II.B. Site Geology/Hydrogeology

ORR is located in the East Tennessee Valley, which is part of the Valley and Ridge Province of the Appalachian Mountains. The East Tennessee Valley is bound to the west by the Cumberland Mountains of the Appalachian Plateau Province and to the east by the Smokey Mountains of the Blue Ridge Province. The defining characteristics of the Valley and Ridge Province are the southwest trending series of ridges and valleys caused by crustal folding and faulting due to compressive tectonic forces, as well as the differential weathering of the various formations underlying the area.

The contaminated areas on the ORR were separated into large tracts of land that are typically associated with the major hydrologic watersheds (EUWG 1998). These watersheds are:

1. East Tennessee Technology Park (ETTP) Watershed
2. Bethel Valley Watershed
3. Melton Valley Watershed
4. Bear Creek Valley Watershed
5. Upper East Fork Poplar Creek (UEFPC) Watershed

For the purposes of this health assessment, the ETTP Watershed will be discussed independently. The Bethel Valley and Melton Valley Watersheds will, however, be discussed together, as will the Bear Creek Valley and UEFPC Watersheds. These groups were created based on the similar hydrogeology of watersheds as well as the similarity of the nature of ORR operations in each watershed.

The vast majority of information available concerning the geology and hydrogeology of the site indicates that groundwater occurs as shallow flow with short flow paths to surface water (ORNL 1982; MMES 1986; USGS 1986b; USGS 1988; USGS 1989; USDOE 2004; SAIC 2004). The fractures and solution cavities, which are common in this karst region, occur in shallow (0–100 ft. deep) bedrock and significantly decrease at depth (>100 ft. deep). As much as 95% of all groundwater from ORR discharges into local streams and eventually into the Clinch River (USDOE 2004).

Groundwater beneath the ORR is typically very shallow and approximately 95% ends up as surface water before leaving the site boundary (USDOE 2004).

It is unlikely that contaminated groundwater at the ORR will flow beneath, and continue to flow away from, streams and rivers that surround the site. Groundwater and surface water and groundwater contamination sources are extensively interconnected on the ORR, and are primarily in the shallow subsurface (with the exception of deep-well injection conducted at ORNL, which will be discussed in the Melton Valley Watershed section of this document). Furthermore, core samples have shown that beneath the alluvium at the bottom of the stream beds in this area is a silty-clay horizon that likely impedes downward groundwater movement (USGS 1989). The incised meander of the Clinch River in bedrock also represents a major topographic feature that prevents groundwater from passing beneath the river (ORNL 1982). ATSDR scientists conclude that on-site contaminated groundwater does not likely migrate beneath and away from streams and rivers either as slug-flow or in fractures, solution channels, or other conduits in the bedrock.

II.C. Off-Site Groundwater Data

ATSDR scientists queried the Oak Ridge Environmental Information System (OREIS) Database for all groundwater sampling data from residential wells, monitoring wells, and from seeps and springs. The query resulted in over 2150 on-site sampling locations and over 120 off-site sampling locations with hundreds of thousands of data points with dates ranging from the mid 1980s to 2004. The specific sources of data are

- ORNL Groundwater Monitoring Data (1991–2004)
- ORNL Bethel Valley Watershed RI 1997
- ORNL White Oak Creek Watershed RI 1996
- Y-12 Upper East Fork Poplar Creek RI 1997
- Y-12 Groundwater Protection Program (Ongoing)
- ORR Integrated Water Quality Program 1998
- ORR Water Resources Restoration Program (Ongoing)
- ORR Remediation Effectiveness Reports (2000–2005)
- K-25, K-1070-A Burial Ground – Brashears Creek
- Lower East Fork Poplar Creek Operable Unit
- Atomic City Auto Parts Site Characterization
- TDEC Environmental Monitoring Reports (through 2003)

In 1996, TDEC initiated a residential well sampling program. TDEC identified 71 residential wells for sampling. Most were situated southwest and within 2 miles of ORR boundaries because, given the hydrology and geomorphology of the area, these were the areas most likely affected by contaminated groundwater from ORR. In conjunction with the residential well sampling program, TDEC conducted a house-to-house survey of homeowners about their concerns with groundwater. The results of this survey revealed that there were no anecdotal problems with groundwater quality. The analytical results of the residential well sampling program indicated that there was no “discernable” impact on residential wells from activities on the ORR (TDEC 2004).

These sampling locations were first separated into on-and off-site locations. Because this health assessment focuses on off-site (outside ORR boundaries) exposure to groundwater contamination, only off-site sampling data were evaluated. Next, the sampling locations were differentiated based on whether they came from residential wells, monitoring wells, or from seeps and springs. A further distinction was made based on proximity of the sampling locations to the main facilities of ORR: near ETTP, near ORNL, or near the Y-12 Complex. Maps are included (Figure 3, Figure 4, and Figure 5) and sampling results will be discussed for each area in their respective sections.

The only data gaps that were identified during the data evaluation process were the relative irregularity of residential well sampling. These wells are not regularly and systematically sampled in the same way that monitoring wells are. In TDEC’s 2005 Environmental Monitoring Plan (TDEC 2005), “older” residential wells are typically only sampled when there is a specific

request or other justification to do so. In the mid-1990s, when the majority of available data in the OREIS database were collected, TDEC conducted a sweeping residential well sampling as part of their 1996 Residential Well Sampling Program. Newly installed residential wells are included in the current (2005) sampling plan.

II.D. East Tennessee Technology Park (ETTP) Watershed

The 1,700-acre K-25 site, which includes the former S-50 plant (37 acres), is now called the East Tennessee Technology Park (ETTP). The K-25 site is close to the ORR's western border; it is situated along Poplar Creek, near the creek's confluence with the Clinch River in Roane County, approximately 10 miles west of downtown Oak Ridge (ChemRisk 1999a; U.S. DOE 1996A).

Operational History

In October 1944, the S-50 plant started separating uranium by liquid thermal diffusion; the plant closed in September 1945. The K-25 site was used from 1945 to 1964 to enrich weapons-grade uranium through gaseous diffusion. From 1965 to 1985, the site used uranium hexafluoride in the gaseous diffusion process to manufacture commercial-grade uranium. All gaseous diffusion operations ceased at the site in 1985, and the site was closed in 1987. Since 1996, reindustrialization has been the focus of the K-25 site, which now houses two business centers—the Heritage Center and the Horizon Center. The site also maintains the Toxic Substances and Control Act (TSCA) incinerator — it is the only facility in the country authorized to incinerate wastes with radioactive and hazardous contaminants that contain PCBs.

Geology/Hydrogeology

The ETTP was constructed almost entirely on the limestone bedrock of the Chickamauga Group (see Figure B-1). The Chickamauga Group is between 450 and 600 meters thick in the Oak Ridge area. Although the formation is predominantly limestone in composition, it resists dissolution and large cavities are rare. Consequently, water storage remains near the surface in the unconsolidated zone because of the low hydraulic conductivity of the bedrock. Cracks and fissures do occur in the Chickamauga Group and, therefore, prevent any prediction of groundwater flow direction and rate in the bedrock (MMES 1986; USGS 1986b; USGS 1988; USGS 1989; SAIC 2004). Because, however, these cracks and fissures decrease with depth, deep groundwater flow is very limited. The Chickamauga Group is considered a flow-limiting aquitard (ORNL 1982; MMES 1986; USGS 1997). The lithology of the Rome Formation, which underlies the southeastern portion of the ETTP, consists of shales and siltstones which have typically low hydraulic conductivities; but the complex fractures and fissures in this formation makes nearly impossible an accurate prediction of groundwater flow path.

Because the local water table occurs just below the surface in the unconsolidated zone, groundwater flow is generally consistent with the surface topography. But the rate and direction of groundwater flow in the ORR vary, and are often affected by fluctuations in precipitation as well as flood control operations both up and down stream. Groundwater recharge comes from diffuse rainwater infiltration through the permeable, well-drained silty soils typical of the area. During high precipitation events, however, the clay content in the soil can prevent rapid infiltration and could result in significant surface run off. Groundwater discharge occurs through

evapotranspiration during the spring and summer months, but is predominantly discharged into surface water via seeps and springs. Most groundwater at ORR ultimately ends up in the Clinch River serving as base flow for small streams and tributaries, including Mitchell Branch and Poplar Creek near the ETTP area (MMES 1986, SAIC 2004).

Contamination at ETTP

Dye tracing has been used to identify exit points for groundwater discharge to surface waters around the ETTP. Monitoring wells have been installed at each of these exit points to evaluate contaminant concentrations in these areas and to monitor the migration of known contaminant plumes. As of FY 2003 sampling, volatile organic compound (VOC) concentrations have shown a general decreasing trend at exit point monitoring wells. Results from monitoring of the bedrock well (BRW-083) and the unconsolidated zone well (UNW-107) near the confluence of Mitchell Branch and Poplar Creek have shown no detectable levels of VOCs. These wells are considered a significant exit point for several commingling groundwater plumes emanating from the eastern portions of ETTP, including the K-1070-C/D burial grounds and the K-1401 area.

Testing at exit point monitoring wells BRW-035 and BRW-068, between the K-901 holding pond and the Clinch River, has occasionally shown low concentrations of TCE and 1,2-DCE, chloroform, gross alpha and gross beta activity; all below the respective MCLs. VOC contaminated groundwater does, however, discharge to surface water from several seeps and springs north of the K-901 holding pond, including Spring 21-002.

Another significant contaminant source area for the ETTP is the K-27 building. VOC concentrations in the groundwater in this area range from 20 µg/L (UNW-096) to 130 µg/L (UNW-038). Both of these unconsolidated zone monitoring wells are southwest of K-27 along Poplar Creek. Monitoring wells (BRW-016) north of K-27 along Poplar Creek typically reveal TCE degradation products such as *cis*-1,2-DCE and vinyl chloride. FY 2003 sampling from BRW-016 revealed vinyl chloride concentrations slightly above the MCL of 2 µg/L.

As is the case north of K-27, the distal portions of the commingled VOC plumes near the Mitchell Branch are largely composed of TCE degradation products *cis*-1,2-DCE and vinyl chloride. In both cases, this can indicate that the source of contamination is significantly upgradient, or that the source of contamination has been eliminated. It could also be a result of increased biodegradation in those particular areas. A review of FY 2003 monitoring data collected from known and suspected exit point locations shows that contaminant (largely VOC) concentrations have either remained constant or have decreased from previous years. These steady or decreasing groundwater concentrations have also resulted in decreased impact on ETTP perimeter surface waters. VOC concentrations from the Mitchell Brach weir (K-1700) have decreased from 1997 — 1998 (SAIC 2004).

Off-Site Groundwater Monitoring Data

Seeps and Springs

Comparison values are doses or substance concentrations set well below levels that are known or anticipated to result in adverse heath effects (ATSDR 2005) — see Appendix A.

Lead and manganese were the only substances detected above comparison values (CVs) in seeps and springs near ETTP. Lead was only detected in five samples out of 28. Three out of

those were above the 15-ppb MCL for lead. Of the 12 detected samples of manganese, only one sample was above the 500-ppb CV for manganese. For both substances, all samples that were detected above the respective CVs were taken from the CCC Well #2 (See Figure 3). Also for both substances, samples taken from an adjacent location (CCC Well #1) on the same day(s) were below detection limits.

Table 1: Contaminants Detected Above Comparison Values in Seeps or Springs Near ETTP

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date*
Lead	5 / 28	3	15	95.4	CCC Well #2	3/5/1996
Manganese	12 / 15	1	500	995	CCC Well #2	9/8/1995

Monitoring Wells

No contaminants were detected above CVs in monitoring wells outside of the ORR boundaries near the ETTP.

Residential Wells

The only contaminant detected above CV in residential wells near ETTP is boron. Boron has been detected in four samples collected on September 22, 1998 from four different wells. Only one of these samples was detected above the 100-ppb CV. This sample was taken from RW-A-15 and yielded a boron concentration of 154 ppb. No subsequent sampling has been conducted at these wells.

ATSDR Conclusion for the ETTP Watershed

Lead, manganese and boron are naturally occurring elements. Lead and manganese were both detected above CVs in seeps outside the ORR. Because neither lead nor manganese could be detected in samples collected concurrently at adjacent sampling locations, it is unlikely that these substances are associated with groundwater contamination. Likewise, boron was only detected above its CV in one sample. Concurrent sampling at adjacent wells revealed concentrations well below the CV. As part of the Water Resources Restoration Program for ETTP, exit pathway monitoring wells are continually monitored. Groundwater contamination at ETTP does not migrate off-site; rather, it is discharged into surface water. The ETTP Environmental Monitoring Plan includes surface water surveillance (ORNL 2004). ATSDR scientists have concluded that the public (community) is not being exposed to groundwater contamination from ETTP.

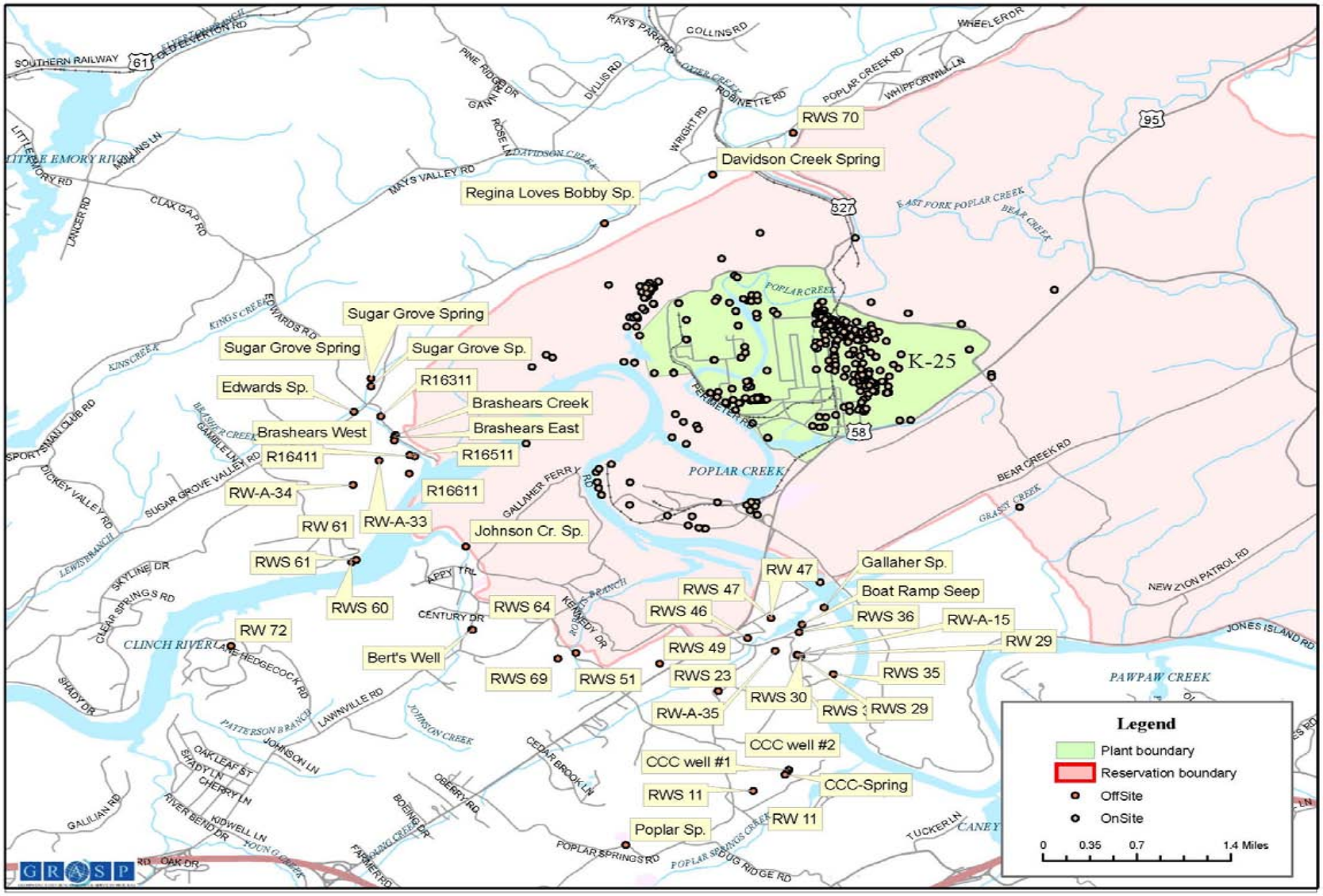

Figure 3: Off-Site Groundwater Sampling Locations Near ETTP

II.E. Bethel Valley Watershed and Melton Valley Watersheds

The X-10 site, now known at the Oak Ridge National Laboratory (ORNL) is about 10 miles southwest of the city center of Oak Ridge in Roane County and encompasses approximately 26,580 acres. It is surrounded by heavily forested ridges that include Chestnut Ridge, Haw Ridge, and Copper Ridge (ChemRisk 1999a; TDOH 2000). The X-10 Site is situated within two watersheds: Bethel Valley and Melton Valley (ORNL et al. 1999). The main laboratory at X-10 is located along Bethel Valley Road, within Bethel Valley (ChemRisk 1999a; ORNL et al. 1999). The X-10 site also contains remote facilities and waste storage areas in Melton Valley (ORNL et al. 1999). White Oak Creek begins in Bethel Valley and flows south along the eastern border of the plant and travels through a gap in Haw Ridge before entering Melton Valley. From Melton Valley, White Oak Creek joins the Clinch River below Melton Hill Dam (ChemRisk 1999a). See Figure 1 for the location of White Oak Creek and the relationship between X-10, White Oak Dam, the Clinch River, and the Watts Bar Reservoir.

Operational History

Beginning in the early 1940s, radioactive material was used on the ORR for various processes such as uranium enrichment, plutonium production, plutonium separation, and the development of separation processes for additional radionuclides (ChemRisk 1993b; Jacobs Engineering Group Inc. 1996). The X-10 site was built in 1943 as a “pilot plant” to demonstrate plutonium production and chemical separation. The government had intended to operate the facility for only 1 year. This initial time period was, however, extended indefinitely as operations were continued and expanded at X-10 (ChemRisk 1999a; TDOH 2000). After World War II the facility’s focus was broadened to include non-weapons related activities, such as the physical and chemical separation of nuclear products, the creation and assessment of nuclear reactors, and the production of a range of radionuclides for global use in the medicinal, industrial, and research disciplines (ChemRisk 1993b). In the 1950s and 1960s, the X-10 site became a worldwide research center to study nuclear energy and to investigate the physical and life sciences related to nuclear energy. From 1958 to 1987, the Oak Ridge Research Reactor operated to support various scientific experiments at X-10. For many years this reactor was the main radionuclide supplier to what was known as the Free World for medical, research, and industrial purposes (ChemRisk 1993b).

Geology/Hydrogeology

The entire X-10 site was built on the Chickamauga Group (see Figure B-1). This aquifer formation is a flow-limiting strata that has a relatively low hydraulic conductivity. This formation is subject to upper-level fracturing, but these cracks and fissures are typically only a few centimeters wide and serve as groundwater storage as opposed to facilitating the spatial movement of groundwater (MMES 1986). Haw Ridge separates Bethel Valley from Melton Valley. This ridge was formed partially from thrust faulting by compressive tectonic forces millions of years ago. It is also a result of differential weathering. Underlying Haw Ridge is the Rome Formation. This siliciclastic formation is composed primarily of siltstone, sandstone and shale (USGS 2004). The Rome formation is more resistant to weathering than the Chickamauga Group, which underlies the Bethel Valley to the north, and the Conasauga Group, which underlies Melton Valley to the south.

Groundwater in the ORR area generally occurs in the unconsolidated zone. Depth to the water table, depending on seasonal variability, in the Bethel Valley ranges from 1 to 35 feet and from 1 to 67 feet in Melton Valley. Groundwater flow paths most often mirror the surface topography, with diffuse discharge to surface waters or as discharge via springs and seeps. In the Bethel Valley a hydrologic divide separates surface water flow in the western third of the watershed. West of the divide, surface water and groundwater flow west to Raccoon Creek and eventually into the Clinch River. East of the divide, waters flow east to White Oak Creek. Groundwater flow generally follows these topographic trends, and flow paths to surface water are relatively short (ORNL 2004).

White Oak Creek flows through a gap in Haw Ridge from Bethel Valley to Melton Valley. Soils in the Melton Valley area, overlying the Conasauga Shale, have a low primary porosity and, therefore, have a low storage capacity. Because of the shallow active zone and the interaction with surface water, the common concept of contaminated groundwater plume migration is not appropriate in this area. The water that infiltrates into the upper weathered zone eventually discharges into streams via the “bathtub effect” — where water collects in a low area, or trench, causing an overflow at the downgradient end (MMES 1986). This overflow occurs as springs or seeps, from which water flows downhill to creeks and streams.

Contamination in Bethel Valley and Melton Valley

The major operations at X-10 take place within the Bethel Valley Watershed. The main plant, key research facilities, primary administrative offices, as well as various forms of waste sites, are situated in Bethel Valley. Over the past 60 years, X-10 releases have contaminated the Bethel Valley Watershed. Mobile contaminants primarily leave the Bethel Valley Watershed via White Oak Creek. These contaminants travel from the Bethel Valley Watershed to the Melton Valley Watershed, where further contaminants enter White Oak Creek. Then, the contaminants that have been discharged to White Oak Creek are released over White Oak Dam and into the Clinch River (U.S. DOE 2001d).

Bethel Valley Contamination

For the purpose of environmental investigation and remediation, the Bethel Valley area was subdivided into four regions. The regions are; Raccoon Creek, West Bethel Valley, Central Bethel Valley, and East Bethel Valley. The Raccoon Creek area lies on the western most portion of the valley west of Highway 95. West Bethel Valley lies east of Highway 95 and west of the ORNL main plant area. While the Raccoon Creek area does not have any known contaminant source areas, West Bethel Valley contains a burial ground (SWSA 3) and adjacent landfills, which have resulted in soil and groundwater contamination in West Bethel Valley as well as Raccoon Creek. Radiological wastes were stored in SWSA 3 from 1946 to 1951 from DOE facilities all over the country. The SWSA 3 and the adjacent landfills cover approximately 18 acres in Bethel Valley. Over the years, seasonal surface water infiltration and heavy rain events have resulted in contaminant leaching from SWSA 3 and the adjacent landfills. Subsurface contaminant movement was short, flowing to Raccoon Creek to the southwest, and northeast to the Northwest Tributary (SAIC 2004).

While the Raccoon Creek and the West Bethel Valley areas have relatively small defined contaminant release areas, the Central and East Bethel Valley areas have extensive soil and groundwater contamination. The Central Bethel Valley contains the main ORNL plant site and has over 150 sites that have been identified for environmental restoration (SAIC 2004). The leading areas of concern in terms of groundwater contamination in the Central Bethel Valley are the Corehole 8 plume and in some building sumps which have tested positive for mercury contamination. That said, however, the only groundwater plume that is regularly monitored on a watershed scale is the Corehole 8 plume (SAIC 2004).

The Corehole 8 Plume, which was identified at X-10 in 1991, is a plume of groundwater that is contaminated with Sr 90 (SAIC 2002b, US EPA 2002a). In 1994, a removal site evaluation revealed that contaminated groundwater was leaching into X-10's storm drain system and was being released into First Creek. First Creek is a stream that feeds into White Oak Creek and ultimately flows into the Clinch River. Further evaluation indicated that the contaminated groundwater was seeping into the storm drain system via three catch basins on the western portion of X-10 (SAIC 2002b). In November 1994, an action memorandum was approved, and by March 1995 a groundwater collection and transmission system was being used at the Corehole 8 Plume to prevent groundwater infiltration (SAIC 2002b; US EPA 2002a). Through this system, groundwater is treated by X-10's Process Waste Treatment Plant (PWTP) and then released through a National Pollutant Discharge Elimination System (NPDES) outfall.

In August 1995, DOE prepared a removal action report that required monthly monitoring of the storm drain outfall close to the joining of First Creek and the Northwest Tributary. In addition, acting on suggestions from the 1997 remediation effectiveness report (RER), monthly composite samples are taken at this area, as well as at the Corehole 8 sump (SAIC 2002b). Surface water monitoring in October 1997 revealed elevated levels of Sr 90 and uranium 233 (U 233) in First Creek. In December 1997, further investigation indicated that this contamination was entering the area through two unlined storm drain manholes. As a result, in March 1998 DOE established another interceptor trench that linked to one of the plume's collection sumps. An addendum to the original action memorandum was approved in September 1999. This addendum, which was intended to increase the effectiveness of the initial remedial action, endorsed more groundwater extraction and treatment activities at the Corehole 8 Plume (SAIC 2002b; SAIC 2004). The source of the Corehole 8 plume is the W-1A tank in the North Tank Farm. This tank was commissioned in 1951 to receive LLLW from Buildings 3019, 3019B, and 2026, but use of the tank was discontinued in 1986 because of leaks in the transfer lines. Grab samples of soil around the W-1A tank revealed extremely high levels of transuranic waste (TRU). The tank is still in place because removal of the tanks would result in a high dose rate to the workers (SAIC 2004).

Melton Valley Contamination

In the late 1950s, scientists at ORNL began experimenting with injecting low-level radioactive waste mixed with a Portland cement into induced fractures of the underlying bedrock. The geologic formation involved was a low-permeability formation of the Conasauga Group called the Pumpkin Valley Shale. Two experimental sites were developed for testing of this disposal method. The first was Hydrofracture-1 (HF-1) and the other was HF-2. At each site 24 observation and monitoring wells were installed. Various experiments revealed that the Pumpkin Valley Formation could effectively and safely contain the contaminated grout. Continued

experimental and, later, successful operational waste disposal was performed at two other injection sites (Old Hydrofracture Facility and New Hydrofracture Facitily: OHF and NHF) — at least until operations were halted in 1982. The Underground Injection Control regulations promulgated by the USEPA effectively eliminated hydrofracture waste injections at ORNL (SAIC 1997; ORNL 2000). In 2000, Bechtel Jacobs Company LLC (BJC) contracted Tetra Tech NUS, Inc and their subcontractor Texas World Operations, Inc. to perform the plugging and abandonment (P&A) of 111 wells in Melton Valley (Whiteside et al. 2002). As of FY 2002, demolition and deconstruction (D&D) activities at OHF had been completed and 110 of 111 hydrofracture wells are now plugged and abandoned (P&A), exceeding ALARA principles on the project (SAIC 2004; Whiteside et al. 2002). Contaminated grout is expected to remain in the induced hydrofractures in the Pumpkin Valley Shale or within boreholes or wells penetrated by grout. There is no known contribution to surface water contamination from hydrofracture waste (SAIC 1997).

Melton Valley served as the U. S. Atomic Energy Commission's (AEC's) Southern Regional Burial Ground for wastes for ORNL and over 50 other facilities. X-10 disposed of its radioactive wastes (liquid and solid) in Melton Valley, and also operated its experimental facilities within this watershed (U.S. DOE 2002a, 2002b). The major burial grounds are SWSA's 4, 5, and 6. Wastes were buried predominantly in unlined trenches and auger holes. Consequently, discharges from Melton Valley's waste areas have produced secondary contamination sources that include sediment, groundwater, and soil contamination. Furthermore, contaminants discharged from Melton Valley travel off the reservation through surface water and flow into the Clinch River (SAIC 2002b; USGS 1988). As a result, the greatest impact to off-site receptors is from strontium 90 (^{90}Sr), tritium (^{3}H), and cesium 137 (^{137}Cs) contaminated surface water flowing across the White Oak Dam (WOD). The three primary release areas in Melton Valley are the SWSA 4 seep areas, and SWSA 5 Seeps C and D (SAIC 2004).

The SWSA 4 seeps area is located at the X-10 site (U.S. DOE 2001e). Data collected at the ORR suggest that releases from SWSA 4 have contributed to approximately 25% of the overall ^{90}Sr discharged over White Oak Dam (SAIC 2002b). SWSA 4 consists of 23 acres used between 1951 and 1974 for industrial and radioactive waste burial (SAIC 2002b). DOE's investigation revealed that two seeps produced about 70% of the overall ^{90}Sr discharged from SWSA 4 (SAIC 2002; U.S. DOE 2001e). Because contaminants from these waste trenches migrated into White Oak Creek, grouting techniques were used to reduce the releases of ^{90}Sr from these trenches; these activities were completed in October 1996. Surface water monitoring revealed that, as of 2001, these efforts had resulted in the ^{90}Sr releases being reduced by about 33% (SAIC 2002b).

In 1994, DOE conducted an assessment and remedial activities at SWSA 5 Seeps C and D. The assessment found that ^{90}Sr was discharged from the X-10 site, and that Seeps C and D were major sources of off-site releases. Seeps C and D are located in the southern portion of WAG 5, which consists of a burial site used for radioactive waste disposal between 1951 and 1959 (SAIC 2002b; U.S. DOE 2001f). Since ^{90}Sr could potentially constitute a significant threat to off-site populations, one of DOE's main goals was to minimize these discharges from SWSA 5 into the White Oak Creek system (SAIC 2002b; U.S. DOE 2001f; U.S. EPA 2002a). The objective of these remedial activities was to reduce the quantity of ^{90}Sr in collected groundwater by at least 90% (SAIC 2002b; U.S. DOE 2001f).

DOE's 1994 investigation showed that Seep C was a major source of ^{90}Sr releases to White Oak Creek (SAIC 2002b). Of the strontium detected at White Oak Dam between 1993 and 1994, 20% to 30% was released from Seep C. In March 1994, an action memorandum was accepted, and by November 1994, a "French" drain had been installed at Seep C. The French drain collects the groundwater and directs it to a unit for treatment; this treatment unit consists of drums filled with minerals that filter the ^{90}Sr. Once the groundwater is treated, it is released into Melton Branch. Thus, the primary goal of these remediation activities is to lower the amount of ^{90}Sr released to Melton Branch, and therefore to off-site locations (SAIC 2002b; U.S. DOE 2001f). According to samples taken in 2000 and 2001, the treatment unit has prevented over 99% of the ^{90}Sr at Seep C from entering Melton Branch (SAIC 2002). The amount of ^{90}Sr is greater downstream from Seep C than upstream, which suggests that a portion of the ^{90}Sr from WAG 5 bypasses the treatment unit (SAIC 2002b; U.S. DOE 2001f). Currently, there are bimonthly sampling and weekly inspections of the treatment unit at Seep C (SAIC 2002b).

Seep D was also a major source of ^{90}Sr to the White Oak Creek watershed (SAIC 2002b). Of the ^{90}Sr detected at White Oak Dam between 1993 and 1994, 7% was released from Seep D. An action memorandum was passed in July 1994, and a groundwater treatment unit was installed and functioning at Seep D by November 1994. Once the groundwater has been treated, it is released to Melton Branch (SAIC 2002b; U.S. DOE 2001f). Data collected in 2000 and 2001 showed that this treatment unit has prevented over 99% of the ^{90}Sr at Seep D from entering Melton Branch (SAIC 2002b). The amount of ^{90}Sr is, however, greater downstream at Seep D than upstream. This suggests that small quantities of ^{90}Sr going into Melton Branch did not originate from the Seep D pumping location (SAIC 2002b; U.S. DOE 2001f). Daily inspections are conducted at Seep D and monthly sampling is performed on the treatment unit, as well as upstream and downstream of Melton Branch (SAIC 2002b).

All of the waste areas in the Melton valley are in the aquitard formations of the Conasauga Group, where permeability and, consequently, groundwater migration, is limited (USGS 1988). As is the case in much of the ORR, groundwater flow is very shallow and is closely coupled with surface water. More than 95% of the rainwater that infiltrates the soil ends up as surface water in White Oak Creek and eventually in to the Clinch River (ORNL 1982; SAIC 2004). As a result, most of the monitoring that is performed in Melton Valley concerns surface water with emphasis on the WOD.

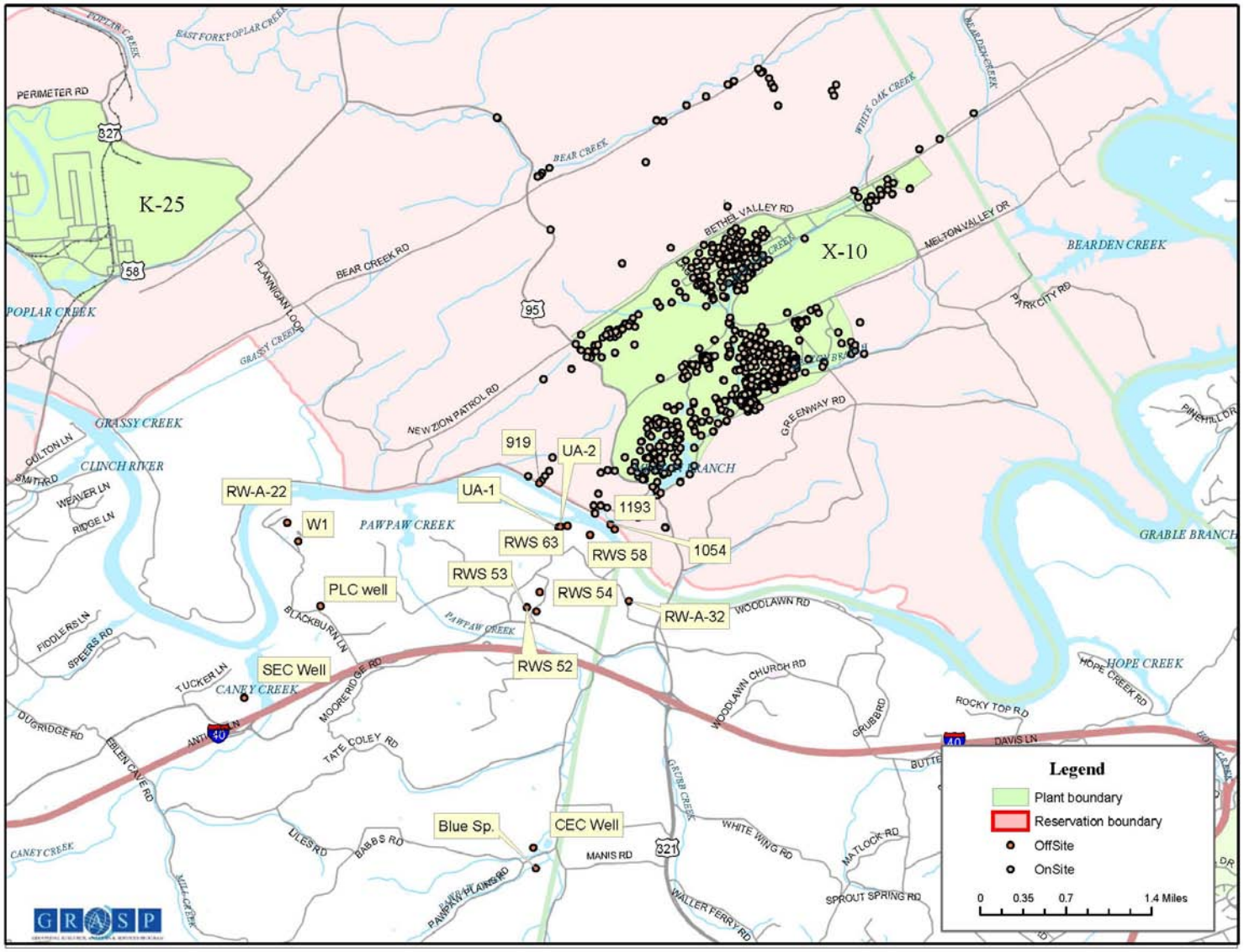

Figure 4: Off-Site Groundwater Sampling Locations Near ORNL

Off-Site Groundwater Monitoring Data

Seeps and Springs

Thallium was detected in one of seven samples from seeps and springs off-site near ORNL. The detected sample was taken from the SEC Well on March 4, 1996 and revealed a concentration of 2.4 ppb, which is slightly above the 2-ppb MCL for thallium. Thallium was not detected in a sample collected from the same location 6 months earlier. Subsequent sampling at that location has not been conducted.

Monitoring Wells

Table 2: Contaminants Detected Above Comparison Values in Monitoring Wells in the Bethel Valley and Melton Valley Watersheds

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date*
Boron	8 / 9	8	100	EMEG	243	1193	5/13/1994
Iron	6 / 11	1	10950	RBC for tap water	16200	PLC Well	9/7/1995
Thallium	2 / 11	2	2	MCL	2.4	PLC Well	3/4/1996

Boron was only detected in one well — well #1193. Boron was not detected in the most recent sample from this well, which was taken on April 3, 1996. Iron was only detected above the 10950-ppb CV in one sample. This sample was taken from the PLC Well in September of 1995. A subsequent sample, 6 months later from the same well yielded a concentration of 2550 ppb — well below the CV. Both samples with elevated thallium concentrations were taken from the PLC Well. No subsequent sampling has taken place for thallium at the PLC Well.

Residential Wells

No contaminants have been detected above comparison values in residential wells near the ORNL.

ATSDR Conclusion for Bethel Valley and Melton Valley Watersheds

Groundwater in Bethel Valley and Melton Valley has short flow-paths to surface water — namely, First Creek, Raccoon Creek, the Northwest Tributary and White Oak Creek. Contaminated groundwater has not migrated to the ORR boundary. Remediation of groundwater in Bethel Valley is ongoing as it is in Melton Valley. Contaminant concentrations in general are either decreasing or are steady. No site-related groundwater contamination reated to operations in Bethel or Melton Valleys is beyond the ORR boundaries. Thallium has been detected sporadically in seeps/springs and monitoring wells near ORNL. While subsequent sampling has not been conducted at the specific locations (SEC Well and PLC Well), concurrent sampling from adjacent locations has not been able to detect thallium. Iron and boron were not

detected in subsequent sampling events. No contamination has been detected in residential wells near ORNL. For these reasons, ATSDR concludes that no public (community) exposure is expected to groundwater contamination emanating from the ORNL.

II.F. Bear Creek and Upper East Fork Poplar Creek Watersheds

The Bear Creek watershed and the Upper East Fork Poplar Creek (UEFPC) watershed comprise a large portion of Bear Creek Valley on the ORR. Bear Creek Valley is bordered by Chestnut Ridge and Pine Ridge. The 825-acre Y-12 plant, now called the Y-12 National Security Complex, is located in Bear Creek Valley and lies predominantly in the UEFPC watershed.

Operational History

From 1944 to 1947, the Y-12 Complex was used to enrich uranium electromagnetically. In 1952, the facility was converted to enrich lithium-6 using a column-exchange process and to fabricate components for thermonuclear weapons using high-precision machining and other specialized processes. In 1992, after the Cold War ended, Y-12's mission was curtailed — the plant is currently used for weapons disassembly and weapon renovation operations. The National Nuclear Security Administration uses the Y-12 National Security Complex as the primary storage site for highly enriched uranium. While operational levels have increased since 1992, the total operations have not approached the levels experienced before the 1990s.

Geology/Hydrogeology

The Y-12 Complex is located in the eastern end of Bear Creek Valley. It is bordered on the south by Chestnut Ridge and on the north by Bear Creek Road and Pine Ridge (ChemRisk 1999). The main Y-12 production area is about 0.6 mile wide and 3.2 miles long; the area contains roughly 240 principal buildings, of which about 18 were directly involved with processing or storage of uranium compounds (ChemRisk 1999). The Y-12 Complex is located within the corporate limits of the city of Oak Ridge, about 2 miles south of downtown (ChemRisk 1999). It is less than ½-mile from the Scarboro community, but Pine Ridge (which rises to about 300 feet above the valley floor) separates the Y-12 Complex from the main residential areas of Oak Ridge (TDOH 2000).

Bear Creek Valley and Union Valley are underlain by the Conasauga Group. This formation is typically flow-limiting; however, the Maynardville Formation, which is a sub-group of the Conasauga, is a local aquifer and is the primary transport mechanism for groundwater and contaminants from the Y-12 Complex (SAIC 2004). Pine Ridge to the north of the Y-12 Complex and Union Valley is composed of the dense shales of the Rome Formation. This formation is higher in elevation than Bear Creek Valley and Union Valley and has a significantly lower hydraulic conductivity which prevents groundwater from flowing from the Maynardville Formation north to the residential areas of Scarboro and Oak Ridge (USGS 1989, SAIC 2004). Groundwater in the UEFPC watershed typically flows along strike in the Maynardville Formation between 100 ft and 400 ft below ground from west to east in Union Valley (Jacobs EM Team 1997a).

Contamination at Bear Creek Valley and UEFPC Watersheds

Bear Creek Valley Watershed

In the June 2000 *Record of Decision* (ROD) *for the Phase I Activities in Bear Creek Valley and the Oak Ridge Y-12 Plant*, Bear Creek Valley was divided into three Zones for the purposes of establishing and evaluating performance standards for each zone in terms of resulting land and resource uses and residential risks following remediation.

Zone 1 is the area of Bear Creek Valley Watershed west of surface water monitoring location BCK 7.87. The pre-ROD situation for this zone was that there was no unacceptable risk to residential or recreational users of the land or resources in this area of the valley. The agreed-upon goal for this zone was to maintain the "unrestricted use" classification. Monitoring locations, scheduling of sampling and parameters to be monitored were established throughout this zone to ensure that the goals of the ROD would be achieved (SAIC 2004).

Groundwater sampling in FY 2003 revealed no uranium was detected above MCLs in Zone 1. Uranium that was detected in Zone 1 was only found in GW-715 at a concentration substantially lower than results from FY 2002 sampling. These data indicate that uranium concentrations might be going down overall after peaking following a 5-year increase in this well from 1998. Since 1998, GW-715 has also yielded detectable concentrations of nitrate, ^{99}Tc, gross alpha, and gross beta. At 43 feet deep, GW-715 is the shallowest well in Zone 1 and represents the close relationship with the surface water in Bear Creek. The contaminants detected in groundwater are also typically detected at surface water sampling locations along Bear Creek. In fact, losing reaches of Bear Creek contribute to groundwater recharge between Northern Tributary #9 (NT-9) and surface water sampling station #6 (SS-6) (SAIC 2004). Because of high-flow conditions, FY 2003 saw anomalously high AWQCs exceedences. But these levels are expected to decrease markedly, thus reducing Zone 1groundwater contamination.

Zone 2 is the area of Bear Creek Valley between Bear Creek surface water stations BCK 7.87 and BCK 9.47. The short-term land use goals for this zone are recreational; the long-term goal is to attain unrestricted use classification. The ROD identifies the comparative criteria for groundwater in Zone 2 as MCLs. The remedial action objective (RAO) for cleanup levels in Zone 2 is the risk to potential residents in the area to be below 1×10^{-5}. The RAO applies as the performance criterion at BCK 9.47, which is the eastern, upgradient extent of Bear Creek in Zone 2 and the integration point (IP) for contaminants in Bear Creek Valley.

In FY 2003, samples collected at the IP exceeded secondary MCLs for aluminum and manganese. Uranium was detected in the August 2003 sampling event, but levels remained in the background range, so over the past 10 years the slight downward trend continues. According to these results, as of FY 2003 Zone 2 continues to meet criteria for the remediation goal of recreational land use.

The total flux of contaminants from all sources exiting the watershed in surface water and groundwater is evaluated at the IP. In the 1994 remedial investigation, mass balance equations and calculations were performed and revealed that — as measured at the Maynardville Limestone picket A — of the total amount of water passing through the IP, only 3% was

groundwater. In other words, up to 99% of contaminants exiting the former waste disposal sites in Bear Creek Valley are intercepted at the IP.

Zone 3 is the area of Bear Creek Valley that lies east of the IP (BCK 9.47). The BYBY, the S-3 Site and the BCBG are located in Zone 3. The remediation goal for Zone 3 is to reduce contaminant levels to be consistent with long-term industrial land use. Groundwater cleanup criteria in Zone 3 have not been determined but contaminant concentrations are being monitored and compared to MCLs for evaluation. Following previously observed trends, uranium, nitrate, manganese, and for many years several VOCs have exceeded MCLs in Zone 3. For example, nitrate concentrations in GW-526 have been historically increasing as a result of the plume's center of mass migrating along strike, but have remained relatively stable since 1995. The closure of the S-3 Site has resulted in decreasing concentrations of uranium, nitrate, and ^{99}Tc in GW-276; and stable-to-slightly decreasing concentrations of uranium, nitrate, and TCE have been observed at exit pathway picket B.

As is the case throughout much of the ORR, a very high interconnectivity exists between surface and groundwater. Gaining and losing reaches of Bear Creek occur along the entire Bear Creek Valley, and often the contamination of surface water results in increasing contaminant concentrations in the shallow ground water and vice versa. Completion of remedial actions in Bear Creek Valley has, however, resulted in substantial reductions in contaminants in general. The short- and long-term goals set forth in the ROD, in terms of land use and risk to residents, are being met.

UEFPC Watershed

Groundwater contamination occurs beneath the entire UEFPC watershed and continues east, across the ORR boundary, into Union Valley. This contaminated plume is made up of several commingling plumes from a variety of sources. The contaminants detected in one of the six monitoring wells in the Maynardville Limestone and in two springs feeding Scarboro Creek were consistent with those found in the carbon tetrachloride plume emanating from the Y-12 Complex (Jacobs EM Team 1997a). Although the sources of most of these contaminants can not be confirmed, they are likely a result of various leaks and spills throughout the Y-12 facility. The east end of the Y-12 complex has been used primarily for maintenance and as a shipping and receiving area. Carbon tetrachloride, the primary VOC in the east end VOC (EEVOC) contaminant plume, was used extensively in the 1940s in the electromagnetic uranium separation process. The high, historical, on-site concentrations of carbon tetrachloride (>8000µg/L) indicate that DNAPLs probably are present.

Groundwater in the UEFPC watershed typically flows along strike from west to east in the Maynardville Formation between 100 ft and 400 ft below ground. The Maynardville Limestone is the primary pathway for contaminant migration from Y-12. Because of the Maynardville Limestone's well-developed karst system, groundwater from adjacent formations tends to flow toward it (Jacobs EM Team 1997a). And because of the high interconnectivity with surface water, groundwater discharges at seeps and springs constitutes much of the base flow of Scarboro Creek and UEFPC. Depth to groundwater in this area is between 1 and 4 feet below

Groundwater in adjacent formations flows toward the Maynardville Limestone because of the formation's relatively high hydraulic conductivity and well-developed karst system.

ground during the winter and between 2 and 7 feet below ground in the summer (USGS 1989). Groundwater in this area responds quickly to storms and can exhibit high flow rates with rapid dilution. A silty-clay glei horizon exists beneath EFPC and impedes downward groundwater migration (USGS 1989).

In accordance with CERCLA requirements, in 1997 the Interim Record of Decision (ROD) for Union Valley was published. This ROD contains the selected interim remedial action for Union Valley, and considers two interim alternatives: Alternative 1 – no action, and Alternative 2 – institutional controls. The selected action was Alternative 2, which consists of the following institutional controls: 1) DOE obtains license agreements with property owners notifying them of the potential contamination, and requiring them to notify DOE of any changes in use of groundwater or surface water in certain areas and, 2) appropriate DOE verification of compliance with the agreements and notification to state and local agencies. This remedy is not the final remedy for Union Valley; thus it does not have provisions to reduce the toxicity, mobility, or volume of the contaminants of concern. Subsequent actions for this characterization area are forthcoming. In the meantime, however, the purposes of this interim action are to 1) ensure that public health is protected while final actions are being developed and implemented, and 2) identify and, if necessary, prohibit future activities with a potential to accelerate the rate of contaminant migration from the characterization area or to increase the extent of the contaminant plume (Jacobs EM Team 1997a).

The EEVOC plume is the only confirmed off-site contamination of ORR groundwater (USDOE 2004). While it is important to understand the sources and magnitudes of on-site contamination — especially as they relate to contamination off-site — the purpose of this PHA is to determine the extent of off-site groundwater contamination using existing information and the effect, if any, this contamination might have on the public health. The Tennessee Department of Environment and Conservation (TDEC) conducts groundwater sampling at locations on the ORR and at off-site locations. In CY 2003, 6 residential wells and 17 exit pathway springs were sampled. In the 2003 Environmental Monitoring Report (TDEC 2003a), TDEC reports findings from three off-site springs (Bootlegger, Cattail, and SS-7) and one groundwater well (GW-919). While traces of VOCs from the EEVOC plume have historically been detected in the Bootlegger spring, early in CY 2003, dilution, as a result of higher than average rainfall events, resulted in non-detects in this spring. Union Valley contains no residential wells.

Off-Site Groundwater Monitoring Data

Seeps and Springs

Not surprisingly, the samples that contained concentrations of substances above CVs came from springs just east of the ORR boundary near the Y-12 Complex. These springs are within the known extent of the EEVOC plume. These results are from a one-time sampling event on March 21, 1996. Samples were collected from each sampling location, split, and then assigned separate sample identification numbers. Of the 15 ‘Samples Detected Above CVs’ listed in Table 3, 13 of them are from two split samples from SCR7.14SP and SCR7.16SP. Two other samples (from SCR7.1SP and SCR7.18SP) had elevated levels of manganese. There has been no subsequent sampling of these springs.

Table 3: Substances Detected Above CVs in Seeps or Springs Near the Y-12 Complex

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date*
Benzene	1 / 8	1	5	MCL	7	SCR7.14SP	3/21/1996
Boron	16 / 16	4	100	EMEG	880	SCR7.14SP	3/21/1996
Iron	13 / 16	3	10950	RBC for Tap Water	44000	SCR7.14SP	3/21/1996
Manganese	15 / 16	6	500	RMEG	2900	SCR7.16SP	3/21/1996
Selenium	1 / 1	1	50	MCL	69	SCR7.16SP	3/21/1996

Residential Wells

No contaminants were detected above CVs in off-site residential wells near the Y-12 Complex. The nearest residential well (RWS 67) is over 2 miles from the Y-12 Complex.

Monitoring Wells

In off-site monitoring wells near the Y-12 Complex, 30 chemical contaminants and 12 radionuclides were detected above comparison values. Nine chemicals (indicated by superscript 3 in Table 4) were detected above CVs, but only in wells in the EFPC floodplain. Wells in the EFPC floodplain include WDANE4, NOAND1, WFANE1, BRAND7, and others with similar naming convention as shown on Figure 5. As previously mentioned, groundwater does not migrate from Union Valley beneath Pine Ridge (see ATSDR's response to Public Comment #2); it is unlikely therefore that any contamination in the EFPC floodplain is a direct result of groundwater contamination emanating from the Y-12 Complex. Of the 30 total chemicals, 14 (indicated by superscript 4 in Table 4) were either detected below CVs or not detected at all in concurrent or subsequent samples taken from wells in Union Valley. Additional comments regarding the monitoring for each substance are included in Table 4.

Of the 12 radionuclides detected above CVs (Table 5), 7 were not detected above CVs, or not detected at all in subsequent samples. Five of the radionuclides were only detected above CVs in the EFPC floodplain (except radium in one sample in GW-169). Concurrent sampling of gross beta from GW-169 (the only radium exceedance) yielded a concentration 10 times lower than the CV.

Table 4: Contaminants Detected in Monitoring Wells Near the Y-12 Complex

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date†*	*Comments*
2,4-Dinitro phenol ‡	15 / 103	15	20	RMEG	50	EFPC Floodplain*	3/12/1991	All samples detected above CVs were taken from wells in the EFPC Floodplain.
2-Nitroaniline‡	15 / 113	15	3.3	RBC for Tap Water	50	EFPC Floodplain*	3/12/1991	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Acetone‡	81 / 247	1	9000	RMEG	14000	WDANE4	11/19/1990	The only sample detected above the CV was taken from a well in the EFPC Floodplain.
Aluminum §	188 / 347	33	20000	EMEG	140000	GW-169	9/28/1995	Aluminum has not been detected in subsequent samples in GW-169. Several wells in the EFPC Floodplain yielded aluminum concentrations above the CV.
Arochlor-1260‡	4 / 82	4	0.033	RBC for Tap Water	1	EFPC Floodplain*	3/12/1991	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Arsenic§	39 / 310	7	10	MCL	83	GW-169	9/28/1995	Arsenic has not been detected in subsequent samples.
Barium §	350 / 354	1	2000	MCL	3150	NOAND1	6/14/1991	Another sample on the same day (6/14/1991) from the same well yielded a concentration of only 412 ppb.
Benzene‡	15 / 237	3	5	MCL	7	NOAND1	11/08/1990	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Beryllium	36 / 196	20	4	MCL	28.1	NOAND5	6/18/1991	Elevated levels of beryllium have only been found in GW-169 in Union Valley; however, several wells in the EFPC floodplain have shown concentrations above the CV.
Boron	183 / 184	75	100	EMEG	2900	GW-232	3/12/1991	All samples detected above the CV have come from wells located within the known extent of the EEVOC.
Carbon tetrachloride	45 / 244	26	7	RMEG	200	GW-170	11/17/1994	All samples detected above the CV have come from one well, GW-170, located within the known extent of the EEVOC.

Table 4: Contaminants Detected in Monitoring Wells Near the Y-12 Complex (continued)

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date†*	*Comments*
Chloroform§	52 / 249	1	100	EMEG	134	GW-170	2/2/1994	Samples collected on the same day from the same well were below the CV. Subsequent samples were also below the CV.
Chromium§	88 / 354	13	100	LTHA	720	GW-169	4/27/1992	Subsequent samples were well below the CV for chromium.
Cobalt§	74 / 354	3	100	EMEG	144	WFANE1	11/19/1990	In two of the three wells where samples exceeded the CV, subsequent samples were below the CV.
Copper§	139 / 354	10	100	EMEG	6320	WFANE1	11/19/1990	Most samples detected above CVs were taken from wells in the EFPC Floodplain.
Dibenzo(a,h) anthracene ‡	11 / 113	11	0.009	RBC for Tap Water	11	BRAND7	11/2/1990	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Flouride §	124 / 198	1	4000	MCL	4900	GW-169	5/18/2000	Only one sample exceeded the CV. Concurrent and subsequent samples from adjacent wells were below the CV.
Ideno(1,2,3-cd)pyrene‡	15 / 113	15	0.092	RBC for Tap Water	12	WAANE12	3/14/1991	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Iron §	300 / 354	78	10950	RBC for Tap Water	200000	GW-169	9/28/1995	The only well in Union Valley with elevated iron levels was GW-169. All other samples exceeding the CV were in the EFPC Floodplain.
Lead	93 / 296	38	15	MCLG	1200	GW-169	4/27/1992	Samples from both Union Valley and the EFPC floodplain exceeded the CV.
Manganese	309 / 354	193	500	RMEG	27600	NOAND3	6/18/1991	Samples from both Union Valley and the EFPC floodplain exceeded the CV.
Mercury ‡	41 / 119	22	2	MCL	280	WFANE1	11/19/1990	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Methylene chloride ‡	130 / 250	4	600	EMEG	4200	BRAND7	11/2/1990	All samples detected above CVs were taken from wells in the EFPC Floodplain.
Nickel§	100 / 358	16	100	LTHA	657	WFANE1	11/19/1990	Samples from both Union Valley and the EFPC floodplain exceeded the CV.

Table 4: Contaminants Detected in Monitoring Wells Near the Y-12 Complex (continued)

Substance	*Detects / Samples*	*Samples Detected Above CVs*	*CV (ppb)*	*CV Source*	*Max Conc. (ppb)*	*Max Location*	*Max Conc. Date†*	*Comments*
Selenium§	37 / 259	4	50	EMEG	72	GW-230	9/20/1995	All samples detected above the CV have come from wells located within the known extent of the EEVOC.
Tetrachloro-ethylene§	77 / 259	23	5	MCL	11	GW-170	11/17/1994	All samples detected above the CV have come from wells located within the known extent of the EEVOC.
Thallium	38 / 88	38	2	MCL	7	GW-170	2/2/1994	All but one sample detected above CVs were taken from wells in the EFPC Floodplain. Only one sample was detected above the CV in GW-170 in 1994. Thallium was never detected in adjacent wells. Subsequent sampling for thallium in GW-170 has not been conducted.
Trichloro-ethylene §	67 / 261	3	5	MCL	6	GW-169	3/1/1991	All samples detected above the CV have come from wells located within the known extent of the EEVOC.
Vanadium§	80 / 366	37	30	EMEG	300	GW-169	9/28/1995	The only well in Union Valley with elevated vanadium levels was GW-169. All other samples exceeding the CV were in the EFPC Floodplain.
Zinc	272 / 354	7	3000	EMEG	12000	GW-230	6/18/1996	All samples detected above the CV have come from wells located within the known extent of the EEVOC.

*Several locations reported the same maximum concentration. All locations were in the EFPC Floodplain.

†Where more than one sampling location yielded the same maximum concentration, the most recent sample date is reported.

‡Contaminants detected above CVs only in the EFPC Floodplain.

§In all subsequent samples from wells in Union Valley, contaminants were either detected below CVs or not detected at all.

Table 5: Radionuclides Detected Above CVs in Monitoring Wells Near the Y-12 Complex

Radionuclide	*Detects / Samples*	*Samples Detected Above CVs*	*CV (pCi/L)*[1]	*Max Conc. (pCi/L)*	*Max Location*	*Max Date*	*Comments*
Alpha radiation	122 / 177	9	15	81.3	GW-232	11/7/2001	Subsequent samples in all wells have been below detection limit.
Am-241	70 / 72	38	7.25	110	NOAND1	3/8/1991	All samples above the CV were from the EFPC Floodplain.
Beta radiation	164 / 189	5	50	2560	GW-230	8/7/2002	Subsequent samples in all wells have been either below detection limit or below the CV.
Gross beta	41 / 41	1	50	57.5	GW-169	9/28/1995	Concurrent sampling from this well yielded 4.9 pCi/L.
Iodine-129	27 / 27	2	14	21.6	GW-170	3/22/1995	Subsequent samples in all wells have been below the CV.
Neptunium-237	52 / 53	29	13.8	239	WEANE3	3/8/1991	All samples above the CV were from the EFPC Floodplain.
Radium	109 / 109	14	5	26.3	NOAND2	11/8/1990	All samples above the CV were from the EFPC Floodplain except one from GW-169. Subsequent samples from GW-169 were below the CV.
Radium-228	5 / 8	1	2	2.11	GW-230	12/13/1995	Subsequent samples have been either below detection limit or below the CV.
Thorium-234	13 / 13	3	435	655	GW-172	9/26/1994	Subsequent sampling has not occurred.
Uranium-234	111 / 113	8	30	109	WFANE1	11/19/1990	All samples above the CV were from the EFPC Floodplain.
Uranium-235	87 / 114	2	30	54.9	GW-230	9/28/1994	Subsequent samples have been either below detection limit or below the CV.
Uranium-238	119/ 124	7	30	115	WFANE1	11/19/1990	All samples above the CV were from the EFPC Floodplain.

[1]Based on Federal Guidance 13, 2 liters water/day