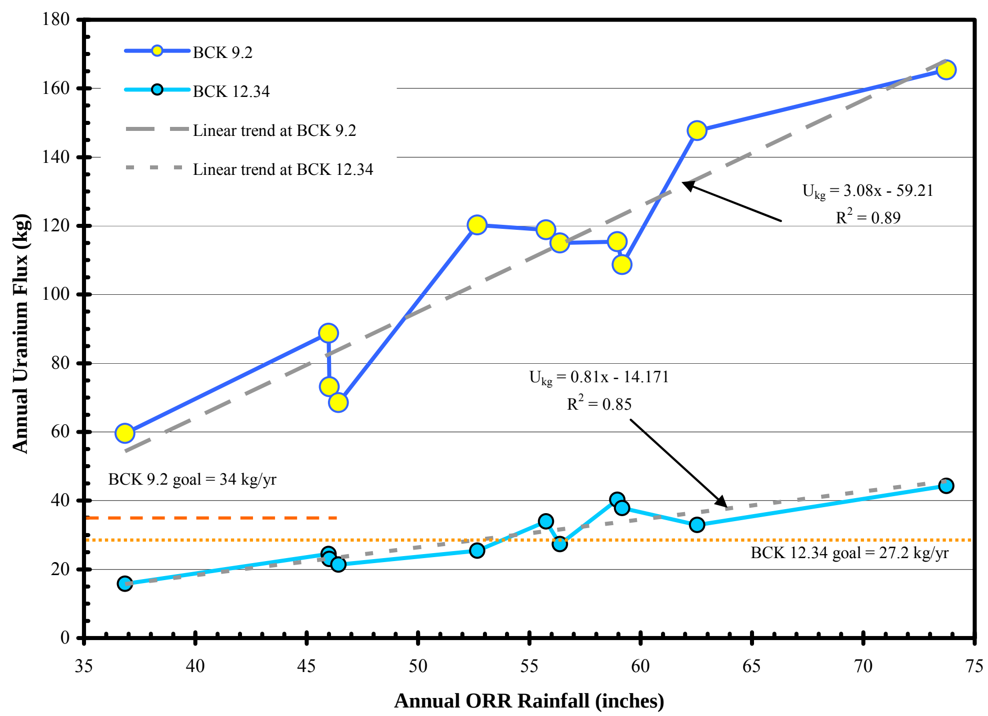

Figure 4.5. Average annual rainfall vs. annual uranium flux at Bear Creek kilometer 9.2 and 12.34.

BCK = Bear Creek kilometer U = uranium

Estimates were made of the uranium contributions from NT-5, and NT-7. These estimates suggest that NT-5 contributed less than 0.5 kg of uranium and NT-7 may have contributed approximately 1 kg of uranium during FY 2011.

Including all directly measured and estimated uranium sources contributing to the stream, the mass balance of uranium in the Bear Creek system during FY 2011 shows that about 104.4 kg of uranium were measured or estimated to enter Bear Creek in Zone 3 and 108.7 kg of uranium were measured discharging from Zone 3 at BCK 9.2. These data indicate a mass balance difference of about 4% for the measured/estimated inputs and the measured discharge during FY 2011. Historic sampling of filtered and unfiltered water samples at the integration point indicated that there was essentially no difference in the uranium concentration of the turbid versus filtered samples. This indicates that the uranium is transported in Bear Creek primarily as a dissolved constituent.

Within Zone 3, industrial exposure scenario comparisons were applicable since the Record of Decision 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 2011 were about 22, 2, and 44 pCi/L, respectively. These results are based on analysis of 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 <http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search>, using exposure duration of 250 days/year, exposure frequency of 25 years and 1 L/d ingestion rate. The ^{235}U has been less than the 22 pCi/L industrial exposure goal since the Record of Decision was implemented.

Nitrate and cadmium are also key contaminants of concern in surface water in Bear Creek Valley. The principal source of nitrate contamination is legacy disposal of 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 Bear Creek Valley. 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 160 mg/L. Figure 4.6 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 2011, the average nitrate concentration was 40 mg/L based on 52 weekly grab sample results. None of the grab samples collected during FY 2011 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. 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 2011 contained an average of 3.4 μg/L cadmium with a maximum measured concentration of 7 μg/L, which is the same as FY 2010 levels. Sampling data at the downstream integration point for Zone 3, BCK 9.2, suggest that cadmium meets the AWQC before the stream enters Zone 2.

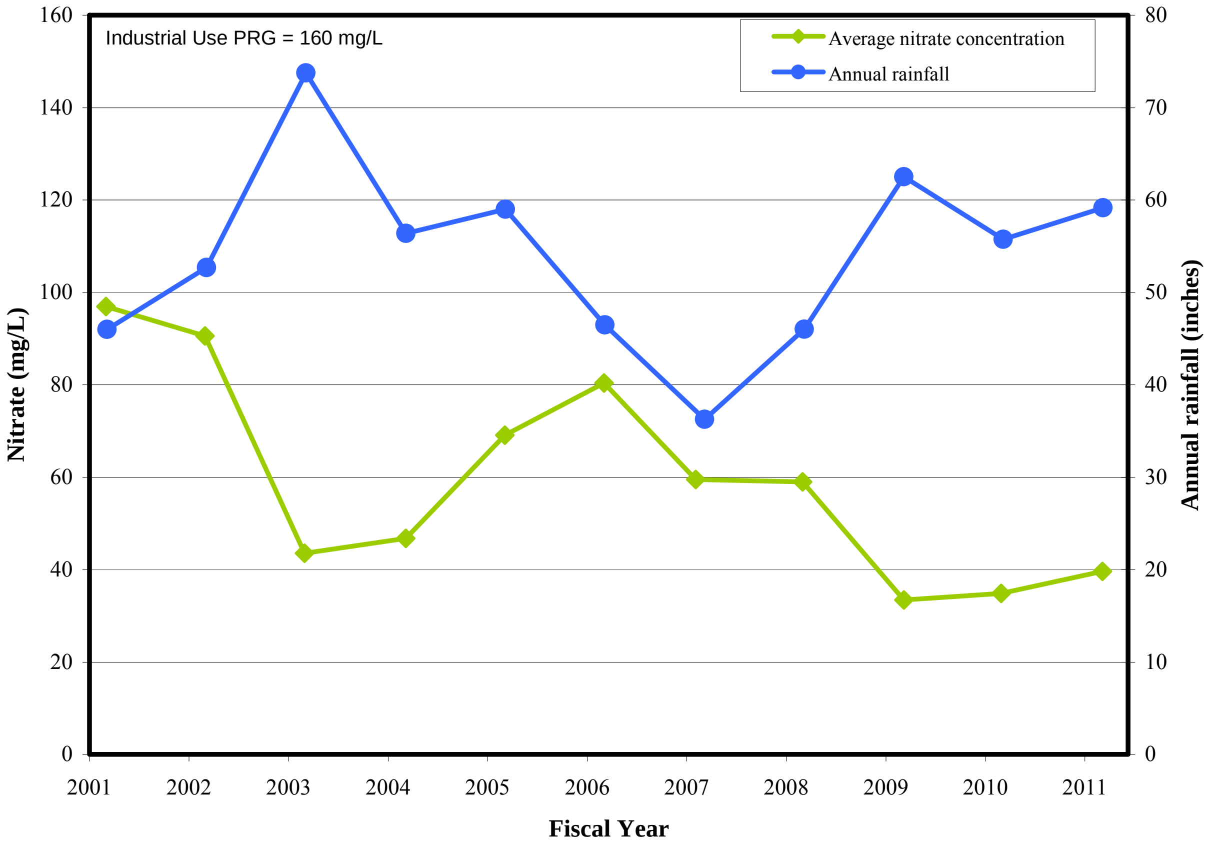

Figure 4.6. Bear Creek Kilometer 12.34 average nitrate concentration and annual rainfall.

PRG = preliminary remediation goal

Because of the levels of uranium, VOCs, and PCBs that discharge from NT-8 into Bear Creek, grab samples were collected at several locations in NT-8 to identify points of entry of contaminants into the stream. This was identified as an issue in the 2011 Remediation Effectiveness Report which is being closed out in this RER (Table 4.14) with the presentation of the following information. On April 19, 2011, samples were collected at 10 locations within the NT-8 drainage. The analytical results confirm that the eastern branch of NT-8 that originates in Burial Ground D-West was the principal source of uranium and was a significant source of PCBs. (An open issue remaining in Table 4.14 which will be reviewed at the time of the NT-8 Early Action, as identified in Appendix E, is the review of the non-CERCLA groundwater seepage collection system associated with Burial Ground C-West). Mass balance estimates of the uranium discharge from the eastern branch to the mouth of NT-8 indicated about 75 g/d leaving the burial ground compared to about 65 g/d at the mouth of the watershed. If annualized, these instantaneous flux estimates equate to about 27 kg of uranium leaving the burial ground and about 23 kg discharging from NT-8 into Bear Creek. Variations in accuracy of the flow measurement near the burial ground compared to the measurement in the flume at the mouth of NT-8 may account for the difference in flux values.

The highest concentrations of VOCs were detected in the western branch of NT-8 just upstream of the confluence of the two branches. Tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, and vinyl chloride were detected. The source of these VOCs at this location is attributed to discharge of plume water that evolves from the DNAPL area beneath Burial Ground A and extending westward beneath NT-7. VOC contaminant flux estimates suggest approximately 9 grams/day of VOCs were discharge from the western branch while approximately 8 grams/day were estimated to discharge at the mouth of NT-8.

The highest concentrations of PCBs were detected at the fence line along the western edge of Burial Ground C-West and near the mouth of NT-8. PCBs are very prone to becoming attached to soil and sediment particles and are not good tracers for the purpose of mass balance estimates along a stream channel. In addition to the known PCB source in Burial Ground C-West, the dense non-aqueous-phase liquid contamination beneath Burial Ground A and west of NT-7 is known to contain PCBs.

Boneyard/Burnyard

Effectiveness of remediation at the Boneyard/Burnyard is measured by water quality in the NT-3 stream (see Tables 4.4 and 4.6, and Figure 4.1). In addition to surface water monitoring at the Boneyard/Burnyard, the *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard* (DOE 2003) specifies monitoring of benthic macroinvertebrate and fish communities in NT-3. Stream channel stability monitoring along NT-3 is no longer conducted. Benthic macroinvertebrate and fish community monitoring are presented in Sect. 4.2.2.3.

The remediation goal for the Boneyard/Burnyard 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 all years since remediation was completed in 2002 until recently. 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 Boneyard/Burnyard remediation, uranium activities in NT-3 decreased significantly and uranium isotope ratios also changed. Table 4.9 is a tabulation of annual average activities of ^{234}U and ^{238}U measured in NT-3. Boneyard/Burnyard remediation was completed in summer of 2002 and the FY 2002 and 2003 uranium activities show the rapid decrease following remediation. An increase in uranium activities from 2004 through 2009 is apparent.

Table 4.9. Annual average ^{234}U and ^{238}U activities at North Tributary-3

Fiscal Year	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	Boneyard/Burnyard 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 resumed

NT-3 surface water uranium isotope ratios were examined to evaluate the significance of this increase with regard to the Boneyard/Burnyard remedy. The data summary in Table 4.9 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 2 to 3 (indicative of a depleted uranium source having a high fraction of ^{238}U) downward to average values near 1. Along with the initial shift in $^{238}U/^{234}U$ ratio, the ^{235}U activities decreased to very low to undetectable levels. However, as uranium activities increased in 2007, the ^{235}U activities increased again as well. The $^{234}U/^{235}U$ ratios observed since 2007 suggest that the recurrent uranium discharge originates from a depleted uranium source having a different isotopic signature than the remediated Boneyard/Burnyard source. These isotopic shifts in the NT-3 surface water suggest that the Boneyard/Burnyard 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 4.7, two other waste disposal units remain in the NT-3 watershed – the Hazardous Chemical Disposal Area and the Unit 6 Landfill. The uranium being measured in NT-3 surface water may be indicative of releases from one or both of these areas.

4.2.2.2 Groundwater Monitoring

Remedial action objectives in the *Record of Decision for the Phase 1 Activities in Bear Creek Valley* (DOE 2000), include "*protect future residential users of the valley in Zone 1 from risks from exposure to groundwater…*" Groundwater quality goals for each zone are in Table 4.3, and Table 4.6 includes the Bear Creek Valley watershed CERCLA performance monitoring requirements that fulfill these objectives. Groundwater sampling locations are shown on Figure 4.8. At a minimum, wells GW-712, -713, and -714 (Picket W), located in the western portion of the valley at the Zone1/Zone 2 boundary, are monitored semiannually for nitrate; metals, including uranium; and VOCs. These three wells sample groundwater from the Maynardville Limestone. Wells GW-683 and GW-684 (Picket A) are located near the boundary of Zones 2 and 3 and are monitored semiannually for metals, including uranium, and nitrate. Maximum contaminant levels are used in Zone 1 as the screening criteria and concentration trends are used elsewhere to evaluate performance.

Zone 1

As noted in Table 4.3, the Record of Decision goal is to "maintain clean groundwater and surface water so that the area continues to be acceptable for unrestricted use." With this goal in mind, during FY 2011 groundwater monitoring in Zone 1 included sampling of one spring (SS-6) and three monitoring wells (GW-712, GW-713, and GW-714) located near the boundary with Zone 2. Well GW-712 is about 458 ft deep. VOCs have never been detected in well GW-712. Table 4.10 includes results of nitrate analyses for wells GW-712, GW-713, and GW-714 from FY 2000 through FY 2011. Nitrate has been intermittently detected in GW-712 at low (less than 1.4 mg/L) to trace concentrations, and nitrate was detected at 0.051 mg/L in FY 2011. Uranium isotopes have been intermittently detected (maximum of 1.87 pCi/L ^{234}U in FY 2003). Uranium-234 was detected in well GW-712 at 0.752 pCi/L in January and 0.321 pCi/L in July in FY 2011.

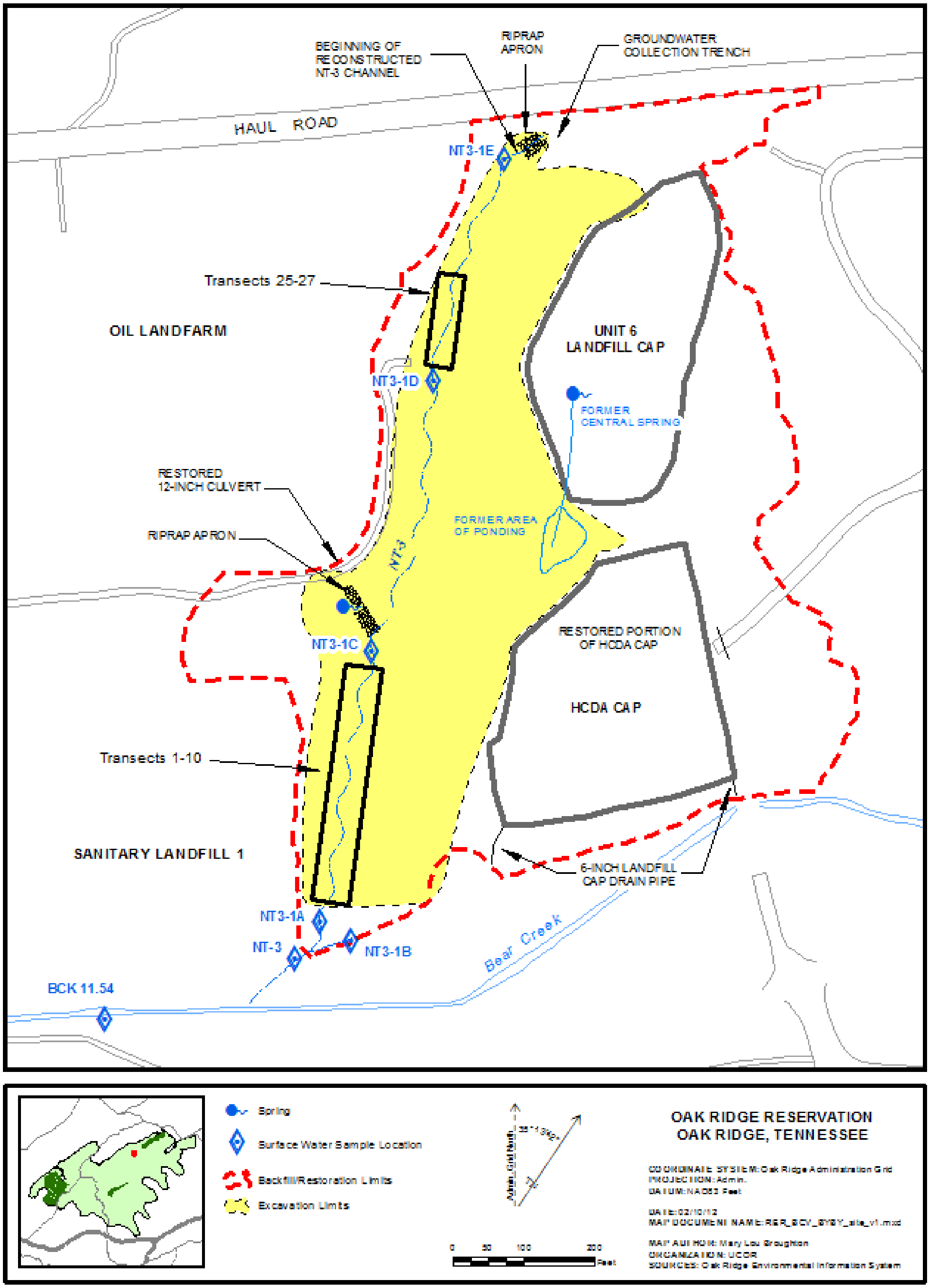

Figure 4.7. Location of Boneyard/Burnyard site and monitoring locations.

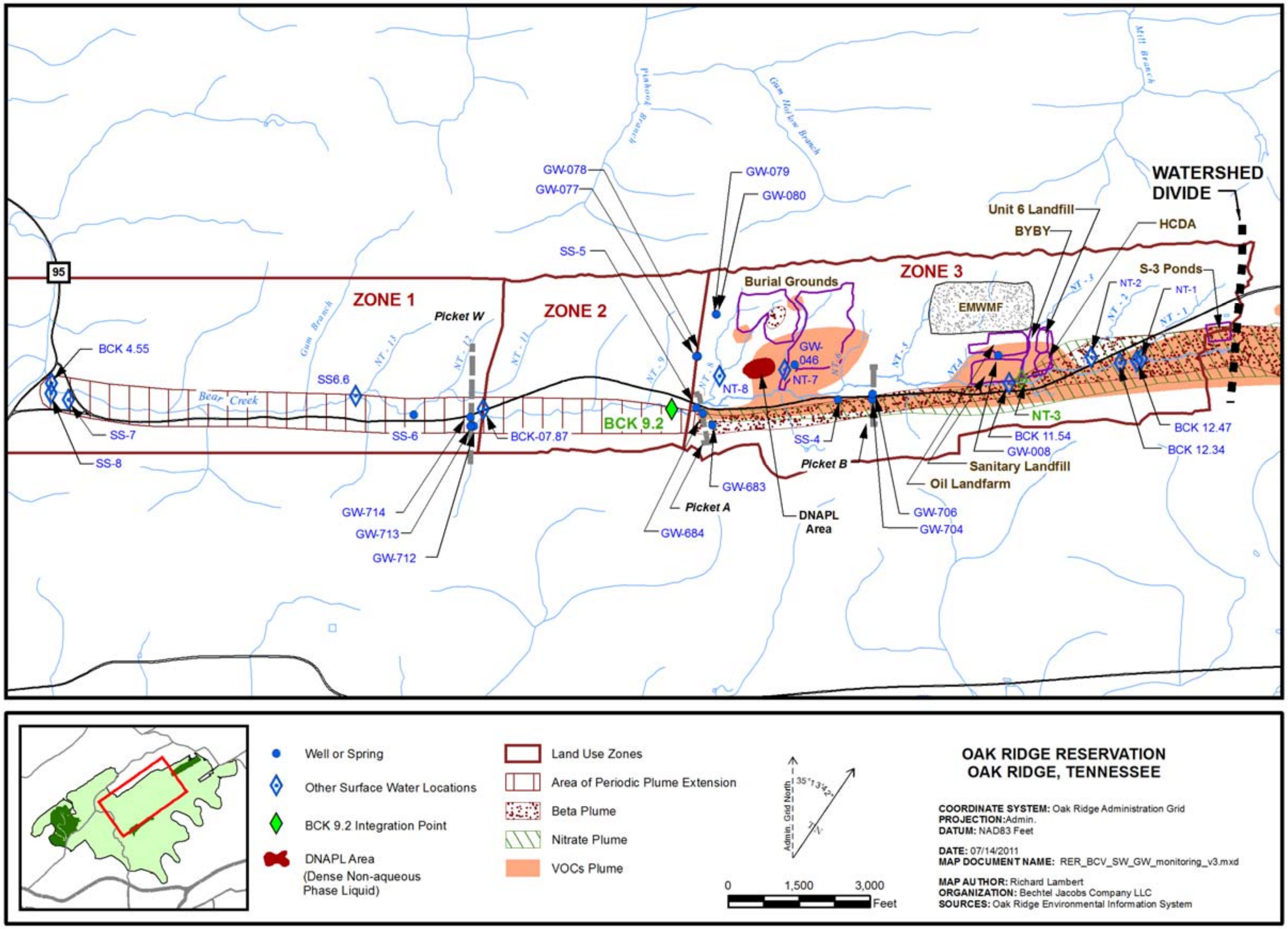

Figure 4.8. Bear Creek Valley end use zones and surface water and groundwater monitoring locations.

Table 4.10. Nitrate concentrations measured in wells GW-712, GW-713, and GW-714[a]

GW-712 (458 ft deep)			GW-713 (314 ft deep)			GW-714 (145 ft deep)[b]	
Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)	Qualifier	Date	Nitrate (mg/L)
1/10/2000	0.02		1/6/2000	0.67		1/5/2000	0.46
7/10/2000	1.4		7/10/2000	1.3		7/11/2000	4
1/2/2001	0.03		1/3/2001	0.33		1/2/2001	3.7
7/2/2001	0.02	U	7/10/2001	0.061		7/2/2001	1.8
1/3/2002	0.02	U	1/3/2002	0.02	U	1/2/2002	1.6
7/1/2002	0.034		7/1/2002	0.02	U	7/1/2002	1.7
1/6/2003	0.13		1/6/2003	0.16		1/6/2003	1.6
7/7/2003	0.22		7/7/2003	0.2		7/7/2003	1.3
1/6/2004	0.02	U	1/5/2004	0.02	U	1/5/2004	1.1
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

[a]Environmental Protection Agency drinking water maximum contaminant level is 10 mg/L.
[b]Note nitrate detected at specified levels at all dates in this well.

Well GW-713 is about 315 feet deep. Well GW-713 has experienced periodic trace-to-low (maximum 14 μg/L) concentrations of PCE, TCE, 1,1,1-TCA, and 1,2-DCE, although no VOCs were detected in FY 2011. 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 but was not detected in well GW-713 in FY 2011. Uranium isotopes have been intermittently detected in well GW-713 at low concentrations (< 1.7 pCi/L). Uranium-234 was detected at 0.744 pCi/L in July in FY 2011. Beta activity was detected in well GW-713 in January of FY 2011 at an estimated level 4.36 J pCi/L.

Well GW-714 is about 145 feet deep. 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. Since 2004 nitrate concentrations have varied at levels less than 1 mg/L. Nitrate was detected in GW-714 at concentrations of 0.61 and 0.16 mg/L in FY 2011. Uranium isotopes are also detected in well GW-714. Since FY 2000, both ^{234}U and ^{238}U have exhibited gradual increases from less than 1 pCi/L observed to maximum levels of about 4.5 pCi/L ^{234}U in FY 2003 and about 1.4 pCi/L ^{238}U in FY 2004. Following those observed maxima, uranium levels have decreased to levels of about 1 pCi/L or less. With the exception of a ^{234}U detection of 1.7 pCi/L in July this trend continued in FY 2011. While ^{235}U is not routinely detected in well GW-714, it was detected at 0.449 pCi/L in July of FY 2011. The peak uranium isotope levels coincided with the FY 2003 and 2004 period of excess rainfall that affected groundwater and surface water contaminant levels across the Oak Ridge Reservation. Beta activity was detected in well GW-714 at 4.69 pCi/L in January of FY 2011.

The one spring monitored in Zone 1 in FY 2011 was SS-6 (Figure 4.8). Sampling of this spring is conducted semiannually during the high-flow wet season (typically during winter) and during the low-flow dry season (during summer months). Springs in Bear Creek Valley 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 surface water and groundwater comingle. This comingling 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 Bear Creek Valley 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.

Figure 4.9 shows nitrate concentrations in the Zone 1 springs from 1995 through FY 2011. Nitrate is commonly detected at Bear Creek Valley springs at concentrations less than 50% of the maximum contaminant level (10 mg/L). Table 4.11 contains the results of uranium isotope analyses conducted on Zone 1 spring samples from FY 2000 through FY 2011. The FY 2011 levels detected in Spring SS-6 are consistent with those of previous years. Also included in Table 4.11 is the total uranium calculated from the results of detected (unqualified) isotopic activities. Review of the calculated uranium mass and the measured uranium metal values shows that total uranium in the spring water has been below the 30 μg/L maximum contaminant level with the exception of two results.

Uranium isotopic ratios in the spring water discharges have been compared to those from other key source areas in Bear Creek Valley including the S-3 Ponds, discharge at BCK 12.34, NT-3 water, NT-08 water, and the combined discharge monitored at BCK 9.2. The cumulative distribution characteristics of the uranium isotope ratios in the spring water samples suggests uranium from any and all of the major Bear Creek Valley source areas may be present in the springs.

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 maximum contaminant level effective dose equivalent 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 qualified as estimated values because the measured activities are very close to the detection limits. While ^{99}Tc was not detected in spring SS-6 samples in FY 2011, beta activity was detected at 4.01 and 5.91 pCi/L in January and July, respectively.

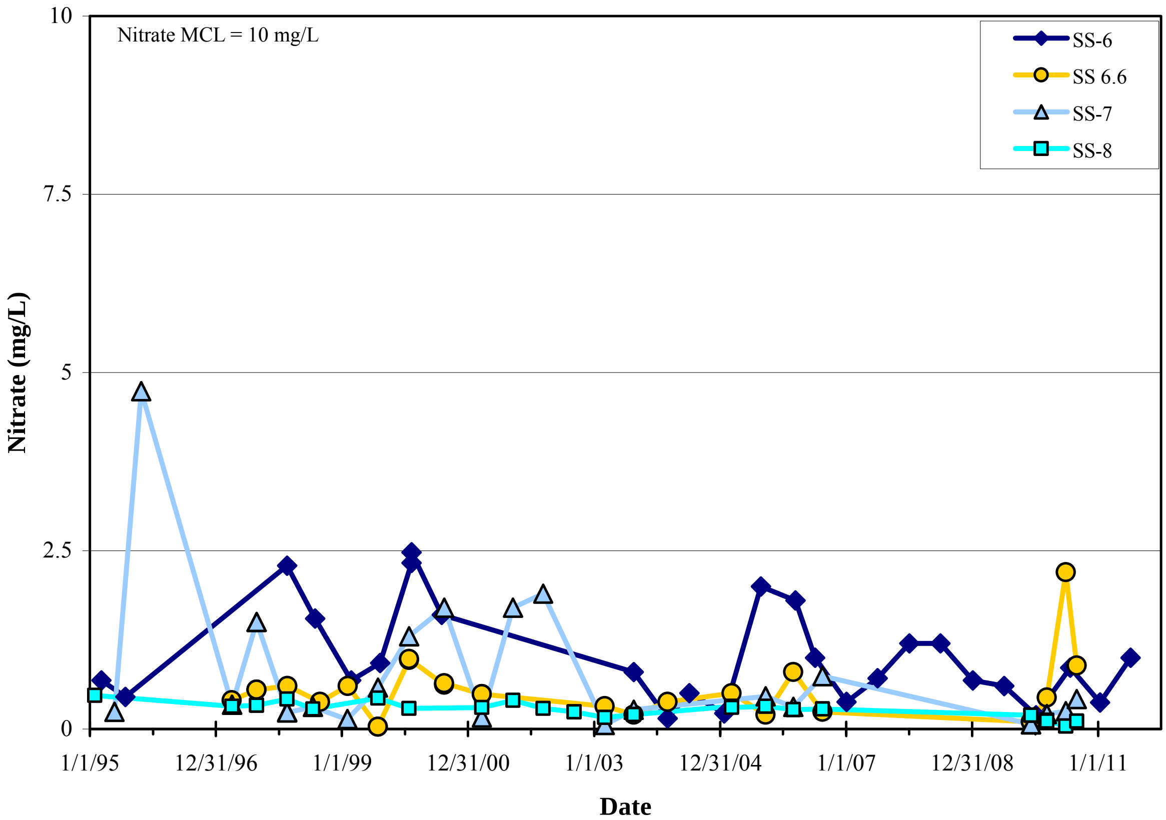

Figure 4.9. Nitrate concentrations in Zone 1 springs.

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. Nitrate is detected in SS-6 springwater. Nitrate concentrations are variable and, since FY 2000, have fluctuated from a maximum of about 2.5 mg/L (in 2000) to a low of about 0.2 mg/L in 2005. In FY 2011, the highest observed nitrate concentration was 1.0 mg/L. Uranium isotopes (^{234}U and ^{238}U) are detected in SS-6 springwater. Measured activities are variable with a maximum ^{234}U level of about 5.9 pCi/L in FY 2000 and FY 2011 values of 1.01 and 2.05 pCi/l for January and July, respectively. Measured activity levels for ^{238}U were highest in FY 2000 (8.3 pCi/L), with FY 2011 values of 1.3 and 3.02 pCi/L for January and July, respectively.

Table 4.11. Uranium isotope activities in Zone 1 Spring samples, 2000-2011

Uranium isotopic data for SS-6

Date	U-234 (pCi/L)	U-235(pCi/L)	U-238(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	0
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

Uranium isotopic Data for SS-6.6

Date	U-234 (pCi/L)	U-235(pCi/L)	U-238 (pCi/L)	Total U[b] 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	0
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	0
3/2/2004	2.42±1.79 J	0.48±0.93 U	0.9±1.2 U	0
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
12/7/2009	0.54±0.394	-0.0235±0.229 U	0.475±0.372	1.4
3/9/2010	0.449±0.458 U	0.786±0.512	1.58±0.675	5.1
6/28/2010	5.52±1.02	0.533±0.353	10.3±1.38	31. 5[b]
8/30/2010	1.56±0.519	0.298±0.268 U	2.64±0.664	8

Table 4.11. Uranium isotope activities in Zone 1 Spring samples, 2000-2011 (cont.)

Uranium isotopic data for SS-7

Date	U-234(pCi/L)	U-235(pCi/L)	U-238(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
8/16/2000	3.68±1.24	0.41±0.39 J	5.58±1.67	16.9
3/22/2001	0.34±0.23 J	-0.01±0.01 J	0.64±0.33	1.9
9/18/2001	2.26±0.56	0.19±0.14 J	3.75±0.82	11.4[1]
3/12/2002	1.59±0.54	-0.01±0.01 U	3.77±0.97	11.4
3/4/2003	1.07±0.53	0.4±0.34 J	0.37±0.3 J	1.70E-04
8/19/2003	0.72±0.4	0.13±0.18 U	1.59±0.63	4.8
9/21/2005	2.69±0.83	0.16±0.22 U	3.4±0.96	10.3
2/28/2006	0.74±0.41	0.2±0.23 U	1.21±0.54	3.7
8/17/2006	2.76±0.98	0.07±0.17 U	6.13±1.6	18.6
12/7/2009	0.724±0.461	0.252±0.279 U	0.24±0.28 U	1.20E-04
3/9/2010	0.791±0.49	0.19±0.237 U	0.785±0.469	2.4
6/28/2010	1.06±0.428	0.0723±0.147 U	1.34±0.47	4.1
8/30/2010	1.16±0.47	0.346±0.255	1.81±0.576	5.6

Uranium isotopic data for SS-8

Date	U-234 (pCi/L)	U-235(pCi/L)	U-238 (pCi/L)	Total U[b] µg/L
1/25/2000	0.15±0.23 U	0.04±0.11 U	0.2±0.23 U	
8/16/2000	0.7±0.47 J	0.12±0.21 U	0.45±0.37 J	
3/22/2001	0.27±0.35 U	-0.12±0.09	0.06±0.06 U	
9/18/2001	0.18±0.19 J	0.18±0.19 U	0.25±0.22 J	
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	1.05±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	0.1±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	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	0.52±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	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	0.55±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	0.343±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	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	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

[a]Total uranium calculated from detected individual isotopic masses.
[b]Total uranium metal analysis indicated 27.6 µg/L.

Throughout the past 10 years of Zone 1 springs monitoring, there has been one equivocal detection of uranium at a level that slightly exceeded the 30 μg/L maximum contaminant level. This was the June 28, 2010 calculated 31.5 μg/L value based on isotopic masses for ^{234}U and ^{238}U. The uranium metal result for the same sample was slightly less than the maximum contaminant level at a reported 27.6 μg/L.

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 4.8. Contaminant concentrations continue to remain low and per the approved Bear Creek Valley Monitoring Plan will continue to be monitored and reported on yearly in the Remediation Effectiveness Report. Therefore, an issue identified from the 2010 Remediation Effectiveness Report is closed in this RER concerning the intermittent nature of this plume.

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 Bear Creek Burial Grounds. Six wells near the land use zone boundary are monitored to evaluate groundwater contaminants migrating into Zone 2. Two wells are constructed in the Maynardville Limestone along the transect designated as Picket A in Figure 4.8.

The groundwater quality goal for Zone 2 is to eventually achieve unrestricted use and, therefore, maximum contaminant levels and residential risk-based concentrations are used as screening comparison levels. Wells GW-683 and GW-684 sample groundwater upgradient of its discharge at spring SS-5. Well GW-683 is 197.5 ft deep and well GW-684 is 129.6 ft deep. The principal contaminants detected in these wells that presently or have historically exceeded the screening criteria are nitrate and uranium isotopes (Figure 4.10). Nitrate is compared to the maximum contaminant level 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. The only constituent that exceeded residential risk target levels at the Zone 2 boundary is ^{238}U. The FY 2011 ^{238}U activities measured at GW-683 were 4.34 pCi/L in February and 1.54 pCi/L in August. Both values were less than the ^{238}U RBC of 5.5 pCi/L. The activities of ^{238}U in GW-684 were higher, with 5.45 pCi/L measured in February and 5.64 pCi/L measured in August. Historic trends of nitrate and uranium isotopes show an apparent decrease in levels during 2003 through 2005, followed by an increase during 2006 through 2008. During 2003 through 2005, above normal rainfall appears to have caused dilution of contaminant concentrations in the Maynardville Limestone, followed by a gradual increase during the drought years of 2006 through 2008, and another decrease during FY 2009 and FY 2010 when rainfall was again above average. Consistent with this inferred rainfall and contaminant concentration pattern, the nitrate and uranium concentrations showed a decreasing trend during FY 2010 associated with the above average rainfall. During FY 2011 nitrate and uranium in wells GW-683 and GW-684 were below their respective maximum contaminant levels and risk-based concentrations and appear to be stable with the exception of August ^{238}U in well GW-684 which increased to slightly above risk-based concentration. Also, during FY 2011 ^{99}Tc was detected in both February and August samples from well GW-684 at 13.2 and 12.5 pCi/L respectively. Mercury was detected at low levels in one sample from each well.

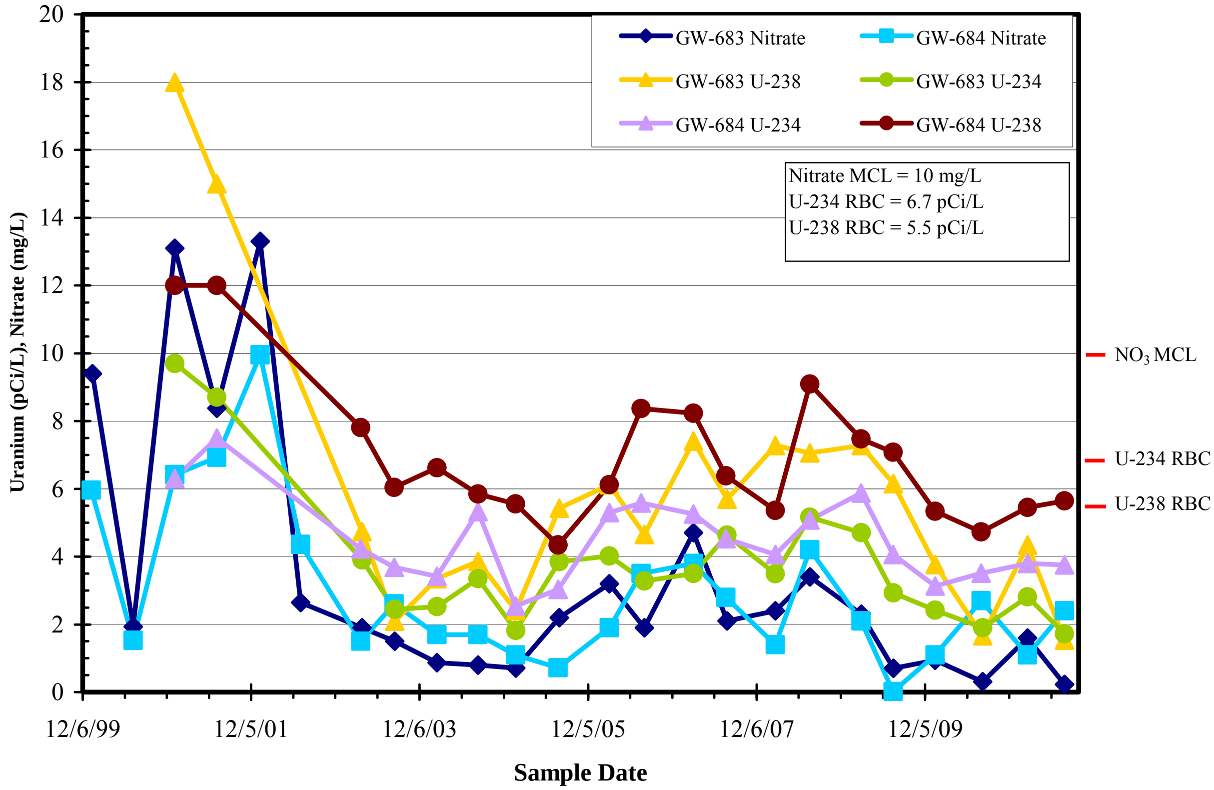

Figure 4.10. Constituents detected above risk-based concentration or maximum contaminant level at wells GW-683 and GW-684.

Beta activity was detected in both quarterly samples in both wells GW-683 and GW-684.

Wells GW-683 and GW-684 sample groundwater contamination that originates from upgradient sources, such as the S-3 Ponds, and flows through karst conduits in the Maynardville Limestone prior to rising to discharge into Bear Creek as spring SS-5 (Figure 4.8). A portion of the groundwater contaminant plume shown on Figure 4.8 terminates at the known plume discharge point at SS-5. Groundwater sampling further to the west at the Picket W wells (Figure 4.8) shows the presence of nitrate and uranium, which are derived from upgradient sources. Transient episodes of groundwater contaminant migration must occur through bedrock groundwater flow pathways in Zone 2 in order for the observed deep groundwater contamination and low level contaminants measured in spring discharges in Zone 1 to exist. 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 dense non-aqueous-phase liquid at depth beneath the Bear Creek Burial Grounds. 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 the 2011 Remedial Effectiveness Report (DOE 2011a) and is carried forward in the Remediation Effectiveness Report, Table 4.14.

Wells GW-077 (100 feet deep), GW-078 (21 feet deep), GW-079 (65 feet deep), and GW-080 (30 feet deep) are sampled for metals, including uranium, and VOCs. Neither uranium nor VOCs were detected in any of these four wells during FY 2011. These are the only wells available to sample along the Zone 2/Zone 3 boundary at the western edge of the Bear Creek Burial Grounds. The possibility of deeper groundwater contamination migration from the dense non-aqueous-phase liquid area beneath the Bear Creek Burial Grounds cannot be evaluated with the existing well network.

Zone 3

Existing CERCLA decision documents pertinent to Bear Creek Valley do not stipulate groundwater actions or remediation levels to be attained within Zone 3. The Record of Decision indicates source area remedial actions 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 Resource Conservation and Recovery Act post-closure permit sampling of wells GW-008 near the Oil Landfarm and GW-046 in the Bear Creek Burial Grounds (Figure 4.8).

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. The wells sample groundwater from depths of 256 and 182 ft, respectively, and are located midway between BCK 11.54 and SS-5. 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 4.11. During FY 2011, contaminant levels continued their seasonal fluctuations and were consistent with previous years.

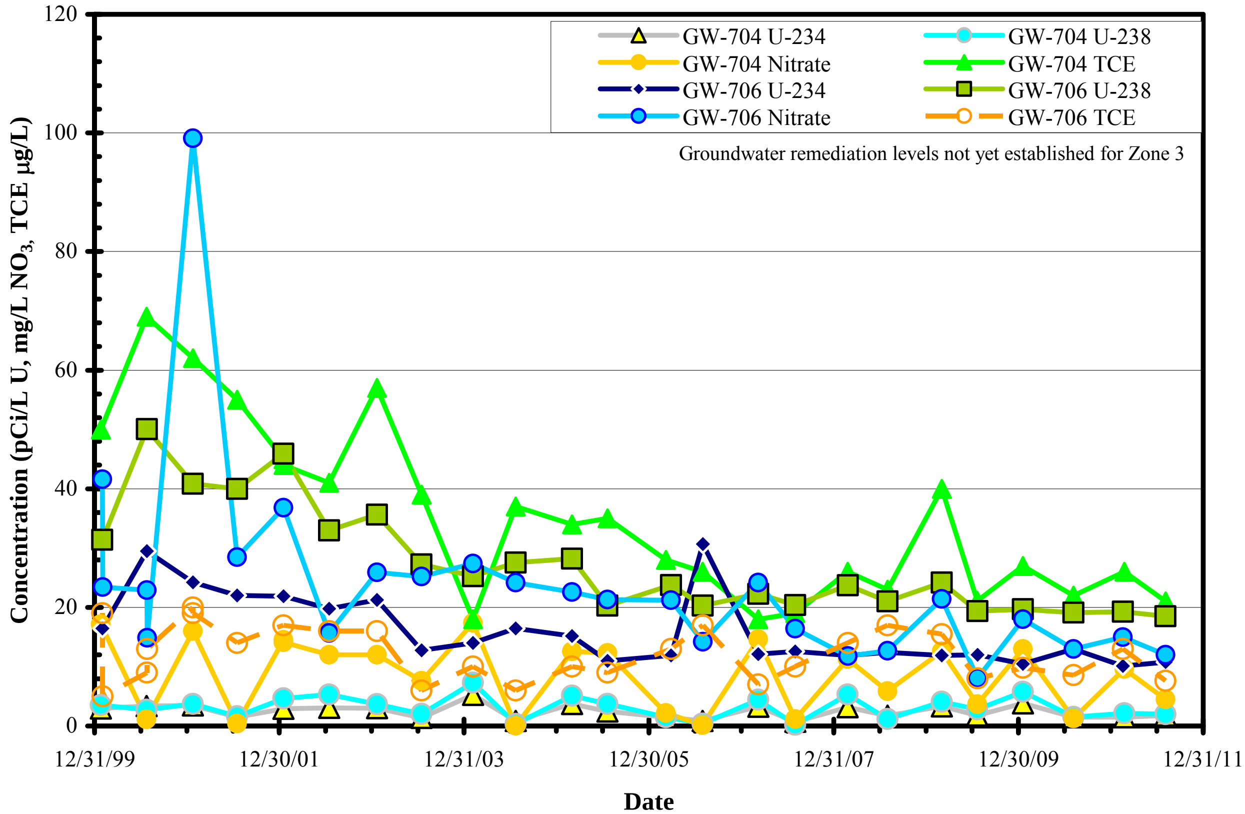

Figure 4.11. Principal contaminant trends in wells GW-704 and GW-706.

Wells GW-008 and GW-046 are located at the Oil Landfarm and Bear Creek Burial Grounds, respectively. Well GW-008 samples groundwater from a depth of about 25 ft and GW-046 samples groundwater from a depth of about 20 feet. Concentration trends for the principal contaminants of concern in these wells are shown in Figure 4.12. The relatively low VOC concentrations in GW-008 did not change greatly during FY 2011. VOC concentrations at well GW-046 generally showed decreases during FY 2011 following increases initiated during the period of above normal rainfall starting in FY 2009. The VOC concentration behavior in well GW-046 during FY 2009 through FY 2011 is similar to that observed in FY 2003, an earlier time period that experienced above average rainfall. This response in the groundwater system suggests that increased rainfall causes groundwater discharges from the capped burial ground area.

Groundwater surveillance monitoring of the Bear Creek Burial Grounds conducted by the Y-12 Groundwater Protection Program documents increasing VOC concentrations in the noncarbonate, fractured bedrock underlying the area. Contaminant plumes in Bear Creek Valley, as interpreted by the Y-12 Groundwater Protection Program, are depicted graphically in Figure 4.8. The concentration of PCE has exceeded 100 ppm at a depth of 270 ft in one well not shown in Figure 4.8 in the western Bear Creek Burial Grounds. PCE transformation products are also present at high concentrations in nearby wells and cis-1,2-DCE is routinely measured at >2 ppm concentrations in two nearby wells not shown in Figure 4.8. These contaminants are not detected to date in wells that lie further west of the burial grounds and Bear Creek Tributary NT-8. However, PCE, TCE, and cis-1,2-DCE are detected in surface water at the mouth of NT-8.

4.2.2.3 Aquatic Biological Monitoring

4.2.2.3.1 Watershed Monitoring

Aquatic biological monitoring of stream sites in Bear Creek Valley watershed (Figure 4.1) is used to measure the effectiveness of watershed-scale remedial actions. Biological monitoring data for streams in Bear Creek Valley 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 Bear Creek Valley 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 4.1). 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 rockbass from lower Bear Creek increased in 2011, averaging 0.79 µg/g in fall 2010 and 0.68 µg/g in spring 2011 (Figure 4.13). These mercury levels are over three-fold higher than those found in the same species from the Hinds Creek reference site (Hinds Creek kilometer 20.6, Figure 4.1) (Hinds Creek mean of 0.18 µg/g in 2011) and are above the Environmental Protection Agency-recommended fish-based AWQC of 0.3 µg/g. Monitoring of contaminant bioaccumulation in sunfish in upper Bear Creek began in FY 2010 and continued in FY 2011. Redbreast sunfish were collected along the stretch of Bear Creek between BCK 4.6 and BCK 9.9. Average mercury concentrations in redbreast sunfish from this stretch of the creek were 0.39 µg/g in fall 2010 and 0.29 in spring 2011. These concentrations are comparable to those seen in FY 2010. While these concentrations are lower than the levels seen in rockbass at BCK 3.3, redbreast sunfish feed on lower trophic level prey, and typically have between 15-40% lower Hg levels than in rockbass collected from the same site.

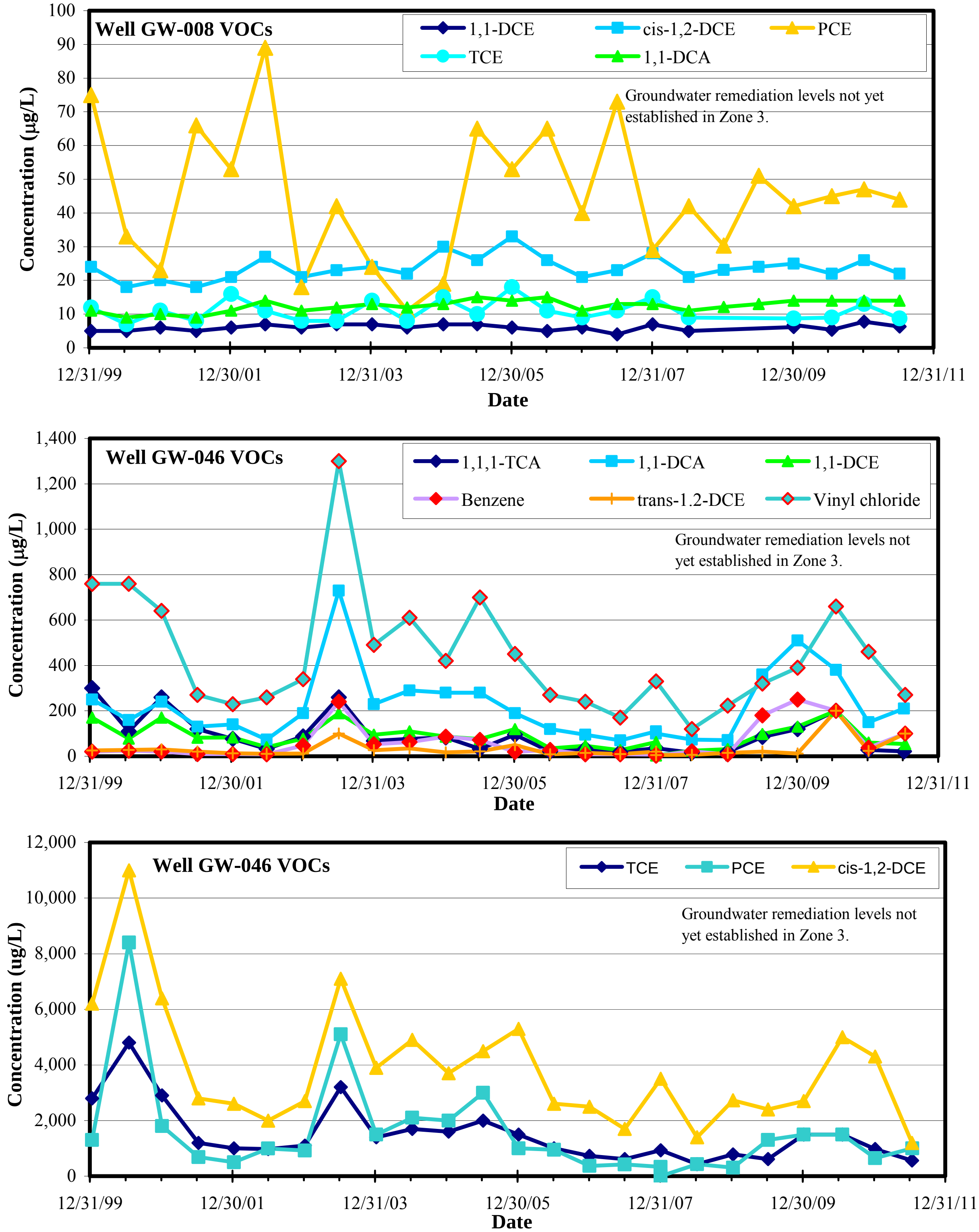

Figure 4.12. Volatile organic compound concentration trends in wells GW-008 and GW-046.

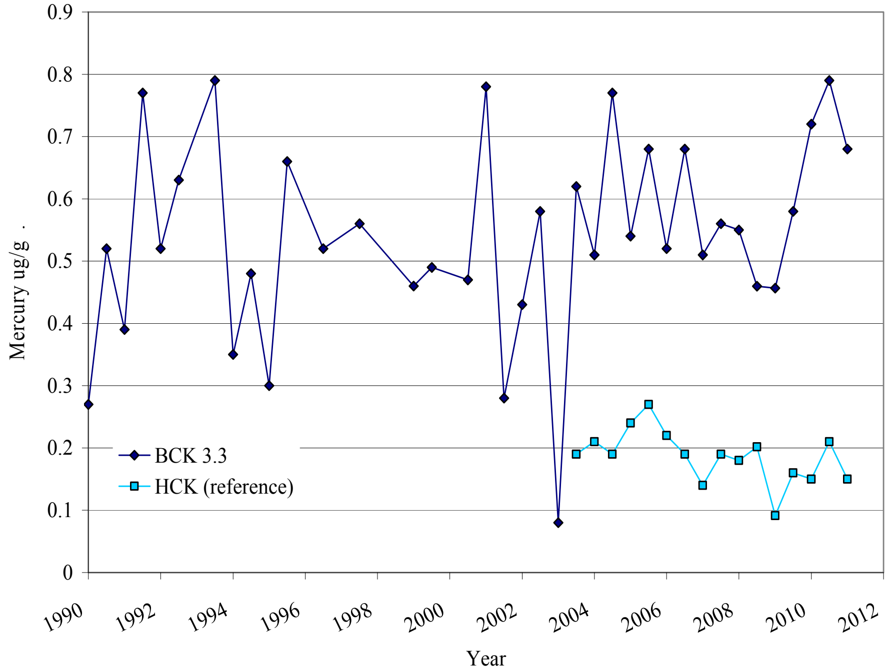

Figure 4.13. Mean concentrations of mercury in rockbass from lower Bear Creek, Bear Creek kilometer 3.3, 1990–2011.

As in recent years, concentrations of nickel, cadmium, and uranium in stoneroller minnows were highest in upper Bear Creek and decreased with increasing distance downstream. With the exception of nickel concentrations that were similar to the reference site, cadmium and uranium concentrations in fish from the lower end of the creek were higher than reference values in 2011 (Figure 4.14, Figure 4.15, Figure 4.16).

PCB concentrations in stoneroller minnows in fall 2010 and spring 2011 averaged between 2-4 µg/g, continuing the long-term trend of elevated levels in fish (Figure 4.17). PCB levels 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 at a relatively high range of 2-4 µg/g PCBs.

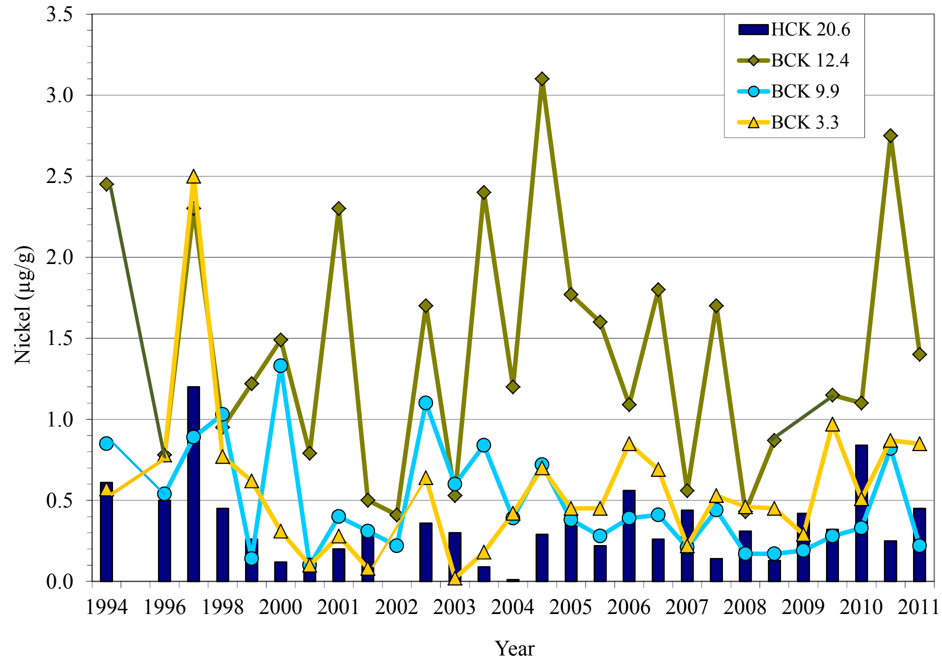

Figure 4.14. Mean nickel concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (Hinds Creek kilometer 20.6), 1994–2011.

BCK = Bear Creek kilometer HCK = Hinds Creek kilometer

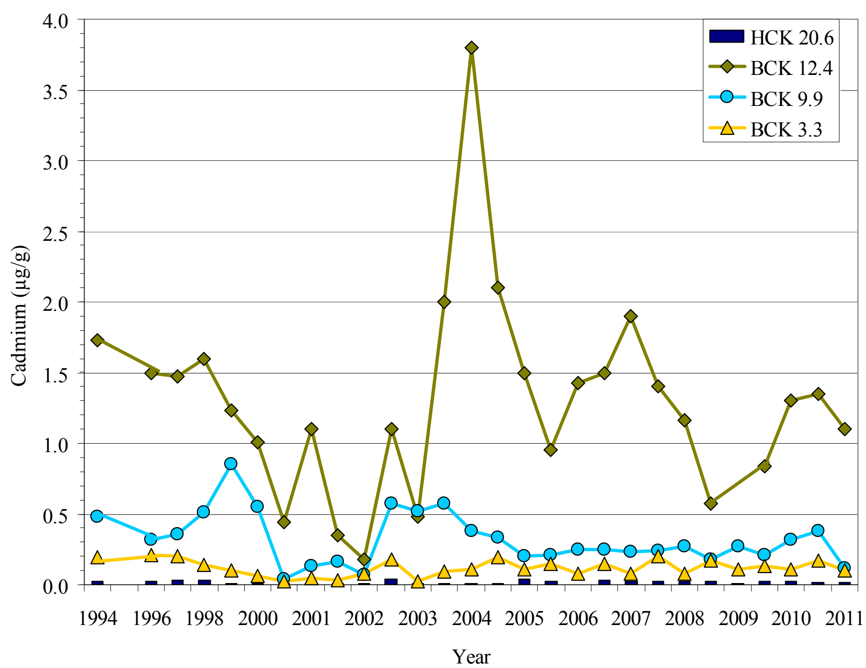

Figure 4.15. Mean cadmium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (Hinds Creek kilometer 20.6), 1994–2011.

BCK = Bear Creek kilometer HCK = Hinds Creek kilometer

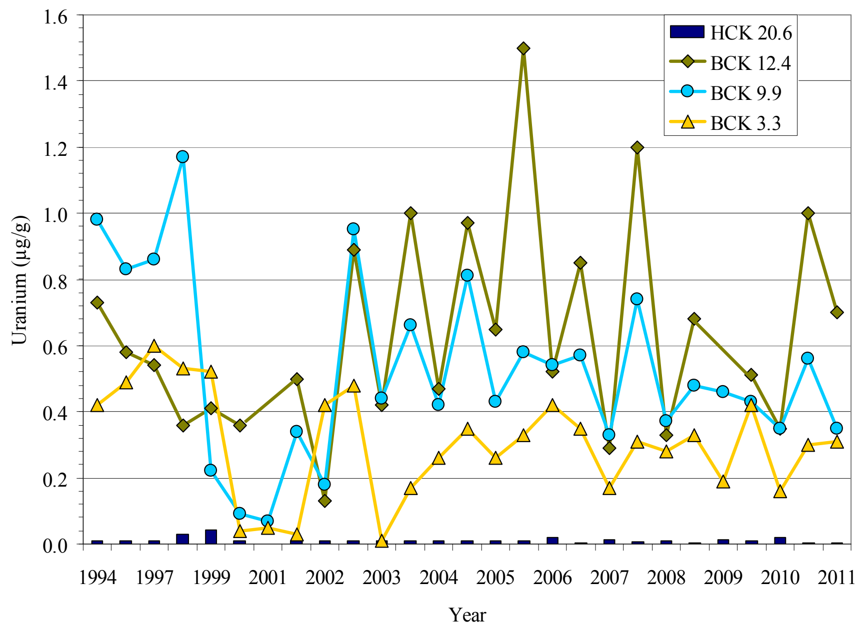

Figure 4.16. Mean uranium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (Hinds Creek kilometer 20.6), 1994–2011.

BCK = Bear Creek kilometer HCK = Hinds Creek kilometer

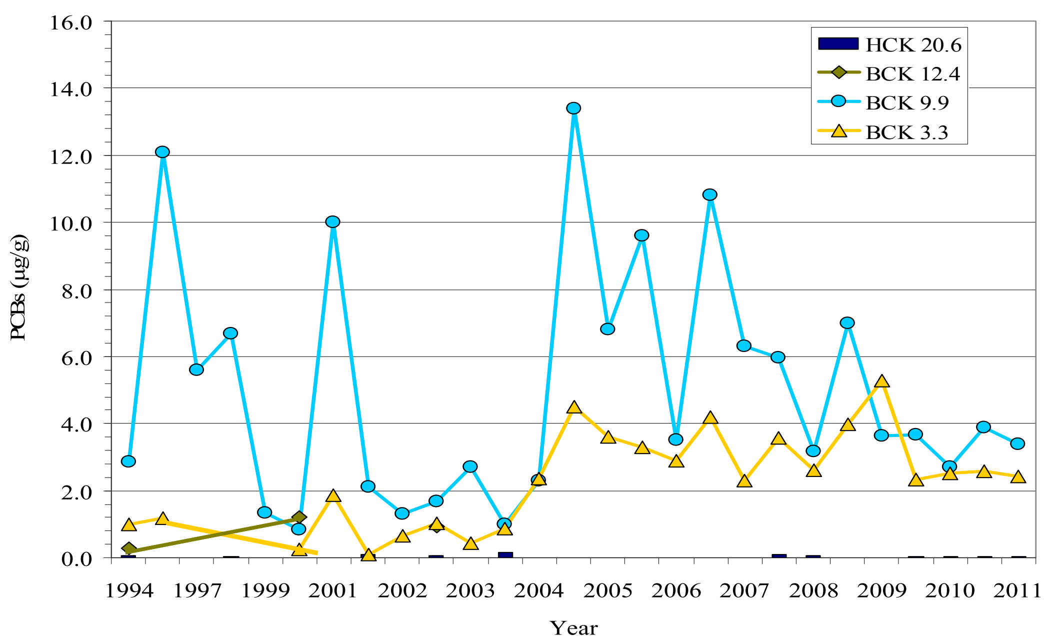

Figure 4.17. Mean polychlorinated biphenyl concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (Hinds Creek kilometer 20.6), 1994–2011.

BCK = Bear Creek kilometer HCK = Hinds Creek kilometer

The fish communities in Bear Creek have generally been stable or display minor variation in terms of species richness in recent samples with upward trends in 2011. The downstream sites (BCK 3.3 and BCK 9.9) have lower numbers of species relative to a larger reference stream (Bushy Fork kilometer 7.6), but are similar to or higher than a smaller reference stream (Mill Branch kilometer 1.6) (Figure 4.18). This is especially encouraging for BCK 3.3, as it is located downstream of almost all discharges or contaminated seeps in Bear Creek watershed. The sample site in the middle section of Bear Creek (BCK 9.9) had shown a steady increase in species richness, aided perhaps in recent years by the bypass of the downstream weir which allowed more upstream migration of fish species. Both sites are somewhat limited in sensitive species, primarily in abundance measures. BCK 12.4 and NT-3 fish communities are below total richness values of a comparable reference stream (Mill Branch kilometer 1.6), suggesting they are more susceptible to stress (Figure 4.19). 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 (M. Greeley personal communication) and biota impairment.

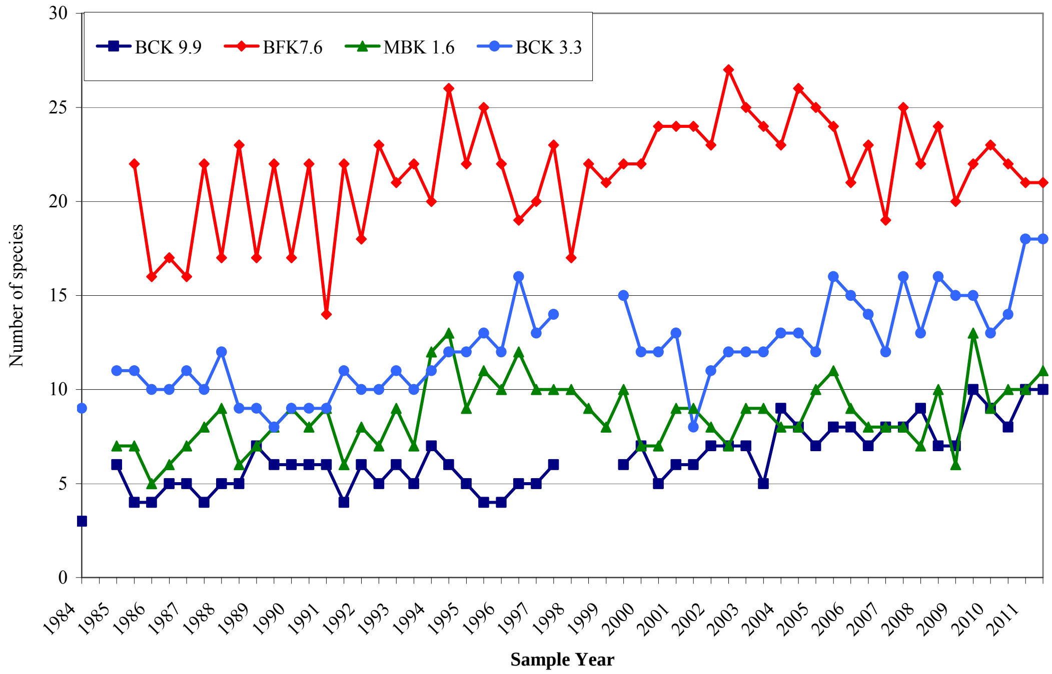

Figure 4.18. Species richness (number of species) in samples of the fish community in Bear Creek (BCK), and reference streams, Brushy Fork (BFK) and Mill Branch (MBK), 1984–2011.[a]

[a]Interruptions in data lines for Bear Creek kilometer sites indicate no results available for those periods.

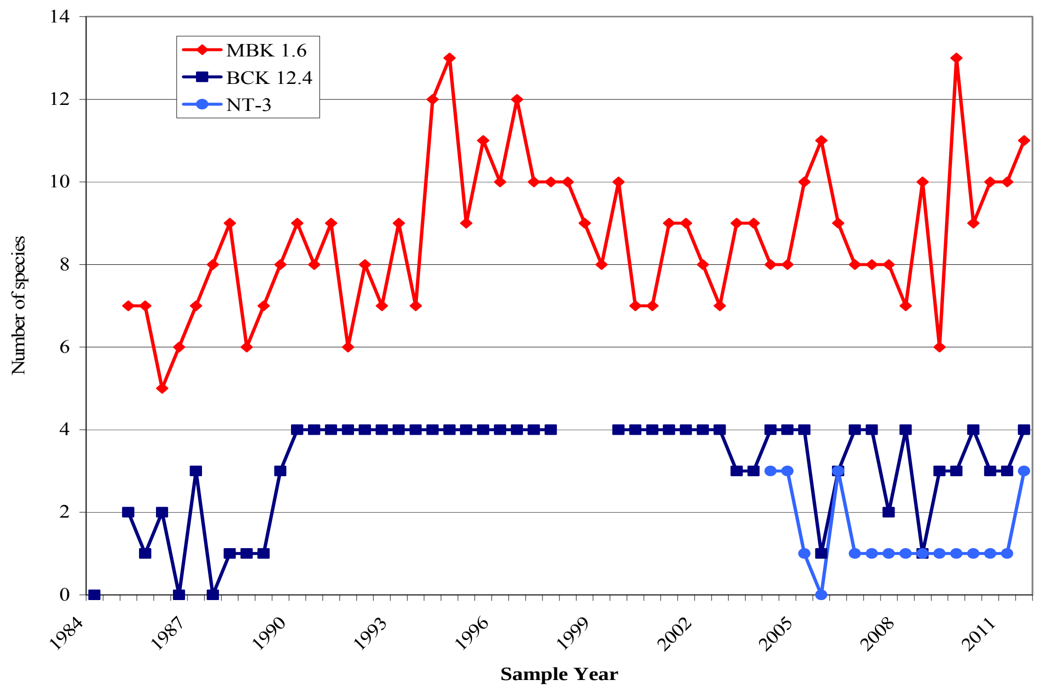

Figure 4.19. Species richness (number of species) in samples of the fish community in Bear Creek (BCK), North Tributary (NT-3), and a reference stream, Mill Branch (MBK), 1984–2011.[a]

[a]Interruptions in data lines for Bear Creek kilometer sites indicate no results available for those periods.

Upper Bear Creek (BCK 12.4) and NT-3 continue to support considerably fewer pollution-intolerant benthic macroinvertebrate taxa than nearby reference streams, and, as in past years, this difference is most pronounced during October sampling periods (Figure 4.20). Long-term trends in the number of pollution-intolerant invertebrate taxa at BCK 9.9 continue to indicate the presence of mild to moderate impacts. As noted for BCK 12.4 and NT-3, evidence of degradation at BCK 9.9 is clearly present during October sampling periods. However, comparable numbers to the reference site in April sampling periods suggests better stream conditions at BCK 9.9 than upstream sites. Even further downstream at BCK 3.3, results continue to indicate that the condition of invertebrate community is comparable to reference conditions.

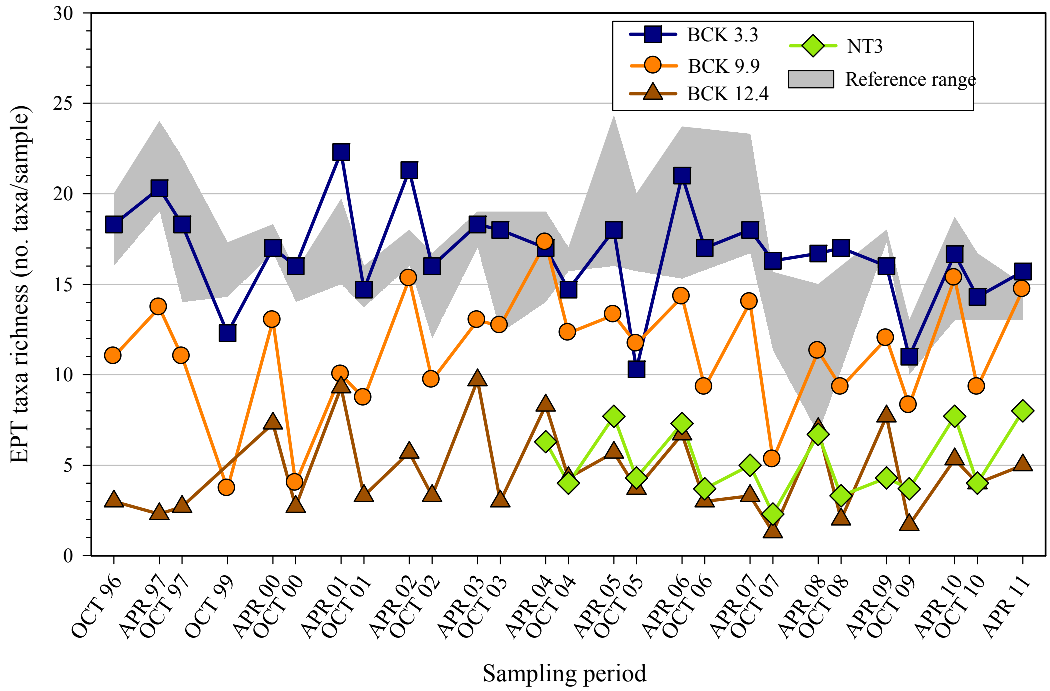

Figure 4.20. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in Bear Creek, NT-3, and range of mean values among reference streams (two sites in Gum Hollow Branch and one site in Mill Branch), October 1996–April 2011.

BCK = Bear Creek kilometer; NT-3 = North Tributary #3 to Bear Creek. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, caddisflies, and stoneflies.

4.2.2.3.2 Boneyard/Burnyard Stream Performance Monitoring

North Tributary-3 Riparian Monitoring

NT-3 stream habitat and riparian surveys were conducted in July 2011. Surveys continued for the eighth year, three years beyond the 5-year monitoring requirement (DOE 2003a). The additional monitoring was conducted because habitat and stream communities were still in poor condition at the end of the initial five-year period (Peterson *et al*. 2009). Surveys included measures of in-stream habitat within established stream transects (Figure 4.7). Riparian habitat included primarily vegetation cover (percent cover and species richness) within 10m X 5m plots corresponding to the surveyed stream habitat transects. Transect and plot results from the stream and riparian surveys are presented in tables 4.12 and 4.13.

Table 4.12. Summary of transect physical habitat metrics for North Tributary-3, July 25, 2011

Transect [b]	Stream width (m)	Percentage substrate [a]							Percent embeddedness [c]
		Plant detritus	Small boulder	Cobble	Gravel	Sand/ fines	Silt	Clay	
0	.7	25	0	12.5	62.5	0	0	0	66.3
1	.3	0	0	0	50	0	50	0	45
2	.4	0	0	0	60	40	0	0	27
3	.9	0	0	0	60	20	0	20	54
4	.8	0	0	0	33.3	22.2	22.2	22.2	76.4
5	.6	67	0	0	0	0	33.3	0	87.5
6	.4	0	0	0	20	0	80	0	5
7	.5	0	0	16.7	33.3	0	50	0	59.2
8	.3	25	0	0	0	0	0	75	87.5
9	.7	12.5	0	12.5	62.5	0	12.5	0	59.7
10	1.5	10	0	10	50	20	10	0	80.3
25	.6	14.3	28.6[d]	14.3	42.9	0	0	0	6.1
26	.6	42.9	0	14.3	14.3	0	28.6	0	70
27	.6	14.3	0	14.3	42.9	0	14.3	14.3	38.9

[a]Particle size ranges in mm: clay = <0.004, silt = 0.004 – 0.062, sand/fine sediment = 0.062 − 2.0, gravel = 2.0 − 64.0, cobble = 64.0 − 250.0, small boulder = 250.0 − 610.0.

[b]Transects 0 through 10 and 25 through 27 are 10 m apart. Transects 10 and 25 are 150 m apart.

[c]Percent embeddedness = percent of surface of predominant particles covered by fine sediment. Measurements were taken every 10 cm across transect.

[d]28.6% of transect is represented by large boulder (not small boulder); particle size = 610.0 − 2000.0.

Table 4.13. Vegetation metrics. The percent ground and canopy cover, plant species diversity, the amount of riparian overhang, and planted tree/shrub survival and condition for each monitored transect at the NT-3 restoration site, July 27, 2011

Transect/ Plot #	% Canopy	% Ground Cover	Number of plant species	L Bank Overhang (cm)	R Bank Overhang (cm)
0	35	100	21	17	45
1	12	90	10	20	15
2	1	100	9	7	40
3	1	95	17	46	24
4	0	90	14	46	44
5	15	90	23	17	30
6	2	70	10	30	23
7	0	80	15	29	42
8	1	80	6	13	14
9	3	90	11	32	12
10	0	80	14	0	20
25	7	90	14	27	40
26	50	90	14	60	50
27	58	95	12	60	30
2011 Ave	13.2	88.6	13.6	28.9	30.6

In general, NT-3 is a small first order stream that is around a half meter wide in most places in summer. The stream widens during high flows to as much as 1-2 meters, with overland sheet flow in some bends that allows for some riparian wetland development. In FY 2011 there was clear water evident in many pools, and most included fish.

The FY 2011 sediment characterization showed a diversity of particle sizes. Stream sediments are primarily of a gravel substrate, with cobbles, sand, fine sediments, and clays in some stream sections. There seemed to be more silt particles in some areas of the stream in 2011 than in FY 2010. Surrounding banks were well vegetated and erosion-related issues were not apparent. All other substrate categories measured, including plant detritus, were similar to the FY 2010 survey. Filamentous algae continued to be present in some areas of the stream.

The results of the FY 2011 vegetation survey showed continued high percent plant cover (average 88.6%) (Table 4.13). Although this measurement was lower than the 2010 cover measurement of 97%, percent cover was similar to FY 2009 (91%). In general, ground cover was greatest near the stream and open-ground clay areas were primarily found on the sloped ground near the top of the stream banks. Not surprisingly, the riparian area is primarily open habitat; however, stream vegetation overhang in FY 2011 was found to be greater than FY 2010. Canopy cover for FY 2011 (13.2%) was similar to FY 2010 (13.6%).

The average number of plant species observed per plot in 2011 (13.6) was slightly higher than in 2010 (11). Although species richness is down relative to the early years of the restoration, this is due to the most aggressive and well established plant species taking over the survey plots. As in recent past years, the top of banks with poorest soils contained the greatest percentage of nonnative *Lespedeza*. *Lespedeza cuneata* is a well-known invasive plant that commonly out-competes native species. Planted big bluestem (*Andropogon gerardii*) and little bluestem (*Schizachyrium scoparium*) were still present within many of the survey plots; however, it appears that they are being overrun by *Lespedeza* in certain areas. DOE will use invasive species control methods in FY 2012 in an effort to control the *Lespedeza*.

Boneyard/Burnyard Performance Summary

Instream and riparian habitat metrics, including percentage of fine sediments, percent plant cover, percent canopy, and number of plant species have all improved in FY 2011 relative to the early years of the mitigation project. Continued successional changes in vegetation to more shrub and tree species is expected within the restoration area over time. Because of the encroachment of an invasive plant species in the riparian zone, additional actions will be conducted to control invasive species.

Given the improved habitat, and by agreement with the Environmental Protection Agency and TDEC, the riparian monitoring at NT-3 will no longer be conducted. An Appendix I-12 letter has been sent to EPA and TDEC requesting formal approval (included as an Issue Carried Forward from the 2008 Remediation Effectiveness Report in Table 4.14). Fish and benthic community monitoring will continue in future years and provide a long-term measure of water quality trends.

4.2.2.3.3 Environmental Management Waste Management Facility Haul Road Mitigation Site

In 2005, an extension to the existing EMWMF haul road was constructed as a component of the CERCLA remedy. As a result of the wetland losses from the haul road construction, compensatory wetland mitigation was required. The primary restoration action was associated with the bypass of the existing Bear Creek weir and the old U.S. Geological Survey gauging station to restore natural stream flow in this section of creek. As part of that effort, a new wetland was created within the old stream channel.

Monitoring of restored or created mitigation sites for five years is a conventional requirement of TDEC's wetland-mitigation Aquatic Resources Alteration Permit (as required by Section 401 of the Clean Water Act). The monitoring strategy adopted, beginning shortly after construction was completed in the summer of 2006, the substantive monitoring requirements of typical wetland and stream restorations is similar in strategy to the NT-3 restoration monitoring (also conducted in the Bear Creek watershed).

The five year quantitative monitoring program for this site ended in 2010. An Appendix I-12 letter has been sent to EPA and TDEC seeking formal approval (included as an Issue Carried Forward from the 2011 Remediation Effectiveness Report in Table 4.14). However, visual surveys were conducted in FY 2011 because of dramatic changes to the hydrology of the mitigation site. In January 2011, the existing beaver dam at the site was breached, and the ponded area at the site was completely drained. This changed the character of the site and restored near-previous stream flow patterns for a short period of time. However, there were continued signs of beaver in the area including tracks, cuttings, bark stripping and slides. Fresh tracks and belly marks were also observed at the entrance to the existing beaver lodge. Tracks were also noted around the area of the dam breach, indicating that beaver were actively trying to make reparations to the dam. Actual repairs to the dam breach were noticeable by early February. However, a significant rain event in early March caused another blowout in the dam. Based on routine observations made at the site following that breach it appeared that beaver had abandoned the site for an extended period of time. During this time period no tracks, slides, feeding or damming activities were noted at the site. Sometime in early June beavers reoccupied the site and dam reparations were being made. By the end of June much of the site was once again flooded. A mid-July significant rain event did not cause a breach in the dam and the area remained flooded through August, creating habitat conditions similar to those in existence prior to the January breach. Figure 4.21 is a series of photographs that depicts water level changes in the constructed section of Bear Creek in 2011.

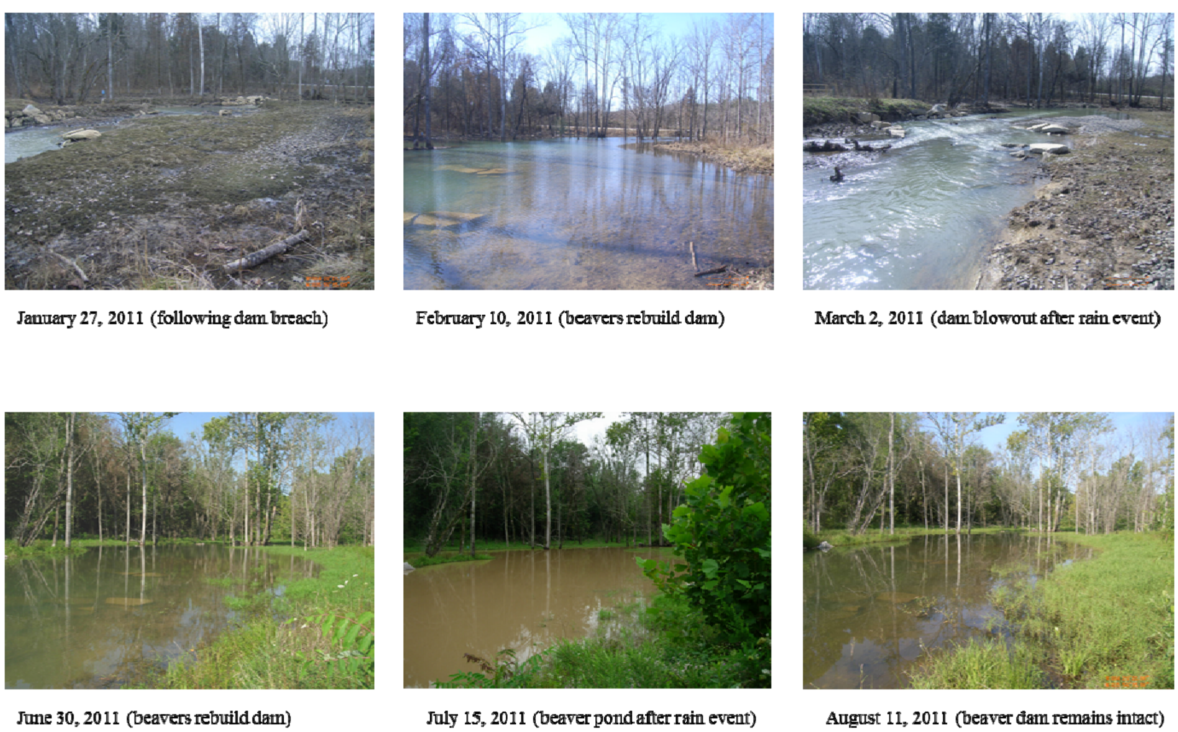

Figure 4.21. Photographic series depicting changes in water levels at constructed area of Bear Creek, Fiscal Year 2011.

At the end of FY 2011, the Haul Road mitigation site again provided significant habitat for wildlife - wooded swamp conditions coupled with adjacent second growth areas and upland forest. The juxtaposition of these communities provided good habitat structure to support diverse wildlife populations. Observations made at the site during FY 2011confirmed the site was being used by important species.

Reptile and amphibian populations appeared to be thriving at the site. Frog populations appeared to be particularly robust, with the presence of bullfrogs (*Lithobates catesbeianus*), green frogs (*Lithobates clamitans melanota*), upland chorus frogs (*Pseudacris feriarum*) and spring peepers (*Pseudacris crucifer*). Cumberland sliders (*Trachemys scripta troostii*), a common pond turtle, also appeared to be thriving in the area. Northern watersnakes (*Nerodia sipedon sipedon*) also frequented the area.

Birds common to swamps noted at the site include belted kingfisher (*Megaceryle alcyon*) and red-shouldered hawk (*Buteo lineatus*). Belted kingfishers favor habitat situations that provide good fish and amphibian populations as prey items. The red-shouldered is a hawk species that frequents swampy wooded areas where it will nest and prey on snakes and frogs. Similar habitats in the area support wood ducks (*Aix sponsa*), prothonotary warblers (*Protonotaria citrea*) and other cavity nesting species. Furthermore, the presence of two such cavity nesters on the Oak Ridge Reservation, the red-headed woodpecker (*Melanerpes erythrocephalus*) and brown-headed nuthatch (*Sitta pusilla*), have been linked, at least anecdotally, to beaver activity (Roy *et al*. 2001).

Visual surveys were conducted in FY 2011 in an effort to evaluate major changes to site hydrology. Although the site underwent a significant transformation as the result of beaver activity, impacting originally intended mitigation plans, this did not prevent the development of the area into a viable and productive natural community. Beavers are endemic to the area and play an important role in the natural evolution toward the establishment of diverse riparian habitats on the Oak Ridge Reservation. Beaver are particularly well-known inhabitants of the Bear Creek Valley where they are seen in varying numbers up and down the watershed, dependent on local food availability and normal cycles in colony sizes. The various changes in hydrology evident in Figure 4.21 are part of the natural environment and are not deemed to be related to the mitigation design or actions. No further monitoring of the site will be conducted.

4.2.3 Performance Summary

Following is a summary of the FY 2011 Bear Creek Valley watershed performance monitoring;

- During FY 2011, surface water monitoring at the integration point (BCK 9.2) showed that the Record of Decision goal of ≤34 kg/yr of uranium was not attained. The measured uranium flux at the IP was about 109 kg. About 29% of the uranium flux is attributed to surface water discharged from the S-3 Ponds plume and about 51% of the uranium flux originated in the Bear Creek Burial Grounds and discharged to Bear Creek via NT-8. Other contributors to the total uranium flux include deeper groundwater flows in the S-3 plume that discharge to Bear Creek via springs SS-4 and SS-5 and diffuse bed seepage, as well as smaller contributions from NT-3, NT-5, and NT-7. During FY 2011, the risk level associated with uranium at the integration point remained about twice the goal. An issue concerning the ungauged flux carried forward from the 2006 Remediation Effectiveness Report is being closed off in this Remediation Effectiveness Report, Table 4.14. Flux has been balanced within Bear Creek to within 4% over the last few years (flow paced monitoring was reinstated at NT-3 and NT-5, and BCK 10.15 was added).

- In FY 2011 samples were collected within the NT-8 drainage at several locations to identify points of entry of contaminants into the stream. The analytical results confirm that the eastern branch of

NT-8 that originates in Burial Ground D-West was the principal source of uranium and was a significant source of PCBs. Additionally, the highest source of VOCs is attributed to a discharge of plume water that evolves from the DNAPL area beneath Burial Ground A and extending westward beneath NT-7.This closes off an issue from the 2011 Remediation Effectiveness Report concerning the source of contaminants in NT-8, Table 4.14. Additionally, an open issue remains in the table which is the review of the non-CERCLA groundwater seepage collection system associated with BCBG D-West. This will be completed at the time of the NT-8 Early Action, as identified in Appendix E.

- Both nitrate and cadmium concentrations meet AWQC requirements at the watershed integration point (BCK 9.2).

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

- Groundwater contaminant trends in monitored areas are relatively stable and changes from FY 2010 levels are minor. Increases in some VOC constituents were observed in groundwater at the Bear Creek Burial Grounds. An issue carried forward in Table 4.14 documents the lack of groundwater monitoring wells in Zone 2, this will be addressed and evaluated in the future Bear Creek Valley Groundwater ROD. In Zone 1 groundwater, an area of intermittent plume extension in the Maynardville Limestone is shown on Figure 4.8. Contaminant concentrations continue to remain low and per the approved Bear Creek Valley Monitoring Plan will continue to be monitored and reported on yearly in the Remediation Effectiveness Report. Therefore, an issue identified from the 2010 Remediation Effectiveness Report is closed in this Remediation Effectiveness Report concerning the intermittent nature of this plume.

- Improved habitat at the Bear Creek Weir restoration site has been noted for several years. Temporary changes in habitat as a result of beaver dam breaches are considered a normal aspect of small streams on the Oak Ridge Reservation. The beaver dam has been repaired and the current habitat the site includes significant floodplain forest and wetlands. Therefore, at the Bear Creek Weir restoration site (BCK 4.6), a recommendation is made to stop stream habitat, riparian vegetation, and wetland monitoring at this location. This issue is carried forward from the 2011 Remediation Effectiveness Report, Table 4.14. DOE submitted an Appendix I-12 letter requesting approval of the change to TDEC and EPA.

- Instream and riparian habitat metrics in FY 2011 were improved at NT-3. Continued successional changes in vegetation is expected to occur over time. Given the improved habitat, an Appendix I-12 letter has been sent to EPA and TDEC requesting approval of the change.

4.2.4 Facility Operations and Land Use Controls

4.2.4.1 Requirements

Watershed-scale Requirements

- Long-term stewardship requirements outlined in the Record of Decision for the Phase I Activities in Bear Creek Valley (DOE 2000) include land use controls to restrict groundwater and surface water use consistent with designated end use for each zone (Table 4.2, Figure 4.2). Objectives of these land use controls include preventing unauthorized contact, removal, or excavation of buried waste in the Bear Creek Valley watershed; precluding residential or recreational use of Zone 3; and preventing unauthorized access to contaminated groundwater in the Bear Creek Valley watershed. The Record of Decision also states that DOE will maintain the Bear Creek Valley Phase I sites as controlled industrial areas and limit public access by posting signs and conducting security patrols.

- Boneyard/Burnyard—The site will be inspected by the Y-12 Surveillance and Maintenance 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—Control and restrict access; once action is complete, inspect and maintain the passive *in situ* treatment system.

- Disposal Area Remedial Action Solids Storage Facility—Control and restrict access.

Single-Project Scale Requirements

- Bear Creek Valley Operable Unit 2 – Maintain vegetated soil cover.

4.2.4.2 Status of Requirements

Watershed-scale

Land use controls in place in the Bear Creek Valley watershed were maintained throughout FY 2011 as part of the Y-12 Surveillance and Maintenance Program and in conjunction with B&W Y-12. Current land use restrictions in Bear Creek Valley, i.e., government-controlled, heavy-industrial land use in Zone 3 and access restrictions in Zone 2, were maintained.

Individual remedial actions under the *Record of Decision for the Phase I Activities in Bear Creek Valley* underwent routine site inspections conducted by the Y-12 Surveillance and Maintenance Program as follows:

- Burnyard/Burnyard—All components of the site were inspected semiannually in FY 2011, 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. Maintenance was required in FY 2011 to repair a damaged "Danger" sign, and to replace missing screens on cap drains 1 and 2. This site also received routine mowing.

- S-3 Ponds Pathway 3 and Disposal Area Remedial Action Solids Storage Facility—These remedial actions have not yet been implemented. Access control requirements were maintained in FY 2011 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.

Single-Project Scale

Spoil Area 1 and the SY-200 Yard sites of the Bear Creek Valley Operable Unit 2 were inspected quarterly by the Y-12 Surveillance and Maintenance Program in FY 2011 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. Minor maintenance was required at the SY-200 Yard to repair a small crack in the asphalt running toward the storm drain on the east end of the parking lot. A maintenance request was submitted to repair a broken sign post at Spoil Area 1. Both sites received routine mowing. The deed restrictions for both areas were verified at the Anderson County Register's of Deeds office.

4.3 BEAR CREEK VALLEY ISSUES AND RECOMMENDATIONS

The issues and recommendations for the Bear Creek Valley watershed are in Table 4.14.

Table 4.14. Summary of Bear Creek Valley watershed issues and recommendations

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
None.			
Issue Carried Forward			
1. Documented discharge of contaminants from upstream sources in NT-8. (2011 RER)[b]	1. (a) Item was closed out, see Completed/Resolved Issues below. (b) Engineering design and operational records for the non-CERCLA groundwater seepage collection system in the NT-8 headwaters associated with BCBG D-West will be reviewed and the system performance will be evaluated.	DOE/ EPA & TDEC	NT-8 Surface Water Early Action: refer to FFA Appendix E and J for planned implementation schedule.
2. A scarcity of groundwater monitoring wells in Zone 2 makes it impossible to precisely map and track groundwater contaminant transport pathways from a DNAPL area in the BCBGs and potentially into Zone 1. (2011 RER)[b]	2. Evaluation of potential pathways and installation of additional wells will be included in the work plan associated with the future BCV Groundwater ROD.	DOE/ EPA & TDEC	BCV Groundwater ROD; refer to FFA Appendix E and J for planned implementation schedule.
3. Five years of monitoring has been completed at the Bear Creek restoration site (BCK 4.6). The site is in excellent condition and is well on its way to recovery. (2011 RER)[b]	3. DOE recommends that stream habitat, riparian vegetation and wetland monitoring be discontinued. DOE submitted an Appendix I-12.	DOE/ EPA & TDEC	FY 2012 when BCV Monitoring Plan Addendum and I-12 letter are concurred to by EPA/TDEC.
4. In addition to surface water monitoring at the BYBY, the PCCR (DOE 2003d) specifies stream-stability monitoring, riparian vegetation monitoring, and in-stream biological monitoring of the restored NT-3 channel. (2008 RER)[b]	4. DOE recommended that riparian vegetation monitoring be discontinued because of improved habitat. DOE submitted an Appendix I-12 letter for EPA/TDEC approval to discontinue this monitoring.	DOE/ EPA & TDEC	FY 2012 when BCV Monitoring Plan Addendum and I-12 letter are concurred to by EPA/TDEC.

Table 4.14. Summary of Bear Creek Valley watershed issues and recommendations (cont.)

Issue[a]	Action/Recommendation	Responsible parties Primary/Support	Target response date
Completed/Resolved Issues			
1. Documented discharge of contaminants from upstream sources in NT-8. (2011 RER)[b]	1. (a) Surface water samples were collected along a transect from the NT-8 flume upstream to the BCBG fence identifying the inputs of uranium, VOCs, and PCBs to NT-8 in FY 2011, results are included in the 2012 RER. (b) Issues Carried Forward, see above.	DOE/ EPA & TDEC	FY 2011 with submission of 2012 D2 RER
2. Monitoring results for Zone 1 of BCV exhibit trace-to-low contaminant concentrations in groundwater, thereby compromising the Phase I ROD goal to maintain clean groundwater acceptable for unrestricted use. (2010 RER)[b]	2. The contaminant concentrations have remained low and are observed intermittently at various monitoring locations. In FY 2010, concentrations continued to trend downward or were not observed at all. The intermittent plume in the Maynardville Limestone were monitored during FY 2011 and no MCLs were exceeded.	DOE/ EPA & TDEC	FY 2011 with submission of 2012 D2 RER
3. Results for BCK 9.2 show an increase in the proportion of ungauged uranium flux beginning in FY 2002. Increasing uranium trends are not observed at gauged monitoring stations, or in principal groundwater exit points contributing to Bear Creek surface flow. (2006 FYR)[b]	3. Uranium flux mass balance in the Bear Creek watershed is complicated by the karst groundwater system. However, during FY 2010 the mass balance between source area contribution and the BCK 9.2 total matched within an 1% (<1 kg). DOE submitted an Appendix I-12 letter (and included the revised pages from the BCV Watershed Monitoring Plan) to the regulators recommending re-instatement of flow paced monitoring at NT-3 and NT-5 and the creation of an additional flux monitoring station at BCK 10.15 (downstream of SS-4 but upstream of NT-7) to attempt to determine inputs to the stream channel from karst discharge. The Appendix I-12 letter was accepted by both TDEC and EPA. Flow calibration at BCK 10.15 is on-going in FY 2011. Sources of uranium flux have been identified	DOE/ EPA & TDEC	BCV Monitoring Plan Addenda and I-12 letter concurred on by acceptance of the regulators in January 2012.

[a] A "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remediation Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remediation Effectiveness Report for Five-Year Review 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., (2006 Five Year Review)

4.4 REFERENCES

DOE 1996. *Record of Decision for the Bear Creek 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, U. S. Department of Energy, Environmental Restoration and Waste Management Division, Oak Ridge, TN.

DOE 2000. *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, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2001. *Removal Action Report on the Bear Creek Valley S-3 Ponds Pathways 1 and 2 at the Y-12 National Security Complex, Oak Ridge, Tennessee*, DOE/OR/01-1945&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2003. *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee*, DOE/OR/01-2077&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007a. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007b. *Addendum to the Removal Action Report for the Bear Creek Valley Interception Trenches for the S-3 Uranium Plume, Pathway 1 and 2 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-1836&D1/A1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2008a. *Focused Feasibility Study for the Bear Creek Burial Grounds at the Y-12 National Security Complex, Oak Ridge, Tennessee*, DOE/OR/01-2382&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2008b. *Proposed Plan for the Bear Creek Burial Grounds at the Y-12 National Security Complex, Oak Ridge, Tennessee*, DOE/OR/01-2383&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011a. *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2505&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011b. *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&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

Peterson, M. J., J. G. Smith, M. G. Ryon, W. K. Roy, and J. A. Darby, 2009. *Stream Mitigation Monitoring of North Tributary 3 (NT-3), Bear Creek Valley, Oak Ridge, Tennessee*. ORNL/TM-2009/053.

Roy, W. K., J. W. Evans, and M. G. Ryon. 2001. *The red-headed woodpecker and brown-headed nuthatch on the Oak Ridge Reservation: relationship to recent landscape changes*. The Migrant 72(1) 1-12.

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5. CERCLA ACTIONS ON CHESTNUT RIDGE

5.1 INTRODUCTION AND STATUS

5.1.1 Introduction

Table 5.1 lists CERCLA actions on Chestnut Ridge, and Figure 5.1 locates the key CERCLA sites and actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. All of the actions have long-term stewardship requirements (Tables 5.1 and 5.2) and are included in these performance evaluations. Chestnut Ridge is not physically situated within one of the five established watersheds but is located south of Y-12 National Nuclear Security Administration site (Y-12) (Figure 5.1). Because Chestnut Ridge is dissected by a number of small tributaries rather than forming a single defined hydrologic watershed, all completed remedies have been single-project actions to address known or potential sources of releases.

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 2011). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

5.1.2 Status

Chestnut Ridge Single-Project Actions

During FY 2011, no additional CERCLA actions were implemented or completed, nor were any associated *Federal Facility Agreement* documents submitted or approved for CERCLA actions located on Chestnut Ridge. Monitoring in support of performance assessments and evaluations continued.

Table 5.1. CERCLA actions on Chestnut Ridge

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations / Land Use Controls required	Section
Single-project actions				
United Nuclear Corporation Disposal Site	ROD: 06/28/91	RA complete.	Yes/Yes/Yes	5.2
		• PCR (DOE/OR/01-1128&D1) approved 09/06/94.		
Kerr Hollow Quarry	NFA ROD[b] (DOE/OR/02-1398&D2): 09/29/95	RA completed under approved RCRA closure plan.	Yes/Yes/Yes	5.3
Filled Coal Ash Pond/Upper McCoy Branch	ROD (DOE/OR/02-1410&D3): 02/21/96	RA complete. RAR (DOE/OR/01-1596&D1) approved 06/03/97.	Yes/Yes/Yes	5.4

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* and is available at <http://www.ucor.com/ettp_ffa_appendices.htm>.
[b]*Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant* (DOE 1995) defers all Long-Term Stewardship requirements to the RCRA post-closure permits.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
NFA = no further action
PCR = phased completion report
RA = remedial action
RAR = remedial action report
RCRA = Resource Conservation and Recovery Act
ROD = record of decision

Table 5.2. Long-term stewardship requirements on Chestnut Ridge

Site/Project	Long-Term Stewardship Requirements		Status	Section
	Land Use Controls	Engineering controls		
United Nuclear Corporation Disposal Site	• Installation of access controls	• Maintain cap	• Engineering controls remain protective.	5.2.2
Kerr Hollow Quarry[a]	• Access controls (fences and locked gates) • Deed restrictions	• Inspections	• Land Use Controls in place. • Engineering controls remain protective.	5.3.2
Filled Coal Ash Pond/Upper McCoy Branch	• Controls to limit access	• Inspect and maintain dam, slope, and spillway	• Engineering controls remain protective.	5.4.3

[a]All requirements deferred to Resource Conservation and Recovery Act post-closure permit.

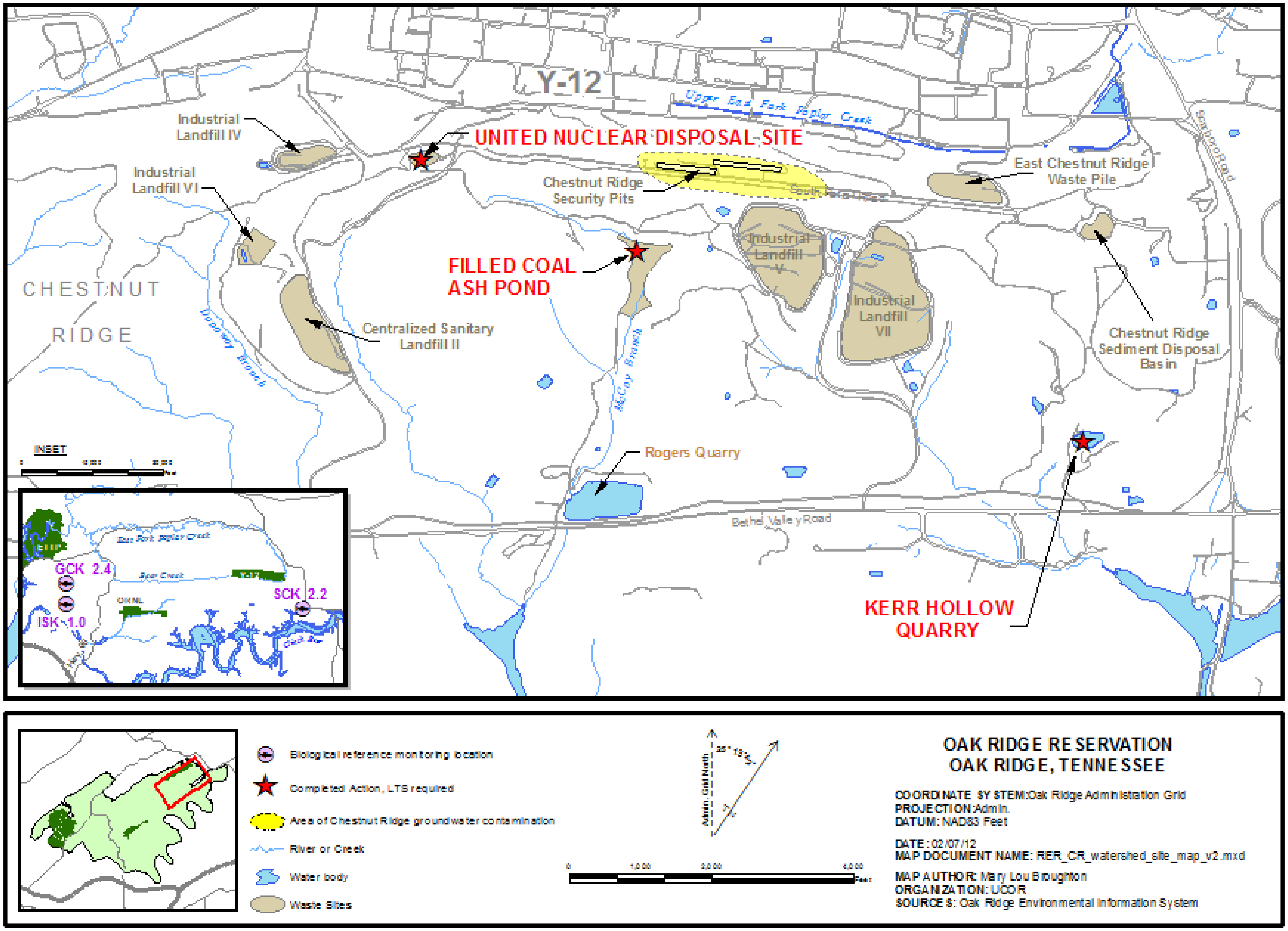


Figure 5.1. CERCLA actions on Chestnut Ridge.

5.2 UNITED NUCLEAR CORPORATION DISPOSAL SITE REMEDIAL ACTION

5.2.1 Performance Monitoring

5.2.1.1 Performance Monitoring Goals and Objectives

The United Nuclear Corporation Disposal Site is a 1.3-acre landfill located near the crest of Chestnut Ridge south of Y-12 (Figure 5.1 and Figure 5.2). The *Record of Decision United Nuclear Corporation Disposal Site Declaration* (DOE 1991a) 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-gallon 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 United Nuclear Corporation Disposal Site uranium recovery facility in Wood River Junction, Rhode Island. In addition, Formerly Utilized Sites Remedial Action 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.

The major goal of the United Nuclear Corporation Disposal Site remedial action (DOE 1991a) is to "ensure that mobile contaminants in the United Nuclear Corporation 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* (DOE 1991b) 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 1991a) is to control contaminant migration so that nitrate is less than the Safe Drinking Water Act limit of 10 mg/L and no more than 2 pCi/L of ^{90}Sr will occur in groundwater, which is within the CERCLA 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 1993) 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*, 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

Groundwater monitoring was performed in FY 2011 at upgradient well 1090 and downgradient wells GW-203, GW-205, GW-221 and at a downgradient spring designated UNC SW-1 (Figure 5.2). 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 5.3. Strontium-90 analysis has not been conducted on samples from UNC SW-1 pending results of gross beta screening. Potassium-40 was analyzed in well GW-205 and the UNC SW-1 (Table 5.3).

In FY 2011, nitrate concentrations downgradient of the site have remained well below the 10 mg/L Safe Drinking Water Act MCL and the "not expected to exceed range" of 8 mg/L. Also, the downgradient nitrate concentrations, with the exception of August (Quarter 4) sample from well GW-203, were below

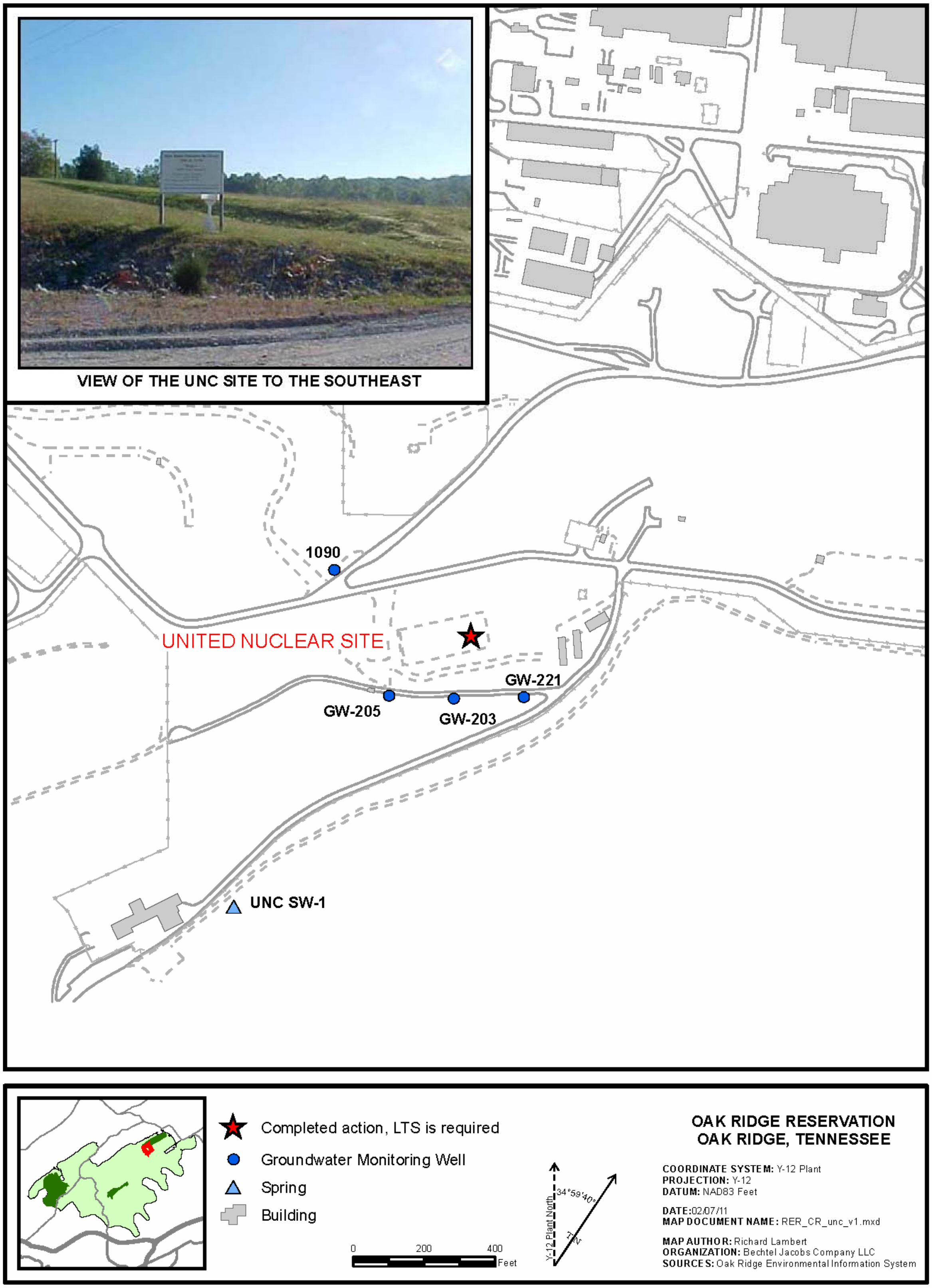


Figure 5.2. United Nuclear Corporation Disposal Site.

Table 5.3. Analytical results for performance indicator constituents at the United Nuclear Corporation Disposal Site, FY 2011

Date	Upgradient well	Downgradient wells			Downgradient spring
	1090	GW-203	GW-205	GW-221	UNC SW-1
Nitrate (mg/L)					
Q2-11	0.76	0.53	0.33	0.49	0.14
Q4-11	0.73	0.99	0.15	0.43	0.16
Gross alpha (pCi/L)					
Q2-11	<1.95 U	<2.1 U	<3.28 U	<2.03 U	<2.45 U
Q4-11	<2.06 U	<2.12 U	<2.81 U	<2.44 U	<2.58U
Gross beta (pCi/L)					
Q2-11	<4.24 U	<3.74 U	14.6±2.64 J	<3.73 U	<4.36 U
Q4-11	<3.32 U	<3.47 U	14.9±2.39	<3.54 U	4.26±1.81
^{90}Strontium (pCi/L)					
Q2-11	<2.3 U	<1.92 U	<1.88 U	<1.99 U	
Q4-11	<1.88 U	<1.89 U	3.06±0.941	2.34±0. 872	
^{40}Potassium (pCi/L)					
Q2-11	-	-	<170U	-	<144 U
Q4-11	-	-	<164 U		<126U

Bold value indicates gross alpha above the Safe Drinking Water Act maximum contaminant level (MCL) [15 picoCuries per liter (pCi/L)] or gross beta above the effective dose equivalent (50 pCi/L) to the MCL (4 mrem/yr).

GW = groundwater well
U = Not detected or result less than minimum detectable activity
J = estimated value

the concentrations in the upgradient well. In FY 2011, ^{90}Sr was detected in monitoring locations GW-205 (3.06±0.941 pCi/L**)** and GW-221 (2.34±0.872 pCi/L**)** in the August (Quarter 4) samples. These levels exceed the 2 pCi/L specified for groundwater in the *Record of Decision United Nuclear Corporation Disposal Site Declaration* (DOE 1991a).

Gross alpha activities have remained well below the 15 pCi/L maximum contaminant level in FY 2011. Gross beta activity in groundwater at the site was below the 50-pCi/L screening value for compliance with a 4-mrem/yr dose limit for man-made radionuclides. Gross beta results in FY 2011 for well GW-205 were 14.6 J and 14.9 pCi/L, which is less than reported in FY 2010. Gross beta was detected at UNC SW-1 at 4.26 ± 1.81 pCi/L in the August (Q4) sampling in FY 2011.

The history of monitoring at well GW-205 started in 1987. In 1998 the well purge method was changed from a standard 3-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 has ranged between 9.5 and 10.5. During FY 2011, the pH at well GW-205 was 8.59 in March (Quarter 2) and 9.41 in August (Quarter 4), which is consistent with past data.

During FY 2010, ^{40}K was reported in the radiological analyses conducted on site groundwater (well GW-205) and surface water (UNC SW-1). Potassium-40 was not detected at either of those locations in FY 2011 samples. In FY 2011 samples from both locations were below detection limits for ^{40}K. As discussed in the *FY 2009 Remediation Effectiveness Report*, (DOE 2009) natural potassium in the environment (in bedrock, soils, and groundwater) contains a known natural abundance of ^{40}K. The concentration of radioactive ^{40}K based on its natural abundance in total elemental potassium has been calculated for all samples from GW-205. The calculated ^{40}K activities closely track (within ~20 pCi/L except for a single outlier) the beta activity values indicating that increased potassium concentrations that are detected under lower stress sampling are responsible for the increase in beta activity. Analyses for other beta-emitting radionuclides (^{99}Tc, ^{90}Sr) have not detected site-related contaminants other than low concentrations of ^{90}Sr. As noted above, ^{90}Sr was detected at low levels in the Q4 samples at both GW-205 and GW-221.

Figure 5.3 shows the measured beta activity, the computed beta activity attributable to the total potassium in groundwater samples, and the residual beta activity that would not be attributable to the natural potassium. Several of the samples had measured beta activities less than the computed potassium beta and, therefore, negative residual results are not plotted. As shown, the typical residual beta activity is near or less than 20 pCi/L, with the exception of the single elevated beta value measured in July 2006. Numeric drinking water criteria do not exist for the gross beta screening measurement in water supplies. This is because beta activity is a general measure of radioactivity and risk factors for different beta-emitting radionuclides vary. However, various agencies have selected target levels ranging from about 25 to 50 pCi/L, above which further identification of radionuclides and evaluation of risk is indicated. Well GW-205 was redeveloped in the fall of 2010. Subsequent sampling showed a decrease in both total potassium and gross beta activity.

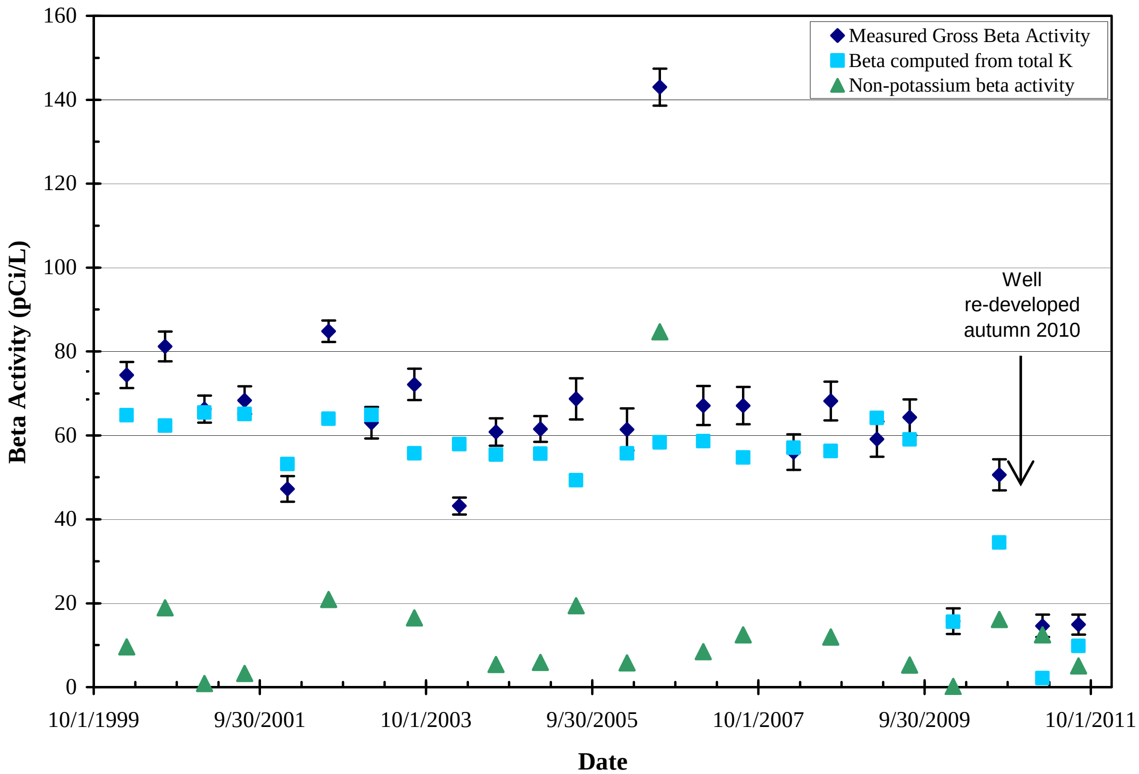


Figure 5.3. Well GW-205 measured and computed beta activity.

Table 5.4 presents the ^{90}Sr analytical results for the four monitoring wells at the United Nuclear Corporation Disposal Site. Strontium-90 has been detected sporadically at low concentrations in groundwater adjacent to the United Nuclear Corporation Disposal site. The FY 2006 17.8 pCi/L result from well GW-205 exceeded the maximum contaminant level effective dose equivalent but was below the United Nuclear Corporation Disposal Site Feasibility Study (DOE 1991b) estimate of a maximum groundwater ^{90}Sr concentration of 50 pCi/L. Strontium-90 was detected at about 2.5 pCi/L in well GW-221 in FY 2011 Q4. This result is similar to the level detected in this well during FY 2006 and FY 2008.

Table 5.4. United Nuclear Corporation 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	**<2.3U**	<1.92U	<1.88	<1.99
Aug 11	**<1.88U**	<1.89U	3.06 ±0.941	2.34 ± 0.872

[a]All values pCi/L.

Bold value exceeds 8 pCi/L effective dose equivalent to the beta particle and photon activity maximum contaminant level of 4 mrem/year.

J = estimated value

U = reported concentration was below the minimum detectable activity

During FY 2011, 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 and beta activity levels are below drinking water criteria and are similar to results from site monitoring wells.

5.2.1.3 Performance Summary

As discussed in previous Remediation Effectiveness Reports (DOE 2010 and DOE 2011), elevated gross beta activity continues to be observed in downgradient well GW-205 and in FY 2011 at UNC SW-1, suggesting a potential contaminant release from the site. The gross beta activity does not appear to be caused by ^{90}Sr, but does track closely to ^{40}K. The downgradient spring (UNC SW-1), added to the monitoring network in FY 2008 to assess the potential impacts of groundwater seepage on surface water quality, exhibits data consistent with results from other downgradient monitoring wells at the site that do not detect any contaminants of concern above an action limit. However, because of detected gross beta in the United Nuclear Corporation SW-1 in FY 2011 the August (Quarter 4) sample, an issue has been added to Table 5.7 and it is recommended that ^{90}Sr be added to the analytical suite for that location.

5.2.2 Facility Operations and Land Use Controls

5.2.2.1 Requirements

The *Post-Construction Report for the United Nuclear Corporation Disposal Site* (DOE 1993) requires that surveillance activities continue for 30 years from completion of remediation to ensure that the cap adequately contains the waste in the site (Table 5.2). 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 United Nuclear Corporation Disposal Site were inspected semiannually in FY 2011 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 2011 except routine mowing. Additionally, the United Nuclear Corporation 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 United Nuclear Corporation Disposal Site Issues and Recommendations

Because of detected gross beta in the United Nuclear Corporation SW-1 in the August (Quarter 4) FY 2011 sample, it is recommended that ^{90}Sr be added to the analytical suite.

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 1995) (Figure 5.1 and Figure 5.4) presents the decision for No Further Action at the site, deferring all monitoring, reporting, and maintenance requirements to the *Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime* (TDEC 1996) and amendments. Because the Resource Conservation and Recovery Act closure left contaminated material in place, the permit requires monitoring of groundwater. Resource Conservation and Recovery Act required monitoring is described in this section. The *Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* was reissued in September 2006 (TDEC 2006), 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 No Further Action *Record of Decision for Kerr Hollow Quarry* (DOE 1995). The *Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TDEC 2006) 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 post-closure permit 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* 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 (DOE 1995).

5.3.1.2 Evaluation of Performance Monitoring Data

During FY 2011, annual groundwater monitoring was conducted in upgradient/background well GW-231 and in downgradient/point-of-compliance wells GW-143, GW-144, and GW-145 (Figure 5.4) for metals, VOCs, gross alpha, and gross beta. Statistical analyses of target constituents were conducted in accordance with the post-closure permit. Monitoring results and statistical analyses are reported to the Tennessee Department of Environment and Conservation in post-closure permit monitoring reports. Site-specific background values were determined for each inorganic target list constituent using historical data for upgradient wells along Chestnut Ridge and including current monitoring results for upgradient well GW-231. Groundwater samples from all of the downgradient wells at the site had target list constituent concentrations below the applicable background values during FY 2011. Therefore, a release of target list constituents to groundwater is not indicated at Kerr Hollow Quarry and No Further Action was necessary per requirements of the post-closure permit.

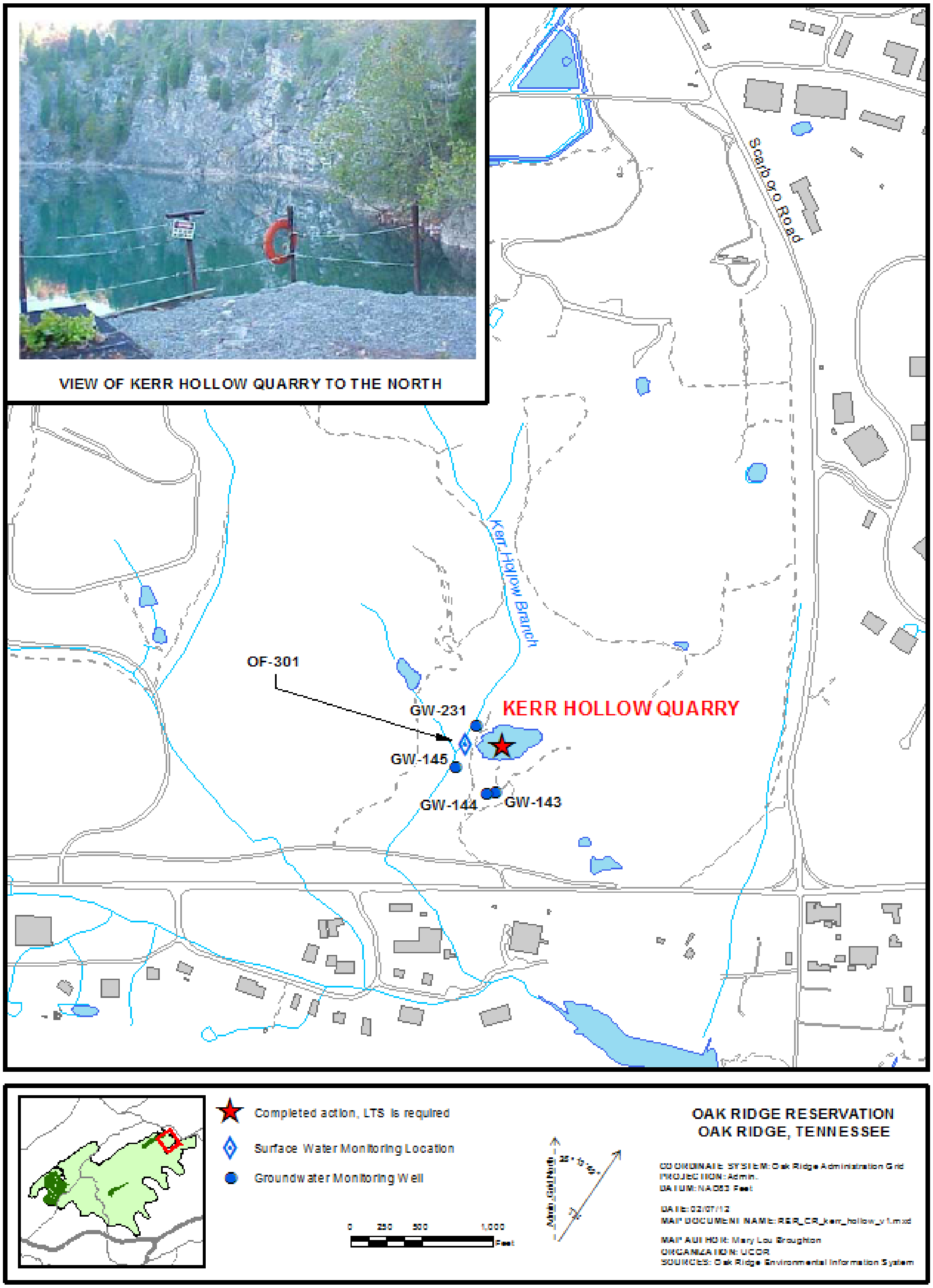


Figure 5.4. Kerr Hollow Quarry.

5.3.1.3 Performance Summary

Results of statistical evaluations of FY 2011 groundwater analytical data for Kerr Hollow Quarry do not indicate a contaminant release for the uppermost aquifer and do not warrant any response action specified in the *Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TDEC 2006).

5.3.2 Facility Operations and Land Use Controls

5.3.2.1 Requirements

The *Record of Decision for Kerr Hollow Quarry* (DOE 1995) does not specify any requirements; however, the *Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime* (TDEC 2006) requires that all security components, signage, survey benchmarks, and monitoring systems at Kerr Hollow Quarry be inspected quarterly throughout the post-closure care period of 30 years (Table 5.2). 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's of Deeds office.

5.3.2.2 Status of Requirements

Kerr Hollow Quarry was inspected quarterly in FY 2011 by the Y-12 Surveillance and Maintenance 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. Minor maintenance included repairing a damaged "Danger Keep Away" sign, and removing fallen trees from across the fence and road.

Additionally, the Kerr Hollow Quarry is located outside Y-12 property protection area; therefore, separate security fencing and signs exist at the site. The Kerr Hollow Quarry deed restrictions were filed on April 28, 1994 at the Anderson County Register's of Deeds Office and remain in place.

5.3.3 Kerr Hollow Quarry Issues and Recommendations

There are no 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 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 1996) was to remediate the Filled Coal Ash Pond and vicinity. The *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (DOE 1997a) 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 remedial action also includes long-term monitoring of the dam and controls to limit access.

The goal of the remedial action (DOE 1996) 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 1996) 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* 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 1997) specifies that surface water samples "be collected and analyzed for the primary COCs (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 Branch 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 Filled Coal Ash Pond vicinity in accordance with applicable or relevant and appropriate requirements for protection of aquatic resources specified in the *Record of Decision for Chestnut Ridge Operable Unit 2*. 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.

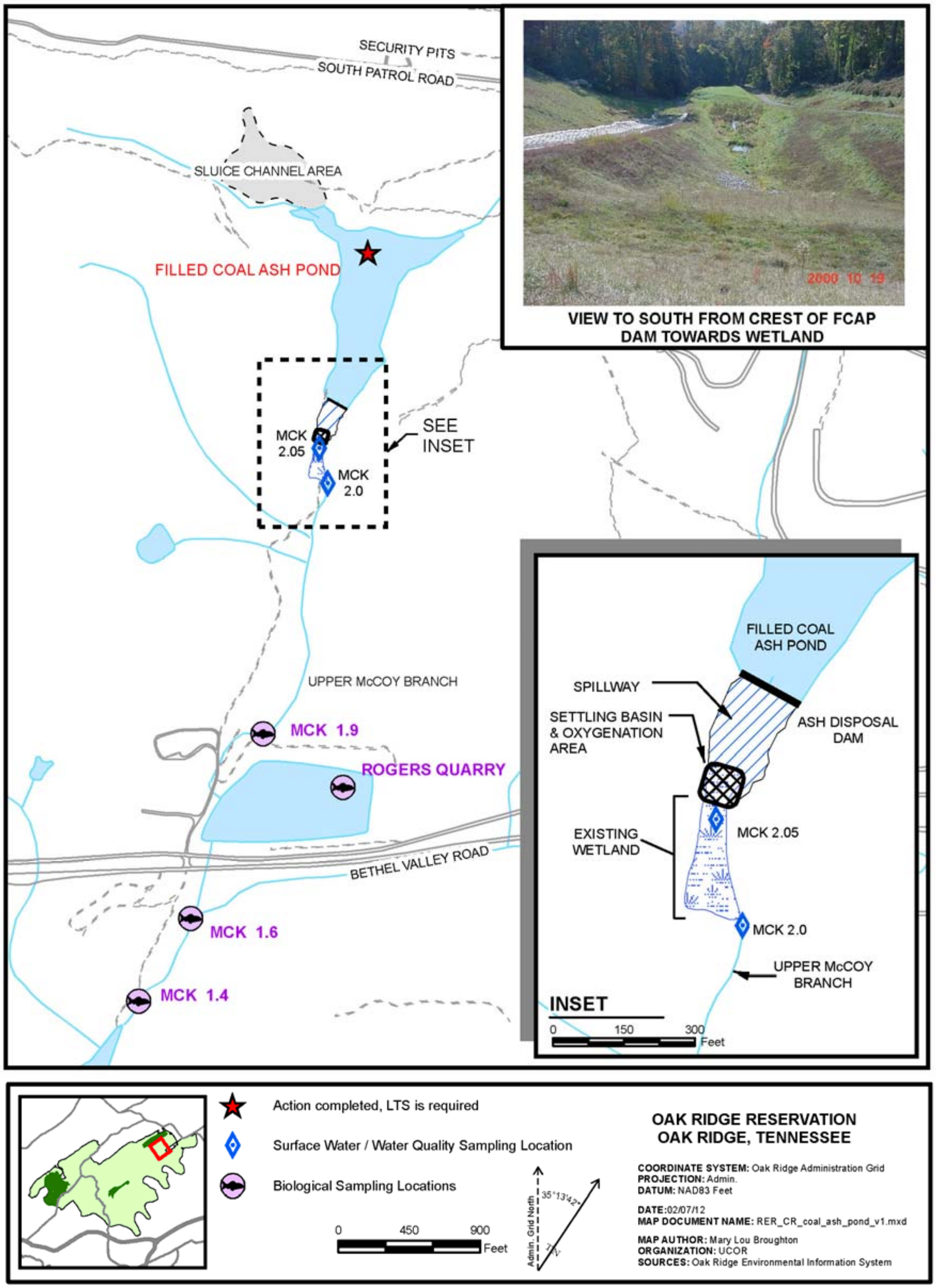


Figure 5.5. Filled Coal Ash Pond.

5.4.1.2 Evaluation of Performance Monitoring Data

5.4.1.2.1 Surface Water

Results for surface water monitoring at Filled Coal Ash Pond in FY 2011 did not exceed the upper range of baseline values from pre-remediation monitoring conducted in FY 1996. Results for pre-remediation baseline monitoring and FY 2011 monitoring are presented in Table 5.5 and Table 5.6, respectively. Both filtered and unfiltered sample results are provided for the baseline sample event in which 4 replicate samples were collected on the same date. Table 5.6 includes results for unfiltered samples taken at locations above and below the wetland during both sampling events and field filtered aliquot results from the August samples.

Table 5.5. Summary of Filled Coal Ash Pond 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)		
		Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev
Arsenic	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
Iron	mg/L	--[c]	0.014	--[c]	20.1	48	23.1	0.091	0.26	0.114	16.7	43	17.7
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
Zinc	mg/L	0.022	0.052	0.022	0.035	0.056	0.023	--[c]	0.009	--[c]	0.072	0.2	0.091

[a]Dam effluent/wetland influent.
[b]Wetland effluent.
[c]value not determined because only 1 valid result was available.

Avg = average
Max = maximum
MCK = McCoy Branch kilometer
Stdev = standard deviation

Table 5.6. Summary of FY 2011 post-remediation data from McCoy Branch kilometer 2.05 and 2.0

		Wet-season sample		Dry-season sample		
Analyte	Units	MCK 2.05[a] Mar-24	MCK 2.0[b] Mar-24	MCK 2.05[a] Aug 23 Unfilt. / Filt.	MCK 2.0[b] Aug 23 Unfilt. / Filt.[c]	AWQC
Aluminum	mg/L	<0.1 U	<0.1U	0.17 / <0.1U	<0.1U / <0.1U	N/A
Arsenic	mg/L	**0.023**	**0.011**	**0.018 / 0.011**	**0.02** / 0.0066	0.01[d]
Iron	mg/L	0.73	0.19	0.47 / <0.1U	0.51 / <0.1U	N/A
Manganese	mg/L	0.36	0.16	0.52 / 0.061	0.4 / 0.3	N/A
Zinc	mg/L	<0.01 U	<0.01U	<0.01U / <0.01U	<0.01U / <0.01U	0.12[e]

[a] Dam effluent/wetland influent.
[b] Wetland effluent.
[c] Unfiltered result followed by filtered sample result. Field filtered aliquot collected in August only.
[d]Source: Tennessee Department of Environment and Conservation 1200-4-3-.03(4) recreation criteria for organisms only.
[e]Source: Tennessee Department of Environment and Conservation 1200-4-3-.03(3) criterion continuous concentration for protection of fish and aquatic life. Ambient water quality criteria for zinc are hardness dependent. *The 0.12 mg/L Ambient water quality criteria for zinc is based on the most conservative criterion for hardness.*

Bold value indicates sample concentration exceeds ambient water quality criteria.
AWQC = ambient water quality criteria
MCK = McCoy Branch kilometer
N/A = not applicable
U = not detected

The FY 2011 concentrations of contaminants of concern (Al, As, Fe, Mn, and Zn) above (MCK 2.05) and below (MCK 2.0) the wetland showed that, although the wetland does attenuate arsenic levels in the site discharge, arsenic exceeded the AWQC of 0.01 mg/L in both the upstream and downstream locations. The March 2011 results, representing the wet-season, are typically lower than the dry-season results although the iron and manganese levels were high in the September samples. Results for contaminants of concern presented in Table 5.6 show aluminum and manganese decreasing through the wetland (MCK 2.05 to MCK 2.0) and arsenic and iron remaining constant. This suggests the likelihood of arsenic coprecipitation with particulate iron in the samples. In FY 2011, only arsenic exceeded the AWQC upstream and in unfiltered samples downstream of the Filled Coal Ash Pond wetland. Concentrations have decreased since the remedial action.

The historic data presented in Figure 5.6 shows that elevated measurements in the upstream location (MCK 2.05) are almost ten times higher for iron than observed downstream of the wetland. The elevated measurements appear to occur when oxyhydroxide precipitate conditions are observed in the Filled Coal Ash Pond leachate, consistent with low rainfall conditions. The reduction factors for arsenic between the upstream and downstream monitoring locations range from a low of 25% to a high of >99% with an average of about 74% between FY 1998 and FY 2011.

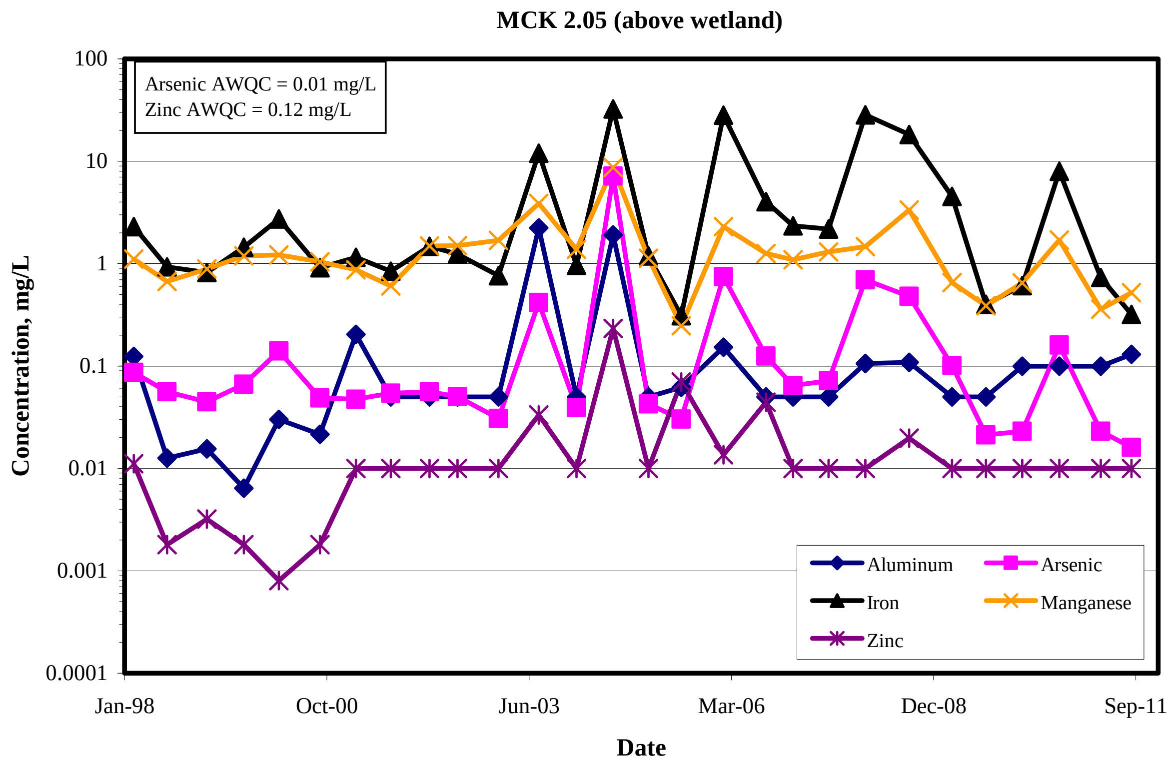
5.4.1.2.2 Biota

Fly-ash disposal from Y-12 into the Filled Coal Ash Pond, 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 bioaccumulation 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 selenium concentrations in largemouth bass in Rogers Quarry increased from 1.3 µg/g in 2010 to 1.45 µg/g in 2011, remaining above typical background concentrations (~0.5 µg/g), suggesting continuing low level inputs from the Filled Coal Ash Pond (Figure 5.7). Arsenic concentrations continued to be near background levels since 2007. Average mercury concentrations in bass from Rogers Quarry increased to 0.86 µg/g, but remained within the range of values observed in the last decade (Figure 5.7).

The species richness (number of species) of the fish community at MCK 1.6 in McCoy Branch (Figure 5.5) has shown a wide range of variation in recent samples, but has generally been lower in 2010-2011 samples than in the 1990s (Figure 5.8). The species richness at MCK 1.9 remained stable, where introduction of the western blacknose dace appears to be successful, and the recently introduced creek chub were present in 2011 samples increasing total richness to 3 (Figure 5.8). Both sites were below mean reference values for 2011 and had far fewer sensitive species such as darters.

The number of pollution-intolerant benthic macroinvertebrate taxa (EPT taxa richness) continued to show a distinct and clear seasonal trend at MCK 1.4, where the highest values consistently occur in April (Figure 5.9). Seasonal changes at MCK 1.9, in contrast, continued to be more subtle, with neither season consistently having more EPT taxa present. EPT taxa richness was lower at both sites in McCoy Branch than the reference range in October 2010 and April 2011, which contrasts with recent years when EPT richness had been within the reference range during at least one of the two collection periods at both sites.



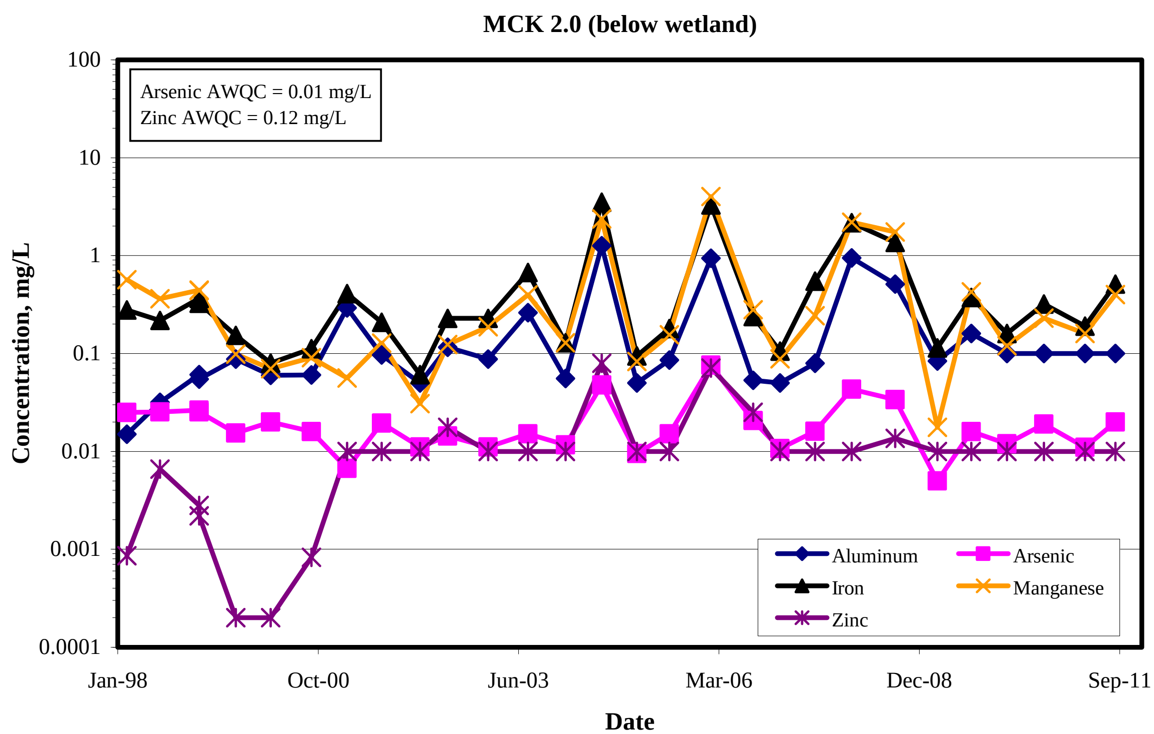


Figure 5.6. Historic data at MCK 2.0 and MCK 2.05 between FY 1998 and FY 2011.

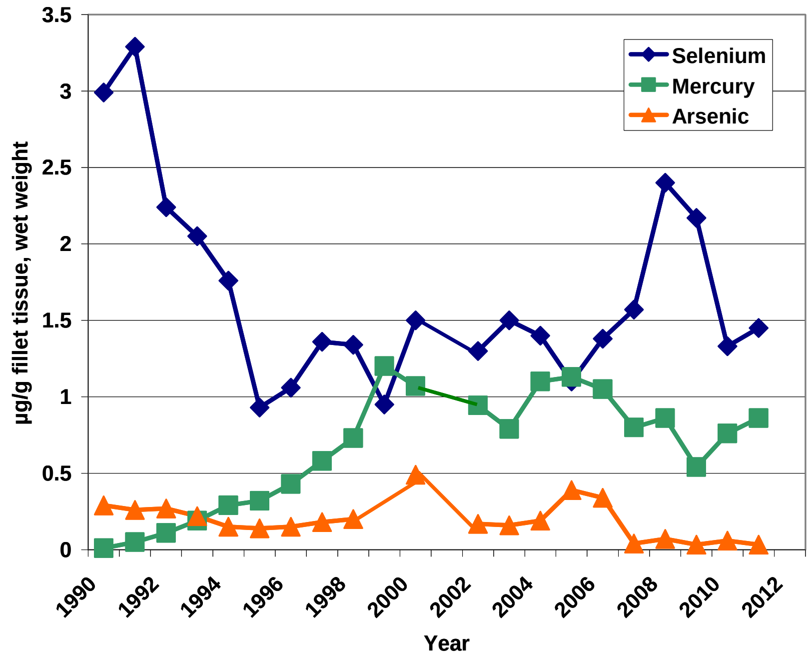


Figure 5.7. Mean concentrations of selenium, mercury, and arsenic in fillets of largemouth bass from Rogers Quarry (n=6).

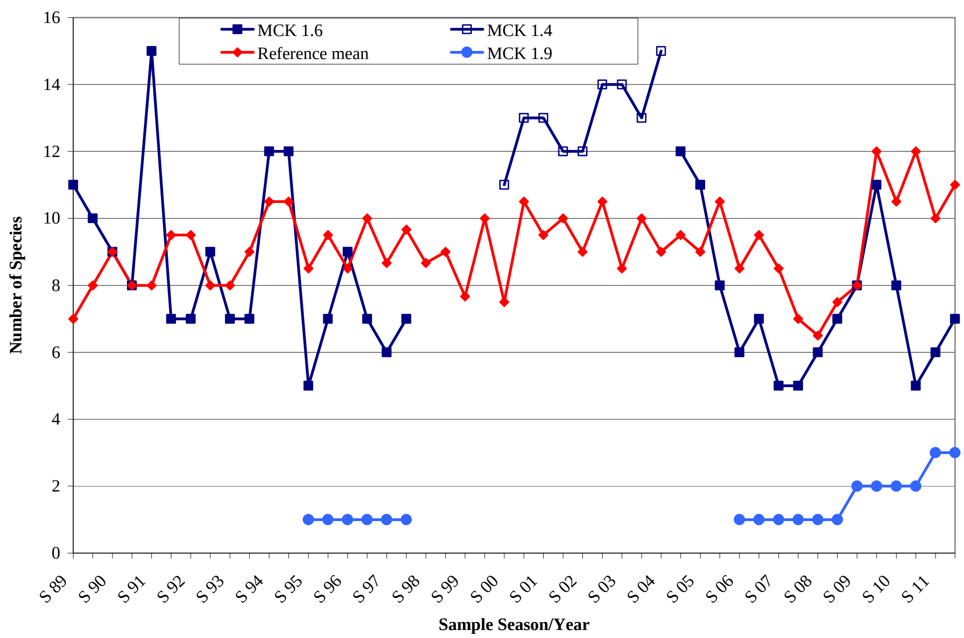


Figure 5.8. Species richness (number of species) in samples of the fish community in McCoy Branch (MCK) and the mean value of two-three reference streams, Scarboro Creek (SCK), Grassy Creek (GCK), and Ish Creek (ISK) 1989–2011.

See Figure 5.1 for locations of reference sampling sites. Interruptions in data lines for MCK sites indicate no results available for those periods. S = Spring.

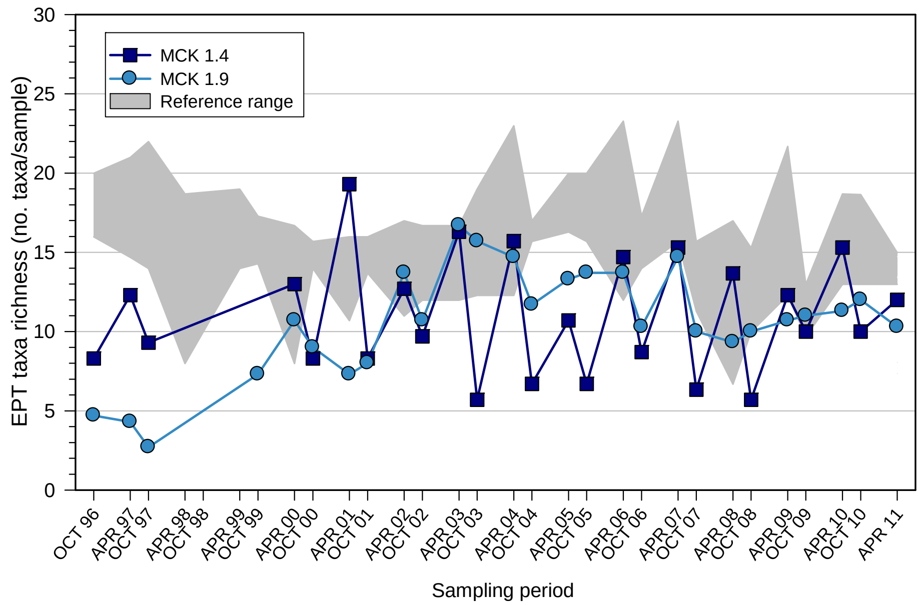


Figure 5.9. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in McCoy Branch, and range of mean values among reference streams (First Creek, Fifth Creek, Gum Hollow Branch, Mill Branch, Walker Branch, and White Oak Creek), 1996–2011.

EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, caddisflies, and stoneflies.

5.4.2 Performance Summary

The monitoring results since the remedial action indicate that the remedy is successfully lowering the concentration of contaminants of concern in surface water as it exits the wetland. Arsenic concentrations, however, generally exceed AWQC in both the upgradient and downgradient locations at the Filled Coal Ash Pond wetland, although concentrations have decreased since implementation of the remedial action. Arsenic levels in Rogers Quarry fish have been near background. However, selenium and mercury concentrations are substantially higher in fish relative to concentrations found in reference stream fish. Stream community measures show that McCoy Branch is improving but remains below the values observed in reference streams.

5.4.3 Facility Operations and Land Use Controls

5.4.3.1 Requirements

The requirements for Filled Coal Ash Pond are summarized in Table 5.2. The *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (DOE 1997) 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 Filled Coal Ash Pond 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-year, 24-hour intensity.

5.4.3.2 Status of Requirements

All components of the Filled Coal Ash Pond were inspected quarterly in FY 2011 by the Y-12 Surveillance and Maintenance 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. Minor maintenance included removing downed trees from the road, and removing vegetation covering signs above the spillway. A 25-year, 24-hr intensity rainfall event occurred on September 6, 2011 and inspections were performed at Y-12 sites. No erosion issues were identified.

5.4.4 Filled Coal Ash Pond Issues and Recommendations

There are no recommendations.

5.5 CHESTNUT RIDGE ISSUES AND RECOMMENDATIONS

The issues and recommendations for Chestnut Ridge are in Table 5.7.

Table 5.7. Chestnut Ridge issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
1. Gross beta detected in UNC SW-1 in fourth quarter sample.	1. Add ^{90}Sr to the analytical suite for that location. DOE will submit an Appendix I-12 letter for EPA/TDEC approval with changed pages from the UEFPC Monitoring Plan.	DOE EPA & TDEC	FY 2012/2013 when Appendix I-12 letter is concurred by EPA/TDEC
Issue Carried Forward			
None.			
Completed/Resolved Issues			
None.			

[a] A "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remediation Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remedial Effectiveness Report for Five Year Review so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

5.6 REFERENCES

DOE 1991a. *Record of Decision United Nuclear Corporation Disposal Site Declaration, Y-12 Plant, Oak Ridge, Tennessee*, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1991b. *Feasibility Study for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, ES/ER-15&D1, Y/ER/Sub-90/VK168/3&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1993. *Post-Construction Report for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1128&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1995. *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/02-1398&D2, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1996. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee*, DOE/OR/02-1410&D3, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 2007. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2010. *2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2437&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011. *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2505&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1997. *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*, DOE/OR/01-1596&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

TDEC 1996. *Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime, TNHW-088, 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.

TDEC 2006. *RCRA Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime, TNHW-128, 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.

6. CERCLA ACTIONS IN UPPER EAST FORK POPLAR CREEK WATERSHED

6.1 INTRODUCTION AND STATUS

6.1.1 Introduction

The Upper East Fork Poplar Creek (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 Figure 6.1 locates the key CERCLA sites and actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. Only sites that have long-term stewardship requirements (Table 6.1) are included in these performance evaluations. Remedial action objectives that form the basis for the interim remedial actions are based on the end uses depicted in Figure 6.2. These end uses require certain restrictions regarding site access and allowable activities as listed in Table 6.2.

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 2011f). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

6.1.2 Status

Watershed-Scale Actions

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) addresses mercury-contaminated soil, sediment, and groundwater discharges that are considered to be principal threat source material that contribute contamination to surface water.

Table 6.1. CERCLA actions in UEFPC Watershed

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations/ Land Use Controlss required	Section
Watershed-scale actions				
Phase I Interim Source Control Actions	ROD (DOE/OR/01-1951&D3): 05/02/02 NSC: 10/05/06 NSC: 05/17/07 Erratum to the 10/05/06 NSC: 06/09/08 NSC: submitted 09/30/09; pending approval	Actions complete		
		• PCCR for BSWTS for Building 9201-2 (DOE/OR/01-2218&D1) approved 07/01/05.	Yes/Yes/Yes	6.2.2
		Actions in progress		
		• RAWP WEMA remediation (DOE/OR/01-2447&D2) approved 8/26/10.	TBD[c]	--
		• UEFPC sediments (81-10 Area)		
		Actions not yet implemented		
		• UEFPC & Lake Reality sediment/soil removal.	TBD[c]	--
Phase II Interim Remedial Action for Contaminated Soils and Scrapyard	ROD (DOE/OR/01-2229&D3): 04/21/06	Actions in progress		
		• RDR/RAWP for Y-12 Salvage Yard – Scrap Removal (DOE/OR/01-2376&D2) approved 01/21/09.	TBD[c]	--
		• RAWP UEFPC soils remediation (DOE/OR/01-2423&D1 Attachment A.1) submitted 8/10/10.		
Single-project actions				
Y-12 East End VOC Plume	AM (DOE/OR/01-1819&D2): 06/25/99	RmAR (DOE/OR/01-2297&D1): 06/07/06	Yes/Yes/No	6.3.1
Union Valley	IROD (DOE/OR/02-1545&D2): 07/10/97	--[b]	No/No/Yes	6.3.2
Mercury Tanks (Tanks 2100-U, 2101-U, 2104-U)	IROD (DOE/OR/02-1164): 09/26/91	RAR (DOE/OR/01-1169&D1): 12/20/93	No/No/No	--
Plating Shop Container Areas	ROD (DOE/OR-1049&D3): 09/30/92	NFA	No/No/No	--
Abandoned Nitric Acid Pipeline (Upper East Fork Poplar Creek Operable Unit 2)	ROD (DOE/OR/02-1265&D2): 09/12/94	NFA	No/No/No	--
Building 9201-4 Exterior Process Piping	AM (DOE/OR/02-1571&D2): 04/22/97	RmAR (DOE/OR/02-1650&D1): 09/30/99	No/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/ Facility Operations/ Land Use Controlss required	Section
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): 02/24/99	No/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): 02/24/99	No/No/No	--
Demolition projects				
Y-12 Building D&D	Time critical AM (DOE/OR/01-2404&D1): 05/04/09 (Removal of legacy materials from Bldgs. 9201-5 and 9204-4) DOE/OR/01-2404&D1/A1): submitted 09/30/11	RmAR (DOE/OR/01-2519&D1): submitted 09/28/11	TBD[c]	--
	Time critical AM (DOE/OR/01-2405&D1): 05/04/09 (Demolition of Bldgs. 9735 and 9206)	RmAR (DOE/OR/01-2502&D1): submitted 08/11/11	No/No/No	--
	Time critical AM (DOE/OR/01-2406&D1): 05/04/09 [Demolition of Bldgs. 9211, 9220, 9224, and 9769 (Biology Complex)]	RmAR (DOE/OR/01-2508&D1): submitted 06/02/11	No/No/No	--
	AM (DOE/OR/01-2462&D2): 09/29/10 (Y-12 Facilities D&D)		TBD[c]	--

[a]Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* and is available at <**http://www.ucor.com/ettp_ffa_appendices.htm**>.
[b]This action was completed prior to uniform adherence to the Remedial Action Report process; hence, no Remedial Action Report exists for this decision.
[c]RmAR was not approved in FY 2011; therefore, long-term stewardship requirements are not identified.

AM = action memorandum
BSWTS = Big Spring Water Treatment System
EEVOC = East End Volatile Organic Compound
IROD = Interim Record of Decision
NFA = no further action
NSC = Non-Significant Change
PCCR = phased construction completion report
RAR = remedial action report
RAWP = remedial action work plan
RDR = remedial design report
RmAR = removal action report
ROD = record of decision
TBD = to be determined
UEFPC = Upper East Fork Poplar Creek
WEMA = West End Mercury Area

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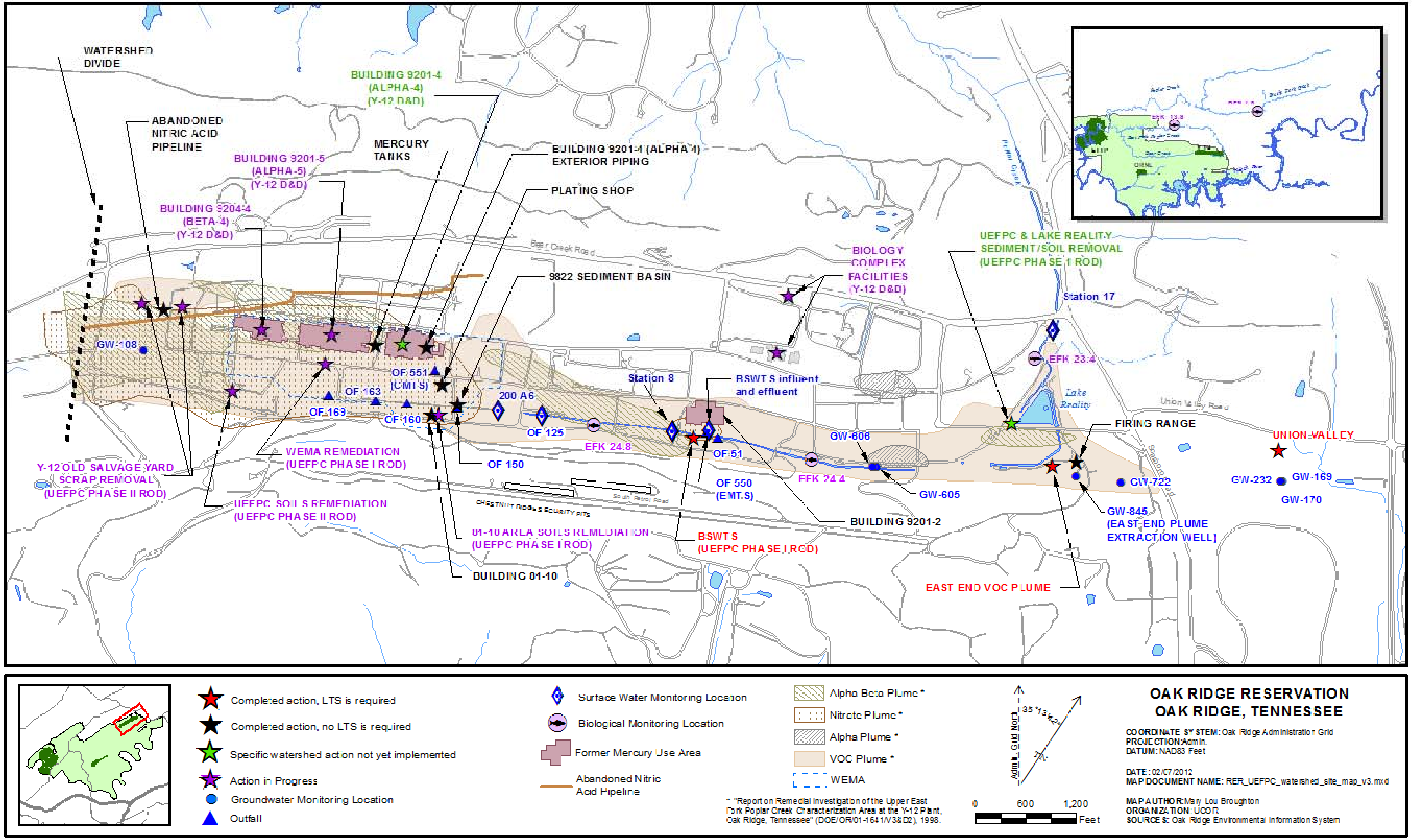

Figure 6.1. Upper East Fork Poplar Creek Watershed.

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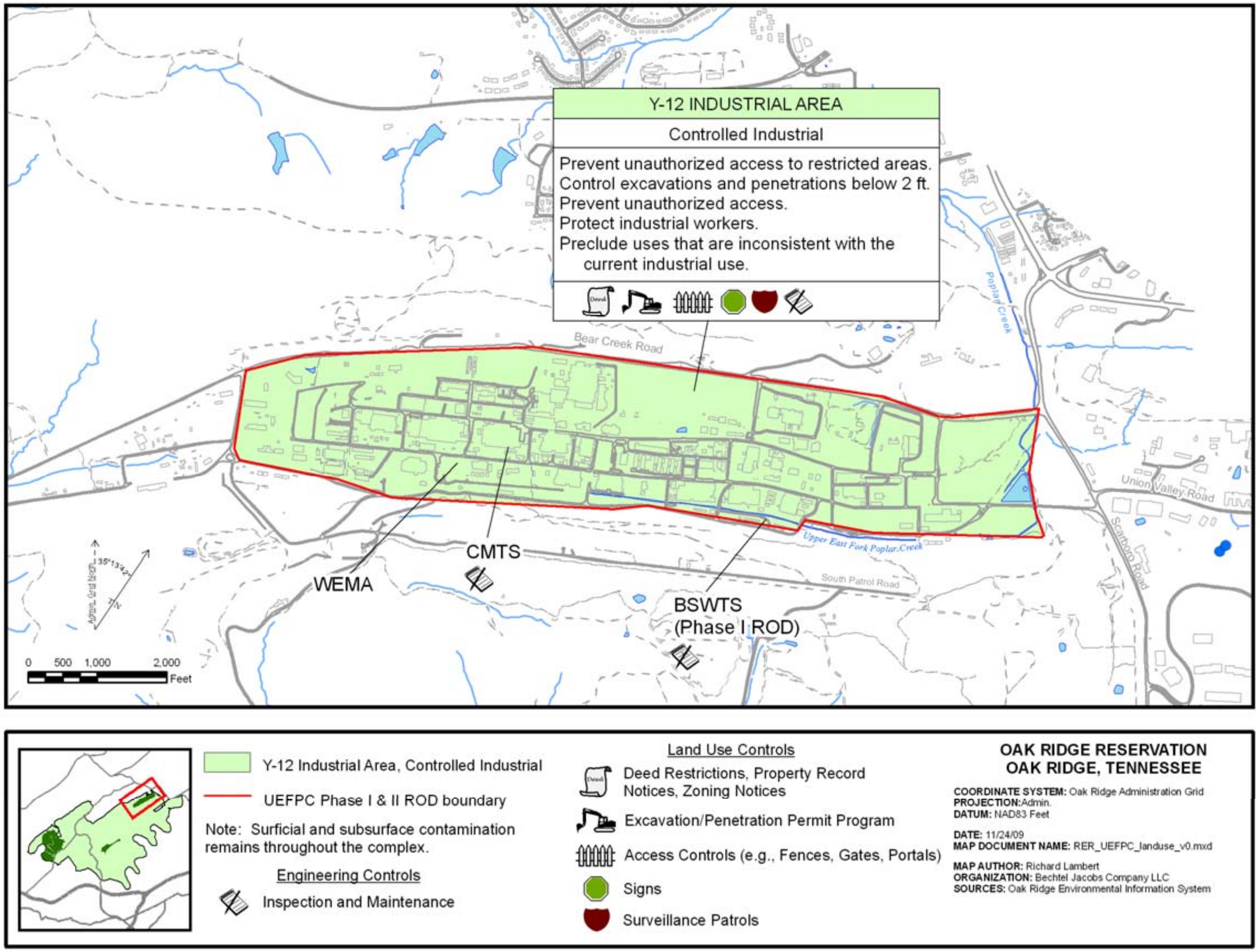

Figure 6.2. UEFPC Phase I and II Record of Decision-designated end use and interim controls.

Table 6.2. Facility operations and land use controls required in Upper East Fork Poplar Creek watershed

Site/Project	Requirements		Status	Section
	Land Use Controls	Engineering controls		
Watershed-scale actions				
ROD for Phase I Interim Source Control Actions in the UEFPC Watershed[a] ▪ BSWTS PCCR	Watershed Land Use Controls Administrative: ▪ land use and groundwater deed restrictions ▪ property record notices ▪ zoning notices ▪ permits program Physical: ▪ access controls ▪ signs ▪ security patrols	▪ Operations and maintenance of treatment facilities	▪ Physical Land Use Controls in place. ▪ Administrative Land Use Controls required at completion of actions. ▪ Engineering controls remain protective.	6.2.4
UEFPC Union Valley Interim Action	Institutional controls related to groundwater use. ▪ License agreements ▪ Annual property owner notification ▪ Annual title searches ▪ Annual water use surveys ▪ Annual notification to well drillers		▪ Land Use Controls in place.	6.3.2.2

[a]Remaining actions have not been implemented (e.g., West End Mercury Area).
BSWTS = Big Spring Water Treatment System
ROD = record of decision
UEFPC = Upper East Fork Poplar Creek

Clean up and repair of storm sewers in the West End Mercury Area was initiated in FY 2009. The initial phase included the videotaping of more than 20,000 linear feet of storm sewer to determine the condition of the sewers. The *Engineering Study Report for the West End Mercury Area (WEMA) Storm Sewer Remediation Project* (DOE 2009b) documents the results of this initial phase and was used to prepare the *Remedial Design Report/Remedial Action Work Plan for the West End Mercury Area (WEMA) Storm Sewer Remediation Project* (DOE 2010b) for remediation of the storm sewers. During FY 2011, more than 8000 linear feet of storm sewer were cleaned, and approximately 1200 linear feet were lined.

A *Characterization Plan for the 81-10 Area* (DOE 2009c), the site of a historic mercury recovery process, establishes procedures for the characterization of mercury contamination in soils in the 81-10 area. The characterization activity was conducted in FY 2010 to determine the nature and extent of mercury contamination in soils and to determine if this contamination is a source to UEFPC. The results were reported in the *Upper East Fork Poplar Creek Soils 81-10 Area Characterization* Report (DOE 2011a) and indicate that this contamination is not impacting UEFPC.

- The initial project of the *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek* (DOE 2006a) is removal of scrap from the

Y-12 Old Salvage Yard. Cleanup of the 7-acre Y-12 Old Salvage Yard was initiated in May 2009 (DOE 2008; DOE 2009d). Removal of all scrap was completed in FY 2011, and the *Phased Construct*ion *Completion Report for Scrap Metal Removal* was submitted on April 11, 2011 (DOE 2011b). Soil characterization in the scrapyard was initiated in FY 2011, and soil contributing to future groundwater contamination with volatile organic compounds was completed. Characterization and disposal of staged soil is scheduled for completion in FY 2012. The *Upper East Fork Poplar Creek Soils Remedial Action Work Plan* (DOE 2009a) was approved with an *Addendum* (DOE 2010a) containing a Dynamic Work Plan. This *Remedial Action Work Plan*:

- includes all remediation projects identified in the *Record of Decision for Phase I Interim Source Control* Actions and *Record of Decision for Phase II Interim Remedial Actions.*
- describes a strategy for sequencing and performing these remediation activities.

- integrates priorities for current planned soils remediation with the proposed Integrated Facilities Disposition Program remediation activities.

Upper East Fork Poplar Creek Demolition Projects

- The Removal Action Work Plan for the Y-12 Facilities Deactivation/Demolition Project (DOE 2010c) was approved by the regulators and describes a process to streamline the deactivation process. This plan addresses the demolition of all non-time critical removal action facilities at Y-12, totaling more than 100 buildings and facilities. Additional CERCLA documentation will be required for individual subproject activities.

- The removal of legacy material from the Alpha 5 (Building 9201-5) and Beta 4 (Building 9204-4) buildings under the time-critical Action Memorandum for the Removal of Legacy Materials from Building 9201-5 and 9204-4 (DOE 2009e) was completed in FY 2011, and the Removal Action Report (DOE 2011c) was submitted on September 28, 2011.

- Demolition of Building 9735 and a portion of Building 9206 performed under the time-critical Action Memorandum for the Demolition of Buildings 9735 and 9206 (DOE 2009f) was completed in FY 2011, and the Removal Action Report (DOE 2011d) was submitted on August 11, 2011.

- The Beta 3 (9204-3) Legacy Material Disposition project completed the refurbishment of the Actinide Lab area glove boxes and associated ventilation systems to maintain containment capability, completed glove box post refurbishment maintenance evaluation, completed glove box debris characterization, and removed and disposed of debris.

- Demolition of four of the seven Biology Complex Buildings performed under the time-critical Action Memorandum for the Demolition of Buildings 9211, 9220, 9224, and 9769 (Biology Complex) (DOE 2009g) was completed in FY 2011 and documented in the Removal Action Report (DOE 2011e).

6.2 PHASE 1 INTERIM SOURCE CONTROL ACTIONS IN THE UPPER EAST FORK POPLAR CREEK CHARACTERIZATION AREA

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) addresses principal threat source material source control remedies designed to reduce mercury loading within UEFPC. The remedial action objective for the selected remedy is to restore surface water to human health recreational risk-based values at Station 17 (DOE 2002). Principal components of the decision include:

- hydraulic isolation (e.g., capping contaminated soils) of the West End Mercury Area;
- 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;
- Land use controls 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 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 System to the Big Spring Water Treatment System in December 2006. The East End Mercury Treatment System and Outfall 550 are no longer in operation.

6.2.1 Performance Goals and Monitoring Requirements

Performance measures and monitoring requirements are summarized in Table 6.3, and monitoring locations are shown in Figure 6.1.

Table 6.3. Performance measures for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Watershed

Site	Record of Decision goal	Performance standard	Monitoring location	Schedule and parameters
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 U or Zn 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.
Central Mercury Treatment System	Ongoing treatment of effluents from West End Mercury Area 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 Bldg. 9201-2 sumps was tied-in to BSWTS December 2006	200 ppt mercury	Outfall 550 flow piped to the BSWTS in December 2006	Discontinued.
West End Mercury Area	Protect recreational surface water users	Reduction by ~50% of mercury flux in West End Mercury Area outfalls. Reduction will be monitored in outfalls and is anticipated within one year of remediation.[a]	Outfalls 150, 160, 163, and 169	Continuous flow-paced monitoring for mercury (minimum weekly collection frequency) prior to remediation.
Upper East Fork Poplar Creek 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.

[a]Baseline monitoring re-instated FY 2010.

BSWTS = Big Springs Water Treatment System
UEFPC = Upper East Fork Poplar Creek
VOCs = volatile organic compounds
WTS = Water Treatment System

6.2.2 Evaluation of Performance Monitoring Data

6.2.2.1 Surface Water

6.2.2.1.1 Surface Water Quality Metrics and Monitoring Requirements

Surface water quality metrics utilized to evaluate progress toward attainment of the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) goals are summarized in Table 6.3, and monitoring locations are shown in Figure 6.1.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) includes a 200 ppt performance metric for mercury in surface water at the UEFPC integration point (Station 17) based on an adult recreator consuming 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 kilometer 23.4. To achieve the watershed-wide mercury reduction objectives, individual components of the Phase I remedy have action-specific performance standards. The Big Springs Water Treatment System and Central Mercury Treatment System effluent must meet the 0.2 µg/L (200 ppt) interim performance goal for mercury.

6.2.2.1.2 Surface Water Monitoring Results

Continued monitoring of effluent from the Central Mercury Treatment System (Outfall 551), which treats building sump discharges from the West End Mercury Area, is specified in the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) pending demonstration of the effectiveness of actions (e.g., hydraulic controls, storm sewer relining/replacement).

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) states that the mercury limit for the Central Mercury Treatment System is 200 ppt. The Central Mercury Treatment System effluent discharges through Outfall 551. Effluent samples were collected from weekly composites at Outfall 551 and analyzed for mercury. The total volume of water treated in FY 2011 was 2,587,015 gallons, which is more than was treated in FY 2009 or FY 2010. During FY 2011, approximately two thirds of effluent samples exceeded the 200 ppt goal. However, because the flow volume is small, the total mercury discharge was less than 2 grams. Due to 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 2007b) was approved in May 2007 so that the Central Mercury Treatment System no longer receives water from sump pumps located in the basement of Building 9201-5. The Central Mercury Treatment System continues treatment of Building 9201-4 sump water (a much larger source of mercury). The Central Mercury Treatment System experienced no downtime during FY 2011. Once the brine system has been rerouted, the collection of 9205-1 sump pump water will be re-evaluated.

Extensive mercury contamination exists in the West End Mercury Area 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 storm drains through cracks and open joints. Once in the storm drains, the mercury accumulates in low points moves with the current of storm water. Twelve (12) pounds of metallic mercury were recovered from Manhole D3-330, west of 9805-1, in six events in FY 2011.

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 West End Mercury Area. 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 Big Spring Water Treatment System 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 Big Spring Water Treatment System would cut off flow to Outfall 51, during Big Spring Water Treatment System construction it was discovered that, in addition to flow from the spring box, Outfall 51 also provides a conduit for drainage of the Big Spring Water Treatment System area shallow subsurface flow.

The Big Spring Water Treatment System has been fully operational since September 26, 2005. Similar to FY 2010, during FY 2011 the Oak Ridge area experienced slightly above average rainfall which was responsible for increased flow into the Big Spring Water Treatment System groundwater collection system. The amount of inflow exceeded the system design treatment capacity which necessitated allowing bypass flows to occur during significant time periods during the wetter than average months.

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) specifies a 0.2 µg/L (200 ppt) goal for mercury in Big Spring Water Treatment System effluent. Outfall 51 and Big Spring Water Treatment System effluent are separate monitoring locations. Figure 6.3 provides a comparison of mercury concentrations at Outfall 51 and the Big Spring Water Treatment System effluent.

An issue was identified in 2010 to better identify the mass of Hg flux from Outfall 51 when the Big Spring Water Treatment System is bypassed. During FY 2011, a flow measuring device was installed at Outfall 51 to measure wet season flows discharging from the outfall. Baseflow from Outfall 51 ranged from about 50 gpm to about 80 gpm during February prior to Big Spring Water Treatment System bypass flow. When bypass flow started on February 28, Outfall 51 flow rates increased and remained high through the duration of treatment system bypass that ended in mid-May. During the bypass period, Outfall 51 baseflow discharges ranged from about 105 – 110 gpm to 135 – 140 gpm. The total estimated mercury discharge from Outfall 51 during FY 2011 is estimated to be less than 0.5 kg. Outfall 51 mercury discharge summary data is included in Table 6.4 along with other UEFPC watershed mercury discharge data.

The average mercury concentration from Outfall 51 was 1.7 µg/L during FY 2011, which is slightly greater than the values measured during FY 2007 and FY 2008.

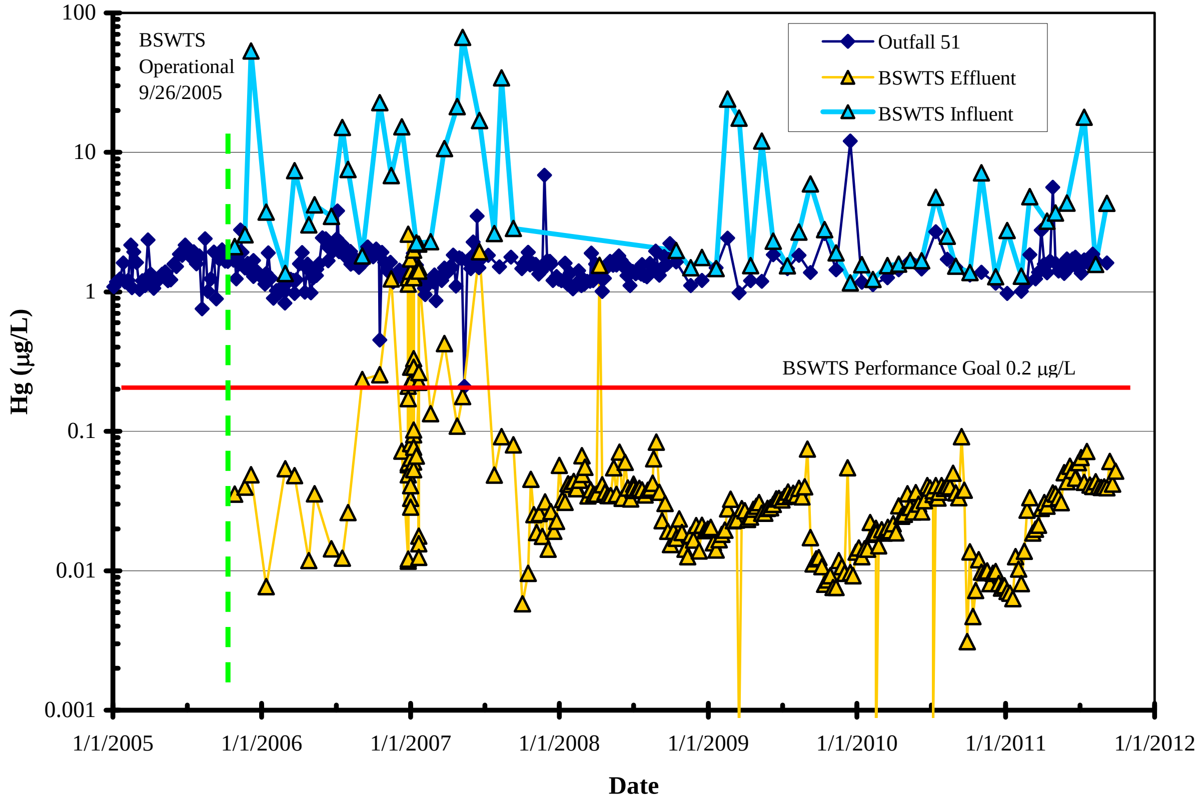

Figure 6.3. Mercury concentrations at Outfall 51 and Big Spring Water Treatment System (BSWTS).

Table 6.4. Summary statistics for daily mercury discharge from monitored locations in UEFPC watershed

Outfall	Median[1]	Mean[1]	Max[1]	Hg flux[2]
OF150	0.96	8.5	224	3,210
OF160	0.33	1.6	64	495
OF163[3]	27[3]	174[3]	4,966[3]	64,266[3]
OF169	1.8	13.1	782	4,992
Sum of WEMA Outfalls				72,962
200A6	13.8	32.1	587	11,636
Station 8[4]	6.8	27.7	826	10,087
OF51	0.66	0.86	4.2	< 500
BSWTS	0.036	0.034	0.09	12.4
Station 17 NPDES	11.5	33.4	569	12,189
Station 17 EM[5]	23	61	1,848	24,008

[1] Values are grams/day.

[2]Hg flux is total grams for FY2011.

[3] Flow volumes at OF163 were biased high due to sediment buildup near the monitor. Flux values are biased high.

[4]Station 8 data based on weekly grab samples. All others based on continuous flow-paced composite samples.

[5]EM operates continuous flow-paced sampling at a mid-channel location at Station 17.

During FY 2012, a continuous flow and sampling system was installed on the Big Spring Water Treatment System bypass discharge pipe. The amount of mercury discharge during bypass flows will be determined to quantify the contribution to total UEFPC mercury discharges. With the installation of the additional measuring devices an issue identified to better quantify water volume and total mercury discharges from the 2011 Remediation Effectiveness Report is closed out, Table 6.10.

The average Big Spring Water Treatment System influent concentration was about 4.5 μg/L which was more than twice the level of FY 2010. In FY 2011, the Big Spring Water Treatment System treated approximately 112 million gal of contaminated water, which was about 7 million gal more than was treated during FY 2010. Since July 2008, the Big Spring Water Treatment System effluent is sampled continuously and weekly composite samples are analyzed for total mercury. The average mercury concentration in Big Spring Water Treatment System effluent during FY 2011 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 2002). None of the weekly composite samples exceeded the 0.2 μg/L effluent goal during FY 2011. The FY 2011 total mercury flux discharged in the treated Big Spring Water Treatment System effluent was approximately 12.4 grams. BSWTS mercury discharge summary data is included in Table 6.4 along with other UEFPC watershed mercury discharge data. Based on comparison of the average influent and effluent mercury concentrations for FY 2011, the treatment effectiveness was greater than 98%.

West End Mercury Area Mercury Discharges (OF150, OF160, OF163, OF169 and OF200A6)

In accordance with the Phase I UEFPC ROD and an agreement with the UEFPC CERCLA Core Team, the monitoring of discharges from outfalls OF150, OF160, OF163, and OF169 was temporarily suspended between the end of FY 2006 and the first quarter of FY 2010. During that time period, continuous monitoring was conducted at OF200A6 which is the integration point for all storm water discharges from the West End Mercury Area. Since January 2010, flow-paced continuous sampling has been operated at five locations related to the West End Mercury Area. In early January 2010, flow-paced continuous sampling devices became operational at Outfalls OF150, OF160, OF163, and OF169. These outfalls carry the principal West End Mercury Area drainages into the main storm drain 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 storm drain that carries discharge from the West End Mercury Area to the headwater of the UEFPC and the other outfalls are located to the west and upstream in the storm drain network (Figure 6.1). Outfall 200A6 serves as an integration point for contamination leaving the West End Mercury Area.

During FY 2011, a major storm drain sediment removal and drain pipe repair project was conducted to remove accumulated sediment and repair deteriorated pipe sections in portions of the West End Mercury Area. The project field work occurred between late February and the end of September 2011. Coincident with work in the storm drains there were increases in mercury concentration and flux at the West End Mercury Area manholes, at Outfall 200A6, and at Station 17.

Table 6.4 includes summary statistical data for the amount of mercury measured at the four West End Mercury Area manholes, Station 200A6, 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 2011. The episodic discharges of high levels of mercury are apparent when median, mean, and maximum daily mercury loadings are compared. Inspection of the total mercury flux column shows that it is not possible to establish a reasonable mass balance of mercury discharge during FY 2011. This is attributed to a strong particle association of mercury. Much of the mercury is transported as mercury contaminated sediment, either in suspension or as a mobile bed load that is most mobile during storm events. Position of the composite sampler intake tube is an important variable that influences the likelihood of pulling bed load sediment into the sampler. In the West End Mercury Area manholes the sample tube intakes are mounted on the lower sidewall of the concrete culverts. The OF200A6 culvert is 9-feet in diameter and the sampler tube is positioned about 1 foot off bottom of the culvert to prevent it from becoming buried in sediment. The other West End Mercury Area manholes are on smaller diameter pipes and the sample tube intake is closer to the very bottom of the pipe where they apparently do gather more of the heavier sediment fraction. During FY 2011, a sediment accumulation in the storm drain culvert near the OF163 flow monitor and sampling devices caused a positive bias in the flow volume. This has caused a positive bias in the estimated mercury flux calculated for OF163. At Station 17, the sample tube intakes are suspended off the bottom of the stream channel. Two very similar sampling systems are in place at Station 17 with different sample intake locations separated by less than 10 meters. Data in Table 6.4 for Station 17 show the variability in monitoring results based on sample collection position instream. Differences in the summary mercury fluxes measured by the two samplers are attributed to greater suspended sediment capture at the mid-stream location compared to the downstream location.

During FY 2011, the total mercury discharge estimated from Outfalls 150, 160, 163, and 169 combined was approximately 73 kg. Figure 6.4 shows the proportional contributions of mercury discharge from each of the West End Mercury Area storm drain branches in FY 2011. During the nine months of FY 2010 that the monitoring systems operated (January – September), the combined mercury discharge of the four outfalls was approximately 2.4 kg. The ranking of the four outfalls remained the same in FY 2011 as it was in FY2010 and during FY 2011 OF163 is estimated to have contributed 88% of the mercury while OF169, OF 150, and OF160 contributed 7%, 4%, and 1% respectively.

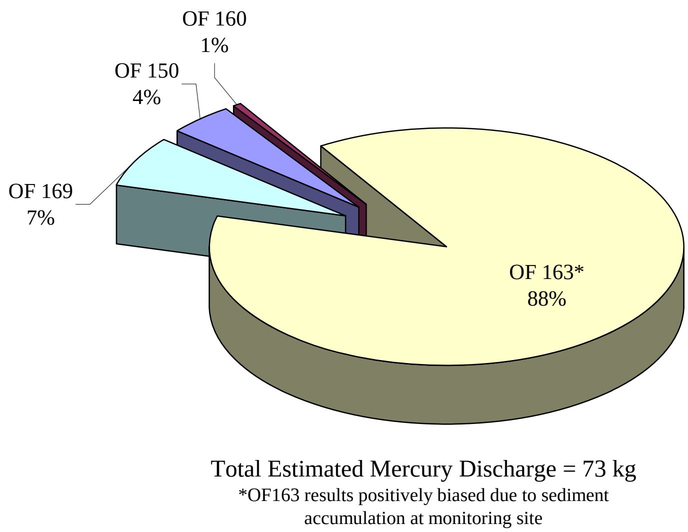

Figure 6.4. West End Mercury Area storm drain percentage contributions to the total measured FY 2011 mercury discharge.

Figure 6.5 shows semi-log graphs of the weekly mercury flux, total flow, and total suspended solids for the four West End Mercury Area storm drain manholes. Weeks during which active storm drain cleanout was being conducted in each of the storm drain watersheds are indicated by red symbols for the mercury flux value. Large increases in mercury flux were measured in each of the manholes during time periods when sediment cleanout was under way. Although all the storm drain systems experience elevated total suspended solids during storm events, total suspended solids levels increased during periods of active work in the storm drains and much of the mercury discharge is contaminated sediment. The relationship between total suspended solids and mercury flux indicate periods when the suspended solids apparently contain greater and lesser amounts of mercury. For example, at OF169 several prominent total suspended solids peaks between September 2010 and January 2011 had relatively small affects on the measured mercury flux while the peaks that occurred after March during storm drain cleanout activities accompanied 10- to 15-fold increases in the mercury flux. Pre-cleanout total suspended solids peaks at OF150, 160, and 163 do coincide with somewhat larger mercury flux increases indicative that the mobile sediment in those areas prior to cleanout activities was more contaminated than that which was passing through OF169. At the end of September 2011, the weekly mercury fluxes remained elevated compared to levels measured prior to the storm drain work at Outfalls 150 and 163. Levels at OF 160 were near the pre-construction conditions and at OF169 levels were still highly variable because some cleanout activity occurred in September in that area.

The affects of the storm drain cleanout work was also very apparent at OF200A6 and at Station 17. Figure 6.6 shows semi-log graphs of the weekly mercury flux, total flow, and total suspended solids measured at OF200A6 and Station 17. Like the graphs for the West End Mercury Area manholes, the flux values measured during storm drain cleanout activity are plotted as red symbols. The mercury flux behavior was very similar to the conditions in the West End Mercury Area although peak flux levels tended to be lower downstream. This is thought to be because of differences in sediment uptake in samplers as discussed previously.

Station 8

Surface water monitoring at Station 8 is conducted to measure mercury concentrations and estimate mercury flux in the reach upstream to Outfall 200A6, and downstream to Station 17. Sampling consists of weekly grab sampling for mercury with a simultaneous instantaneous flow measurement. During FY 2011, the measured mercury concentrations at Station 8 ranged from 229 to 9,473 ng/L and averaged 1,100 ng/L. The daily mercury flux in UEFPC at Station 8 based on the grab samples and instantaneous flow measurements ranged from about 2.5 g/d to about 825 g/d and averaged about 28 g/d. Based on the weekly grab samples and average daily flux, the annual flux estimate for mercury at Station 8 is approximately 10.1 kg. This estimate is lower than the Outfall 200A6 flux of about 11.6 kg shown in Table 6.4. The reason for this difference is that the once per week grab sampling provides relatively infrequent sampling coverage compared to the continuous flow-paced sampling that is conducted at Outfall 200A6. The daily flux calculated from the Station 8 sampling was compared with the calculated flux for the same dates at Outfall 200A6. That comparison showed that the general fluctuations observed at both stations were similar until West End Mercury Area storm drain sediment removal started at the end of February. During the storm drain work the daily loadings at OF200A6 remained much higher than at Station 8.

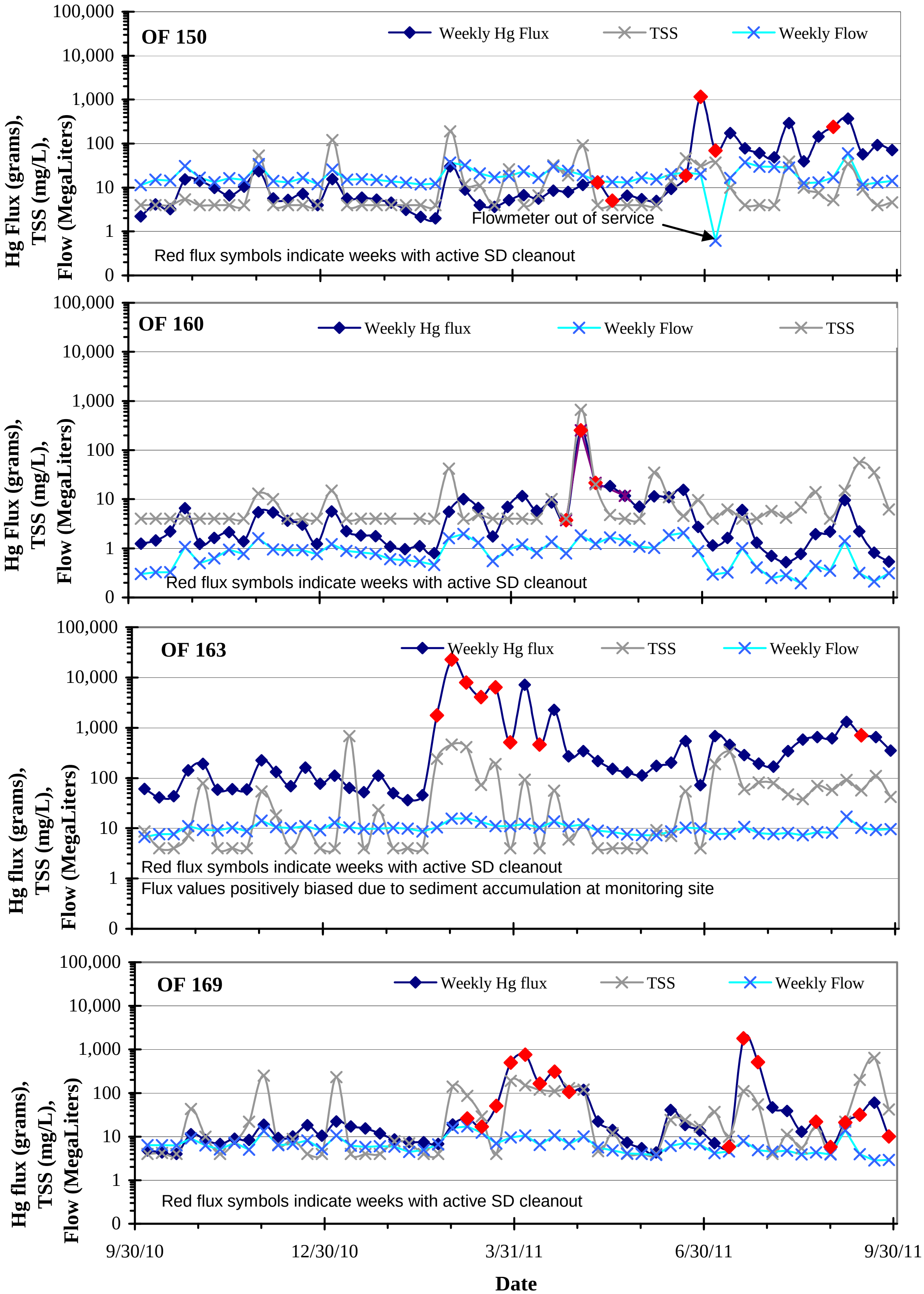

Figure 6.5. West End Mercury Area manhole weekly mercury flux, flow, and total suspended solids (TSS).

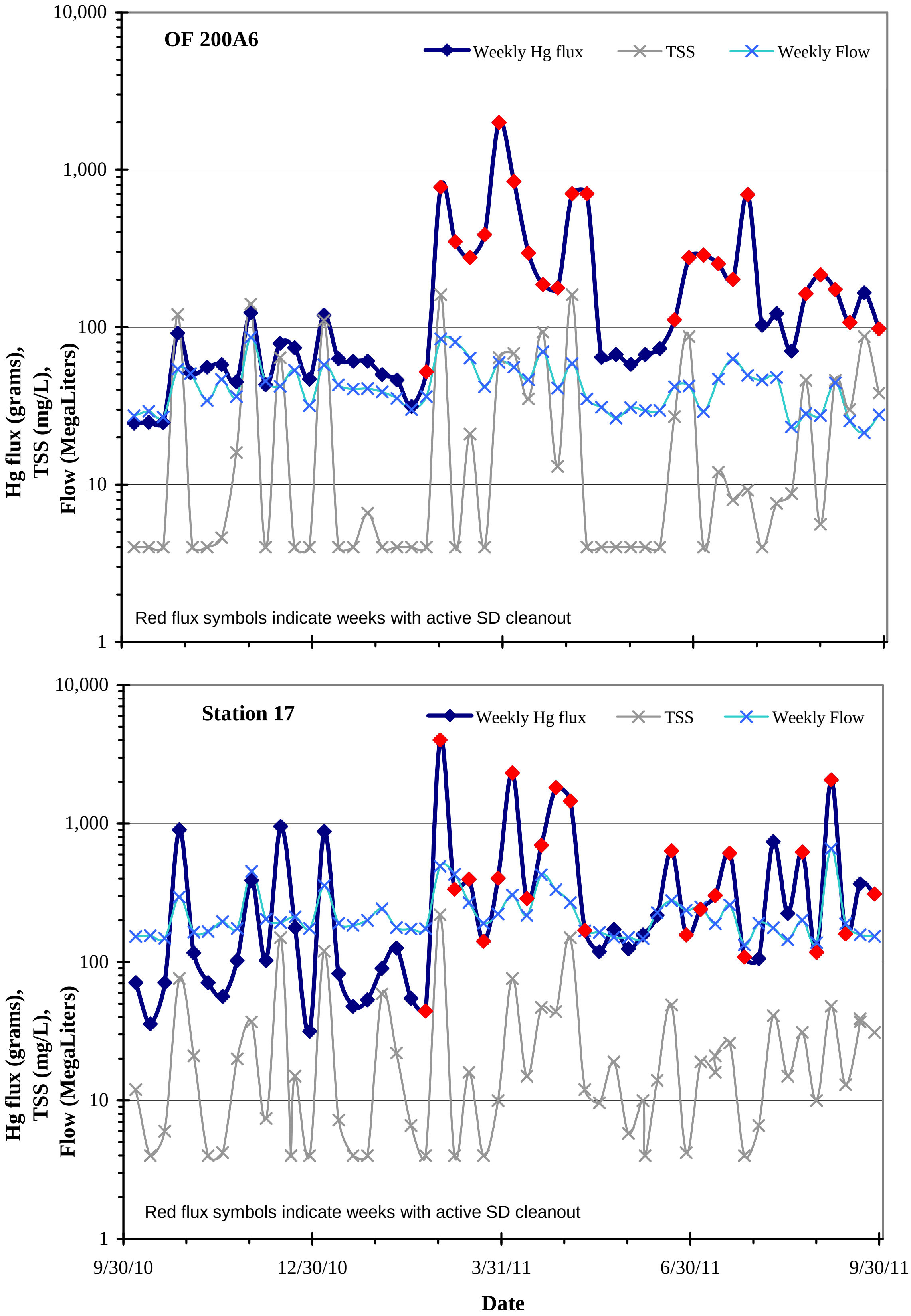

Figure 6.6. OF200A6 and Station 17 weekly mercury flux, flow, and total suspended solids.

Integration Point Monitoring Results at Station 17

Station 17 is the integration point where the stream leaves Y-12 and Department of Energy 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 6.7 includes the Station 17 measured flows, calculated daily mercury fluxes for the National Pollutant Discharge Elimination System sampler and the Environmental Management sampler, comparative mercury concentrations for the two samplers, and the daily rainfall. The apparent role of West End Mercury Area storm drain work was summarized in the preceding section.

Locations of mercury source areas are shown on Figure 6.1. As shown in Table 6.4, the FY 2011 mercury discharge measured at Station 17 based on flow-paced continuous sampling data collected by the National Pollutant Discharge Elimination System monitoring program was about 12.2 kg. In previous years, flux mass balance suggested ungauged contributors from groundwater and storm drain discharges downstream of Outfall 200A6. However, because of the wide disparities in calculated fluxes attributed to sediment discharges related to the West End Mercury Area storm drain cleaning project, flux balancing within the watershed is not feasible for FY 2011.

Annual fluxes and average concentrations of uranium and mercury at Station 17 from FY 2000 through FY 2011 are in Table 6.5. Figure 6.8 is a graph of annual mercury and uranium fluxes at Station 17.

The daily mercury flux measured at Station 17 from FY 2000 through FY 2011 has been examined to determine the differences between the years pre- and post- startup of the Big Spring Water Treatment System and to show the changed conditions during FY 2011. All the calculated daily mercury flux results were ranked and cumulative distribution functions were created. Figure 6.9 shows the results of this data evaluation. The average and standard deviation of ranked daily flux for the pre- and post- Big Spring Water Treatment System time periods are shown along with the FY 2011. The median daily mercury flux at Station 17 from FY 2000 through FY 2005 was 11.5 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 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.

Station 17 Mercury Discharge Data FY 2011

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Hg Flux (grams)	599	326	288	581	1,020	2,691	2,296	419	1,419	1,265	718	566	12,189

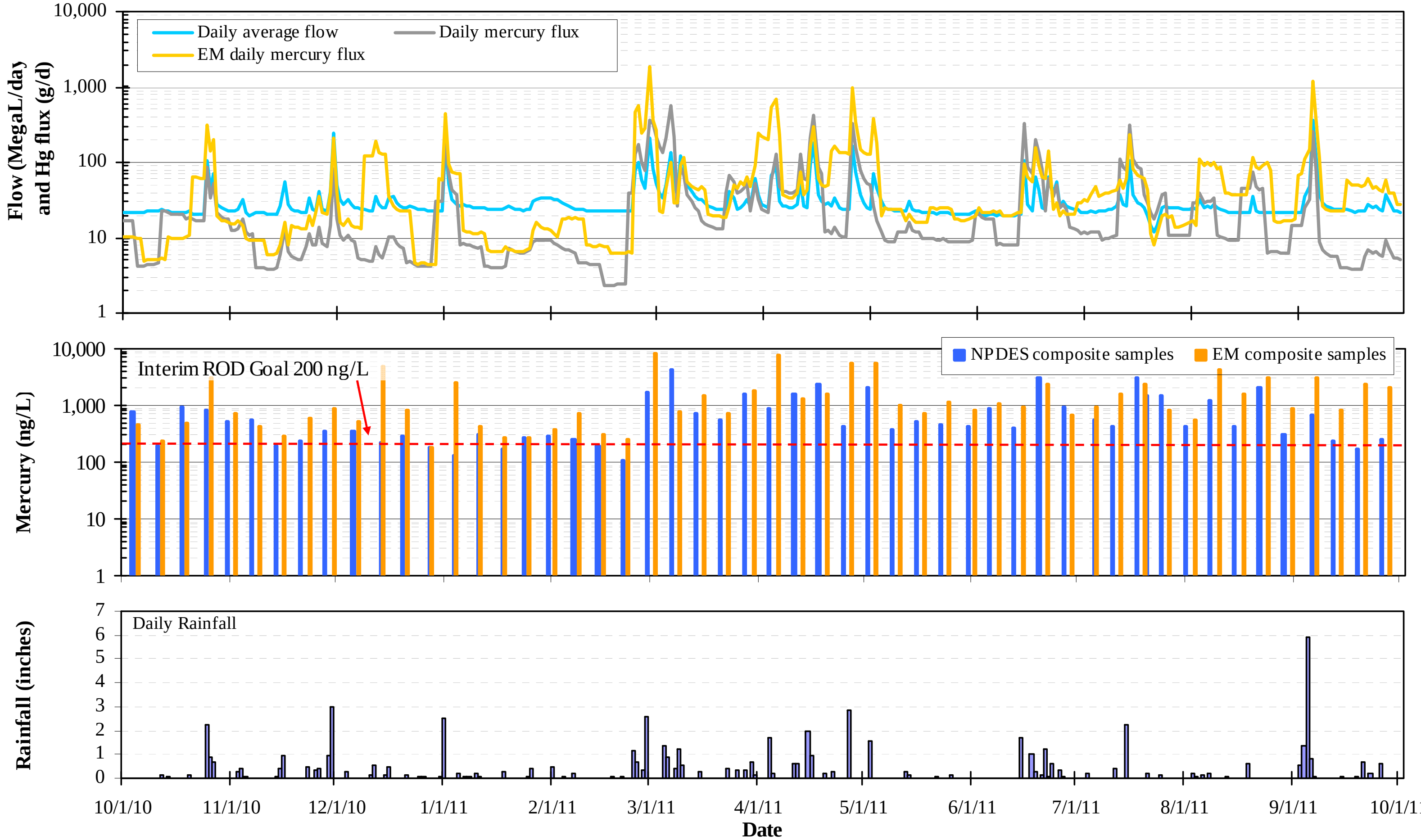

Figure 6.7. Summary of FY 2011 mercury discharge data for Station 17.

NPDES = national pollutant discharge elimination system
EM = environmental management

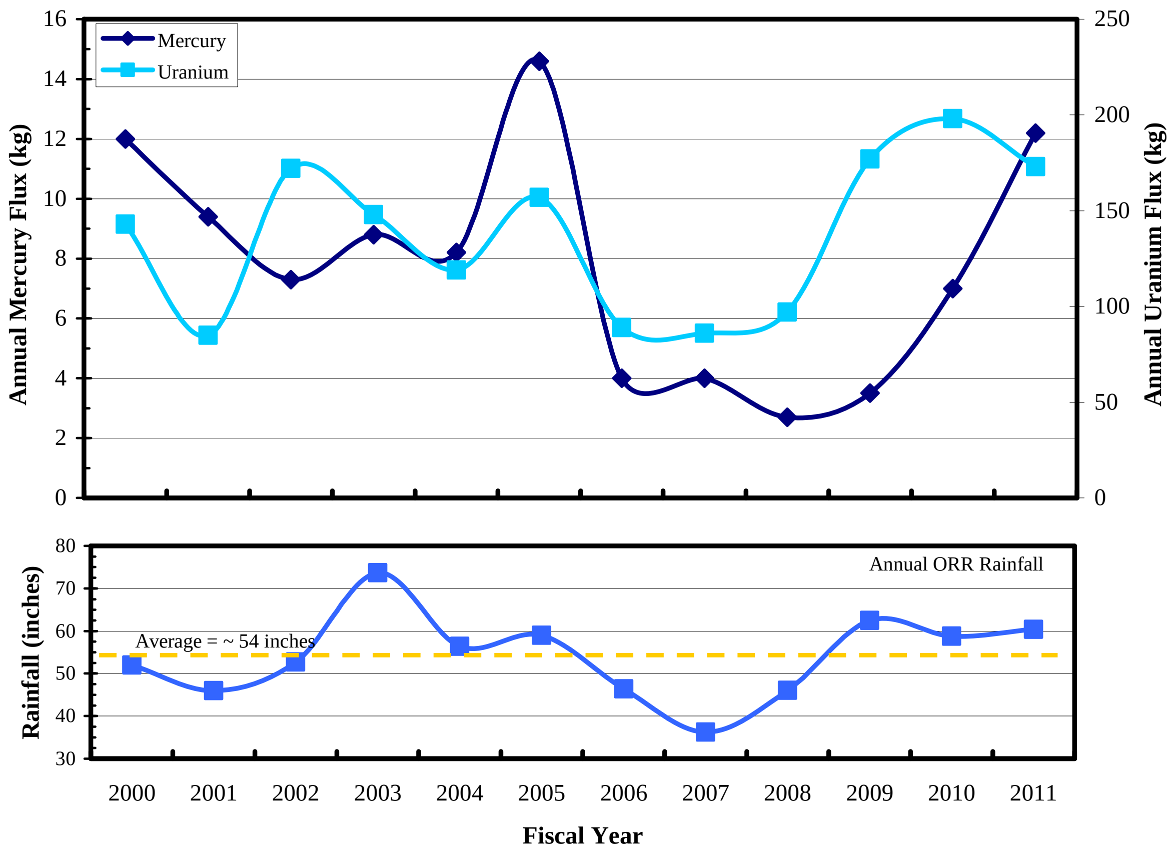

Figure 6.8. Annual mercury and uranium fluxes at Station 17 and annual rainfall.

ORR = Oak Ridge Reservation

Table 6.5. Annual uranium and mercury fluxes[a] and average concentrations at Station 17

Date	Hg flux (kg)	Avg Hg (µg/L)[b, c]	U flux (kg)	Avg U (mg/L)	Annual rainfall (in)[d]
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	**0.817**	173	0.013	60.4

[a]Record of Decision flux goals for Uranium and mercury at Station 17 do not exist.
[b]**Bold** values exceed *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) mercury concentration goal of 200 ppt (0.2 µg/L) for Station 17.
[c]Reported average is for 7-day continuous flow-paced samples.
[d]Average annual rainfall = 54 in.
Avg = average

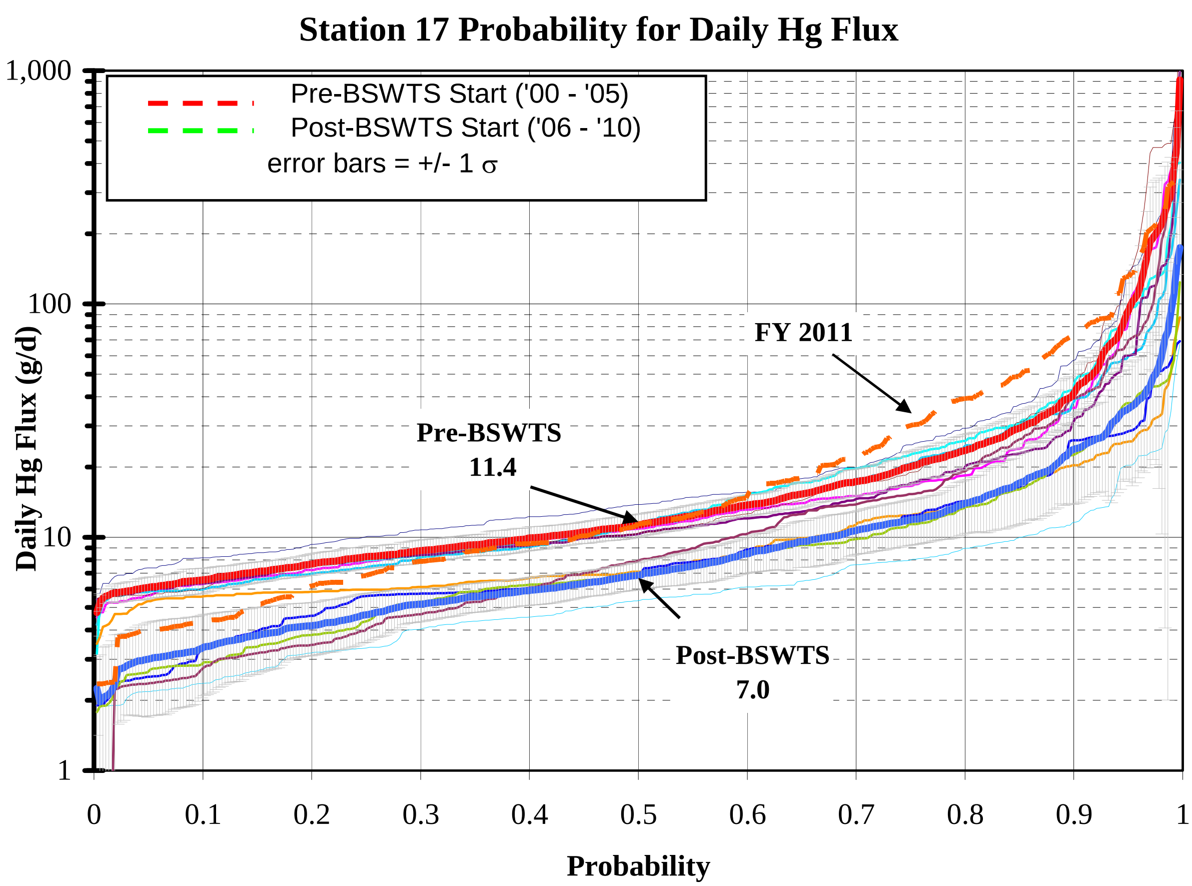

Figure 6.9. Pre- and post-Big Spring Water Treatment System (BSWTS) startup mercury daily flux at Station 17.

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 6.1. 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 West End Mercury Area is a source of uranium flux at Outfall 200A6. Another significant source of uranium that may enter UEFPC is the former Oil Skimmer Basin located adjacent to the original UEFPC channel in the eastern end of the plant area. As shown in Table 6.5 and Figure 6.8, the uranium flux and average concentrations measured at Station 17 during FY 2011 remained elevated compared to the drought years. 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 was about 13 µg/L, although four samples (one in January, two in March, and one in April) were greater than the 30 µg/L maximum contaminant level. The maximum detected uranium concentration was 41.7 µg/L.

Zinc was analyzed in weekly grab samples collected at Station 17 during FY 2011 for comparison to the AWQC (120 µg/L). The maximum detected zinc concentration during FY 2011 was 66 µg/L and none of the zinc samples exceeded the AWQC.

6.2.2.2 Aquatic Biological Monitoring

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.* 2011a). For the last ten years, the bioaccumulation studies have been augmented by twice yearly monitoring of aqueous mercury concentrations and speciation at sites throughout the length of UEFPC.

Average aqueous mercury concentrations at Station 17 (Figure 6.1) have increased significantly over the past two years and were in excess of 600 ng/L in 2011, comparable to concentrations seen at this site in the late 1990s and exceeding the 200 ng/L goal (Figure 6.10). Concentrations had previously decreased to ~300 ng/L after installation of the Big Springs Water Treatment System in 2006. As discussed in the previous sections, the recent increases in mercury water concentrations is thought to be related to West End Mercury Area storm drain clean-out activities.

Despite the substantial increase in aqueous mercury concentrations, mercury concentrations in fish fillets and whole body composites did not increase accordingly, but remained comparable to concentrations seen in recent years. Although the recent values were within the normal range at this site, there was an increase in mercury concentrations in fish between the fall of 2010 and spring 2011, more consistent with previous water increases. Because mercury accumulates primarily through food chain rather than aqueous exposure, there may be a time lag before the increases in aqueous mercury are fully propagated into fish tissues.

Whole body composites of stoneroller minnows collected at East Fork kilometer 24.5 (Figure 6.1) averaged 1.03 ± 0.18 µg/g in 2011, comparable to concentrations seen in these fish in 2010. Although the target species for mercury monitoring in fish fillets in East Fork Poplar Creek is redbreast sunfish (shown in red in Fig. 6.10), this species has become increasingly difficult to collect throughout the creek, and where redbreast are not encountered, rockbass (shown in green in Figure 6.10) are collected in their place. Previous studies have shown that rockbass have at least 15-20% higher Hg levels than redbreast sampled concurrently from the same site, most likely because their diet includes higher trophic level organisms with greater mercury content. For the FY 2011 period, the mean mercury concentrations in rockbass from EFK 23.4 in December 2010 was 0.68 + 0.06 µg/g (SE), with a range of 0. 37 – 0.81 µg/g mercury. In spring 2011, the mean +/- SE was 0.90 +/- 0.06 µg/g with a range of 0. 71 - 1.11 µg/g. For the first time since 2003, three redbreast sunfish were collected from East Fork kilometer 23.4 in spring 2011. The average mercury concentration in fillets of these three fish was 0.51 ± 0.07 µg/g, lower, but within the range of concentrations seen in these fish before the Big Spring Water Treatment System was implemented (Figure 6.10).

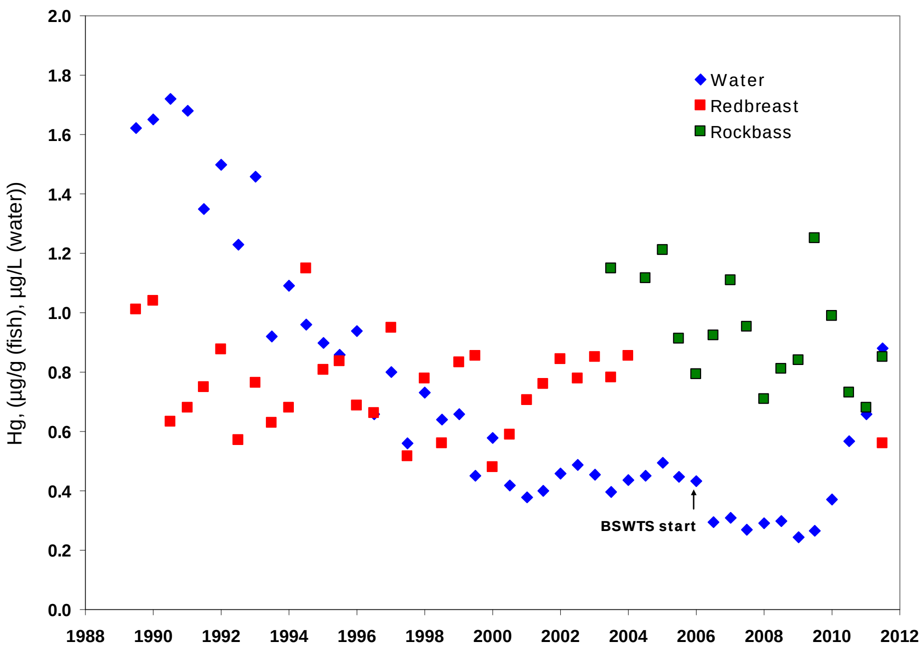

Figure 6.10. Mean concentration of mercury in redbreast sunfish and rockbass at East Fork kilometer 23.4 versus trailing 6-month mean concentration of mercury in water.

Overall, the lack of response in fish to changes in mercury concentrations in water is a complex issue that is being investigated by scientists and environmental managers throughout the Department of Energy complex. A number of recent publications have focused on mercury sources, transport, and fate that may be helpful in future remedial decision-making (Peterson *et al.* 2011b, Southworth *et al.* 2011, and Southworth *et al.* 2010). This closes out an issue from the 2007 Remediation Effectiveness Report concerning the elevated fish concentration, Table 6.10. See Chapter 7 (CERCLA Offsite Actions) for additional information about mean mercury concentrations in sunfish in UEFPC and hydrologically-connected locations downstream in Lower East Fork Poplar Creek (LEFPC) and the Clinch River/Poplar Creek.

Mean PCB concentrations in whole body composites of stoneroller minnows at East Fork kilometer 24.5 (5.40 + 0.40 µg/g) decreased slightly from levels seen in 2010, although levels greater than 5 µg/g are relatively high. Total PCB concentrations in sunfish fillets at East Fork kilometer 23.4 increased in 2011 (0.68 µg/g), but still remained much lower than the peak levels observed in the mid-1990s (Figure 6.11).

After substantial increases in the species richness (number of species) at East Fork kilometer 23.4 in the late 1980s and early to mid-1990s, the number of fish species has leveled out in recent years, with somewhat regular seasonal variation (Figure 6.12), but remains below comparable reference fish communities like Brushy Fork kilometer 7.6 (inset, Figure 6.1). In contrast, the species richness of the fish community further downstream at East Fork kilometer 13.8 has continued to improve, and now routinely meets or exceeds richness at the reference site. The improvement at East Fork kilometer 13.8 includes more sensitive species, such as darters and suckers, but the density of these sensitive species is still below reference values.

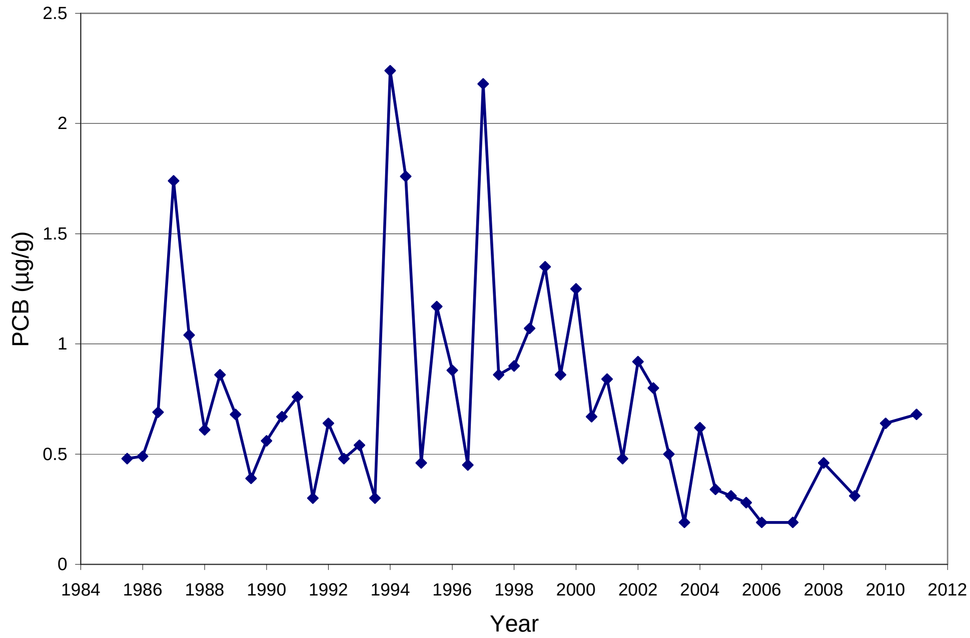

Figure 6.11. Mean concentrations of polychlorinated biphenyls in redbreast sunfish and rockbass at East Fork kilometer 23.4, 1985–2011.

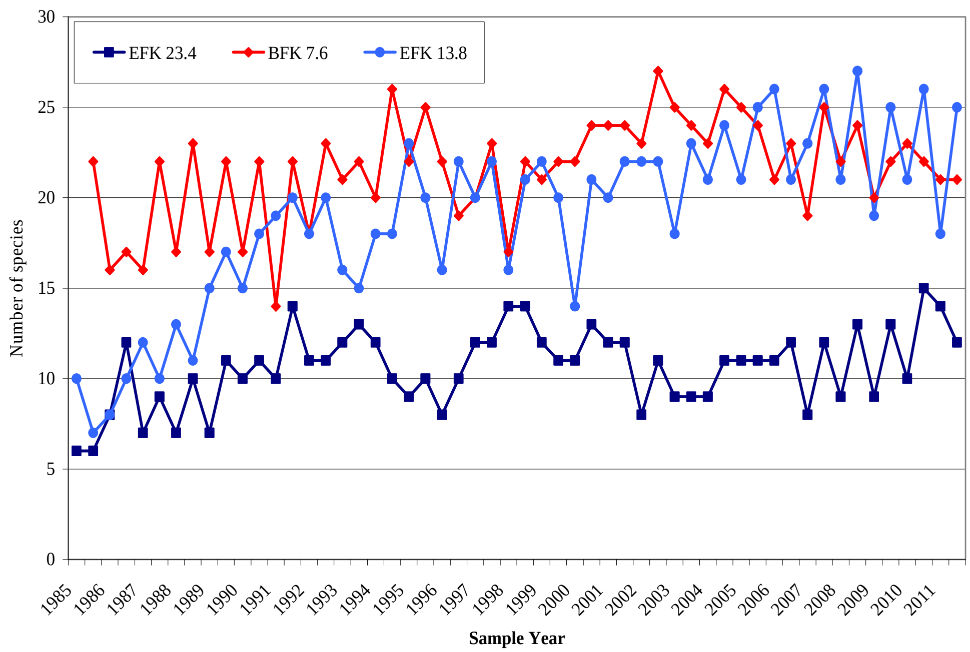

Figure 6.12. Species richness (number of species) in samples of the fish community in East Fork Poplar Creek and a reference stream, Brushy Fork, 1985–2011.

EFK = East Fork kilometer
BFK = Brushy Fork kilometer

No unusual change was observed in taxonomic richness of the pollution-intolerant benthic macroinvertebrates at East Fork kilometer 24.4 in 2011 compared with results from 1997 – 2010 (Figure 6.13), suggesting that environmental conditions and the macroinvertebrate community have stabilized at that site. East Fork kilometer 23.4 continues to support at least one or two more pollution-intolerant taxa per sample than East Fork kilometer 24.4.

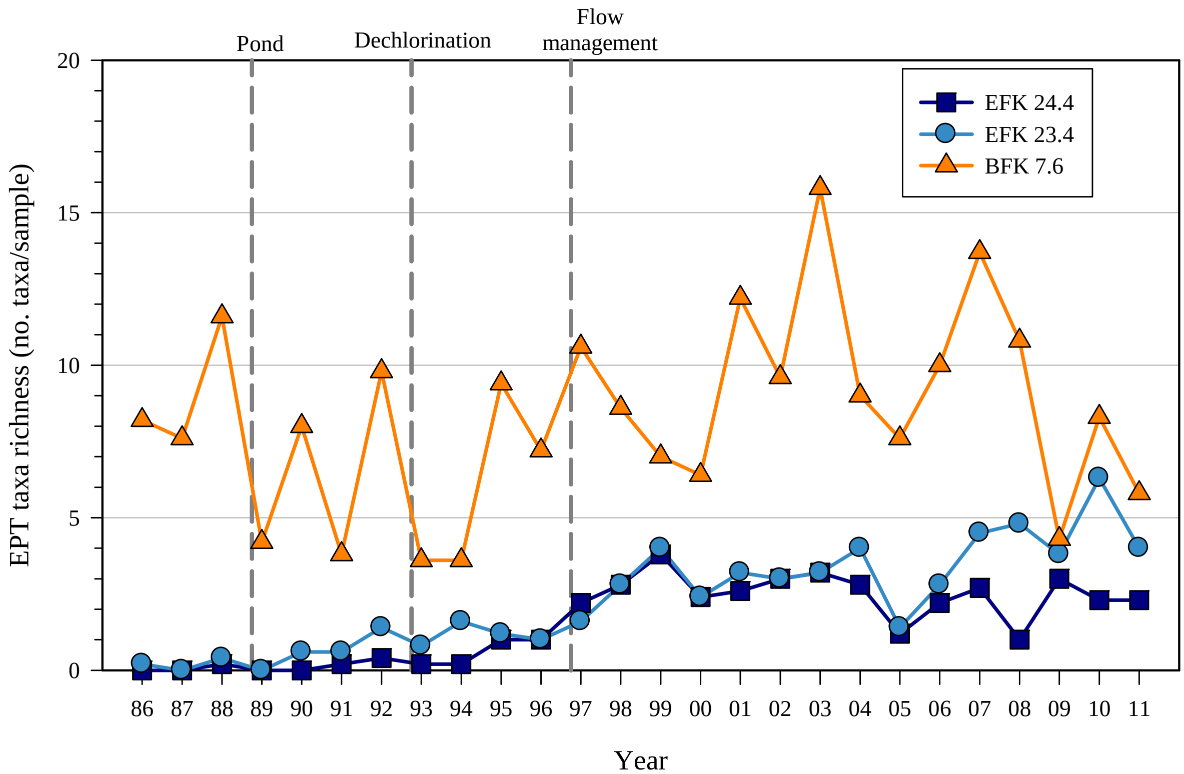

Figure 6.13. Mean (n = 5; n = 4 after 2006) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in Upper East Fork Poplar Creek and Brushy Fork, April sampling periods, 1986–2011.[a,b]

[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, caddisflies, and stoneflies.

6.2.2.3 Groundwater Quality Monitoring

The *UEFPC Remedial Investigation/Feasibility Study* (DOE 1998) 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 6.1 illustrates 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 feet deep well located in the eastern portion of the S-3 Ponds Plume. Figure 6.14 shows analytical results for ^{99}Tc and nitrate in well GW-108. These contaminants, which far exceed their drinking water standards (900 pCi/L effective dose equivalent based on 4 mrem/yr maximum contaminant level for beta activity and photon particles for ^{99}Tc, and 10 mg/L for nitrate), originate from the S-3 Ponds in a low pH plume finger that seeps eastward into the UEFPC watershed. The nitrate concentrations show a gradually decreasing trend, excluding the obvious outlier datapoint from 2005, while the ^{99}Tc activities have been relatively stable since about 2004 with the exception of one outlier datapoint in 2009.

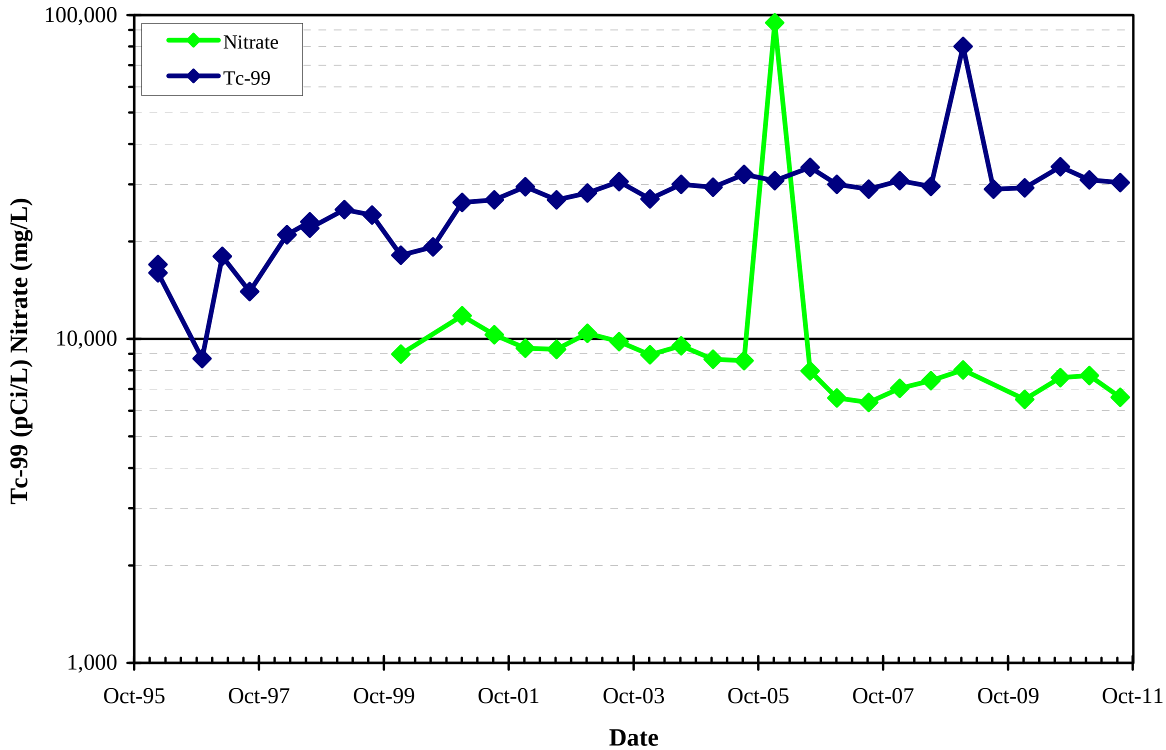

Figure 6.14. Well GW-108 nitrate concentration and ^{99}Tc activity.

Wells GW-605 and GW-606 are located in the Maynardville Limestone exit pathway upgradient of the East End Volatile Organic Compound plume interception and treatment system (Figure 6.1). Well GW-605 is a relatively shallow well (40.5 feet deep), while GW-606 is deeper (175 feet deep). Figure 6.15 shows concentrations of signature contaminants in wells GW-605 and GW-606. GW-605 exhibits a long-term decreasing trend for alpha activity although levels increased somewhat during FY 2011. The alpha activity is associated with uranium which was present at 0.14 – 0.16 mg/L (greater than the 0.03 mg/L maximum contaminant level) in semiannual samples collected during FY 2011. The source of uranium contamination in groundwater in the area is not known. The VOC concentrations are seasonally variable and decreased during FY 2011 to levels measured in the 2006 to 2008 time period. Groundwater in the vicinity of GW-605 tends to follow the hydraulic gradient eastward into the edge of the East End VOC plume extraction well drawdown feature where it enters the plume treatment system.

At well GW-606 concentrations of carbon tetrachloride and its degradation product chloroform have decreased since the East End VOC 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 6.15, the nitrate concentration increased after groundwater withdrawal started and has fluctuated in the concentration range between 8 and 16 mg/L. During FY 2011, nitrate in GW-606 decreased somewhat and the most recent value was about 9 mg/L, which is less than the 10 mg/L MCL for nitrate. Well GW-606 contains about 5 μg/L of uranium and PCE is present at 4 – 5.5 μg/L. TCE was not detected during FY 2011 although it has been present historically. Like the VOCs detected in well GW-605, the nitrate contamination is thought to be captured in the zone of influence of the East End VOC treatment system. Section 6.3.1 presents performance monitoring data relevant to the Y-12 East End VOC plume removal action.

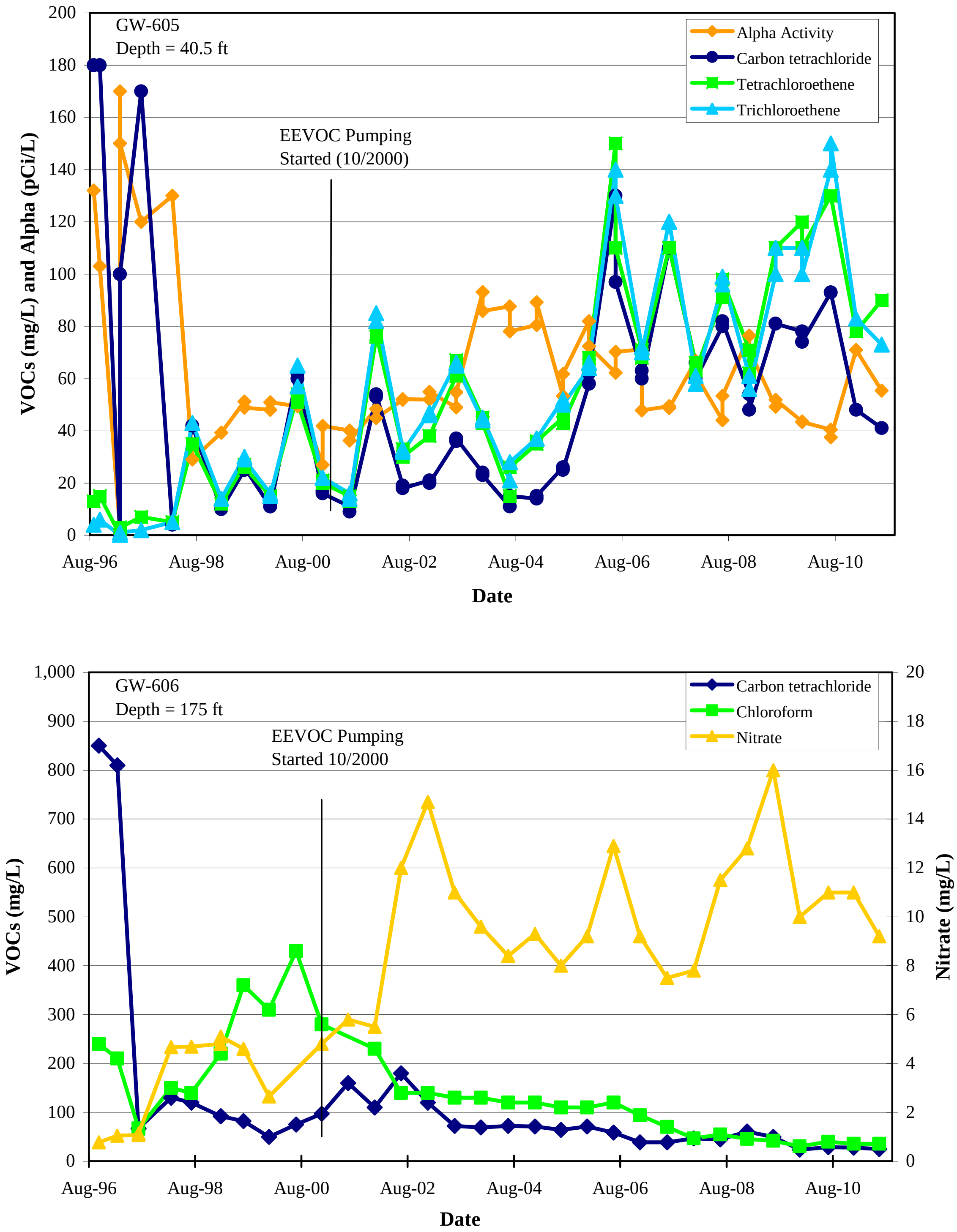

Figure 6.15. Wells GW-605 and GW-606 signature contaminant concentrations.

6.2.3 Performance Summary

Following is a summary of the FY 2011 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 2002) goal at Station 17 is 200 ng/L. The average flow-paced composite mercury concentration during FY 2011 was 817 ng/L. Although significant reductions in mercury concentration were observed following startup of the Big Spring Water Treatment System, and in response to drought conditions during 2007 and 2008, the interim goal for mercury concentrations has not yet been attained on an annual average basis. The increased concentrations measured during FY 2011 are related to sediment disturbances that occurred during the West End Mercury Area storm drain cleanout process.

- Surface water contaminant discharge conditions in UEFPC were adversely affected by disturbances related to the West End Mercury Area storm drain sediment removal project. High concentrations and high fluxes of mercury were measured throughout UEFPC.

- The Big Spring Water Treatment System was fully operational during FY 2011 and although no significant downtime or operational problems occurred, inflow volumes exceeded treatment capacity which caused bypass of untreated water to discharge via Outfall 51 and at the Big Spring Water Treatment System equalization tank overflow. Based on available data it is estimated that 0.3 to 0.5 kg of mercury may have been discharged via Outfall 51. During FY 2012, a sampling system was nstalled on the equalization tank overflow to measure the amount of water and mercury that is discharged to UEFPC without treatment. The average effluent concentration for Big Spring Water Treatment System was 0.029 µg/L, which is slightly greater than the past two years but is less than the performance standard of 0.2 µg/L. In addition to continued monitoring of the mercury concentrations during high flows at Outfall 51, the equalization tank overflow water will be monitored. With the installation of the additional monitoring an issue to better quantify water volume and total mercury discharges identified from the 2011 Remediation Effectiveness Report is closed out, Table 6.10.

- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux at Station 17 in FY 2011 remains elevated relative to levels observed in drought years. Uranium concentration and fluxes in UEFPC originate from groundwater seepage and storm water transport of surface contamination at Y-12. Groundwater contamination in the West End Mercury Area is a source of uranium flux at Outfall 200A6. In addition to groundwater plume discharges to surface water, another source of the increased uranium flux observed at Station 17 may be the former Oil Skimmer Basin.

- Aquatic biological monitoring shows that mercury concentrations remain stable in fish tissue at EFK 23.4 near the watershed integration point. PCB concentrations in fish increased to 0.64 µg/g in 2010 but remained much lower than peak levels. The lack of a response in fish to decreased mercury concentrations in water is an ongoing issue. Recently, two reports have been drafted or published which focused on mercury sources, transport, and fate (Southworth et al. 2010, Peterson, et al. 2011b). Additionally, remedial measures required by the UEFPC Phase 1 ROD, including the clean up and repair of storm sewers in the West End Mercury Area, are expected to reduce Hg concentrations at Station 17. These activities close out two issues identified in previous Remediation Effectiveness Reports that deal with elevated fish tissue concentrations. Although fish and benthic communities in UEFPC are relatively stable, they continue to show impairment compared to the reference streams.

6.2.4 Facility Operations and Land Use Controls

6.2.4.1 Requirements

The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) specifies maintenance and land use controls to reduce the risk of human exposure to contaminants (Table 6.2). Required maintenance activities specified in the Record of Decision include periodic inspections and repair of the West End Mercury Area asphalt caps upon completion. The West End Mercury Area asphalt caps were never constructed and a draft Explanation of Significant Difference was submitted on 09/28/11 to remove them from the Record of Decision. The land use controls include an excavation/penetration permit program, property record restrictions, property record notices, zoning notices, signs, and surveillance patrols for the former mercury use areas in Y-12.

6.2.4.2 Status of Requirements

Because not all of the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (DOE 2002) actions have been completed, no maintenance activities and land use controls were required to be verified as part of this action in FY 2011. However, Y-12 is an active federal installation and many of the land use controls in UEFPC are already in place to prevent consumption of fish from UEFPC and to control/monitor access by workers and the public, including an ongoing excavation-penetration permit program. Signs are in place and the security patrols continue to provide protection. Operation and maintenance of water treatment systems (Central Mercury Treatment System and Big Spring Water Treatment System) are discussed in Sect. 6.2.2.

6.3 SINGLE PROJECT ACTIONS IN THE UPPER EAST FORK POPLAR CREEK WATERSHED

6.3.1 East End Volatile Organic Compound Plume

The East End VOC plume (DOE 1999) extraction/treatment system began operation in 2000 to prevent further migration of the VOC-contaminated groundwater plume off the Oak Ridge Reservation. 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 2006b). The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* recommended continuation of the current plume interception system and specified evaluation of the system performance in the annual Remediation Effectiveness Report.

6.3.1.1 Performance Goals and Monitoring Objectives

The goals of the removal action (DOE 1999) 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 1998), and a *Union Valley Interim Study Remedial Site Evaluation* (Y-12 1995) 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 1999). The *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE 2006b) identified changes to monitoring frequencies and analysis, which were implemented in the FY 2007 monitoring. 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 performance goal of the treated effluent is to meet the recreational AWQC recreational (for organism only) (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.

6.3.1.2 Evaluation of Performance Monitoring Data

6.3.1.2.1 Groundwater Monitoring Data

Figures 6.16 and 6.17 show the East End VOC chlorinated hydrocarbon concentrations before pumping at well GW-845 was started in FY 2000, and in FY 2011 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.

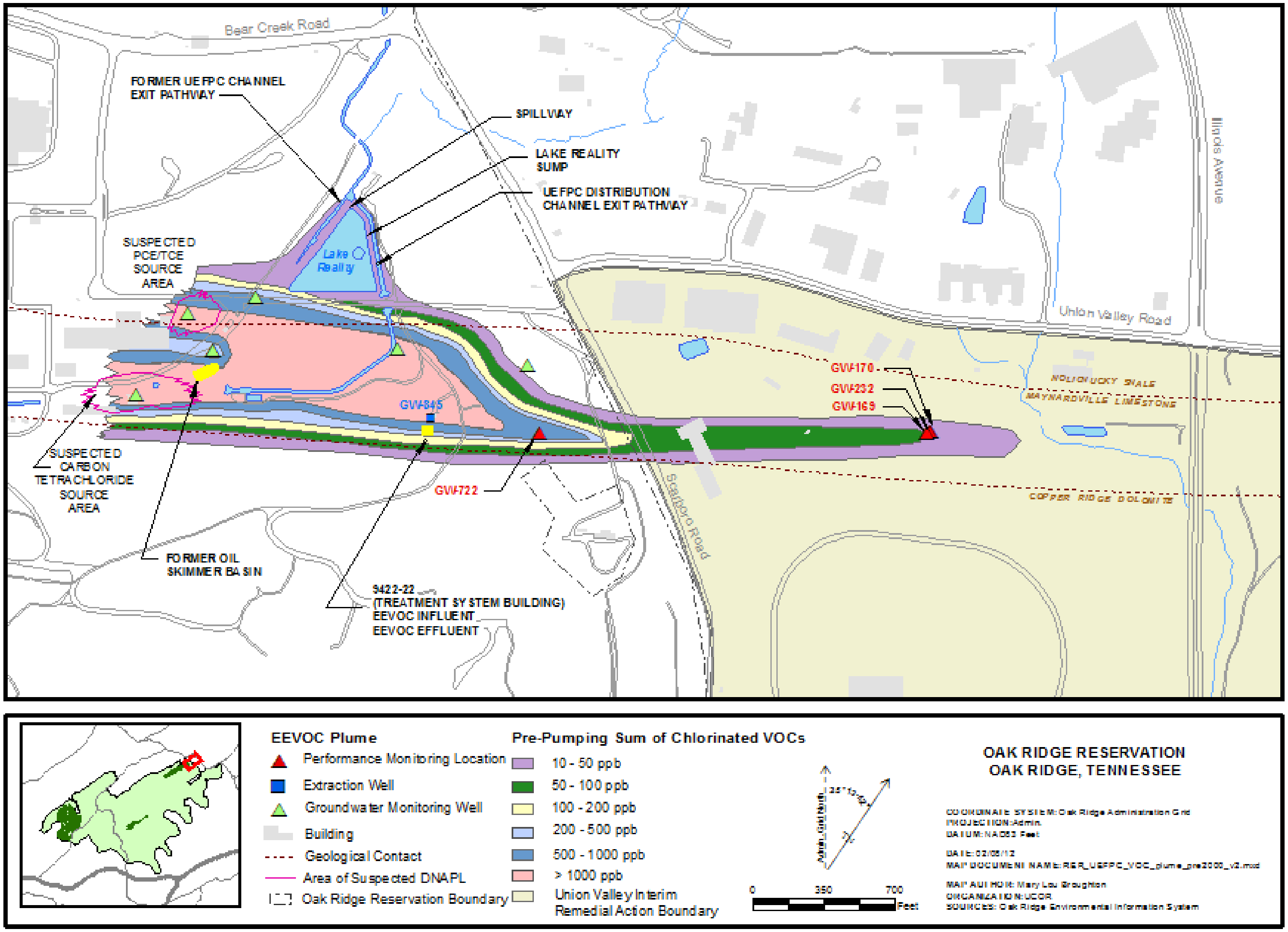

Figure 6.16. East End Volatile Organic Compound Plume before pump and treatment system startup (1998-2000).

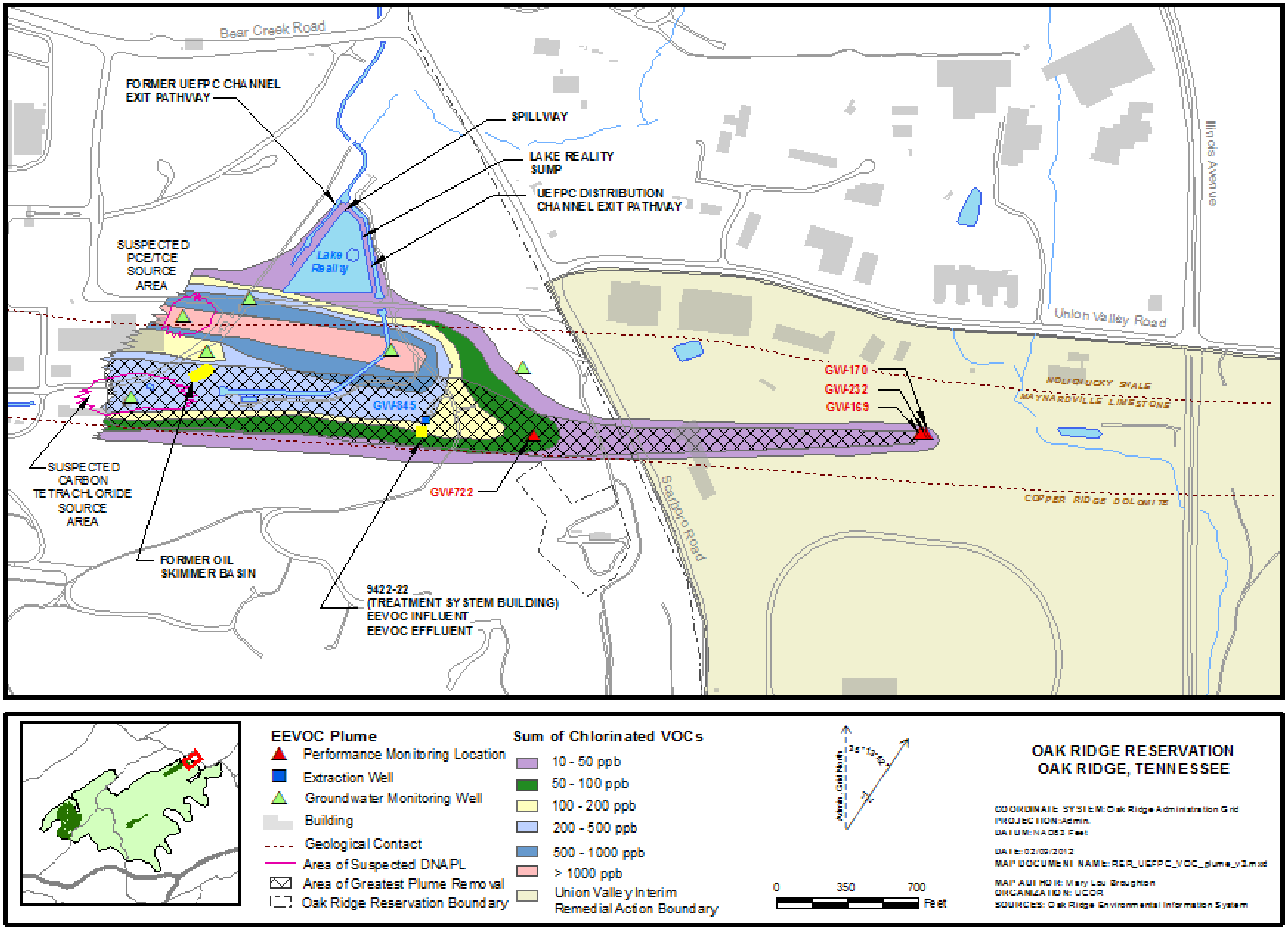

Figure 6.17. East End Volatile Organic Compound plume in Fiscal Year 2011 showing region of maximum chlorinated volatile organic compound removal.

The groundwater extraction system has effectively withdrawn contaminant mass from the more permeable limestone area, but the contaminated groundwater is not as effectively withdrawn from the shaley 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 6.18 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 6.18, 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 1999), 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 2006b) specified quarterly sampling and analysis at the extraction well; well GW-722 located approximately 180 meters (600 feet) downgradient of the extraction well; and wells GW-169, -170, and -232 located about 730 meters (2400 feet) east along geologic strike in Union Valley (Figures 6.16 and 6.17). 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 meters (1000 feet) west of well GW-845 (Figures 6.16 and 6.17). 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 2007c) and *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE 2006b), sampling of well GW-232 in Union Valley has been discontinued and sampling frequency and target analytes at other specified (DOE 1999) wells have been modified.

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 2006b) 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 applicable or relevant and appropriate requirement for this treated discharge.

6.3.1.2.2 Maynardville Limestone Exit Pathway

The East End VOC 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 about 200 µg/L or less (Figure 6.19). Likewise, chloroform concentrations have stabilized at about 10 to 15 µg/L.

Signature VOCs within the intermediate and deep intervals of the Maynardville Limestone directly downgradient of the pumping well (Figure 6.18) also decreased significantly relative to baseline data. This pathway is monitored via well GW-722 (Port 14 at 425 feet below ground surface, Port 17 at 385 feet below ground surface, Port 20 at 333 feet below ground surface, and Port 22 at 313 feet below ground surface). The ports discussed here contain the highest concentrations of contaminants. Other ports in well GW-722 are sampled by the Y-12 Groundwater Protection Program. That monitoring confirms that carbon tetrachloride, PCE, and TCE are generally not detected or occur at concentrations below maximum contaminant levels in other ports since the pump and treatment operation started. The FY 2011

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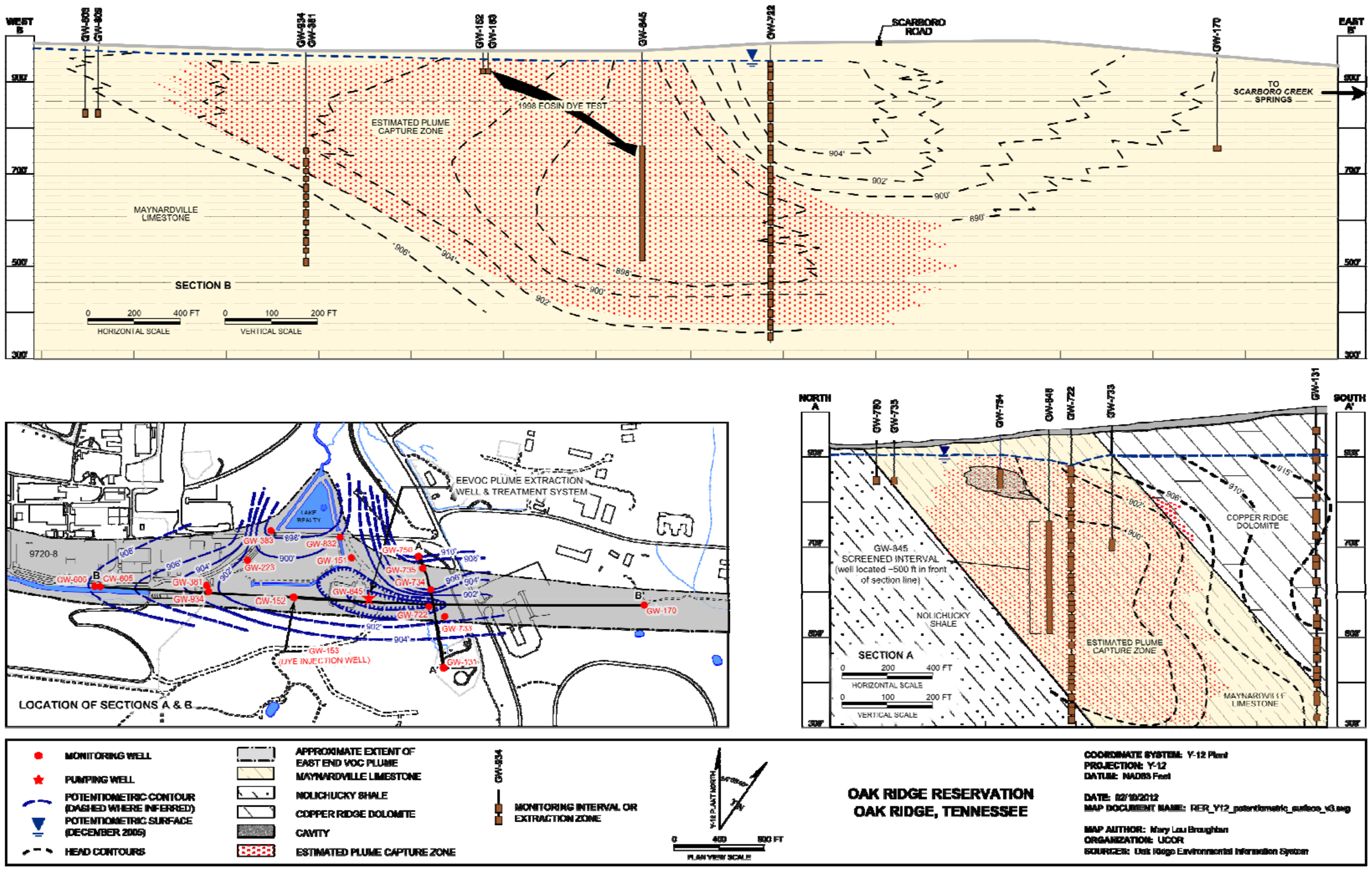

Figure 6.18. Potentiometric surface at the eastern Y-12 area.

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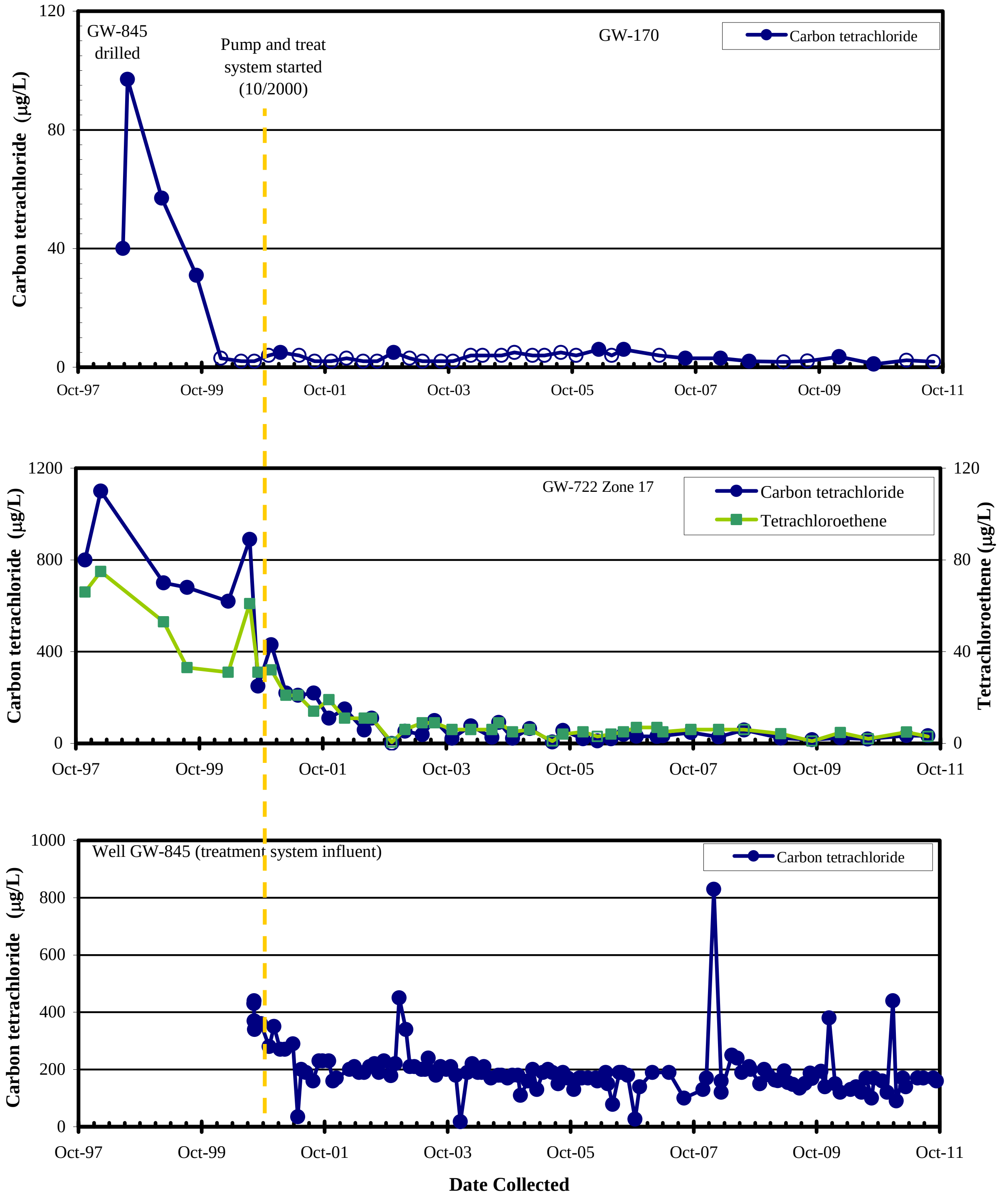

Open symbol indicates estimated (J qualified) result less than required reporting limits

Figure 6.19. Selected Volatile Organic Compound trends in the Maynardville Limestone exit pathway.

analytical results for several signature VOCs in well GW-722, Port 17, are in Table 6.6. 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 6.19). 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.

Table 6.6. Selected FY 2011 data for Y-12 East End Volatile Organic Compound Plume performance

Chemical	Station Name Sample Date Units	GW-169 3/1/2011	GW-169 8/4/2011	GW-170 3/1/2011	GW-170 8/9/2011
Alpha activity	pCi/L	<3.16 (U)	dry	< 2.12 (U)	< 2.06 (U)
Beta activity	pCi/L	< 3.94 (U)	dry	12.9 ±2.31	12.7 ±2.23
Carbon tetrachloride	μg/L	< 1 U	dry	2.3	1.9
Chloroform	μg/L	< 1 U	dry	< 1 U	< 1 U
Tetrachloroethene	μg/L	< 1 U	dry	1	2.6
Trichloroethene	μg/L	< 1 U	dry	1.5	1.5
Nitrate	mg/L	0.68	dry	0.34	0.35

Chemical	Station Name Sample Date Units	GW-722-17 3/15/2011	GW-722-17 7/20/2011	GW-722-14 3/15/2011	GW-722-14 7/19/2011
Carbon tetrachloride	μg/L	34	33	18	14
Chloroform	μg/L	6	5	2.1	5 U
Tetrachloroethene	μg/L	4.9	3 J	2.6	5 U
Trichloroethene	μg/L	1.3	5 U	1.1	5 U

GW = groundwater well
J = estimated value
U = Not detected or result less than minimum detectable activity and/or counting errors (radiological results)

In Union Valley east of Scarboro Road (Figures 6.16 and 6.17), signature VOCs (Table 6.6) have historically been detected in wells GW-169 (water table interval) and GW-170 (intermediate interval; 120 feet below ground surface), which are directly along strike to the east of Y-12. Well GW-170 has historically had the highest levels of carbon tetrachloride and chloroform with highly variable concentrations, but with an overall decline since 1994. Since East End VOC operation started in 2000, carbon tetrachloride concentrations have stabilized at about 5 μg/L or less. A sharp decrease of carbon tetrachloride concentrations occurred in well GW-170 prior to the East End VOC 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.

Low levels of benzene (1 to 4 μg/L) have been detected intermittently in well GW-170 since first appearing in FY 2001. Wells that sample groundwater on Department of Energy property in the exit pathway of the plume (GW-733, GW-722, and GW-734 shown on Figures 6.16 and 6.17) show less frequent and lower (estimated 1 to 2 μg/L) benzene concentrations, which suggests that the benzene detected in off-site well GW-170 may not originate from the East End VOC plume. The off-site area is an industrial park. A source for benzene in the well has not been identified to date. All detected results are below the maximum contaminant level for benzene which is 5 μg/L.

6.3.1.2.3 Treatment System Performance

Treatment system performance monitoring began in November 2000, following system startup. During FY 2011, the treatment system experienced a major service outage from March 26 to May 6 caused by lightning damage to the pump motor controller. The pump control system required redesign because the original equipment parts were no longer available. Other operational issues included brief outages in late December 2010 to early January 2011 caused by air stripper pump discharge pipe plugging, a 1-day power outage in February, a 2-day power outage in June caused by lightning damage, and a 3-day outage in July for transformer replacement. Figure 6.20 shows the actual East End VOC treated water volume and a comparison line based on a planned constant pumping and treatment rate. Due to the outage during April, the system was operated at an increased throughput to attain the planned total treatment volume by year's end.

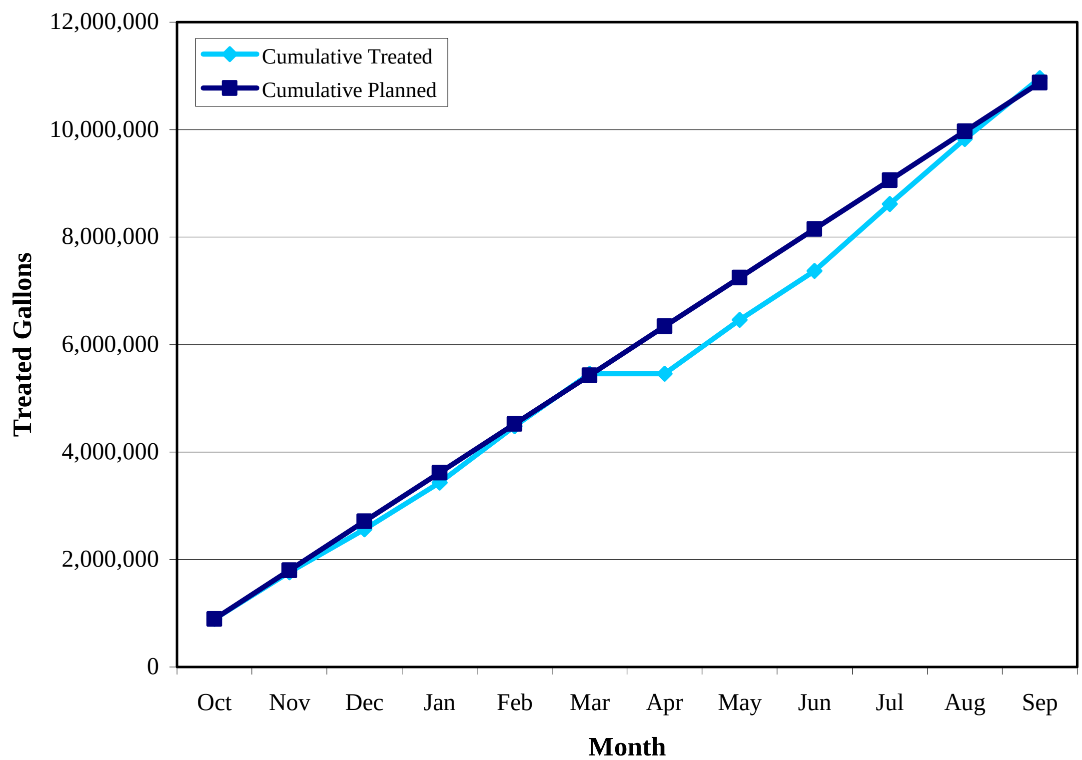

Figure 6.20. East End Volatile Organic Compound treatment system cumulative water treated during Fiscal Year 2011.

To evaluate the effectiveness of the treatment system, influent and corresponding effluent samples have been collected since operations began. In FY 2011, concentrations of carbon tetrachloride in treatment system influent (from well GW-845) ranged from 90 μg/L to 440 μg/L and averaged 179 μg/L for the year (Table 6.7). The concentration range for carbon tetrachloride in the effluent stream was 62 μg/L to

140 μg/L and averaged 114 μg/L. Removal efficiency for carbon tetrachloride ranged from about 12.5% to 75% and averaged about 35% in FY 2011 while removal efficiency for chloroform ranged from 0% to about 26% and averaged about 8%. Table 6.8 summarizes total mass removals for the principal VOCs since operations began in 2000. Inspection of Table 6.8 shows that there has been a gradual deterioration in treatment system efficiency over the FY 2009 through FY 2011 period. The progressive deterioration of air stripper efficiency is identified as an issue.

Table 6.7. East End Volatile Organic Compound plume treatment system performance data, Fiscal Year 2011

Chemical	Date	Influent result (μg/L)	Effluent result (μg/L)	Percent reduction	Estimated net mass removal (kg)[a]
Carbon tetrachloride	10/26/2010	160	78	51%	0.28
	11/23/2010	120	62	48%	0.19
	12/28/2010	440	110	75%	1.00
	1/17/2011	90	140	36%	0.16
	2/24/2011	170	120	29%	0.20
	3/15/2011	140	100	29%	0.15
	5/23/2011	170	120	29%	0.19
	6/27/2011	170	130	24%	0.14
	8/24/2011	170	140	18%	0.28
	9/13/2011	160	140	13%	0.09
FY 2011 annual average:		**179**	**114**	**35%**	
FY 2011 annual mass removal:					**2.7[b] kg**
Chloroform	10/26/2010	10	9.3	7%	0.002
	11/23/2010	8.9	7.6	15%	0.004
	12/28/2010	31	23	26%	0.024
	1/17/2011	11	11	0%	0.000
	2/24/2011	12	11	8%	0.004
	3/15/2011	9.7	9.2	5%	0.002
	5/23/2011	11	10	9%	0.004
	6/27/2011	11	9.7	12%	0.004
	8/24/2011	11	11	0%	0.000
	9/13/2011	9.1	9.2	-1%	0.000
FY 2011 annual average:		**12.5**	**11.1**	**8%**	
FY 2011 annual mass removal:					**0.04 [b] kg**
PCE	10/26/2010	22	15	32%	0.02
	11/23/2010	25	15	40%	0.03
	12/28/2010	59	17	71%	0.13
	1/17/2011	22	16	27%	0.02
	2/24/2011	28	23	18%	0.02
	3/15/2011	22	18	18%	0.01
	5/23/2011	26	22	15%	0.02
	6/27/2011	27	21	22%	0.02
	8/24/2011	28	25	11%	0.03
	9/13/2011	21	20	5%	0.00
FY 2011 annual average:		**28**	**19.2**	**26%**	
FY 2011 annual mass removal:					**0.31 [b] 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.

[b]Estimate is low because volatile organic compound data are not available for April 2011. Facility operated normally during March.

U = Result less than method reporting limits or minimum detectable activity

Table 6.8. Estimated mass removals for key East End Volatile Organic Compound plume constituents since inception of treatment operations

Fiscal Year	Carbon tetrachloride (kg)	Chloroform (kg)	Tetrachloroethene (kg)
2001	9.18	0.805	0.741
2002	7.69	0.396	0.81
2003	9.96	0.437	1.03
2004	7.39	0.269	0.832
2005	6.33	0.296	0.860
2006	6.66	0.338	0.856
2007	5.67	0.216	0.625
2008	7.21	0.368	1.07
2009	6.8	0.20	0.88
2010	4.9	0.21	0.
2011	2.7	0.04	0.31
Totals	**74.5**	**3.58**	**8.69**

An effluent concentration limit was not stipulated for the treatment system. However, to maintain protectiveness of the environment and to monitor the effectiveness of the treatment system, the East End VOC treatment system effluent is sampled and analyzed monthly for VOCs.

Maximum FY 2011 results of selected organic and radiological constituents in both influent and effluent samples are in Table 6.9. Reductions observed for other signature VOCs detected in the influent stream (Table 6.7 and Table 6.9) is consistent with the relative ranking of their volatility as indicated by their respective Henry's Law constants (i.e., carbon tetrachloride > PCE > chloroform).

During FY 2011, monitoring data for treatment system influent show that average levels of ^{234}U and ^{238}U increased slightly compared to FY 2010, although the levels remain much lower than those measured during FY 2008. Figure 6.21 is a graph of the measured activities of ^{234}U and ^{238}U throughout the East End VOC treatment system operations through FY 2011. Table 6.9 includes the maximum East End VOC treatment system influent and effluent uranium isotopic activities. The maximum and average effluent levels of ^{234}U and ^{238}U appear slightly greater than the influent levels although the apparent differences are not statistically significant based on t-testing using the Environmental Protection Agency's ProUCL software. The average isotopic activities in effluent equate to about 4 μg/L of uranium metal, which is equal to the project-specified detection limit for uranium as a metal, and is much less than the 30 μg/L maximum contaminant level reference concentration. Based on the average groundwater withdrawal rate throughout FY 2011, the uranium mass discharged from the East End VOC system was approximately 0.16 kg for the year. This mass is a minor contribution to the yearly uranium mass measured at Station 17 (Sect. 6.2.2.1.2).

Table 6.9. Summary of East End Volatile Organic Compound plume groundwater treatment system performance results, Fiscal Year 2011

Analyte[a]	Units	Maximum influent detect (GW-845)	Maximum effluent detect
2-Butanone	μg/L	10 U	10 U
Carbon tetrachloride	μg/L	440	140
Chloroform	μg/L	28	23
1,1-DCA	μg/L	1.1	< 1 U
1,1,1-TCA	μg/L	< 1 U	< 1 U
Cis-1,2-DCE	μg/L	7.3	4.3
Trans-1,2-DCE	μg/L	< 1 U	< 1 U
PCE	μg/L	59	23
TCE	μg/L	9.7	4.3
Nitrate[b]	mg/L	1.4	1.3
Total uranium[b]	mg/L	0.004 U	0.004 U
^{234}U[b]	pCi/L	3.51 ± 0.749	3.71 ± 0.789
^{235}U[b]	pCi/L	0.496 ± 0.295	0.253 ± 0.201
^{238}U[b]	pCi/L	1.87 ± 0.553	1.94 ± 0.573

[a]All volatile organic compounds detected are listed.
[b]Note system design and remedy is targeted for volatile organic compounds.
GW = groundwater well
U = Result less than method reporting limits or minimum detectable activity

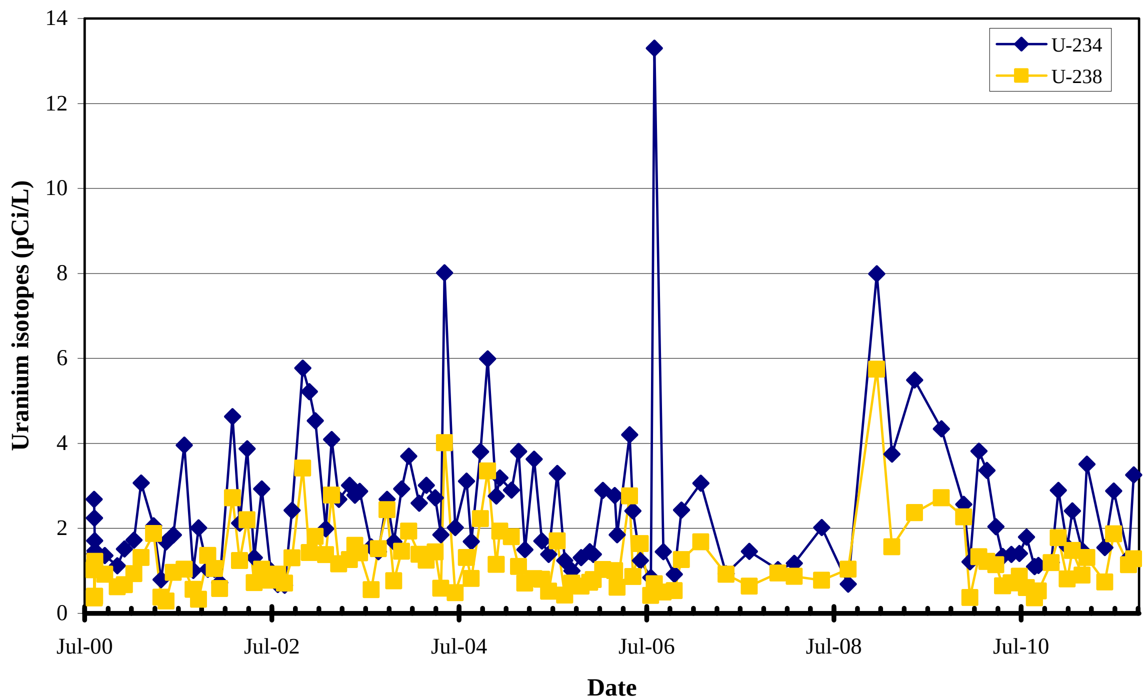

Figure 6.21. Activities of ^{234}U and ^{238}U in East End Volatile Organic Compound treatment system influent.

The *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE 1999) acknowledged the potential for other contaminants to increase in the East End VOC collected groundwater over time as a result of the groundwater withdrawals. The Action Memorandum recognized the possibility that the treatment process can be modified to accommodate treatment of other contaminants, as warranted.

6.3.1.3 Performance Summary

The East End VOC plume treatment system performance is measured by evaluating reductions in VOC concentrations downgradient of the extraction well, GW-845. FY 2011 data indicate that the groundwater pump and treatment system has effectively withdrawn contaminant mass from the permeable limestone downgradient in Union Valley, however, the effectiveness of the air stripper treatment unit deteriorated during FY 2011. Treatment unit performance deterioration is identified as an issue for CERCLA remedy effectiveness. During FY 2011, uranium concentrations in the East End VOC water remained low with total uranium results less than 4 µg/L.

6.3.1.4 Facility Operations and Land Use Controls

6.3.1.4.1 Requirements

No requirements were specified in the *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume* (DOE 1999).

6.3.1.4.2 Status of Requirements for FY 2011

Although no requirements are specified, the site remained protected by the DOE 229 Boundary access controls and was regularly patrolled by security personnel. In addition, groundwater use remained restricted within Y-12 and Union Valley.

6.3.2 Union Valley Interim Action

Location of the Union Valley Interim Action (DOE 1997) 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.

6.3.2.1 Performance Goals and Monitoring Objectives

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 East End VOC Plume Removal Action, included construction of a groundwater treatment facility to prevent further migration of the VOC-contaminated groundwater plume off of the Oak Ridge Reservation into Union Valley. The East End VOC plume performance monitoring objectives are discussed in Section 6.3.1.

6.3.2.2 Facility Operations and Land Use Controls

6.3.2.2.1 Requirements

The *Record of Decision for an Interim Action for Union Valley* (DOE 1997) requires that DOE ensure that the required property title searches and appropriate notifications are made until a final Record of Decision 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 record of decision to determine whether any affected property has changed hands;
- Notify property owners, the Oak Ridge city manager, and the TDEC/DOE Oversight Division 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.

6.3.2.2.2 Status of Requirements

Compliance with all requirements was verified in FY 2011. DOE-Oak Ridge Office Realty Officer provided documentation that property owners, the Oak Ridge City Manager, and TDEC/DOE Oversight Division 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 by the anniversary date of the record of decision (July 10th) and that property owners were surveyed by telephone, as required, was provided by the Property Management Office. Land use control verification information used to document these results was compiled by the Property Management Office in conjunction with DOE Realty Office. A copy of the documentation is submitted to the Water Resources Restoration Program for use in the annual Remediation Effectiveness Report. Original documents are maintained by the Project Document Control Office.

6.4 UPPER EAST FORK POPLAR CREEK WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the UEFPC watershed are in Table 6.10.

Table 6.10. Upper East Fork Poplar Creek watershed issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
None.			
Issues Carried Forward			
None.			
Completed/Resolved Issues			
1. During FY 2010 inflow to BSWTS exceeded system design treatment capacity necessitating bypass flow to occur during significant periods of time.	1. Recommend additional data collection at Outfall 51 to better quantify water volume and total mercury discharges, which is necessary to support any modification to BSWTS capacity. Flow meter and sampling system were installed on 8-inch overflow pipe.	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER
2. Mercury concentrations in fish within the UEFPC system remain elevated, despite decreasing concentrations in aqueous mercury levels. (2007 RER)[b]	2. A team consisting of DOE EM, NNSA, and Office of Science continue working together to develop a conceptual model(s) for mercury fate and transport relevant to methyl mercury concentrations in the UEFPC ecosystem. Two recent reports focused on mercury sources, transport, and fate have been drafted or published (Southworth *et al*. 2010, Peterson *et al.* 2011a).	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER
3. FY 2005 pre-action mercury concentrations at Station 17 are above the 200-ppt performance goal. Hg concentrations in fish in UEFPC have yet to respond to commensurate reductions of Hg from historical RMPE actions. Biota monitoring in UEFPC shows impaired diversity and density of pollution-intolerant species. (2006 FYR)[b]	3. Remedial measures including the recent clean up and repair of storm sewers in the West End Mercury Area required by the UEFPC Phase I ROD are expected to reduce Hg concentrations at Station 17. FY 2010 mercury levels in UEFPC fish remain above federal AWQC, but are less than peak levels observed in 2001-2002. Issue will continue to be monitored and discussed in future RERs.	DOE/ EPA & TDEC	FY 2011 with submission of D2 RER UEFPC Phase I ROD, refer to the FFA Appendix E and Appendix J for planned implementation schedules.

[a]A "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remedial Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remediation Effectiveness Report for Five-Year Review so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year of the Remediation Effectiveness Report or the Five-Year Review in which the issue originated is provided in parentheses, e.g., (2007 RER).

Table 6.10. Upper East Fork Poplar Creek watershed issues and recommendations (cont.)

AWQC = ambient water quality criteria
BSWTS = Big Spring Water Treatment Systtem
DOE = Department of Energy
EM = Environmental Management
EPA = Environmental Protection Agency
FFA = Federal Facility Agreement
FYR = Five Year Review
NNSA = National Nuclear Security Administration
RER = Remedial Effectiveness Report
ROD = record of decision
RMPE = reduction of mercury in plant effluents
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek

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DOE 1999. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, DOE/OR/01-1819&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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DOE 2006a. *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee,* DOE/OR/01-2229&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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7. CERCLA OFF-SITE ACTIONS

7.1 INTRODUCTION AND STATUS

7.1.1 Introduction

Table 7.1 lists the CERCLA actions outside of the Oak Ridge Reservation. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. All sites have long-term stewardship requirements (Table 7.1), so all sites are included in this performance evaluation. Table 7.2 provides a summary of facility operations and land use controls for each action.

Poplar Creek, the Clinch River, and Watts Bar Reservoir comprise a single, hydrologically connected system through which contaminants originating on the Oak Ridge Reservation are transported. In September 1999, the monitoring plans for the Clinch River/Poplar Creek and Lower Watts Bar Reservoir were combined in the *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek* (DOE 2004) to better identify and evaluate changes in contaminants of concern concentrations in fish. However, the CERCLA decisions and evaluations of effectiveness are discussed separately (Sects. 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 *2011Third Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 2011). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year in the CERCLA Five-Year Review.

7.1.2 Status

A Non-Significant Change to the *Record of Decision for the Lower Watts Bar Reservoir Operable Unit* (DOE 1995a) clarifying that the decision included ecological protection was prepared in 2009. Per the *2008 Remedial Effectiveness Report* (DOE 2008), changes will be discussed with the regulators to assure protectiveness sampling in Lower Watts Bar Reservoir and Clinch River/Poplar Creek. Any additional or ambiguous sampling will be codified and changes, as appropriate, will be made to decision documents or provided in the applicable Sampling and Analysis Plan/Quality Assurance Program Plan.

Early morning on December 22, 2008, a retaining wall failed at the Tennessee Valley Authority Kingston Fossil Plant in Roane County, Tennessee. More than 5.4 million cubic yards of coal ash spilled from an on-site holding pond to cover more than 300 acres of surrounding land and waters of the Clinch River arm of Watts Bar Lake. The Tennessee Valley Authority, local, state and federal agencies continue to work on recovery and clean-up of the release of ash at the plant. The recovery is proceeding in phases. The first phase, dredging of the Emory River, has essentially been completed. More than 3.5 million cubic yards of ash and sediment have been removed from the river and adjoining areas. Ongoing fish assessments continue with an emphasis on the presence of ash-related metals including arsenic, selenium, and mercury.

Table 7.1. CERCLA actions at off-site locations

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations / Land Use Controls required	Section
Completed actions				
Lower East Fork Poplar Creek	ROD (DOE/OR/02-1370&D2): 08/17/95 ESD (DOE/OR/02-1443&D2): 11/15/96	RAR (DOE/OR/01-1680&D5) approved 08/15/00.	Yes/No/Yes	7.2
Clinch River/Poplar Creek	ROD (DOE/OR/02-1547&D3): 09/23/97	RAR (DOE/OR/02-1627&D3) approved 06/14/99. • Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units (DOE/OR/01-1820&D3)	Yes/No/Yes	7.3
Lower Watts Bar Reservoir	ROD (DOE/OR/02-1373&D3): 09/29/95	RAWP[b] (DOE/OR/02-1376&D3) approved 05/25/96. • Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units (DOE/OR/01-1820&D3)	Yes/No/Yes	7.4

[a] Detailed information of the status of ongoing actions is from Appendix E of the Federal Facility Agreement and is available at <http://www.bechteljacobs.com/ettp_ffa_appendices.shtml>.
[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
ESD = explanation of significant differences
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
ROD = record of decision

Table 7.2. Facility operations and land use controls for CERCLA actions at off-site locations

Site/Project	Requirements		Status	Section
	Land Use Controls	Engineering controls		
Lower East Fork Poplar Creek	Annual land use survey at Dean Stallings Ford Periodic survey to detect residential use of shallow groundwater		▪ Land use controls in place.	7.2.4
Clinch River/Poplar Creek	Fish consumption advisories Permits for sediment disturbing activities Survey to confirm effectiveness of fish consumption advisories (one time only) Survey of local irrigation practices (one time only prior to issuing surface water record of decision)		▪ Land use controls in place.	7.3.4
Lower Watts Bar Reservoir	Fish consumption advisories Permits for sediment disturbing activities		▪ Land use controls in place.	7.4.4

7.2 LOWER EAST FORK POPLAR CREEK REMEDIAL ACTION

7.2.1 Performance Goals and Monitoring Objectives

The *Record of Decision for Lower East Fork Poplar Creek* (DOE 1995b) 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 7.1).

A major component of the selected remedy for Lower East Fork Poplar Creek (LEFPC) was to perform appropriate monitoring to ensure effectiveness. The *Remedial Action Report on the Lower East Fork Poplar Creek Project* (DOE 2000) provides a description of all measures taken during the remedial activities to comply with applicable or relevant and appropriate requirements and supplemental monitoring activities. The following monitoring was performed during FY 2011:

- Monitored mercury inputs from UEFPC to LEFPC 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 2002).

- Performed an annual survey of the former Dean Stallings Ford automobile dealership parking lot to ensure land use has not changed that will bring into question the protectiveness of leaving soils with > 400 ppm mercury.

7.2.2 Evaluation of Performance Monitoring Data

As a requirement of the *Remedial Action Report on the Lower East Fork Poplar Creek*, (DOE 2002) 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 7.1). A full discussion of the historical and current trends in mercury releases at Station 17 is presented in Sect. 6.2.2.1.2.

The effect of the upstream mercury source in LEFPC and downstream spatial trends in mercury bioaccumulation in various sunfish species (rockbass, redbreast, and bluegill) is depicted in Figure 7.2. Different species of fish are encountered at different sites, and these species can vary greatly in their mercury content. Within LEFPC, mercury concentrations in rockbass increase with increasing distance downstream. This is consistent with the pattern observed in previous years. There appears to be considerable variation in concentrations in redbreast concentrations, which may be explained in part by the small sizes of individual fish and the relatively low numbers of fish available (and comprising the mean). Regardless of the sunfish species, it is evident that the mercury content in fillets of sunfish is above the Environmental Protection Agency’s AWQC of 0.3 µg/g throughout LEFPC and at the mouth of Poplar Creek, but decreases below this threshold within a few km downstream in the Clinch River.

At East Fork kilometer 6.3, the long-term trend since the 1980s is of increasing mercury concentrations in fish (Southworth *et al.* 2011; Figure 7.3). However, trend analysis is again complicated by the change in fish species availability. If considering redbreast or rockbass temporal trends only, there is no clear evidence of an increasing or decreasing trend in recent years (especially over the 2003-2011 time period).

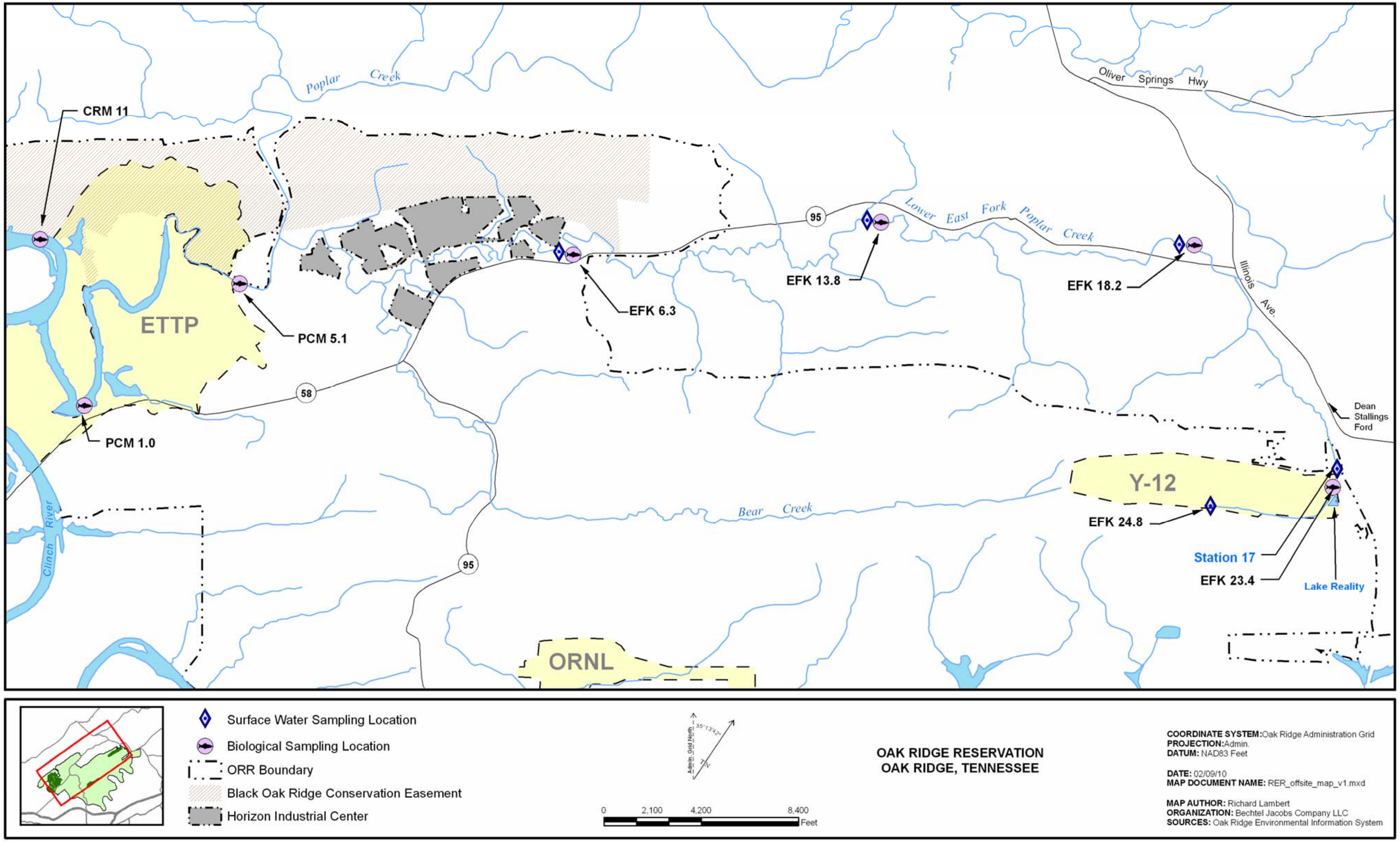

Figure 7.1. Lower East Fork Poplar Creek.

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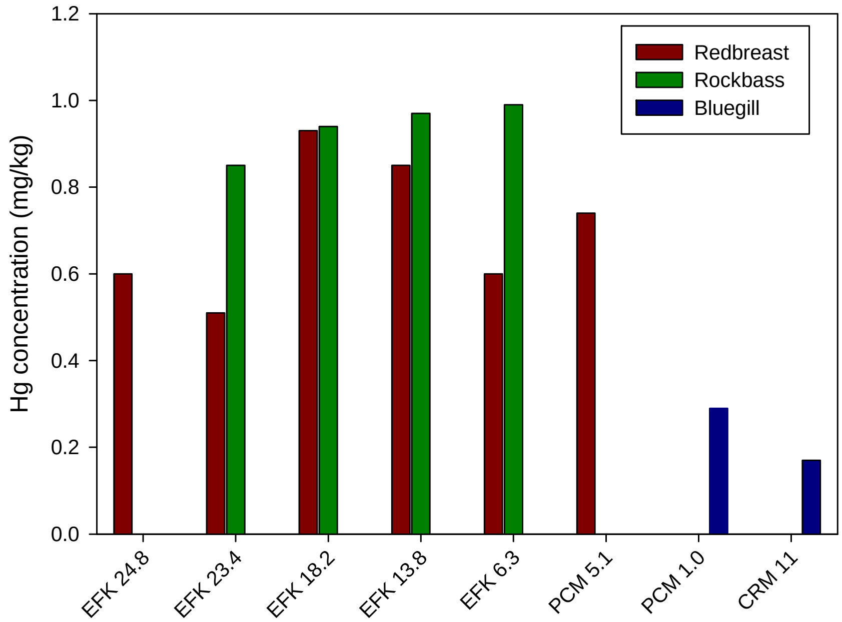

Figure 7.2. Spatial pattern of mercury bioaccumulation in various fish species in Lower East Fork Poplar Creek (EFK), Poplar Creek (PCM) and the Clinch River (CRM) in 2011.

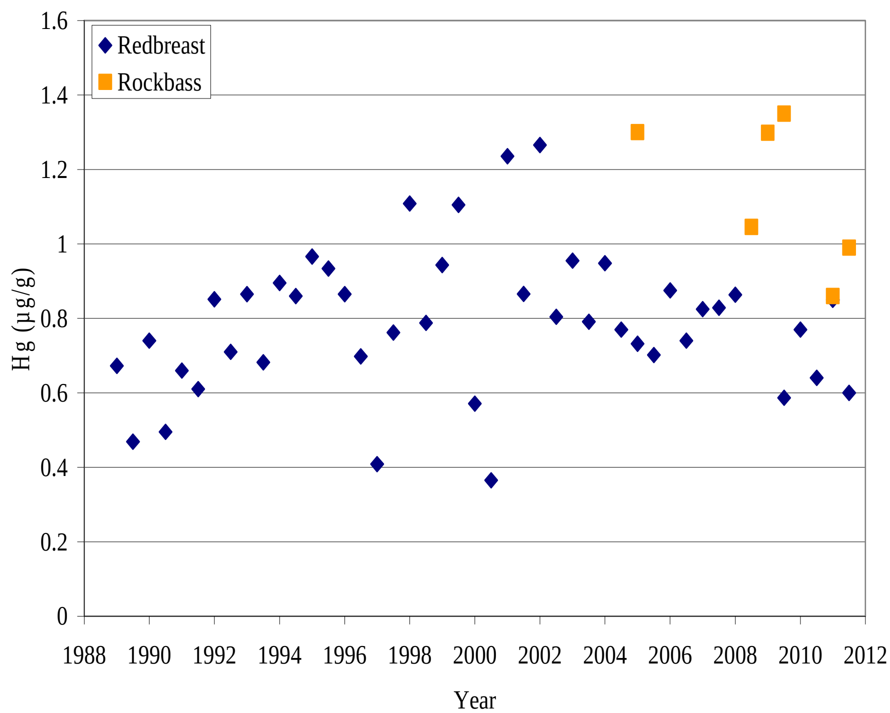

Figure 7.3. Mean mercury concentration in muscle tissue of redbreast sunfish at East Fork kilometer 6.3.[a]

[a]When redbreast sunfish could not be found, rockbass (orange boxes) were collected instead.

Experimental simulation of mercury methylation dynamics in LEFPC

The relative role of in-stream sediments in LEFPC versus continued releases of mercury from the Y-12 facility is not well understood. The *Record of Decision for Lower East Fork Poplar Creek* (DOE 1995b) addressed soil, floodplain sediment, and groundwater, and deferred surface water and creek bed sediments to a future record of decision. Various environmental factors including water chemistry characteristics can impact sediment microbes that methylate mercury. Changes in water or sediment chemistry or biological communities could be a factor in explaining the currently higher levels of mercury in LEFPC.

Controlled experimental studies were conducted by Oak Ridge National Laboratory scientists in FY 2011, using indoor stream mesocosms (Figure 7.4) to examine the factors controlling mercury methylation in LEFPC. Four indoor stream mesocosms (23 x 0.32 m) containing 200 L of stream water re-circulating at 10 L/m were set up to simulate conditions in LEFPC. Mercury-contaminated fine grained sediments from East Fork kilometer 6.3 were placed in two of the streams, and experiments were designed to investigate whether “legacy” sediment-bound mercury or “fresh” inputs of dissolved mercury were more readily available for methylation.

Among the factors that affect methy lmercury production in LEFPC, the concentration of aqueous inorganic mercury inputs from the headwaters and flux of dissolved organic matter appear to be important. Several experiments were conducted during FY 2011 in the artificial streams to manipulate organic matter and mercury content in the streams in order to determine their effect on methyl mercury production. Results showed that methyl mercury production was stimulated with increased aqueous inorganic mercury concentrations, both in streams with a hard substrate simulating conditions in UEFPC, and in streams with a sediment substrate, simulating LEFPC. By increasing aqueous mercury concentrations, methyl mercury concentrations increased from baseline concentrations (0.05 ng/L) to a maximum of 0.3 ng/L at the highest inorganic mercury concentrations. The concentrations of mercury added to the streams were environmentally relevant (comparable to concentrations seen in LEFPC), as were the concentrations of methyl mercury measured after mercury additions. Additions of dissolved organic carbon (achieved by leaching peat moss in a basic solution) appeared to sustain inorganic mercury in solution for a longer time and also increased aqueous methyl mercury concentrations in the artificial streams. Future experiments will examine whether dissolved organic matter enhances aqueous methyl mercury concentrations by increasing methylation rates, decreasing demethylation rates, or enhancing the solubility of methyl mercury. Future experiments will also further examine the role of dissolved vs particulate sources of mercury on methyl mercury production in the artificial streams.

These controlled experiments may help explain the unexpected mercury bioaccumulation trends in LEFPC. Importantly, the findings may help elucidate the role of water-borne mercury relative to in-stream sediment sources in controlling mercury methylation, and thereby help guide future remedial decision-making.

7.2.3 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 2011, the flow-paced continuous monitoring detected an average concentration of 817 ng/L and a mass flux of about 43.2 kg mercury (see Sect. 6.2.2.1.2). The levels of mercury in fish tissue in the LEFPC have remained elevated.

Figure 7.4. Experimental stream mesocosms used to investigate the relative roles of sediment-associated and waterborne mercury as precursors for methyl mercury formation.

7.2.4 Facility Operations and Land Use Controls

7.2.4.1 Requirements

The *Record of Decision for Lower East Fork Poplar Creek* (DOE 1995b) states that although residential use of soil horizon (shallow) groundwater is not realistic, as a safeguard, DOE will periodically perform a survey to determine if shallow groundwater is being used as a potable water supply by residents along Lower East Fork Poplar Creek.

The *Remedial Action Report on the Lower East Fork Poplar Creek Project* (DOE 2000) 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 record of decision (DOE 1995b) and exposure pathways remain protected (Table 7.2).

7.2.4.2 Status of Requirements

Periodic surveys to detect residential use of shallow groundwater were performed in FY 2007 and FY 2009. A list of residential wells was obtained from the Tennessee Department of Environment and Conservation in FY 2011. The list includes the construction dates of the wells. Wells added to the list since 2009 were evaluated to determine the location in relation to Lower East Fork Poplar Creek. Based on this evaluation, there were no new wells that can be used for residential use along Lower East Fork Poplar Creek.

7.2.5 Lower East Fork Poplar Creek Recommendations

No changes for LEFPC are recommended.

7.3 CLINCH RIVER/POPLAR CREEK

7.3.1 Performance Goals and Monitoring Objectives

The Clinch River/Poplar Creek Operable Unit extends 34 river miles from the mouth of the Clinch River at Tennessee River mile 567.5 [Clinch River mile 0.0] at Kingston, upstream past the Melton Hill Reservoir dam at Clinch River mile 23.1, to the upstream boundary of the Oak Ridge Reservation at Clinch River mile 43.7 (Figure 7.5). 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 Clinch River mile 12.0, upstream to its confluence with LEFPC at Poplar Creek mile 5.5 (Figure 7.1).

A major component of the *Record of Decision for the Clinch River/Poplar Creek Operable Unit* (DOE 1997) 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 1999a). 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 1999b) was prepared.

Based on sampling results from 1999–2004, the combined monitoring plan was revised in FY 2004. This revised plan is presented in *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units* (DOE 2004). This monitoring plan 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 Five-Year Review (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 Record of Decision-specified requirements to detect changes in fish contaminant concentrations and to evaluate whether institutional controls, i.e., the fish consumption advisory, are effective (DOE 2004). 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 Record of Decision requirements for the Clinch River/Poplar Creek hydrologic unit is satisfied by conducting annual sampling of contaminant concentrations in fish. Sites sampled in FY 2011 include four sites in the Clinch River, a site in Poplar Creek, and two reference sites upstream in Melton Hill Reservoir that are sampled for comparison purposes (Figure 7.5). The sites sampled are based on their position below key Department of Energy 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 2003). 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.

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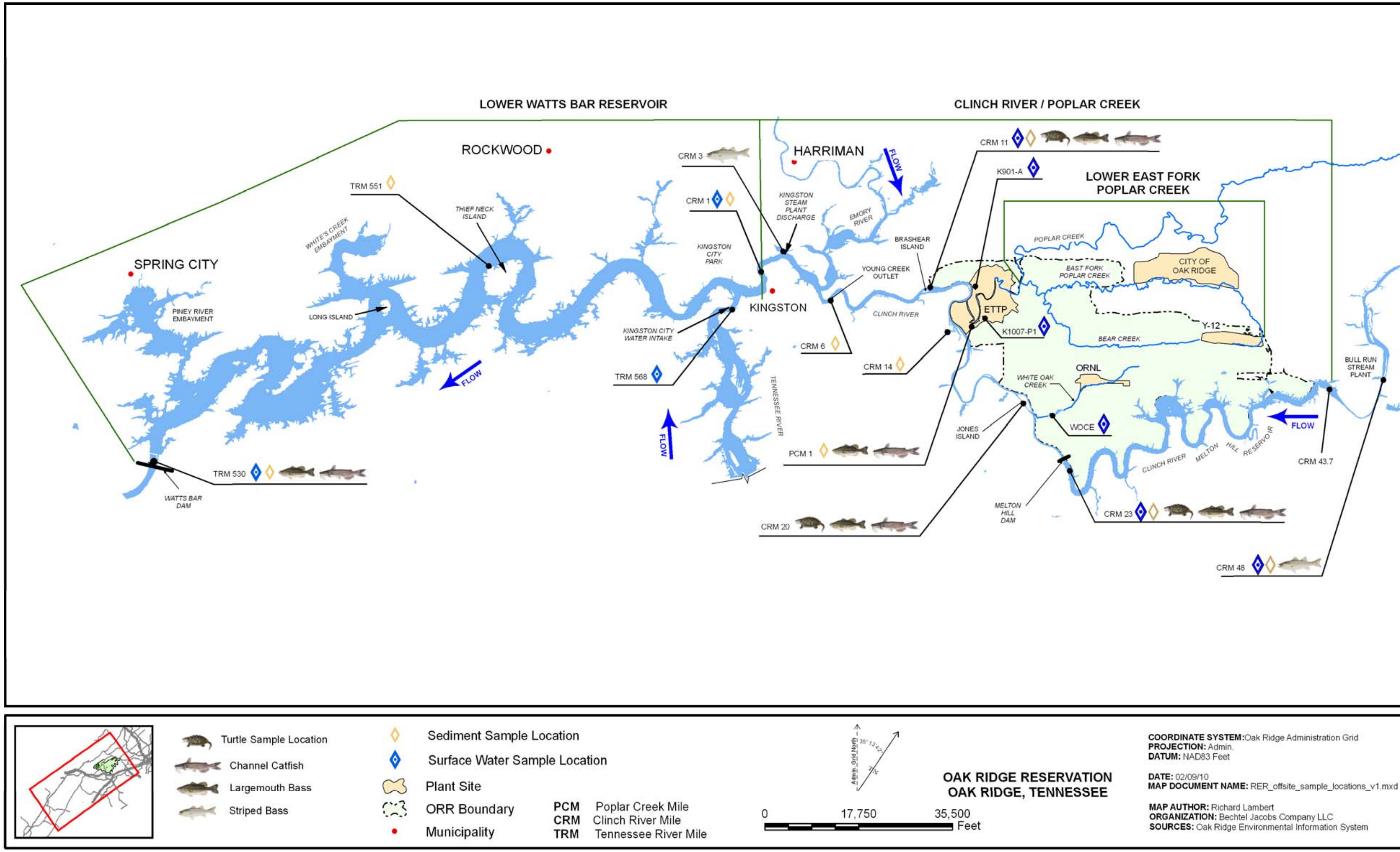

Figure 7.5. Monitoring locations in the Clinch River/Poplar Creek and Lower Watts Bar Reservoir operable units.

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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 23.4–24.7, PCM 1, CRM 10.5–12, and CRM 19.7-20.7 (catfish and largemouth bass), annually, summer only	PCBs (catfish only), total mercury, ^{137}Cs (CRM 19.7–20.7 only), and total lipid
Bull Run Steam Plant effluent (CRM 48), Kingston Steam Plant effluent (CRM 3) (striped bass), winter only	PCBs and total lipid
Turtles: CRM 23.4–24.7, CRM 19.7–20.7, and CRM 10.5–12, 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
PCB = polychlorinated biphenyls
PCM = Poplar Creek mile
TAL = target analyte list
WOCE = White Oak Creek Embayment

Fish consumption advisories are issued by the Tennessee Department of Environment and Conservation http://www.tn.gov/twra/fish/contaminants.html/ The basis of the advisories can be Food and Drug Administration limits or Environmental Protection Agency or state risk calculations. Tennessee Department of Environment and Conservation has issued the following:

- East Fork of Poplar Creek including Poplar Creek embayment, from the mouth to New Hope Pond (replaced by Lake Reality) (in Y-12) for mercury and PCBs for no fish consumption and also to avoid contact with water.

- Clinch River arm of Watts Bar Reservoir for PCBs for no consumption of striped bass and a precautionary advisory for catfish and sauger.[1]

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 Tennessee Wildlife Resources Agency's annual fishing regulations.

7.3.2 Evaluation of Performance Data

The selected remedy identified in the *Record of Decision for the Clinch River/Poplar Creek Operable Unit* (DOE 1997) is still in place and effective. Institutional controls prevent exposure to contaminated sediment

[1]A precautionary advisory is for children, pregnant women and nursing mothers that they should not consume the named fish species, and all other persons should limit consumption of the named species to one meal per month.

[via the Watts Bar Interagency Working Group]; fish consumption advisories are issued by Tennessee Department of Environment and Conservation; 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 2011 monitoring for Poplar Creek and the Clinch River arm of Watts Bar Reservoir are provided in Table 7.4. PCB concentrations in channel catfish are comparable to those observed in 2010 at most sites and remain substantially lower than concentrations observed during the 1980s and 1990s (Figure 7.6). PCB concentrations in Clinch River channel catfish have been trending downward for more than a decade, although there is substantial year-to-year variability. PCBs in channel catfish from Poplar Creek are similarly variable (Figure 7.6). The influence of PCB flux in the Poplar Creek/East Fork Poplar Creek drainage, which has historically been evident in higher PCB concentrations in catfish at Poplar Creek mile 1, was again evident in 2011. The highest mean PCB concentration in catfish of all sites monitored was again found in Poplar Creek. PCB levels in striped bass at Clinch River mile 3 were lower than at Clinch River mile 48, likely because, as in previous years, the fish encountered at Clinch River mile 3 were significantly smaller in 2011 (mean weight 5429 g) than at Clinch River mile 48 (mean weight 9283 g). These concentrations were comparable to values seen in recent years, and within the range of normal inter-annual variation observed at these sites. TDEC typically issues fish consumption advisories in water where fish exceed 0.8-1.0 ppm PCBs. Concentrations in striped bass from Melton Hill Reservoir and the Clinch River portion of Watts Bar Reservoir continue to be high enough to be of concern relative to human consumption.

Mean mercury concentrations exceeded the Environmental Protection Agency fish tissue-based recommended water quality criterion (0.3 µg/g) in catfish and largemouth bass from Poplar Creek mile 1 and in largemouth bass from Clinch River mile 11 (Table 7.4). Levels of ^{137}Cs were below analytical detection limits in all fish collected from the sample site downstream of Oak Ridge National Laboratory.

7.3.3 Performance Summary

Performance monitoring of the Clinch River and Poplar Creek continues to indicate a downward trend in fish PCB concentrations since the late 1980s. PCBs in channel catfish are below the fish advisory levels in most years in the Clinch River, but have been at or near the advisory limits in the last couple of years in Poplar Creek. Striped bass are routinely above 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 the highest levels in fish in Poplar Creek and lower levels with distance downstream. Overall, the performance monitoring has been successful in addressing the record of decision 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 2011[a]

Monitoring location		Total PCBs (µg/g)		Mercury (µg/g)		Cs-137 (pCi/g)
Site	**Description**	**Channel catfish**	**Striped bass**	**Largemouth bass**	**Channel catfish**	**Channel catfish**
Clinch River						
CRM 20	Jones Island downstream of WOC	0.18 ± 0.03		0.25 ± 0.02	0.07 ± 0.02	< 0.07
CRM 11	Brashear Island downstream of Poplar Creek	0.14 ± 0.02		0.39 ± 0.06	0.10 ± 0.01	
CRM 3	Kingston Steam Plant discharge		1.21 ± 0.34			
Poplar Creek						
PCM 1	Near K-1007-P1 outlet	0.48 ± 0.04		0.51 ± 0.08	0.36 ± 0.04	
LWBR						
TRM 530	Watts Bar Reservoir forebay	0.24 ± 0.15		0.17 ± 0.02	0.21 ± 0.04	
Reference sites (upstream of CR/PC-LWBR)						
CRM 48	Bull Run Steam Plant (Melton Hill Reservoir)		1.65 ± 0.41			
CRM 23	Melton Hill Reservoir forebay	0.08 ± 0.01		0.17 ± 0.03	0.05 ± 0.01	

CRM = Clinch River mile
CR/PC = Clinch River/Poplar Creek
LWBR = Lower Watts Bar Reservoir
PCB = polychlorinated biphenyls
PCM = Poplar Creek mile
TRM = Tennessee River mile
WOC = White Oak Creek

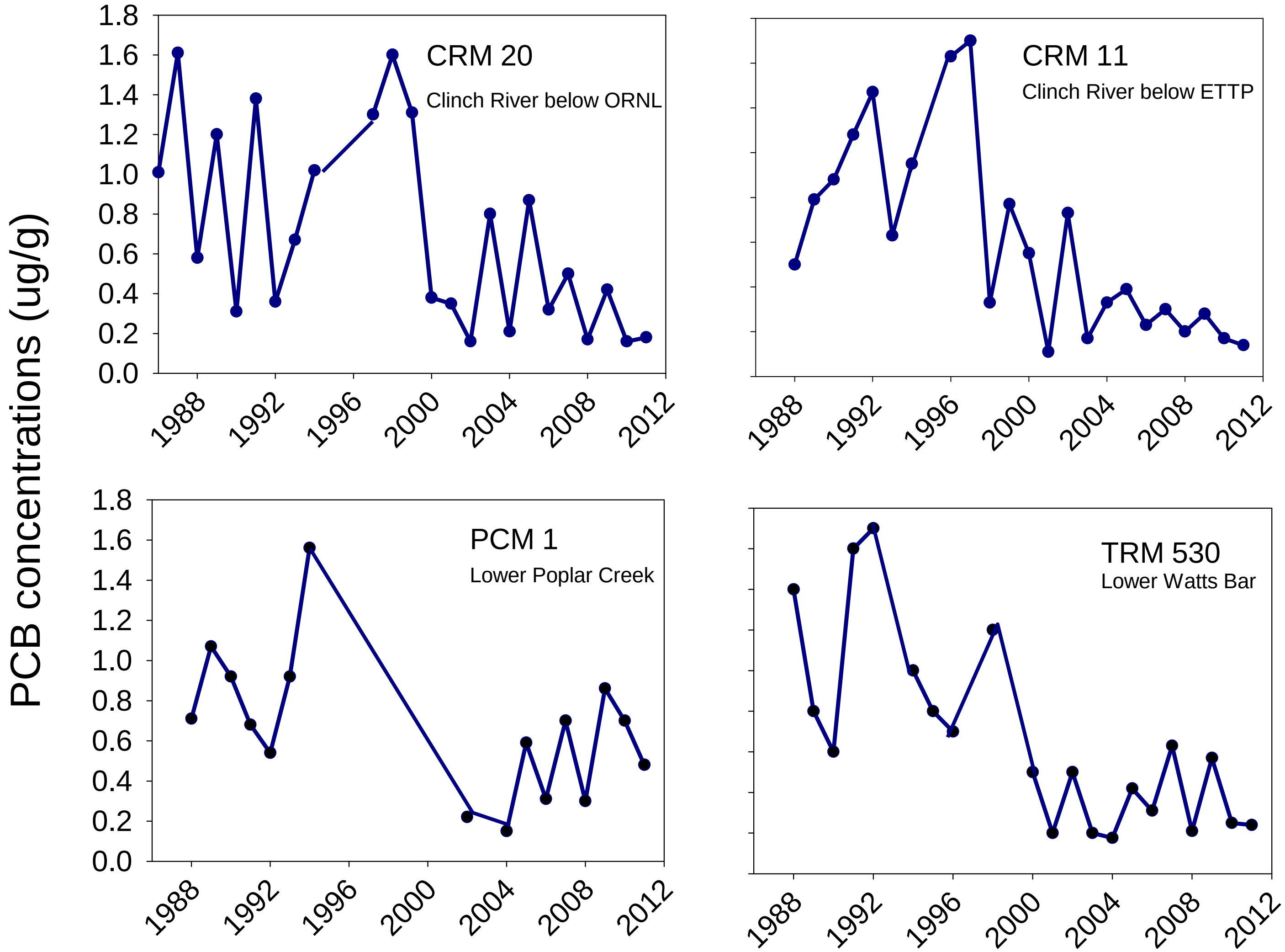

Figure 7.6. Average polychlorinated biphenyl concentrations in channel catfish from Clinch River/Poplar Creek and LWBR sites, 1986–2011.
(Courtesy of multiple programs in the early years, including Biological Monitoring and Abatement program, ASER, and Tennessee Valley Authority, 1986–2003).

7.3.4 Facility Operations and Land Use Controls

7.3.4.1 Requirements

Requirements specified in the *Remedial Action Report for Clinch River/Poplar Creek* (DOE 1999a) include institutional controls (Table 7.2) for the Clinch River/Poplar Creek and Lower Watts Bar Reservoir:

- continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish.
- continued scrutiny of sediment-disturbing activities in Lower Watts Bar Reservoir by the Watts Bar Interagency Working Group, comprised of Tennessee Department of Environment and Conservation, Tennessee Valley Authority, Army Corps of Engineers, and Department of Energy, to prevent exposure to potentially contaminated dredged soil.
- conduct of a survey of irrigation practices.
- determination of the effectiveness, i.e., awareness, of fish consumption advisories.

7.3.4.2 Status of Requirements

TDEC, Division of Water Pollution Control, maintains fish consumption advisories for the local area. The Tennessee Water Resources Agency posts these advisories on their web site, and it was last updated in August 2008. These same advisories are included in the Tennessee Wildlife Resources Agency's 2011 Tennessee Fishing Guide that is available on-line and where fishing licenses are sold.

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 2007b). 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.

After the Tennessee Valley Authority ash spill, the Tennessee Wildlife Resources Agency advised until further notice that fishing should be avoided in the lower section of the Emory River (Figure 7.5). The Emory River was reopened to navigation on May 29, 2010. Tennessee Wildlife Resources Agency, along with Tennessee Department of Environment and Conservation, urged the public to follow the fishing advisory for the lower Clinch River that existed prior to the ash spill. In the Clinch River arm of Watts Bar, there is a fish consumption advisory against eating striped bass and a precautionary advisory for catfish and sauger. A precautionary advisory means that children, pregnant women and nursing mothers should not consume the fish species named. All other persons should limit consumption of the named species to one meal per month. Given the data generated to date, Tennessee Department of Environment and Conservation feels the existing fishing advisory is protective of public health. The state will continue to monitor the levels of contaminants in fish tissue and will inform the public if current conditions change.

7.3.5 Clinch River/Poplar Creek Recommendations

No Clinch River/Poplar Creek changes are recommended.

7.4 LOWER WATTS BAR RESERVOIR

7.4.1 Performance Goals and Monitoring Objectives

The Lower Watts Bar Reservoir operable unit extends 38 river miles from Tennessee River mile 567.5, at the mouth of the Clinch River, downstream to the Watts Bar Reservoir dam at Tennessee River mile 529.9 (Figure 7.5).

The original post-Record of Decision monitoring plans for the action are in the *Remedial Action Work Plan for Lower Watts Bar Reservoir* (DOE 1996). As discussed in Section 7.3.1, monitoring requirements for the Lower Watts Bar Reservoir are included with requirements for Clinch River/Poplar Creek in a *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units* (DOE 2004).

The overall goal of the remedy for Lower Watts Bar Reservoir 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 *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units* (DOE 2004) and summarized in Table 7.5.

Table 7.5. Monitoring locations in Lower Watts Bar Reservoir

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 530–532 (catfish and large mouth bass), annually, summer only	PCBs, total mercury, and total lipid

[a]Analyses listed are those required to monitor effectiveness.
[b]Sampling takes place the year before the Five Year Review, e.g., Fiscal Year 2010 for the 2011 Five-Year Review.

PCB = polychlorinated biphenyl
TAL = target analyte list
TRM = Tennessee River mile

Fish consumption advisories are issued by the TDEC at the web sitehttp://www.tn.gov/twra/fish/contaminants.html/. The basis of the advisories can be Food and Drug Administration limits or Environmental Protection Agency or State risk calculations. TDEC has issued the following:

- Watts Bar Reservoir (Roane, Meigs, Rhea and Loudon) for PCBs for no consumption of catfish, striped bass, and hybrid (striped bass-white bass). Precautionary advisory for white bass, sauger, carp, smallmouth buffalo and largemouth bass.

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 Tennessee Wildlife Resources Agency's annual fishing regulations.

7.4.2 Evaluation of Performance Monitoring Data

Performance monitoring in Lower Watts Bar Reservoir has primarily focused on the *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units* (DOE 2004) requirements to evaluate changes in fish contaminant levels. These trending results are directly related to the Record of Decision 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 Record of Decision 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 in 2011 averaged 0.24 µg/g in channel catfish (Table 7.4). In general, Tennessee Department of Environment and Conservation has issued fish consumption advisories when PCB levels in fish are approximately 0.8 to 1 µg/g (or higher). PCB concentrations in channel catfish have remained below the advisory level since 1998. The current levels are substantially lower than the concentrations observed in the 1980s and 1990s when the advisories were first issued (Figure 7.6).

Mercury concentrations in fish from Lower Watts Bar Reservoir are also low, averaging equal to or less than 0.21 µg/g depending on species (Table 7.4). This level is less that the Environmental Protection Agency fish tissue-based recommended water quality criterion of 0.3 µg/g. Mercury concentrations in the 0.2 µg/g range are typical of largemouth bass and channel catfish in Tennessee reservoirs.

7.4.3 Performance Summary

Performance monitoring results from Lower Watts Bar Reservoir obtained during FY 2011 continue to indicate that mercury and PCB levels in fish are below commonly-used fish advisory levels.

7.4.4 Facility Operations and Land Use Controls

7.4.4.1 Requirements

The *Remedial Action Work Plan for Lower Watts Bar Reservoir* (DOE 1996) requires institutional controls (Table 7.2), including continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish and continued scrutiny of sediment-disturbing activities in Lower Watts Bar Reservoir by the Watts Barr Interagency Working Group to prevent exposure to potentially contaminated dredged soil.

7.4.4.2 Status of Requirements

TDEC, Division of Water Pollution Control, maintains fish consumption advisories for the local area. The Tennessee Wildlife Resources Agency posts these advisories on their web site and it was last updated in August 2008. These same advisories are also published in the Tennessee Wildlife Resources Agency's 2011 Tennessee Fishing Guide that are available on-line and where fishing licenses are sold.

The Watts Bar Interagency Working Group provided continued controls on sediment-disturbing activity in the deep-water channel. In FY 2011, eleven dredging permit applications were received and approved.

A review of the efficacy of institutional controls preventing sediment exposure and the effectiveness of the fish consumption advisory was provided in the *2011 Third Reservation-wide CERCLA Five-Year Review* (DOE 2011). 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.

After the Tennessee Valley Authority ash spill, the Tennessee Wildlife Resources Agency and TDEC urged the public to follow the fishing advisory for Watts Bar that existed prior to the ash spill. In the Tennessee River portion of Watts Bar there is a fish consumption advisory against eating striped bass, catfish, and hybrid (striped bass-white bass), and a precautionary advisory for white bass, sauger, carp, smallmouth buffalo, and largemouth bass. A precautionary advisory means that children, pregnant women and nursing mothers should not consume the fish species named. All other persons should limit consumption of the named species to one meal per month. Given the data generated to date, TDEC feels the existing fishing advisory is protective of public health. The state will continue to monitor the levels of contaminants in fish tissue and will inform the public if current conditions change.

7.4.5 Lower Watts Bar Reservoir Recommendations

No Lower Watts Bar Reservoir changes are recommended.

7.5 OFF-SITE 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
2012 Current Issue			
None.			
Issue Carried Forward			
None.			
Completed/Resolved Issues[b]			
None.			

[a] A "Current Issue" is an issue identified during evaluation of FY 2011 data for inclusion in the 2012 Remedial Effectiveness Report. An "Issue Carried Forward" is an issue identified in a previous year's Remedial Effectiveness Report or Five-Year Review 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. (2006 Five-Year Review).

7.6 REFERENCES

DOE 1995a. *Record of Decision for the Lower Watts Bar Reservoir Operable Unit, Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/02-1373&D3, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1995b. *Record of Decision for Lower East Fork Poplar Creek, Oak Ridge, Tennessee,* DOE/OR/02-1370&D2, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 1996. *Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee*, DOE/OR/02-1376&D3, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE 1997. *Record of Decision for the Clinch River/Poplar Creek Operable Unit, Oak Ridge, Tennessee,* DOE/OR/02-1547&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1999a. *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee,* DOE/OR/02-1627&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 1999b. *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&D1, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2000. *Remedial Action Report on the Lower East Fork Poplar Creek Project, Oak Ridge, Tennessee*, DOE/OR/01-1680&D5, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2002. *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, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2003. *2003 Remediation Effectiveness Report for the U. S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, DOE/OR/01-2058&D2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2004. *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&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007a. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007b. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2289&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2008. *2008 Remedial Effectiveness Report for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee, Volume 2: Data and Evaluations*, DOE/OR/01-2366&D2/V2, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Southworth, GR, MJ Peterson, WK Roy, and TJ Mathews. 2011. *Monitoring Fish Contaminant Responses to Abatement Actions: Factors that Affect Recovery*. Environmental Management 47:6: 1064-1076.

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8. CERCLA ACTIONS AT 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 process. Table 8.1 lists the CERCLA actions at ETTP, and Figure 8.1 locates the key CERCLA sites and remedial actions. In subsequent sections performance goals and objectives, monitoring results, and an assessment of the effectiveness of each completed action are discussed. Only sites that have performance monitoring and/or long-term stewardship requirements (Table 8.1) are included in these performance evaluations. Remedial action objectives that form the basis for the remedial actions are based on the end uses in Figure 8.2. The long-term stewardship requirements associated with these end uses are listed in Table 8.2.

Completed CERCLA actions at ETTP are gauged against their respective actions 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. 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 and, therefore, several surface water integration points (Figure 8.1). The collected data provides a preliminary evaluation of the early indicators of effectiveness for each subwatershed.

For remedial action purposes, ETTP is divided into zones. Zone 1 comprises approximately 1400 acres outside the fenced main plant area, and Zone 2 comprises approximately 800 acres of the main plant area. The remainder of the site, which encompasses approximately 2800 acres surrounding Zones 1 and 2, is primarily uncontaminated and is part of DOE's planned footprint reduction. Figure 8.2 illustrates the end uses and interim controls identified in the *Record of Decision for Interim Actions in Zone 1* (DOE 2002a) and *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (DOE 2005a).

To date, most 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 releases to exit pathways from ETTP, the goals of many of these actions have not included specific, measurable performance criteria for reductions in flux or risk in surface water and groundwater at the watershed scale. More recent watershed-scale decisions (DOE 2002a; DOE 2005a) 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 and sediments, and ecological receptors will be evaluated and addressed by future CERCLA decision(s).

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 8 of Volume 1 of the *2007 Remedial Effectiveness Report* (DOE 2007a). This information is updated in the annual Remediation Effectiveness Report and republished every fifth year at the time of the CERCLA Five-Year Review.

Table 8.1 CERCLA actions at the East Tennessee Technology Park

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility OPS / LUCs required	RER section
Watershed-scale actions				
Zone 1 Interim Remedial Actions	ROD (DOE/OR/01-1997&D2): 11/08/02	PCCRs complete or in progress		
		• Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2) approved 04/03/06.	No/No/Yes	8.2
		o Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2/A1/R2) approved 02/28/11.	No/No/Yes	
		• K-1007 Ponds/Powerhouse PCCR (DOE/OR/01-2294&D2) approved 10/04/06.	No/No/Yes	
		o K-1007 Ponds/Powerhouse PCCR (DOE/OR/01-2294&D2/A1) submitted 06/29/10.		
		o K-1007 Ponds/Powerhouse PCCR (DOE/OR/01-2294&D2/A2) submitted 06/20/11		
		• K-770 Scrap Removal PCCR (DOE/OR/01-2348&D1) approved 05/30/07.	No/No/Yes	
		o K-770 Scrap Removal PCCR Addendum (DOE/OR/01-2348&D1/A1) approved 12/03/10.	No/No/No	
		• FY 2008 PCCR for Units Z1-01, Z1-03, Z1-38, Z1-49 (DOE/OR/01-2367&D2) approved 04/23/08.	No/No/Yes	
Zone 2 Soil, Buried Waste, and Subsurface Structure Interim remedial actions	ROD (DOE/OR/01-2161&D2): 04/19/05	PCCRs complete or in progress		
		• FY 2006 PCCR for Zone 2 (DOE/OR/01-2317&D2) approved 02/08/07.	Yes/No/Yes	8.3
		• FY 2007 PCCR for Zone 2 (DOE/OR/01-2723&D2) approved 06/09/08.	No/No/Yes	
		• FY 2008 PCCR for EU Z2-33 in Zone 2 (DOE/OR/01-2368&D2/R1) approved 09/28/09.	No/No/Yes	
		o FY 2008 PCCR for EU Z2-33 in Zone 2 - Erratum (DOE/OR/01-2368&D2/R2 approved 12/16/09.		
		• FY 2009 PCCR for EU Z2-36 in Zone 2 (DOE/OR/01-2399&D1) approved 06/03/09.	No/No/Yes	
		• FY 2009 PCCR for Zone 2 EUs 11, 12, 17, 18, 29, 38 (DOE/OR/01-2415&D2) approved 04/02/10.	No/No/Yes	
		• FY 2010 PCCR for EU Z2-31 in Zone 2	No/No/Yes	

Table 8.1. CERCLA actions at the East Tennessee Technology Park (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility OPS / LUCs required	RER section
		(DOE/OR/01-2443&D2) approved 10/22/10.		
		• FY 2010 PCCR for EU Z2-32 in Zone 2 (DOE/OR/01-2452&D1) approved 04/08/10.	No/No/Yes	
Single-project actions				
K-1417-A/B Drum Storage Yards remedial action[b]	ROD (DOE/OR-991&D1): 09/19/91	RA complete	No/No/No	--
		• RAR (Letter) approved 03/02/95.		
K-1070-C/D SW-31 Spring remedial action [b]	IROD (DOE/OR-1050&D2): 09/30/92 ESD (DOE/OR/02-1132&D2): 07/08/93	RA complete.		
		• Remedial Action Effectiveness Report (RAER) (DOE/OR/01-1520&D1) approved 12/11/96.	Yes/No/No[c]	--
		o Addendum (DOE/OR/01-1520&D1/R1/A1) to RAER to terminate action approved 02/28/07.		
K-1407-B/C Ponds remedial action[b]	ROD (DOE/OR/02-1125&D3): 09/30/93	RA complete	Yes/Yes/Yes	8.4.1
		• Also, closed under RCRA.		
		• RAR (DOE/OR/01-1371&D1) approved 08/16/95.		
K-1401 and K-1420 Sumps Removal Action[b]	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)	Removal action complete.	No/No/No	--
		• RmAR (DOE/OR/01-1754&D2) approved 02/01/99.		
		o Addendum to RmAR (DOE/OR/01-1754&D2/A1) to terminate operation approved 04/21/06.		
K-1070-C/D and Mitchell Branch Removal Action[b]	AM (DOE/OR/02-1611&D2): 08/25/97	Removal action complete	Terminated[d]	--
		• RmAR (DOE/OR/01-1728&D3) approved 03/02/99.		
		• Approval to terminate operation of non-cost effective system 12/17/04.		
K-901-A and K-1007-P Pond Removal Action	AM (DOE/OR/02-1550&D2): 10/15/97	Removal action complete	Superseded	8.4.2
		• RmAR (DOE/OR/01-1767&D2) approved 11/12/99.		
K-1070-C/D G-Pit and Concrete Pad remedial action[b]	ROD (DOE/OR/02-1486&D4): 01/23/98	RA complete	No/Yes/Yes	8.4.3
		• RAR (DOE/OR/01-1964&D2) approved 10/15/03.		
		• Completion letter (waste) approved 10/29/03.		
K-1070-A Burial Ground remedial action[d]	ROD (DOE/OR/01-1734&D3): 01/13/00	RA complete	No/No/No	8.4.4
		• RAR (DOE/OR/01-2090&D1) approved 11/28/03.		
K-1085 Old Firehouse Burn Area	AM (DOE/OR/01-1938&D1): 03/27/01	Removal action complete		

Table 8.1. CERCLA actions at the East Tennessee Technology Park (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility OPS / LUCs required	RER section
Drum Burial Site Removal Action [b]		• RmAR (DOE/OR/01-2050&D1) conditionally approved 02/18/03.	No/No/No	--
		• Completion Letter approved 01/19/07.		
Outdoor LLW Removal Action	AM (DOE/OR/01-2109&D1): 11/14/03	Removal action complete		
		• RmAR (DOE/OR/01-2225&D2) approved 08/24/05.	No/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)	• RmAWP (DOE/OR/01-2359&D2) approved 01/09/09.	Yes/Yes/Yes	8.4.2
		• Addendum to the RmAWP (DOE/OR/01-2359&D2/A1) approved 08/16/10.		
		• RmAR (DOE/OR/01-2456&D1/R1) approved 03/10/11 (supersedes DOE/OR/01-1767&D2)	Yes/Yes/Yes	
Mitchell Branch Chrome Reduction removal action	AM (DOE/OR/01-2369&D1): 12/20/07 (Reduction of Hexavalent Chromium Releases to Mitchell Branch Time-Critical RA) [b] 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).	• Removal action ongoing (water collection and treatment).	Yes/Yes/No	8.4.5
		• RmAR (DOE/OR/01-2384&D1) submitted 07/30/08; review and approval suspended 10/09/08. [e]		
		• RmAWP (DOE/OR/01-2484&D1) approved 11/17/10. Start-up phase of treatment system to reduce hexavalent chromium to trivalent chromium in progress.		
Demolition projects				
K-25 Auxiliary Facilities Group I Building Demolition removal action [b]	AM (DOE/OR/02-1507&D2): 01/17/97	Removal action complete		
		• RmAR (DOE/OR/01-1829&D1) issued August 1999.	No/No/No	--
		o Addendum I (DOE/OR/01-1829&D1/A1) approved 06/02/05.		
		o Addendum II (DOE/OR/01-1829&D1/A2) approved 06/05/06.		
K-29, K-31, and K-33 Equipment Removal and Building Decontamination removal action [b]	AM (DOE/OR/02-1646&D1): 09/30/97	Removal action complete		
		• RmAR (DOE/OR/01-2290&D3) approved 06/08/07.	No/No/No	--
		o Addendum (DOE/OR/01-2290&D3/A1) submitted 09/26/07; EPA approved 01/25/08; TDEC conditionally approved 11/01/07.		
		o Addendum (DOE/OR/01-2290&D3/A2) approved 03/16/09.		
K-25 Auxiliary Facilities Group II,	AM (DOE/OR/01-1868&D2): 08/03/00	Removal action complete		

Table 8.1. CERCLA actions at the East Tennessee Technology Park (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility OPS / LUCs required	RER section
Phase I Building Demolition, Main Plant removal action[b]		• RmAR (DOE/OR/01-2116&D2) approved 09/24/04.	No/No/Yes	--
K-25 and K-27 Buildings Demolition removal action[b]	AM (DOE/OR/01-1988&D2): 02/13/02 NSC (DOE/OR/01-2259&D1): 12/16/05	Removal action in progress	No/No/No	--
		• PCCR (DOE/OR/01-2275&D1) for Hazardous Materials Abatement conditionally approved 12/19/05.		
		• Completion of Hg ampoules disposal in accordance with the PCCR (DOE/OR/01-2275&D1) approved 03/17/06.		
		• Completion Letter, Disposition of Centrifuge and Y-12 Materials, Excess Materials Removal, K-25/K-27 D&D 06/30/08.		
		• PCCR for FY 2008 Earned Value (DOE/OR/2396&D2) approved 10/19/09.		
		o PCCR for FY 2008 Earned Value – Erratum (DOE/OR/01-2396&D2) submitted 10/30/09.		
		• PCCR for FY 2009 Earned Value (DOE/OR/01-2436&D2) approved 06/29/10.		
		• PCCR for Excess Material Removal (DOE/OR/01-2392&D3) submitted 03/30/11.		
		• PCCR for FY 2010 Earned Value (DOE/OR/01-2494&D2) approved 08/03/11.		
		• PCCR (K-25 East Wing Characterization, Foaming, NE Bridge) (DOE/OR/01-2538&D1) submitted 09/23/11.		
K-25 Auxiliary Facilities Group II, Phase II Building Demolition, K-1064 Peninsula Area removal action[b]	AM (DOE/OR/01-1947&D2): 07/31/02	Removal action complete		
		• RmAR (DOE/OR/2339&D1) approved 06/27/07.	No/Yes/Yes	8.5
		• PCCR, DOE/OR/01-2183&D1, approved 11/22/05.		
		• PCCR, DOE/OR/01-2184&D1/A1, approved 02/22/06		
		• PCCR, DOE/OR/01-2184&D1/A2, approved 09/30/06		
K-25 Group II, Phase 3 Building Demolition, Remaining Facilities removal action	AM (DOE/OR/01-2049&D2): 09/30/03	Removal action in progress		8.5
		• FY 2004 PCCR PUF (DOE/OR/01-2193&D2) approved 03/28/05.	No/No/No	

Table 8.1. CERCLA actions at the East Tennessee Technology Park (cont.)

CERCLA action	Decision document: date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility OPS / LUCs required	RER section
		• FY 2005 PCCR PUF (DOE/OR/01-2269&D2)[b] approved 02/15/06.	No/No/No	
		• FY 2005 PCCR LR/LC Facilities (DOE/OR/01-2270&D2) [b] approved 02/15/06.	No/No/No	
		• FY 2006 PCCR PUF (DOE/OR/01-2326&D2) [b]approved 11/05/09.	No/No/No	
		• FY 2006 PCCR LR/LC Facilities (DOE/OR/01-2327&D2)[b] approved 12/02/09.	No/Yes/Yes	
		• BOS D&D-Labs D&D PCCR (DOE/OR/01-2309&D2)[b]approved 08/30/07.	No/No/No[f]	
		• FY 2007 PCCR PUF (DOE/OR/01-2363&D2)[b] approved 06/25/08.	No/No/No	
		• FY 2007 PCCR LR/LC Facilities (DOE/OR/01-2362&D3)[b] approved 09/27/10.	No/Yes/Yes	
		• K-29 Process Building PCCR (DOE/OR/01-2336&D2)[b] approved 10/18/07.	No/YesYes	
		• K-1420 Decon & Recovery Facility PCCR (DOE/OR/01-2341&D2)[d] approved 10/26/07.	No/Yes/Yes	
		• Building K-1401 PCCR (DOE/OR/01-2365&D2)[b] approved 02/27/09.	No/No/No[h]	
		• Building K-1401 PCCR (DOE/OR/01-2365&D2/A1)[d] submitted 03/24/09.		
		• FY 2008 PCCR LR/LC Facilities (DOE/OR/01-2394&D1)[b] approved 03/13/09.	No/Yes/Yes	
		• FY 2008 PCCR PUF (DOE/OR/01-2395&D1)[b] approved 02/09/09.	No/No/No	
		• FY 2009 PCCR for LR/LC Facilities (DOE/OR/01-2434&D2)[b] approved 09/14/11.	No/Yes/Yes	
		• FY 2009 PCCR for PUF (DOE/OR/01-2435&D2)[d] approved 04/12/10.	No/No/No	
		• PCCR for Poplar Creek - 3High Risk Facilities (DOE/OR/01-2444&D2)[b] approved 07/28/10.	No/Yes/Yes	
		• PCCR (SW-31 Spring Transfer Line) (DOE/OR/01-2520&D1 submitted 06/22/11.		

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

Table 8.1. CERCLA actions at the East Tennessee Technology Park (cont.)

[b]Action completed, or to be completed, as defined/required in CERCLA decision document listed. However, site requires subsequent CERCLA decision/action, e.g., the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2005a).

[c]Collection and treatment of SW-31 Spring discharge is no longer required per addendum to the RAER. However, per the RAER, interim spring monitoring is required.

[d]See discussion of terminated action in FY 2007 Remediation Effectiveness Report, Volume 1, Chapter 8.

[e]EPA suspended review of the time-critical Removal Action Report on 10/09/08. This document will be superseded by a non-time critical action Removal Action Report.

[f]The Phased Construction Completion Report for the Group II, Phase 3 BOS-LABS D&D 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 long term stewardship of these sites is no longer reported in the Remediation Effectiveness Report.

[g]Although the Bldg. K-1401 Phased Construction Completion Report documents the building demolition and prescribes long-term stewardship requirements for the remaining slab, the K-1401 slab was removed in 2009 and long-term stewardship 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 Exposure Unit Z2-31 in Zone 2* (DOE 2010a), which was submitted to the regulators in August 2010 and is pending approval.

AM = Action Memorandum
BOS = Balance of Site
EUs = Exposure Units
IROD = Interim Record of Decision
LR/LC = low risk/low complexity
LTS = long-term stewardship
PCCR = Phased Construction Report
PUF = predominantly uncontaminated facilities
RAER = Remedial Action/Effectiveness Report
RAR = Remedial Action Report

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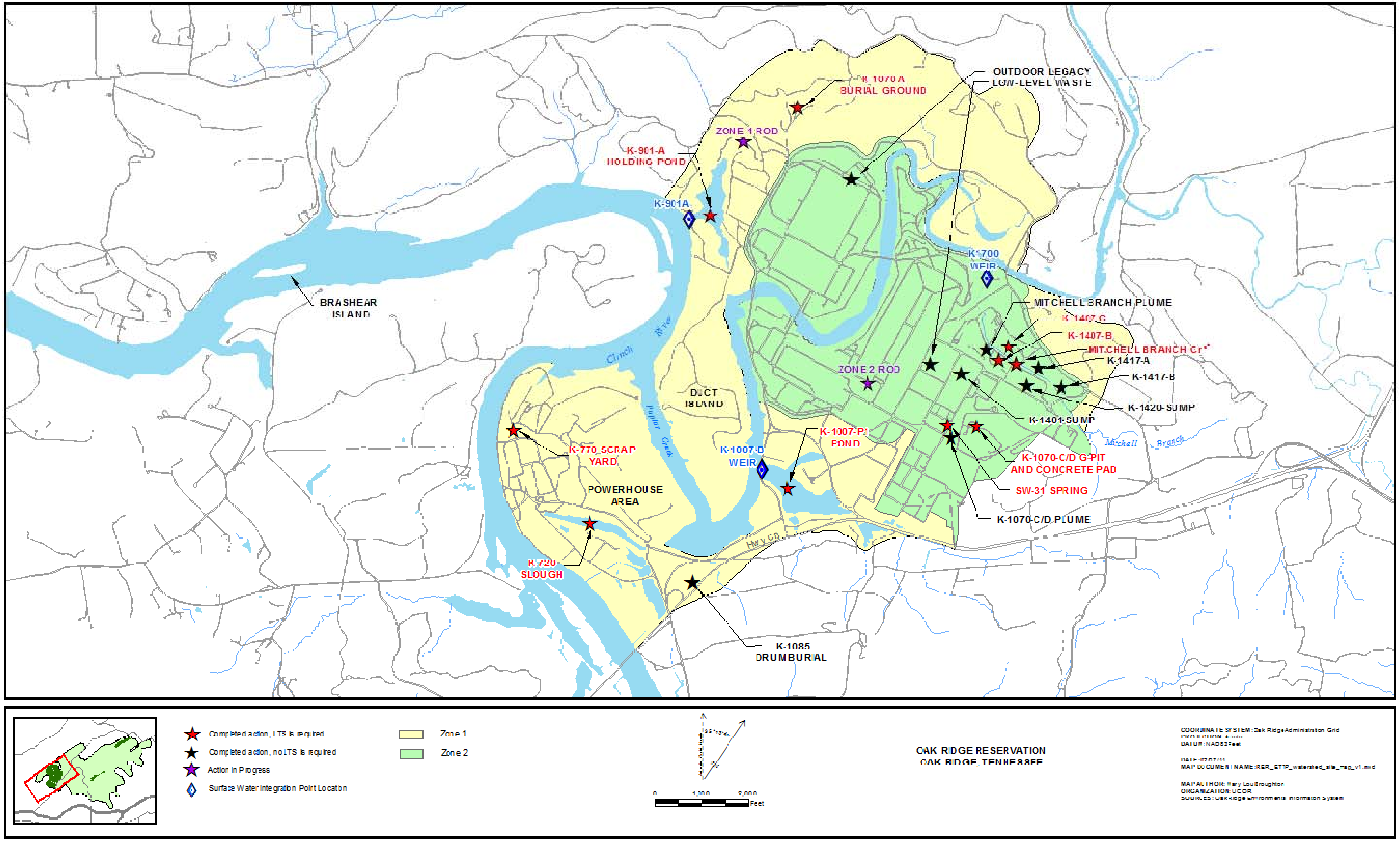

Figure 8.1. East Tennessee Technology Park.

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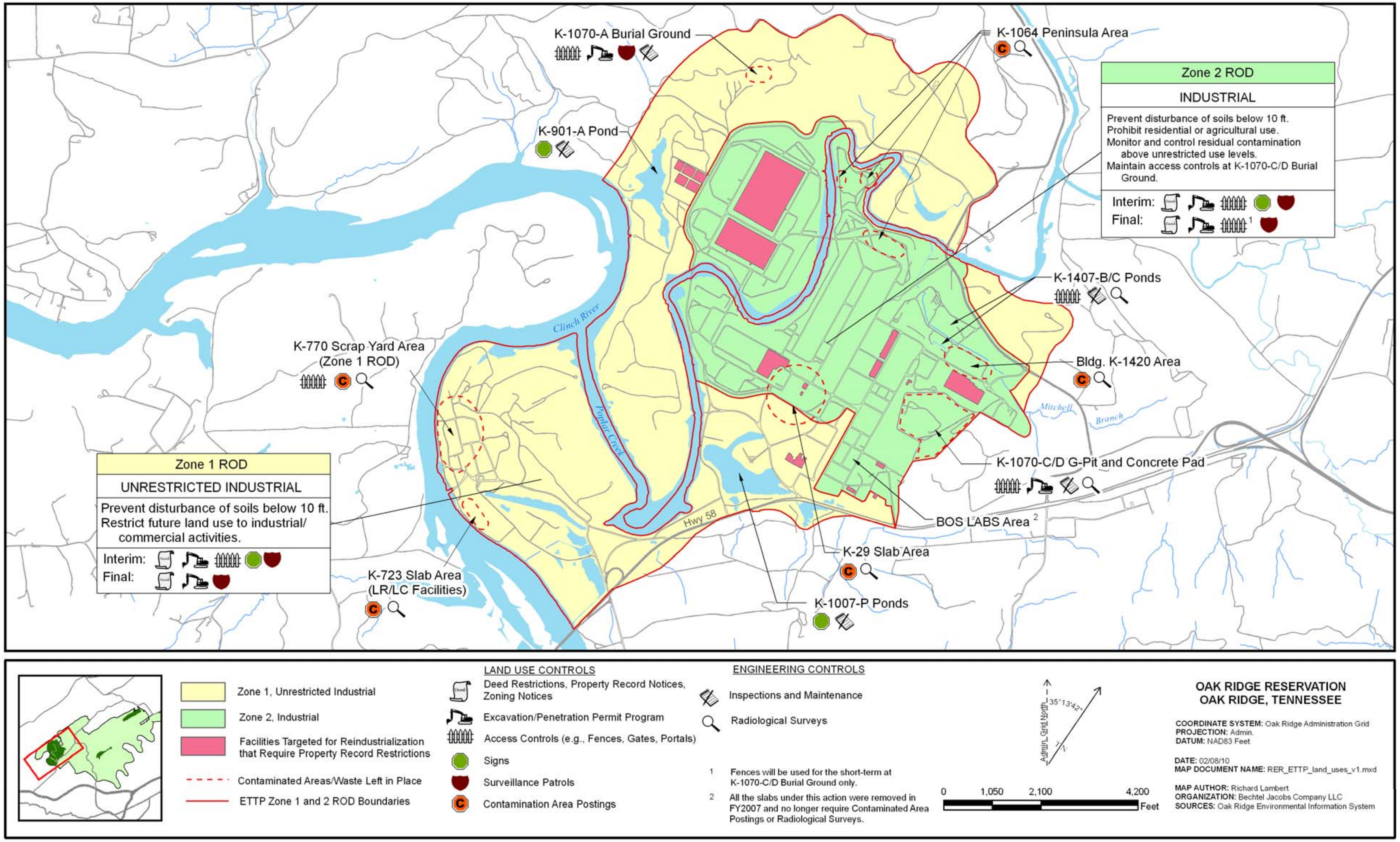

Figure 8.2. East Tennessee Technology Park Zones 1 and 2 Record of Decision-designated end uses and interim controls.

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Table 8.2. Long-term stewardship requirements for CERCLA actions at East Tennessee Technology Park

Site/Project	LTS requirements: LUCs	LTS requirements: Engineering controls	Status	RER section
Watershed-scale actions				
ROD for Interim Actions for Selected Contaminated Areas Within Zone 1, ETTP ▪ Duct Island/K-901 Area PCCR and Addendum ▪ K-1007 Ponds/Powerhouse PCCR and Addenda ▪ K-770 Scrap Removal PCCR and Addendum ▪ FY 2008 PCCR for EUs Z1-01, Z1-03, Z1-38, and Z1-49	Watershed LUCs Administrative: ▪ property record restrictions ▪ property record notices ▪ zoning notices ▪ permits program Physical: ▪ access controls ▪ signs ▪ security patrols K-770 PCCR specific: ▪ fencing ▪ Contamination area postings	K-770 PCCR specific: ▪ radiological surveys	Watershed LUCs ▪ Physical LUCs in place. ▪ Administrative LUCs required at completion of actions. K-770 PCCR specific: ▪ LUCs in place. ▪ Engineering controls remain protective.	8.2.1
ROD for Soil, Buried Waste and Subsurface Structure actions in Zone 2, ETTP ▪ FY 2006 PCCR ▪ FY 2007 PCCR ▪ FY 2008 PCCR ▪ FY 2009 PCCR ▪ FY 2010 PCCR	Watershed LUCs Administrative: ▪ property record restrictions ▪ property record notices ▪ zoning notices ▪ permits program Physical: ▪ access controls ▪ signs ▪ security patrols K-1070-C/D Burial Ground specific: ▪ access controls		Watershed LUCs ▪ Physical LUCs in place. ▪ Administrative LUCs required at completion of actions. ▪ Property record restrictions filed upon transfer of buildings in Zone 2. K-1070-C/D Burial Ground specific: ▪ LUCs in place.	8.3.3
Completed single-project actions				
K-1407-B/C Ponds remedial action	▪ Access and activity controls	S&M, including ▪ Periodic inspections ▪ Radiological and industrial hygiene surveillance	▪ LUCs in place. ▪ Engineering controls remain protective.	8.4.1.4
ETTP Ponds Removal Action	▪ Signs	▪ Maintain weir	▪ LUCs in place. Engineering controls remain protective.	8.4.2.5
K-1070-C/D G-Pit and Concrete Pad remedial action	▪ Fences ▪ EPP program	▪ Maintain vegetated soil cover on concrete pad ▪ Periodic radiological surveys	▪ LUCs in place. ▪ Engineering controls remain protective.	8.4.3.1

Table 8.2. Long-term stewardship requirements for CERCLA actions at East Tennessee Technology Park (cont.)

Site/Project	LTS Requirements		Status	RER section
	LUCs	Engineering controls		
K-1070-A Burial Ground	▪ Access controls ▪ EPP program ▪ Surveillance patrols	▪ Maintain soil cover	▪ LUCs in place. ▪ Engineering controls remain protective.	8.4.4.1
Mitchell Branch Chrome Reduction removal action	▪	▪ Operations and maintenance of collection and treatment system	▪ Engineering controls remain protective	8.4.5.4
Demolition Projects				
K-25 Auxiliary Facilities Group II, Phase 1 Building Demolition, Main Plant	▪ EPP program		▪ LUCs in place.	--
K-25 Auxiliary Facilities Group II, Phase 2 Building Demolition, K-1064 Peninsula Area	▪ Contamination area postings	▪ radiological surveys	▪ LUCs in place. ▪ Engineering controls remain protective.	8.5.1
K-25 Group II, Phase 3 Building Demolition, Remaining Facilities ▪ FY2006 PCCR-LR/LC Facilities ▪ BOS D&D-Labs PCCR[a] ▪ K-29 Process Building PCCR ▪ K-1420 Decon & Recovery Facility PCCR ▪ Bldg K-1401 PCCR[b] ▪ FY2008 PCCR-LR/LC Facilities ▪ FY2007 PCCR-LR/LC Facilities ▪ FY2009 PCCR-LR/LC Facilities ▪ Poplar Creek High Risk Facilities PCCR	▪ Contamination area postings	▪ radiological surveys	▪ LUCs in place. ▪ Engineering controls remain protective.	8.5.1

[a]All the slabs under this action were removed in FY 2007 and no longer require contamination area postings or radiological surveys.

[b]Although the Bldg. K-1401 Phased Construction Completion Report documents the building demolition and prescribes long-term stewardship requirements for the remaining slab, the K-1401 slab was removed in 2009 and long-term stewardship 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 2010a), which was approved October 2010.

BOS = balance of sites
EPP = excavation/penetration permit
ETTP = East Tennessee Technology Park
EUs = Exposure Units
LR/LC = low risk/low complexity
LTS = long-term stewardship
LUC = land use controls
PCCR = Phased Construction Completion Report
RER = Remediation Effectiveness Report
ROD = Record of Decision
S&M = surveillance and maintenance

8.1.2 Status

8.1.2.1 East Tennessee Technology Park Watershed-scale Actions

The *Record of Decision for Interim Actions in Zone 1* (Figure 8.2) (Zone 1 Interim ROD) (DOE 2002a) includes remedial actions for unrestricted industrial use to a depth of ten feet and for sources of groundwater contamination. Major components of the Zone 1 Interim ROD are:

- excavation of contaminated soil in the K-895 Cylinder Destruct Facility Area (EU-49) and in the Powerhouse Area (including K-725 Beryllium Building Slab) (EU-30);
- excavation of the Blair Quarry burial area (EU-77);
- removal of scrap metal and debris from the K-770 area (EU-27 through -33);
- removal of sludge and demolition of the K-710 sludge beds and Imhoff tanks (EU-26);
- characterization of areas with insufficient data to determine if a release occurred or if the potential for a release is present; and
- interim land use controls to prevent access to remaining contamination.

Zone 1 was divided into four geographic areas for evaluation for unrestricted industrial use to 10 feet below ground surface–the Duct Island Area, K-901 Area, K-1007 Ponds Area, and the Powerhouse Area. The characterization and final status assessments for these four geographic areas were conducted using Dynamic Verification Strategy (DOE 2007c). These four areas are further divided into Exposure Units (EUs) (Figure 8.3).

The status of the Zone 1 Interim ROD is summarized in Figure 8.3 and Table 8.3 and is discussed below. Remediation of the soil under the Zone 1 Interim ROD was completed.

- The *Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area* (DOE 2006a) documents the characterization results for 21 EUs and identifies areas that require remediation (EUs 1, 3, and 9). An additional eight EUs were addressed in an *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1, East Tennessee Technology Park* (DOE 2010b). It documents completion of characterization in EUs 11, 17 through 22, and 26, and of remediation in EU 26 (several small soil actions) and EU 9 (underground storage tanks and K-1085 soils) as recommended in the original Phased Construction Completion Report. A second *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area* (DOE 2011a) addressed EUs 27 through 33. In EUs 29, 30, 31, there is suspected to be buried asbestos-containing material, and a final decision on remediation will be deferred to the Zone 1 Final ROD. While awaiting that decision, there are land use controls for these three EUs.

  Water bodies within the EUs of the K-1007 Ponds Area and Powerhouse North Area comprise 9.2 acres and are addressed in Sect. 8.4.2.

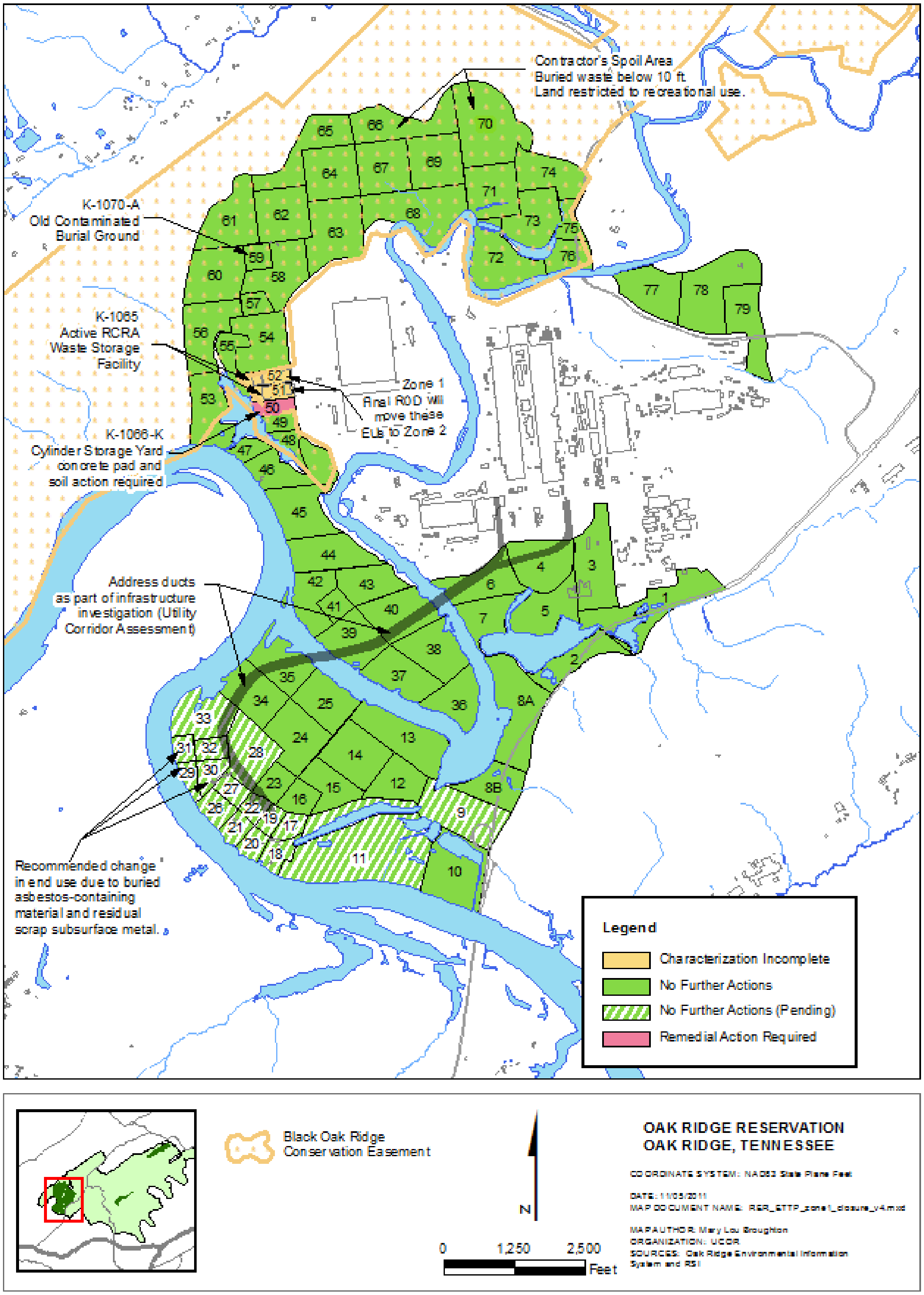


Figure 8.3. East Tennessee Technology Park Zone 1 status.

Table 8.3. East Tennessee Technology Park Zone 1 completion documents and Exposure Unit status

Fiscal Year of Completion Document	Evaluated		No Further Action		Remedial Action Required		Remedial Action Completed	Remedial Action Remaining
	# of EUs	# of Acres	# of EUs	# of Acres	# of EUs	# of Acres[a]	# of EUs	# of EUs
Zone 1 Totals (80 EUs, 1,341.5 acres)								
K-1007 Ponds and Powerhouse Areas (36 EUs, 579.2 acres)								
Duct Island and K-901 Areas (44 EUs, 762.3 acres[b])								
K-1007 Ponds and Powerhouse Area PCCR (FY2006)	21	396.5	18	318.5	3	78	0	3 (EU-1, 3, 9)
Duct Island and K-901 Area PCCR (FY2006)	39	686.8	37	662.2	2	24.6	0	2 (EU-38, 49)
FY2006 Totals	**60**	**1,083.3**	**55**	**980.7**	**5**	**102.6**	**0**	**5**
K-770 Scrap Removal Project PCCR (FY2007)[c]	-	-	-	-	-	-	-	-
FY2007 Totals	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PCCR for EU 1, 3, 38, 49 (FY2008)	-	-	4	77.3	-	-	4 (EU-1, 3, 38, 49)	1 (EU-9)
FY2008 Totals	**0**	**0**	**4**	**77.3**	**0**	**0**	**4**	**1**
FY2009 Totals	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
K-1007 Ponds and Powerhouse Area PCCR Addendum 1 (FY2010-Pending) EUs 9, 11, 17-22, 26	8[d]	117.2	9	142.6	1[d]	7.4	2 (EU-9, 26)	0
FY 2010 Totals	**8**	**117.2**	**9**	**142.6**	**1**	**7.4**	**2**	**0**
Duct Island and K-901 Area PCCR Addendum (FY 2011)[e]	5	71	4	66.2	1	4.8	0[e]	1 (EU-50)
K-770 Scrap Removal Project PCCR Addendum (FY2011)[f]	-	-	-	-	-	-	-	-
K-1007 Ponds and Powerhouse Area PCCR Addendum 2 (FY 2011-Pending) EUs 27, 29-33	**7**	**65.5**	**7**	**65.5**	**6**	**60.2**	**6 (EU-27, 29-33)**	**0**
FY 2011 Totals	**12**	**136.5**	**11**	**131.7**	**7**	**65**	**6**	**1**
As of 9/30/11	**80**	**1,337[g]**	**79**	**1,332.3**	**-**	**-**	**-**	**1**
Remaining for Evaluation	**0**	**0**	**EUs 50, 51, and 52 are being transferred to Zone 2**					

[a]Represents the sum of the acreages of all EUs in which a remedial action is required.
[b]4.5 acres of this total are pond and stream sediments and will be addressed in the final record of decision.
[c]Documents the removal and disposition of scrap metal and debris from EU-27 through 33. Soil removal remains.
[d]EU-9 was evaluated in FY 2006 and is not included in this total. EU-9 (25.4 acres) is however included in the No Further Action total (post-remedial action).
[e]The D2/A1 version of this PCCR includes the evaluation of EUs 50, 51, and 52 and documents the.K-1066-J and -K Yard wooden cylinder saddles remedial action in EU-50. However, the D2/A1/R1 version removes EUs 50, 51, and 52 from the PCCR and notes that the three EUs are being transferred to Zone 2. Documentation of the remedial action was removed in the D2/A1/R1 version as well. K-1066-K Yard PCB-contaminated debris and adjacent soil removal in EU-50 is still required. This remedial action will transfer to Zone 2 with the Final Zone 1

Table 8.3. East Tennessee Technology Park Zone 1 completion documents and Exposure Unit status (cont.)

Record of Decision. The totals shown on this line still include EUs 50, 51, and 52 so that the totals for Zone 1 will add up. Once the Final Zone 1 Record of Decision is approved, these totals will be adjusted to reflect the final number of Zone 1 EUs and acreage.

[f]Documents the transfer of cesium casks to complete the K-770 Scrap Removal Project.

[g]4.5 acres not included in this total are pond and stream sediments and will be addressed in the Final Zone 1 Record of Decision.

EU = exposure unit
FY = fiscal year
PCCR = Phased Construction Completion Report

- Completion of the K-770 Scrap Removal Project was documented in the *Construction Completion Report for the K-770 Scrap Removal Project* (DOE 2007d). During scrap removal, three cesium casks were discovered. The containerized casks were transported to ORNL in April 2006 for storage until final disposition planned for the Nevada Test Site. An Addendum to the Phased Construction Completion Report for the K-770 Scrap Removal Project (DOE 2010c) documents the transfer of responsibility of disposal of the three casks to waste management.

  Remediation of the K-770 Scrapyard Soil in EUs 27 through 33 was initiated in FY 2009 and continued in FY 2010 with the shipment of approximately 97,000 yd3 of soil to the EMWMF for disposal. Remediation of the K-770 Scrapyard Soil was 99% complete at the end of FY 2010.

- The *Phased Construction Completion Report for the Duct Island Area and K-901 Area* (DOE 2006b) documents completion of the remedial activities at Blair Quarry, describes the risk assessment evaluations performed and determinations made using Dynamic Verification Strategy, and identifies additional sites requiring remediation (EUs 38 and 49). An *Addendum to the Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1 East Tennessee Technology Park* (DOE 2009a) addresses five additional EUs (EUs 50, 51, 52, 66, and 70). The addendum documents Dynamic Verification Strategy results for these 5 EUs, the evaluation of a recreational end use for Contractor's Soil Area in EU-66 and 70, and the remedial action for the K-1066-J and –K Yard cylinder saddle (EU-50) and recommends EUs 50, 51, and 52 be removed from Zone 1 and transferred to Zone 2. A permitted Resource Conservation and Recovery Act storage facility is located on these three EUs and should not be characterized and remediated until the facility is closed.

- The FY 2008 *Phased Construction Completion Report for Exposure Units Z1-01, Z1-03, Z1-38, and Z1-49* (DOE 2008a) documents the remedial actions completed within each of the specified EUs as recommended in the *Phased Construction Completion Report for the Duct Island Area and K-901 Area* (DOE 2006b) (the Duct Island South soil mounds in EU 38 and the K-895 Cylinder Destruct Facility in EU 49) and the *Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1 at East Tennessee Technology Park* (DOE 2006a) (the Happy Valley Service Station in EU 1 and the K-1055 Gasoline/Diesel Station Tanks in EU 3).

- The *Fiscal Year 2009 Phased Construction Completion Report for Zone 2 Exposure Units 11, 12, 17, 18, 29, and 38* (DOE 2009b) received regulatory approval on April 2, 2010.

Work continued in FY 2011 to convert the Zone 1 Interim ROD to a final Record of Decision that will address groundwater, surface water, and ecological protection.

The *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (Zone 2 ROD) (DOE 2005a) includes remedial actions for unrestricted industrial use to a depth of 10 feet and for sources of groundwater contamination (Figure 8.2). Major components of the Zone 2 ROD are:

- Assess data sufficiency for each EU and supplement data as necessary to determine if remediation levels are exceeded. Verify all acreage in Zone 2 as compliant with soil remediation levels established by the Zone 2 ROD.

- Remove soil up to 10 feet in depth that exceeds remediation levels set to protect a future industrial worker; remove soils to bedrock, water table, or acceptable levels of contamination to protect underlying groundwater to maximum contaminant levels.

- Remove or decontaminate subsurface structures to average remediation levels met across an EU and maximum remediation levels met at any location to a depth of 10 feet.

- Remove the debris in the K-1070-B Burial Ground, regardless of depth, to minimize potential future impact to surface water; remove soil that exceeds remediation levels for protection of workers (upper 10 feet) or protection of groundwater (water table or bedrock).

- Remove the debris and soil in the K-1070-C/D Burial Ground that exceeds remediation levels for the protection of workers (upper 10 feet) or protection of groundwater (water table or bedrock).

- Implement land use controls to prevent exposure to residual soil 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). The characterization and final status assessments are conducted using Dynamic Verification System.

The status of the Zone 2 ROD is summarized in Figure 8.4 and Table 8.4 and discussed below. As shown in Table 8.4, there currently are 1EUs in Zone 2 that have been determined as No Further Action, with 8 EUs still requiring remedial action (EU-11, 12, 17, 28, 29, 38, 41, 42), and 17 EUs (EU-4-6, 13-16, 19-22, 25, 26, 30, 35, 39, and 40) remaining for evaluation.

- The *Fiscal Year 2006 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park* (DOE 2006c) addresses 108.8 acres in six EUs (2, 7, 9, 10, 27, and 42). Based on the results of Dynamic Verification Strategy, approximately 93.2 acres were recommended for No Further Action and two soil remedial actions were recommended in EU 42 (K-1004-J Underground Tanks Site Soil Excavation and K-1004-J Vaults Remedial Action).

- The *Fiscal Year 2007 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park* (DOE 2007e) addresses characterization of approximately 195.5 acres in 11 EUs (1, 3, 8, 23, 24, 28, 34, 37, 41, 43, and 44) and remedial actions for Balance Sites-Laboratories slabs and soil in EU 33; soil removal and backfilling of the K-1407 E&F Holding Ponds in EU 35; demolition of the ETTP Steam Plant (Building K-1501) in EU 36; soil excavation at the K-1407-C Soil Piles (EU 28); and excavation of soil surrounding the K-1071 Concrete Pad (EU 41). The backfilling of Building K-150l basement and two small adjacent pits in EU 36 also was described.

- The *Fiscal Year 2008 Phased Construction Completion Report for EU Z2-33* (DOE 2009c) addressed characterization of approximately 18 acres in EU 33 and remedial actions for Balance of Site Laboratories subgrade pits in EU 33, two small surface soil areas south of K-1004-J Laboratory in EU 42 [Remedial action identified in the *Fiscal Year 2006 Phased Construction Completion Report for the Zone 2* (DOE 2006c)], and the K-1006 Development Laboratory north sump..

- The *Fiscal Year 2009 Phased Construction Completion Report for EU Z2-36* (DOE 2009d) addresses characterization of approximately 15 acres, all of which are recommended for No Further Action.

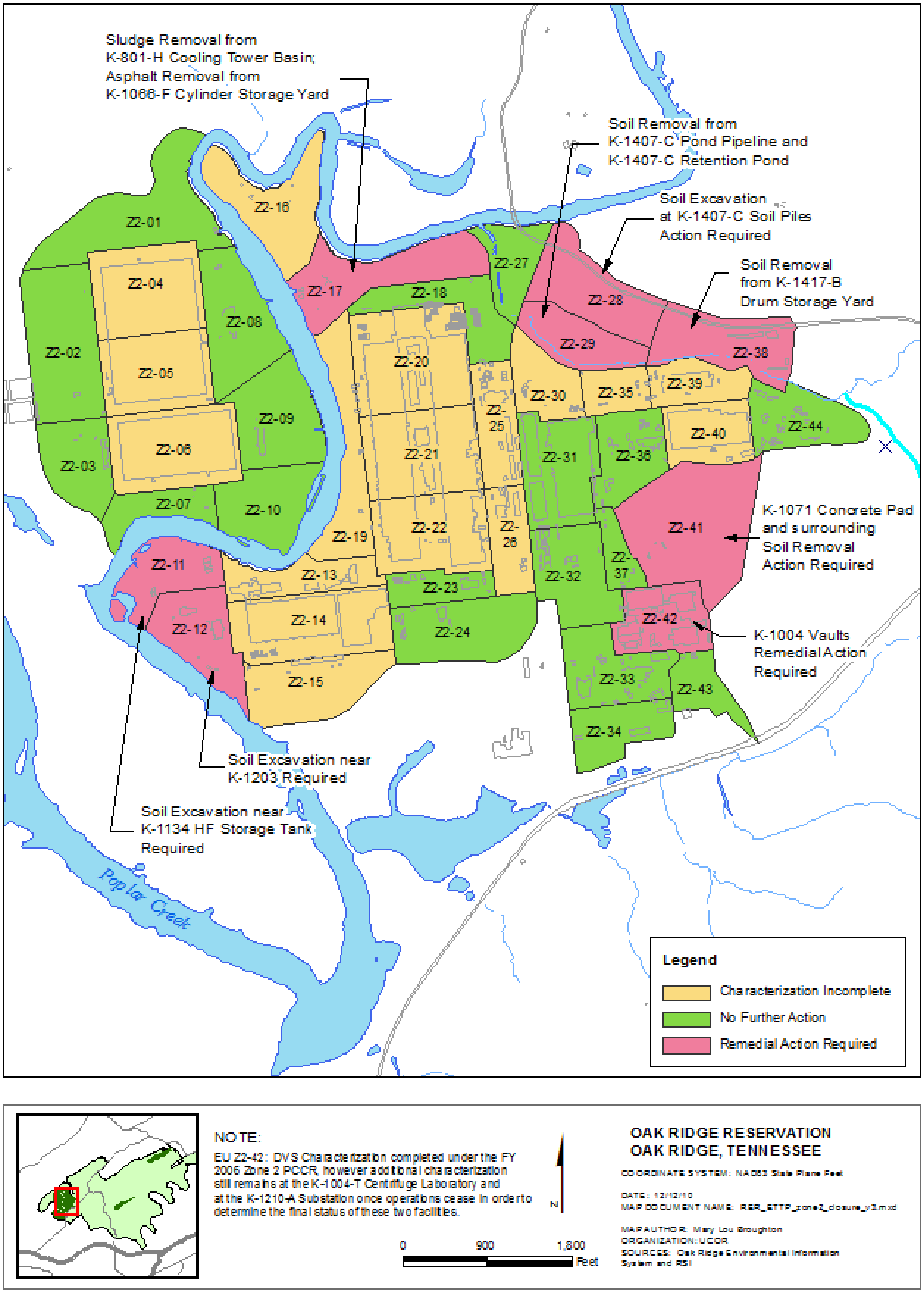


Figure 8.4. East Tennessee Technology Park Zone 2 closure document and action status.

Table 8.4. East Tennessee Technology Park Zone 2 completion documents and Exposure Unit status

Fiscal Year of Completion Document	Evaluated		No Further Action		Remedial Action Required		Remedial Action Completed	Remedial Action Remaining
	# of EUs	# of Acres	# of EUs	# of Acres	# of EUs	# of Acres[a]	# of EUs	# of EUs
FY 2006 Zone 2 PCCR (EU-2, 7, 9, 10, 27, 42)	6	108.8	5	93.2	1 (EU-42)	15.5	0	1 (EU-42)
FY2006 Totals	**6**	**108.8**	**5**	**93.2**	**1**	**15.5**	**0**	**1**
FY 2007 Zone 2 PCCR (EU-1, 3, 8, 23, 24, 28, 34, 37, 41, 43, 44)	11	195.5	9	143.1	2 (EU-28, 41)	58.5	3 [b] (EU-33,35,36)	3 (EU-28, 41, 42)
FY2007 Totals	**11**	**195.5**	**9**	**143.1**	**2**	**58.5**	**0**	**3**
FY 2008 Zone 2 PCCR (EU-33)	1	18	1	18	1 (EU-33)[c]	18	2 (EU-33 and 42 [d])	3 (EU-28, 41, 42 [d])
FY2008 Totals	**1**	**18**	**1**	**18**	**1**	**18**	**2**	**3**
FY 2009 Zone 2 PCCR (EU-36)	1	15	1	15	0	0	0[e]	3 (EU-28, 41, 42)
FY 2009 Zone 2 PCCR (EU-11, 12, 17, 18, 29, 38)	6	109	1	15.5	5 (EU-11,12,17, 29,38)	93.5	0	8 (EU-11,12,17, 28, 29, 38, 41, 42)
FY2009 Totals	**7**	**124**	**2**	**30.5**	**5**	**93.5**	**0**	**8**
FY 2010 Zone 2 PCCR (EU-32)	1	18.4	1	18.4	1 (EU-32)	18.4	1 (EU-32)	8 (EU-11,12,17, 28, 29, 38, 41, 42)
FY 2010	**1**	**18.4**	**1**	**18.4**	**1**	**18.4**	**1**	**8**
FY 2010 Zone 2 PCCR - Pending (EU-31)	1	21	1	21	1 (EU-31)	21	1 (EU-31)	8 (EU-11,12,17, 28, 29, 38, 41, 42)
FY 2011	**1**	**21**	**1**	**21**	**1**	**21**	**1**	**8**
As of 9/30/11	**27**	**485.7**	**19**	**324.2**	**11**	**224.9**	**4**	**8**
Zone 2 Totals	**44**	**819**						
Remaining for Evaluation	**17**	**333.3**	**EU-4-6, 13-16, 19-22, 25, 26, 30, 35, 39, 40**					

[a]Represents the sum of the acreages of all Exposure Units in which a remedial action is required.

[b]Remedial actions performed in EUs-33, 35, and 36 are documented in this PCCR. Performance of these remedial actions does not enable the EUs to meet the risk criteria of the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (DOE 2005a) Remedial Action Objectives. Characterization and/or additional remedial actions have not been completed. Therefore, these remedial actions do not factor in to the totals.

Table 8.4. East Tennessee Technology Park Zone 2 completion documents and Exposure Unit status (cont.)

[c]A revision to the *FY 2008 Phased Construction Completion Report for EU-33* (DOE 2009c) received regulatory approval on December 2, 2009 and added the K-1006 Development Laboratory north sump remedial action in EU-33 to the PCCR.
[d]EU-42 Soil remedial action completed under this PCCR. The K-1004-J vaults remedial action remains to be completed.
[e]There were no completed remedial actions in EU-36 documented in this PCCR. The backfilling of the building K-1501 basement and 2 small adjacent pits in EU-36 was described in the *FY 2007 Phased Construction Completion Report* (DOE 2008b).

EU = Exposure Unit
PCCR = Phased Construction Completion Report

- The *Fiscal Year 2009 Phased Construction Completion Report for Zone 2 Exposure Units 11, 12, 17, 18, 29, and 38* (DOE 2009b) addresses characterization of approximately 109 acres and recommends remedial actions in EU 11 (soil excavation near the former K-1134-A HF storage tank), EU-12 (soil excavation near the K-1203 Area), EU-17 (sludge removal from the K-801-H Cooling Tower Basin and removal of the K-1066-F Cylinder Storage Yard Pad), EU-29 (soil excavation at the K-1407-C Retention Basin and K-1407-C Pond Pipeline Sites), and EU-38 (soil removal in the K-1417-B Drum Storage Yard Site).

- The *Fiscal Year 2010 Phased Construction Completion Report for EU Z2-32* (DOE 2010d) addresses characterization of 18.4 acres, of which all are recommended for No Further Action and documents the removal of a small amount of contaminated soil and gravel in the K-1066-G Yard.

- The *Fiscal Year 2010 Phased Construction Completion Report for EU Z2-31 in Zone 2, East Tennessee Technology Park* (DOE 2010a) addresses characterization of approximately 21 acres and the removal of the K-1035 building slab and sub-slab piping and the acid, neutralization and steam cleaning pits located immediately south of the building.

- Remediation of the K-1070-B Burial Ground under the Zone 2 ROD continued in FY 2011.

The two-phase groundwater treatability study began in FY 2009 to support selection of a groundwater remedy. The purpose of the study is to determine the feasibility of two in situ treatment technologies – thermal conductive heating and biological treatment - to restore groundwater. The first phase was to characterize and delineate suspected areas of solvent contamination. A total of 14 boreholes were installed to depths of 110 to 160 feet below ground surface near the former K-1401 Vapor Degreasing Area. A design characterization plan was developed and approved by the regulators to collect additional information for a pilot scale treatability study to determine the effectiveness of in situ thermal treatment.

8.1.2.2 East Tennessee Technology Park Single-Project Actions

- During FY 2007, hexavalent chromium was detected in surface water in Mitchell Branch in exceedance of AWQC. In response to this condition, a time-critical *Action Memorandum for Reduction of Hexavalent Chromium Releases Into Mitchell* Branch (DOE 2007f) was performed to install and operate groundwater extraction wells to capture chromium-contaminated groundwater. The *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2008c) documented the action. The long-term solution to the release of hexavalent chromium to Mitchell Branch is documented in the non-time critical *Action Memorandum for the Long-Term of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010e) that supersedes the time-critical removal action (DOE 2007f). Construction of a chromium water treatment system was completed in FY 2011, and operations are planned to start in FY 2012.

- The *Action Memorandum for the Ponds at the East Tennessee Technology Park* (DOE 2007b) was completed and documented in the *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE 2010f).

- Sampling of the SW-31 Spring is no longer required, but the decision and completion document still requires the monitoring. Therefore, an issue has been identified (Table. 8.13) to Revise the Addendum to the Remedial Action/Effectiveness Report for the K-1070 Operable Unit SW31 Spring Phase 2 Remedial Action (DOE 2007).

8.1.2.3 East Tennessee Technology Park Demolition Projects

- Buildings K-25 and K-27. An *Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park* (DOE 2002b) requires the buildings be demolished to slab. Full-scale demolition of Building K-25 began in December 2008 with the West Wing. In FY 2011 the East Wing was separated from the technetium-99 area and demolition of the East Wing was initiated.

- Buildings K-29, K-31, and K-33. The *Action Memorandum for Equipment Removal and Building Decontamination for Buildings K-29, K-31, and K-33, East Tennessee Technology Park* (DOE 1997a) was approved in 1997 to decontaminate and remove equipment from Buildings K-29, K-31, and K-33, and the *Removal Action Report for Equipment Removal and Building Decontamination for Buildings K-29, K-31, and K-33, East Tennessee Technology Park* (2007g) documented completion. Building K-29 was later demolished as part of the *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park* (DOE 2003a).

- Group I Auxiliary Facilities. In FY 1997, the *Action Memorandum for the Group I Auxiliary Facilities, K-25 Site* (DOE 1997b) Group I Building Demolition to demolish five ETTP auxiliary facilities was signed. This project was completed in FY 2006 with the final addendum to the Removal Action Report Memorandum for K-25 Auxiliary Facilities Group I Building Demolition [DOE 1999. *Removal Action Report for the K-25 Auxiliary Facilities Decommissioning Group I Buildings Demolition Project at the East Tennessee Technology Park* (DOE 1999); *Removal Action Report Addendum (Waste Disposition) for the K-25 Auxiliary Facilities Decommissioning Group I Building Demolition Project at the East Tennessee Technology Park* (DOE 2005b); *Addendum II for Waste Disposition to the Removal Action Report for the K-25 Auxiliary Facilities Decommissioning Group I Building Demolition Project at the East Tennessee Technology Park* (DOE 2006d)].

- Group II, Phase 1 Main Plant Facilities. In FY 2000, DOE signed the *Action Memorandum for the K-25 Auxiliary Facilities Demolition Project Main Plant Buildings, East Tennessee Technology Park* (DOE 2000a) to demolish the ETTP main plant facilities. This project began in August 2000 and was completed in December 2003. In FY 2004, the Removal Action Report for K-25 Auxiliary Facilities Group II, Phase I Building Demolition (DOE 2004) was approved.

- Group II, Phase 2 Building Demolition (K-1064 Peninsula). DOE signed the Action Memorandum for K-25 Auxiliary Facilities Group II, Phase II Building Demolition (DOE 2002c) in July 2002 for the demolition of 18 facilities and the removal of scrap material located in the K-1064 peninsula area. In FY 2007, the work was completed, and the Removal Action Report for K-25 Auxiliary Facilities Group II, Phase II Building Demolition (DOE 2007h) was approved June 27, 2007.

- Group II, Phase 3 Remaining Facilities Demolition. In September 2003, an Action Memorandum for the Remaining Facilities Demolition Project (DOE 2003a) was approved to demolish approximately 500 remaining facilities at ETTP. Over the past few years, completion of demolition has been documented by several PCCRs (Table 8.1).

8.2 ZONE 1 INTERIM RECORD OF DECISION

8.2.1 Long-Term Stewardship Requirements

Long-term stewardship requirements for CERCLA actions are summarized in 8.2. The *Record of Decision for Interim Actions in Zone 1* (DOE 2002a) establishes "unrestricted industrial" as the end use for Zone 1 and requires land use controls to prevent disturbance of soils below 10 feet in depth and to restrict future land use to industrial/commercial activities. To implement restrictions that prohibit more aggressive use of this area and to restrict access to this area until that land use has been achieved, seven land use controls will be implemented. Until the land use is achieved, reliance will be primarily on property record and zoning notices, the excavation/penetration permit 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. The objectives of these Zone 1 land use controls 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 excavation/penetration permit 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.

The application of land use controls to specific areas in Zone 1 is discussed below:

- The Phased Construction Completion Reports completed under the Record of Decision for Interim Actions in Zone 1 for the Duct Island/K-901 Areas state that the No Further Action decision means that an Exposure Unit is available for unrestricted industrial use to a depth of 10 feet below ground surface. All Exposure Units that have been cleared for industrial use to a depth of 10 feet have a high probability of being cleared for industrial use to all depths, with the exception of Exposure Unit 59. Exposure Unit 59 contains the K-1070-A Old Contaminated Burial Ground where a previous remedial action was conducted (See Sect. 8.4.4). Exposure Unit 59 does not pose a threat to groundwater and is considered No Further Action; however, subsurface data indicate unacceptable concentrations of radionuclides and organic chemicals for lifting of land use controls at depths below 10 feet. Because formerly buried wastes are present at depths in this Exposure Unit, land use controls are in place.

The *Addendum to Phased Construction Completion Report for the Duct Island Area and K-901 Area* (DOE 2010g) recommends recreational end-use for the Contractors Spoil Area in Exposure Unit-66 and Exposure Unit-70. These two Exposure units are included in the Black Oak Ridge Conservation Easement managed by the State of Tennessee as a Wildlife Management Area and State Natural Area. A large portion of these two Exposure Units (15.6 acres) comprises the Contractors Spoil Area construction debris and fly-ash landfill. It has been recommended that Exposure Unit 66 and Exposure Unit 70 be changed to a recreational end use, which implicitly assumes activities only on the surface. The revised *Addendum to Phased Construction Completion Report for the Duct Island Area and K-901 Area* (DOE 2010g) lists interim land use controls for Exposure Unit-66 and Exposure Unit-70 that include property record restrictions, property record notices, zoning notices, excavation/penetration permit program, access controls, signs, and surveillance patrols.

- All Exposure Units within the K-1007 Ponds/Powerhouse Areas that have been cleared for industrial use to a depth of 10 feet have a high probability of being cleared for industrial use to all depths, with the exception of Exposure Unit 9 at the K-1085 Burn Area, Exposure Unit 11 at the K-720 Fly Ash Pile Site, and Exposure Units 29, 30, and 31. Exposure Unit 9 required a remedial action at the K-1085 Old Firehouse Burn Area to remove contaminated soils to 12 feet below ground surface. This action was documented under the *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area* (pending as of September 30, 2011) (DOE 2010b). Exposure Unit 9 is considered No Further Action post-remedial action; however, due to groundwater contaminated with VOCs, it is recommended that soils below 10 feet be available for restricted use only. Exposure Unit 11 does not require a remedial action and is considered\ No Further Action; however, groundwater beneath the K-720 Fly Ash Pile is contaminated with SVOCs, metals, and radionuclides. Because contaminated groundwater is present at depths in these Exposure Units, land use controls are in place.

  A second *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North* Area (DOE 2011a) addressed Exposure Units 27 – 33. 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 No Further Action determination, an end use change is proposed for Exposure units 29, 30, and 31 due to the asbestos-containing material and metal debris that remain buried on site.

- The *Phased Construction Completion Report for the K-770 Scrap Removal Project of the Zone 1 Remediation at the East Tennessee Technology Park* (DOE 2007d) interim controls are no longer required since all contaminated areas and slabs that required monitoring have been removed. Final long-term stewardship requirements for this area are documented in the second *Addendum to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1, East Tennessee Technology Park* (DOE 2011a) as described in the section above. Exposure Units 29, 30, and 31 require land use controls per the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park* (DOE 2002a) due to suspected asbestos-containing material and metal debris that remain buried on site.

8.2.2 Status of Requirements for FY 2011

Restrictions were maintained for government-controlled industrial land use. The excavation/penetration permit functioned according to established procedures and plans for the site. Signs were maintained to control access, and surveillance patrols conducted as part of routine surveillance and maintenance inspections were effective in monitoring access by unauthorized personnel.

General land use controls for Zone 1 remained in place (see above).

The northern section (see Figure 8.3) of Zone 1 was identified as a conservation easement, the Black Oak Ridge Conservation Easement, on March 14, 2005. The Black Oak Ridge Conservation Easement 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 *Record of Decision for Interim Actions in Zone 1* (DOE 2002a) is unrestricted industrial, i.e., recreational use was not designated. DOE acknowledges the land use of the conservation easement is different from the end use in the *Record of Decision for Interim Actions in Zone 1* (DOE 2002a). This difference is included as an issue in Sect. 8.7. The *Addendum to Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1* (DOE 2010g) was approved in FY2011 and evaluates a recreational end use for Contractor Spoils Area in Exposure Units 66 and 70. Signs are present in Exposure Units 66 and 70 along the Black Oak Ridge Conservation Easement and at other locations where recreationers can access restricted areas stating "Road Impassable. No access to Restricted Area."

8.3 ZONE 2 SOIL, BURIED WASTE, AND SUBSURFACE STRUCTURE REMOVAL ACTIONS RECORD OF DECISION

8.3.1 Performance Goals and Monitoring Objectives

Major components of the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (DOE 2005a) (Figure 8.2) remedy include:

- Assess data sufficiency for each EU and supplement data as necessary to determine if remediation levels are exceeded. Verify all acreage in Zone 2 as compliant with soil remediation levels established by the Record of Decision.

- Remove soil up to 10 feet in depth that exceeds remediation levels set to protect a future industrial worker; remove soils to bedrock, water table, or acceptable levels of contamination to protect underlying groundwater to MCLs.

- Remove or decontaminate subsurface structures to average remediation levels met across an EU and maximum remediation levels met at any location to a depth of 10 feet.

- Remove the debris in the K-1070-B Burial Ground, regardless of depth, to minimize potential future impact to surface water; remove soil that exceeds remediation levels for protection of workers (upper 10 feet) or protection of groundwater (water table or bedrock).

- Remove the debris and soil in the K-1070-C/D Burial Ground that exceeds remediation levels for the protection of workers (upper 10 feet) or protection of groundwater (water table or bedrock).

- Implement land use controls to prevent exposure to residual soil 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 Dynamic Verification Strategy. 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 Remedial Action Objectives for Zone 2 are to:

- protect human health under an industrial land use to an excess lifetime cancer risk at or below 1 x 10-4 and non-cancer risk levels at or below a Hazard Index of 1,

- protect groundwater to levels at or below maximum contaminant levels.

The industrial risk scenario is based on the direct contact routes of exposure of incidental ingestion, inhalation of particulates and vapors, dermal contact, and external exposure. The industrial worker is assumed to have an exposure frequency of 2000 hours/year (8 hours/day for 250 days/year) and an exposure duration of 25 years (DOE 2005a). When soil remedial actions are completed, they are deemed effective for industrial end use based on confirmatory sampling evaluated against the established remediation levels.

The monitoring requirements include monitoring of groundwater adjacent to potential sources of groundwater contamination, including the K-1070-C/D Burial Ground (DOE 2005a). This monitoring will continue until a final Zone 2 ROD is approved. Monitoring of groundwater adjacent or downgradient of other contaminant sources throughout ETTP is addressed in Sect. 8.7.

8.3.2 Evaluation of Performance Monitoring Data – FY 2011

8.3.2.1 Results of Groundwater Monitoring Adjacent to Potential Source Areas

Monitoring locations, analytical parameters, and clean-up levels were not specified for groundwater monitoring at the K-1070-C/D Burial Ground (Figure 8.5), although the primary contaminants of concern in that area are VOCs. Semiannual samples are analyzed for VOCs and general water quality parameters in numerous 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.

Monitoring wells UNW-114, TMW-011, and UNW-064 (Figure 8.5) monitor the VOC plume leaving the K-1070-C/D Burial Grounds. 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) that were the source of this plume. VOC concentrations continued to decrease through about 2005 when concentrations stabilized. Concentrations at well UNW-064 (Figure 8.6) and UNW-114 (Figure 8.7) increased slightly during FY 2009 and FY 2010 in response to the above average rainfall that occurred during those years. The primary VOC detected in well UNW-114 near the K-1070-C/D Burial Grounds during FY 2011 was the degradation product 1,1-DCA at 290 - 400 µg/L. 1,1-DCA can be formed as a product of anaerobic biodegradation of PCE and TCE and by the hydrolysis of 1,1,1-TCA. Significant concentrations of 1,1-DCA were detected in wells TMW-011 (Figure 8.8) (330 - 550 µg/L), and UNW-064 (120 - 160 µg/L). Other VOCs detected in concentrations ≥85 µg/L were 1,1-DCE (150 - 370 µg/L) and TCE (120 µg/L) at TMW-011, TCE at UNW-114 (110 µg/L and chloroethane (110 µg/L) at UNW-064. MCLs were exceeded for 1,1-DCE (7 µg/L), TCE (5 µg/L), and vinyl chloride (2 µg/L) at all three wells. The PCE concentration in well TMW-011 and UNW-114 exceeded the MCL (5 µg/L) and the cis-1,2 DCE concentration in well TMW-011 increased to 97 µg/L, above the MCL (70 µg/L). Slight increases in concentrations of several VOCs were observed during FY 2011, presumably as a result of the fluctuations in rainfall.

8.3.2.2 Performance Summary

Removal of soil and debris from the K-1070-C/D Burial Grounds in 1999 has reduced the concentration of VOCs in groundwater downgradient of the removal area. An evaluation of VOC concentrations in wells UNW-064 and TMW-011 over the past several years indicates that generally VOC concentrations in groundwater have declined and remain relatively stable with fluctuations related to climatic cycles. 1,1-dichloroethane and TCE increased noticeably in well UNW-114 in FY 2011. Increases in some VOC concentrations resulting in maximum contaminant level exceedances were observed in FY 2011 likely due to fluctuations in precipitation.

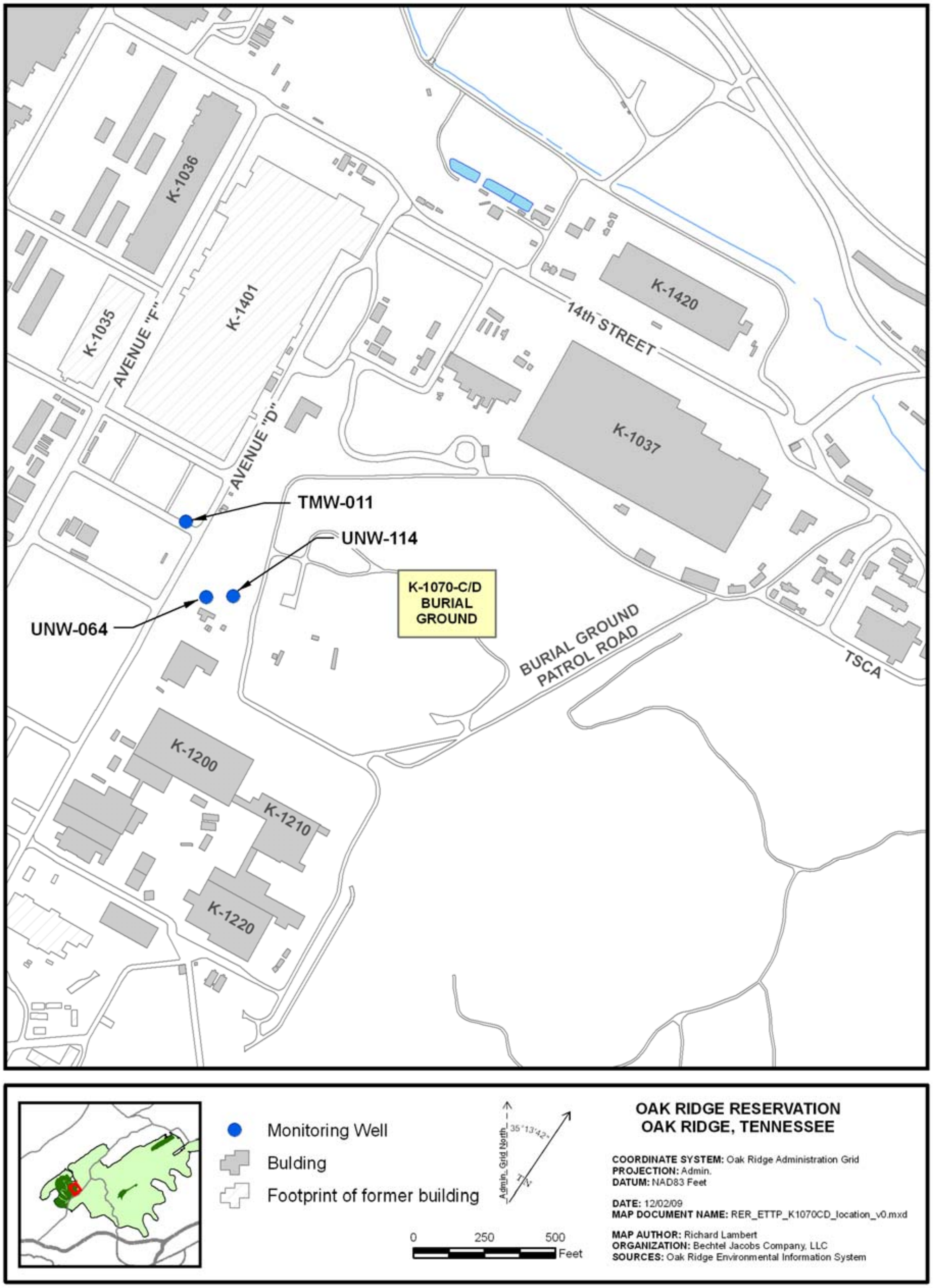


Figure 8.5. Location map for K-1070-C/D Burial Ground.

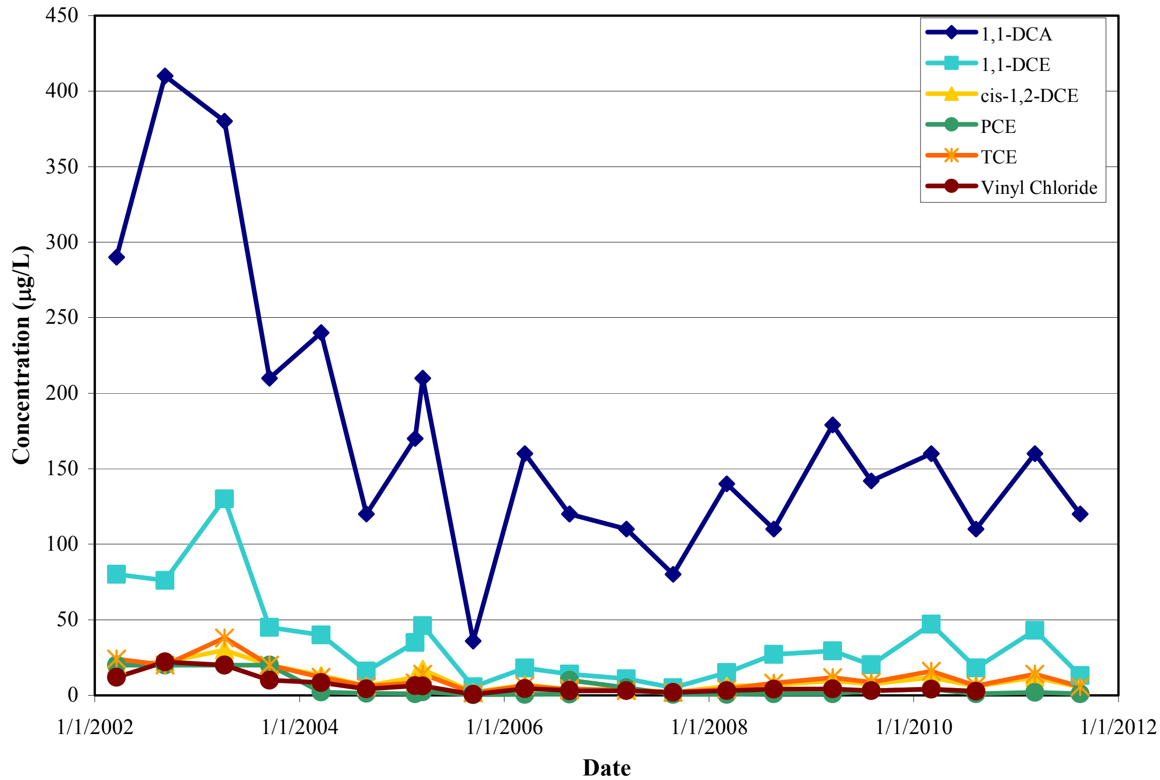


Figure 8.6. Volatile organic compound concentrations in well UNW-064 for FY 2002 through FY 2011.

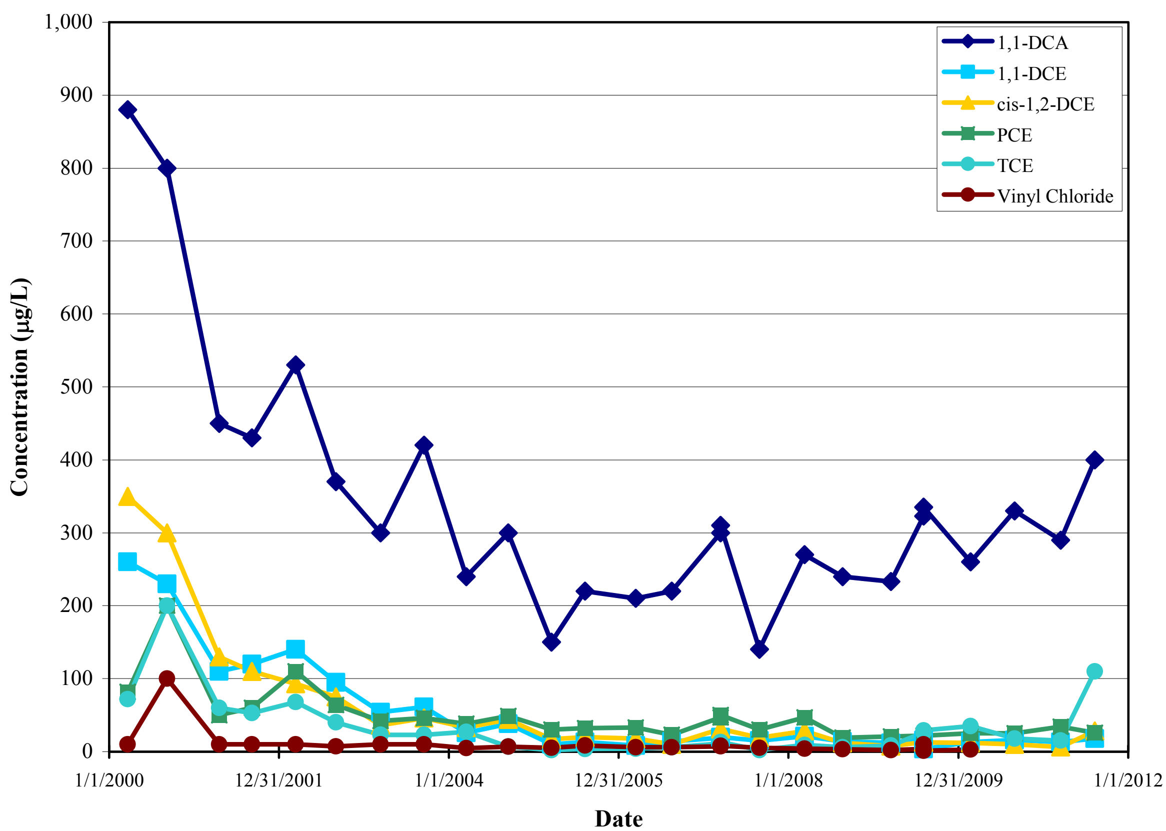


Figure 8.7. Volatile organic compound concentrations in well UNW-114 for FY 2000 through FY 2011.

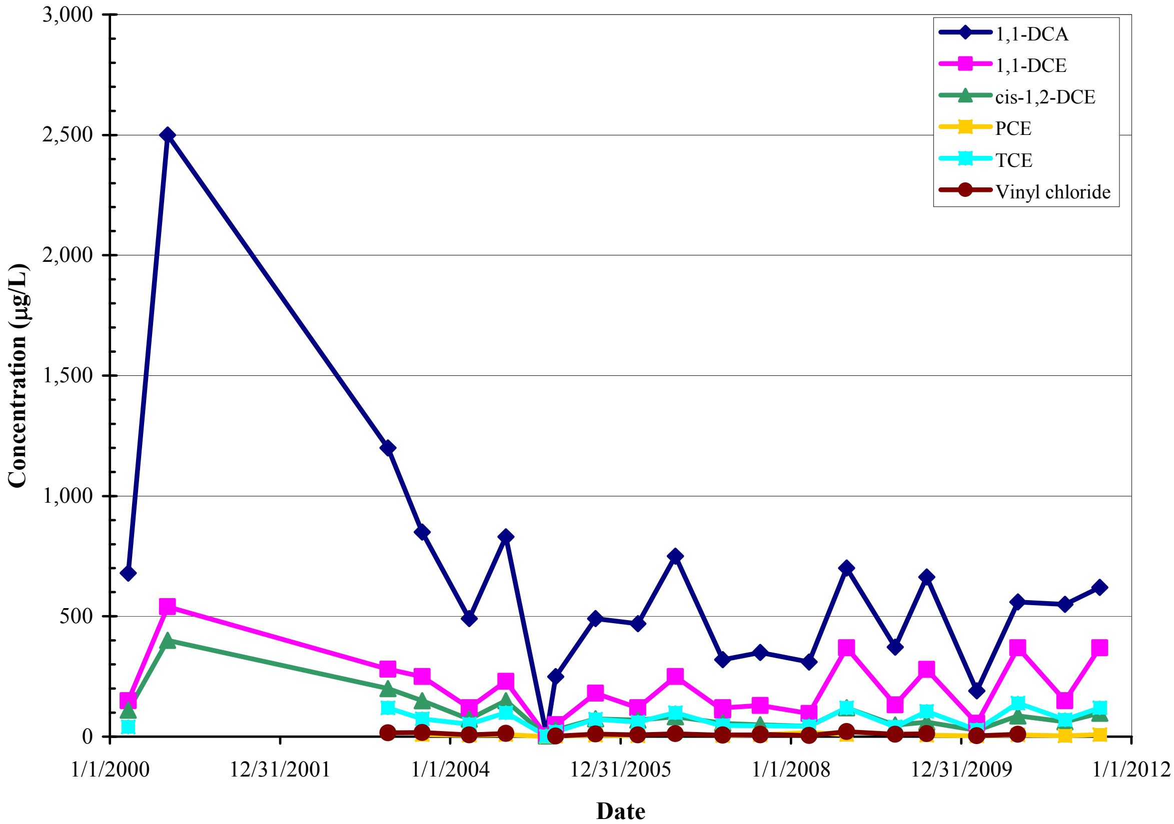


Figure 8.8. Volatile organic compound concentrations in well TMW-011 for FY 2000 through FY 2011.

8.3.3 Compliance with Long-Term Stewardship Requirements

8.3.3.1 Requirements

The *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (DOE 2005a) establishes "industrial" as the land use to a depth of 10 feet. To implement restrictions that prohibit residential or agricultural use of this area under the Record of Decision and to restrict access to this area until that end use has been achieved, seven land use controls will be implemented: (1) property record restrictions, (2) property record notices, (3) zoning notices, (4) excavation/penetration permit program, (5) access controls, (6) signs, and (7) surveillance patrols. The objectives of these Zone 2 land use controls follow:

- Control land use to prevent exposure to contamination by controlling excavations or soil penetrations below 10 feet 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 re-establish 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 remedial action 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 land use controls 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 excavation/penetration permit 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. Details of these land use controls will be included in the Zone 1 and Zone 2 Remedial Action Reports. Fences, signs, and surveillance patrols will be used to restrict access only in the short term until remediation is complete.

The application of land use controls to specific areas in Zone 2 is discussed below:

- The *Fiscal Year 2006 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park* (DOE 2006c) states that the No Further Action decision means that an Exposure Unit is available for unrestricted industrial use to a depth of 10 feet below ground surface. All Exposure Units that have been cleared for industrial use to a depth of 10 feet have a high probability of being cleared for industrial use to all depths, with the exception of Exposure Unit 42. Exposure Unit 42 required two remedial actions -- two small soil actions south of K-1004-J Laboratory and the K-1004-J vaults remedial action. This first action was documented under the Fiscal Year 2006 Phased Construction Completion Report (DOE 2006c). The second action remains to be completed. Exposure Unit 42 is considered No Further Action post-remedial action; however, due to substantial VOC contaminant concentrations present in the groundwater north of Building K-1225, it is recommended that soils below 10 feet in Exposure Unit 42 at this location be available for restricted use only. Because formerly contaminated groundwater is present at depths in this Exposure Unit, land use controls are in place.

- The *Fiscal Year 2007 Phased Construction Completion Report for the Zone 2 Soils, Slabs, and Subsurface Structures at East Tennessee Technology Park* (DOE 2007e) states that the No Further Action decision means that an Exposure Unit is available for unrestricted industrial use to a depth of 10 feet below ground surface. All Exposure Units that have been cleared for industrial use to a depth of 10 feet have a high probability of being cleared for industrial use to all depths, with the exception of Exposure Units 28, 34, 37, 41, and 44. Exposure Unit 28 and 41 require remedial action. Both are considered No Further Action post-remedial action; however, following the proposed remedial action in Exposure Unit 28 contaminated soils left in place will remain, and Exposure Unit 41 contains the K-1070-C/D Burial Ground and K-1070 Pits. Exposure Units 34, 37 and 44 all contain a VOC groundwater plume below 10 feet; therefore, it is recommended that soils below 10 feet in these Exposure Units be available for restricted use only. Because formerly buried wastes and/or contaminated groundwater is present at depths in all of these Exposure Units, land use controls are in place.

- Exposure Unit 33 evaluated in *Fiscal Year 2008 Phased Construction Completion Report for EU Z2-33 in Zone 2, East Tennessee Technology Park* (DOE 2009c) is recommended for unrestricted industrial use to 10 feet below ground surface. However, a VOC groundwater plume is known to exist in the central portion of Exposure Unit 33 at a depth of +/- 25 feet. Therefore, it is proposed to retain land use restrictions below 10 feet for Exposure Unit 33. Mowing is required at the Balance of Site-Laboratory Area in Exposure Unit 33 until native/no-maintenance grasses can be planted. Because formerly contaminated groundwater is present at depths in these Exposure Units, land use controls are in place.

- EU 36 evaluated in *Fiscal Year 2009 Phased Construction Completion Report for EU Z2-36 in Zone 2, East Tennessee Technology Park* (DOE 2009d) is recommended for unrestricted industrial use to 10 feet below ground surface. However, a VOC groundwater plume is known to exist in the central portion of Exposure Unit 36 at a depth of +/- 25 feet. Therefore, it is proposed to retain land use restrictions below 10 feet for Exposure Unit 36. Because formerly buried wastes and/or contaminated groundwater is present at depths in all of these Exposure Units, land use controls are in place.

- The Exposure Units evaluated in the *Fiscal Year 2009 Phased Construction Completion Report for Zone 2 Exposure Units 11, 12, 17, 18, 29, and 38 at East Tennessee Technology Park* (DOE 2009b) are recommended for unrestricted industrial use to 10 feet below ground surface. However, VOC groundwater plumes are beneath the southeast portions of Exposure Units 12 and 18, and radiologically contaminated soils lie below the 10 feet depth at the K-1407-C Retention Pond in Exposure Unit 29. Therefore, it is proposed to retain land use restrictions below 10 feet for Exposure Units 12, 18, and 29. Because formerly buried wastes and/or contaminated groundwater is present at depths in all of these Exposure Units, land use controls are in place.

- Exposure Unit 32 evaluated in the *Fiscal Year 2010 Phased Construction Completion Report for EU Z2-32 in Zone 2, East Tennessee Technology Park* (DOE 2010d) is recommended for unrestricted industrial use to 10 feet below ground surface. Because there is no presence of buried waste or groundwater contamination, it is proposed that land use restrictions below 10 feet be lifted.

The K-1066-G Yard remains a fenced and graveled area that may require periodic mowing or herbicide application. The locations of former Buildings K-1008-A through F and K-1020 slabs are planted with domestic grass that will require mowing.

- EU 31 evaluated in the *Fiscal Year 2010 Phased Construction Completion Report for EU Z2-31 in Zone 2, East Tennessee Technology Park* (DOE 2010a) is recommended for unrestricted industrial use to 10 feet below ground surface. However, a VOC groundwater plume is known to exist in the central portion of Exposure Unit 31 at a depth of +/- 25 feet. Therefore, it is proposed to retain land use restrictions below 10 feet for Exposure Unit 31. Because contaminated groundwater is present at depths in this Exposure Unit, land use controls are in place.

8.3.3.2 Status of Requirements for FY 2011

Short-term restrictions were maintained for government-controlled industrial land use. Signs were maintained to control access, and surveillance patrols conducted as part of routine surveillance and maintenance inspections were effective in monitoring access by unauthorized personnel. The excavation/penetration permit program functioned according to established procedures and plans for the site. Signs and access controls at the K-1070-C/D Burial Ground were inspected annually by the ETTP Surveillance and Maintenance Program.

General land use controls for Zone 2 (DOE 2005a) remained in place (see above).

8.4 COMPLETED SINGLE ACTIONS AT EAST TENNESSEE TECHNOLOGY PARK WITH MONITORING AND/OR LONG-TERM STEWARDSHIP REQUIREMENTS

8.4.1 K-1407-B/C Ponds Remedial Action

The.*Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site* (DOE 1993a) 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 Resource Conservation and Recovery Act closure action. The location of the K-1407-B/C ponds at ETTP is shown in Figure 8.1 and Figure 8.9.

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 Goals and Monitoring 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 1993a).

The *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin* (DOE 1995a) 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. However, VOCs are the primary groundwater contaminant in the Mitchell Branch area of the ETTP. Remediation target concentrations were not established in the CERCLA decision documents for use in post-remediation monitoring. As recommended by EPA, with concurrence from TDEC, performance monitoring is conducted in wells UNW-003, UNW-009, and the Mitchell Branch weir (K-1700 Weir), shown on Figure 8.9.

8.4.1.2 Evaluation of Performance Monitoring Data

8.4.1.2.1 Monitoring Results – Groundwater (UNW-003, UNW-009)

The primary groundwater contaminants in the K-1407-B and -C ponds area of the ETTP are VOCs, which are widespread in this portion of the plant, including contaminant sources upgradient of the ponds. Groundwater samples were collected at UNW-003 and UNW-009 in March and August 2011. Monitoring results for FY 2011 at wells are generally consistent with results from previous years. Gross alpha activity was detected at 4.96 pCi/L in March and at 3.54 pCi/L in August at UNW-003 and was not detected at UNW-009 in March or August. Gross beta activity ranged from 11.6 to 22.5 pCi/L at UNW-003. Gross beta activity was not detected in March but was detected in August at at 4.19 pCi/L at UNW-009. The radionuclide ^{99}Tc was detected at 20.5 pCi/L in August in UNW-003. ^{234}U was not detected in in UNW-009, but was detected at 4.13 pCi/L in March and 2.18 pCi/L in August in UNW-003. None of the metals having primary drinking water standards exceeded those levels. With one exception, iron was elevated

Figure 8.9. Location of K-1407-B/C Ponds.

above its secondary drinking water standard in all but one unfiltered sample aliquots. Only the field-filtered (i.e., dissolved) samples for iron from UNW-003 were below its secondary standard. The secondary standard for aluminum was not exceeded in any samples. Manganese exceeded its secondary drinking water standard in both filtered and unfiltered aliquots from both wells during both sampling events. The elevated manganese levels are likely caused by chemical reduction in the local groundwater induced by reductive dehalogenation of VOCs.

High concentrations of several VOCs are present in groundwater in well UNW-003 downgradient of the former K-1407-B Pond and adjacent to Mitchell Branch. Significant concentrations of parent compounds PCE (170-1000 µg/L) and TCE (1500-5900 µg/L) and the degradation products 1,1-DCE (230-1100 µg/L), 1,1-DCA (310-1000 µg/L) , cis-1,2-DCE (920-2600 µg/L), and vinyl chloride (120) µg/L) were detected at UNW-003 in FY 2011. The detection of VOCs at concentrations well above 1,000 µg/L and the steady concentrations over recent years strongly suggest the presence of dense non-aqueous phase liquids in the vicinity of this well. The Zone 2 final Record of Decision will address groundwater contamination present in the area of the former ponds.

8.4.1.2.2 Monitoring Results – Surface Water

Monitoring results for Mitchell Branch during FY 2011 are similar to the FY 2010 results. Chromium concentrations remained low during FY 2011. ^{99}Tc and ^{90}Sr activities were each detected in a single sample. VOCs were detected in surface water at the Mitchell Branch (K-1700) Weir (Figure 8.10), which is consistent with historical results for this location. The VOCs detected included cis-1,2-DCE, 1,1-DCA, chloroform, TCE, carbon tetrachloride, and vinyl chloride (see Sect. 8.6 for a discussion of water quality trends at the K-1700 Weir). Tennessee fish and aquatic life Water Quality Criteria (TDEC 2004) have not been established for DCE, TCE, vinyl chloride, chloroform, or PCE; however, there are Tennessee Water Quality Criteria for recreation (organisms only criteria) for chloroform, 1,1-DCE, PCE, TCE, and vinyl chloride. Concentrations of each detected VOC at the K-1700 Weir are less than the Tennessee Water Criteria for recreation, organisms only.

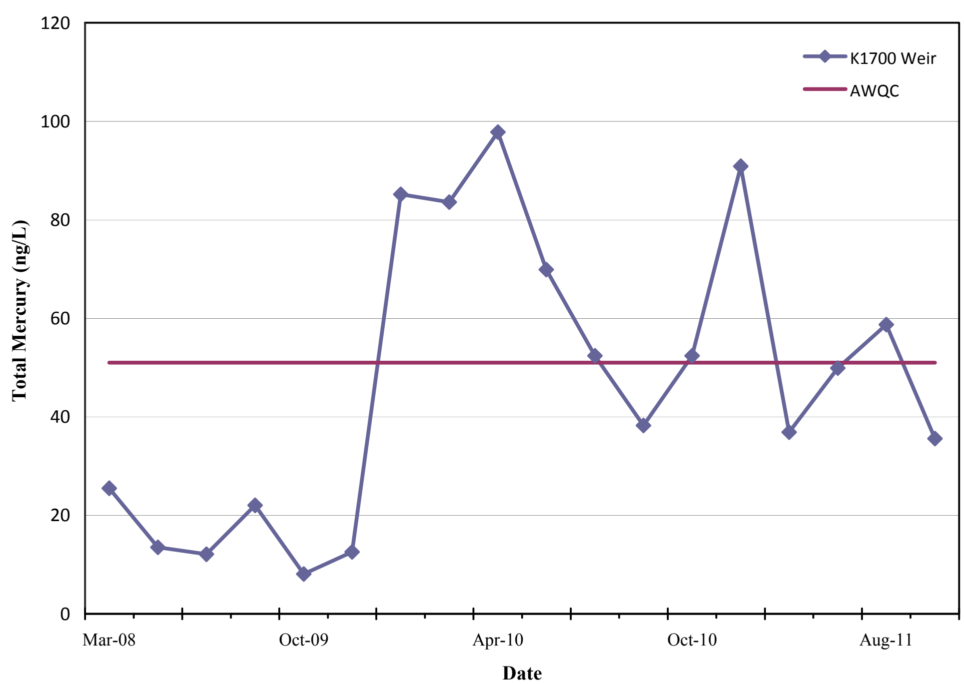


Figure 8.10. Mitchell Branch in-stream sampling location K-1700.

Metals detected at the K-1700 Weir in FY 2011 include aluminum, barium, chromium, iron, manganese, and mercury. Of the detected metals, only mercury and hexavalent chrome exceeded the AWQC. During FY 2006, lead exceeded the fish and aquatic life criterion continuous concentration of 2.5 µg/L. Arsenic, selenium, lead, zinc and cadmium were not detected above AWQC at the K-1700 Weir during FY 2011.

During FY 2007, hexavalent chromium was detected in surface water in Mitchell Branch in exceedance of the AWQC (11 µg/L) and was found to be discharging from Outfall 170 (SD-170 on Figure 8.10). In response to this condition, a time-critical removal action was performed to install and operate groundwater seepage collection pumps to capture chromium-contaminated groundwater associated with the Outfall 170 discharge (DOE 2007f; DOE 2008c). Section 8.4.5 reports on the removal action and its associated monitoring. The instream sampling results at MIK 0.71/0.79 for total chromium varied from nondetect levels to maximum of 0.013 mg/L during FY 2011. The maximum hexavalent chromium concentration during FY 2011 was 0.010 mg/L (See Sect. 8.4.5.2.1).

The ETTP National Pollutant Discharge Elimination System storm water permit was issued on March 4, 2010 with an effective date of April 1, 2010. During the storm water outfall characterization efforts to complete the storm water permit renewal application, mercury was identified as a constituent of concern at outfalls in several subwatershed locations.

In particular, storm water outfalls 170, 180, and 190 were identified as outfalls that will be monitored as a requirement of the new permit at a quarterly frequency. There are no current ETTP operations where mercury is routinely used, so the monitoring is to assess potential mercury releases from legacy sources such as historical operating areas where mercury was used in monometers, thermometers, mercury recovery operations, or in maintenance shops. The investigative sampling will continue to take place during the term of the current storm water permit which is from April 1, 2010 through December 31, 2013.

The outfall sampling results for the three outfalls since April 1, 2010 are in Table 8.5.

Table 8.5. Mercury sampling summary at Mitchell Branch outfall locations

Outfall	Minimum, ng/L	Average, ng/L	Maximum, ng/L
Outfall 170	4	8	13
Outfall 180	4	194	638
Outfall 190	13	61	249

In addition to sampling at the three Mitchell Branch outfall discharge locations, in-stream sampling at the Mitchell Branch K-1700 has also been evaluated as noted in Figure 8.10. Mitchell Branch location K-1700 is immediately upstream from the mixing zone where Mitchell Branch enters the larger Poplar Creek. The results of the in-stream sampling indicate increased levels of mercury at location K-1700 starting in calendar year 2010. Since March of 2010, the mercury results in Mitchell Branch have frequently exceeded the AWQC level of 51 ng/L.

Investigation of the increased results has indicated that as expected the in-stream concentrations begin to increase downstream from storm water outfalls 170, 180, and 190. However, there are additional increases of in-stream mercury water concentrations further downstream from these three outfalls all the way to the final K-1700 sampling point. These same downstream increasing trends have also been measured in other sampling media such as sediment and clam tissue analysis. Mercury has also been measured in fish tissue sampling in the downstream locations. The mean mercury concentration in sunfish fillets in 2011 was calculated as 0.34 mg/kg. These results were similar to measurements in 2010 and are above EPA's recommended criterion of 0.3 mg/kg for mercury in fish.

The potential source of the legacy mercury being measured in Mitchell Branch downstream from the primary outfalls may be attributable to seeps, legacy sediment deposits, or other downstream storm water outfall contributions. In accordance with the National Pollutant Discharge Elimination System permit Storm Water Pollution Prevention Program requirements, the potential sources of mercury into Mitchell Branch will be further investigated in FY 2012.

In addition to the Mitchell Branch mercury outfall sampling, storm water outfall 05A that discharges directly into Poplar Creek is also sampled for mercury discharges on a quarterly basis. The trend results for mercury measurements at outfall 05A are shown in Figure 8.11.

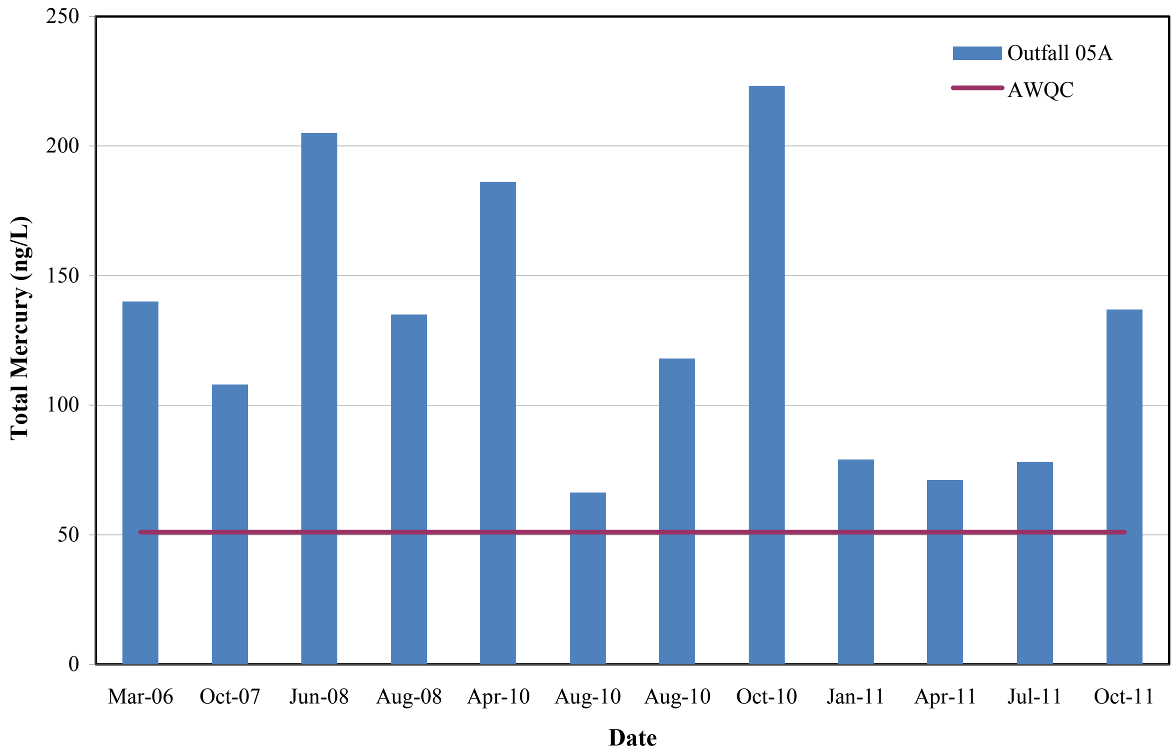


Figure 8.11. Mercury sample results out storm outfall 05A discharge to Poplar Creek.

Storm water outfall 05A drains a subwatershed that primarily includes the inactive sewage treatment plant that was shutdown in 2008. Storm water 05A drains to a sump at a low elevation point adjacent to the perimeter road that acts as a berm between ETTP and Poplar Creek. The sump is equipped with an automatic pump that discharges the collected seep water and storm water runoff under perimeter road and into Poplar Creek.

The results of investigative influent sampling into the collection sump identified seep and storm water runoff piping with mercury results that are similar to the discharges from the sump. In accordance with the National Pollutant Discharge Elimination System permit Storm Water Pollution Prevention Program requirements, additional investigative sampling will occur in FY 2012 in to attempt to identify any direct sources into the storm water piping.

8.4.1.3 Performance Summary

Following is a summary of the FY 2011 K-1407-B/C Ponds performance monitoring:

- Monitoring of surface water at K-1700 Weir in Mitchell Branch is consistent with historic trends with total and hexavalent chromium below the AWQC.
- The presence of mercury in the Mitchell Branch water shed has been known for some time based on its accumulation in fish tissue; however, application of very low detection level laboratory methods was initiated during 2009 which allowed quantitation of mercury against the AWQC.

8.4.1.4 Compliance with Long-Term Stewardship Requirements

8.4.1.4.1 Requirements

Long-term stewardship requirements specified in the *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin* (DOE 1995a) include maintenance of institutional controls (Table 8.2), specifically; conduct periodic inspections, radiological and industrial hygiene surveillances, ensure access and activity controls, and implement maintenance activities.

8.4.1.4.2 Status of Requirements for FY 2011

All components of the K-1407-B/C Ponds site were inspected in FY 2011 by the ETTP Surveillance and Maintenance 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, no additional maintenance was required.

8.4.2 East Tennessee Technology Park Ponds

8.4.2.1 Performance Measures and Monitoring Requirements

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* (DOE 2007b) (Figure 8.2) 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 Interim 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 action memorandum superseded the previous *Action Memorandum for the K-901-A Holding Pond and the K-1007-P1 Pond Removal Action* (DOE 1997c).

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* (DOE 2008d; DOE 2010h). Completion of the removal action is documented in the *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE 2011b).

Monitoring of the K-1007-P1 Holding Pond will be performed in two phases (DOE 2011b). 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. Operational monitoring was conducted in FY 2011.

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 2007b), "*….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…*". Performance monitoring was performed in FY 2011.

8.4.2.2 Evaluation of Operational Monitoring Data

Operational monitoring is conducted at the K-1007-P1 Holding Pond 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 FY 2011 in accordance with the *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE 2011b). 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.

Fish communities in the K-1007-P1 Holding Pond were sampled in November 2009, approximately five months after the pond fish kill, in June 2010, after fish from Poplar Creek were able to enter the pond through a breach in the weir, and again in May 2011 following the stocking of hatchery-reared bluegill (*Lepomis machrochirus*) and redear sunfish (*Lepomis microlophus*). The initial fish kill appeared to be highly successful in eliminating undesirable fish species from the pond. Surveys conducted in 2009 showed the pond to be dominated by bluegill, green sunfish (*Lepomis cyanellus*), and warmouth (*Lepomis gulosus*) (Figure 8.12). The pond was resurveyed in June 2010 following a breach in the weir which allowed the entry of fish from Poplar Creek. For the first time since the removal action, low numbers of undesirable fish, including common carp (*Cyprinus carpio*), smallmouth buffalo (*Ictiobus bubalus*), and gizzard shad (*Dorosoma cepedianum*), were evident in the K-1007-P1 Holding Pond. Though the pond's fish community was still dominated by sunfish (Figure 8.12) and small minnow species, the carp and buffalo accounted for the majority of the biomass in the K-1007-P1 Holding Pond in 2010 (Figure 8.13).

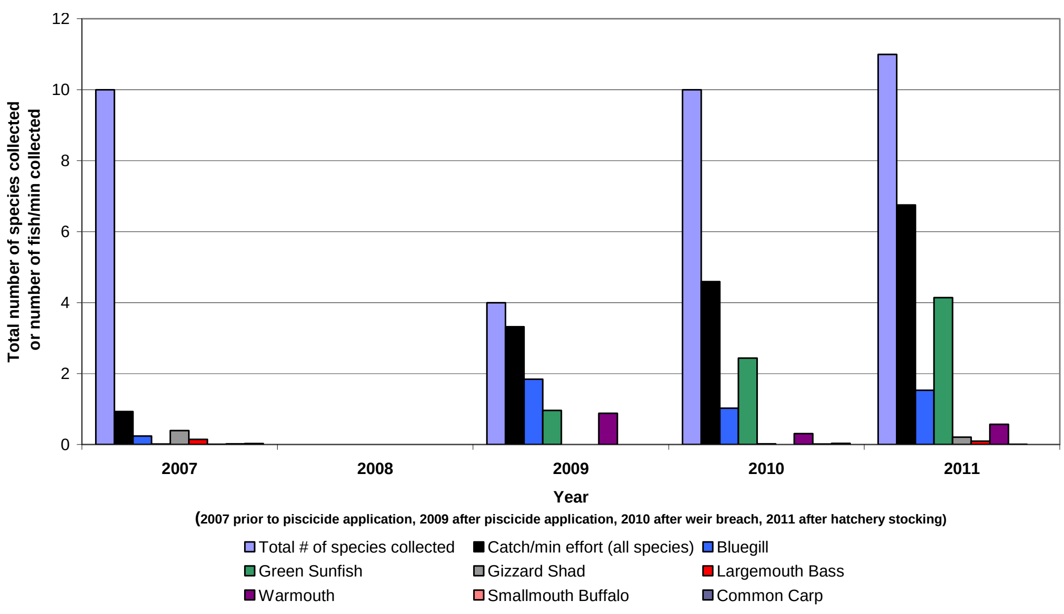


Figure 8.12. Total numbers of species collected and catch per minute of effort for seven species in the K 1007-P1 Pond, 2007-2011.

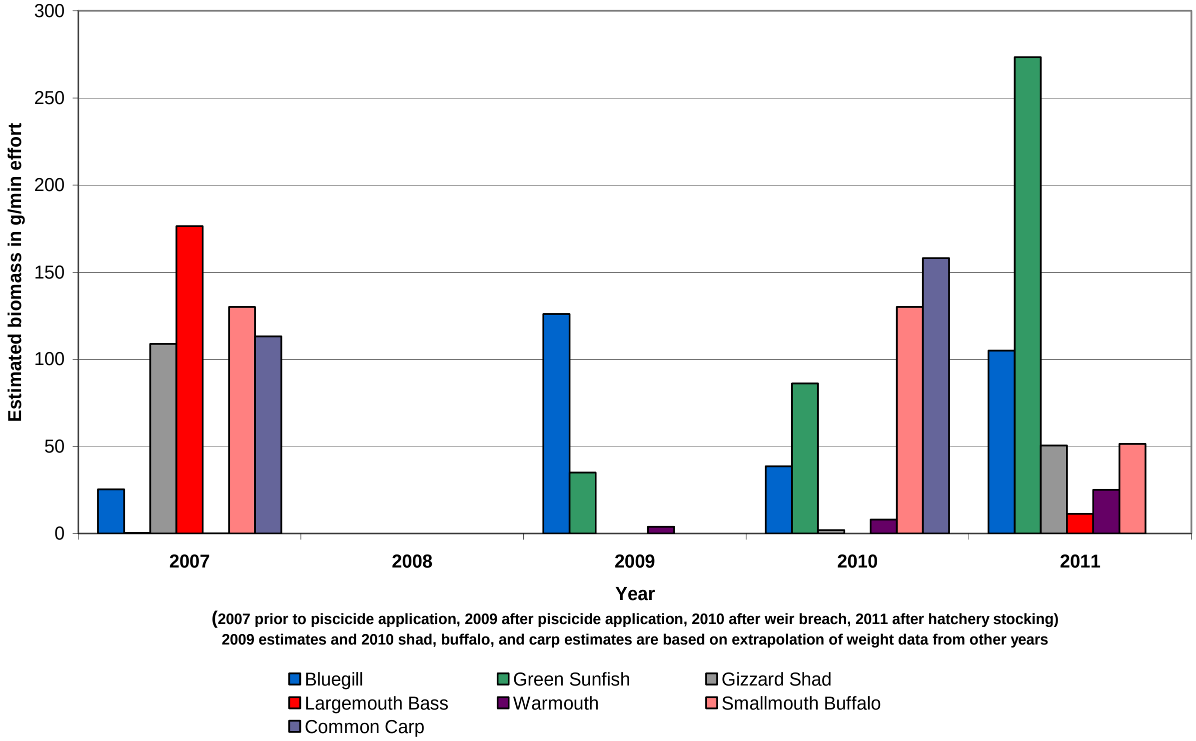


Figure 8.13. Estimated biomass in grams per minute of collection effort for seven fish species in the K-1007-P1 Pond, 2007-2011.

Aggressive removal efforts significantly reduced the carp and buffalo populations by the time the 2011 population survey was conducted. No carp were found during this survey, although they likely still exist in very low numbers. Only one buffalo was found, but because the data in Figure 8.12 are expressed as catch per minute of effort, the collection of a single fish over the course of the entire survey appears insignificant. As can be seen in Figure 8.13, however, even a single buffalofish can comprise a significant portion of the overall biomass in a sunfish-dominated pond.

Approximately 200 largemouth bass (*Micropterus salmoides*) were removed from the K-1007-P1 Holding Pond in 2011, following discovery of a single juvenile on 28 July 2010. It is believed, however, that this species entered the pond via the K-1007-P3 Holding Pond, rather than from Poplar Creek via the K-1007-P1 Holding Pond Outfall weir breach. A single threadfin shad (*Dorosoma petenense*) was also collected during the May 2011 population survey, but like other species that were collected in very small numbers, are not presented Figures 8.12 and 8.13. Work conducted during summer 2011 indicates that there are now breeding populations of three undesirable species in the K-1007-P1 Holding Pond—largemouth bass, gizzard shad, and threadfin shad.

The plant community within the pond has developed substantially since the pond was re-contoured and vegetation planted as part of the removal action. In 2007, the pond was largely devoid of plants except for algae. In 2010-2011, surveys found coverage had increased as much as 7-fold along some transects, although there was variation as a result of temporary water level changes in 2010 (Figure 8.14). The increased coverage was also matched by an increase in plant richness (Figure 8.15) in 2011 that included both species planted during the removal action and volunteer species that may have been present along the periphery of the pond. The establishment of the plant community in the K-1007-P1 Holding Pond is highlighted by aerial photo comparisons between 2009 and 2011 (Figure 8.16).

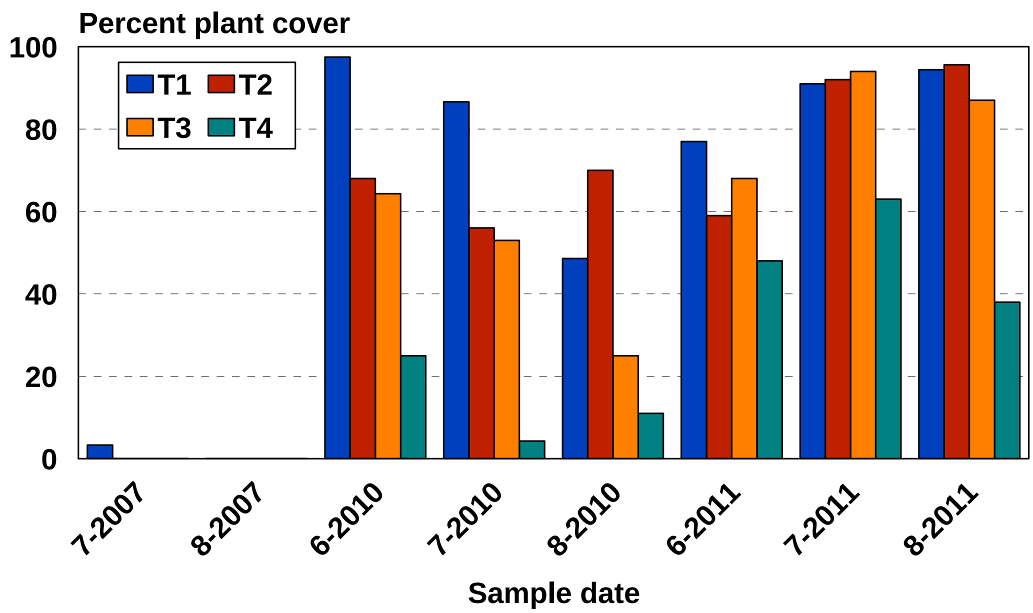


Figure 8.14. Percent vascular plant cover for four transect survey lines in K-1007-P-1 Holding Pond prior to and after the remediation in 2009.

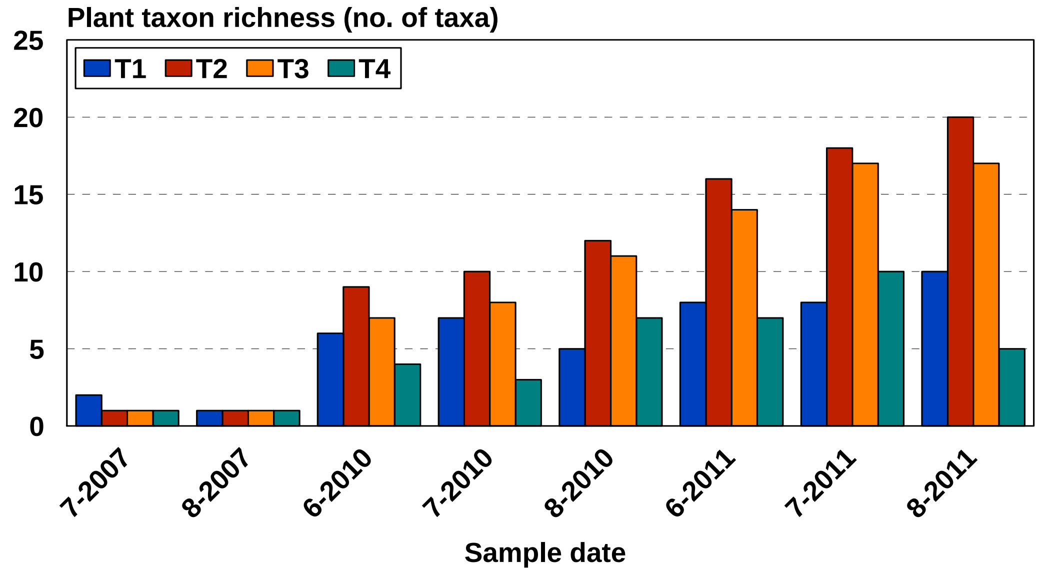


Figure 8.15. Plant taxon richness for four transect survey lines in K-1007-P-1 Holding Pond prior to and after the remediation in 2009.

The success of vegetation growth may be in part due to control of Canada geese (Figure 8.17), which are aggressive herbivores known to damage freshly planted aquatic vegetation, as well as removal of herbivorous fish species. The decrease in the goose population coupled with improvements in habitat has no doubt contributed to increases in the use of the pond by ducks (Figure 8.18).

Water clarity in the K-1007-P1 Holding Pond, as measured by Secchi disk depth, was approximately two-fold greater than prior to the removal action (Figure 8.19). While concentrations of total suspended solids have differed considerably since monitoring began in 2004, concentrations have clearly been lower since the action was completed. Results in 2011 showed that the highest concentrations of total suspended solids were in the shallow east end (i.e., Transect A) in June, but as summer progressed concentrations were progressively higher at mid-pond (Transect B) and the deeper west end. Persistence of this trend in the future will provide strong evidence that the lush vegetation in the east end is providing some help in controlling total suspended solids concentrations in the pond.

In summary, the operational performance data suggests that the desired water quality, plant community, and wildlife manipulations are progressing well toward the desired end state. If the 2012 operational monitoring results indicate stable or improving conditions, further monitoring of water quality, plant community, and wildlife conditions will discontinue in FY 2013. This change in monitoring regime is consistent with the *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE 2011b).

The fish community in the K-1007-P1 Holding Pond continues to change over time, and the effects of the weir breach on the long-term success of the removal action are not yet well understood. As part of ongoing performance monitoring of the pond, fish population surveys will continue to be performed in conjunction with the monitoring of PCB concentrations in fish. An issue is being closed in this Remediation Effectiveness Report concerning the weir breach and the reintroduction of undesirable fish. The weir was fixed and monitoring is ongoing, see Table 8.13.

Figure 8.16. 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) and after two growing seasons, 2011(bottom).

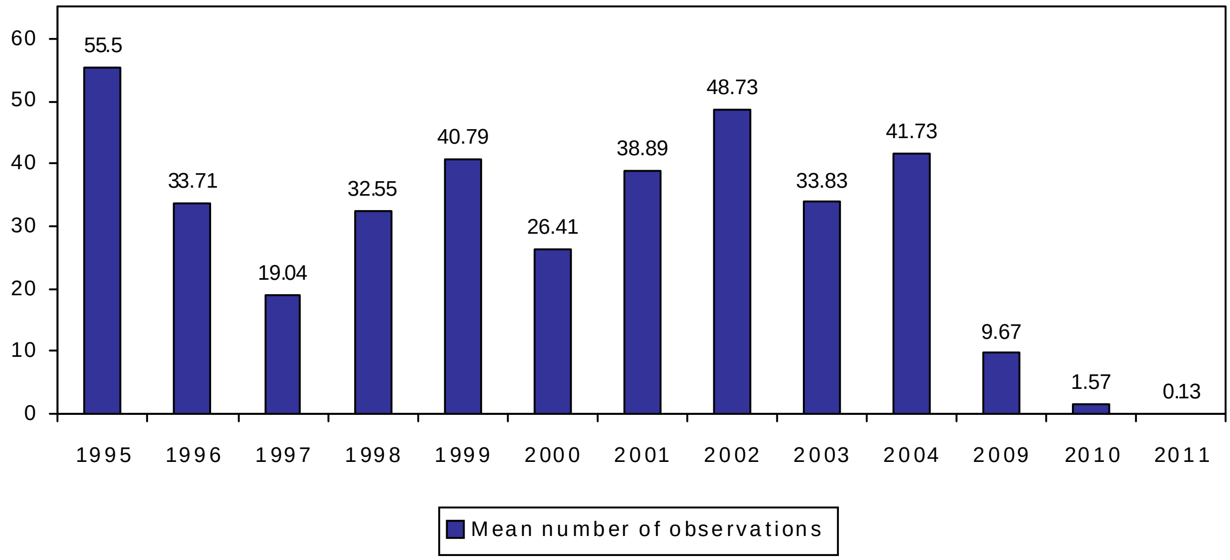


Figure 8.17. Number of geese reported during routine surveys prior to and after the removal action.[1]

[1]All observations based on calendar year for direct comparisons to historical data (1995-2004). Number of surveys varies, dependent on year. 1995-2004 data based on bi-monthly to monthly surveys [1995-1997 & 1999 (N=24), 1998 (N=22), 2000 (N=17), 2001 (N=18), 2002 & 2004 (N=11), 2003 (N=12)]. No formal surveys were conducted 2005-2008. 2009 – 2011 data based on weekly surveys [2009 (N=30), 2010 (N=49), 2011 (N=46)]. 2009 surveys started in May. 2010 surveys based on full year. 2011 surveys only through end of October.

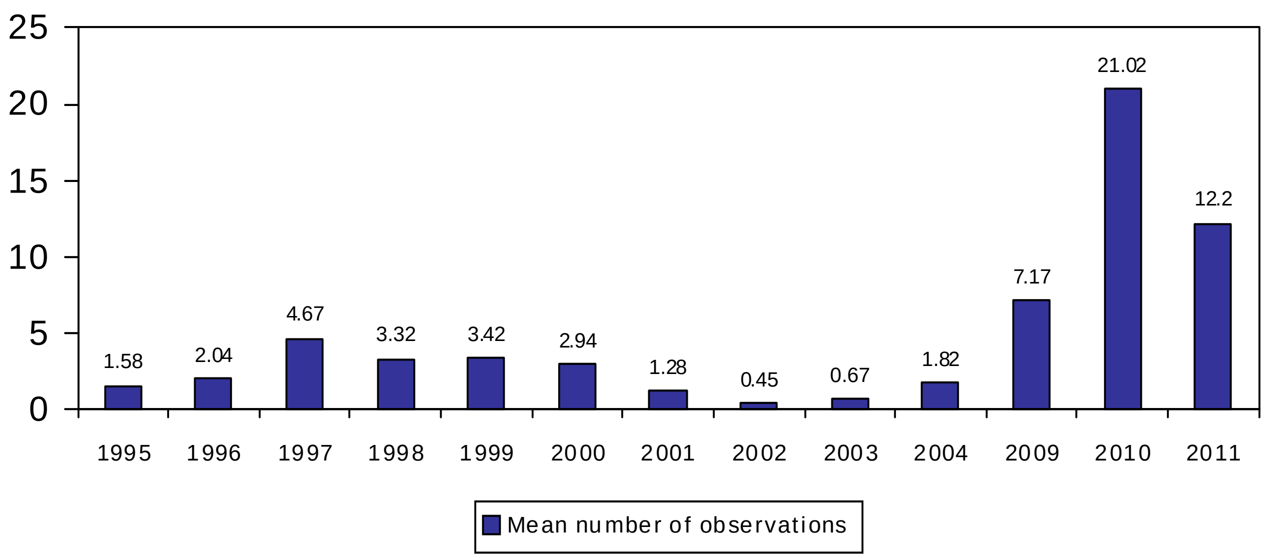
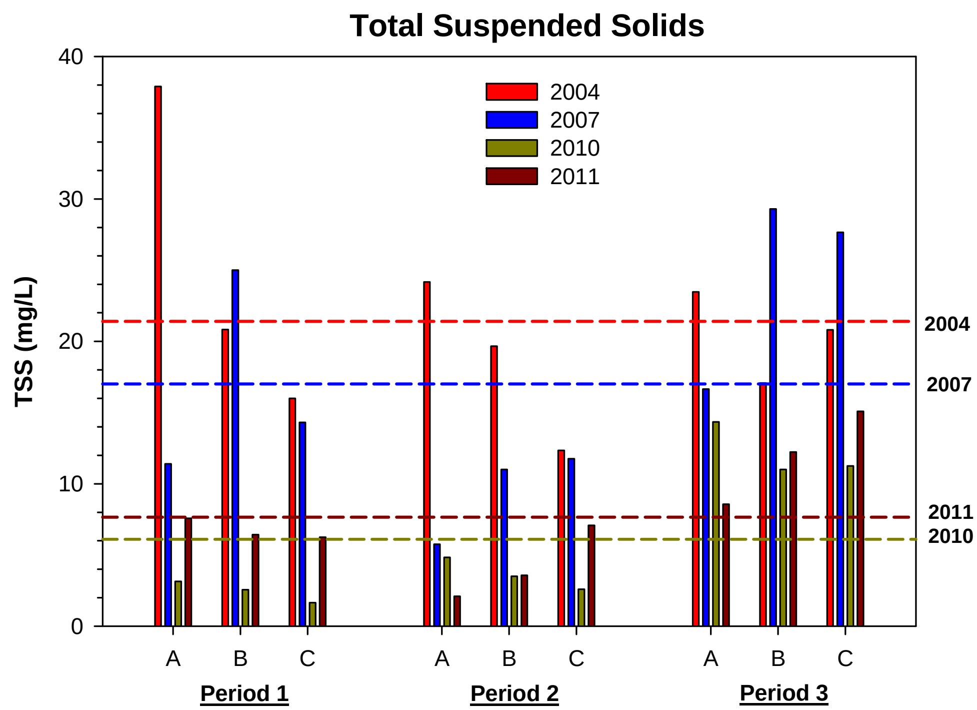


Figure 8.18. Historical occurrence of ducks (all species) at the K-1007-P1 Holding Pond, 1995-2011[1]

[1]All observations based on calendar year for direct comparisons to historical data (1995-2004). Number of surveys varies, dependent on year. 1995-2004 data based on bi-monthly to monthly surveys [1995-1997 & 1999 (N=24), 1998 (N=22), 2000 (N=17), 2001 (N=18), 2002 & 2004 (N=11), 2003 (N=12)]. No formal surveys conducted 2005-2008. 2009 – 2011 data based on weekly surveys [2009 (N=30), 2010 (N=49), 2011 (N=46)]. 2009 surveys based on 30 weeks to correspond with Canada goose survey time period (partial year). 2010 surveys based on full year. 2011 surveys only through October.



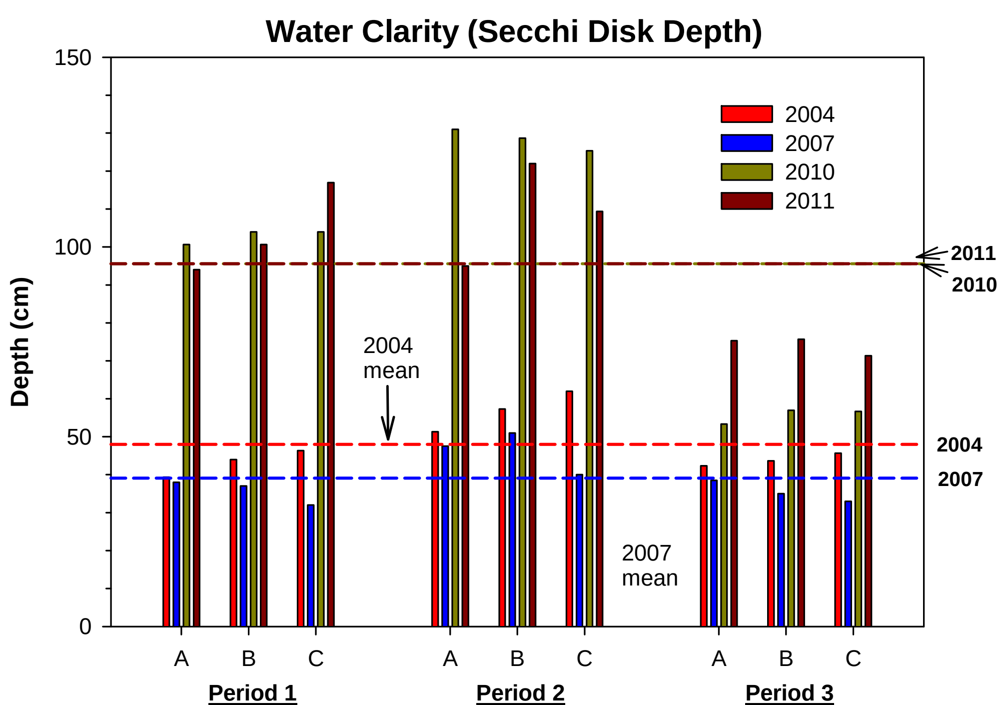


Figure 8.19. Total suspended solids and water clarity results by transect and sample period, prior to and after the removal action.

[1]Transects are approximately evenly space across the pond and sampling periods 1-3 generally refer to spring, early summer, and late summer, during periods of the year with the greatest suspended algae.
Dotted lines reflect annual means.

8.4.2.3 Evaluation of Performance Monitoring Data

Assessment of PCB uptake and exposure in the K-1007-P1 Holding Pond continued in FY 2011, and included the collection and analysis of fillets and whole body fish samples. Fish samples were also collected from the K-901-A Holding Pond and K-720 Slough for analysis of PCBs. The target species for bioaccumulation monitoring in 2011 in the K-1007-P1 Holding Pond was bluegill sunfish (*Lepomis macrochirus*).

While bluegill sunfish were already resident to the K-1007-P1 Holding Pond even after the pond was injected with rotenone, efforts were made to sustain the population by introducing additional bluegill, either from a hatchery or collected from uncontaminated sites. Restocking occurred between February-October 2010. Whole body composites (6 composites of 10 bluegill per composite) and fillets from 20 individual bluegill were analyzed for PCBs to assess the ecological and human health risks (respectively) associated with PCB contamination in the K-1007-P1 Holding Pond. Average PCB levels in bluegill fillets were 1.85 µg/g in bluegill fillets and 5.62 µg/g in whole body composites. These concentrations are significantly lower than levels seen prior to the fish removal in 2009 and are comparable to those seen in bluegill in 2010 (Figure 8.20). The current bluegill concentrations are well below the long-term average PCB concentrations in largemouth bass, which were 5 to 10-fold higher prior to the action (Figure 8.20).

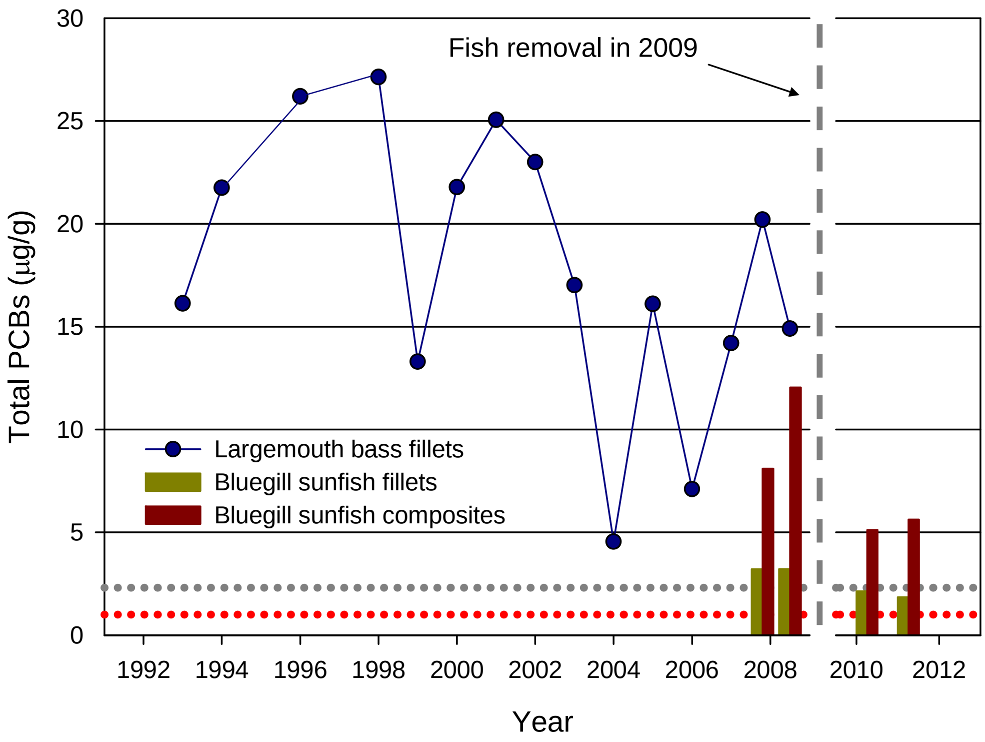


Figure 8.20. Mean concentrations of polychlorinated biphenyls in fish from K-1007-P1 Holding Pond, 1993–2011.

Dotted red line signifies polychlorinated biphenyl goal of 1 µg/g in fillets, and dotted grey line signifies polychlorinated biphenyl goal of 2.3 µg/g whole body.

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, so common carp (*Cyprinus carpio*) and smallmouth buffalo (*Ictiobus bubalus*) were collected to provide a combined total of 20 fish. Carp and buffalo were selected as surrogate species for bass because they are widely distributed, are present at both locations, and have been used historically in other monitoring efforts on the Oak Ridge Reservation for contaminant analyses.

At the K-901-A Holding Pond, PCBs in largemouth bass fillets increased slightly in 2011, but concentrations were within the long-term average variability (Figure 8.21). The average concentration of PCBs in largemouth bass and carp fillets from the K-901-A Holding Pond was 0.50 and 2.06 µg/g respectively. Whole body gizzard shad from the K-901-A Holding Pond, collected as a measure of potential ecological risk to terrestrial wildlife, were substantially higher in concentration (5.57 µg/g) than the fillets in either species. Routine bioaccumulation monitoring in the K-720 Slough began in 2009. In all cases PCB levels in fish collected from the K-720 Slough were significantly lower than in the K-901-A Holding Pond for the same species (Table 8.6). PCB concentrations in largemouth bass collected from the K-720 Slough were significantly lower than in the other monitored ponds, averaging 0.24 µg/g in 2011 (Table 8.6; Figure 8.21). Concentrations in carp and smallmouth buffalo collected from the K-720 Slough were higher than in bass, averaging 0.96 and 0.77 µg/g, respectively.

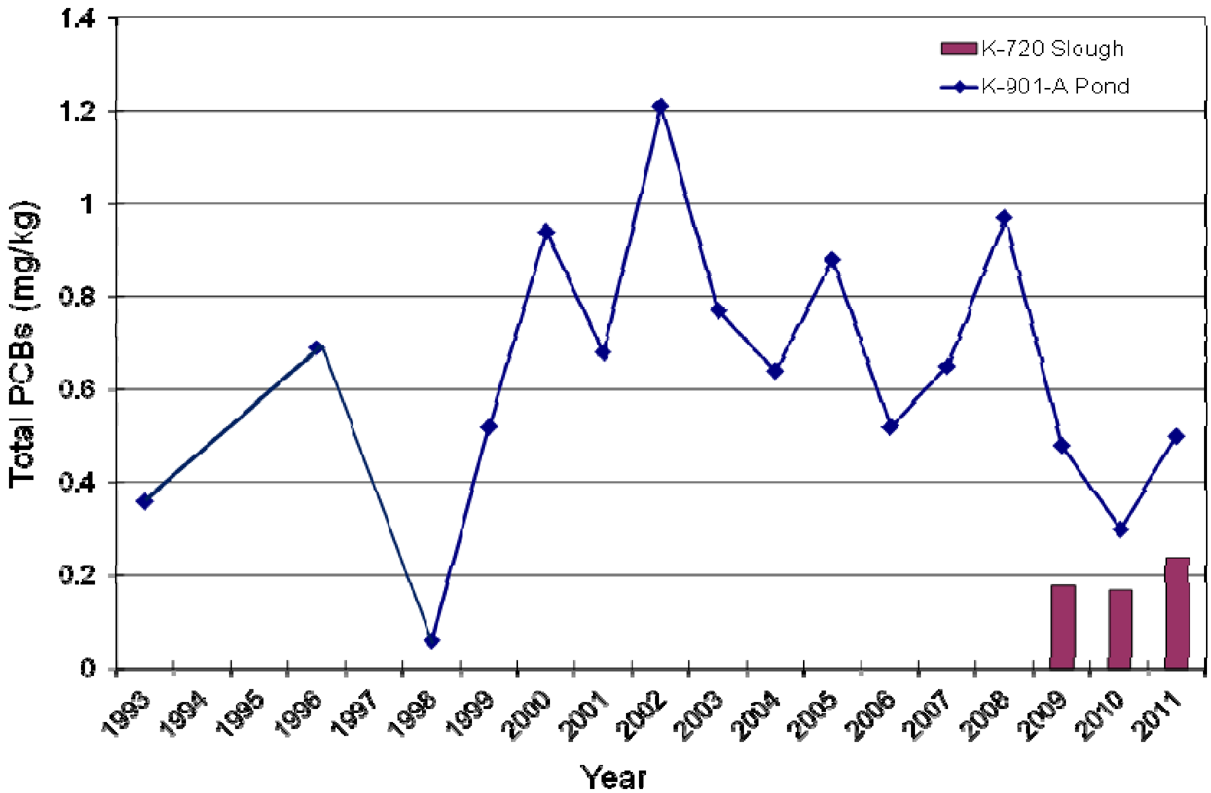


Figure 8.21. Mean concentrations of polychlorinated biphenyls in largemouth bass fillets from K-901-A Holding Pond and K-720 Slough, 1993–2011.

Table 8.6. Total polychlorinated biphenyl (Aroclors 1248, 1254, and 1260) concentrations in fish from the K-1007-P1 Holding Pond, K-720 Slough, and K-901-A Holding Pond, 2011[a]

Site	Species	Sample type	Sample size (n)	Aroclor 1248	Aroclor 1254	Aroclor 1260	Total PCBs (mean ± SE)
K-1007-P1 Pond	Bluegill sunfish	Fillet	20	0.029 ± 0.004 *(0.006 - 0.15)*	1.16 ± 0.21 *(0.26 - 3.8)*	0.65 ± 0.11 *(0.12 - 1.7)*	1.85 ± 0.31 *(0.39 - 5.56)*
		Whole body composites	6	0.07 ± 0.01 *(0.06 - 0.13)*	3.63 ± 0.39 *(3.0 - 5.5)*	1.92 ± 0.10 *(1.7 - 2.3)*	5.62 ± 0.48 *(4.86 - 7.93)*
K-901-A Pond	Largemouth bass	Fillet	10	0.02 ± 0.003 *(0.003 - 0.032)*	0.02 ± 0.002 *(0.003 - 0.032)*	0.47 ± 0.08 *(0.15 - 0.94)*	0.50 ± 0.08 *(0.16 - 1.00)*
	Common carp	Fillet	10	0.06 ± 0.01 *(0.029 - 0.13)*	0.41 ± 0.09 *(0.05 - 0.73)*	1.59 ± 0.28 *(0.86 - 3.6)*	2.06 ± 0.25 *(1.20 - 2.16)*
	Gizzard shad	Whole body composites	6	0.12 ± 0.001 *(0.12 - 0.125)*	1.28 ± 0.05 *(1.1 - 1.4)*	4.17 ± 0.11 *(3.8 - 4.5)*	5.57 ± 0.13 *(5.13 - 6.03)*
K-720 Slough	Largemouth bass	Fillet	3	0.003 ± .00001 *(0.0032 - 0.00325)*	0.12 ± 0.01 *(0.10 - 0.13)*	0.12 ± 0.01 *(0.10 - 0.13)*	0.24 ± 0.02 *(0.20 - 0.26)*
	Common carp	Fillet	4	0.02 ± 0.0002 *(0.015 - 0.017)*	0.31 ± 0.12 *(0.02 - 0.61)*	0.63 ± 0.11 *(0.43 - 0.95)*	0.96 ± 0.21 *(0.63 - 1.58)*
	Smallmouth buffalo	Fillet	13	0.02 ± 0.005 *(0.003 - 0.07)*	0.32 ± 0.09 *(0.003 - 1.2)*	0.43 ± 0.10 *(0.05 - 1.3)*	0.77 ± 0.19 *(0.05 - 2.57)*
	Gizzard shad	Whole body composites	6	0.006 ± 0.002 *(0.003 - 0.010)*	0.11 ± 0.06 *(0.01 - 0.16)*	0.14 ± 0.02 *(0.08 - 0.21)*	0.26 ± 0.03 *(0.18 - 0.33)*

[a]Values are mean concentrations (µg/g) ± SE; range in parentheses.

Temporal trends for whole body fish in K-1007-P1 Holding Pond (bluegill), K-901-A Holding Pond, and K-720 Slough (gizzard shad) are shown in Figure 8.22. In 2009, prior to the fish removal actions, concentrations were highest in whole body fish from K-1007-P1 Holding Pond, and lowest in the K-720 Slough. Concentrations in bluegill from the K-1007-P1 Holding Pond decreased significantly from 2009-2011, such that concentrations were similar to those seen in K-901-A Holding Pond in 2011. Concentrations in K-1007-P1 Holding Pond and K-901-A Holding Pond remain above the goal of 2.3 µg/g in whole body fish, while those in the K-720 Slough are well below this target.

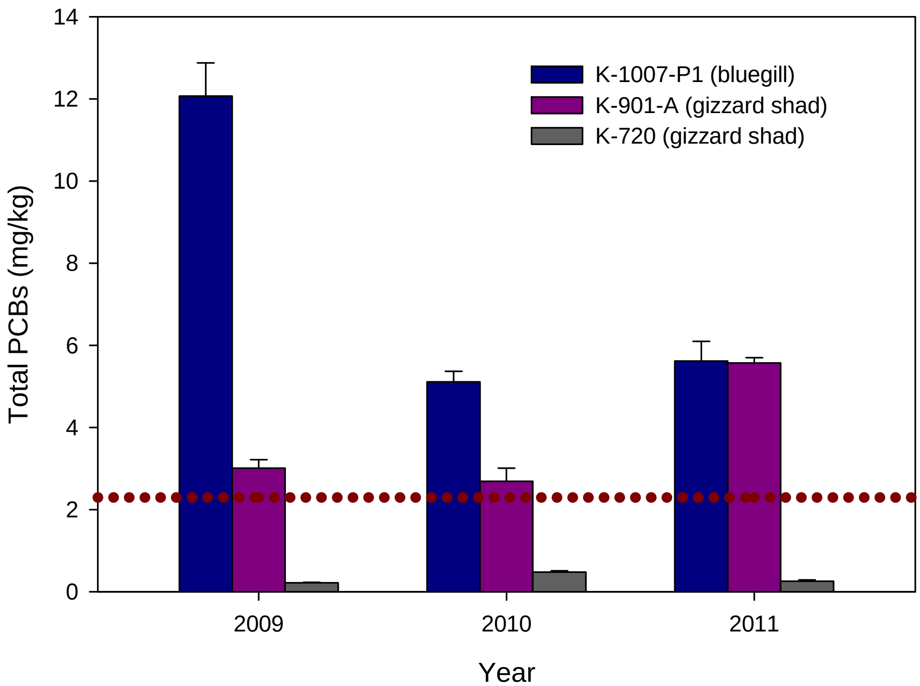


Figure 8.22. Mean concentrations of polychlorinated biphenyls in whole body fish from K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough, 2009–2011.

Dotted line signifies polychlorinated biphenyl goal of 2.3 µg/g in whole body fish.

Caged Asiatic clams (*Corbicula fluminea*) were placed near and within various storm drains entering the K-1007-P1 Holding Pond for a four-week exposure period (June – July 2011). Clams placed in upper and lower Storm Drain-100 in the K-1007-P1 Holding Pond had ~2 – 5.2 µg/g total PCBs, respectively, in their soft tissues. These concentrations are higher than those seen in clams deployed in 2010, but remain within concentrations seen in recent years (Figure 8.23). However, clams placed at Storm Drain-120 had significantly lower PCB concentrations in 2011 (0.75 – 0.97 µg/g) than in 2010 (1.2 – 3.1 µg/g; Figure 8.24). PCB concentrations in clams placed at the K-1007-P1 Holding Pond weir spiked in 2011 in conjunction with a similar increase observed in clams placed at Storm Drain-100 locations, suggesting slightly higher PCB inputs to the pond in 2011. However, the year to year variability in clam concentrations is high and longer-term averages are a better indicator of temporal trends. Overall, current PCB levels in clams at all K-1007-P1 Holding Pond sites are well below peak levels observed in the 2000 time frame.

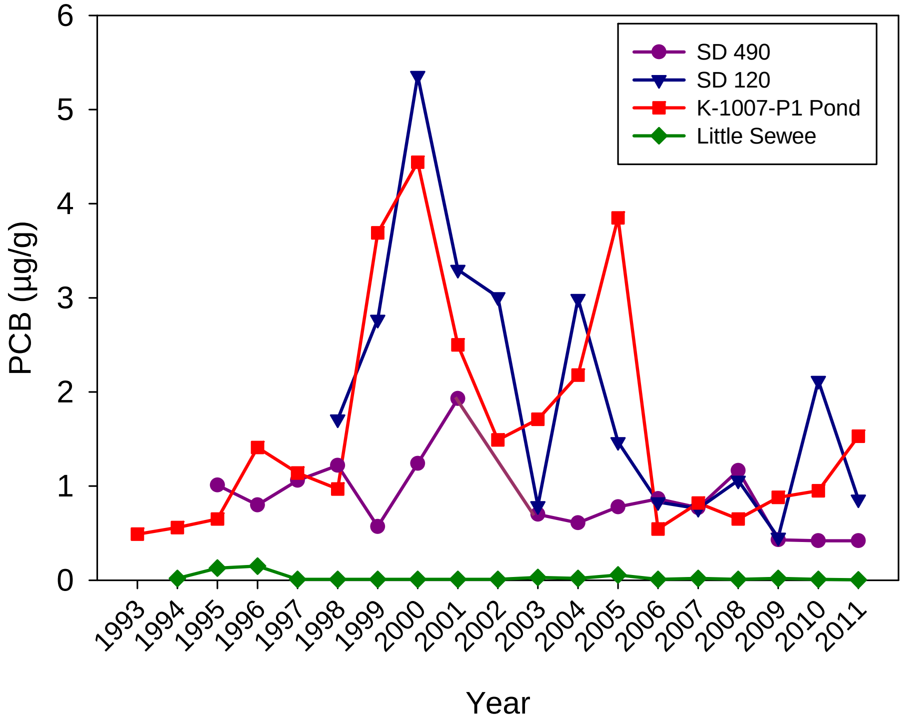


Figure 8.23. Mean Total PCB concentrations (µg/g, wet wt; 1993-2011) in the soft tissues of caged Asiatic clams deployed in the P1 Pond near the weir and storm drains 490 and 120. N=2 composites of 10 clams each per year. Shown in green are data for clams collected form the reference site, Little Sewee Creek (Sweetwater, TN). Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.

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, TN). Total polychlorinated biphenys defined as the sum of Aroclors 1248, 1254, and 1260.

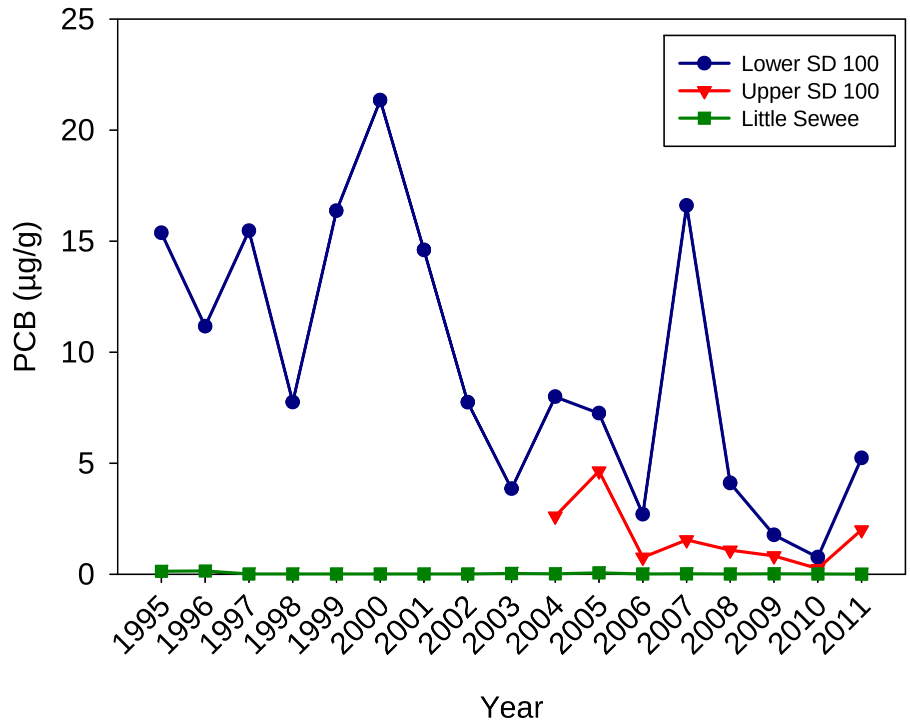


Figure 8.24. Mean total PCB concentrations (µg/g, wet wt; 1995-2011) in the soft tissues of caged Asiatic clams deployed at two locations in SD 100: "upper SD 100", upstream of any possible pond related sources, and "lower SD 100" at the culvert entering the pond and potentially influenced by pond sediment sources.

N=2 composites of 10 clams each per year. Shown in green are data for clams collected form the reference site, Little Sewee Creek (Sweetwater, TN). Total polychlorinated biphenys defined as the sum of Aroclors 1248, 1254, and 1260.

8.4.2.4 Performance Summary

Performance monitoring at the K-1007-P1 Holding Pond began in FY 2010. The baseline trends show PCBs in largemouth bass around 15 µg/g as a long-term average. The current sunfish average in fillet is around 2 µg/g, resulting in a decrease in potential human health risks associated with the change in species alone. Bluegill concentrations have decreased from around 3 µg/g prior to the actions to 2 µg/g currently. Clam studies continue to indicate that storm drains are a source of PCBs to the K-1007-P1 Holding Pond, but resuspension of contaminated sediments in the pond are a more likely important source of PCBs to fish. The removal action at the K-1007-P1 Holding Pond was designed to reduce sediment mobilization and subsequent bioaccumulation in fish. It will take some time for the fish, plant, wildlife, and water quality conditions in the pond to stabilize, allowing a better assessment of whether PCB exposure in the pond has sufficiently decreased. An issue identified from the 2011 Remediation Effectiveness Report is being closed, the breached weir was fixed and PCB concentrations in fish continue to be monitored and evaluated, Table 8.13.

8.4.2.5 Compliance with Long-Term Stewardship Requirements

8.4.2.5.1 Requirements

The *Removal Action Report for the Ponds at the East Tennessee Technology Park* (DOE 2011b) 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 fisherman and specific signs at the K-1007-P1 Holding Pond to provide notice or warning that prohibits mowing in buffer zone. The Removal Action Report also requires surveillance patrols be established and maintained to control and monitor access by fisherman.

8.4.2.5.2 Status of Requirements for FY 2011

Activities conducted at the ponds in FY 2011 included inspections by the ETTP Surveillance and Maintenance 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. No maintenance was required.

8.4.3 K-1070-C/D G-Pit and Concrete Pad Remedial Action

8.4.3.1 Long-Term Stewardship Requirements

The K-1070-C/D G-Pit is the primary source of organic contaminant releases to soil and groundwater in the area. The 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 1998). The location of the area at ETTP is shown in Figures 8.1 and 8.25. 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-feet soil cover over the Concrete Pad until remediated.

The ROD (DOE 1998) and Removal Action Report (DOE 2002d) require interim long-term stewardship activities including maintaining institutional controls (see Table 8.2). Specifically, inspections of the soil cover over the pad are to be conducted weekly to look for erosion, and the grass on the cover is to be mowed at an estimated frequency of five times a year. Annual radiological walkover surveys are to be conducted to confirm the effectiveness of the Concrete Pad soil cover in preventing exposure to ionizing radiation. Existing institutional controls will continue to include semiannual inspections of the fence, as well as ensuring the existing excavation/penetration permit Program remains in place. These controls are to continue until final decisions are made for the K-1070-C/D Burial Ground in the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2* (DOE 2005a).

8.4.3.2 Status of Requirements for FY 2011

The site was inspected by the ETTP Surveillance and Maintenance Program in FY 2011 for items including condition of the warning signs, condition of fencing and locked gate, condition of the 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.

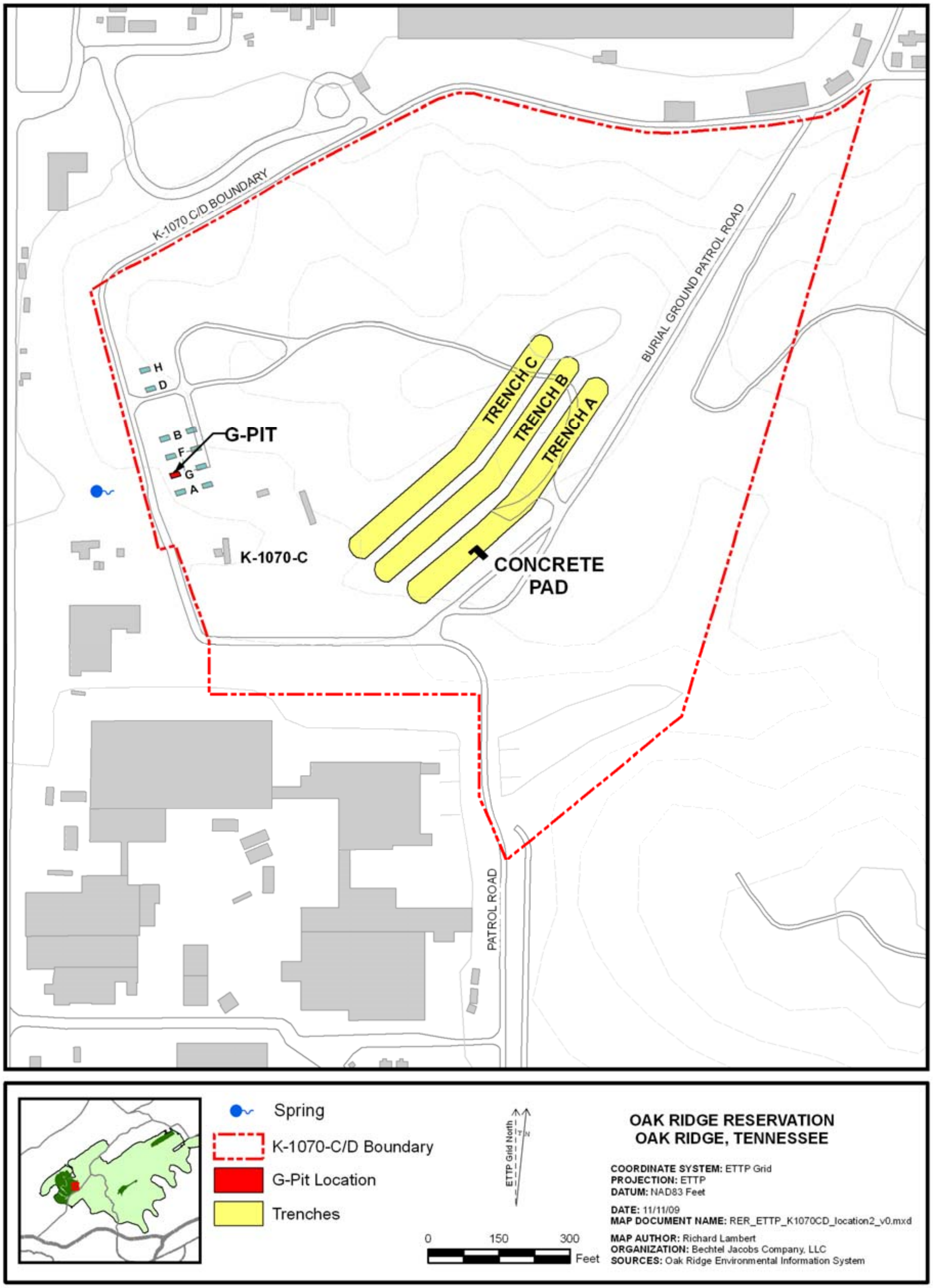


Figure 8.25. Location of K-1070-C/D G-Pit and Concrete Pad.

8.4.4 K-1070-A Burial Ground Remedial Action

8.4.4.1 Compliance with Long-Term Stewardship Requirements

The remedy in the *Record of Decision for the K-1070-A Burial Ground at the East Tennessee Technology Park* (DOE 2000b) (Figures 8.1 and 8.26 included waste removal and disposal, along with institutional controls. Major components of the remedy include:

- Waste characterization,
- Excavation and disposal,
- Residual soil characterization, and
- Backfilling excavated areas with clean fill.

The source removal action addressed the present and projected future principal threats posed by the K-1070-A Burial Ground, primarily chlorinated VOCs and radionuclides. No known unacceptable residual risk from soils for industrial or recreational end use remain within the K-1070-A Burial Ground fenced area subsequent to completion of the remedial action defined in the Record of Decision (DOE 2000e).

Post-remedial action monitoring requirements are not specified for this action, and cleanup standards for environmental media were not identified (DOE 2003b). Until a groundwater decision is finalized, downgradient Spring 21-002 is monitored as an exit pathway point (Sect. 8.6).

The *Record of Decision for the K-1070-A Burial Ground at the East Tennessee Technology Park* (DOE 2000b) states that following implementation of the remedial action, protectiveness at the site will be ensured through continuation of current ETTP sitewide controls including physical and administrative access restrictions, surveillance, security patrols, restrictions on excavation, and restrictions on groundwater and surface water use (DOE 2000b). In addition, the *Remedial Action Report for the K-1070-A Burial Ground at the East Tennessee Technology Park* (DOE 2003b) states that to maintain the effectiveness of the soil cover, the cover will be inspected monthly and the grass on the site will be mowed at an estimated frequency of five times a year. If erosion is found, “clean” soil will be used to repair the eroded area, and the area will be reseeded, if necessary.

8.4.4.2 Status of Requirements for FY 2011

In the spring of 2009, the K-1070-A Burial Ground was seeded with switchgrass by DOE, the Tennessee Water Resources Agency, and the Community Reuse Organization of East Tennessee to support the State of Tennessee’s biofuels initiative to use switchgrass as a feedstock for ethanol production.

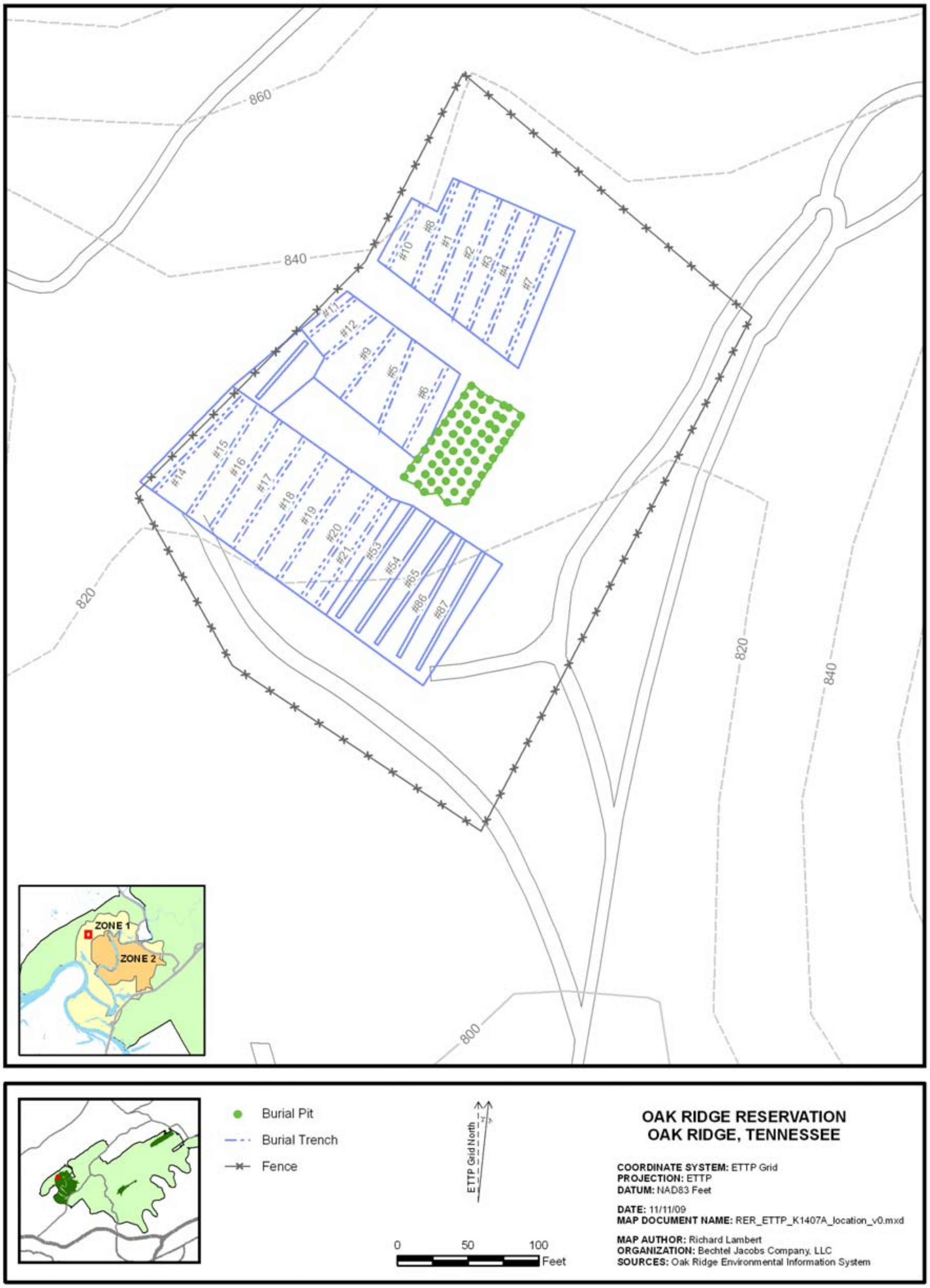


Figure 8.26. Location of former K-1070-A Burial Ground.

The *Dose Assessment and ALARA Evaluation for Release of Switchgrass* (DOE 2009e) provides an assessment of dose and As Low As Reasonably Achievable evaluation associated with the release of approximately 120 bales of switchgrass grown at ETTP for use as biofuel feedstock and a basis for deciding the dose is As Low As Reasonably Achievable. The applicable data consisted of ten ^{234}U, ^{235}U, and ^{238}U detected results from 30 samples of switchgrass. The RESRAD RECYCLE off-the-shelf model was judged to be the best fit, as its exposure scenarios reasonably capture the range of potential exposures for the current application. Furthermore, the conservative parameters chosen provide a worse case estimate of the doses.

The RESRAD RECYCLE model showed the maximum worker dose to be for the ash processor with a dose of 1E-4 millirem (assumed to be received in one calendar year). The maximum exposure to a member of the public from the assumed air release was 3E-5 millirem, which is less than the As Low As Reasonably Achievable goal of 1 millirem/year. In order to evaluate an alternative disposition as required by As Low As Reasonably Achievable evaluation, the RESRAD RECYCLE meat and milk scenario used default parameters which assumed 50% of the meat and milk consumed was from the contaminated source. The model showed an exposure to a member of the public of 4E-1 millirem/year, which is less than the As Low As Reasonably Achievable goal of 1 millirem/year. The doses estimated for the release of switchgrass as fuel are significantly less than if the switchgrass were to be used as fodder. However, both scenarios provide a dose that is less than the As Low As Reasonably Achievable goal of 1 millirem/year.

Monthly inspections of the site for subsidence and erosion per the *Remedial Action Report for the K-1070-A Burial Ground* (DOE 2003b) are no longer applicable. A recommendation was made in the *2011 Five-Year Review* (DOE 2011c) site visit to change the frequency of mowing and the inspections of the site. This recommendation was accepted during the August 11, 2010 Core Team Meeting and changes will be reflected in an upcoming *Addendum to the Remedial Action Report for the K-1070-A Burial Ground*.

8.4.5 Mitchell Branch Chromium Reduction

8.4.5.1 Performance Goals and Monitoring Objectives

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* (DOE 2007f). The location of the removal action is noted on Figures 8.1 and 8.27.

Figure 8.27 shows the locations of Mitchell Branch, relevant monitoring locations, the affected storm drain section, and the hexavalent chromium plume. The removal action was taken due to releases of hexavalent chromium into Mitchell Branch from the storm drain-170 outfall and from seeps at the headwall of the storm drain-170 discharge point. The plume discharge resulted in levels of hexavalent chromium that exceeded state hexavalent chromium water quality chronic criterion of 0.011 mg/L for the protection of fish and aquatic life. At Mitchell Branch Kilometers 0.71 and 0.79, which are locations in Mitchell Branch immediately downstream from the storm drain-170 discharge point, hexavalent chromium levels were measured at levels as high as 0.78 mg/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 thirty 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 storm drain system and into Mitchell Branch.
- Installed a grout wall to impede the release of hexavalent chromium through storm drain-170 headwall seeps into Mitchell Branch.
- Installed two interception wells into the gravel bed that surrounds the storm drain-170 discharge pipes to collect the hexavalent chromium groundwater plume before it infiltrates the storm drain-170 collection system network piping.
- Began operating the two interception wells in December 2007. The collected groundwater is treated at the Central Neutralization Facility, which is a National Pollutant Discharge Elimination System permitted facility that currently provides services to CERCLA and non-CERCLA industrial operations at ETTP.

A *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2008c) 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 2009f) recommending *ex situ* treatment by chromium reduction was approved on December 3, 2009. The non-time critical *Action Memorandum for the Long-Term of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010e) 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 2007e). The *Removal Action Work Plan for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010h) was approved in November 2010. Construction was initiated in spring 2011 and is planned to be completed in December 2011.

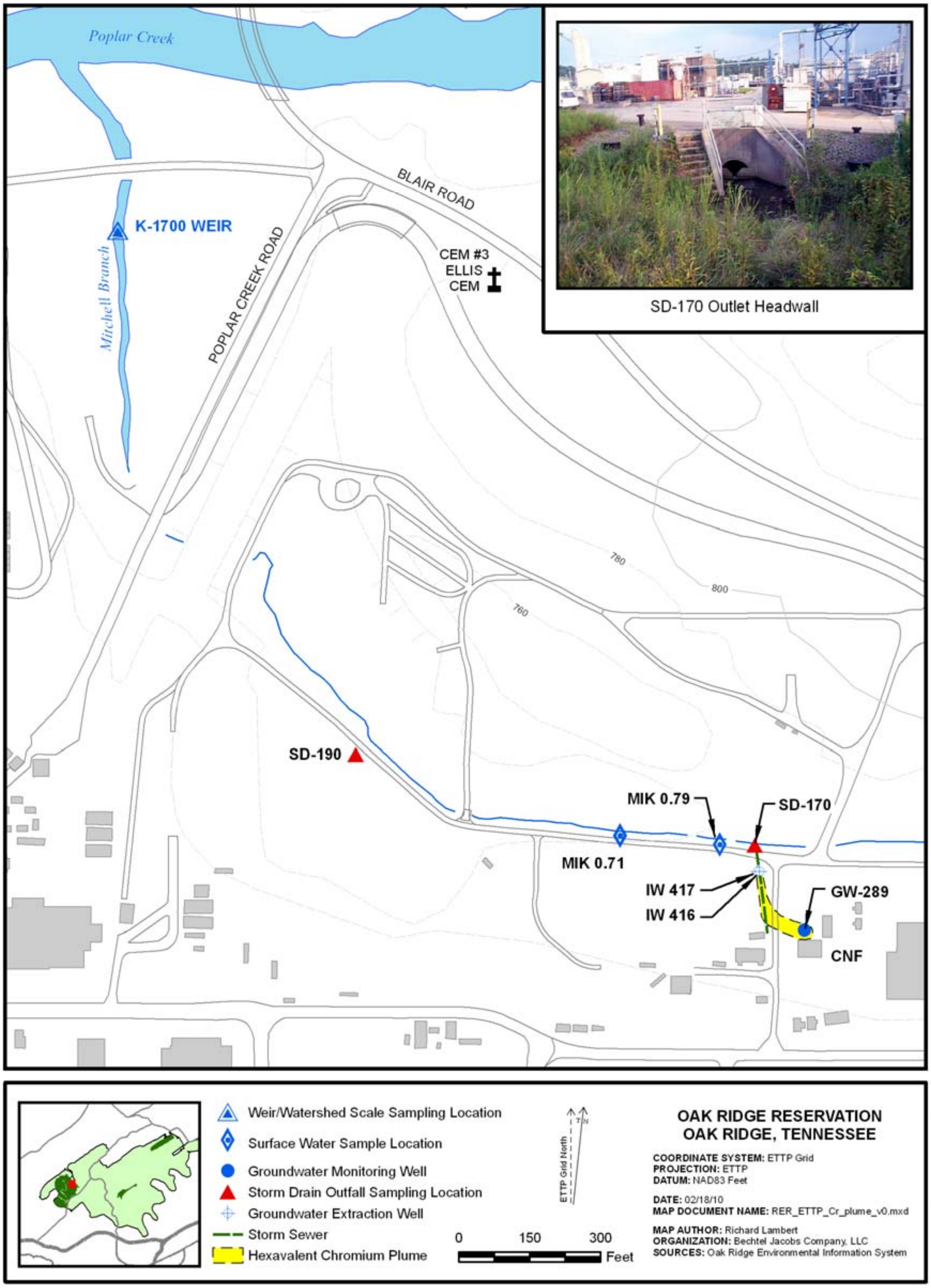


Figure 8.27. Location of hexavalent chromium releases to Mitchell Branch.

Monitoring of the removal action is documented in the *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2008c). 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 Remediation Effectiveness Report. The storm drain-170 quarterly sampling outfall results are also reported in the National Pollutant Discharge Elimination System Permit Discharge 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 chromium sampling points identified in the *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2008c) are:

- storm drain-170 discharge point.
- Mitchell Branch instream location (Mitchell Branch Kilometers 0.71/0.79) that is downstream from storm drain-170. The instream location below storm drain-170 provides an opportunity for the discharges to mix with the Mitchell Branch receiving stream which is considered to be the appropriate location to compare hexavalent chromium concentrations with the AWQC value of 0.011 mg/L.
- Collection system that captures the combined flow from interception wells 416 and 417.
- Monitoring well 289 (location in the groundwater plume).

8.4.5.2 Evaluation of Performance Monitoring Data

The long-term water quality monitoring results for total chromium in Mitchell Branch downstream from storm drain-170 at Mitchell Branch Kilometer 0.79 are in Figure 8.28. 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 anaylsis. During FY 2011, hexavalent chromium comprised approximately 95% of the total chromium values as measured at the groundwater plume monitoring well location. The hexavalent chromium AWQC is provided for reference and comparison purposes.

The surface water results in Mitchell Branch show that the chromium collection system has been effective in reducing the levels of chromium from a maximum measured value of 0.78 mg/L to levels that are now consistently well below the hexavalent chromium AWQC value of 0.011 mg/L during dry and wet weather periods. The one exception over the past year was the sampling event in July 2011 when the measured total chromium value was 0.013 mg/L and the corresponding hexavalent value was 0.010 mg/L which is slightly below the AWQC of 0.011 mg/L. The July 2011 sampling event occurred during an operational period where the pumping rates of the extraction wells had been reduced due to operational treatment repairs at the Central Neutralization Facility.

Short-term results are discussed below:

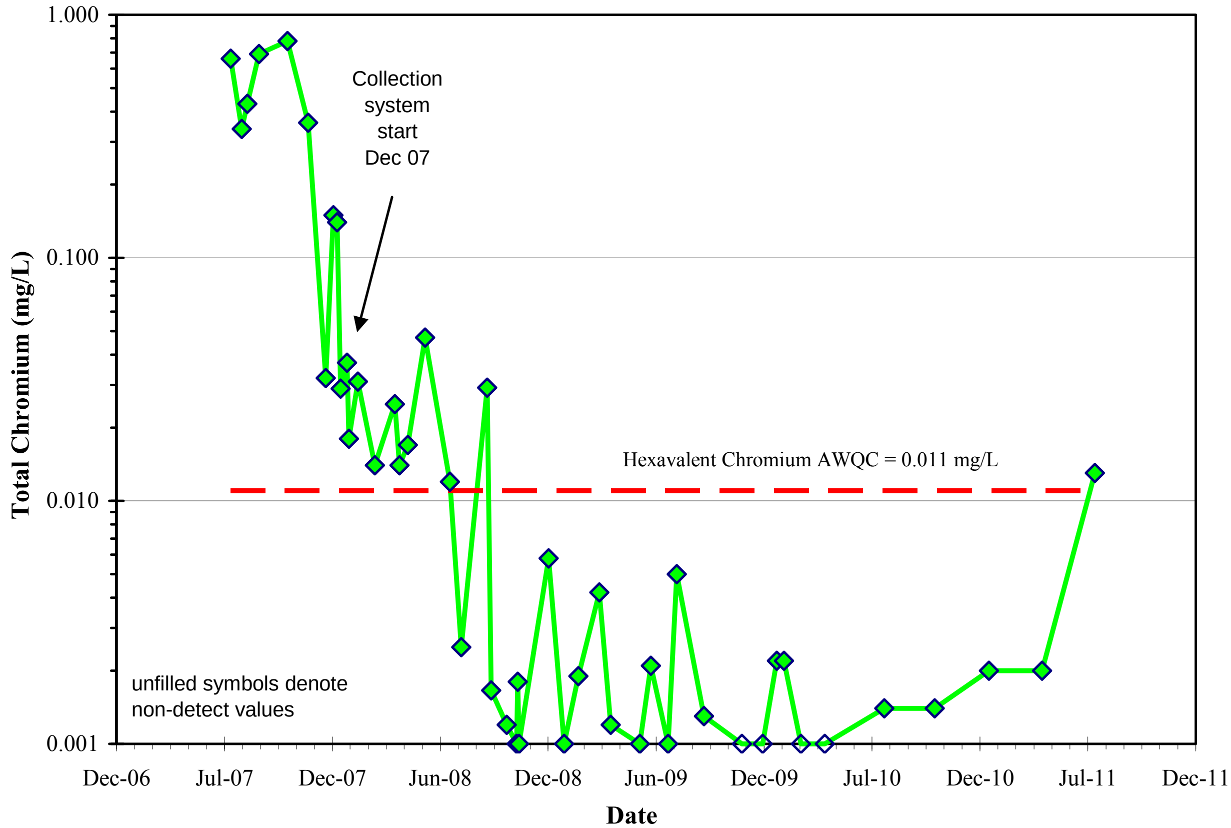


Figure 8.28. Mitchell Branch Kilometer 0.79 chromium concentrations, FY 2007-2011.

- **Surface Water Monitoring Short-Term Data**

The hexavalent chromium quarterly performance monitoring results for FY 2011 are in Table 8.7. Historical sampling and analysis of the chromium in the groundwater plume and in storm drain-170 has established that essentially all of the detected chromium is hexavalent chromium with only a small proportion of the less hazardous trivalent chromium.

The instream sampling results for hexavalent chromium at the Mitchell Branch Kilometer 0.71/0.79 point of compliance varied from nondetect levels to a maximum of 0.010 mg/L during FY 2011. As previously noted, all the results were less than the AWQC value of 0.011 mg/L despite the operational constraints that were occurring at the time of the July 2011 sampling event.

The results for hexavalent chromium at storm drain-170 varied from nondetect levels to a maximum amount of 0.018 mg/L. Again, the maximum result occurred during the July 2011 sampling event during the period of operational constraints.

The hexavalent chromium results for the combined water flows that are collected in interception wells 416 and 417 varied from a low of 0.334 mg/L to a maximum value of 0.435 mg/L.

The hexavalent chromium results at well GW-289 varied from a low of 0.546 mg/L to a maximum value of 1.795 mg/L.

Table 8.7. FY 2011 performance monitoring results for reduction of hexavalent chromium releases into Mitchell Branch

Sample Date	October 2011	January 2011	April 2011	July 2011
Location Description	**Hexavelent Chromium (mg/L)**	**Hexavalent Chromium (mg/L)**	**Hexavalent Chromium (mg/L)**	**Hexavalent Chromium (mg/L)**
Mitchell Branch kilometer 0.71/0.79 (MIK 0.71/0.79) downstream from SD-170	0.006 U	0.006 U	0.006U	0.010
SD-170	0.006 U	0.006 U	0.010	0.018
Collection System (Intercepter wells 416, 417)	0.334	0.414	0.352	0.435
Well 289	1.795	1.547	0.546	1.446
Collection System Pumping Rate, gpm	12.5	9.2	11.9	6.0
SD-170 Base Flow Rates, gpm	49	44	115	22
Weather Conditions	Wet	Dry	Dry	Dry

U Flag indicates nondetection at the analytical detection limit.
MIK = Mitchell Branch Kilometer
SD = storm drain
gpm = gallons per minute

- **Treatment System Performance**

  A significant upgrade was implemented for the hexavalent chromium collection system in January of 2009 by replacing pneumatic pumps with electric pumps. The electric pumps provide the capacity for higher pump rate flows while also providing more consistent performance by reducing maintenance requirements.

  During FY 2011, the chromium collection system operated 100% of the days with only short duration periods where pumping volumes were limited.

  The evaluation of the effectiveness of the collection system is measured by the hexavalent chromium levels at Mitchell Branch Kilometer 0.79 which is the mixing zone point immediately downstream of storm drain-170 and the seeps at the storm drain-170 headwall. As previously noted, the maximum result measured at the instream Mitchell Branch Kilometer 0.79 was 0.010 mg/L, which is below the AWQC level of 0.011 mg/L.

8.4.5.3 Performance Summary

Water sampling in FY 2011 indicates the removal action continues to be highly effective in achieving the goal to meet AWQC levels of 0.011 mg/L for hexavalent chromium in Mitchell Branch immediately downstream from the storm drain-170 discharge.

8.4.5.4 Compliance with Long-Term Stewardship Requirements Requirements

8.4.5.4.1 Status of Requirements for FY 2011

The *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2008c) for the time-critical removal action, the non-time critical *Action Memorandum for the Long-Term of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010e), and the *Removal Action Work Plan for the Reduction of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010h) did not include any long-term stewardship requirements.

There are no long-term stewardship requirements.

8.4.5.4.2 Status of Requirements for FY 2011

No long-term stewardship requirements were specified in the *Action Memorandum for the Long-Term of Hexavalent Chromium Releases into Mitchell Branch* (DOE 2010e). Although no requirements are specified in the action memorandum, the water collection and treatment system undergoes monthly inspections to ensure the system is operating as intended. Routine maintenance in FY2011 included pump flow adjustments due to rainfall and freezing conditions and in preparation for power transition. In January extended downtimes occurred as IW416 and IW417 were removed from service for well development. In May pump IW417 was down and had to be replaced.

8.5 COMPLETED DEMOLITION PROJECTS WITH ACCESS CONTROLS AND LONG-TERM STEWARDSHIP REQUIREMENTS

8.5.1 Long-Term Stewardship Requirements

Over the past several years, most of the CERCLA actions at ETTP focused on completion of building demolition documented by various Phased Construction Completion Reports, some of which included interim requirements for monitoring and access controls because slabs or portions of foundations were left in place. If radiological surveys indicated a slab exceeded the release criteria of DOE Order 5400.5, then interim access controls were implemented and the slab was posted and became part of the radiological surveillance and monitoring program. Table 8.8 identifies the completed demolition projects with remaining contaminated media and the slabs/soil requiring interim land use controls and monitoring. The *Record of Decision for Interim Actions in Zone* 1 (DOE 2002a) and the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone* 2 (DOE 2005a) will determine the final remedy for the contaminated slabs and soil.

Table 8.8. Long-term stewardship monitoring requirements for demolished facilities associated with remaining contaminated media

Area/action[a]	Slab/Foundation (annual radiological survey)[b]	Storm drain (characterize at least once every NPDES permit cycle)	Surface water (characterize annually)
Group II, Phase 2 RmAR for K-1064 Peninsula Area	K-1025-A slab K-1025-B slab K-1025-C slab K-1025-D slab K-1064-D slab K-1025-E K-1064 Salvage Material Yard soil (survey performed only when worker entries required)	SD-230 SD-240 SD-270 SD-280 SD-294 SD-296 SD-297	Surface water from Poplar Creek downstream (K-1007-P1 Holding Pond weir) and upstream from ETTP Mitchell Branch, and the K-901-A Pond.
Group II, Phase 3 PCCR, Bldg. K-1420	• K-1420 slab – storm flow runoff • Uranium Recovery Room and calciner room – quarterly radiological survey • Pad boundary – annual radiological survey	SD-158 SD-160 SD-170	Weir K-1700
Group II, Phase 3 FY 2006 PCCR for Low Risk/Low Complexity Facilities	K-723 slab	SD-780 SD-800 SD-820 SD-830	CRM 9.5 Brashear Island[c]
Group II, Phase 3 PCCR for K-29	K-29 slab	SD-490	Weir K-1007-B4
Group II, Phase 3 FY 2008 PCCR for Low Risk/Low Complexity Facilities	K-1024 slab - Fixed Contamination Area	SD-230 SD-240	Poplar Creek location K-716
Group II, Phase 3 FY 2007 PCCR for Low Risk/Low Complexity Facilities (K-736 slab in accordance	K-736 slab	SD-724 SD-730 SD-740 SD-760 SD-770	CRM 9.5 Brashear Island[c]

Table 8.8. Long-term stewardship monitoring requirements for demolished facilities associated with remaining contaminated media (cont.)

Area/action[a]	Slab/Foundation (annual radiological survey)[b]	Storm drain (characterize at least once every NPDES permit cycle)	Surface water (characterize annually)
with K-770 Scrap Removal PCCR)[d]		SD-780 SD-800 SD-820 SD-830 SD-860 SD-870 SD-880 SD-890 SD-892	
	K-1232-D slab (survey performed only when worker entries required)	SD-362 SD-380	Poplar Creek location K-716
PCCR for Poplar Creek High-Risk Facilities K-1231, K-1233, and K-413	K-413 slab - Fixed Contamination Area K-1231 slab - Fixed Contamination Area	SD-362 SD-380	Poplar Creek location K-716

[a]The Phased Construction Completion Report for the Group II, Phase 3 BOS-LABS D&D requires 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 long-term stewardship of these sites is no longer reported in the Remediation Effectiveness Report. Also, the Phased Construction Completion Report for Building K-401 demolition requires long-term stewardship of the remaining slab. However, the slab was removed in 2009, making long-term stewardship no longer necessary.

[b]The Phased Construction Completion Reports for these demolition projects require annual radiological surveillance; however, the Phased Construction Completion Reports also state that contamination monitoring programs should be reviewed annually by the Project Health Physicists to ensure that appropriate surveys are performed at a frequency that is consistent with existing and potential hazards and activities planned in the area. Therefore, survey frequency may change from year to year.

[c]The Phased Construction Completion Report requires monitoring at Clinch River kilometer 16 Brashear Island; however, the actual sampling point is identified as Clinch River Mile 9.5.

[d]The Phased Construction Completion Report requires annual storm drain monitoring for the K-736 slab; however, the actual sampling frequency is once every NPDES permit cycle. The error was made in the K-770 Scrap Removal Phased Construction Completion Report and mistakenly carried over into the *Fiscal Year 2007 Phased Construction Completion Report for the Low Risk/Low Complexity Facilities Project* (DOE 2007i). Therefore, this table does not represent what is stated in the Phased Construction Completion Reports. A revision to the Phased Construction Completion Reports is planned.

CRM = Clinch River Mile
ETTP = East Tennessee Technology Park
NPDES = National Pollutant Discharge Elimination System
PCCR = phased construction completion report
RmAR = removal action report
SD = storm drain

Post-decision documents for the various demolition projects listed in Table 8.8 include the following requirements: (1) annual radiological surveillance, (2) storm drain characterization performed at least once within each National Pollutant Discharge Elimination System permitting period (≤5 years) for representative outfalls in each storm groupings, and (3) annual surface water monitoring. Figure 8.4 shows the locations of the storm drains and surface water locations relative to areas containing the remaining contamination. Storm drain characterization and surface water monitoring results are used to verify the effectiveness of the Radiological Control Program.

If radiological contamination is found to be migrating out of the contamination area, then additional controls are implemented. The frequency and level of surveillance and monitoring is established at each site by the radiological engineers responsible for the program, in accordance with requirements and criteria set forth in 10 CFR §835, Occupational Radiation Protection.

In general, storm water runoff from concrete or asphalt pads is not sampled directly (the K-1420 slab is an exception). Instead, The ETTP Environmental Compliance Program verifies the effectiveness of the radiological control program through ongoing storm drain sampling and instream water sampling, i.e., monitoring in compliance with the ETTP National Pollutant Discharge Elimination System permit and storm water runoff plans. Storm drain discharges are characterized at least once during each National Pollutant Discharge Elimination System permitting period, a maximum of five years, for a minimum of gross alpha, gross beta, isotopic uranium, and ^{99}Tc. Instream water monitoring is conducted at least annually at Mitchell Branch Weir, K-1007-P1 Holding Ponds Weir (K-1007-B4), K-901-A Pond Weir, upstream of ETTP in Poplar Creek, and downstream of ETTP at Clinch River Mile 9.5 (Brashear Island), and at Poplar Creek location K-716 for a minimum of gross alpha, gross beta, isotopic uranium, and ^{99}Tc. Data are compared to screening levels established at 4% of DOE Order 5400.5 DCG to maintain discharges As Low As Reasonably Achievable.

8.5.2 Status of Requirements for FY 2011

Radiological monitoring of the facilities listed below (Table 8.9) is performed as part of the Radiological Compliance Monitoring, as required by 10 CFR §835 and adopted in the Radiation Protection Program. All surveys are performed and documented in compliance with applicable procedures. Limits that apply to the surveys performed are found in Attachment D to 10 *Code of Federal Regulations* §835, as provided in Table 8.10.

Storm water outfall characterization sampling, which is conducted as part of the ETTP National Pollutant Discharge Elimination System permit Storm Water Pollution Prevention (SWPP) Program, and surface water monitoring, which is conducted as part of the ETTP Environmental Monitoring Program (EMP) are performed as a means to verify the effectiveness of the Radiological Control Program (see Figure 8.29). A summary of the storm water outfall sampling and surface water monitoring conducted for these demolition areas is included in Table 8.11 and is detailed below.

Outfalls 280 and 294 for the K-1064 Peninsula Area were sampled in FY 2011. Storm water outfall Storm Drain-280 results were below screening criteria. The results for Storm Drain-294 were above screening criteria but were similar to historical trends and were below the DOE Order DCG values. The results from the instream sampling in Poplar Creek downstream from the K-1064 Peninsula area were less than 1% of the allowable DCG.

As identified in the *Fiscal Year 2007 Phased Construction Completion Report for the Low Risk/Low Complexity Facilities* (DOE 2007i), storm water from outfalls 724 and 380 will be characterized at least once during each National Pollutant Discharge Elimination System permitting period. Neither of these outfalls were sampled for radiological parameters in FY 2011. The results from instream sampling in the Clinch River at Clinch River mile 9.5 downstream from the outfall 724 discharge points and from Poplar Creek location K-716 downstream from outfall 380 were less than 1% of the allowable DCG.

Table 8.9. Summary of radiological monitoring information for ETTP demolition sites

Facility/Location	Status	Survey frequency[a]	Survey date(s)	Survey summary
Group II, Phase 2 Removal Action Report for K-1064 Peninsula Area				
K-1025-A slab	Fixed Contamination Area	Quarterly	12/30/10, 3/3/11, 6/30/11, 9/13/11	No removable activity above CFR §835 limits detected.
K-1025-B slab	Fixed Contamination Area	Quarterly	12/30/10, 3/3/11, 6/30/11, 9/13/11	No removable activity above CFR §835 limits detected.
K-1025-C slab	Fixed Contamination Area	Quarterly	12/30/10, 3/3/11, 6/30/11, 9/13/11	No removable activity above CFR §835 limits detected.
K-1025-D slab	Fixed Contamination Area	Quarterly	12/30/10, 3/3/11, 6/30/11, 9/13/11	No removable activity above CFR §835 limits detected.
K-1064-D slab	Fixed Contamination Area	Annually	4/28/11	No removable activity above CFR §835 limits detected.
K-1025-E	Fixed Contamination Area	Quarterly	12/30/10, 3/3/11, 6/30/11, 9/13/11	No removable activity above CFR §835 limits detected.
K-1064 Salvage Material Yard soil	Contamination Area	Survey performed only when worker entries required	N/A	N/A
Group II, Phase 3 PCCR for B uilding. K-1420				
K-1420 slab – storm flow runoff	N/A to Radiological Controls.	N/A to Radiological Controls.	N/A to Radiological Controls.	N/A to Radiological Controls.
Uranium Recovery Room and calciner room	Fixed Contamination Area	Annually	7/21/11	No removable activity above CFR §835 limits detected.
K-1420 Pad boundary[b]	Fixed Contamination Area	Annually	7/22/11	No removable activity above CFR §835 limits detected.
Group II, Phase 3 FY 2006 PCCR for Low Risk/Low Complexity Facilities				
K-723 slab	Area down-posted 11/8/10	Survey no longer required. See footnote *a*.	N/A	N/A
Group II, Phase 3 PCCR for K-29				
K-29 slab[b]	Fixed Contamination Area	Annually	9/30/11	No removable activity above CFR §835 limits detected.
Group II, Phase 3 FY 2008 PCCR for Low Risk/Low Complexity Facilities				
K-1024 slab[b]	Fixed Contamination Area	Annually	4/25/11	No removable activity above CFR §835 limits detected.
Group II, Phase 3 FY 2007 PCCR for Low Risk/Low Complexity Facilities				
K-736 asphalt pad	Located within K-770 Contamination Area and is not routinely surveyed	Survey no longer required. See footnote *a*.	N/A	N/A
K-1232-D slab[b]	Contamination Area	Survey performed only when worker entries requires	N/A	N/A

[a]The PCCRs for these D&D projects require annual radiological surveillance, however, the PCCRs also state that contamination monitoring programs should be reviewed annually by the Project Health Physicists to ensure that appropriate surveys are performed at a frequency that is consistent with existing and potential hazards and activities planned in the area. Therefore, survey frequency may change from year to year.

[b]A portion of these slabs is currently being used for storage. There has been no impact to the surface of the slabs. No prep-work or maintenance has been required. The K-1420 Pad boundary south and east sides are non-contaminated areas and are used for temporary storage of clean roll-offs and trucks. The K-29 slab contains material from the K-25/K-27 Project. The K-1024 slab contains a Rubb tent. The K-1232-D slab is being used in support of the K-27 project.

CFR = Code of Federal Regulations
FY = fiscal year
N/A = not applicable
PCCR = Phased Construction Completion Report

Table 8.10. 10 Code of Federal Regulations §835 limits

Radionuclide	Removable dpm/100cm	Total (Fixed + Removable) dpm/100cm
U-Nat, U-235, U-238, and associated decay products	1,000	5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-Nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1000
Beta-Gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	1,000	5,000
Tritium and tritiated compounds	10,000	N/A

dpm = disintegrations per minute Nat = natural occurring

Table 8.11. Summary of storm drain and surface water monitoring information

Slab/Foundation	Storm drain locations (characterize at least once every NPDES permit cycle, ≤ 5 yrs)	2011 Storm drain monitoring summary[a]	Surface water locations (annually)	2011 Surface water monitoring summary
Group II, Phase 2 RmAR for K-1064 Peninsula Area[b]				
K-1025-A slab K-1025-B slab K-1025-C slab K-1025-D slab K-1025-E K-1064-D slab K-1064-H slab[c]	SD-230	Not sampled in 2011	Surface water from Poplar Creek downstream and upstream from ETTP K-1064 Peninsula area	Less than 1% of the allowable DCG
	SD-240	Not sampled in 2011		
	SD-270	Not sampled in 2011		
	SD-280	Sampled in 2011; no results exceeded screening criteria		
	SD-294	2011 results above screening criteria but similar to historical trends and below DCGs		
	SD-296	Not sampled in 2011		
	SD-297	Not sampled in 2011		
Group II, Phase 3 FY 2006 PCCR for Low Risk/Low Complexity Facilities				
K-723 slab	SD-780	Not sampled in 2011	CRM 9.5 Brashear Island	Less than 1% of the allowable DCG
	SD-800	Not sampled in 2011		
	SD-820	Not sampled in 2011		
	SD-830	Not sampled in 2011		
Group II, Phase 3 PCCR for K-29				
K-29 slab	SD-490	Sampled in 2011; no results exceeded screening criteria	K-1007-P1 Pond Weir (Weir K-1007-B4)	Less than 1% of the allowable DCG
Group II, Phase 3 FY 2008 PCCR for Low Risk/Low Complexity Facilities				
K-1024 slab	SD-230	Not sampled in 2011	Poplar Creek location K-716	Less than 1% of the allowable DCG
	SD-240	Not sampled in 2011		
Group II, Phase 3 FY 2007 PCCR for Low Risk/Low Complexity Facilities				
K-736 asphalt pad	SD-724	Not sampled in 2011	CRM 9.5 Brashear Island	Less than 1% of the allowable DCG
	SD-730	Not sampled in 2011		
	SD-740	Not sampled in 2011		
	SD-760	Not sampled in 2011		
	SD-770	Not sampled in 2011		
	SD-780	Not sampled in 2011		
	SD-800	Not sampled in 2011		
	SD-820	Not sampled in 2011		

Table 8.11. Summary of storm drain and surface water monitoring information (cont.)

Slab/Foundation	Storm drain locations (characterize at least once every NPDES permit cycle, ≤ 5 yrs)	2011 Storm drain monitoring summary[a]	Surface water locations (annually)	2011 Surface water monitoring summary
	SD-830	Not sampled in 2011		
	SD-860	Not sampled in 2011		
	SD-870	Not sampled in 2011		
	SD-880	Not sampled in 2011		
	SD-890	Not sampled in 2011		
	SD-892	Not sampled in 2011		
K-1232-D slab	SD-362	Not sampled in 2011	Poplar Creek location K-716	Less than 1% of the allowable DCG
	SD-380	Not sampled in 2011		
Group II, Phase 3 PCCR for Poplar Creek High-Risk Facilities K-1231, K-1233, and K-413				
K-1231 slab	SD-362	Not sampled in 2011	Poplar Creek location K-716	Less than 1% of the allowable DCG
	SD-380	Not sampled in 2011		
K-413 slab	SD-380	Not sampled in 2011	Poplar Creek location K-716	Less than 1% of the allowable DCG
	SD-362	Not sampled in 2011		

[a]Storm drain monitoring performed at least once within each NPDES permitting period (≤ 5 years).

[b]K-1064 Salvage Material Yard soil requires radiological surveys under the K-1064 RmAR. However, it does not require storm water monitoring per the RmAR.

[c]K-1064-H slab requires storm water monitoring under the K-1064 RmAR. However, it does not require rad surveys per the RmAR.

CRM = Clinch River mile
DCG =
FY = fiscal year
NPDES = National Pollutant Discharge Elimination System
PCCR = phased construction completion report
SD = storm drain

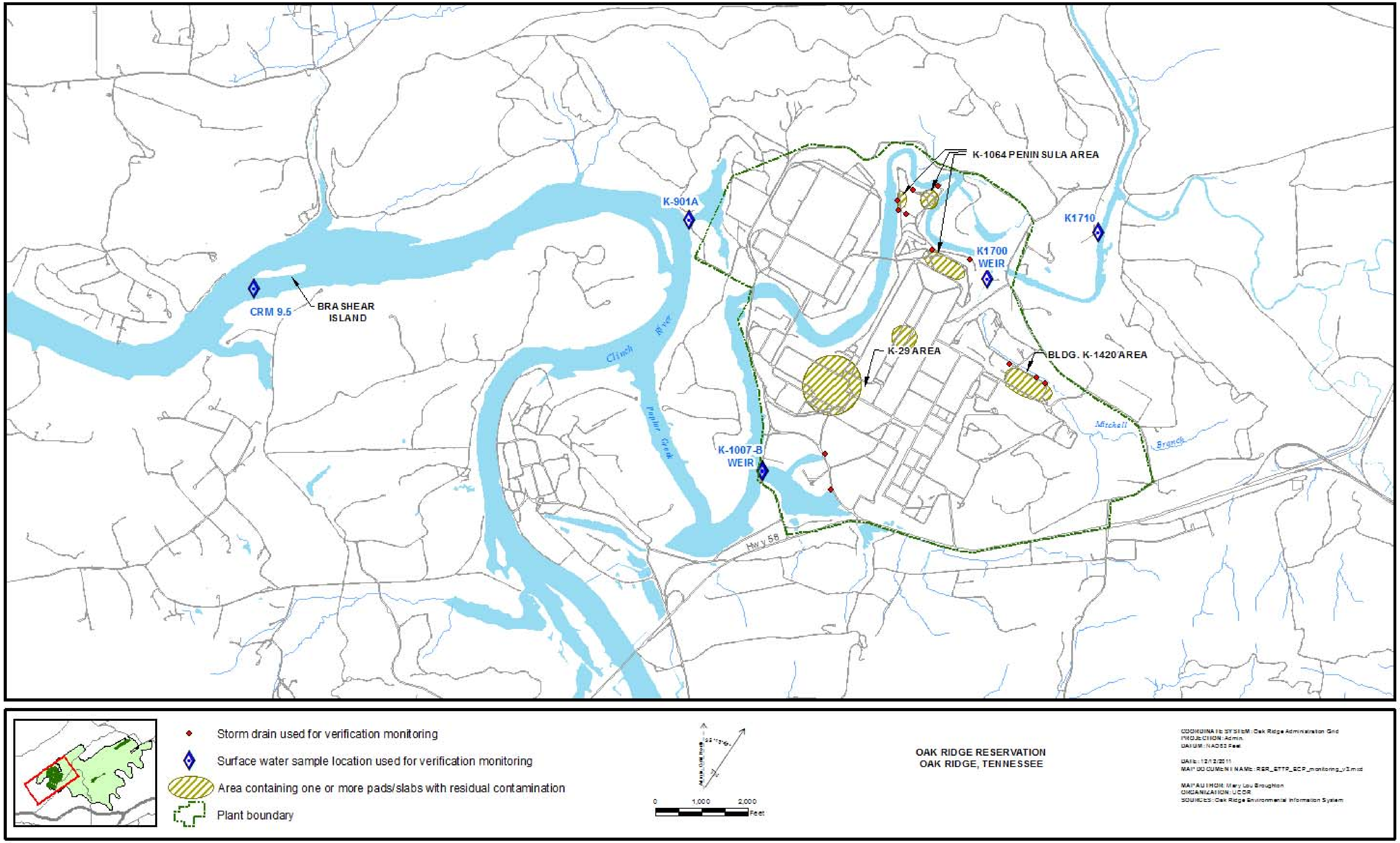


Figure 8.29. ETTP Compliance Program monitoring locations to verify radiological controls of remaining contaminated slabs.

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OTHER WATERSHED MONITORING AT EAST TENNESSEE TECHNOLOGY PARK

This section provides a summary of ETTP sitewide groundwater and surface water conditions, including a discussion of exit pathway contaminant migration. It includes an update on conditions as characterized by the biological monitoring in area surface water bodies.

The status of ETTP long-term CERCLA decision making is provided in Figure 1.5 of Vol. 1 of the 2007 RER (DOE 2007a).

8.5.3 Major Site Contaminant Plumes

Extensive groundwater monitoring at the ETTP site has identified VOCs as the most significant groundwater contaminant on site. For purposes of analyzing the groundwater contaminant issues at ETTP, the RI/FS [*Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2007j)] subdivided the site into several distinct areas–Mitchell Branch watershed, K-1004 and K-1200 area, the K-27/K-29 area, and the K-901 area (Figure 8.30). Each of these areas has significant VOC contamination in groundwater. The principal chlorinated hydrocarbon chemicals that were used at ETTP were PCE, TCE, and 1,1-DCA.

Figure 8.30 shows the distribution and generalized concentrations of the primary chlorinated hydrocarbon chemicals and their transformation products, respectively. 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 ETTP site. In the vicinity of the K-1070-C/D source (see Sect. 8.3.2.1), a high degree of degradation has occurred, although a strong source of contamination still remains in the vicinity of the "G-Pit", where approximately 9000 gal of chlorinated hydrocarbon liquids were disposed in an unlined pit (see Section 8.4.3). Other areas where transformation is significant include the K-1401 Acid Line leak site, and the K-1407-B Pond area (see Sect. 8.4.1.2). Transformation processes are weak or inconsistent at the K-1004 and K-1200 area, K-1035, K-1413, and K-1070-A Burial Ground (see Sect. 8.4.4), and little transformation of TCE is observed in the K-27/K-29 source and plume area.

8.5.4 Exit Pathway Monitoring

Groundwater exit pathway monitoring sites are shown in Figure 8.30. Groundwater monitoring results for the exit pathways are discussed below starting with the Mitchell Branch exit pathway and then progressing in a counterclockwise fashion.

The Mitchell Branch exit pathway is monitored using surface water data from the K-1700 Weir on Mitchell Branch and wells BRW-083 and UNW-107. Figure 8.31 shows the detected concentrations of TCE, 1,2-DCE (essentially all cis-1, 2-DCE), and vinyl chloride at the K-1700 Weir on Mitchell Branch from FY 1994 through FY 2011. These contaminants are the major contaminants in Mitchell Branch, although low concentrations of carbon tetrachloride, chloroform, and TCA are sometimes detected. VOC concentrations measured during FY 2011 were consistent with previous years results at the K-1700 Weir.

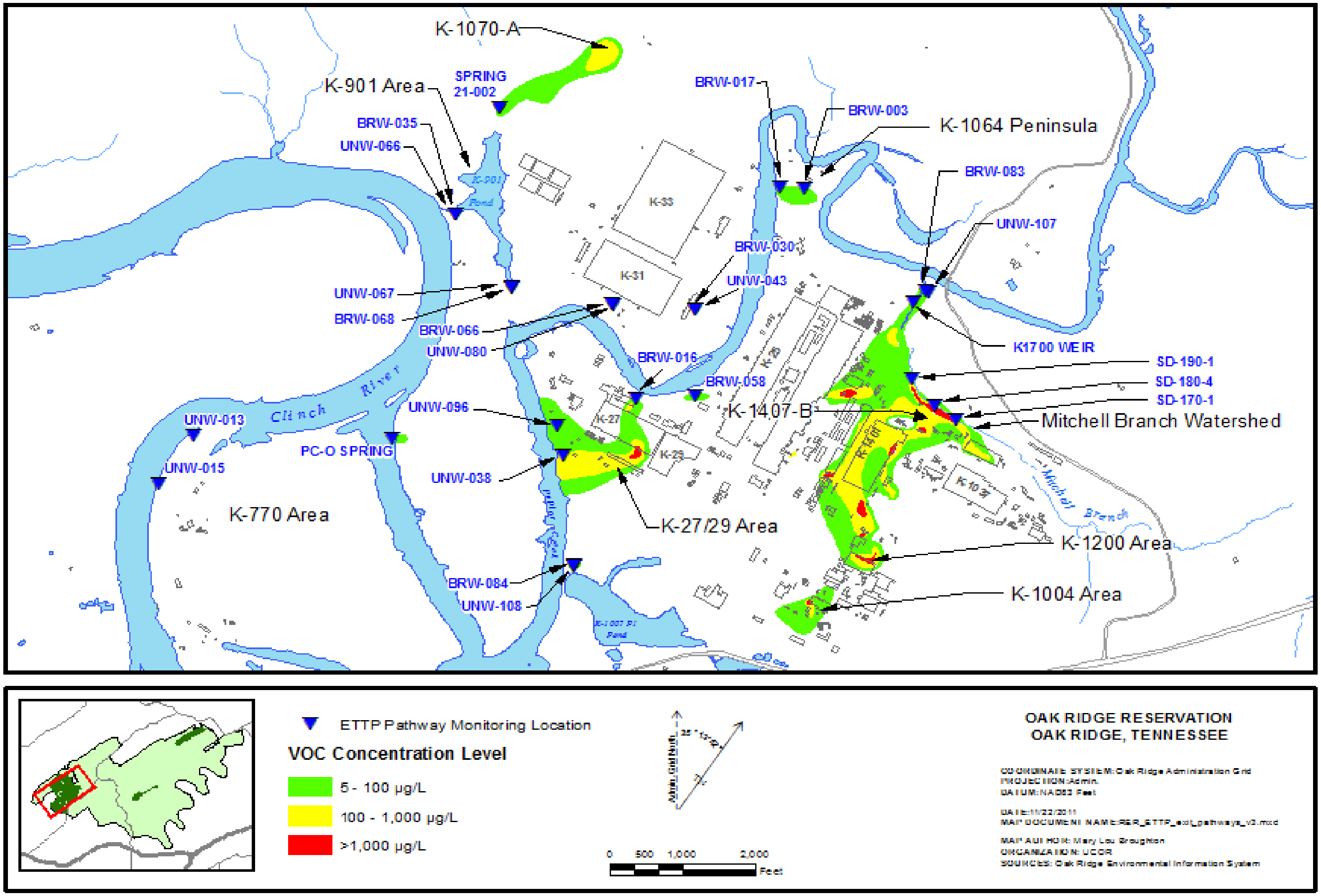


Figure 8.30. ETTP exit pathways monitoring locations.

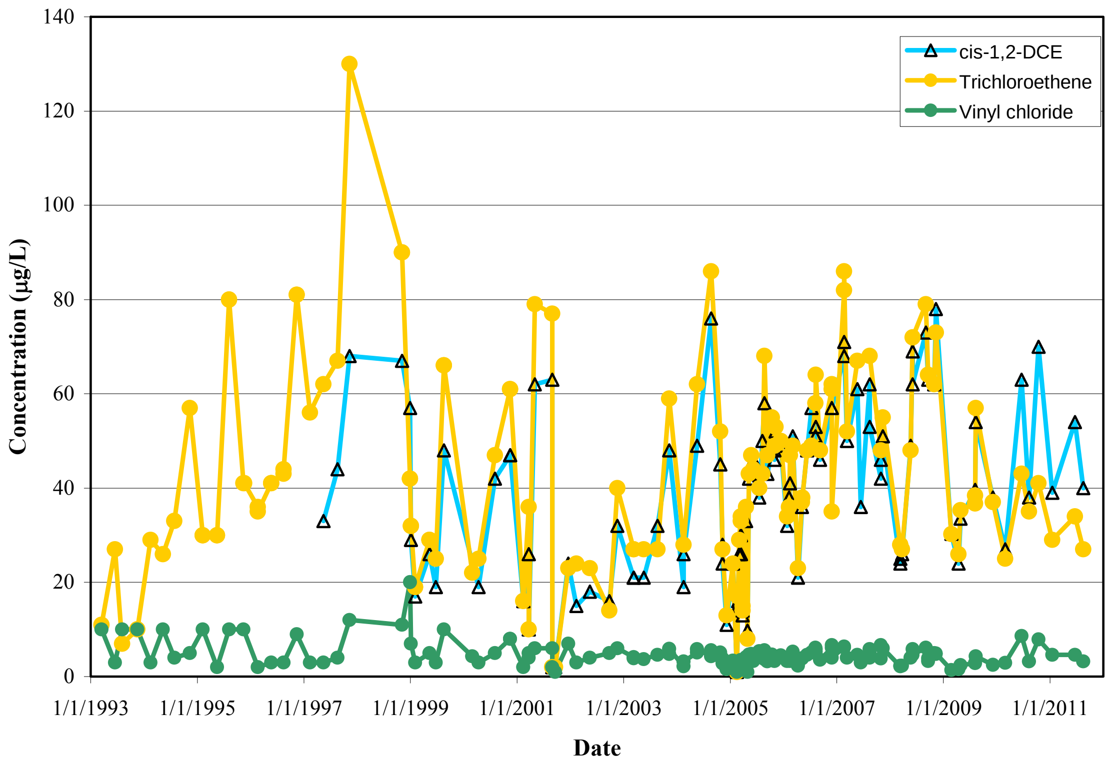


Figure 8.31. K-1700 Weir VOC concentrations.

Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch (Figure 8.32, have been monitored since 1994. Table 8.12 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. PCE and TCE were detected at concentrations greater than their respective MCLs in BRW-083 during FY 2011 as a result of the above average rainfall during the time period FY 2009 through FY 2011.

Wells BRW-003 and BRW-017 (Figure 8.34) monitor groundwater at the K-1064 Peninsula burn area. Figure 8.32 shows the history of VOC concentrations in groundwater from FY 1994 through FY 2011. TCE concentrations have declined in both wells over that period of time. TCE was detected at concentrations slightly below the MCL in well BRW-017 during FY 2011. Both 1,1,1-TCA and cis-1,2-DCE have declined to undetectable concentrations in well BRW-003 but cis-1,2-DCE was detected in both quarterly samples in well BRW-017.

Table 8.12. VOCs detected in groundwater in the Mitchell Branch Exit Pathway

Well	Date	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	Vinyl chloride
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
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

[a]Detection occurred in a field replicate. Constituent not detected in regular sample.

Bold table entries exceed Safe Drinking Water Act maximum contaminant level (MCL) screening values (PCE, TCE = 5 µg/L, cis-1,2-DCE = 70 µg/L, vinyl chloride = 2 µg/L)

All concentrations µg/L.

BRW = bedrock wells J = estimated value ND = Not Detected UNW = unconsolidated wells

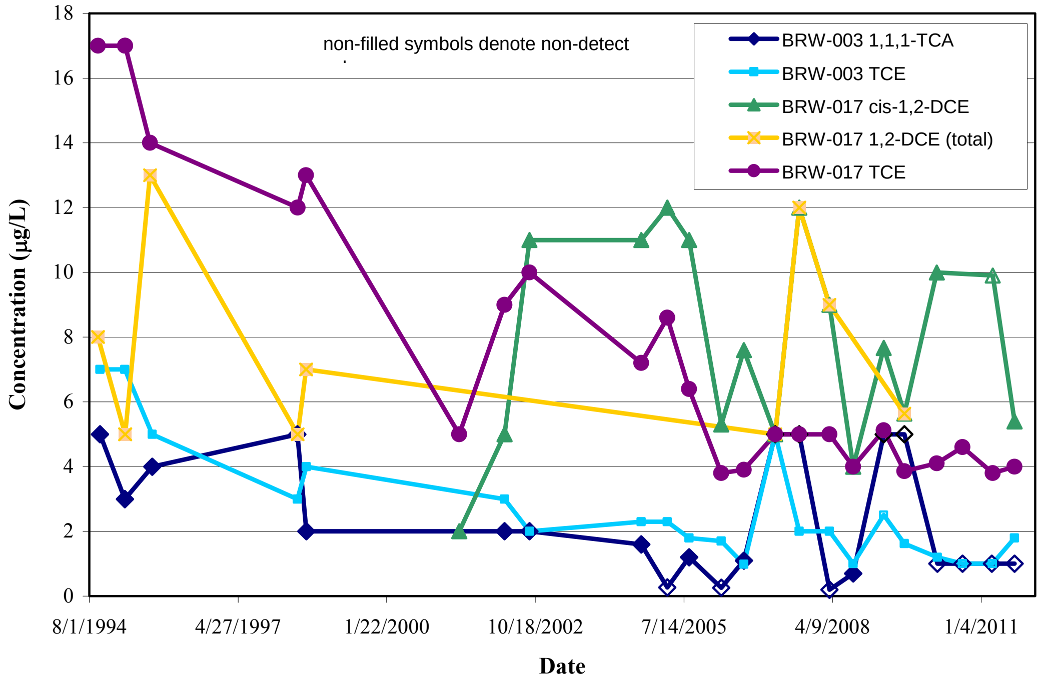


Figure 8.32. VOC concentrations in groundwater at K-1064 Peninsula area.

Groundwater is monitored in four wells (BRW-066, BRW-030, UNW-080, and UNW-043) that lie between buildings K-31/K-33 and Poplar Creek, as shown on Figure 8.30. VOCs are not COCs in this area; however, leaks of recirculated cooling water in the past have left residual subsurface chromium contamination. Figure 8.33 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 2011, field-filtered (i.e., dissolved) and unfiltered samples were collected from UNW-043. In FY 2011 the chromium concentrations in unfiltered samples decreased significantly but were still noticeably higher than those for their filtered counterparts. During FY 2011 both field-filtered and unfiltered samples were collected from wells BRW-066, UNW-043 and UNW-080. Chromium was non-detect in all samples from well BRW-066. With the exception of the Q4 samples

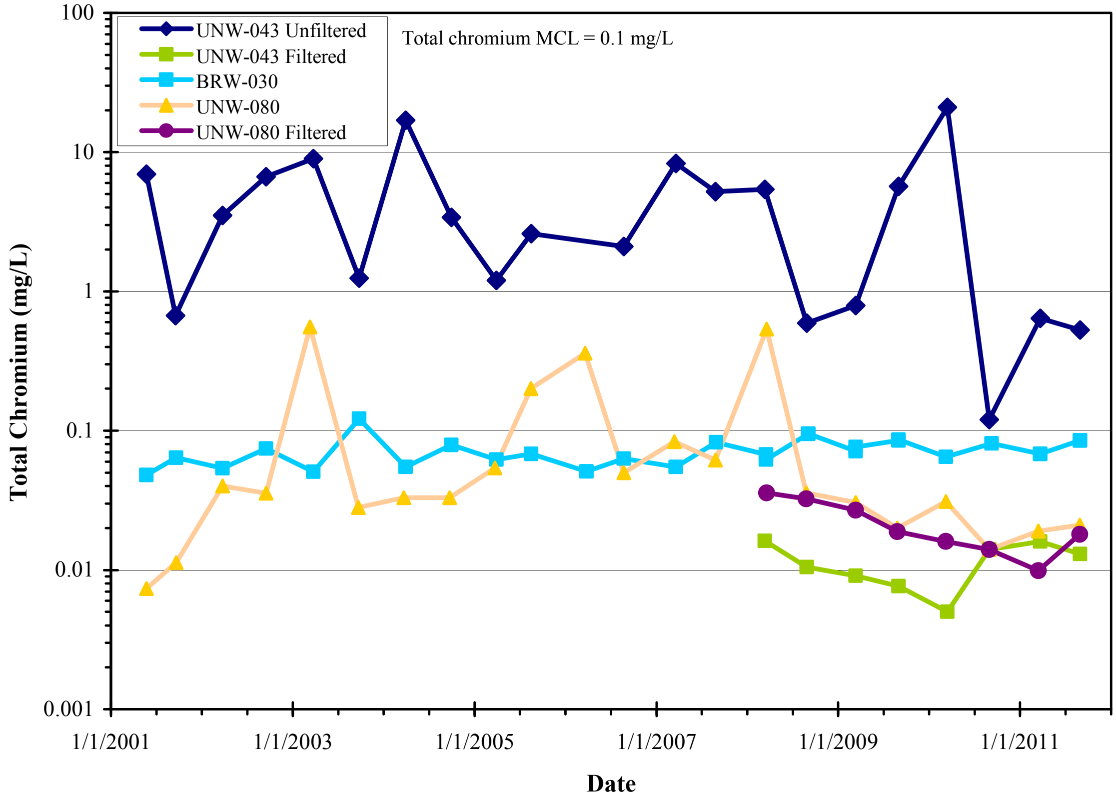


Figure 8.33. Chromium concentrations in groundwater in the K-31/K-33 area.

from well UNW-080, in which the filtered sample had only slightly lower chromium than the unfiltered sample, all filtered samples contained much less chromium than their unfiltered co-samples.

Several exit pathway wells are monitored in the K-27/K-29 area, as shown on Figure 8.30. Figure 8.34 provides concentrations of detected VOCs in wells both north and south of K-27 and K-29 through FY 2011. The source of VOC contamination in well BRW-058 is not suspected to be from K-27/K-29 area operations. With the exception of cis-1,2-DCE in well BRW-058, which appears stable to slightly increasing, the VOC concentrations in this area show very slowly declining concentrations.

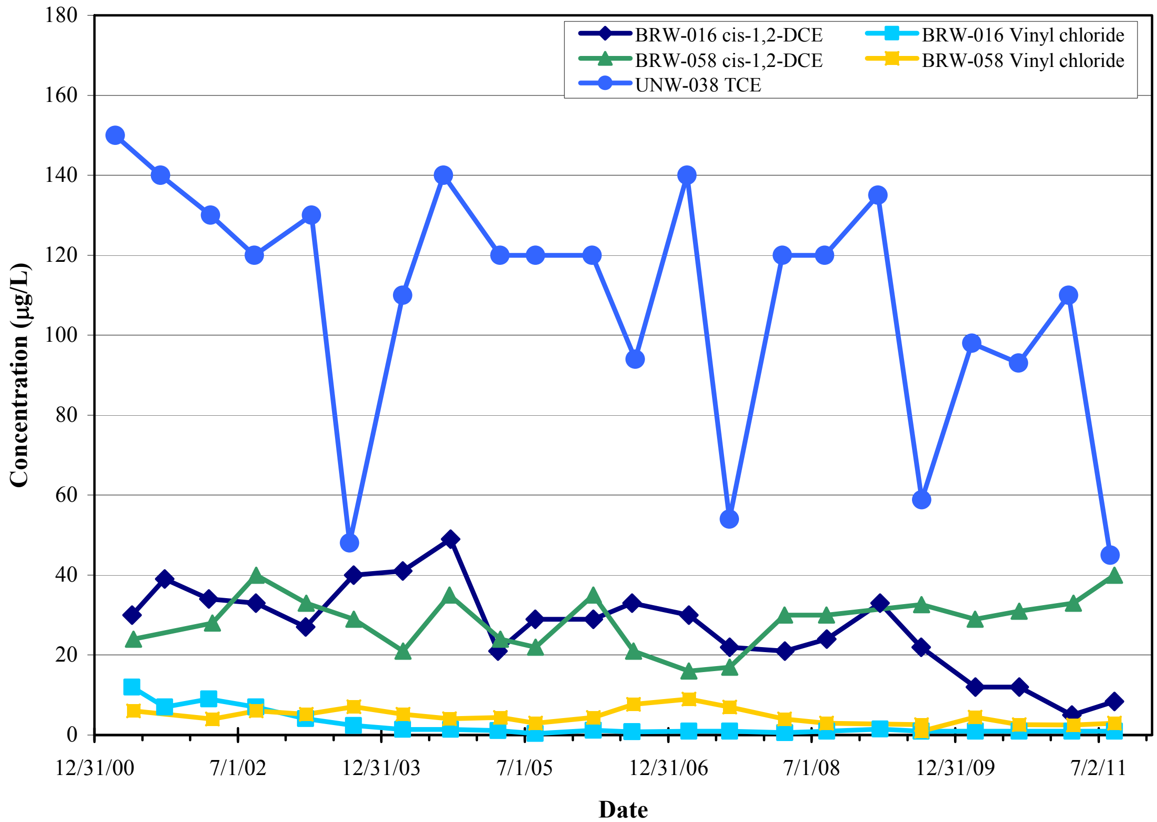


Figure 8.34. Detected VOC concentrations in groundwater exit pathway wells near K-27 and K-29.

Wells BRW-084 and UNW-108 are exit pathway monitoring locations at the northern edge of the K-1007-P1 Pond (see Figure 8.30). These wells have been monitored intermittently from 1994 through 1998 and semiannually from FY 2001 through FY 2011. The first detections of VOCs in these wells occurred during FY 2006 with detection of low (~10 µg/L or less) concentrations of TCE and cis-1,2-DCE. The source area for these VOCs is not known. Volatile organic compounds were not detected in either of these wells during FY 2011. Metals were detected and associated with the presence of high turbidity in the samples. Manganese exceeded its secondary drinking water standard in the filtered sample from UNW-108 in the Q4 sampling event. No other primary or secondary MCLs for metals were exceeded in sample aliquots that were field-filtered prior to acid preservation during FY 2011.

Exit pathway groundwater in the K-901-A Holding Pond area (see Figure 8.30) 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 Pond exit pathway wells during FY 2011 was chloroform in the Q4 sample of well BRW-068. Alpha and beta activity levels were less than 15 pCi/L and 25 pCi/L, respectively, for all wells. TCE is the most significant groundwater contaminant detected in the springs, and the historic TCE concentrations are shown in Figure 8.35. Spring PC–0 was added to the sampling program in 2004. During the spring through autumn seasons, spring PC–0 is submerged beneath the Watts Bar lake level, so this location is accessible for sampling only during winter when the lake level is lowered by TVA. The contaminant source for the PC-0 spring is presumed to be disposed waste at the K-1070-F site. The TCE concentrations, while above the MCL, have shown a decreasing trend but increased in FY 2011. In addition to TCE, uranium isotopes and gross beta activity (at an estimated value) were reported at low levels in FY 2011. At spring 21-002, 1,1,1-TCA, 1,2-DCE, carbon tetrachloride, and PCE are sometimes present at concentrations typically less than 5 µg/L. The TCE concentration at spring 21-002 tend to vary between 5 and about 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 2011 TCE was detected above MCL in both quarterly samples. In addition, low levels of alpha and beta activity were detected as was ^{99}Tc in the Q4 sample.

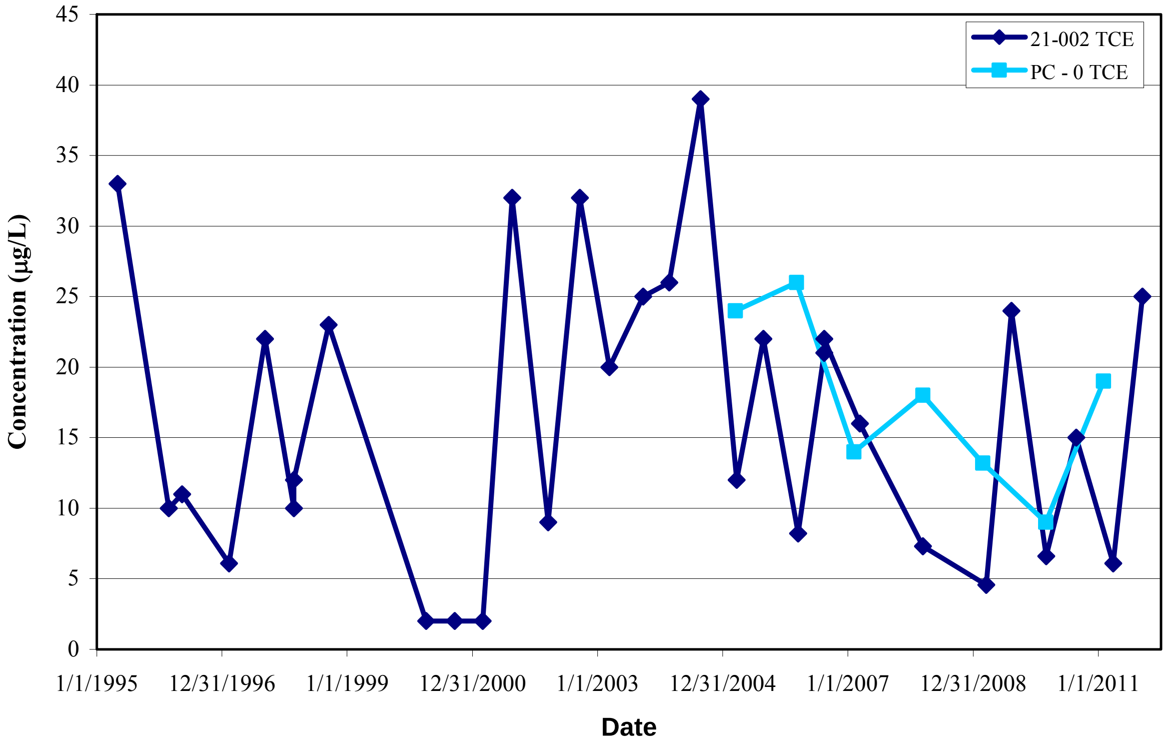


Figure 8.35. TCE concentrations in K-901 area springs.

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 (see Figure 8.30). Well UNW-015 could not be sampled in FY 2011 because of construction activities. Beta activity was detected at 35.1 and 60.7 pCi/L for Q2 and Q4, respectively, in well UNW-013. Figure 8.36 shows the history of measured alpha and beta activity in this area. 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. The alpha and beta activity levels in the area groundwater exhibit stable, but variable, conditions.

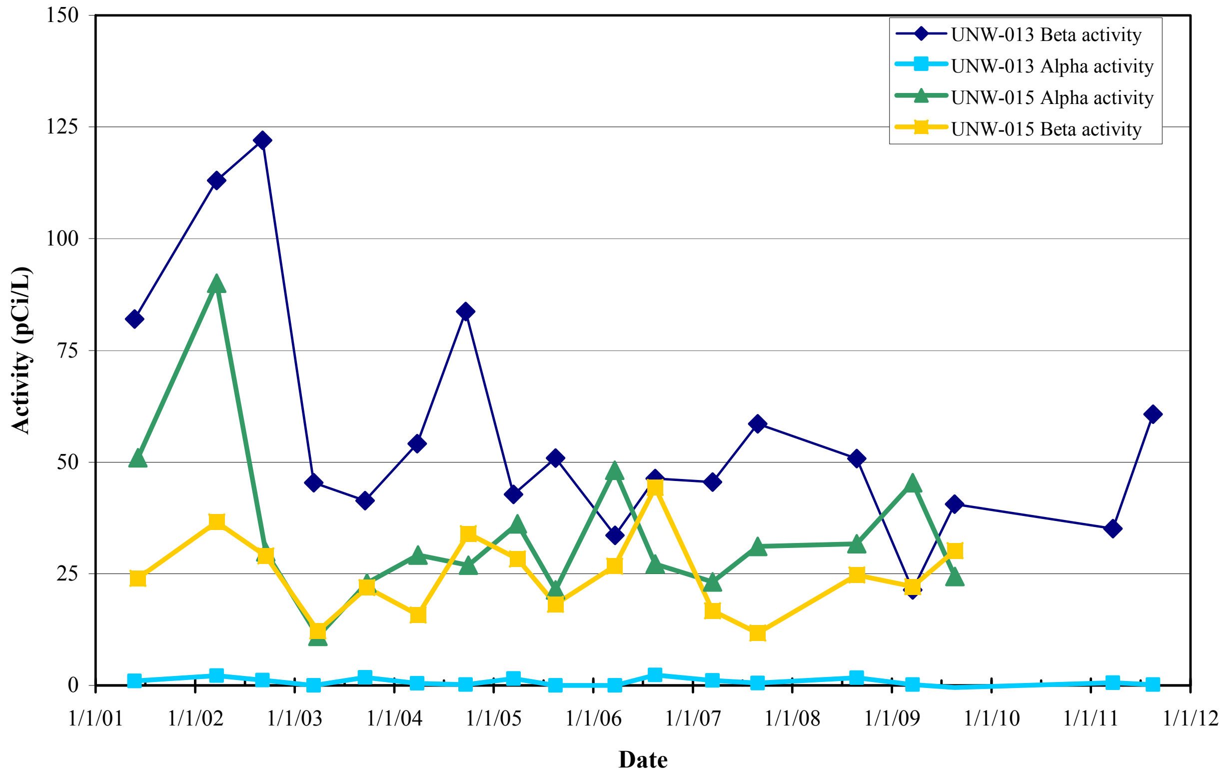


Figure 8.36. History of measured alpha and beta activity in the K-770 area.

8.5.5 Aquatic Biological Monitoring

Long-term trends in PCB accumulation in fish from the K-901-A and K-1007-P1 ponds were presented in Sect. 8.4.2.3.

Biological monitoring in Mitchell Branch, conducted by the ETTP BMAP, includes: (1) contaminant accumulation in fish, (2) fish community surveys, and (3) benthic macroinvertebrate surveys. Mean PCB concentration in redbreast sunfish collected from Mitchell Branch in FY 2011 averaged 1.12 µg/g, within the range of values seen in recent years but well below historically high levels in the late 1990s and early 2000s when levels in fish were in the 3-4 µg/g range (Figure 8.37). The 1-2 µg/g range is still a relatively high level of PCBs for sunfish, which are low in lipids and don't 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 storm drain discharges for a four-week exposure (June – July 2011) to evaluate the importance of PCB sources to the creek. The highest PCB concentrations in clams were found around SD-190 [MIK 0.2 (5.08 µg/g), MIK 0.27 (4.68 µg/g), and MIK 0.3 (5.65 µg/g)] The spatial pattern of PCB contamination in the creek in 2011 remains the same as past years, with the highest values in clams from downstream sites.

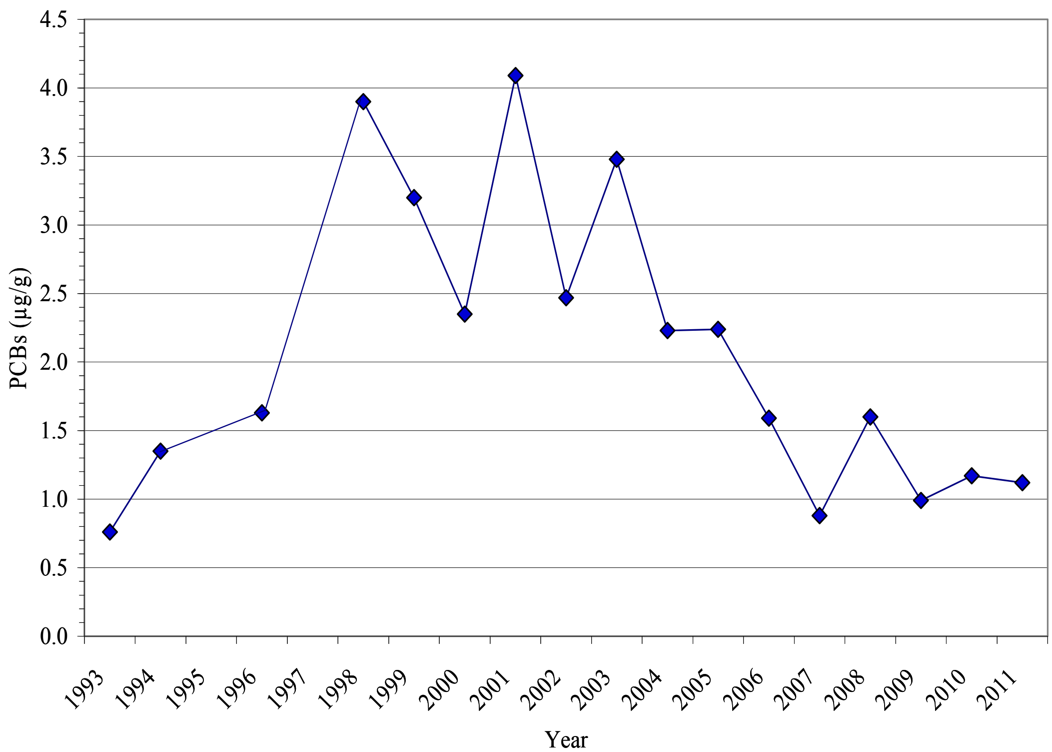


Figure 8.37. Mean PCB concentrations in redbreast sunfish from Mitchell Branch, 1993–2011.

The species richness (number of species) of the fish community in Mitchell Branch (MIK 0.45) has improved since construction of the interceptor trench in early 1998 (Figure 8.38), and has stabilized in recent samples. The trench was operational until February of 2005, at which time it was shut down. The fish community value for MIK 0.45 seen in 2011 is close to the range of richness values of comparable reference streams. Although similar in overall species richness, the fish community at MIK 0.45 does have fewer sensitive species and at lower densities than at comparable reference streams. The presence of sensitive species may increase as water quality improves and habitat stabilizes.

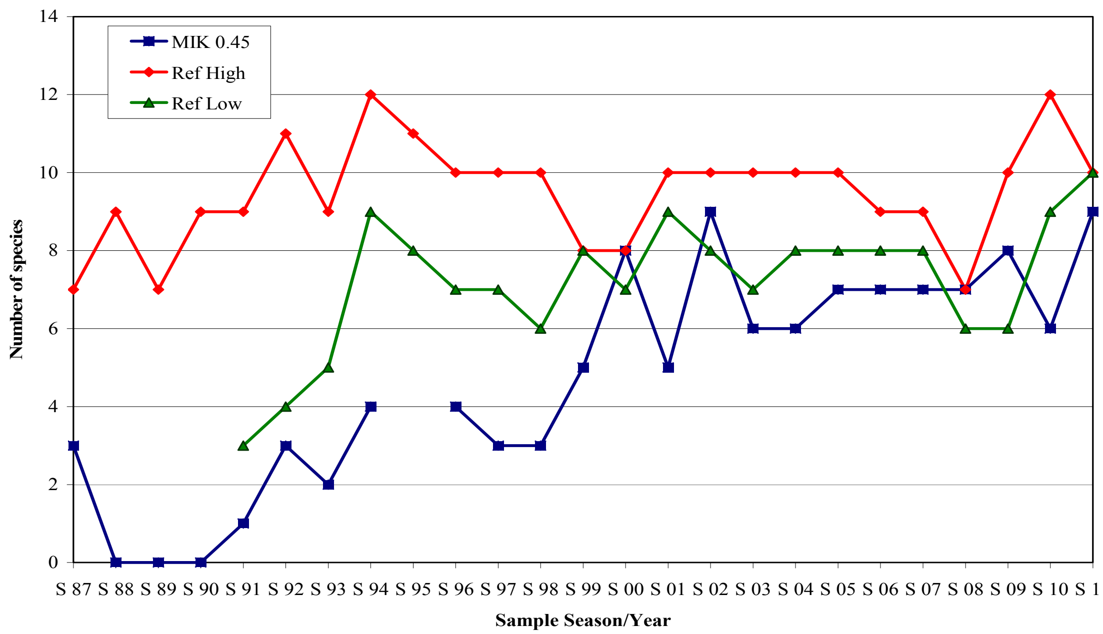
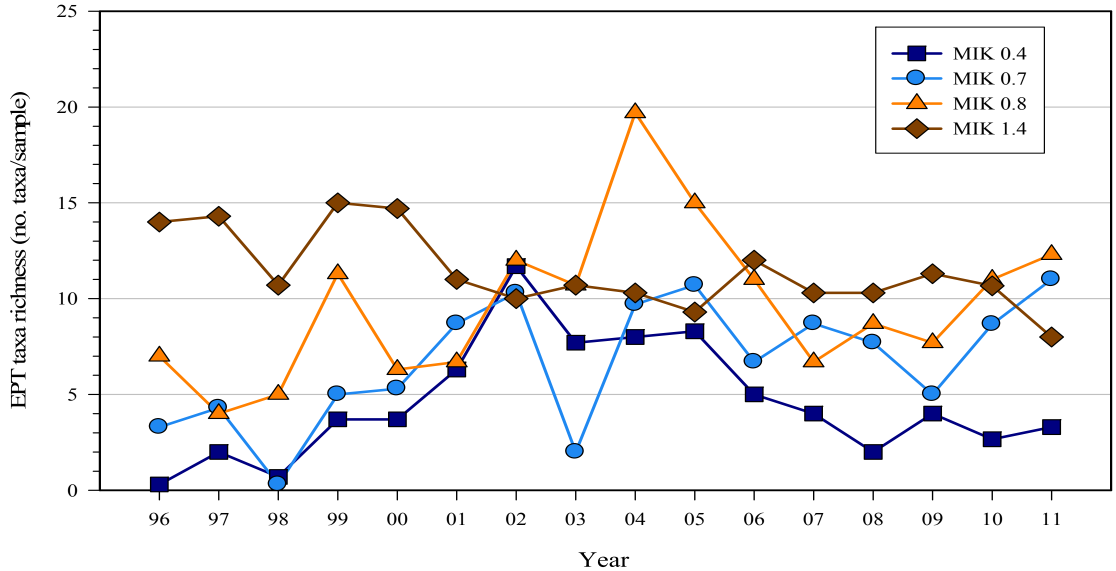


Figure 8.38. Species richness (number of species) in spring samples of the fish community in Mitchell Branch (MIK) and a range of reference streams (Ref. High-Low), 1986 to 2011.[a]

[a]Interruptions in data lines indicate missing samples.

Results from benthic macroinvertebrate assessments of Mitchell Branch continue to indicate that the conditions MIK 0.4 are moderately degraded, while conditions at MIK 0.7 and MIK 0.8 have become more comparable to the reference site (Figure 8.39). The mean number of pollution-intolerant taxa at MIK 0.8 continued its recent trend of fluctuating near that of the reference site, while 2011 represents only the second time since monitoring began in 1986 that the mean for MIK 0.7 has exceeded the reference site mean.



EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, caddisflies, and stoneflies.

Figure 8.39. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in Mitchell Branch at the ETTP, April sampling periods, 1996–2011.

8.5.6 Monitoring Summary

During FY 2011, monitoring results for the principal surface water and groundwater locations indicate that contaminant levels are generally stable to decreasing in most instances. Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell Branch. Mercury detections at storm drain outfalls and the K-1700 Weir indicate the need for additional investigation to identify potential mercury sources.

Contaminants detected during previous years in exit pathway groundwater near the K-1007-P1 weir were not detected in FY 2011. Concentrations of PCE and TCE greater than the MCL were detected in a bedrock well in the exit pathway at the mouth of Mitchell Branch and TCE at well BRW-058 TCE also exceeded MCL in the single sample from PC-0 spring. These contaminant levels are similar to those seen in FY 2010. Manganese exceeded its secondary drinking water standard in one filtered sample. Most of the groundwater plumes monitoring results indicate stable contaminant levels compared to recent years.

Aquatic biological monitoring indicates habitat is stable to improving and in some instances is approaching reference stream conditions.

8.6 EAST TENNESSEE TECHNOLOGY PARK MONITORING CHANGES AND RECOMMENDATIONS

The issues and recommendations for the ETTP watershed are in Table 8.13.

Table 8.13. Summary of technical issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
1. Sampling of the SW-31 Spring is no longer required, but the decision and completion document still requires monitoring.	1. Revise *Addendum to the Remedial Action/Effectiveness Report for the K-1070 Operable Unit SW31 Spring Phase 2 Remedial Action at the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE 2007k).	DOE/ EPA & TDEC	FY 2012
Issues Carried Forward			
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)[b]	1. DOE acknowledges the land use differences that exist between the BORCE use and that which is in the Zone 1. The end use of the portion of Zone 1 that is also identified as part of the BORCE will be changed from industrial to recreational in an amendment to the Zone 1 Interim ROD (DOE 2002a) with the appropriate level of public participation. The *Addendum to the Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2010g) includes the risk assessment to support this change.	DOE/ EPA & TDEC	FY 2012 with amendment to Zone 1 Interim ROD
Completed/Resolved Issues			
1. Fish barrier in K-1007-P1 Holding Pond was damaged during storm events allowing reintroduction of undesirable fish species into the pond.	1. Fish barrier was repaired and undesirable fish were removed to the extent practicable in FY 2010. Performance monitoring initiated, and PCB concentrations in fish will continue to be evaluated.	DOE/ EPA & TDEC	2011 FYR with submission of 2012 D2 RER.

[a] An issue identified as a "Current Issue" indicates an issue identified during evaluation of current FY 2011 data for inclusion in the 2012 Remediation Effectiveness Report. Issues are identified in the table as an "Issue Carried Forward" to indicate that the issue is carried forward from a previous year's Remediation Effectiveness Report so as to track the issue through resolution. Any additional discussion will occur at the appropriate CERCLA Core Team level.

[b] The year in which the issue originated is provided in parentheses, e.g., (2006 FYR).

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9. CERCLA ACTIONS AT OTHER SITES

9.1 INTRODUCTION AND OVERVIEW

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 Oak Ridge Reservation. Table 9.1 lists these CERCLA actions, and Table 9.2 summarizes the requirements for facility operations and land use controls.

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 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 2011).

9.1.2 Status

During FY 2011, no additional CERCLA actions were implemented or completed at the White Wing Scrap Yard or at the Oak Ridge Associated Universities South Campus Facility, and no additional CERCLA actions were implemented or completed that fall into this category.

9.2 WHITE WING SCRAP YARD

The White Wing Scrap Yard is located north of the western end of Bear Creek Valley (Figure 9.1). This remedial action (Table 9.1) removed contaminated surface debris retrievable without excavation. Buried material remains at the site.

9.2.1 Long-Term Stewardship Requirements

White Wing Scrap Yard has facility operations and land use controls requirements (Table 9.2). There are no long-term stewardship requirements in the *Interim Record of Decision for the Oak Ridge National Laboratory, Waste Area Grouping 11, Surface Debris* (DOE 1992). However, the *Interim Remedial Action Post-Construction Report for Waste Area Grouping 11*(DOE 1994b) 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 surveillance and maintenance will continue until decisions are made for future and/or final CERCLA remedial actions at the site."

9.2.2 Status of Requirements

The Y-12 Surveillance and Maintenance Program performed monthly inspections in FY 2011 to inspect components including damaged or missing radiation roping or signs delineating radiation areas; deteriorating access road conditions or damaged or missing gate locks; debris buildup or blockage at the fence/creek boundaries; unauthorized materials placed within the area; damage to site perimeter fencing; and unlocked gate or missing or damaged radiation signs. Additionally, inspections included the separate fenced-in area west of the scrap yard. Surveillance and maintenance personnel inspected the fencing by walking the entire perimeter of the site and the west fenced area. Maintenance included clearing fallen trees from the fencing and routine mowing.

Table 9.1. CERCLA actions at other sites on the Oak Ridge Reservation

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/Document status [a]	Monitoring/ Facility Operations / Land Use Controls required	Section
White Wing Scrap Yard (Waste Area Grouping 11) Surface Debris	IROD (DOE/OR/1055&D4): 10/06/92	PCR[b] (DOE/OR01/-1263&D2) approved 09/14/94.	No/Yes/Yes	9.2
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/No/Yes	9.3

[a] Detailed information of the status of ongoing actions is from Appendix E of the *Federal Facility Agreement* and is available at <http://www.ucor.com/ettp_ffa_appendices.htm>.
[b] This action was completed prior to uniform adherence to the Remedial Action Report process; hence, no Remedial Action Report exists for this decision.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
IROD = Interim Record of Decision
PCR = Post Construction Report
RAR = Remedial Action Report
ROD = Record of Decision

Table 9.2. Facility operations and land use controls for CERCLA actions at other sites on the Oak Ridge Reservation

Site/Project	Requirements		Status	Section
	Land Use Controls	Engineering controls		
White Wing Scrap Yard (Waste Area Gouping 11) Surface Debris	Long-term surveillance and maintenance		Land use controls in place	9.2.1
Oak Ridge Associated Universities South Campus Facility	Environmental Notice filed at Register of Deeds		Land use controls in place	9.3.3

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

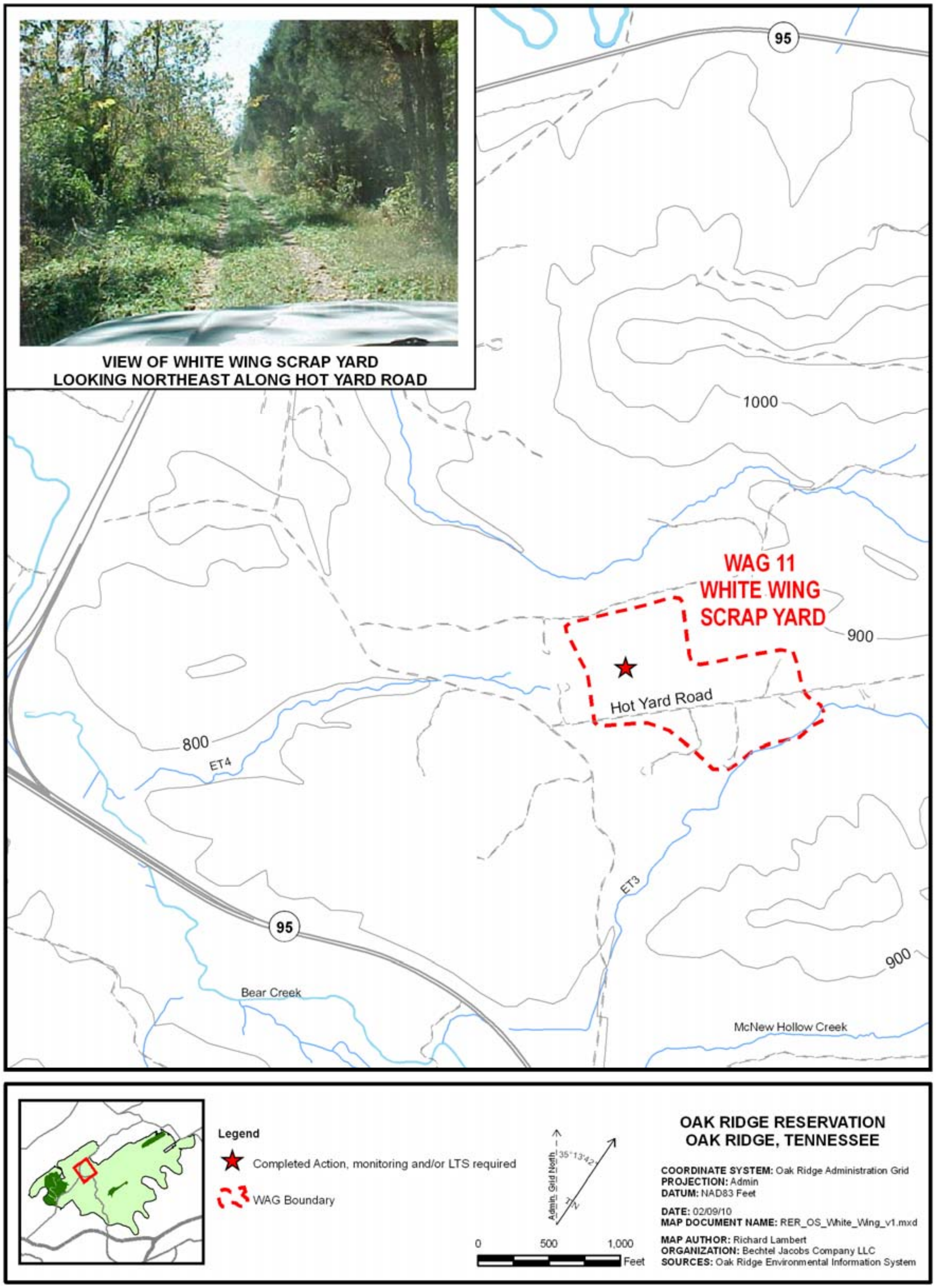

Figure 9.1. Location of White Wing Scrap Yard.

9.3 OAK RIDGE ASSOCIATED UNIVERSITIES SOUTH CAMPUS FACILITY

9.3.1 Performance Goals and Monitoring Objectives

The South Campus Facility is a former experiment station where the radionuclide effects on animals were studied (Figure 9.2). The *Record of Decision for Oak Ridge Associated Universities, South Campus Facility* (DOE 1995) specified groundwater monitoring in the vicinity of a VOC contaminated area and land use controls that include a groundwater-use restriction.

The *Record of Decision for Oak Ridge Associated Universities, South Campus Facility* (DOE 1995) 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 2007b) 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* Review (DOE 2011) recommended that the remedy be continued as monitored natural attenuation for groundwater with the ultimate goal of reaching maximum contaminant levels for VOCs, that annual sampling be continued, and that the plugging and abandonment of the remaining wells be continued except GW-841 and GW-842.

9.3.2 Evaluation of Performance Monitoring Data

During FY 2011, samples were collected from well GW-842 and surface water locations SCF-WS1 and SCF-WS2 and were analyzed for VOCs. Well GW-841 was dry at the time of sampling. Figure 9.3 shows the concentrations of detected VOCs in wells GW-841 and GW-842 from FY 1994 through FY 2011 have exhibited a long-term decreasing concentration history. The FY 2011 results, which were below drinking water standard concentrations, show continuing decreased concentrations compared to the short-term increase observed during 2006 and 2007. No site-related VOCs were detected in the two surface water samples collected during FY 2011.

9.3.3 Facility Operations and Land Use Controls

9.3.3.1 Requirements

The *Record of Decision for Oak Ridge Associated Universities, South Campus Facility* (DOE 1995) 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. The land use restrictions have been maintained and groundwater monitoring has been conducted at the site. These activities are specified in the documents listed in Table 9.1. Table 9.2 provides a summary of facility operations and land use controls requirements.

9.3.3.2 Status of Requirements for FY 2011

An on-line search of the Anderson County Register's of Deeds web site conducted in FY 2011 verified that the notice remains filed.

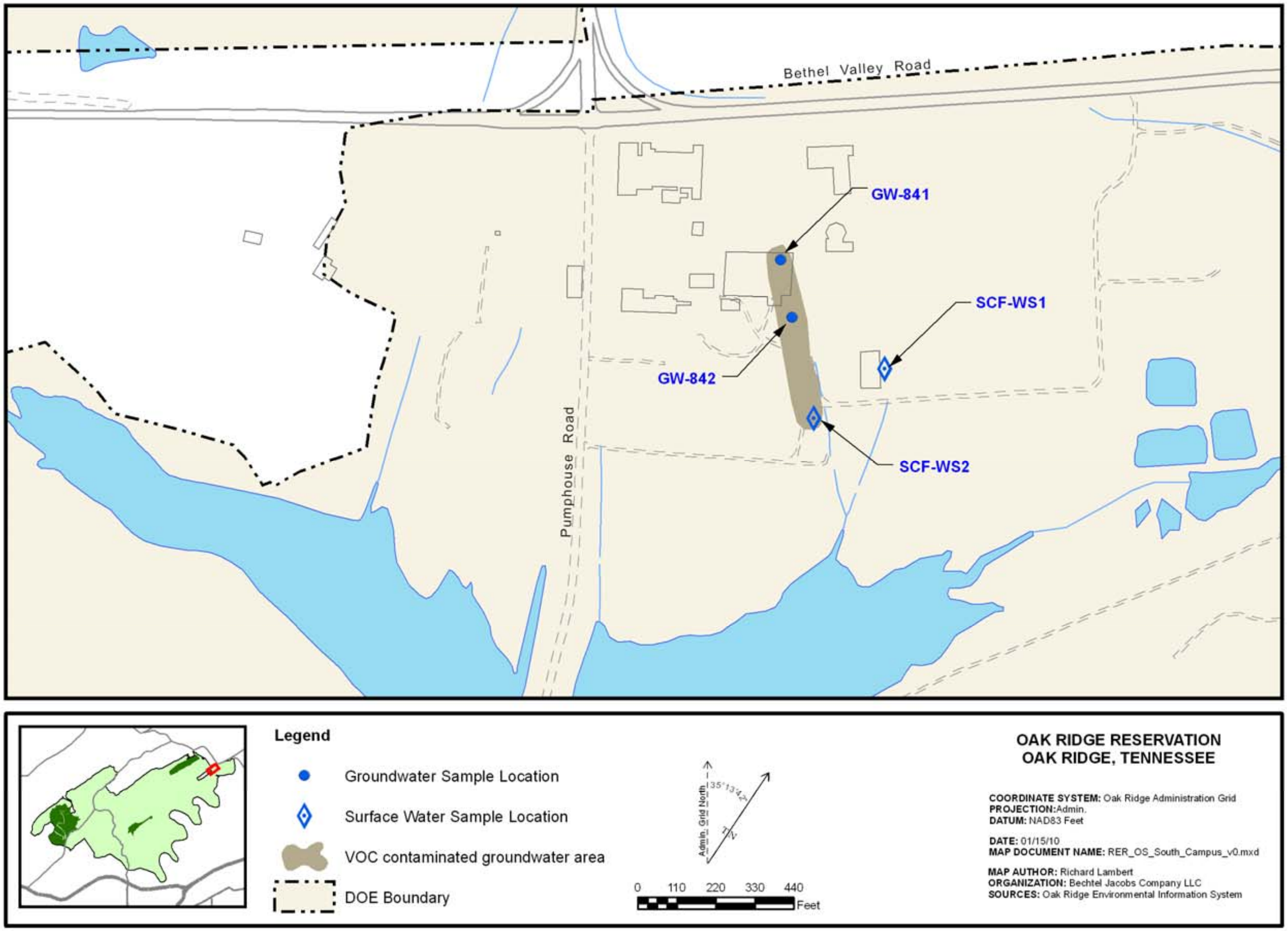

Figure 9.2. South Campus Facility monitoring locations and contaminated groundwater.

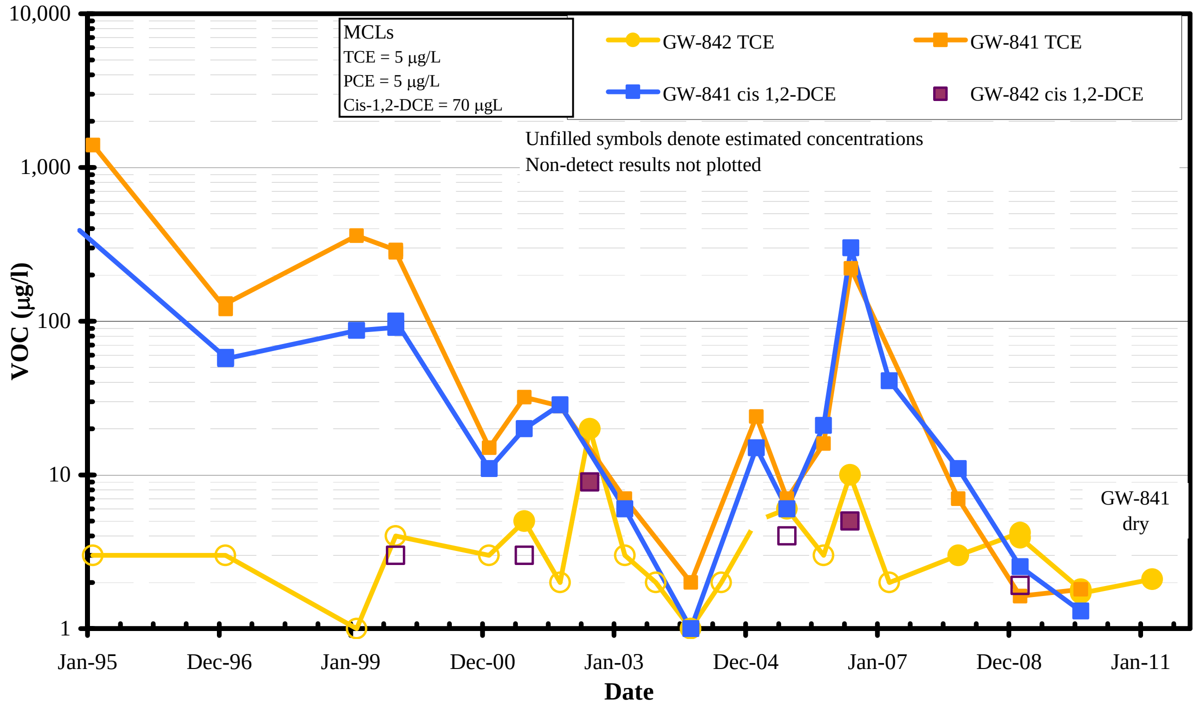

Figure 9.3. Organic compound concentrations in wells GW-841 and GW-842 at South Campus Facility.

9.3.4 Recommendations

The issues and recommendations for the Other Sites are in Table 9.3.

Table 9.3. Summary of issues and recommendations

Issue[a]	Action/ Recommendation	Responsible parties Primary/Support	Target response date
2012 Current Issue			
None.	1.		
Issue Carried Forward			
None.			
Completed/Resolved Issues			
None.			

[a]A “Current Issue” is an issue identified during evaluation of FY 2011 data for inclusion in the *2012 Remediation Effectiveness Report.* An “Issue Carried Forward” is an issue identified in a previous year’s Remediation Effectiveness Report or Five-Year Review so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

9.4 REFERENCES

DOE 1995. *Record of Decision for Oak Ridge Associated Universities, South Campus Facility, Oak Ridge, Tennessee*, DOE/OR/02-1383&D3, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

DOE 2007a. *2007 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2337&D2/V1&V2, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2007b. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-2289&D3, U. S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE 2011. *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&D1, U. S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

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APPENDIX A:
CERTIFICATION OF LAND USE CONTROL IMPLEMENTATION
FY 2011

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CERTIFICATION OF LAND USE CONTROL IMPLEMENTATION FY 2011

The Land Use Control Assurance Plan (LUCAP) requires that the Manager, Department of Energy (DOE) Oak Ridge Office (ORO) annually certify in the Remediation Effectiveness Report (RER) that Land Use Control Implementation Plans (LUCIPs) included as Appendix A of the LUCAP (i.e., approved LUCIPs) are being implemented on the Oak Ridge Reservation. This certification will identify any non-compliance with these LUCIPs and describe steps taken to address any such non-compliance(s). Certification is provided for fiscal year (FY) 2011, comprising the period October 1, 2010, through September 30, 2011. The LUCAP also requires that the annual report serve to notify the EPA and TDEC of any change in the designated officials or of land use changes that are not considered major, as described in Section 2.8 of the LUCAP.

The LUCIP for Melton Valley watershed was approved by EPA and TDEC in May, 2006, and revised through errata to the Melton Valley Remedial Action Report in 2009. Land use controls that were implemented in Melton Valley during FY 2011 are identified in Table A.1.

In accordance with Section 2.9 of the LUCAP (DOE 1999a), I certify based on the information and belief formed after reasonable inquiry that all required land use controls in Melton Valley have been implemented in accordance with the approved LUCIP for the watershed (DOE 2006b). The Land Use Controls in Table A.1 have been implemented, as required.

[signature]

John R. Eschenberg, Acting Manager

3/19/2012

Date

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Table A.1. Verification of Land Use Controls for the Melton Valley Watershed
LUCIP requirements being certified as of September 30, 2011[1]

MV LUCIP Requirements					
Type of control	**Affected areas**	**Implementation**	**Frequency**	**Verification Requirements**	**Certification Documentation[2]**
1. DOE land notation (property record restrictions) 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.	To be drafted and implemented by DOE upon completion of all remediation activities or transfer of affected areas. Filed within 90 days after EPA and TDEC approval of the RAR.	Verify annually that information is being maintained properly.	Verify information properly recorded at County Register of Deeds Office(s).	Certified. WRRP personnel verified that the MV Land Notation is being maintained properly with the Roane County Register of Deeds office.
2. Property Record notices	SWSA 6 ICMAs/HTF; All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.	Notice provided by DOE EM to the public as soon as practicable, but no later than 90 days after approval of the LUCIP. This notice will be supplemented with the DOE Land Notation after completion of remediation (see above).	Verify annually that information is being maintained properly.	Verify information properly recorded at County Register of Deeds Office(s).	Certified. WRRP personnel verified that the MV Property Record Notice, as well as the DOE Land Notation and survey plat, are being maintained properly on the EM website and at the DOE Information Center and that the DOE Land Notation remains properly recorded at the Roane County Register of Deeds office. The MV Property Record Notice was placed in local newspapers during December 2007.
4. Excavation/ penetration permit program	Remediation systems and all waste management areas and areas where hazardous substances/structures remain after remediation at levels requiring land use and/or groundwater restrictions.	Currently established and functioning.	Monitor annually to ensure it is functioning properly.	Verify functioning of permit program against existing procedures.	Certified. MV Engineer verified that the EPP program was functioning during FY 11 against existing procedures.

Table A.1. Verification of Land Use Controls for the Melton Valley Watershed LUCIP requirements being certified as of September 30, 2011 (cont.)[1]

MV LUCIP Requirements					
Type of control	**Affected areas**	**Implementation**	**Frequency**	**Verification Requirements**	**Certification Documentation[2]**
5. State advisories/ postings (e.g., no fishing or contact advisory)	White Oak Lake and White Oak Creek Embayment	Although not a requirement, advisories and postings may be established by TDEC in the future.	Inspect no less than annually.	Conduct field survey and assess signs condition (i.e., remain intact, erect, and legible).	Certified. MV S&M manager conducted field survey and verified that adequate warning signs have been posted by DOE at White Oak Lake dam and at access to the White Oak Creek Embayment and meet the intent of the State advisories/postings. Per the description of the control in the RAR, although not a requirement, advisories and postings may be established by TDEC in the future.
6. Access controls (e.g., fences, gates, portals)	At 20 locations throughout Melton Valley Watershed near major access points.	If necessary, selected in the design or construction completion reports.	Inspect no less than annually.	Conduct field surveys of all controls to assess condition (i.e., remain erect, intact, and functioning).	Certified. MV S&M manager conducted field survey and verified that access controls are in place around MV.
7. Signs	At 20 locations throughout Melton Valley Watershed near major access points. At 6 of the 20 locations around the White Oak Lake and White Oak Creek Embayment at major access points.	In place within 6 months of approval of the LUCIP.	Inspect no less than annually.	Conduct field survey of all signs to assess condition (i.e., remain erect, intact, and legible).	Certified. MV S&M manager conducted field survey and verified that signs are in place at 20 locations around MV, and that 6 of the 20 sign locations around the White Oak Lake and White Oak Creek Embayment also provide notice to resource users of contamination and prohibit fishing/contact

Table A.1. Verification of Land Use Controls for the Melton Valley Watershed LUCIP requirements being certified as of September 30, 2011 (cont.)[1]

MV LUCIP Requirements					
Type of control	**Affected areas**	**Implementation**	**Frequency**	**Verification Requirements**	**Certification Documentation[2]**
8. Surveillance patrols	Patrol of selected areas throughout Melton Valley, as necessary.	Effective immediately following LUCIP approval and conducted no less frequently than once a quarter.	Adequacy of necessary patrols assessed no less than annually.	Verify against procedures/plans that routine patrols conducted.	Certified. MV S&M manager verified that surveillance patrols were conducted according to S&M procedure.
Additional Project-Specific PCCR Requirements					
None specified [3]	MV ISG Trenches 5 & 7 SWSA 6 SWSA 4 Pit and Trenches SWSA 5 TRU Trenches, Soils and Sediments				

[1]Zoning notice to City Planning Commission will be completed if/when Melton Valley contaminated areas are transferred out of DOE federal control.
[2]Documentation of verification completed by WRRP annually.
[3]No attachments to Appendix A of the MV LUCIP as of September 30, 2011.

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APPENDIX B
MELTON VALLEY GROUNDWATER DATA

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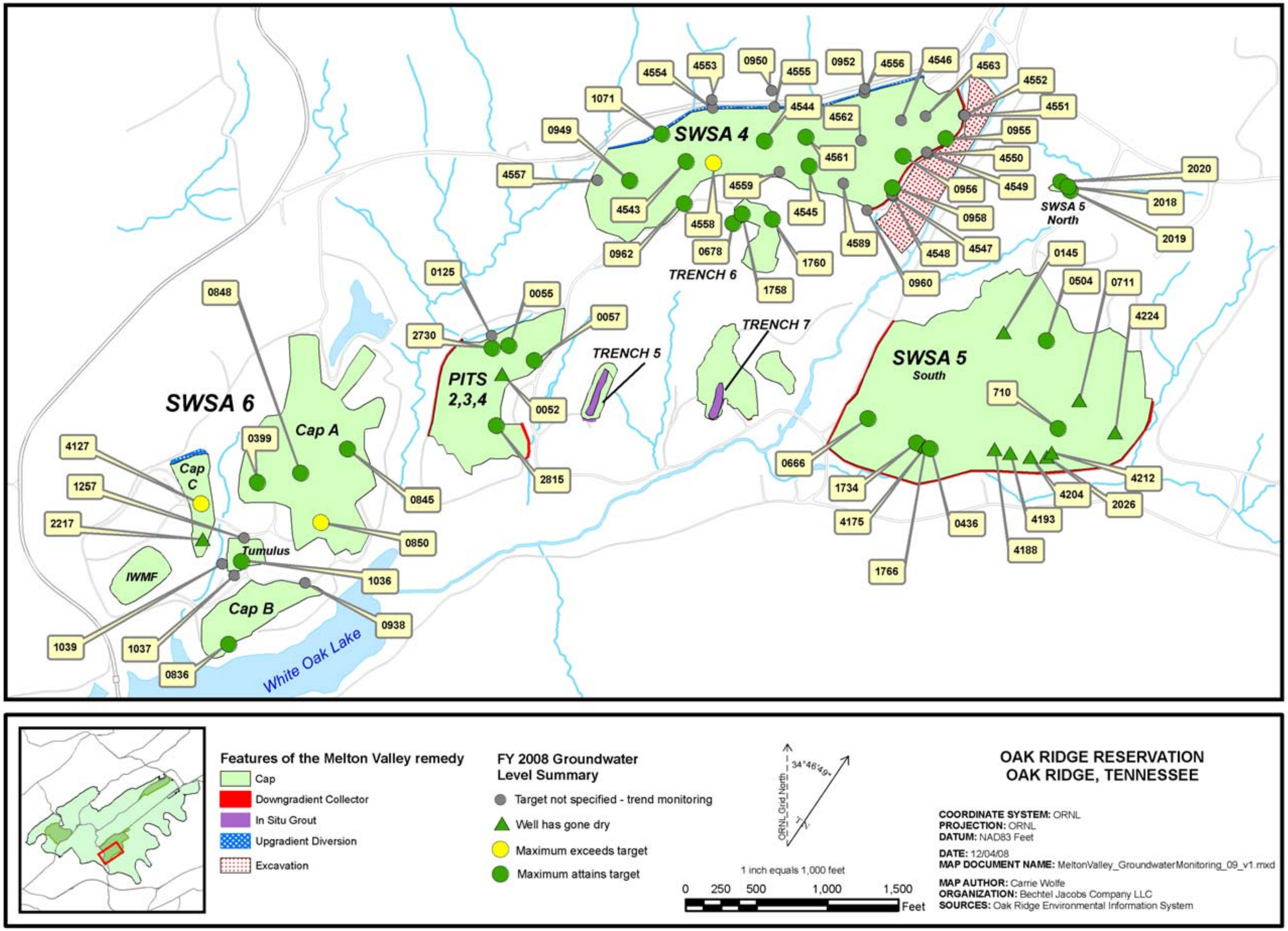


Figure B.1. Locations of groundwater elevation monitoring in Melton Valley.

B.1. FY 2011 Melton Valley Groundwater Level Summary

Well	Area	Meas Freq	Max. Elevation	Observed Range	Target Elevation	Target Range	Meets TE	Meets Fluct	Comment
0052	PT-2,3,4	M	dry	--	791.0	--		--	
0055	PT-2,3,4	C	786.25	0.73	795.00	--	Y	--	Fluctuates below waste zone
0057	PT-2,3,4	M	783.52	2.36	795.00	--	Y	--	Fluctuates below waste zone
0125	PT-2,3,4	M	784.40	2.50	778.70	1.83	--	--	Outside Cap
2730	PT-2,3,4	M	779.15	1.51	791.00	--	Y	--	Fluctuates below waste zone
2815	PT-2,3,4	M	770.25	1.25	789.00	--	Y	--	Fluctuates below waste zone
0678	PT-Trench 6	M	822.78	3.79	836	1.35	--	--	Outside Cap
1758	PT-Trench 6	M	829.94	4.58	836	4.42	Y	N	Fluctuates below waste zone
1760	PT-Trench 6	M	820.86	2.40	836	1.00	Y	N	Fluctuates below waste zone
0949	SWSA 4	C	803.23	1.19	813.78	1.48	Y	--	Fluctuates below waste zone
0950	SWSA 4	C	829.95	8.79	--	--	--	--	Outside Cap, UGT Monitoring
0952	SWSA 4	M	813.81	4.43	810.44	--	--	--	Outside Cap, UGT Monitoring
0955	SWSA 4	M	761.85	3.26	759.42	1.03	N	N	Near SWSA 4 DGT-- fluctuates with DGT level
0956	SWSA 4	C	768.19	0.50	770.49	0.40	Y	Y	
0958	SWSA 4	Q	761.01	1.29	761.25	0.72	N	N	Near SWSA 4 DGT-- fluctuates with DGT level
0960	SWSA 4	Q	763.84	1.51	--	--	--	--	Outside Cap
0962	SWSA 4	Q	819.83	2.96	822.85	0.57	Y	N	At cap edge
1071	SWSA 4	Q	802.55	0.45	802.44	0.79	N	Y	
4543	SWSA 4	C	799.25	2.19	803.31		Y	--	
4544	SWSA 4	C	789.56	0.31	791.89		Y	--	
4545	SWSA 4	C	dry		777.25		Y		
4546	SWSA 4	C	dry		--	1.1	Y		
4553	SWSA 4	M	818.84	3.85			--		Outside Cap, UGT Monitoring
4554	SWSA 4	M	810.44	0.87			--		UGT Monitoring
4555	SWSA 4	C	810.69	1.83	NA	1.25	--		UGT Monitoring
4556	SWSA 4	C	807.70	2.34	NA		--		UGT Monitoring
4557	SWSA 4	M	dry	--	NA	--	Y	--	
4558	SWSA 4	M	789.88	2.17		0.18	--	Y	
4559	SWSA 4	M	777.61	0.19		0.38	--	Y	
4561	SWSA 4	M	791.85	0.26					
4562	SWSA 4	M	782.77	0.21					
4563	SWSA 4	C	778.04	0.50					
4588	SWSA 4	C	762.13	4.42					DGT Monitoring
4589	SWSA 4	C	771.92	0.39					DGT Monitoring
4547	SWSA 4 DGT	C	763.11	6.00					DGT Monitoring

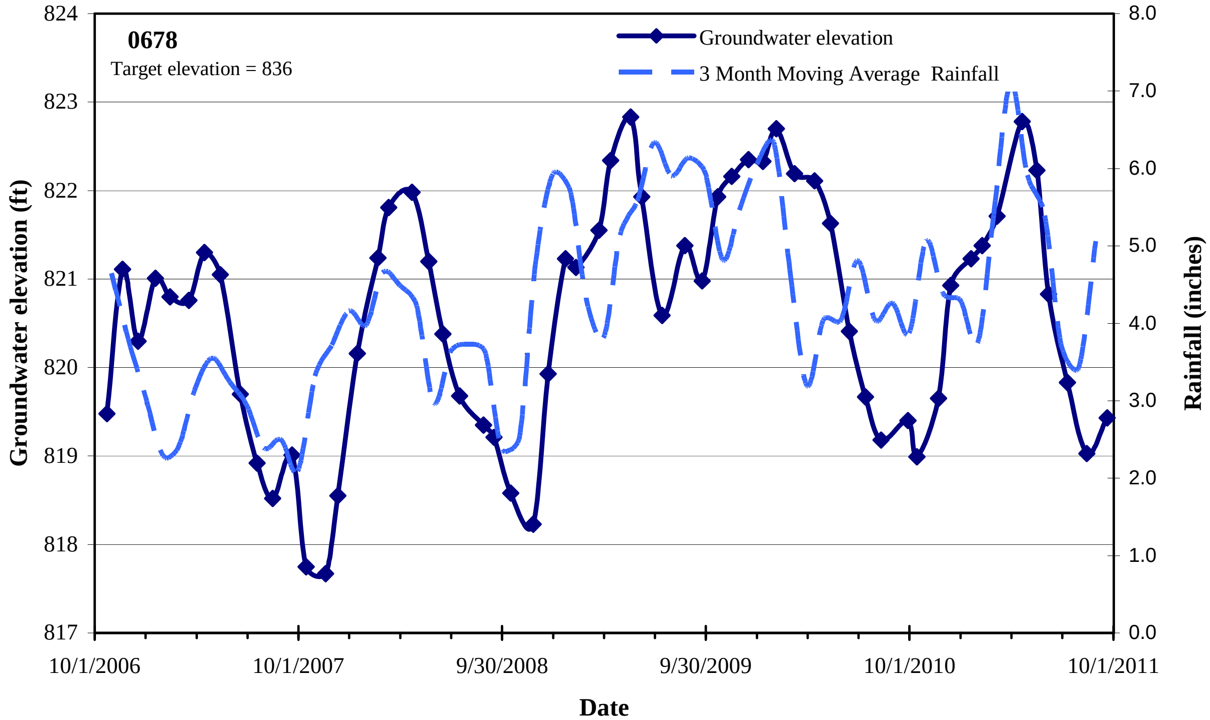
B.1. FY 2011 Melton Valley Groundwater Level Summary (cont.)

Well	Area	Meas Freq	Max. Elevation	Observed Range	Target Elevation	Target Range	Meets TE	Meets Fluct	Comment
4548	SWSA 4 DGT	C	766.90	9.45					DGT Monitoring
4550	SWSA 4 DGT	C	762.73	5.01					DGT Monitoring
4551	SWSA 4 DGT	C	764.47	5.49					DGT Monitoring
4552	SWSA 4 DGT	C	764.91	4.95					DGT Monitoring
4595	SWSA 4 DGT	C	763.16	4.52					DGT Monitoring
4596	SWSA 4 DGT	C	763.16	7.12					DGT Monitoring
4598	SWSA 4 DGT	C	762.18	4.52					DGT Monitoring
4599	SWSA 4 DGT	C	762.64	4.71					DGT Monitoring
4605	SWSA 4 DGT	C	762.29	4.39					DGT Monitoring
4606	SWSA 4 DGT	C	764.63	6.05					DGT Monitoring
4607	SWSA 4 DGT	C	763.66	5.56					DGT Monitoring
4611	SWSA 4 DGT	C	764.64	3.45					DGT Monitoring
2018	SWSA 5-N	M	dry	dry	822.2	2.5	Y	Y	
2019	SWSA 5-N	M	810.69	4.99	824.30	1.67	Y	N	Fluctuates below waste zone
2020	SWSA 5-N	M	dry	--	828.20	0.78	Y	--	
0145	SWSA 5-S	C	dry	--	829.10	1.9	Y	--	
0436	SWSA 5-S	M	767.27	0.44	773.90	2.35	Y	Y	
0504	SWSA 5-S	M	810.76	0.10	813.10	1.83	Y	Y	
0666	SWSA 5-S	M	768.85	0.30	776.10	1.35	Y	Y	
0710	SWSA 5-S	M	780.54	0.61	791.50	1.10	Y	Y	
0711	SWSA 5-S	M	796.67	0.36	806.1	2.9	Y	Y	
1734	SWSA 5-S	C	dry	--	776.70	2.2	Y	--	
1766	SWSA 5-S	M	dry	--	773.9	2.1	Y	--	
2026	SWSA 5-S	C	dry	--	773.3	1.2	Y	--	
4175	SWSA 5-S	M	dry	--	775.80	4.10	Y	--	
4188	SWSA 5-S	M	dry	--	772.90	1.63	Y	--	
4193	SWSA 5-S	M	dry	--	775.40	1.32	Y	--	
4204	SWSA 5-S	M	dry	--	773.00	1.40	Y	--	
4212	SWSA 5-S	M	771.96	--	773.7	1.68	Y	--	Water only observed in one monthly

B.1. FY 2011 Melton Valley Groundwater Level Summary (cont.)

Well	Area	Meas Freq	Max. Elevation	Observed Range	Target Elevation	Target Range	Meets TE	Meets Fluct	Comment
									measurement
4224	SWSA 5-S	M	dry	--	781.6	1.88	Y	--	
0399	SWSA 6	M	776.36	1.01	782.90	1.36	Y	Y	
0836	SWSA 6	M	747.43	2.34	753.00	--	Y	--	Near cap edge, fluctuates below waste zone
0845	SWSA 6	M	781.91	1.2	784.10	0.82	Y	N	Bedrock well, fluctuates below waste zone
0848	SWSA 6	M	777.80	0.33	779.20	0.27	Y	N	Bedrock well
0850	SWSA 6	C	766.86	2.09	765.90	2.1	N	Y	Seasonally exceeds target elevation
0938	SWSA 6	M	757.21	3.82	753.80	--	N	--	Outside cap, bedrock well
1036	SWSA 6	C	759.03	4.87	768.00	--	Y	--	
1037	SWSA 6	M	759.68	5.9	767.00	--	--	--	Outside cap
1039	SWSA 6	M	763.5	4.52	768.00	--	--	--	Outside cap
1257	SWSA 6	M	769.63	3.65	769.00	--	--	--	Outside cap
2217	SWSA 6	C	dry	--	767.6	2.5	Y	--	
4127	SWSA 6	M	774.12	2.12	772.30	2.25	N	Y	Bedrock well

C=continuous groundwater level monitoring using pressure transducer and data logger
M=monthly manual groundwater level measurements
Q=quarterly manual groundwater level measurements



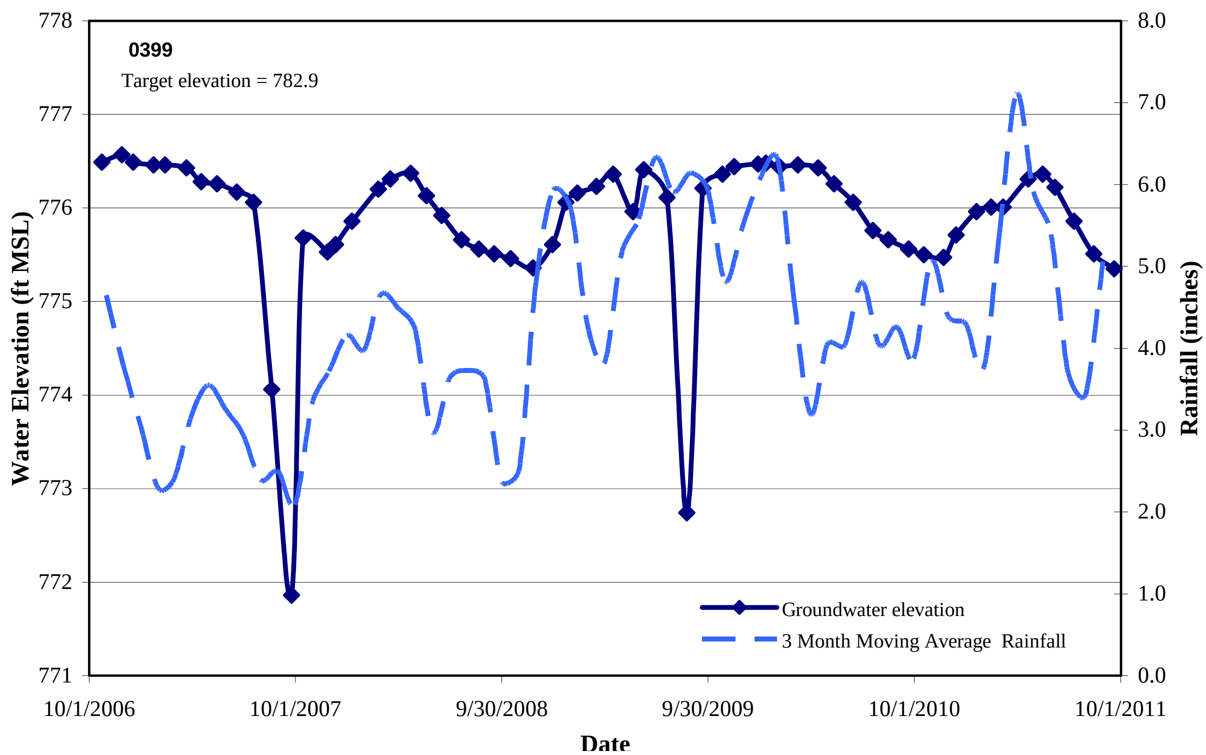
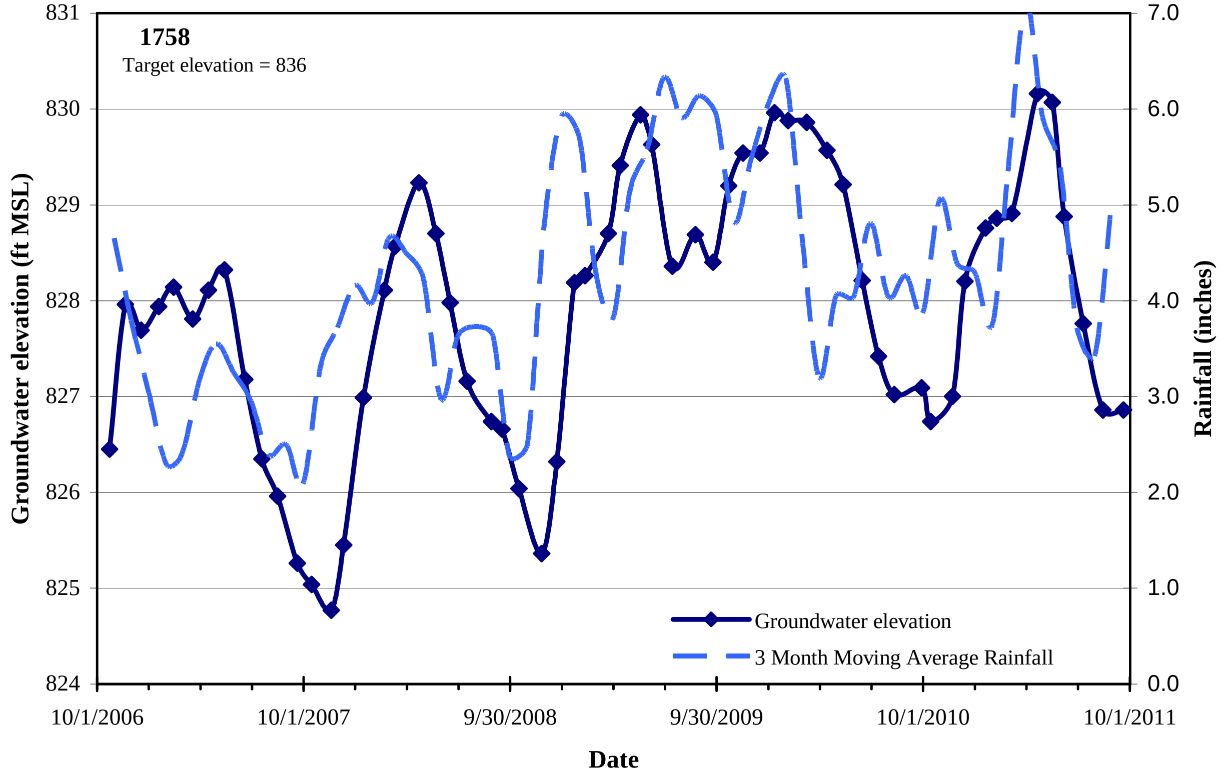


Figure B.2. Well hydrographs for wells 0678 and 0399.



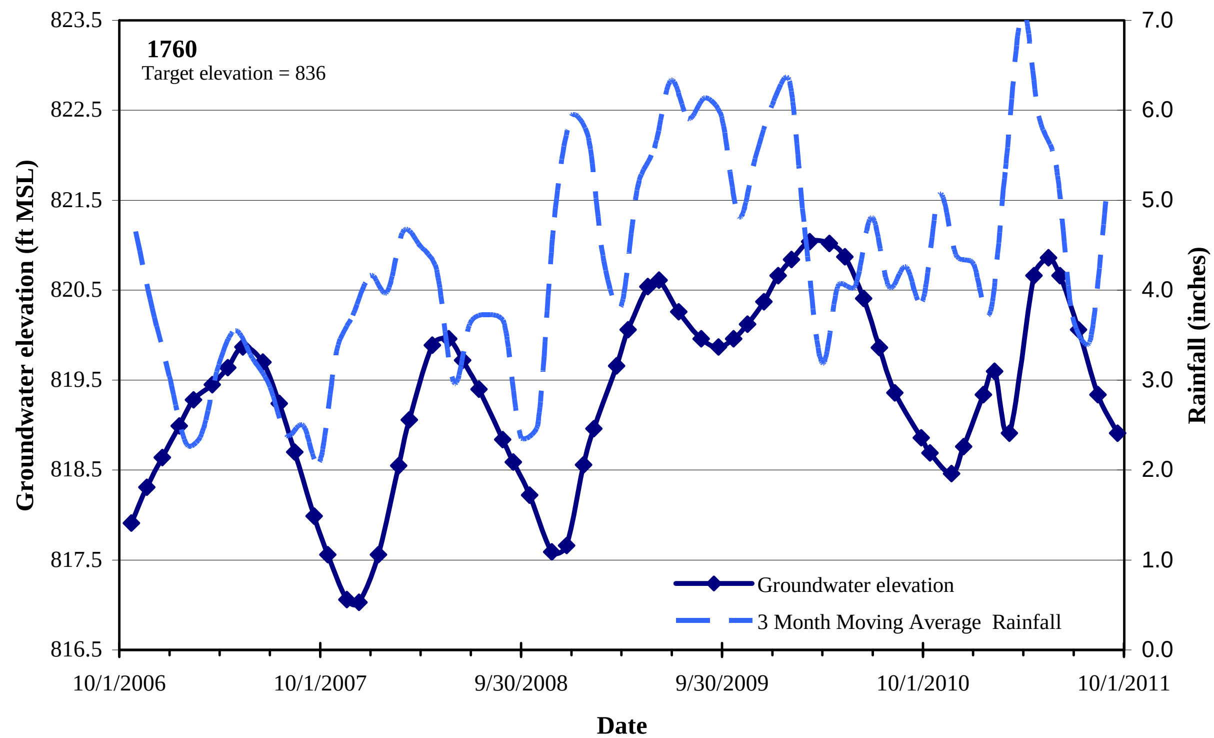
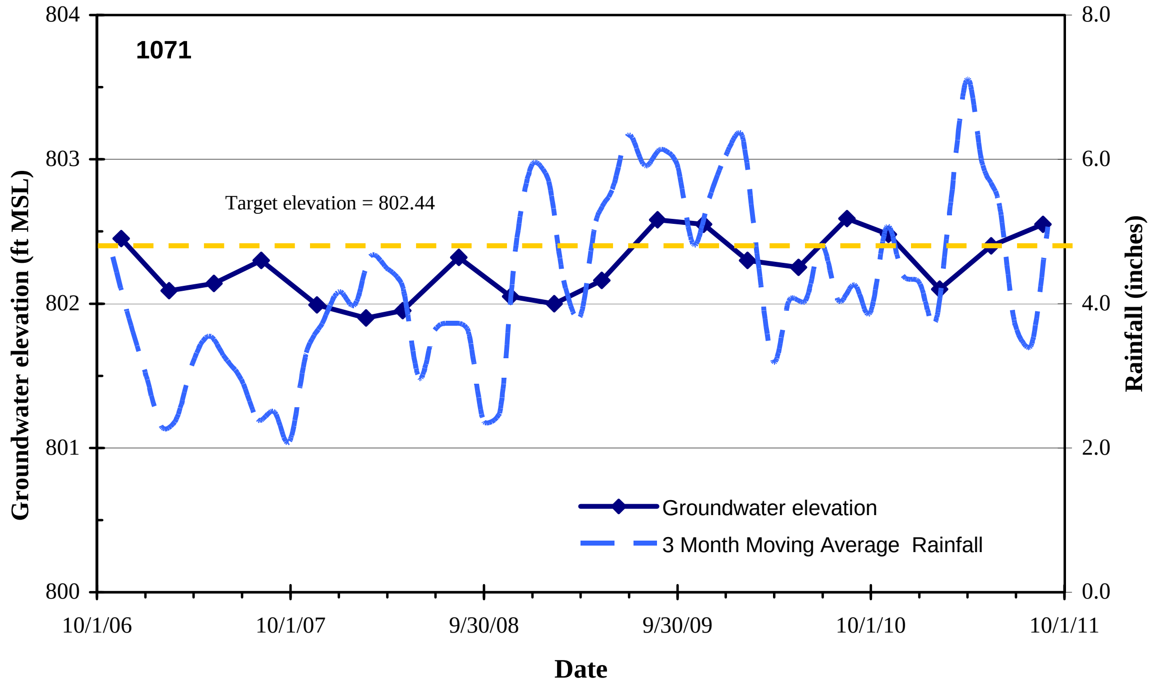


Figure B.3. Well hydrographs for wells 1758 and 1760.



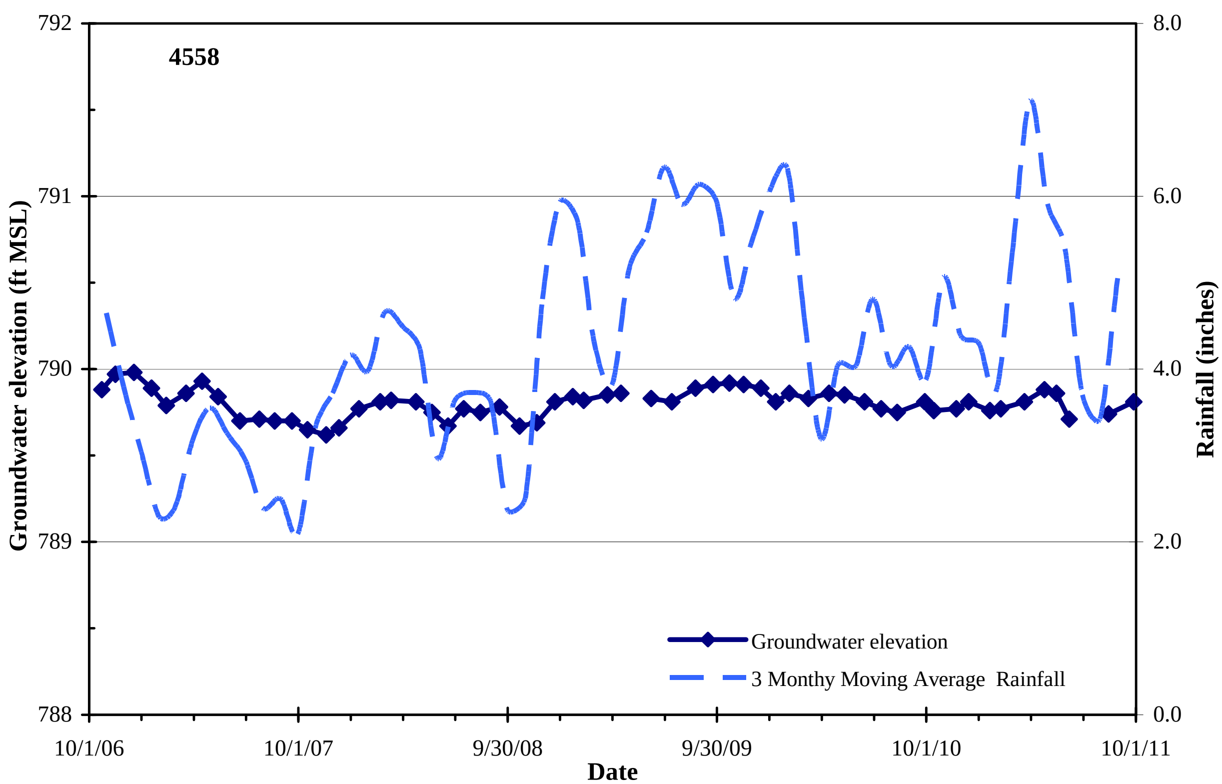
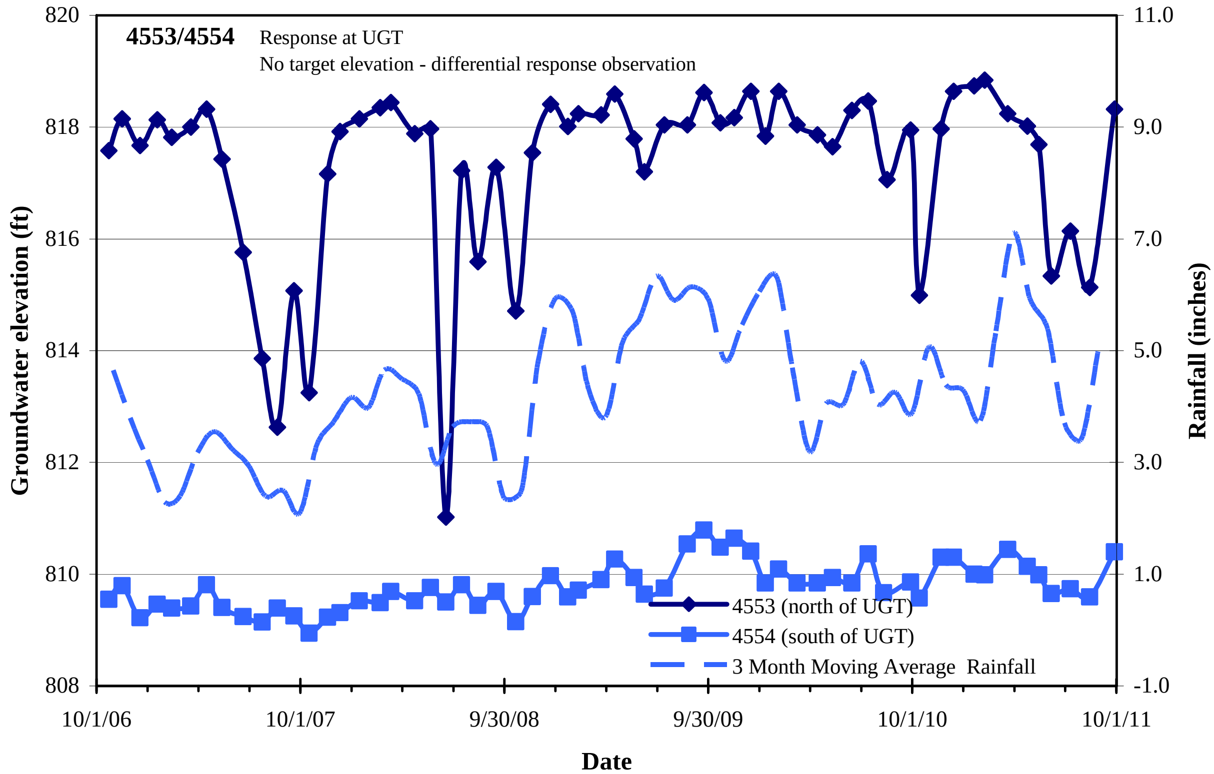


Figure B.4. Well hydrographs for wells 1071 and 4558.



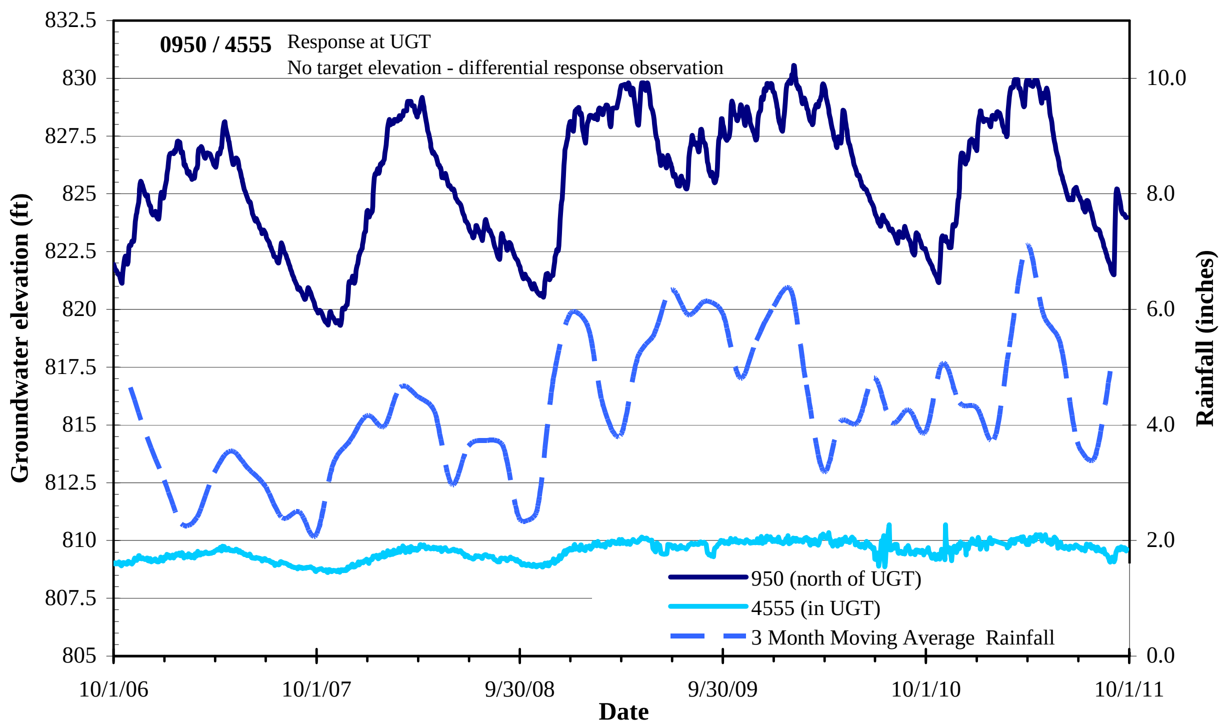
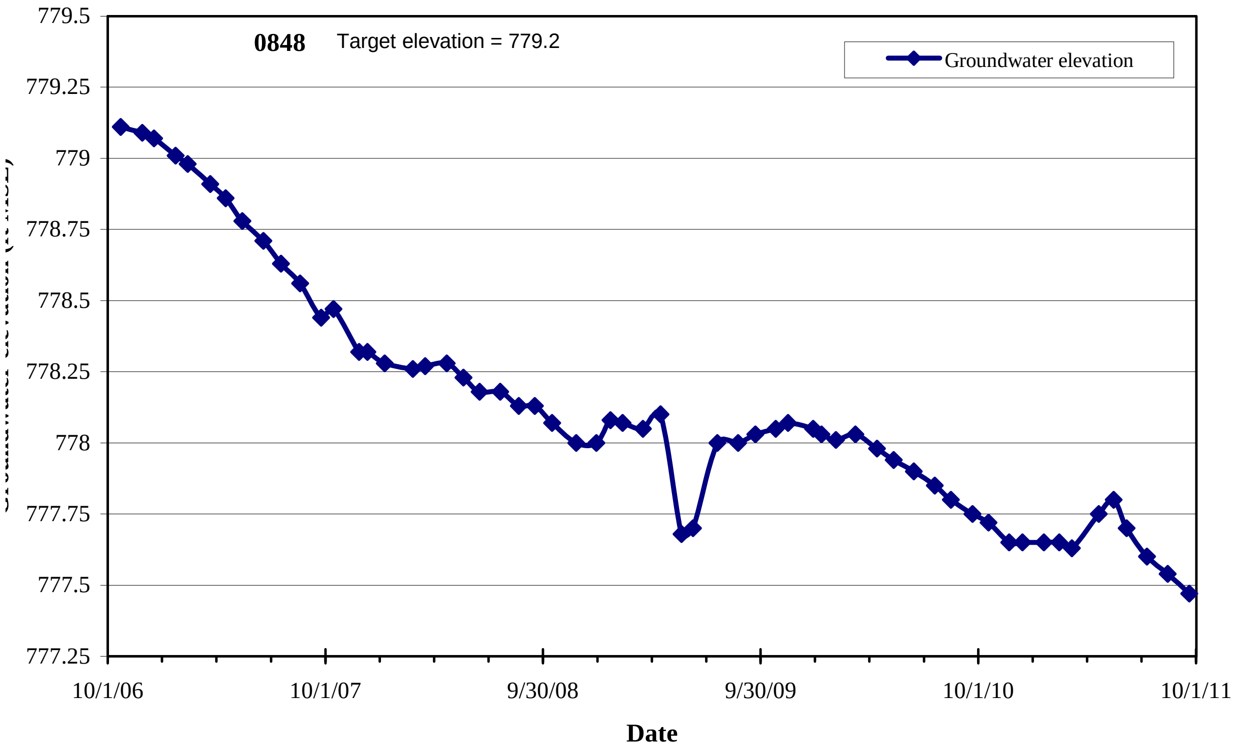


Figure B.5. Well hydrographs for wells 4553/4554 and -0950/4555.



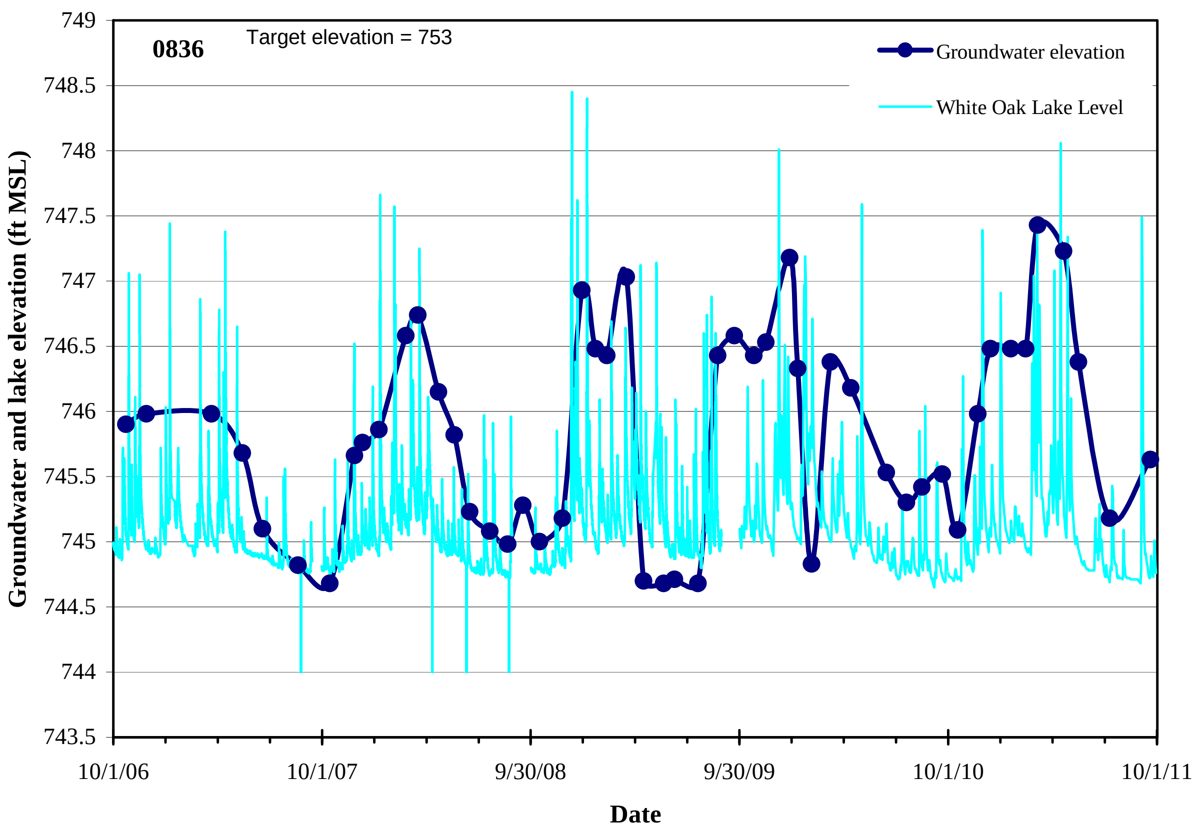
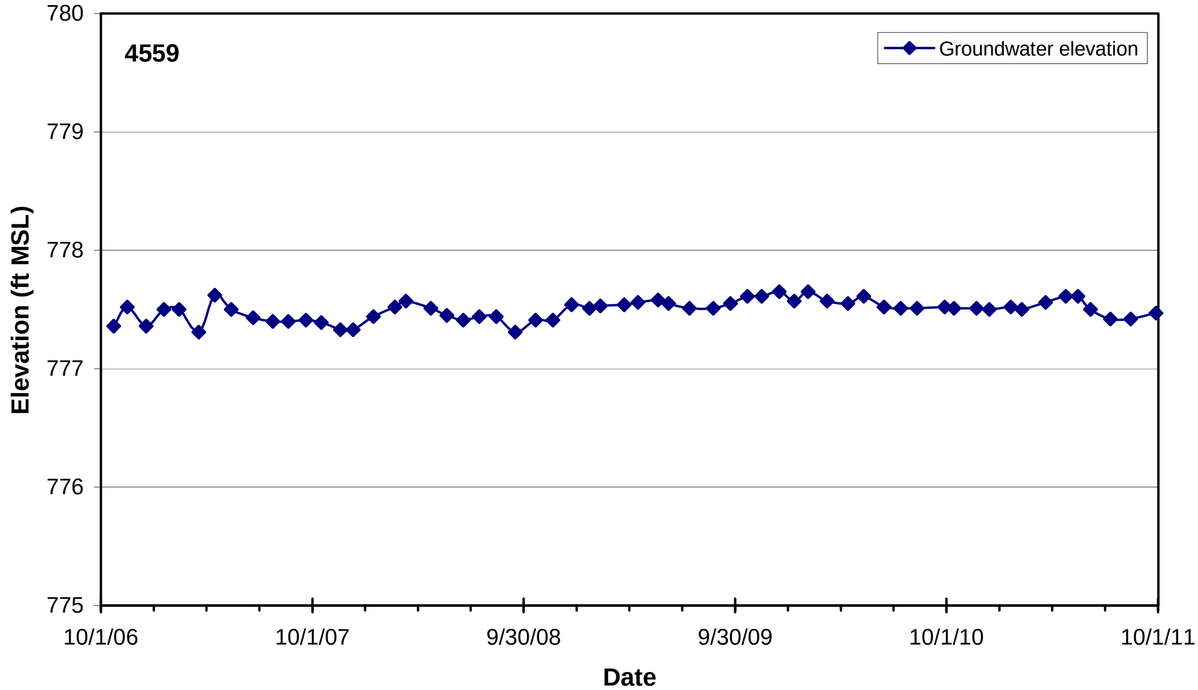


Figure B.6. Well hydrographs for well pairs 0848 and 0836.



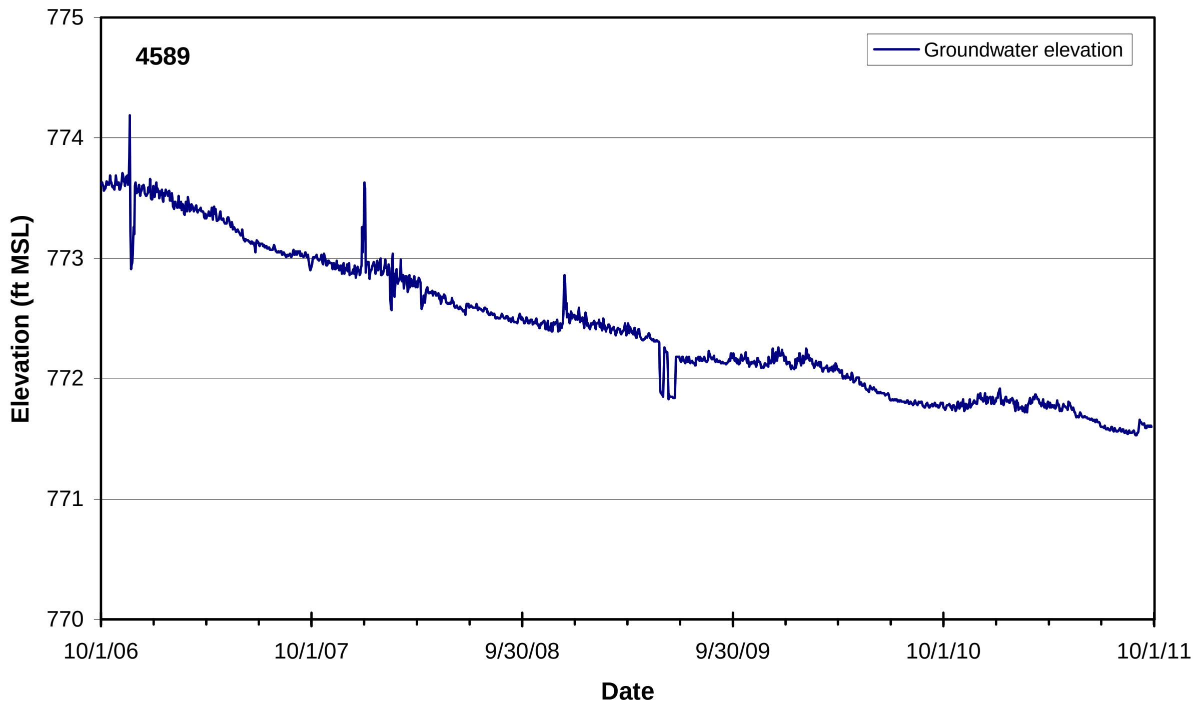
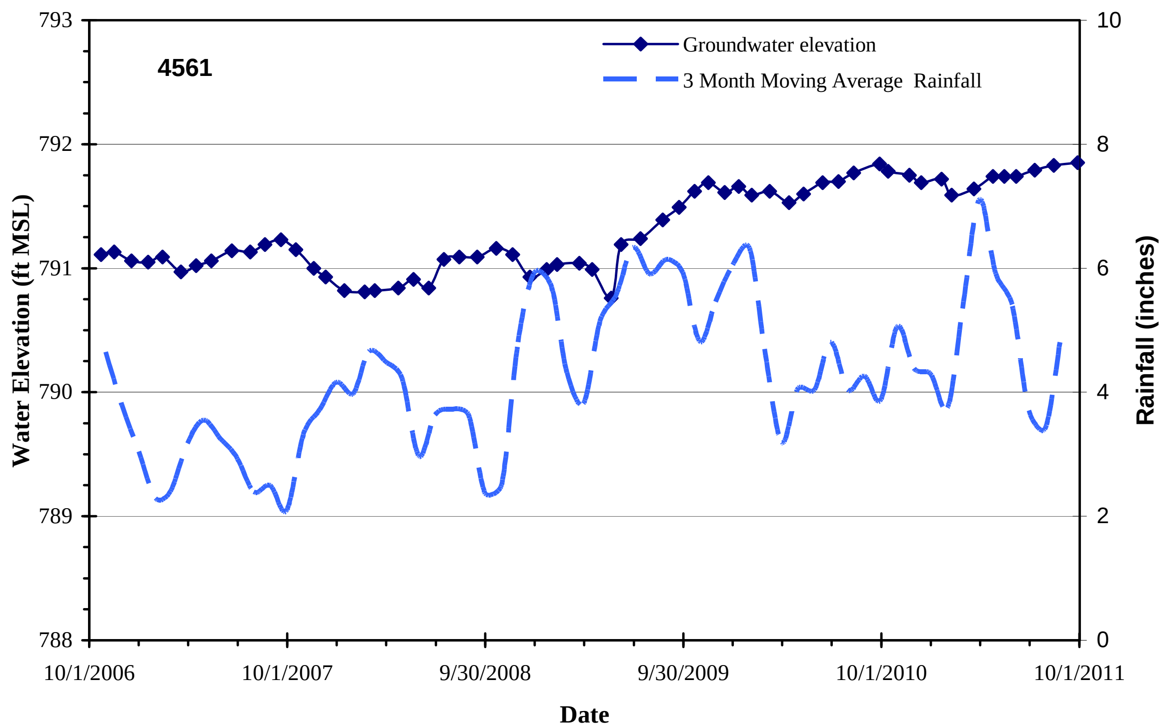


Figure B.7. Well hydrographs for wells 45595 and 4589.



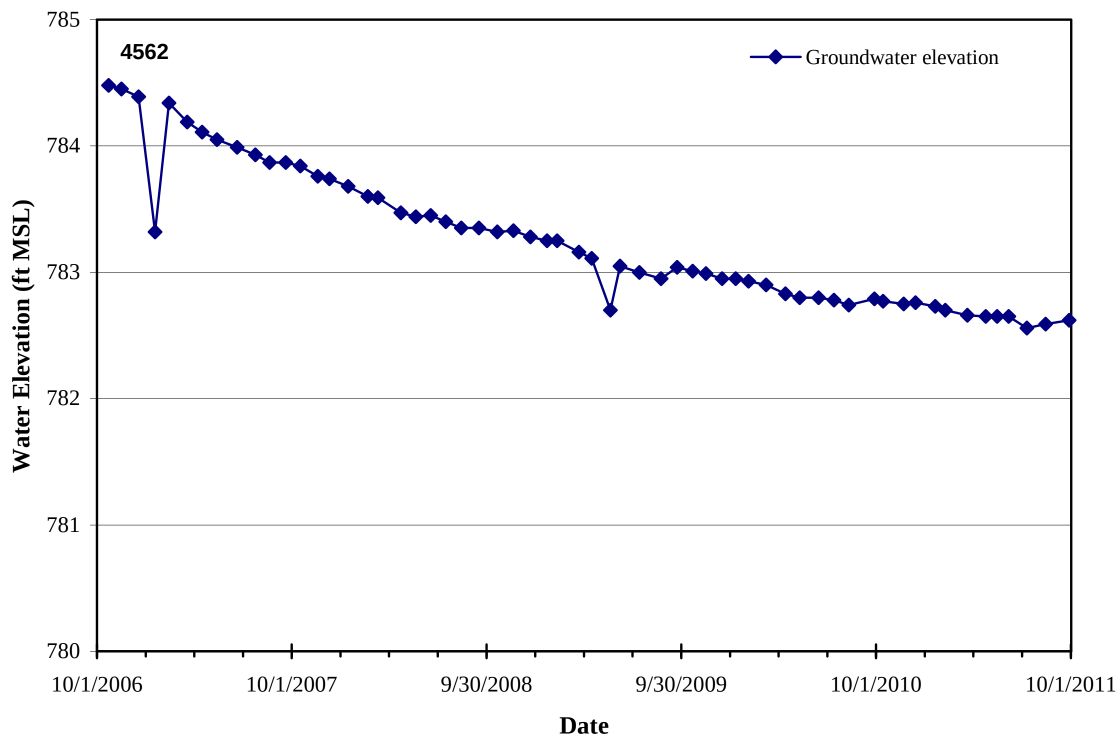
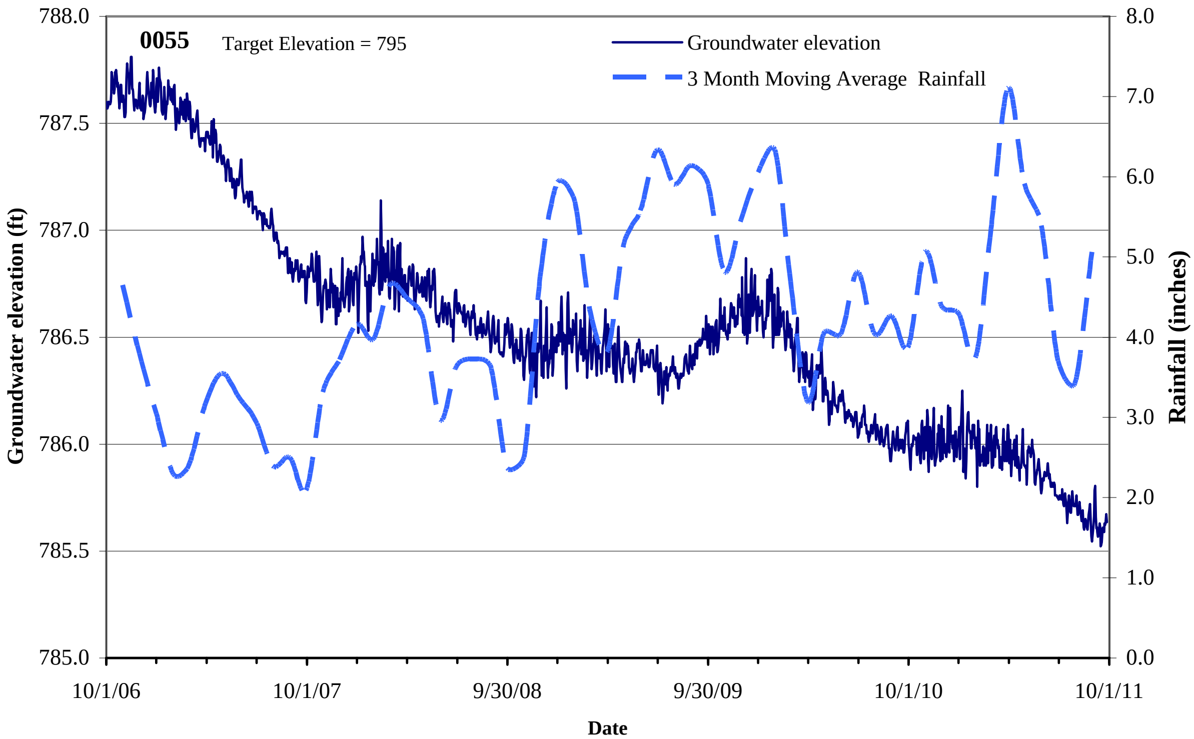


Figure B.8. Well hydrographs for wells 4561 and 4562.



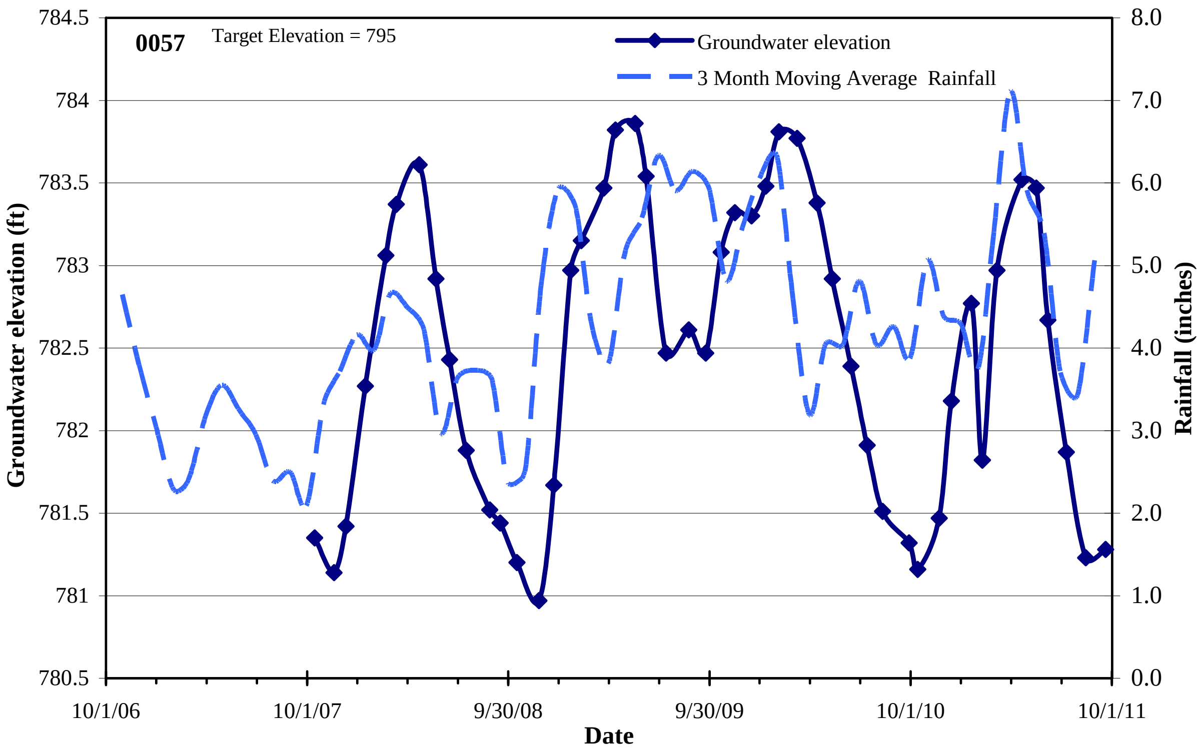
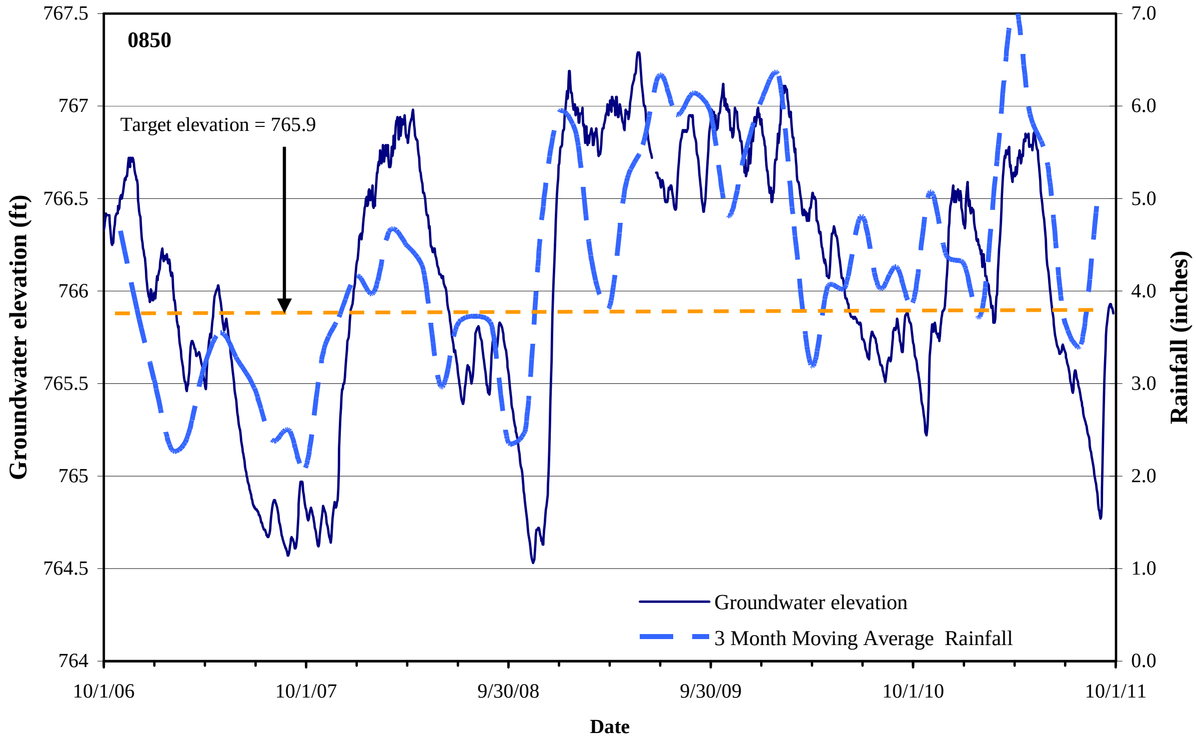


Figure B.9. Well hydrographs for wells 0055 and 00573.



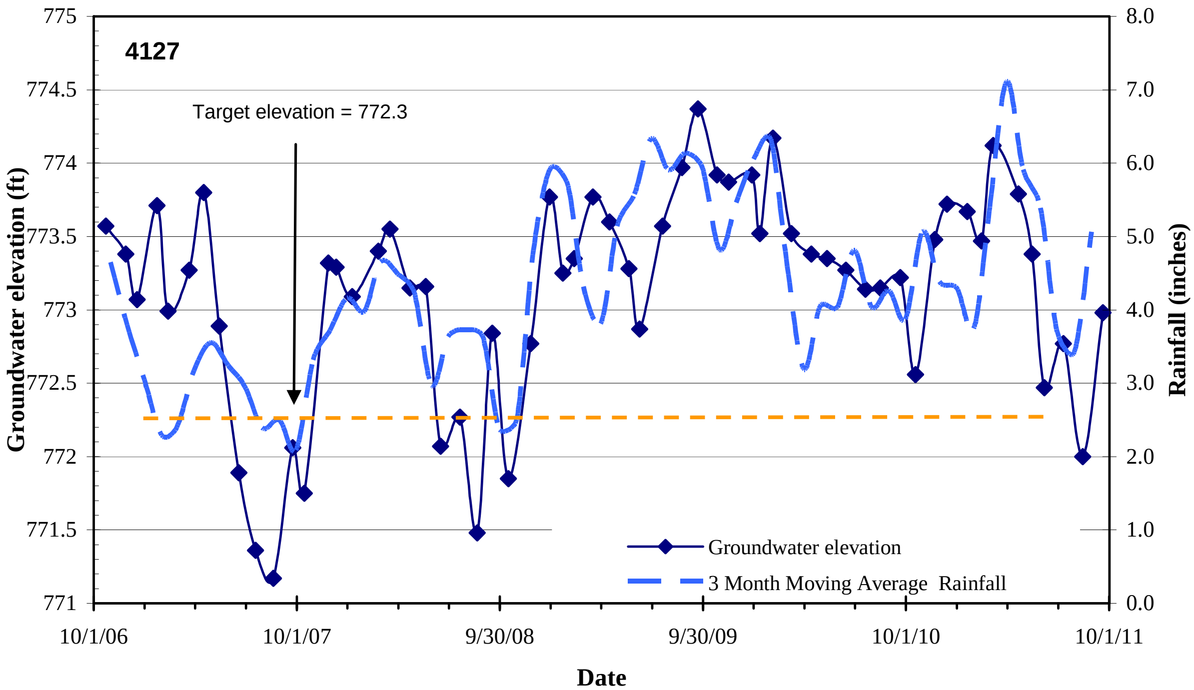
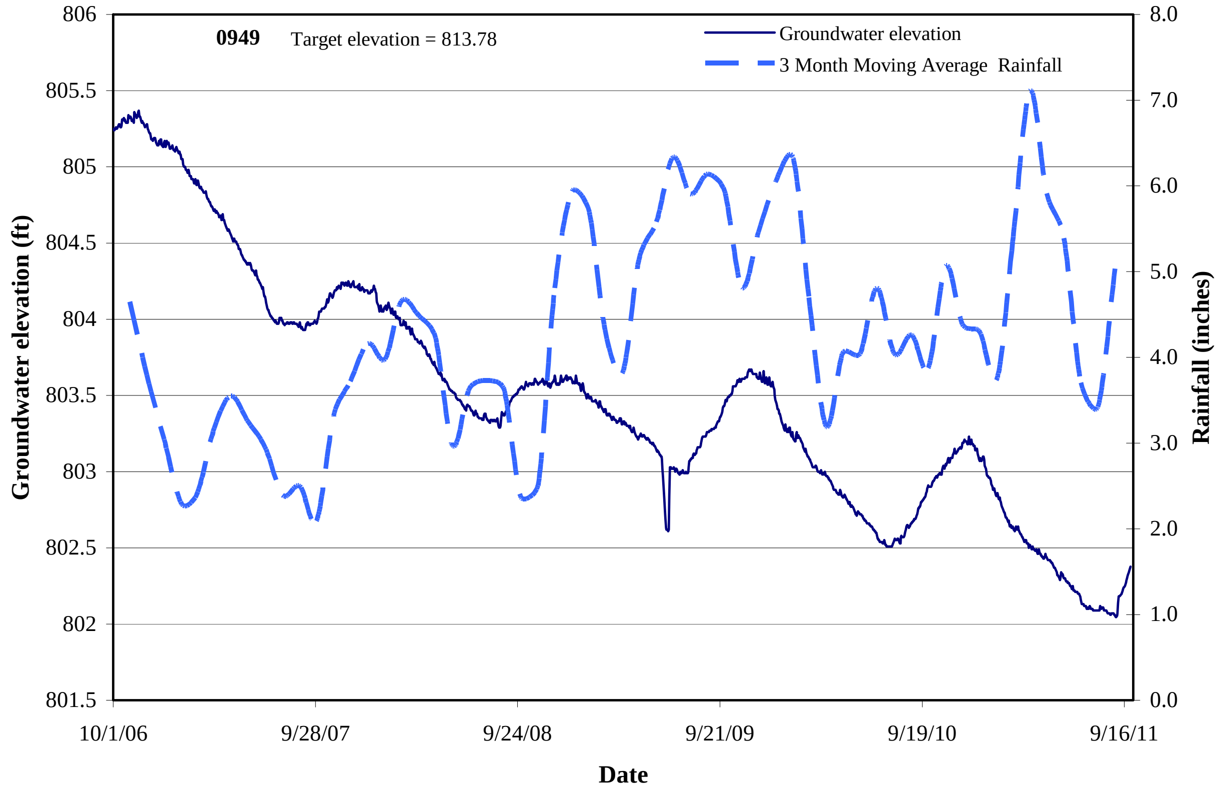


Figure B.10. Well hydrographs for wells 0850 and 4127.



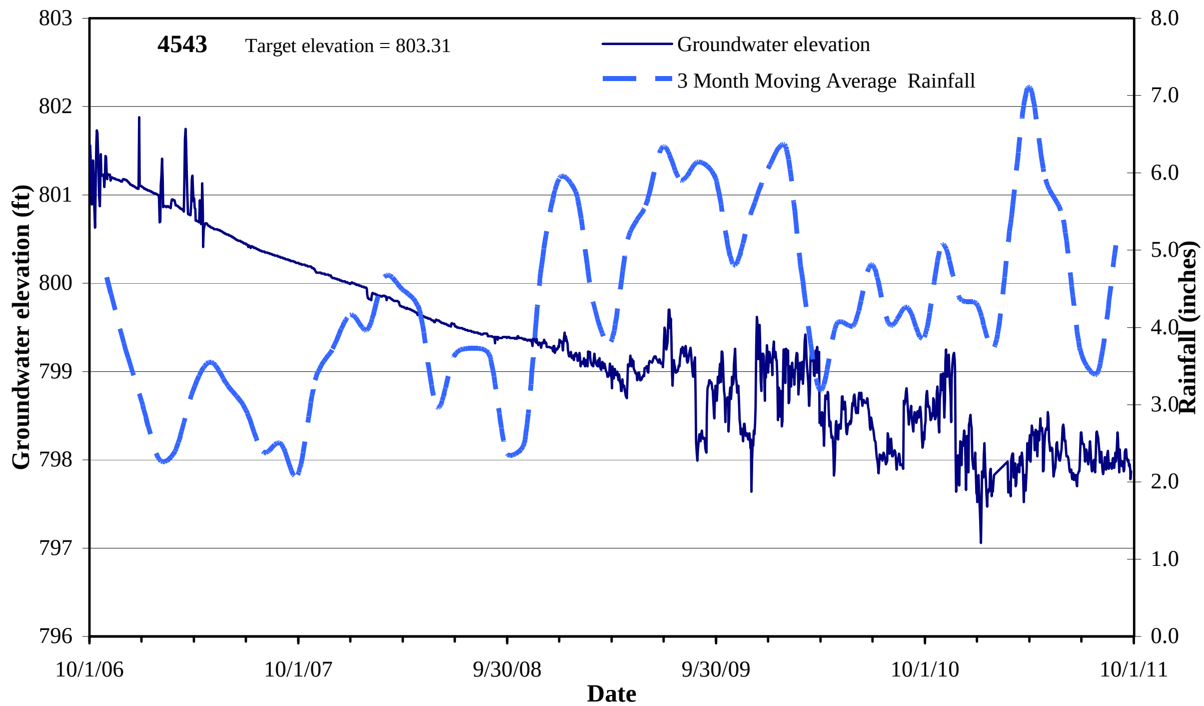
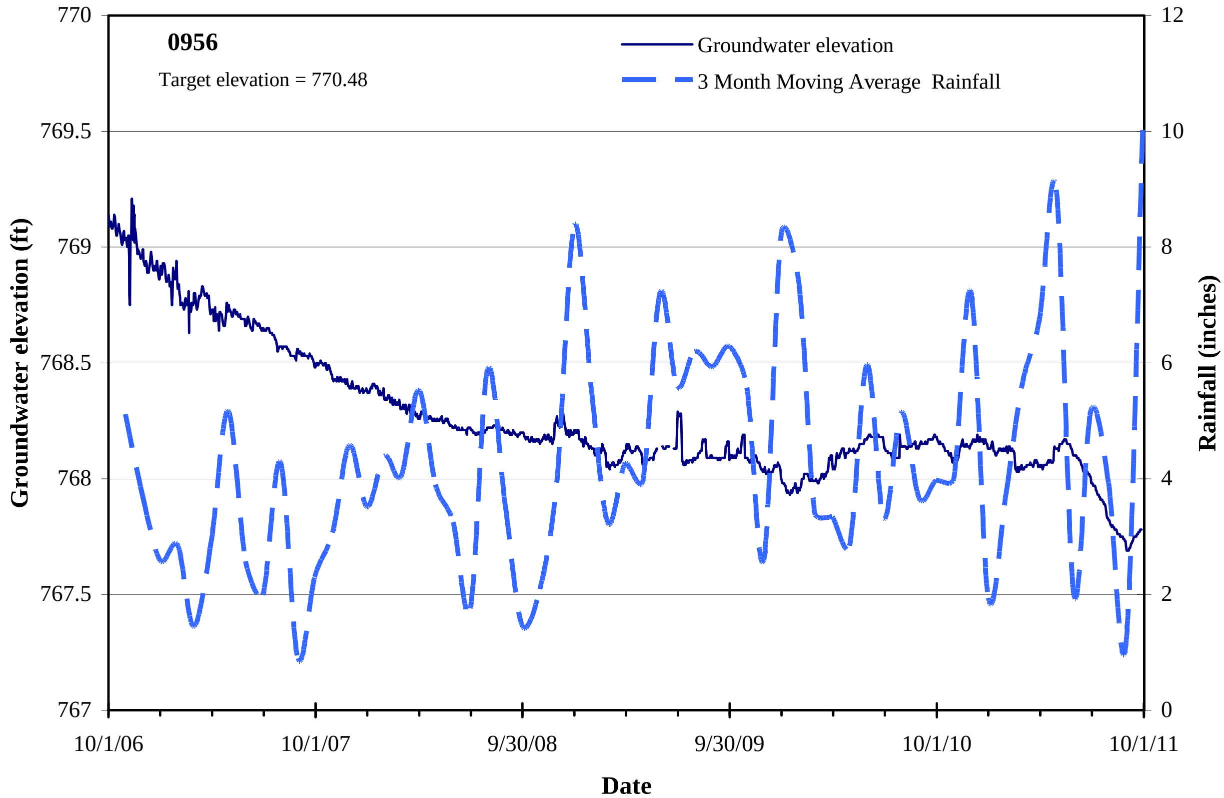


Figure B.11. Well hydrographs for wells 0949 and 4553.



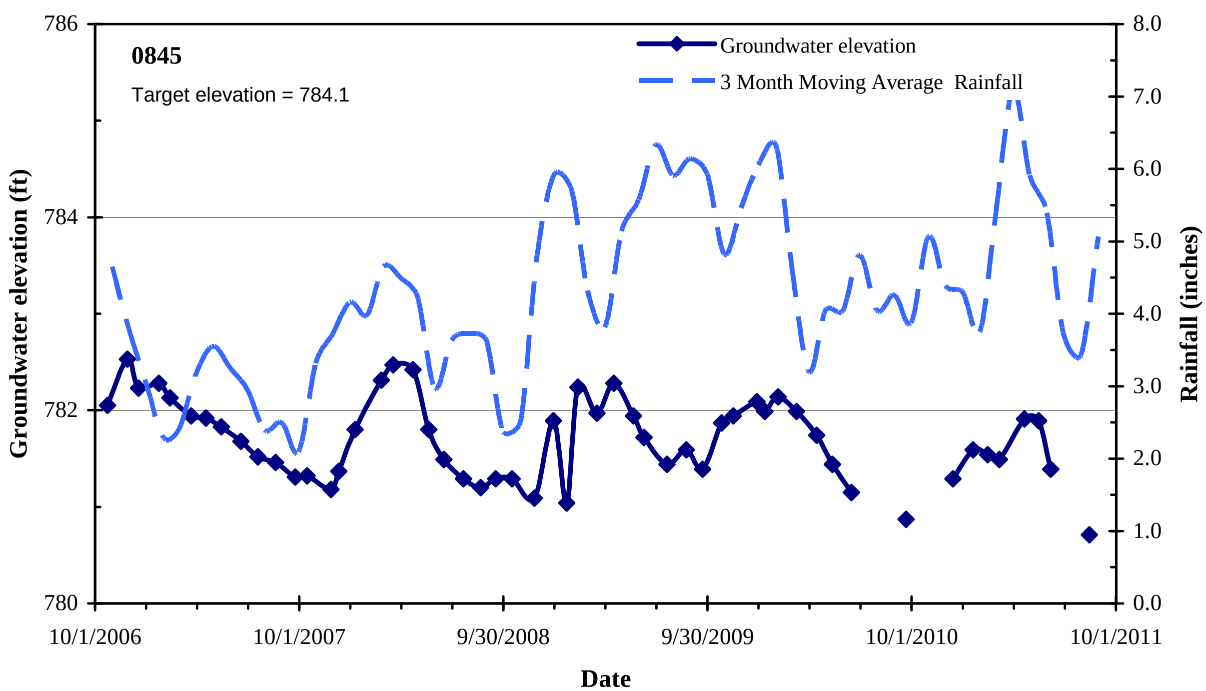
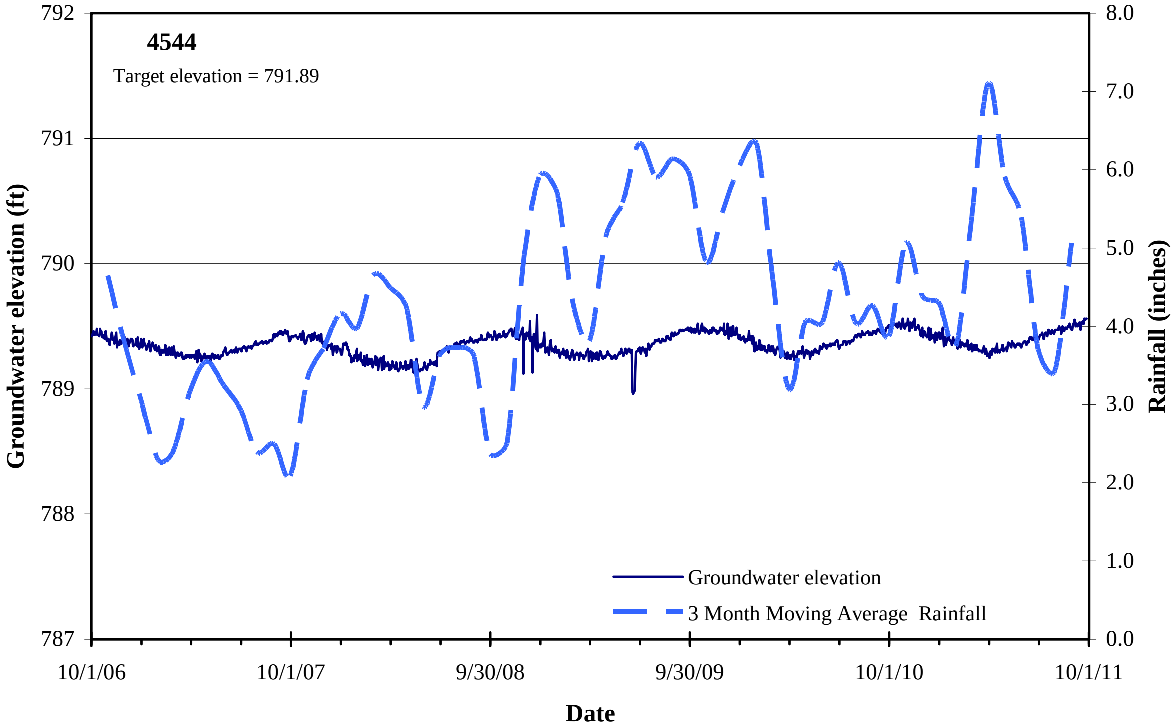


Figure B.12. Well hydrographs for well pair 0956 and well 0845



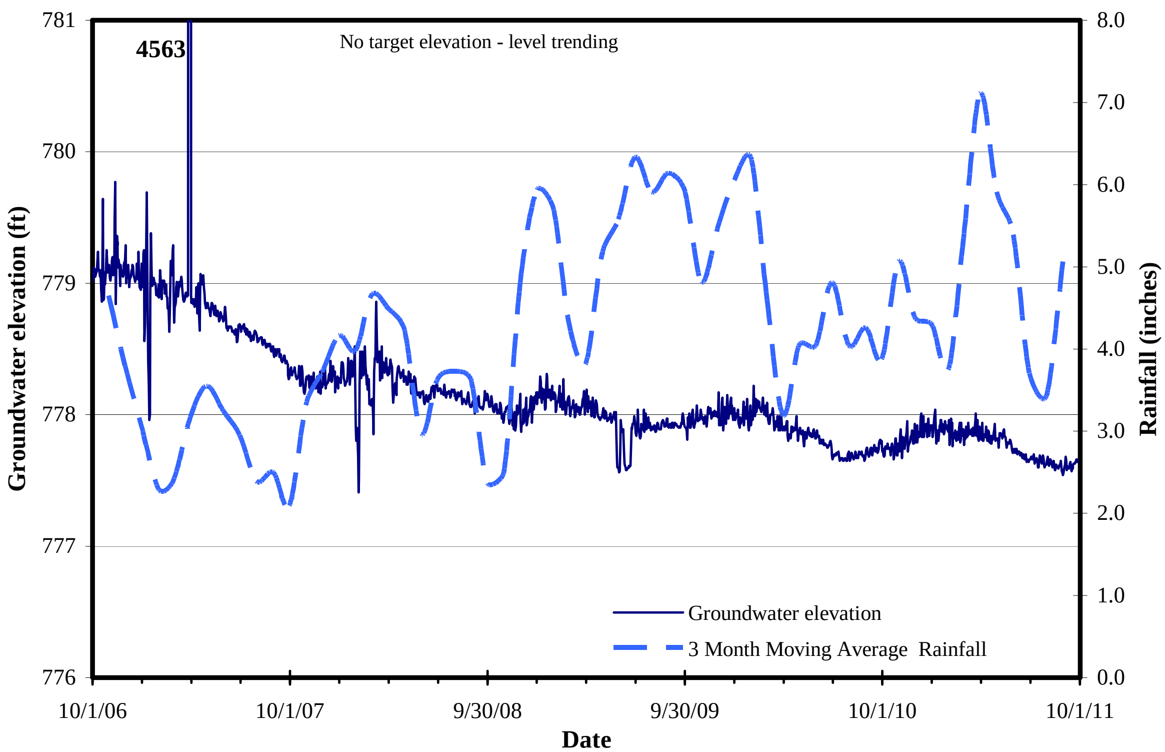
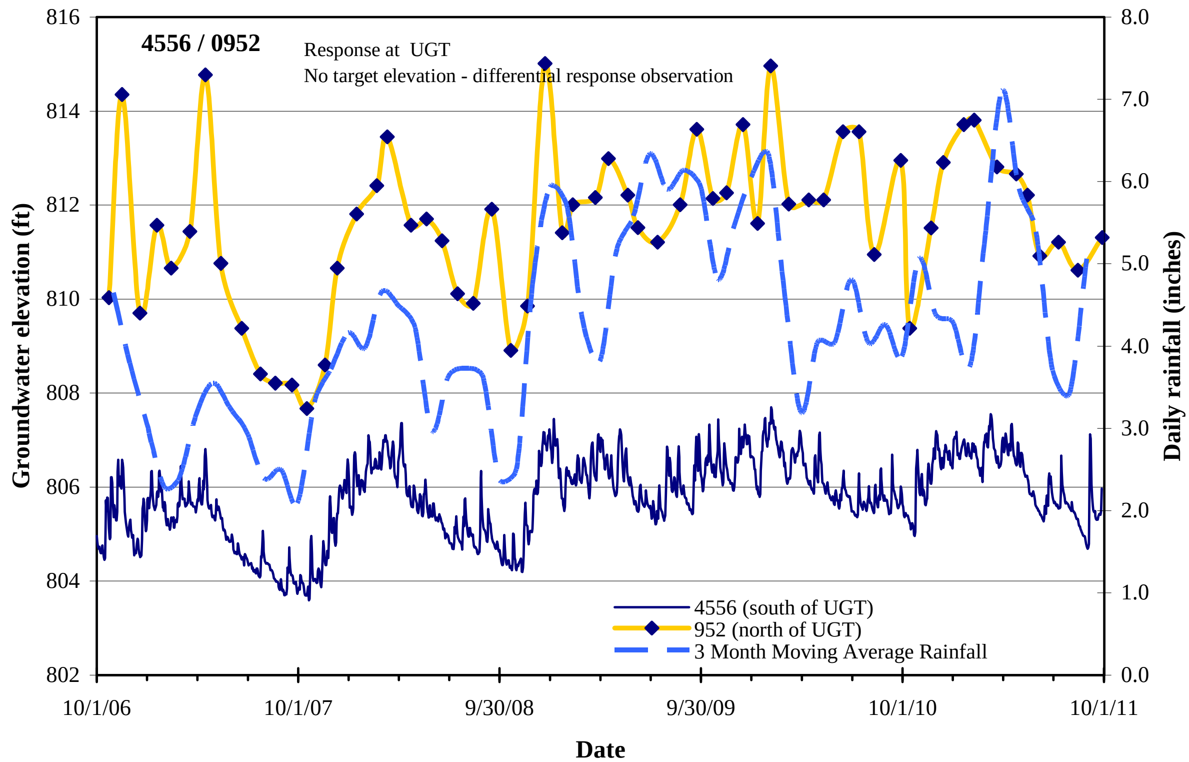


Figure B.13. Well hydrographs for wells 4544 and 4563.



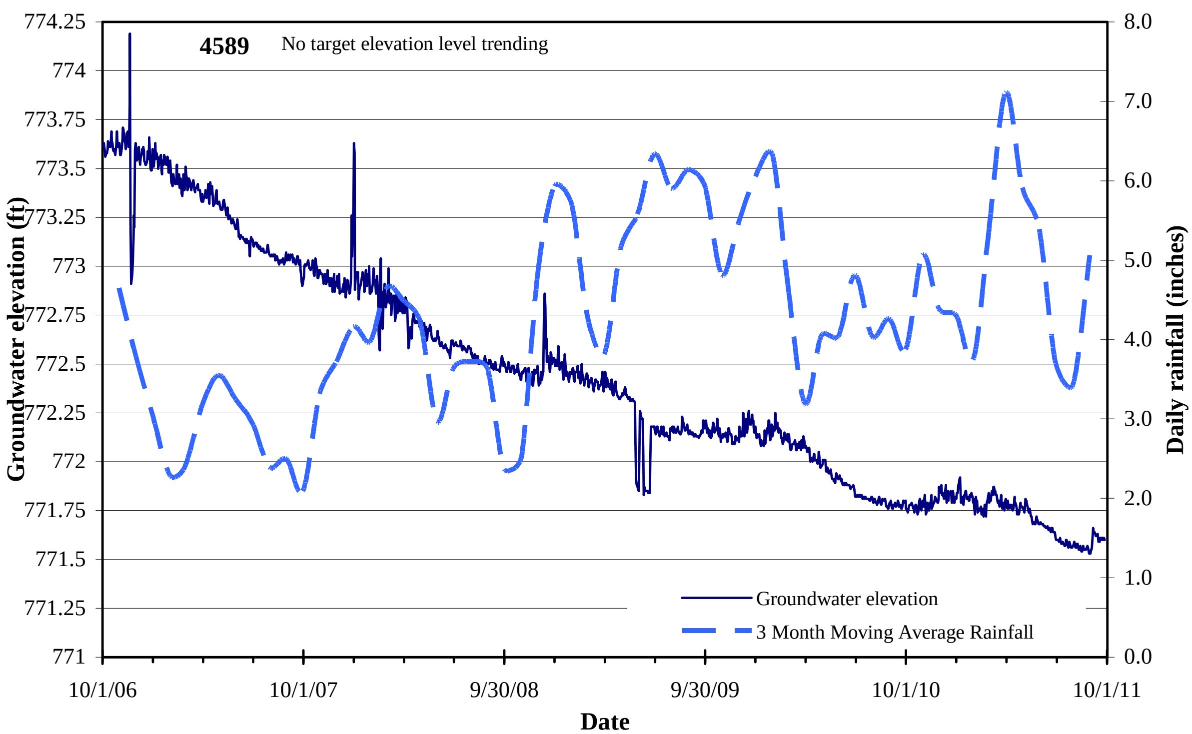
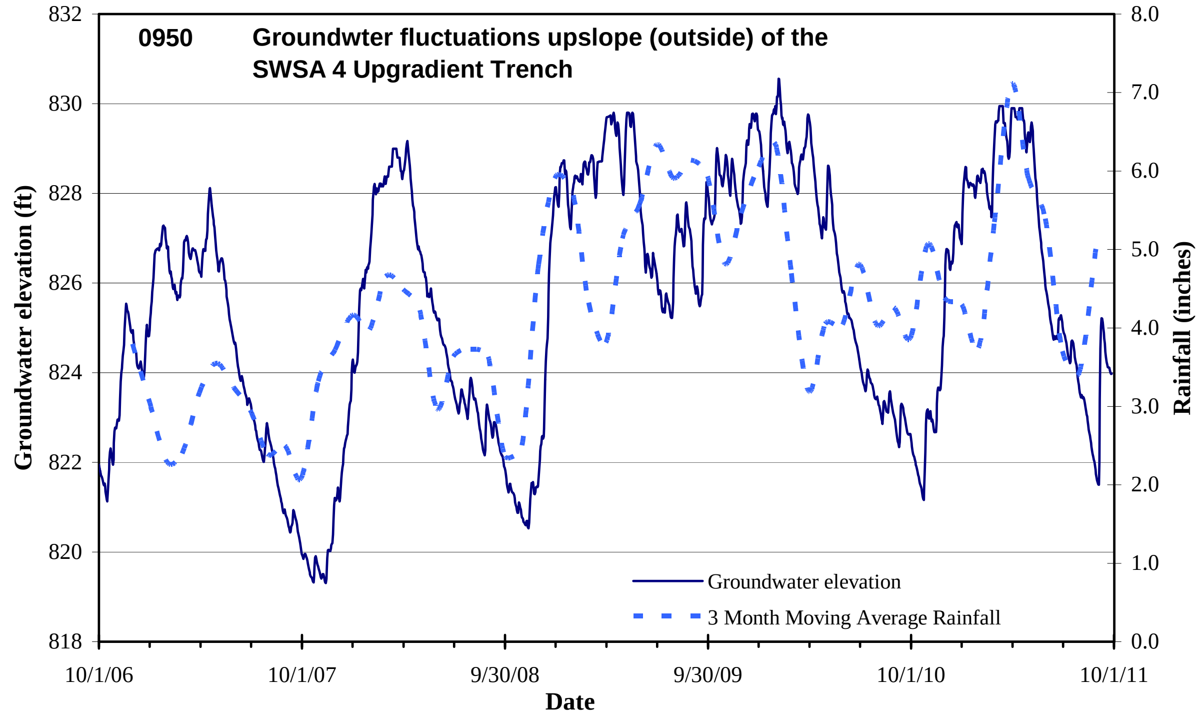


Figure B.14. Well hydrographs for wells 4556/0952 and 4589.



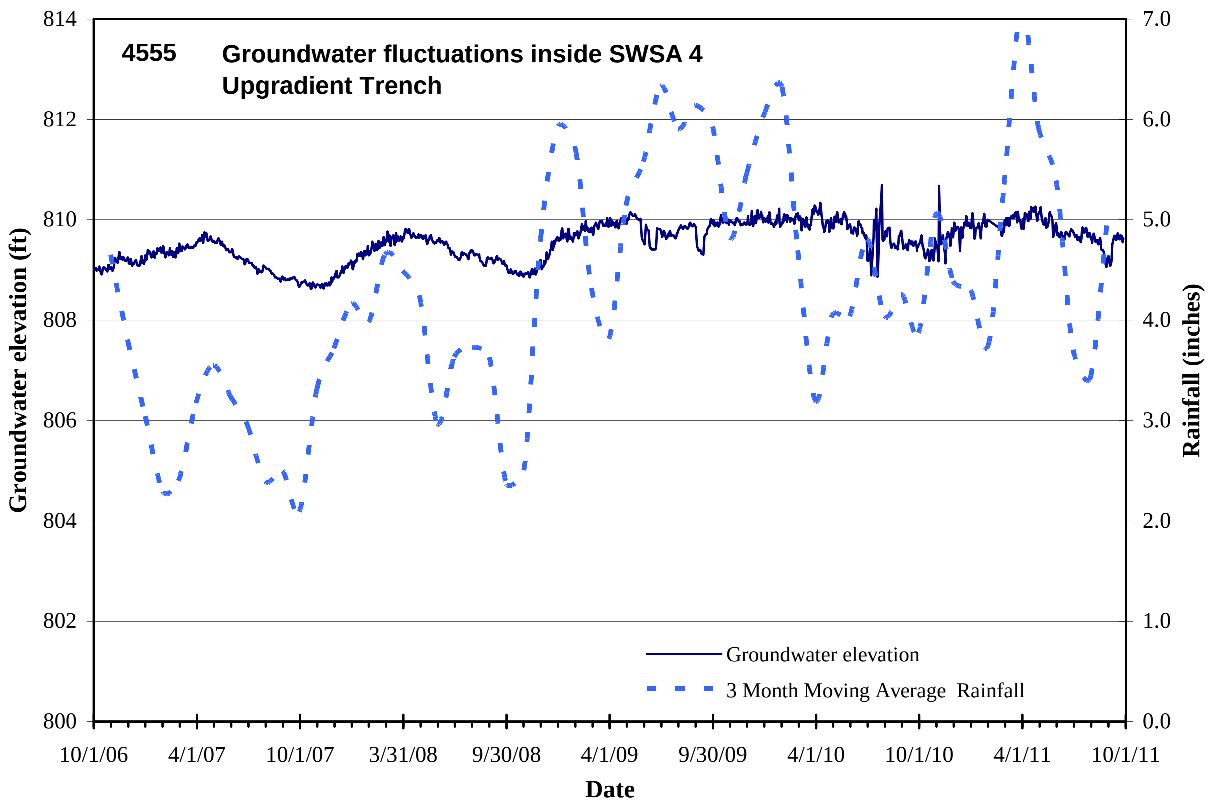


Figure B.15. Well hydrographs for wells 0950 and 4555.

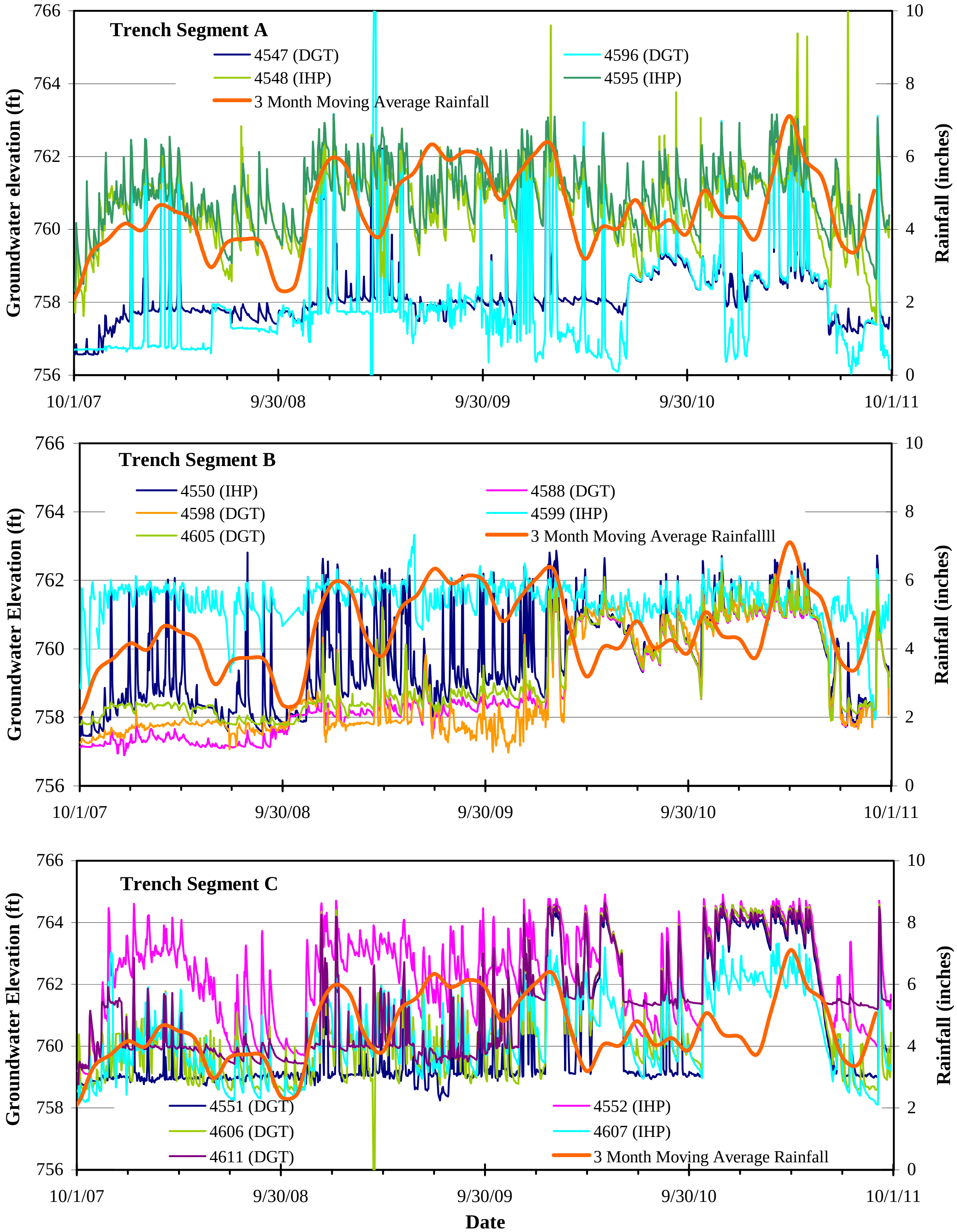


Figure B.16. Well hydrographs for wells at the SWSA 4 downgradient trench (FY 2008).

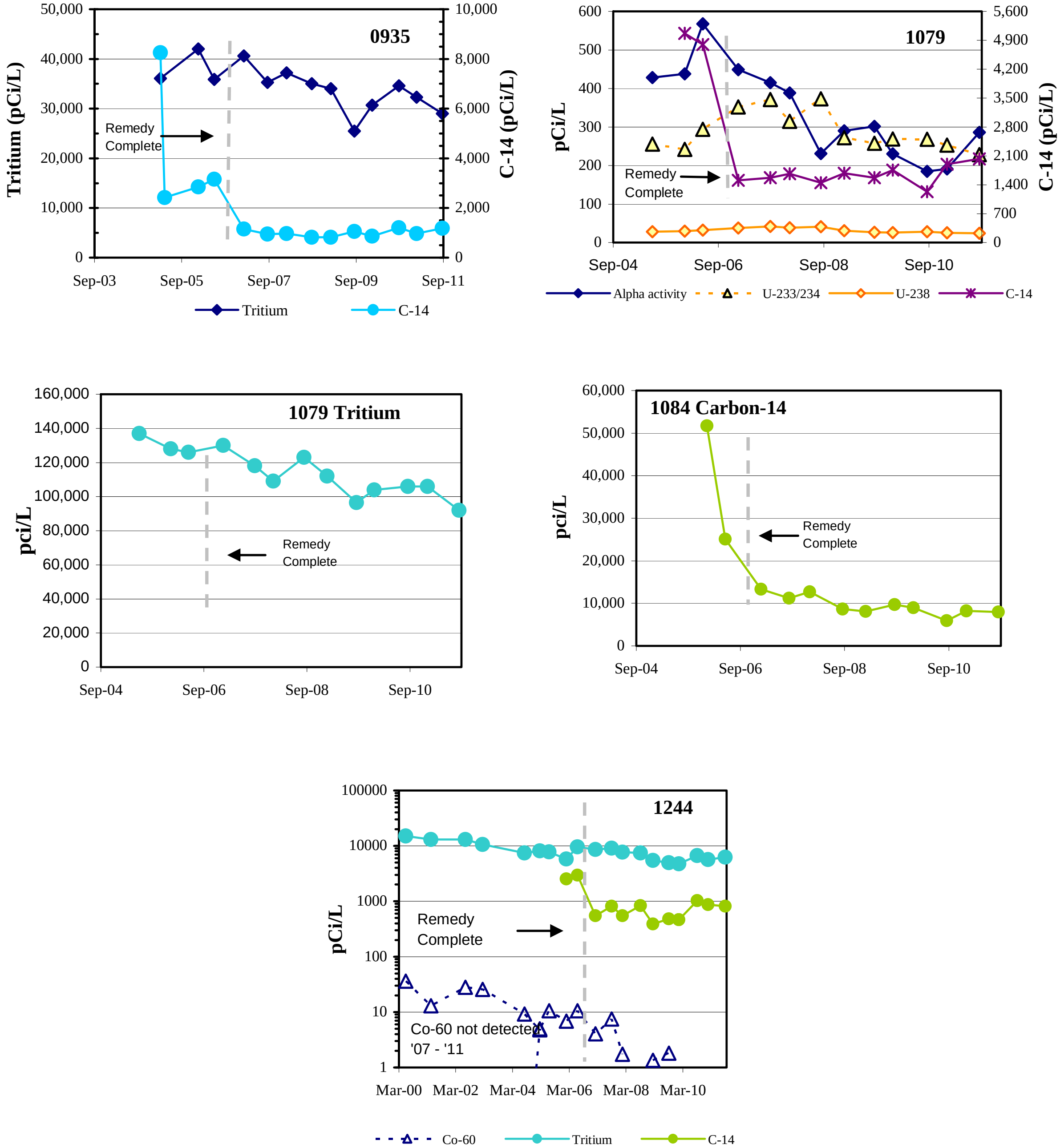


Figure B.17. Concentration trends for selected radionuclides at Pits and Trenches wells 0935, 1079, 1084, and 1244.

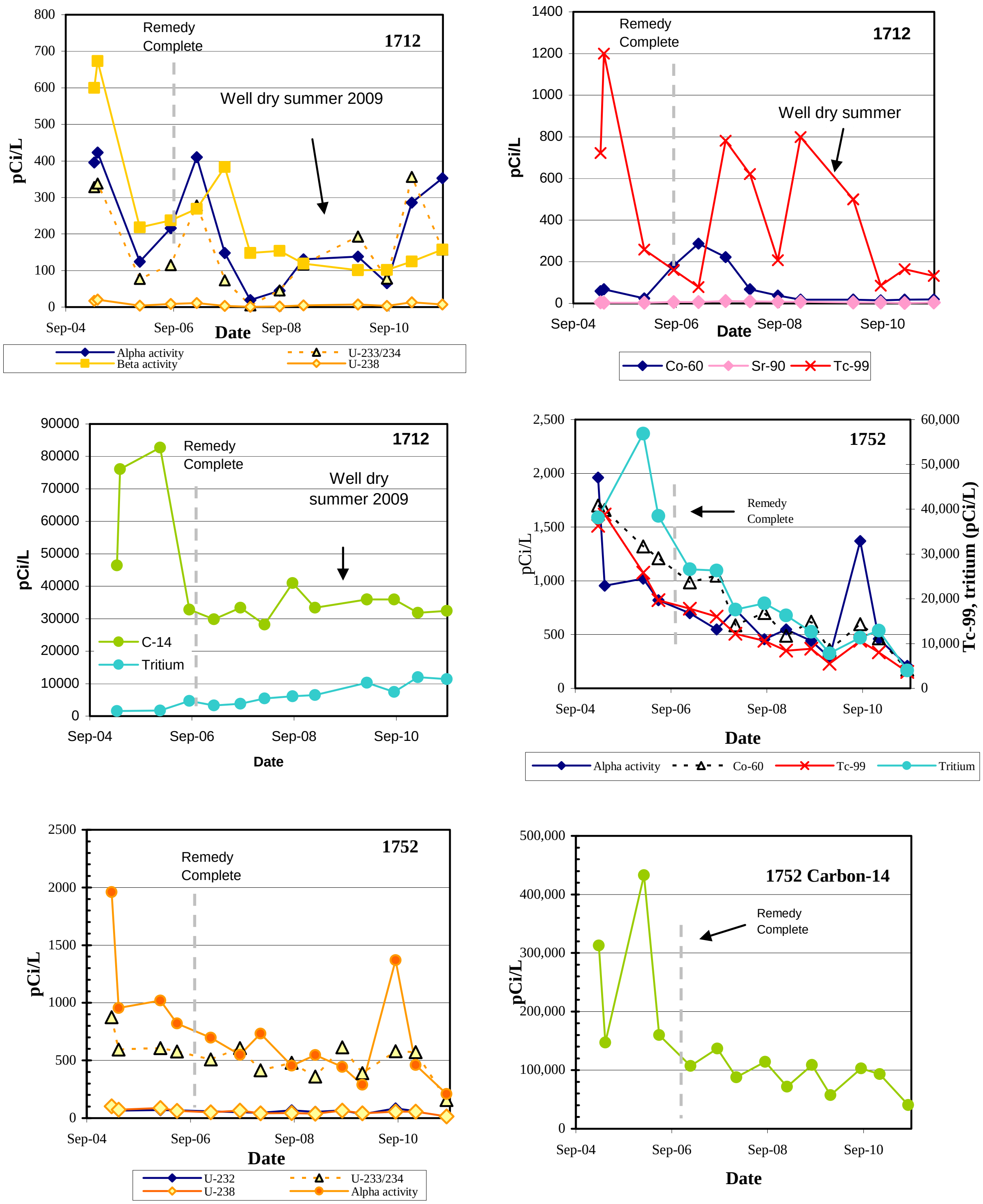


Figure B.18. Concentration histories for selected radionulicides at Pits and Trenches wells 1712, and 1752,.

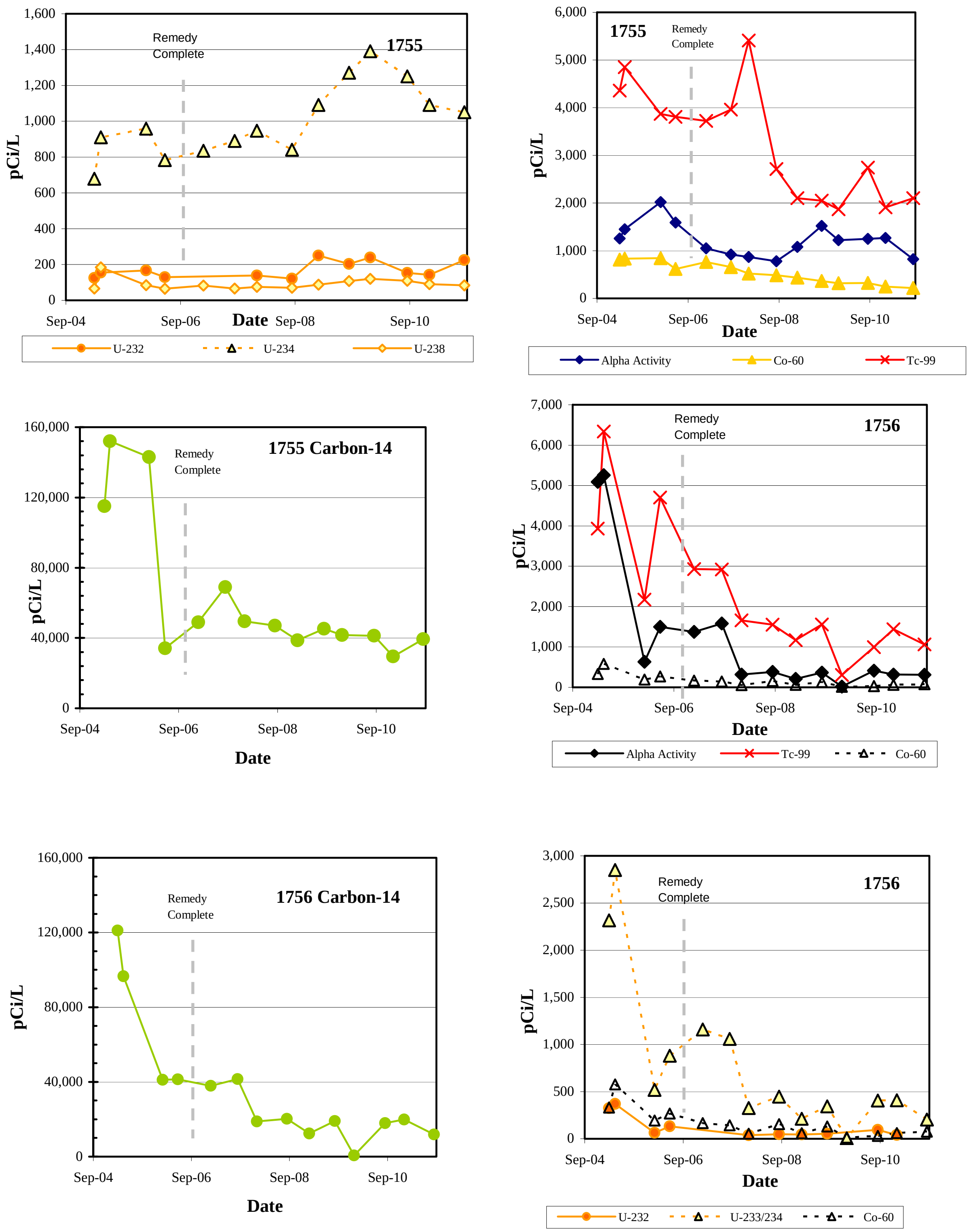


Figure B.19. Concentrations histories for selected radionuclides in Pits and Trenches wells 1755 and 1756,.

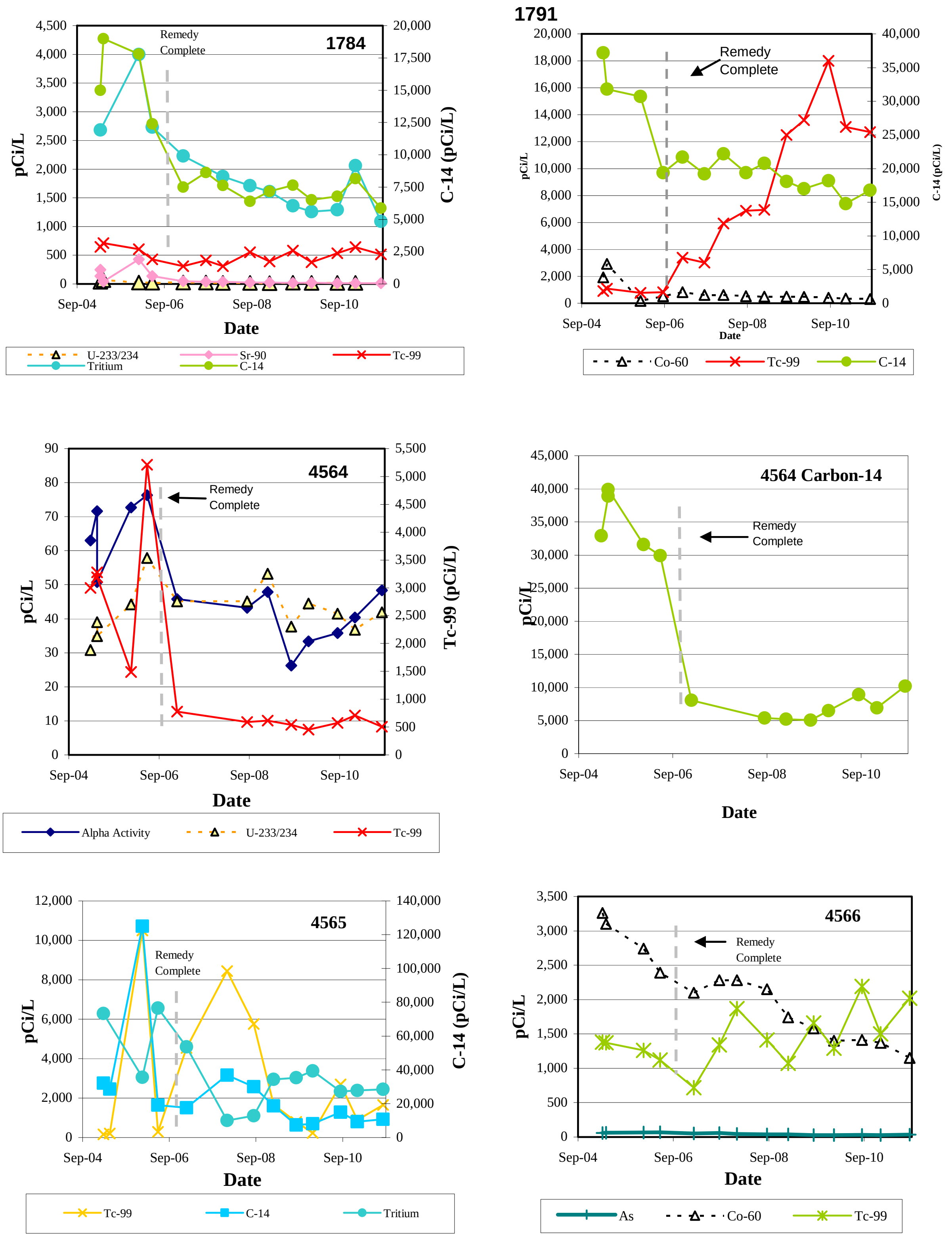
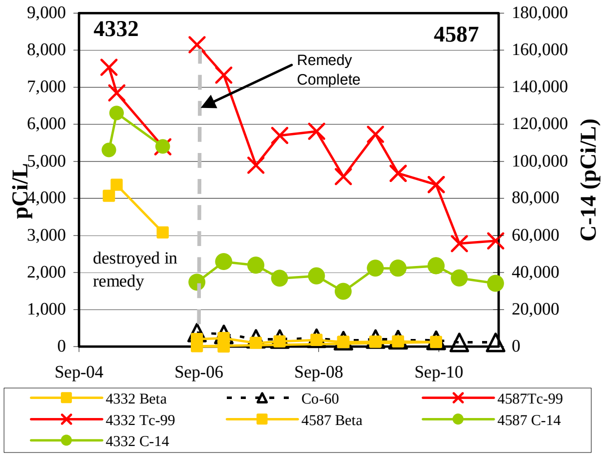


Figure B.20. Concentrations histories for selected radionuclides in Pits and Trenches wells 1784, 1791, 4564, 4565, and 4566.



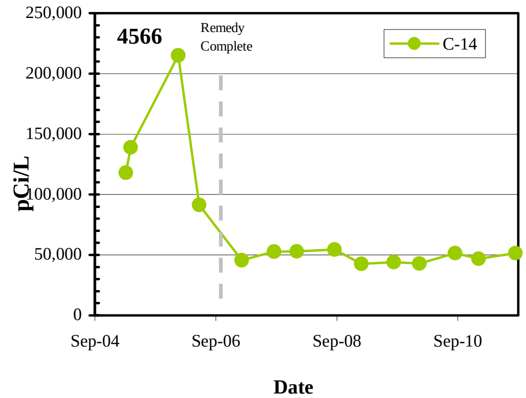


Figure B.21. Concentration histories for selected radionuclides in Pits and Trenches wells 4566, and 4587.

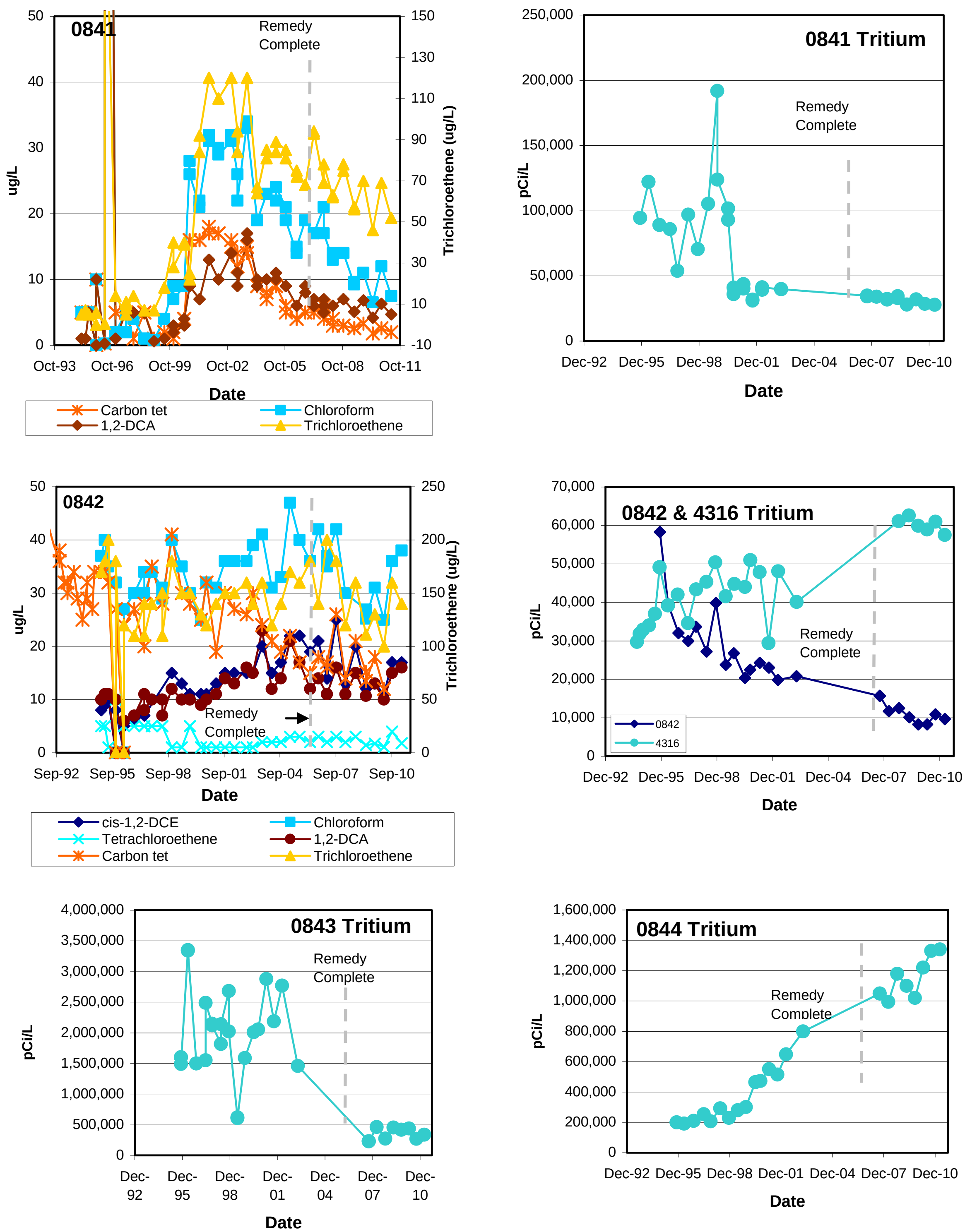
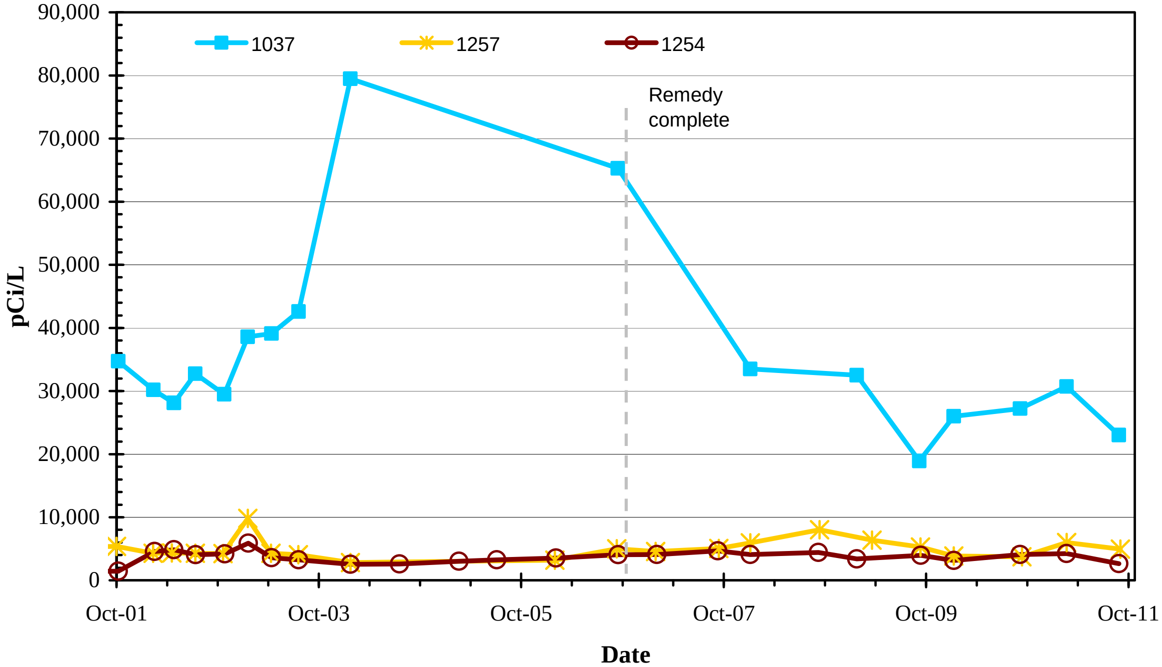


Figure B.22. Concentration trends for contaminants in SWSA 6 wells 0841, 0842, 0843, and 0844.



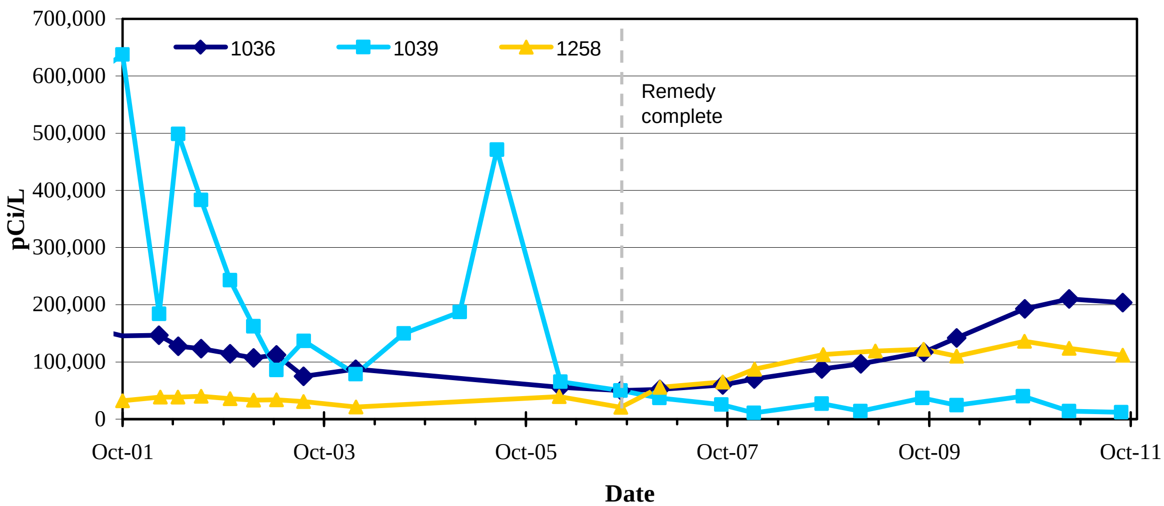


Figure B.23. Tritium trends in groundwater near the Tumulus facility.

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