6. Y-12 Environmental Monitoring Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted at the Y-12 National Security Complex for air, water, and groundwater environmental media.

6.1 Y-12 Complex Radiological Airborne Effluent Monitoring

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 National Security Complex (Y-12 Complex) occurs almost exclusively as a result of plant production, maintenance, and waste management activities. NESHAP regulations for radionuclides require continuous emission sampling of major sources (a "major source" is considered to be any emission point that potentially can contribute more than 0.1 mrem/year effective dose equivalent to an off-site individual). As of January 1, 2005, the Y-12 Complex had continuous monitoring capability on a total of 55 stacks, 46 of which were active and nine of which were temporarily shut down. During 2005, 42 of the 55 stacks suitable for continuous monitoring were judged to be major sources. Eighteen of the stacks with the greatest potential to emit significant amounts of uranium are equipped with alarmed breakthrough detectors, which alert operations personnel to process-upset conditions or to a decline in filtration-system efficiencies, allowing investigation and correction of the problem before a significant release occurs.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to calculation methods approved by the EPA. In 2005, there were 46 unmonitored processes operated by Y-12. These are included as minor sources in the Y-12 Complex source term.

Uranium and other radionuclides are handled in millicurie quantities at facilities within the boundary of the Y-12 Complex as part of Bethel Jacobs Company, LLC, (BJC), UT-Battelle, and BWXT Y-12 laboratory activities. Twenty-nine minor emission points were identified from laboratory activities at facilities within the boundary of the Y-12 Complex as being operated by BWXT Y-12. In addition, the BWXT Y-12 Analytical Chemistry Organization laboratory is operated in a leased facility that is not within the ORR boundary; it is located approximately a mile east of the Y-12 Complex on Union Valley Road. The emissions from the Analytical Chemistry Organization Union Valley laboratory are included in the Y-12 Complex source term. Two minor emission points were identified at the laboratory. The releases from these emission points are minimal, however, and have a negligible impact on the total Y-12 Complex dose.

Emissions from Y-12 Complex room ventilation systems are estimated from radiation control data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration worker-protection guidelines are included in the annual emission estimate. In 2005, three emission points where room ventilation emissions exceeded 10% of the guidelines were identified in Building 9212. However, because the emissions were vented to stacks UB-017, and UB-128, their distributions were not specifically identified or included in the stack emissions.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on monitored operating process exhaust stacks in 2005. Particulate matter (including uranium) was filtered from the stack emissions. Filters at each location were changed routinely, from one to three times per week, and were analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and were washed with nitric acid; the washing was analyzed for total uranium. At the end of the year, the probe-wash data were included in the final calculations in determining total emissions from each stack.

6.1.2 Results

An estimated 0.016 Ci (1.4 kg) of uranium was released into the atmosphere in 2005 as a result of Y-12 activities (Figs. 6.1 and 6.2). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 96% of the curie release was composed of emissions of enriched uranium particulate, even though approximately 16% of the total mass of uranium released was enriched material.

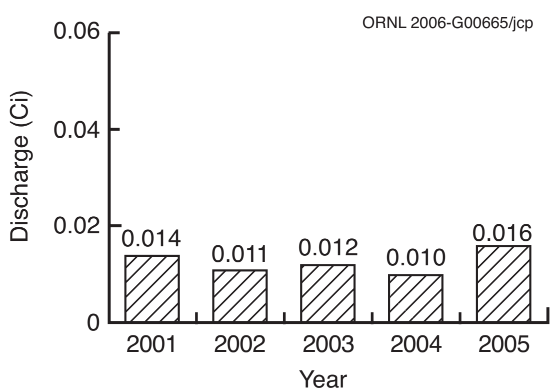

Fig. 6.1. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 2001–2005. 1 Ci = 3.7 × 10^{10} Bq.

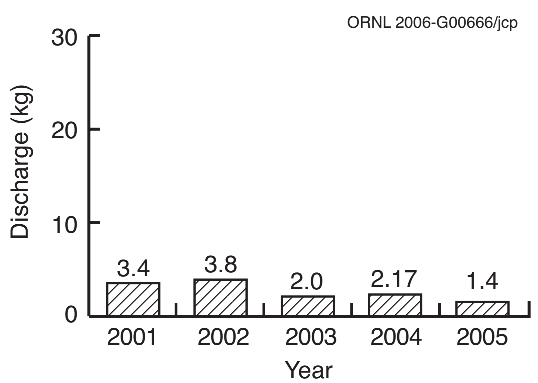

Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 2001–2005.

6.2 Y-12 Complex Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Complex occurs as a result of plant production, maintenance, waste management operations, and steam generation. Most process operations are served by ventilation systems.

In calendar year (CY) 2005, the Y-12 Complex implemented complete compliance and reporting activities for its first Major Source (Title V) Operating Air Permit. the permit covers 35 air emission sources and more than 100 air emission points. Other emission sources at the Y-12 Complex are categorized as being insignificant and exempt from air permitting. Under the Title V operating permit for the complex, sampling, continuous monitoring, and record keeping of key process parameters are recorded and reported to the Tennessee Department of Environment and Conservation (TDEC) in quarterly, semiannual, and annual reports. The initial semiannual report under Title V was submitted in November 2005.

Approximately three-fifths of the permitted air sources release primarily nonradiological contaminants. The remaining two-fifths of the permitted sources process primarily radiological materials. TDEC air permits for the nonradiological sources do not require stack sampling or monitoring except for the two opacity monitors and three NO_x monitors used at the steam plant to ensure compliance with visible emission standards and ozone season emission limits, respectively. For nonradiological sources where direct monitoring of airborne emissions is not required, monitoring of key process parameters is done to ensure compliance with all permitted emission limits.

The 2005 Y-12 Complex annual emission fee was calculated based on 10,033 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $195,643.50. In accordance with TDEC regulations, Rule 1200-3-26-.02(9)(i), when there is no applicable standard or permit condition for a pollutant, the allowable emissions are based on the maximum actual emissions calculations (maximum design capacity for 8760 h/year). More than 90% of the Y-12 Complex pollutant emissions to the atmosphere are attributed to the operation of the steam plant. The emission fee rate was based on $19.50 per ton of regulated-pollutant allowable emissions. The actual emissions are much lower than the allowable amount; however, major sources are required to pay their annual emission fees based on allowable emissions until the issuance of the major source operating permit.

6.2.1 Results

The primary source of criteria pollutants at the Y-12 Complex is the steam plant, where coal and natural gas are burned. Information regarding actual vs allowable emissions from the steam plant is provided in Table 6.1. In addition, the annual toxic release inventory report (required by EPCRA Sect. 313) provides information on other nonradiological Y-12 Complex air emissions (Sect. 2.2.16.3).

Condition E12-6 of the Y-12 Title V operating air permit for the Y-12 Steam Plant requires the opacity monitoring systems to be fully operational 95% of the operational time of the monitored units during each month of the calendar quarter. During 2005, the opacity monitoring systems were operational for more than 95% of the operational time of the monitored units during each month.

Condition E12-7 of the Y-12 Title V operating air permit requires that calibration error tests of the opacity monitoring systems be performed on a semiannual basis. The calibration error tests will be performed on January 1 for both the east and west opacity monitors and again on August 15 and September 8 for the east monitor; the reports will be submitted to the technical secretary for his approval and records. Six 6-min periods of excess emissions occurred during 2005. Quarterly reports of the status of the Y-12 Steam Plant opacity monitors are submitted to personnel at TDEC within 30 days after the end of each calendar quarter. Table F.4 in Appendix F is a record of excess emissions and inoperative conditions for the east and west stack opacity monitors for 2005.

Condition E12-10 of the Y-12 Title V operating air permit requires continuous monitoring of NO_x mass emissions during the ozone season (May 1 through September 30). The cumulative NO_x mass emissions measured from the steam plant for the 2005 ozone season were 215.4 tons of NO_x; the limit is 232 tons.

The results of monitoring a number of key process parameters were provided in a report to TDEC in November 2005. All monitored results were in compliance with the exception of three deviations. All three deviations were at the Dry Ash Handling Facility, where compliance with a particulate emissions limit is demonstrated by daily readings of pressure drop across the bag house filter control device (Permit Condition E17-1). There were two instances of missed readings and one 10-day period when pressure drop readings were outside the expected range. This occurred immediately following routine maintenance to replace old bags with new bags. There were no excess emissions to the environment as a result of this event. The control device was being maintained and operated as expected. A minor permit modification was issued in December 2005 to allow the broader range of pressure-drop readings.

Table 6.1. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2005

Pollutant	Emissions (tons/year)[a]		Percentage of allowable
	Actual	Allowable	
Particulate	33	945	3.5
Sulfur dioxide	2,313	20,803	11.1
Nitrogen oxides[b]	707	5,905	12.0
Nitrogen oxides (ozone season only)	215.4[c]	232	92.8
Volatile organic compounds[b]	2.3	41	5.6
Carbon monoxide[b]	21	543	3.9

[a]1 ton = 907.2 kg.

[b]When there is no applicable standard or enforceable permit condition for some pollutants, the allowable emissions are based on the maximum actual emissions calculation as defined in Tennessee Department of Environment and Conservation Rule 1200-3-26-.02(2)(d)3 (maximum design capacity for 8760 h/year). The emissions for both the actual and allowable emissions were calculated based on the latest EPA compilation of air pollutant emission factors. (EPA 1995 and 1998. *Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources*. Environmental Protection Agency, Research Triangle Park, N.C. January 1995 and September 1998.)

[c]Monitored emissions.

6.3 Y-12 Complex Ambient Air Monitoring

There are no federal regulations, state regulations, or DOE orders that require ambient air monitoring within the Y-12 complex. All ambient air monitoring systems at the Y-12 Complex are operated as a best management practice. With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly during the past several years. In addition, major processes that result in emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by EPA to meet requirements of the NESHAP regulations. ORR air sampling stations (see Chap. 7), operated in accordance with DOE orders, are located around the reservation. Their locations were selected so that areas of potentially high exposure to the public are monitored continuously for parameters of concern.

BWXT Y-12 maintains three uranium ambient air monitors within the Y-12 boundary that, since 1999, have been utilized by TDEC personnel in their environmental monitoring program. Each of the monitors use 47-mm borosilicate glass fiber filters to collect particulates as air is pulled through the units. The monitors control airflow with a pump and rotometer set to average approximately two standard cubic feet per minute. These samplers were operated by TDEC in 2005. In addition, two boundary mercury-monitoring stations (stations 2 and 8) remain in operation and monitor long-term spatial and temporal trends in ambient mercury vapor. The locations of the monitoring stations are shown in Fig. 6.3.

In preparation for the restart of the Oxide Conversion Facility (OCF), an ambient fluoride monitor was co-located with an existing ORR ambient air station in the Scarboro Community. (The ORR ambient network is discussed in Sect. 7.3.) As a measure to quantify any off-site fluoride dispersions, monitoring capability for fluorides was initiated in November 2004 and continued through 2005. In 2005 the OCF was loaded with hydrogen fluoride.

6.3.1 Mercury

The Oak Ridge Y-12 Complex ambient air monitoring program for mercury was established in 1986 as a best management practice. The objectives of the program have been to maintain a database of mercury concentration in ambient air, to identify long-term spatial and temporal trends in ambient mercury vapor, and to demonstrate protection of the environment and human health from releases of mercury at the Y-12 Complex to the atmosphere. Originally, four monitoring stations were operated at the Y-12 Complex, including two within the former mercury-use area. The two atmospheric mercury monitoring stations currently operating at the Y-12 Complex, Ambient Air Station No. 2 (AAS2) and Ambient Air Station No. 8 (AAS8), are located near the east and west boundaries of the complex, respectively (see Fig. 6.3). Since their establishment in 1986, AAS2 and AAS8 have monitored mercury in ambient air continuously with the exception of short periods of downtime because of electrical or equipment outages. In addition to the plant monitoring stations, a control or reference site (Rain Gauge No. 2) was operated on Chestnut Ridge in the Walker Branch Watershed for a 20-month period in 1988 and 1989 to establish local background concentrations at that time.

At the two monitoring sites, airborne mercury vapor is collected by pulling ambient air through a sampling train consisting of a Teflon filter, a flow-limiting orifice, and an iodated charcoal-filled sampling trap. The flow-limiting orifice restricts airflow through the sampling train to about 1 L/min. Actual flow rates are measured weekly in conjunction with trap change-out with a calibrated Gilmont flowmeter. Cold vapor atomic fluorescence after acid digestion is used to analyze the charcoal in each trap for total absorbed mercury. The average concentration of mercury vapor in the ambient air for each 7-day sampling period is calculated by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the charcoal trap.

Average ambient mercury concentrations at the monitoring sites have declined significantly since the late-1980s, with average mercury vapor concentrations at AAS8 declining almost tenfold and at AAS2 approximately threefold. Recent average annual concentrations at these

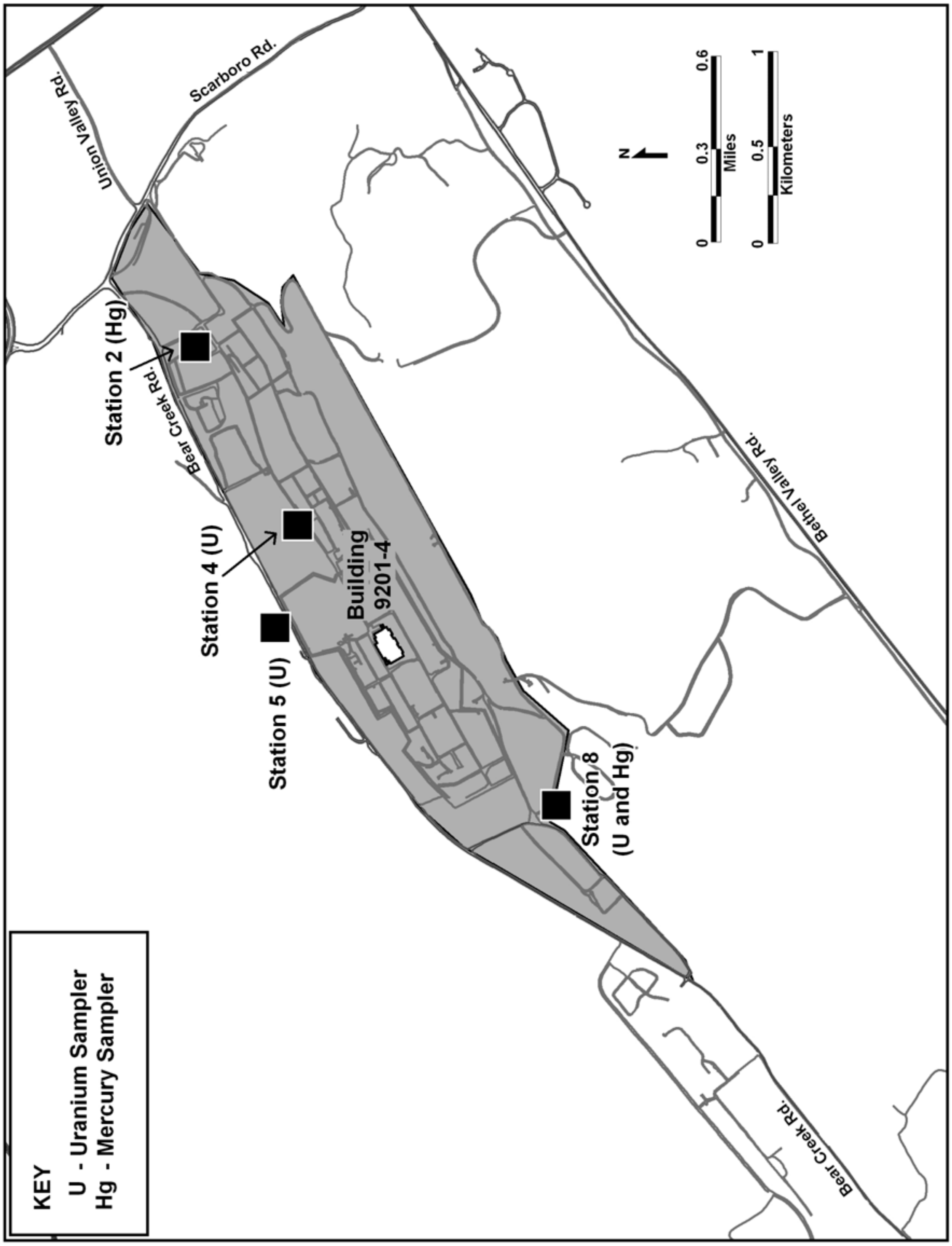

Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Complex.

two boundary stations are comparable to concentrations measured in 1988 and 1989 at the Chestnut Ridge reference site (see Table 6.2) and only slightly elevated above concentrations reported for continental background (i.e., ~0.002 μg/m^3). Average mercury concentration measured at the AAS2 site during 2005 was 0.0036 μg/m^3 and thus was unchanged from the reported 2003 and 2004 average. At monitoring station AAS8, the average annual concentration increased from 0.0050 μg/m^3 in 2004 to 0.0055 μg/m^3 in 2005. Though the difference in the average concentration from 2004 to 2005 is not significant, the 2005 average is significantly different from the 2003 average of 0.0043 μg/m^3 (Student's t-test) and continues an upward trend in mercury at AAS8 dating back to 2003. This upward trend may reflect a temporary increase in ambient concentrations due to the recent increased demolition and excavation in the western end of the plant, resulting in possible disturbances of Hg-contaminated soil and sediment. A similar, though much greater, increase in concentration at AAS8 was observed in the late 1980s (Fig. 6.4, plot B) and is thought to be related to the Perimeter Intrusion Detection and Assessment System and utility restoration projects in progress then. Table 6.2 summarizes the 2005 mercury results and the results from the period from 1986 through 1988 for comparison. Plots A, B, and C in Fig. 6.4 illustrate temporal trends in mercury concentration for the two active mercury monitoring sites since the inception of the program in 1986 through December 2005 (plots A and B) and seasonal trends at AAS8 from 1993 thru 2005 (plot C).

Annual average mercury concentrations during 2005 at the two monitoring stations are comparable to reference levels measured on Chestnut Ridge in 1988 and 1989. These concentrations continue to be below current environmental and occupational health standards for inhalation exposure to mercury vapor:

- the National Institute for Occupational Safety and Health recommended exposure limit of 50 μg/m^3 (time-weighted average for a 10-h workday, 40-h work week),
- the American Conference of Governmental Industrial Hygienists workplace threshold limit value of 25 μg/m^3 (time-weighted average for an 8-h workday and 40-h work week), and
- the current EPA reference concentration for elemental mercury for daily inhalation exposure without appreciable risk of harmful effects during a lifetime (0.3 μg/m^3).

6.3.2 Fluorides

State of Tennessee regulation 1200-3-3-.01 does not define primary standards (affecting public health) for hydrogen fluoride. However, secondary standards (affecting public welfare, i.e., vegetation, aesthetics) are defined in 1200-3-3-.02 for gaseous fluorides expressed as hydrogen fluoride. In anticipation of the startup of the hydrogen fluoride system during CY 2005, arrangements were made to monitor the community adjacent to the Y-12 Complex for the presence of fluorides.

The monitoring methodology chosen for use is in accordance with ASTM D3266, which designates the use of a dual-tape sampler. The time period over which the monitoring occurs is 7 days, and results in a total of fifty-six

Table 6.2. 2005 summary results for the Oak Ridge Y-12 National Security Complex mercury in ambient air monitoring program

Results of the 1986 through 1988 monitoring period are shown for reference

Ambient air monitoring stations	Mercury vapor concentration (μg/m^3)			
	2005 average	2005 maximum	2005 minimum	1986–1988 average
AAS2 (east end of Y-12)	0.0036	0.0086	0.0017	0.010
AAS8 (west end of Y-12)	0.0055	0.0118	0.0019	0.033
Reference Site, Rain Gauge No.2 (1988[a])	N/A	N/A	N/A	0.006
Reference Site, Rain Gauge No.2 (1989[b])	N/A	N/A	N/A	0.005

[a]Data for period from February 9 through December 31, 1988.
[b]Data for period from January 1 through October 31, 1989.

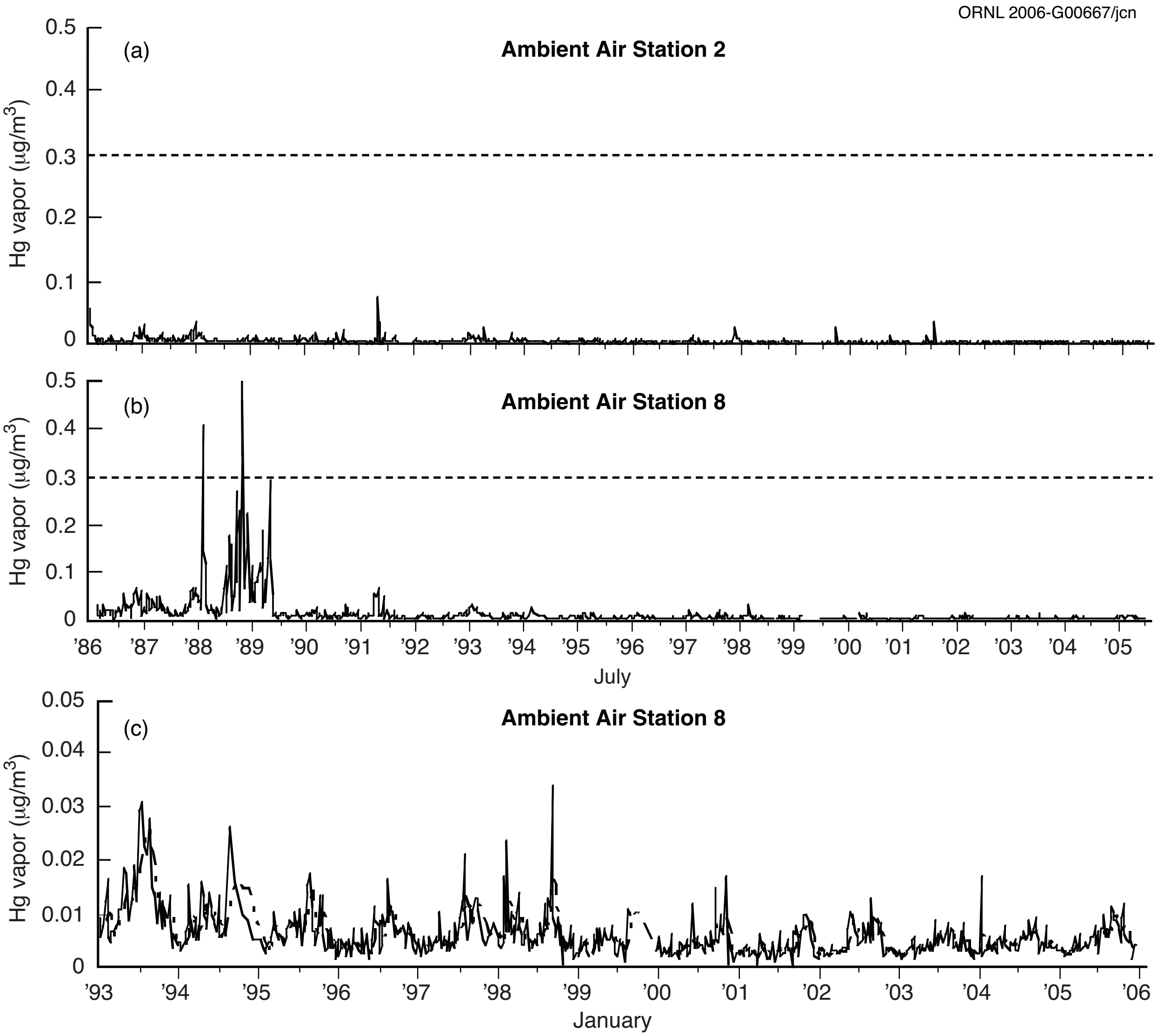

Fig. 6.4. Temporal trends in mercury vapor concentration for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Complex, July 1986 through January 2006.

samples being generated per week (three hours per sample, eight samples per day; seven days per week). Table 6.3 presents the results of the analyses of these samples for the year 2005. The results represent a composite (seven-day average) and serve to provide background information on the presence of fluorides in the surrounding area. The regulatory secondary standard for the 7-day average is 1.6 µg/m^3. Actual monitoring data indicate a maximum of 0.102 µg/m^3.

Table 6.3. Summary results for HF measured as fluorides (7-day average) in the Scarboro Community, 2005

Date	Run time (h)	Volume (m^3)	Fl (µg)	Result (µg/m^3)
1/4	167.3	150.38	10.1	0.067
1/11	168.2	151.21	8.57	0.057
1/18	167.4	150.44	3.59	0.024
1/25	167.8	150.82	2.97	0.020
2/1	168	150.96	11.3	0.075

Table 6.3. (continued)

Date	Run time (h)	Volume (m^3)	Fl (μg)	Result (μg/m^3)
2/8	168.5	151.48	10.2	0.067
2/15	167.6	150.52	15.3	0.102
2/22	168.3	150.87	11	0.073
3/1	167.3	150.32	8.6	0.057
3/8	168.4	151.39	5.55	0.037
3/15	167.1	150.18	5.78	0.038
3/22	168.7	151.62	8.24	0.054
3/29	167.6	150.65	4.27	0.028
4/5	167.4	150.46	5.28	0.035
4/12	No samples	0.28	0	0.000
4/19	168.5	151.39	4.92	0.032
4/26	167.2	150.28	4.13	0.027
5/3	168.3	151.23	2.58	0.017
5/10	167.4	150.51	3.24	0.022
5/17	168	151.06	5.52	0.037
5/24	167.3	150.42	2.22	0.015
5/31	167.9	150.55	2.77	0.018
6/7	167.3	150.31	3.89	0.026
6/14	No samples	0.01	0	0.000
6/21	168.2	150.69	5.38	0.036
6/28	168	151.84	4.92	0.032
7/5	167.3	150.34	3.69	0.025
7/12	138.1	138.12	3.21	0.023
7/19	25 samples	69.93	2.61	0.037
7/26	168	150.3	3.06	0.020
8/2	134.5	117.35	2.78	0.024
8/9	119.8	104.53	1.85	0.018
8/16	167.6	150.48	3.87	0.026
8/23	168.4	151.33	3.24	0.021
8/30	169.9	150.3	3.81	0.025
9/6	168.2	150.35	3.33	0.022
9/13	167.4	150.49	3.9	0.026
9/20	168.6	151.55	3.33	0.022
9/27	167.3	150.51	1.87	0.012
10/4	168.1	151.12	3.9	0.026
10/11	166.5	149.65	3.21	0.021
10/18	169.2	152.12	2.71	0.018
10/25	167	148.02	2.24	0.015
11/1	168	150.87	1.67	0.011
11/8	166.6	148.86	3.09	0.021
11/15	166	19.94	0.357	0.018
11/22	169.4	150.92	2.43	0.016
11/29	168.6	149.27	2.37	0.016
12/6	167.7	150.71	1.72	0.011
12/13	168.2	151.23	1.91	0.013
12/20	167.4	150.192	2.17	0.014
12/27	167.7	150.14	2.12	0.014

6.4 Liquid Discharges—Y-12 Complex Radiological Monitoring Summary

A radiological monitoring plan is in place at the Y-12 Complex to address compliance with DOE orders and National Pollutant Discharge Elimination System (NPDES) Permit TN002968. The permit requires the Y-12 Complex to submit results from the monitoring program quarterly as an addendum to the NPDES discharge monitoring report. There were no discharge limits set by the NPDES permit for radionuclides; the requirement is to monitor and report. The current radiological monitoring plan was developed based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results. Under the existing plan, effluent monitoring is conducted at three types of locations: (1) treatment facilities, (2) other point-source and area-source discharges, and (3) instream locations. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan (Table 6.4).

The radiological monitoring plan also addresses monitoring of the sanitary sewer. The Y-12 Complex is permitted to discharge domestic wastewater to the city of Oak Ridge publicly owned treatment works under Industrial and Commercial User Wastewater Discharge Permit No. 1-91. As required by the discharge permit, radiological monitoring of this discharge is conducted and reported to the city of Oak Ridge, although there are no city-established limits. Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at the Y-12 Complex as part of an initiative to meet the "as low as reasonably achievable" goals. Radiological monitoring of storm water is also required by the NPDES permit. A comprehensive monitoring plan, *Storm Water Pollution Prevention Plan for the Oak Ridge Y-12 Plant*, has been designed to fully characterize pollutants in storm water runoff. The most recent revision of the plan (BWXT 2002) was issued in November 2002, and incorporates radiological-monitoring requirements. There are 75 storm water outfalls and monitoring points located at the Y-12 Complex, and the NPDES permit requires characterization of a minimum of 25 storm water outfalls per year.

6.4.1 Results

Radiological monitoring plan locations sampled in 2005 are noted in Fig. 6.5. Table 6.5 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the derived concentration guides (DCG)s for radionuclides measured in 2005. Radiological data were well below the allowable DCGs.

In 2005, the total mass of uranium and associated curies released from the Y-12 Complex at

Table 6.4. Radiological parameters monitored at the Y-12 Complex in 2005

Parameters	Specific isotopes	Rationale for monitoring
Uranium isotopes	^{238}U, ^{235}U, ^{234}U, total U, weight % ^{235}U	These parameters reflect the major activity, uranium processing, throughout the history of Y-12 and are the dominant detectable radiological parameters in surface water
Fission and activation products	^{90}Sr, ^{3}H, ^{99}Tc, ^{137}Cs	These parameters reflect a minor activity at Y-12, processing recycled uranium from reactor fuel elements, from the early 1960s to the late 1980s, and will continue to be monitored as tracers for beta and gamma radionuclides, although their concentrations in surface water are low
Transuranium isotopes	^{241}Am, ^{237}Np, ^{238}Pu,$^{239/240}$Pu	These parameters are related to recycle uranium processing. Monitoring has continued because of their half-lives and presence in groundwater
Other isotopes of interest	^{232}Th, ^{230}Th, ^{228}Th, ^{226}Ra, ^{228}Ra	These parameters reflect historical thorium processing and natural radionuclides necessary to characterize background radioisotopes

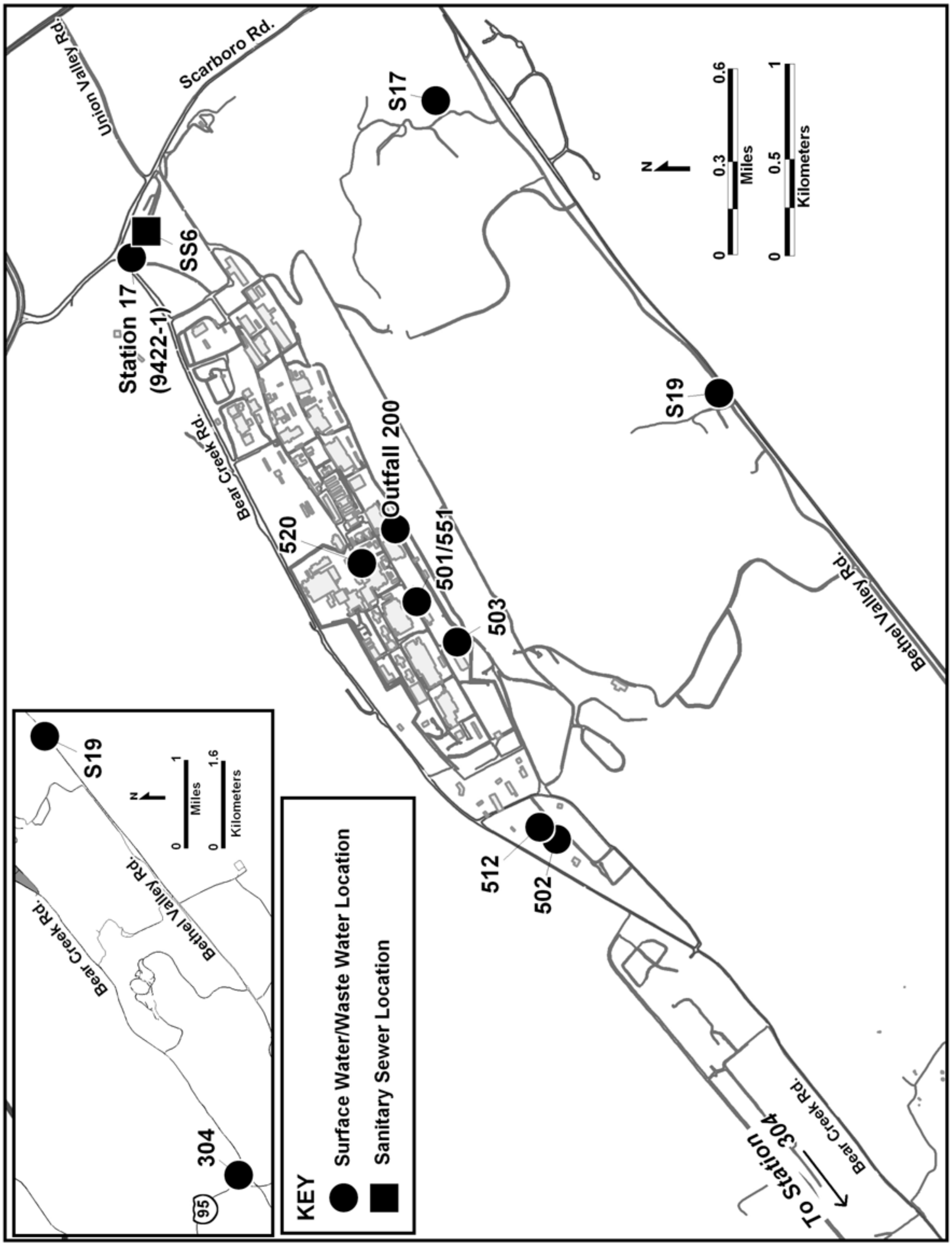

Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Table 6.5. Summary of Y-12 Complex radiological monitoring plan sample requirements

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
Y-12 Complex wastewater treatment facilities				
501	Central Pollution Control Facility	1/week	Composite during batch operation	2.4
502	West End Treatment Facility	1/week	24-h composite	3.5
503	Steam Plant Wastewater Treatment Facility	1/week	24-h composite	No flow
512	Groundwater Treatment Facility	1/week	24-h composite	2.5
520 (402)[a]	Steam condensate	1/week	Grab	0.14
551	Central Mercury Treatment Facility	1/month	24-h composite	2.4
Other Y-12 Complex point and area source discharges				
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-h composite	0.18
S19 (302)[a]	Rogers Quarry	1/month	24-h composite	0.22
Y-12 Complex instream locations				
BCK 4.55 (304)[a]	Bear Creek, complex exit (west)	1/week	7-day composite	1.9
Station 17	East Fork Poplar Creek, complex exit (east)	1/week	7-day composite	0.91
200	North/south pipes	1/week	24-h composite	43.2
Y-12 Complex Sanitary sewer				
SS6	East End Sanitary Sewer Monitoring Station	1/week	7-day composite	0.87

[a]Outfall identifications were changed by the NPDES permit effective July 1, 1995. Former outfall identifications are shown here in parentheses.

the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek, and at the westernmost monitoring station, at Bear Creek kilometer (BCK) 4.55 (the former NPDES outfall 304), was 169 kg, or 0.077 Ci (Table 6.6). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams per liter) by the average flow (million gallons per day). Converting units and multiplying by 365 days per year yields the calculated discharge.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 Complex to discharge wastewater to be treated at the Oak Ridge publicly owned treatment works through the East End Sanitary Sewer Monitoring Station, also

Table 6.6. Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 2001–2005

Year	Quantity released Ci[a]	Kg
Station 17		
2001	0.043	82
2002	0.062	140
2003	0.073	167
2004	0.067	161
2005	0.043	93
Outfall 304		
2001	0.065	136
2002	0.070	141
2003	0.078	179
2004	0.133	142
2005	0.034	76

[a]1 Ci = 3.7×10^{10} Bq.

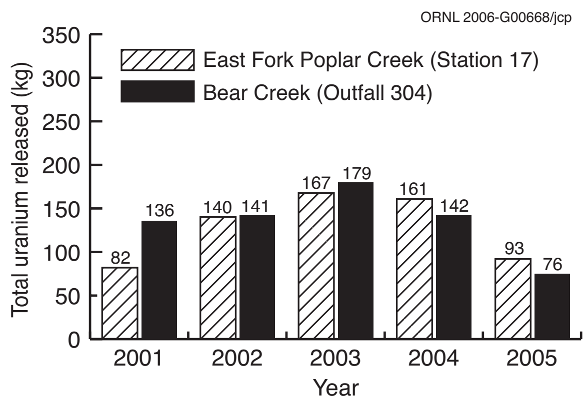

Fig. 6.6. Five-year trend of Y-12 Complex release of uranium to surface water.

identified as SS6 (Fig. 6.5). Compliance samples are collected there. Results of radiological monitoring are reported to the city of Oak Ridge in quarterly monitoring reports.

Table 6.7 presents a summary of 2005 storm water data that exceeded screening levels. More detailed results are given in *Environmental Monitoring on the Oak Ridge Reservation: 2005 Results* (DOE 2006a). (See http://www.ornl.gov/aser.) Uranium remains the dominant radiological constituent and increases during storm flow. This increase is likely due to increased groundwater flow and storm water runoff from historically contaminated areas.

6.5 Nonradiological Liquid Discharges—Y-12 Complex Surface Water and Liquid Effluents

The current Y-12 NPDES permit, issued on April 28, 1995, and effective on July 1, 1995, requires sampling, analysis, and reporting for approximately 90 outfalls. Major outfalls are noted in Fig. 6.7. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, the Y-12 Complex has outfalls and monitoring points in the following water drainage areas: East Fork Poplar Creek, Bear Creek, and several unnamed tributaries on the south side of Chestnut Ridge. These creeks and tributaries eventually drain to the Clinch River.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, steam condensate, and treated process wastewaters, including effluents from wastewater treatment facilities. Groundwater inflow into sumps in building basements and infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared with NPDES limits if a limit exists for each parameter. Some parameters, defined as “monitor only,” have no specified limits.

The water quality of surface streams in the vicinity of the Y-12 Complex is affected by current and historical legacy operations. Discharges from the Y-12 Complex processes flow into East Fork Poplar Creek before the water exits the Y-12 Complex. East Fork Poplar Creek eventually flows through the city of Oak Ridge to Poplar Creek and into the Clinch River. Bear Creek water quality is affected by area source runoff and groundwater discharges. The NPDES permit requires regular monitoring and storm water characterization in Bear Creek and several of its tributaries.

The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit emphasizes storm water runoff and biological, toxicological, and radiological monitoring. Some of the requirements in the permit and the status of compliance are as follows:

- chlorine limitations based on water quality criteria (TDEC 2004) at the headwaters of East Fork Poplar Creek (monitoring ongoing);
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge (monitoring ongoing);
- a radiological monitoring plan requiring monitoring and reporting of uranium and other isotopes at pertinent locations (see Sect. 6.4);
- implementation of a storm water pollution prevention plan and sampling and characterization of storm water at a minimum of 25 locations per year (see Sect. 6.5.2);
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 7 million gal/day (26.5 million L/day) is guaranteed by adding raw water from the Clinch River to the headwaters of East Fork Poplar Creek (see Sect. 6.5.4);
- toxicity limitation for the headwaters of East Fork Poplar Creek (see Sect. 6.6); and
- quarterly toxicity testing at the wastewater treatment facilities and storm drain locations (see Sect. 6.6).

An agreed-to consent order, dated September 27, 1999, resolved outstanding appeals to the NPDES permit by deleting mercury monitoring requirements and instream limits from the permit and deferring them to the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) program. The CERCLA record of decision will define any mercury remediation requirements

Table 6.7. Summary of storm water data above screening levels at the Y-12 Complex

	Outfalls																			
Parameters	017	021	034	042	045	046	047	054	064	102	113	135	200	Sta. 8	S02	S05	S11	S17	S24	S26
Alpha activity															X				X	X
Beryllium																	X			
Chromium			X														X		X	X
Copper		X			X	X	X	X		X	X	X	X				X		X	X
E. coli		X		X	X	X	X	X	X	X			X			X		X	X	
Fecal coliform						X							X						X	
Iron																	X		X	X
Lead																	X			
Manganese	X	X			X	X	X	X		X			X	X	X	X	X	X	X	X
Mercury					X		X		X				X	X			X		X	X
Nitrate as nitrogen																X				
Phosphorus		X			X	X				X			X				X		X	X
Titanium																	X		X	X
Total suspended solids					X	X		X	X	X			X				X		X	X
Uranium-234															X					
Uranium-238															X					
Zinc		X			X	X	X	X	X	X		X	X				X			X
PCB						X	X													

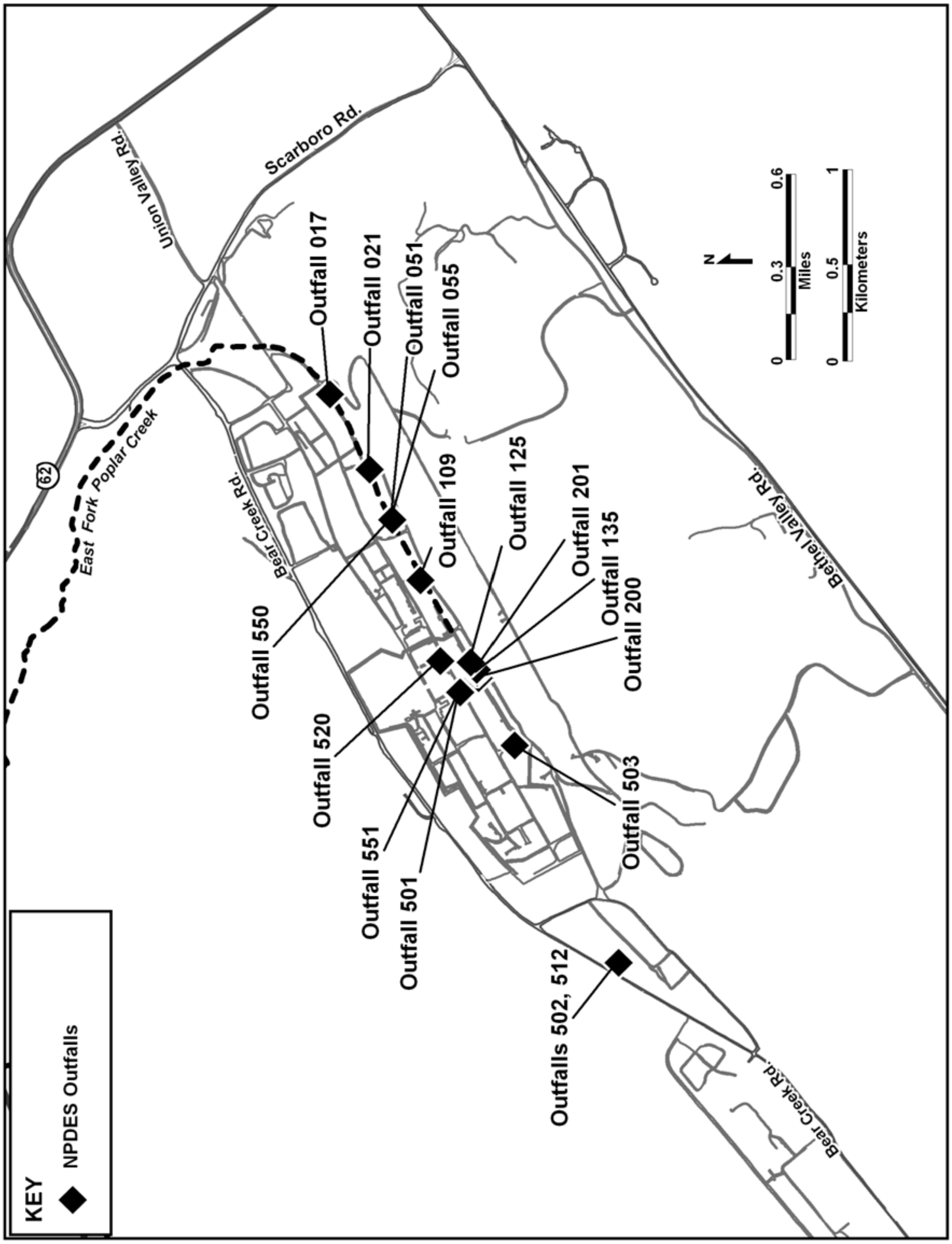

Fig. 6.7. Major Y-12 Complex NPDES outfalls.

for East Fork Poplar Creek. As required, an NPDES permit application was submitted in October 1999, six months prior to the expiration date of the current permit (April 28, 2000). Since April 28, 2000, the Y-12 Complex has continued operation under the current permit. In late 2004, personnel from the TDEC Division of Water Pollution Control initiated efforts related to renewal of the permit.

6.5.1 Sanitary Wastewater

Sanitary wastewater from the Y-12 Complex is discharged to the city of Oak Ridge publicly owned treatment works under Industrial and Commercial Users Wastewater Permit Number 1-91. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants. During 2005, the wastewater flow in this system averaged about 600,000 gal/day.

Compliance sampling is conducted at the East End Sanitary Sewer Monitoring Station (SS-6, Fig. 6.5) weekly. This monitoring station is also used for 24-h flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel use this monitoring station to perform compliance monitoring as required by pretreatment regulations.

6.5.2 Storm Water

The development and implementation of a storm water pollution prevention plan (BWXT 2002) at the Y-12 Complex is designed to minimize the discharge of pollutants in storm water runoff. The plan identifies areas that can reasonably be expected to contribute contaminants to surface water bodies via storm water runoff and describes the development and implementation of storm water management controls to reduce or eliminate the discharge of such pollutants. This plan requires (1) characterization of storm water by sampling during storm events, (2) implementation of measures to reduce storm water pollution, (3) facility inspections, and (4) employee training.

Storm water outfalls at the Y-12 Complex are located in subbasins (drainage areas) and are routinely sampled as required by the NPDES permit. The outfalls are categorized into four categories based on characteristics of the discharged water and are grouped within each category based on similarity as to land use of area drained and possible pollutants. A full chemical and radiological characterization of the discharge during a rain event is not required of all storm water outfalls each year. Representative sampling is permitted due to similarity within the same outfall groupings. A minimum of 25 storm water outfalls is required to be sampled and characterized each year during storm events, including both grab and composite sampling.

During 2005 approximately 3500 data points were generated from storm water samples at the Y-12 Complex. By assessing the quality of storm water discharges from the site and by determining potential sources of pollutants affecting storm water, effective controls can be identified and put into place to reduce or eliminate the pollutant sources.

The storm water pollution prevention plan is reviewed at least annually and is updated as necessary to reflect changes in operations and to incorporate revised monitoring strategies based on data from past years. The most recent revision of this plan was issued in November 2002.

6.5.3 Results and Progress in Implementing Corrective Actions

In 2005, the Y-12 Complex experienced eight NPDES excursions. Three were deviations from the monthly average. Table 6.8 lists the NPDES compliance monitoring requirements and 2005 compliance record. Appendix E provides additional detail on the NPDES compliance.

During 2005, the Y-12 Complex experienced one exceedance of the Industrial and Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge publicly owned treatment works. Table 6.9 lists the Industrial and Commercial Users Wastewater Permit compliance monitoring requirements and the 2005 compliance record.

Review of storm water data from past years indicates that pollutant loads increase during storm events and that water quality may be affected by uncovered scrap metal storage sites. For example, some outfalls are showing levels above screening limits of total suspended solids, fecal coliform, PCBs, and metals during storm

Table 6.8. NPDES compliance monitoring requirements and record for the Y-12 Complex, January through December 2005

Discharge point	Effluent parameter	Effluent limits: Daily avg (lb/d)[a]	Daily max (lb/d)[a]	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall 066	pH, standard units			*b*	9.0	*c*	0
Outfall 068	pH, standard units			*b*	9.0	*c*	0
Outfall 117	pH, standard units			*b*	9.0	*c*	0
Outfall 073	pH, standard units			*b*	9.0	*c*	0
	Total residual chlorine				0.5	*c*	0
Outfall 077	pH, standard units			*b*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 122	pH, standard units			*b*	9.0	*c*	0
	Total residual chlorine				0.5	*c*	0
Outfall 133	pH, standard units			*b*	9.0	*c*	0
	Total residual chlorine				0.5	*c*	0
Outfall 125	pH, standard units			*b*	9.0	100	12
	Total residual chlorine				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*b*	9.0	100	46
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*b*	10.0	100	4
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*b*	9.0	100	119
	Total residual chlorine				0.5	100	75
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*b*	10.0	100	24
Outfall S19 (Rogers Quarry)	pH, standard units			*b*	9.0	100	13
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			*b*	9.0	100	151
	Total residual chlorine				0.5	100	142

Table 6.8. (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)[a]	Daily max (lb/d)[a]	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 201	Total residual chlorine		8.5	0.011	0.019	100	156
(below the	Temperature, degrees C			*b*	30.5	100	156
North/South pipes)	pH, standard units			*b*		100	156
	NOEC *Ceriodaphnia*[d]				100	80	5
	NOEC Fathead minnows[d]				100	100	4
Outfall 200 (North/ South pipes)	Hexane extractable material			10	15	100	157
Outfall 021	Total residual chlorine			0.080	0.188	100	158
	Temperature, degrees C			*b*	30.5	100	158
	pH, standard units				9.0	100	158
Outfall 017	pH, standard units			*b*	9.0	100	53
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*b*	9.0	100	104
	Mercury				0.004	99	104
	Total residual chlorine				0.5	100	101
Outfall 55A	pH, standard units			*b*	9.0	*c*	0
	Mercury				0.004	*c*	0
Outfall 550	pH, standard units			*b*	9.0	100	52
	Mercury			0.002	0.004	100	52
Outfall 551	pH, standard units				9.0	100	46
	Mercury			0.002	0.004	90	46
Outfall 051	pH, standard units			*b*	9.0	100	105
Outfall 501	pH, standard units			*b*	9.0	100	1
(Central	Total suspended solids			31.0	40.0	100	1
Pollution Control	Total toxic organics				2.13	100	1
Facility)	Oil and grease			10	15	100	1
	Cadmium	0.16	0.4	0.075	0.15	100	1
	Chromium	1.0	1.7	0.5	1.0	100	1
	Copper	1.2	2.0	0.5	1.0		1
	Lead	0.26	0.4	0.1	0.2	100	1
	Nickel	1.4	2.4	2.38	3.98	100	1
	Nitrate/nitrite				100		1
	Silver	0.14	0.26	0.05	0.05	100	1
	Zinc	0.9	1.6	1.48	2.0	100	1
	Cyanide	0.4	0.72	0.65	1.20		1
	PCB				0.001		1

Table 6.8. (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)[a]	Daily max (lb/d)[a]	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 502 (West End Treatment Facility)	pH, standard units			*b*	9.0	100	15
	Total suspended solids	18.6	36.0	31.0	40.0	100	15
	Total toxic organics				2.13	100	3
	Nitrate/nitrite			100	150	100	15
	Hexane extractables			10	15	100	15
	Cadmium	0.16	0.4	0.075	0.15	100	15
	Chromium	1.0	1.7	0.5	1.0	100	15
	Copper	1.2	2.0	0.5	1.0	100	15
	Lead	0.26	0.4	0.10	0.20	100	15
	Nickel	1.4	2.4	2.38	3.98	100	15
	Silver	0.14	0.26	0.05	0.05	100	15
	Zinc	0.9	1.6	1.48	2.0	100	15
	Cyanide	0.4	0.72	0.65	1.20	100	15
	PCB				0.001	100	3
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			*b*	9.0	*c*	0
	Total suspended solids	125	417	30.0	40.0	*c*	0
	Oil and grease	62.6	83.4	10	15	*c*	0
	Iron	4.17	4.17	1.0	1.0	*c*	0
	Cadmium			0.075	0.15	*c*	0
	Chromium	0.83	0.83	0.20	0.20	*c*	0
	Copper	4.17	4.17	0.20	0.40	*c*	0
	Lead			0.10	0.20	*c*	0
	Zinc	4.17	4.17	1.0	1.0	*c*	0
Outfall 512 (Groundwater Treatment Facility)	pH, standard units			*b*	9.0	100	121
	Iron				1.0	100	120
	PCB				0.001	100	12
Outfall 520	pH, standard units				9.0	100	18
Outfall 05A	pH, standard units				9.0	*c*	0

[a] 1 lb = 2.205 kg.

[b] Not applicable.

[c] No discharge.

[d] The no-observed-effect concentration (NOEC) is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms during a 6- or 7-day test.

Table 6.9. Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6, January through December 2005

Effluent parameter	Number of samples	Daily average value (effluent limit)[a]	Daily maximum value (effluent limit)[b]	Percentage of compliance
Flow, mgd	365	*c*	1.4	99
pH, standard units	51	*c*	9/6[d]	100
Silver	52	0.05	0.1	100
Arsenic	52	0.01	0.015	100
Benzene	12	0.01	0.015	100
Biochemical oxygen demand	52	200	300	100
Cadmium	52	0.0033	0.005	100
Chromium	52	0.05	0.075	100
Copper	52	0.14	0.21	100

Table 6.9. (continued)

Effluent parameter	Number of samples	Daily average value (effluent limit)[a]	Daily maximum value (effluent limit)[b]	Percentage of compliance
Cyanide	12	0.041	0.062	100
Iron	52	10	15	100
Mercury	52	0.023	0.035	100
Kjeldahl nitrogen	52	45	90	100
Methylene chloride	12	0.027	0.041	100
Nickel	52	0.021	0.032	100
Oil and grease	52	25	50	100
Lead	52	0.049	0.074	100
Phenols—total recoverable	52	0.3	0.5	100
Suspended solids	52	200	300	100
Toluene	12	0.01	0.02	100
Trichloroethene	12	0.018	0.027	100
Zinc	52	0.35	0.75	100

[a]Units in milligrams per liter unless otherwise indicated.
[b]Industrial and Commercial Users Wastewater Permit limits.
[c]Not applicable.
[d]Maximum value/minimum value.

events (see Table 6.7). However, some monitored pollutants are not present at specific outfalls. Detailed storm water data summary tables are given in *Environmental Monitoring on the Oak Ridge Reservation: 2005 Results* (DOE 2006a). (See http://www.ornl.gov/aser/.)

6.5.4 Flow Management (or Raw Water)

Because of concern about maintaining water quality and stable flow in the upper reaches of East Fork Poplar Creek, the NPDES permit requires addition of Clinch River water to the headwaters of East Fork Poplar Creek (North/South Pipe-outfall 200 area) so that a minimum flow of 7 million gal/day is maintained at the point where East Fork Poplar Creek leaves the reservation (Station 17). The permit required that this project be implemented by March 1997, but the work was completed ahead of schedule (August 1996). With the completion of the project, instream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters).

During CY 2005 the flow of Upper East Fork Poplar Creek was maintained in accordance with the permit conditions. The average daily flow during CY 2005 was 8.4 million gal/day.

6.5.5 Mercury Removal from Storm Drain Catch Basins

In May 2003, metallic mercury was observed in two storm drain catch basins located in the west end of the Y-12 Complex. The storm drain line on which the catch basins are located flows into East Fork Poplar Creek at outfall 200. Mercury tends to collect at these low spots in the drain system following heavy rains. During 2005, Y-12 spill response and waste services personnel conducted seven removals and recovered an estimated 12 lb of mercury. A total of 53 lb have been recovered since 2003 and recovery of mercury is expected to continue in 2006.

6.6 Biomonitoring Program

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a biomonitoring program is required that evaluates an East Fork Poplar Creek instream monitoring location (outfall 201), wastewater treatment system discharges, and locations in the storm drain system. Table 6.10 summarizes the results of biomonitoring tests conducted during 2005 on effluent samples from wastewater treatment systems and storm drainage systems. The results of the

Table 6.10. Y-12 Complex Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 2005[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Central Mercury Treatment System (551)	1/6/05	*Ceriodaphnia*	>100	0.11
Storm sewer D3321	1/7/05	*Ceriodaphnia*	61.4	*d*
Storm sewer D3353	1/7/05	*Ceriodaphnia*	70.7	*d*
Groundwater Treatment Facility (512)	1/11/05	*Ceriodaphnia*	17.3	0.06
Storm sewer D2236	1/11/05	*Ceriodaphnia*	13.7	*d*
Storm sewer D2236 (dechlorinated)	1/11/05	*Ceriodaphnia*	>100	*d*
Storm sewer D2321	1/11/05	*Ceriodaphnia*	24.8	*d*
Storm sewer D2321 (dechlorinated)	1/11/05	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (512)	4/13/05	*Ceriodaphnia*	>100	0.13
Storm sewer D2236	4/13/05	*Ceriodaphnia*	31.4	*d*
Storm sewer D2236 (dechlorinated)	4/13/05	*Ceriodaphnia*	40.5	*d*
Storm sewer D2321	4/13/05	*Ceriodaphnia*	70.7	*d*
Storm sewer D2321 (dechlorinated)	4/13/05	*Ceriodaphnia*	74.3	*d*
Storm sewer D3321	4/15/05	*Ceriodaphnia*	12.1	*d*
Storm sewer D3321 (dechlorinated)	4/15/05	*Ceriodaphnia*	71.8	*d*
Storm sewer D3353	4/15/05	*Ceriodaphnia*	>100	*d*
Central Mercury Treatment System (551)	4/19/05	*Ceriodaphnia*	>100	0.10
Central Pollution Control Facility	6/22/05	*Ceriodaphnia*	>100	0.13
Outfall 520	6/27/05	*Ceriodaphnia*	15.0	*e*
Outfall 520	7/8/05	*Ceriodaphnia*	17.8	*e*
Groundwater Treatment Facility (512)	7/13/05	*Ceriodaphnia*	>100	0.05
Storm sewer D4010 (150)	7/14/05	*Ceriodaphnia*	22.6	*d*
Storm sewer D4010 (150) (dechlorinated)	7/14/05	*Ceriodaphnia*	>100	*d*
Storm sewer D4004 (160)	7/14/05	*Ceriodaphnia*	25.5	*d*
Central Mercury Treatment System (551)	7/15/05	*Ceriodaphnia*	>100	0.34
Storm sewer 9422-12	7/19/05	*Ceriodaphnia*	74.3	*d*
Storm sewer 9422-12 (dechlorinated)	7/19/05	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-15	7/19/05	*Ceriodaphnia*	70.7	*d*
Storm sewer 9422-15 (dechlorinated)	7/19/05	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (512)	11/15/05	*Ceriodaphnia*	93.8	0.09
Storm sewer D4010 (150)	11/17/05	*Ceriodaphnia*	50.0	*d*
Storm sewer D4010 (150) (dechlorinated)	11/17/05	*Ceriodaphnia*	94.8	*d*
Storm sewer D4004 (160)	11/17/05	*Ceriodaphnia*	34.2	*d*
Storm sewer D3311 (163)	11/22/05	*Ceriodaphnia*	70.7	*d*
Storm sewer D3311 (163) (dechlorinated)	11/22/05	*Ceriodaphnia*	70.7	*d*
Storm sewer E3411 (169)	11/22/05	*Ceriodaphnia*	>100	*d*
Storm sewer E3411 (169) (dechlorinated)	11/22/05	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (502)	12/7/05	*Ceriodaphnia*	44.6	0.95

[a]Summarized are the effluents and their corresponding 48-h LC_{50}s and instream waste concentrations. Note: Discharges from treatment facilities are intermittent because of batch operations.

[b]The concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 48 h.

[c]IWC = instream waste concentration based on actual flows at Station 17 in East Fork Poplar Creek.

[d]This point is in the storm sewer system; therefore, an IWC is not applicable.

[e]Effluent flowrates are unavailable.

biomonitoring tests are expressed as the concentration of effluent that is lethal to 50% of the test organisms (LC_{50}) during a 48-h period. Thus, the lower the value, the more toxic an effluent. The LC_{50} is compared with the effluent's calculated instream waste concentration to determine the likelihood that the discharged effluent would be harmful to aquatic life in the receiving stream. If the LC_{50} is much greater than the instream waste concentration, it is less likely that there is an instream impact.

Effluent samples from the four wastewater treatment system discharges were tested on *Ceriodaphnia dubia* at least once during 2005. With LC_{50}s greater than 100% in each of three tests, effluents from the Central Mercury Treatment System were consistently nontoxic throughout the year. Effluent from the Groundwater Treatment Facility varied in toxicity, with LC_{50}s ranging from 17.3% to greater than 100% in four 2005 tests. The LC_{50}s for effluents from the West End Treatment Facility and the Central Pollution Control Facility were 44.6% and >100%, respectively, from the single tests conducted on effluent from each of these facilities during 2005. In all cases, the calculated instream waste concentrations of the effluent were less than the LC_{50}s, suggesting that effluents from the individual treatment facilities would not be acutely toxic to the aquatic life of East Fork Poplar Creek.

Various locations in the storm drainage system upstream of outfalls 200 and 201 were also monitored during the year. When chlorine or similar chemicals (e.g., bromine) were detected in a sample, side-by-side tests were conducted with a sample that was treated (dechlorinated) to remove the chlorine or chlorine-like chemical. In all cases where toxicity was detected in the nontreated sample (LC_{50} less than 100%), survival was higher in the dechlorinated sample than in the nontreated sample. In many cases, the full-strength dechlorinated sample did not continue to reduce *Ceriodaphnia* survival, indicating that toxicity was due solely to chlorine or similar chemicals. Because flow is not measured at these storm-drain points, it is not possible to know the contribution of each to the total flow at outfall 201 (i.e., the instream waste concentration). It is notable, however, that the results of the biomonitoring tests at outfall 201 (Table 6.11) demonstrated that when all discharges were combined (treated effluent, storm sewer contribution, plus flow management water) the result was generally an absence of toxicity at outfall 201.

Table 6.11. Y-12 Complex Biomonitoring Program summary information for outfall 201 for 2005[a]

Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
1/6	*Ceriodaphnia*	80	>100
	Fathead minnow	100	>100
1/21[d]	*Ceriodaphnia*	100	>100
4/2	*Ceriodaphnia*	100	>100
	Fathead minnow	100	>100
7/13	*Ceriodaphnia*	100	>100
	Fathead minnow	100	>100
10/6	*Ceriodaphnia*	100	>100
	Fathead minnow	100	>100

[a]Summarized are the no-observed-effect concentrations (NOECs) and the 96-h LC_{50}s for the instream monitoring location, outfall 201.

[b]NOEC as a percentage of full-strength effluent from outfall 201 diluted with laboratory control water. The NOEC must equal one of the test concentrations and is the concentration that does not reduce *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

[c]The concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

[d]Confirmatory toxicity test conducted in response to January 6, 2005 test results.

Table 6.11 summarizes the no-observed-effect concentrations (NOECs) and 96-hour LC_{50}s for the instream monitoring location outfall 201. The NOEC is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms during a 6- or 7-day test. Thus, like the LC_{50}, the lower the value, the more toxic the effluent. Water from the instream monitoring point, outfall 201, was tested four times in 2005 using fathead minnow larvae (*Pimephales promelas*) and five times using *Ceriodaphnia dubia*. The NOECs were 100% for all *Ceriodaphnia* and fathead minnow tests, with the exception of the January 6, 2005 *Ceriodaphnia* test which had an NOEC of 80%; the 96-h LC_{50}s were consistently greater than 100% for both *Ceriodaphnia* and fathead minnows.

6.7 Biological Monitoring and Abatement Programs

The NPDES permit issued to the Y-12 Complex in 1995 mandates a biological monitoring and abatement program (BMAP) with the objective of demonstrating that the effluent limitations established for the facility protect the classified uses of the receiving stream, East Fork Poplar Creek. The BMAP consists of four major tasks that reflect complementary approaches to evaluating the effects of Y-12 Complex discharges on the aquatic integrity of East Fork Poplar Creek. These tasks are (1) toxicity monitoring; (2) biological indicator studies; (3) bioaccumulation studies; and (4) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

Monitoring is currently being conducted at five primary East Fork Poplar Creek sites, although sites may be excluded or added, depending upon the specific objectives of the various tasks. The primary sampling sites include upper East Fork Poplar Creek at East Fork Poplar Creek kilometer (EFK) 24.4 and 23.4 (upstream and downstream of Lake Reality, respectively); EFK 18.7 (also EFK 18 and 19), located off the ORR and below an area of intensive commercial and light industrial development; EFK 13.8 (also EFK 14), located upstream from the Oak Ridge Wastewater Treatment Facility; and EFK 6.3, located approximately 1.4 km below the ORR boundary (Fig. 6.8). Brushy Fork at Brushy Fork kilometer (BFK) 7.6 is used as a reference stream in most tasks of the BMAP. Additional sites off the ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Cox Creek, Hinds Creek, Paint Rock Creek, and the Emory River in Watts Bar Reservoir (Fig. 6.9).

Trends of increases in species richness and diversity at upstream locations over the last decade, along with similar but more subtle trends in a number of other BMAP indicators, demonstrate that the overall ecological health of East Fork Poplar Creek continues to improve. However, the pace of improvement in the health of East Fork Poplar Creek has slowed in recent years, and fish and invertebrate communities continue to be degraded in comparison with similar communities in reference streams.

6.7.1 Toxicity Monitoring

Toxicity monitoring employs EPA-approved methods with *Ceriodaphnia dubia* and fathead minnows to provide systematic information that is used to verify the biological water quality of East Fork Poplar Creek at intervals throughout the year. *Ceriodaphnia* tests were conducted quarterly in 2005 for one site upstream of Bear Creek Road (EFK 24.1). In addition, quarterly toxicity tests with both fathead minnows and *Ceriodaphnia* were conducted at outfall 201 as required by the Y-12 Complex's NPDES permit. Because of the close proximity of outfall 201 (an instream NPDES location in Upper East Fork Poplar Creek) to EFK 25.1, the tests of water from outfall 201 also met the intent of the Y-12 BMAP Plan (Adams et al. 2000) to conduct quarterly toxicity tests at the latter location.

No evidence of toxicity was observed in the 2005 *Ceriodaphnia* tests of EFK 24.1 or fathead minnow tests of outfall 201. One 2005 *Ceriodaphnia* test of outfall 201 demonstrated toxicity through a decrease in reproduction in full-strength effluent, but no toxicity was detected in a follow-up test conducted a few weeks later. These results are generally consistent with the findings of previous *Ceriodaphnia* and fathead minnow tests conducted since flow management began in the latter half of 1996. Toxicity of East Fork Poplar Creek water was detected in other 2005 chronic tests involving fish embryos and clams, which appear more sensitive to water quality conditions in the stream. Fish embryo-larval test results are discussed in Sect. 6.7.3; clam tests are discussed in Sect. 6.7.4.

6.7.2 Bioaccumulation Studies

Mercury and PCBs have been historically elevated in East Fork Poplar Creek fish relative to fish in uncontaminated reference streams. Fish are monitored regularly in East Fork Poplar Creek for mercury and PCBs to assess spatial and temporal trends in bioaccumulation associated with ongoing remedial activities and plant operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*) were sampled twice

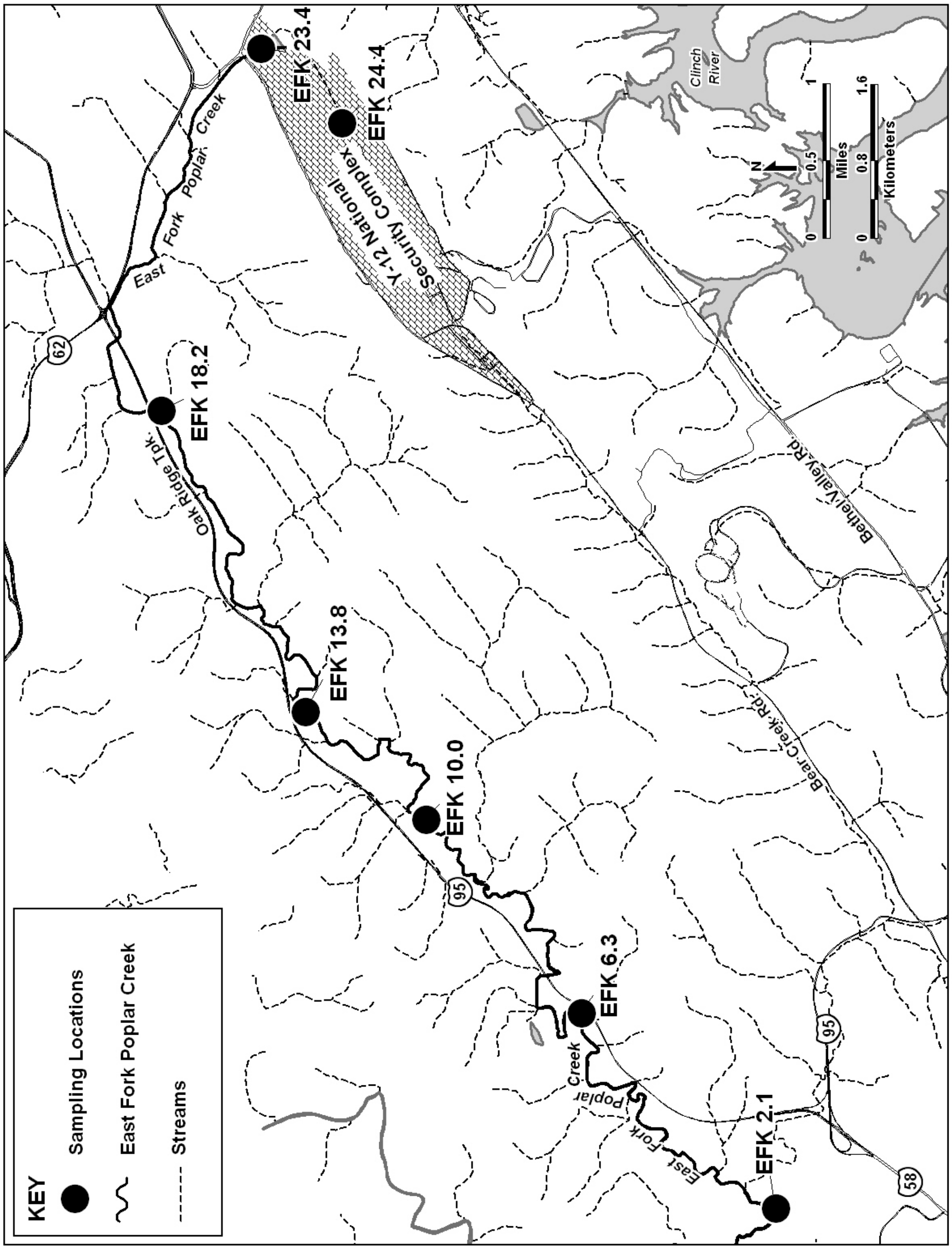

Fig. 6.8. Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex. (EFK = East Fork Poplar Creek kilometer.)

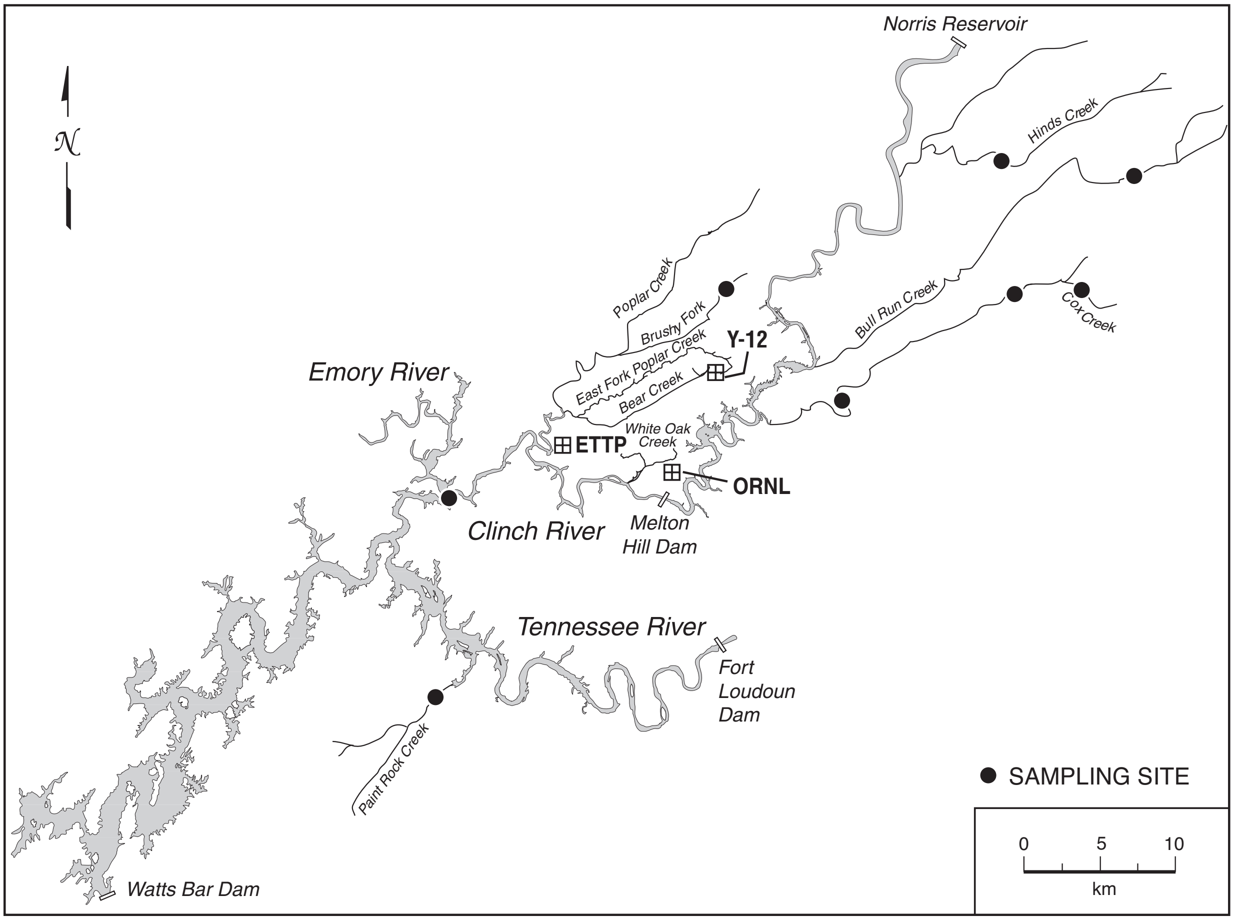

Fig. 6.9. Locations of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex.

during 2005 from the middle to upper reaches of East Fork Poplar Creek and were analyzed for tissue concentrations of the two environmental contaminants. Largemouth bass (*Micropterus salmoides*) were collected once in 2005 from a site in Upper East Fork Poplar Creek (EFK 23.4) to monitor maximum bioaccumulation in larger piscivorous fish of the system. Large scale stoneroller minnows (*Campostoma oligolepis)* were collected from EFK 24.5 to evaluate potential ecological concerns associated with the accumulation of other metals by these prey fish.

Mercury concentrations remained much higher during 2005 in fish from East Fork Poplar Creek than in fish from reference streams. Elevated mercury concentrations in fish from the upper reaches of East Fork Poplar Creek indicate that the Y-12 Complex remains a continuing source of mercury to fish in the stream. Although concentrations have leveled off in recent years, mercury concentrations in water in the upper reaches of East Fork Poplar Creek have decreased significantly over the last fifteen years. In contrast, mercury concentrations in fish have remained relatively constant since the late 1980s (Fig. 6.10). PCB concentrations measured in East Fork Poplar Creek sunfish during 2005 were within ranges typical of past monitoring efforts at these sites, although mean concentrations at EFK 23.4 appear to be trending downward over time (Fig. 6.11).

6.7.3 Biological Indicator Studies

The biological indicator task is designed to evaluate the effects of water quality and other environmental variables on the health and reproductive condition of individual fish and fish

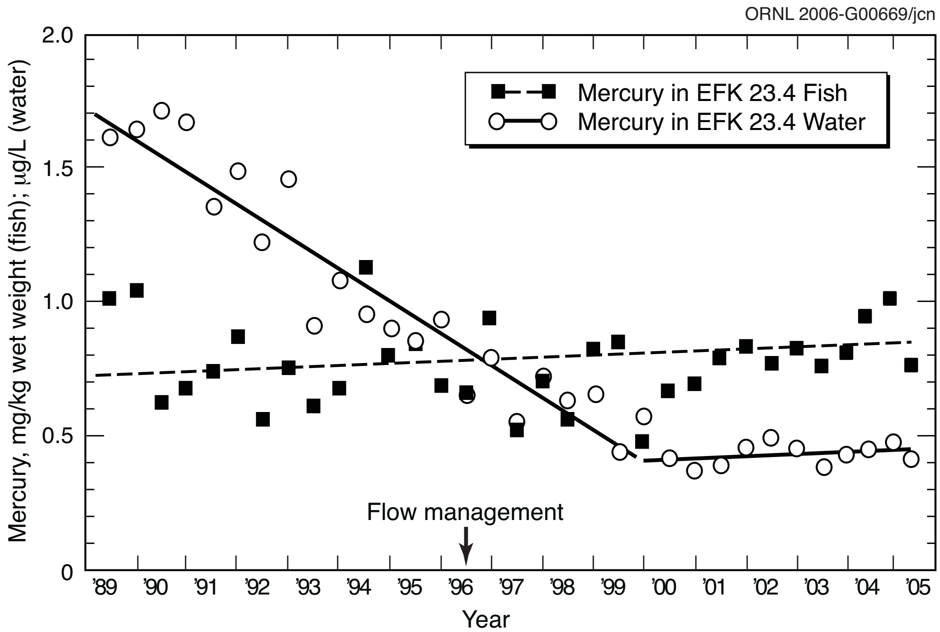

Fig. 6.10. Semiannual average mercury concentration in muscle fillets of redbreast sunfish and water in East Fork Poplar Creek at Station 17 through spring 2005. (EFK = East Fork Poplar Creek kilometer.)

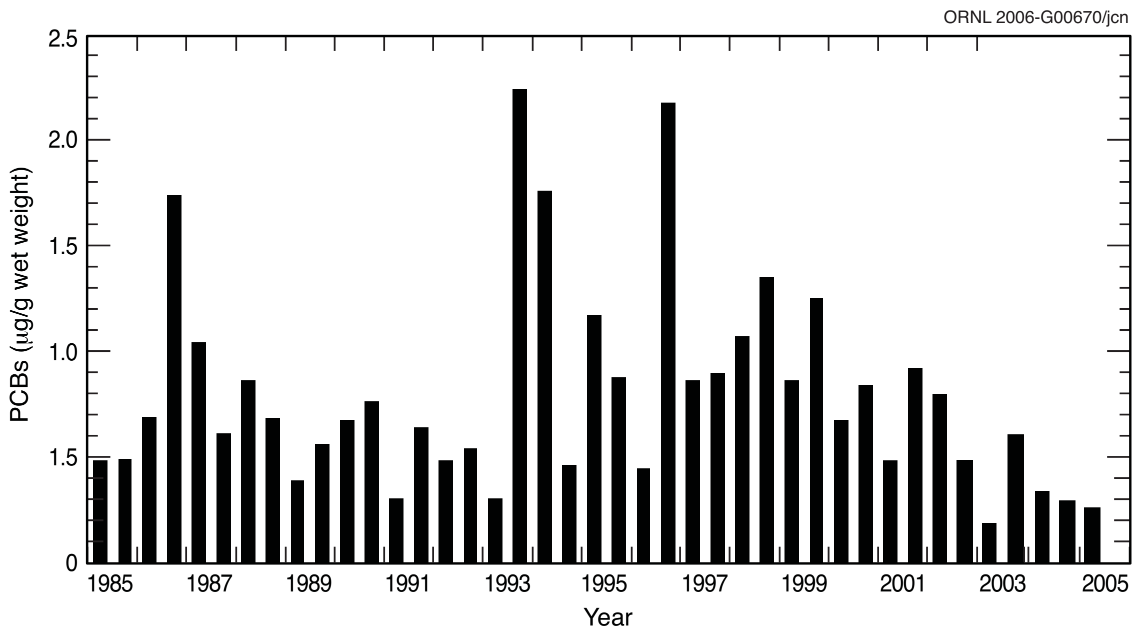

Fig. 6.11. Mean concentrations of PCBs in redbreast sunfish muscle fillets in East Fork Poplar Creek at Station 17 through spring 2005.

populations in East Fork Poplar Creek. Redbreast sunfish and rock bass were sampled from three sites in East Fork Poplar Creek and from two reference streams in the spring of 2005 prior to the onset of the breeding season. A fish embryo-larval test using the medaka (*Oryzias latipes*), a small model fish, was conducted on water from several sites in East Fork Poplar Creek in order to test the ability of young fish to successfully develop in the stream.

Overall trends in many contamination-related bioindicators suggest that there has been measurable improvement in overall fish health in Upper East Fork Poplar Creek in recent years.

However, the health and reproductive condition of fish from upstream East Fork Poplar Creek sites remain lower in many respects than in fish from reference sites or downstream East Fork Poplar Creek sites (see Fig. 6.12 for example of decreasing bioenergetic condition of rock bass moving upstream toward the Y-12 Complex). Furthermore, the abundance of redbreast sunfish, which is not native to the region, continues to decline in both East Fork Poplar Creek and reference streams.

Water from East Fork Poplar Creek upstream of the Oak Ridge Wastewater Treatment Facility adversely affected fish embryos in two of four medaka embryo-larval toxicity tests conducted during 2005 (Table 6.12), demonstrating an improvement in the results of these tests from the previous year.

6.7.4 Ecological Surveys

Periphyton was monitored twice during 2005 from three sites along East Fork Poplar Creek. Algal biomass (Table 6.13) and photo synthetic rates remained higher in East Fork Poplar Creek than in reference streams.

Table 6.12. Results of medaka development toxicity tests conducted on water from ambient sites in East Fork Poplar Creek, 2005

Embryo larval survival (%)

Sample[a]	Quarter			
	First	Second	Third	Fourth
Control	92	96	100	96
EFK 25.1	71	63[b]	55[b]	83
EFK 24.6	75	67[b]	70[b]	96
EFK 23.4	83	42[b]	100	79
EFK 18.2	92	83	90	87
EFK 13.8	100	100	75	87
EFK 10.0	42[b]	21[b]	10[b]	46[b]
EFK 6.3	42[b]	8[b]	15[b]	33[b]

[a]EFK = East Fork Poplar Creek kilometer.
[b]Significant difference from control at $p = 0.05$.

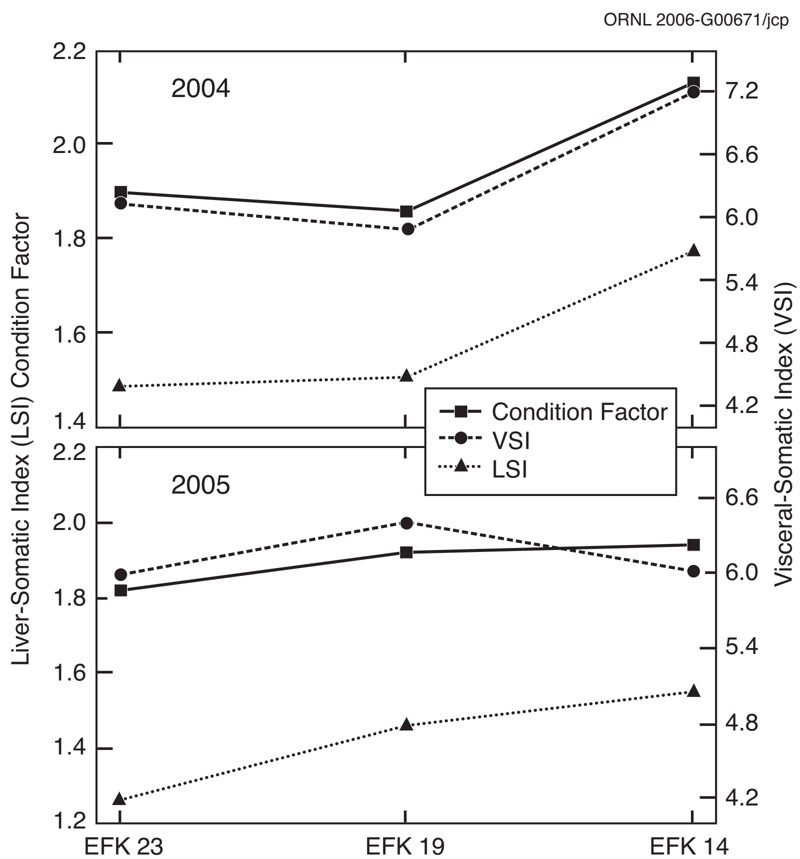

Fig. 6.12. Downstream trends in three bioindicators of fish health in rock bass sampled in 2004 and 2005 from East Fork Poplar Creek. (EFK = East Fork Poplar Creek kilometer.)

Table 6.13. Biomass of periphyton sampled from sites on East Fork Poplar Creek and Brushy Fork, 2005

Algal biomass (μg/Chla/cm)[a]

Sample[b]	Season	
	Spring	Fall
EFK 24.4	30.0 ± 14.6	39.5 ± 7.8
EFK 23.4	37.7 ± 27.3	31.9 ± 10.5
EFK 6.3	9.9 ± 4.4	34.7 ± 6.9
BFK 7.6	12.6 ± 5.2	26.5 ± 10.8

[a]Chla = chlorophyll *a*
[b]EFK = East Fork Poplar Creek kilometer
BFK = Brushy Fork kilometer

Fish communities were monitored in the spring and fall of 2005 at five sites along East Fork Poplar Creek and at two reference streams. Over the past two decades, overall species richness, density, and the number of pollution-sensitive fish species have increased at all sampling locations below Lake Reality (Fig. 6.13). However, improvement in the fish community of East Fork Poplar Creek has slowed in recent years, particularly at sites closest to the Y-12 Complex. Despite improvements, the fish community continues to lag behind reference stream communities in most important metrics of fish diversity and community structure.

Benthic macroinvertebrate communities were monitored at three sites in East Fork Poplar Creek and at two reference streams in the spring of 2005. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded compared with reference communities, especially in the richness of pollution-sensitive community taxa (Fig. 6.14). The pace of improvement in benthic macroinvertebrate communities has slowed in recent years at these sites in the upper reaches of East Fork Poplar Creek.

The effects of in situ exposure on clam growth and survival were tested during 2005 at three sites in East Fork Poplar Creek and at three

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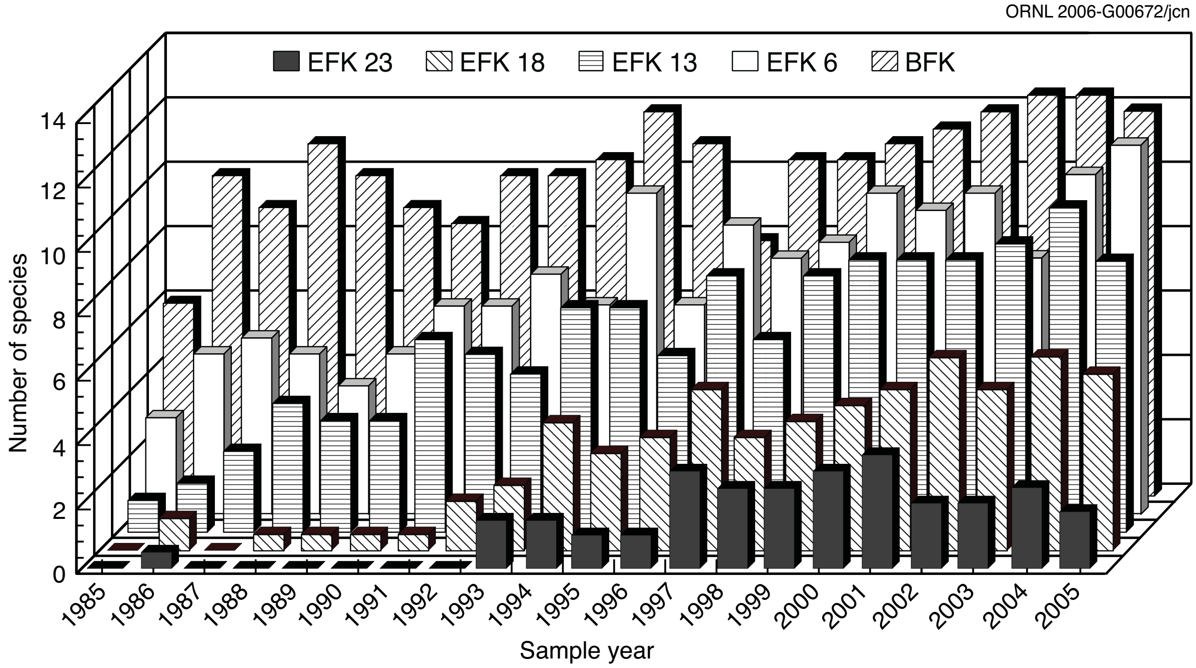

EFK = East Fork Poplar Creek kilometer; BFK = Brushy Fork kilometer.

Fig. 6.13. Comparison of mean abundance of sensitive fish species collected during each year from 1985 through 2005 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork).

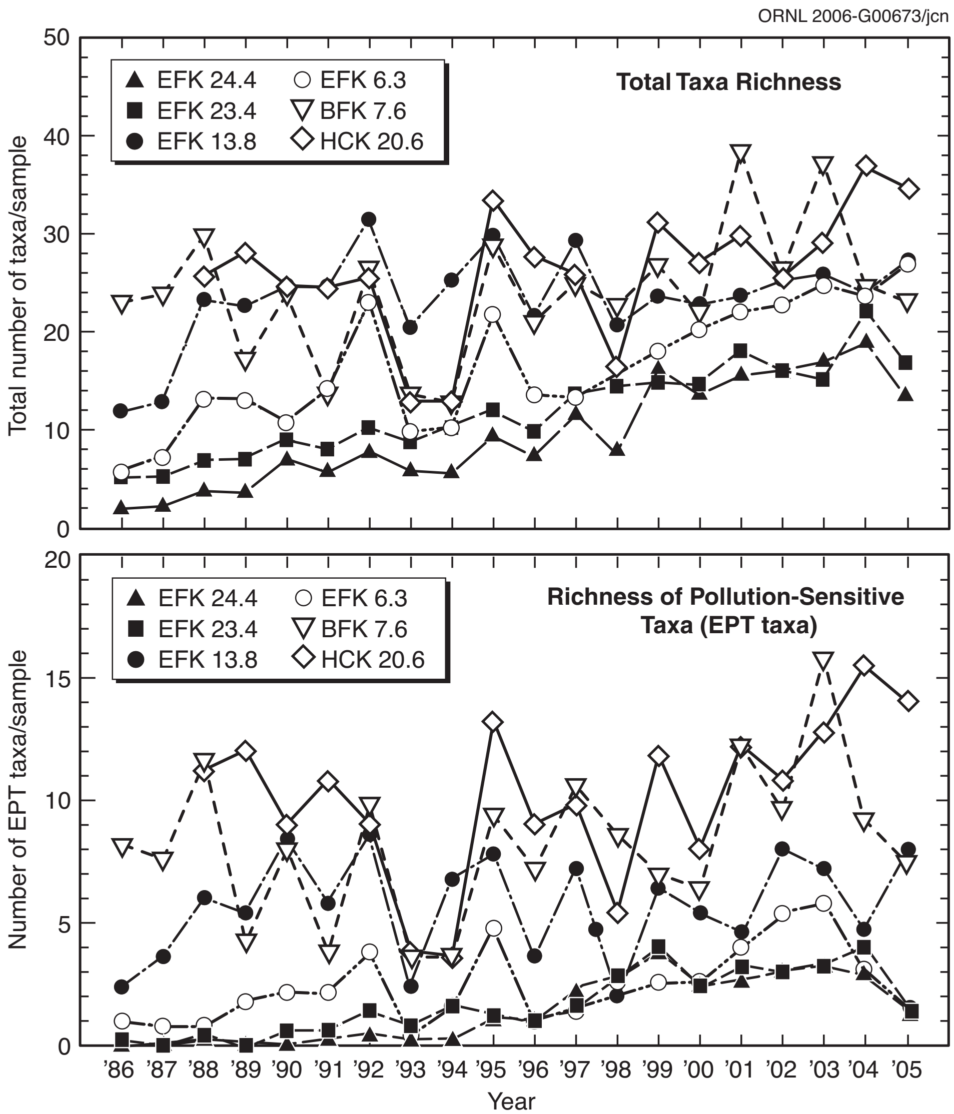

Fig. 6.14. Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities in East Fork Poplar Creek and two reference sites, one on Brushy Fork and one on Hinds Creek (BFK 7.6 and HCK 20.6). (BFK = Brushy Fork kilometer; EFK = East Fork Poplar Creek kilometer; HCK = Hinds Creek kilometer.

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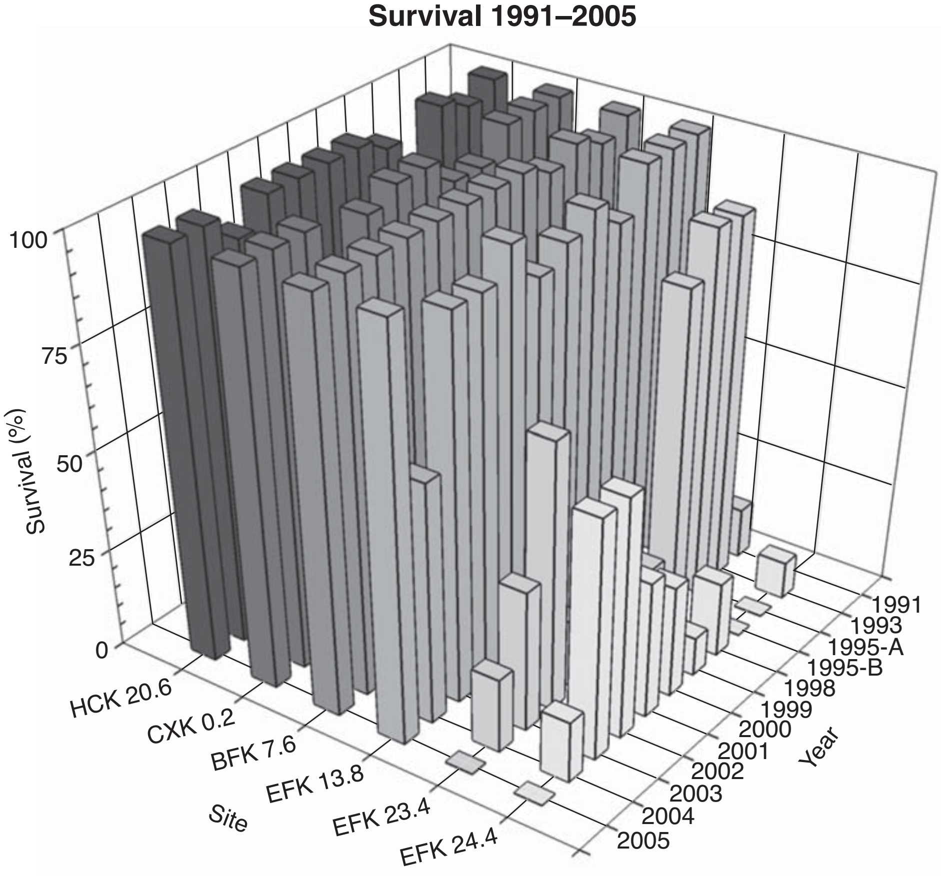

Fig. 6.15. Growth and survival of fingernail clams in in situ bioassays in East Fork Poplar Creek, 1991–2005.

reference streams. In contrast with previous tests conducted in recent years, all clams placed at EFK 23.4 and EFK 24.4 died within the first 3-week exposure period (Fig. 6.15). In comparison, all clams placed at EFK 13.8 and in the reference streams survived through this initial exposure period. This 2005 clam test was stopped after only 3 weeks as a result of the premature deaths of test organisms at the upstream sites.

6.8 Y-12 Complex Ambient Surface Water Monitoring

Routine surface water surveillance monitoring, above and beyond that required by the NPDES permit, is performed as a best management practice. The Y-12 Environmental Compliance Department staff monitor the surface water as it exits from each of the three hydrogeologic regimes that serve as exit pathways for surface water (Fig. 6.16).

Monitoring is conducted in East Fork Poplar Creek at Station 17 (9422-1), near the junction of Scarboro and Bear Creek roads. The current sampling program consists of one 7-day composite each week. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and total suspended solids. Monitoring is conducted in Bear Creek at BCK 4.55 (former NPDES Station 304), which is at the western boundary of the Y-12 Complex area of responsibility. A surveillance sample (a 7-day composite sample) is collected monthly for analysis for mercury; anions (sulfate, chloride, nitrate, nitrite); ICP metals; total phenols; and total suspended solids.

The exit pathway from the Chestnut Ridge Hydrogeologic Regime is monitored via NPDES location S19 (former NPDES Station 302) at Rogers Quarry. S19 is an instream location of McCoy Branch and is sampled monthly (a 24-h composite) for ICP metals. The NPDES

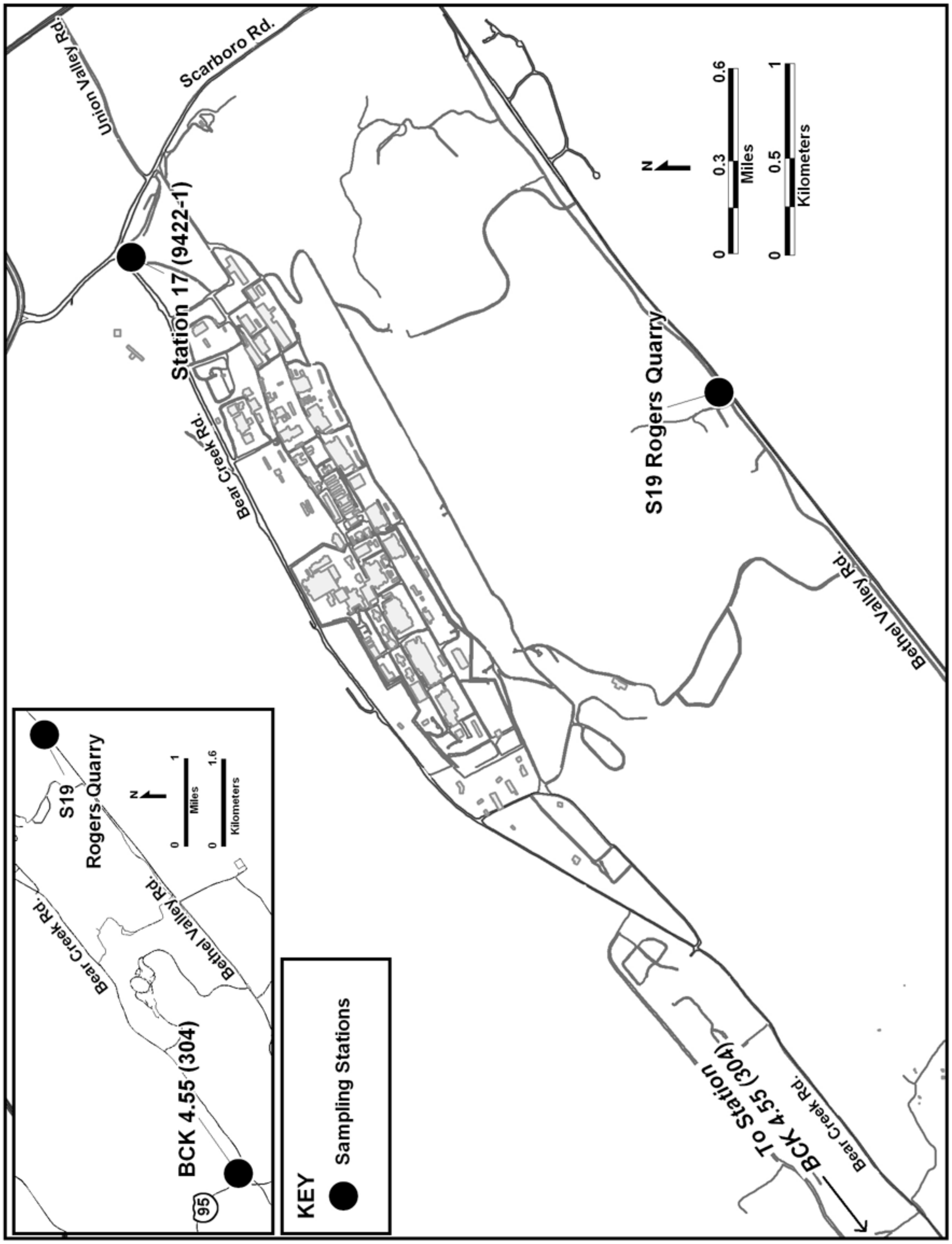

Fig. 6.16. Locations of Y-12 Complex surface water surveillance sampling stations.

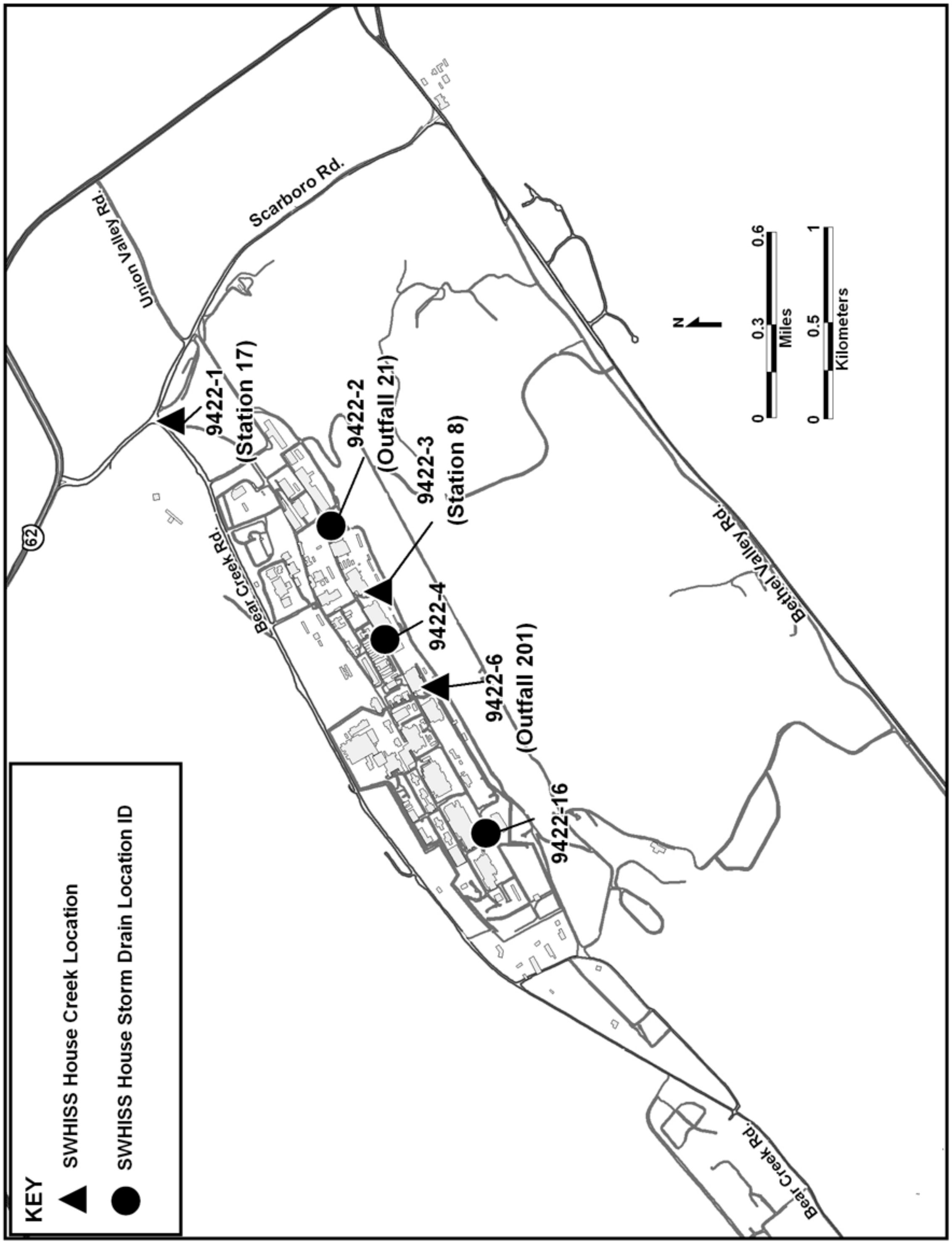

Fig. 6.17. Surface Water Hydrological Information Support System (SWHISS) monitoring locations.

requirement for this location other than a pH limit is to monitor and report metals data only.

In addition to those exit pathway locations, a network of real-time monitors is located at instream locations along Upper East Fork Poplar Creek and at key points on the storm drain system that flows to the creek. The Surface Water Hydrological Information Support System is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 6.17. Not all locations or parameters are operated on a routine basis.

For nonradiological parameters that are sampled and detected above the analytical method reporting detection limit, the data are compared with Tennessee water quality criteria (TDEC 2004). The most restrictive of either the "freshwater fish and aquatic life criterion maximum concentration" or the "recreation concentration for organisms only" standard is used. This comparison serves as a record of water quality, and the comparison to state water quality criteria limits is for informational purposes only; as such, no attempt is made to achieve the lowest possible detection limit for all parameters.

More than 4000 surface water surveillance samples were collected in 2005. Comparisons with Tennessee water quality criteria indicate that only mercury, chromium, zinc, and copper from samples collected at Station 17 were detected at values exceeding a criteria maximum. Results are shown in Table 6.14. Of all the parameters measured in the surface water as a best management practice, mercury is the only demonstrated contaminant of concern.

Additional surface-water sampling is conducted on Bear Creek in accordance with the Y-12 Groundwater Protection Program to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 6.10.4.3).

6.9 Y-12 Sediment Sampling

Historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in sediment. Therefore, as a best management practice, the Y-12 Complex maintains an annual sampling program to determine whether these constituents are accumulating in the sediments of East Fork Poplar Creek and Bear Creek as a result of Y-12 Complex discharges. Results of the most recent monitoring activity are given in Table 6.15. The monitoring results indicate that the radiological levels, including isotopes of uranium and thorium, have not significantly changed.

This activity is also used to comply with DOE Order 5400.5, which states in Chapter II.3.a.2 that measures be taken to prevent the buildup of radionuclides in sediments caused by releases of waste streams to natural waterways. The order limits the amount of activity that may be present in released settleable solids. Because waste streams from the Y-12 Complex have very low settleable-solid contents, this sampling program to measure activity in the sediments of East Fork Poplar Creek and Bear Creek is used to determine whether a buildup of radionuclide concentrations is occurring.

6.10 Groundwater Monitoring at the Y-12 Complex

More than 200 sites have been identified at the Y-12 Complex that represent known or potential sources of contamination to the environment as a result of past waste management practices. Figure 6.18 depicts the major facilities considered as known and/or potential contaminant source areas for which groundwater moni-

Table 6.14. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Complex, 2005[a]

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number exceeding criteria
			Detection limit	Max	Avg		
Chromium	Station 17	111	0.02	0.15	<0.02	0.016	1
Copper	Station 17	111	0.02	0.0575	<0.02	0.0177	2
Mercury	Station 17	360	0.0002	0.0182	<0.0005	0.000051	339
Zinc	Station 17	111	0.05	0.344	<0.06	0.12	3

[a]TDEC. 2004. *General Water Quality Criteria, Criteria of Water Uses—Toxic Substances*. TDEC 1200-4-.03 (j). Tennessee Department of Environment and Conservation Tennessee Water Quality Control Board, Division of Water Pollution Control. Revised January 2004.

Table 6.15. Results of Y-12 Complex sediment monitoring[a]

	2001	+/–	MDA	2002	+/–	MDA	2003	+/–	MDA	2005	+/–	MDA
Station 17												
^{226}Ra (pCi/g)	0.96	0.91	0.065	0.053	0.056	0.56	0.42	0.32	1.3	0.28	0.79	0.065
^{228}Th (pCi/g)	0.039	0.056	0.098	0.00063	0.0035	0.0058	0.46	0.24	0.19	0.44	0.13	0.067
^{230}Th (pCi/g)	0.11	0.064	0.062	–0.015	0.006	0.0057	0.77	0.4	0.15	0.26	0.11	0.092
^{232}Th (pCi/g)	0.042	0.043	0.062	0.0020	0.0029	0.0044	0.36	0.2	0.15	0.34	0.11	0.037
^{234}U (pCi/g)	1.5	0.26	0.063	0.25	0.039	0.0054	0.81	0.21	0.060	1.2	0.29	0.11
^{235}U (pCi/g)	0.050	0.041	0.023	0.012	0.0078	0.0072	0.047	0.057	0.062	0.1	0.071	0.070
^{238}U (pCi/g)	1.2	0.22	0.044	0.31	0.044	0.0054	1.2	0.26	0.050	1.2	0.26	0.050
Mercury (μg/g)	6.67			8.14			37.1			31.5		
Total PCBs (μg/kg)	270			1400			310			330		
BCK 9.4												
^{226}Ra (pCi/g)	1.0	0.77	0.075	0.26	0.096	0.31	–0.16	0.1	1.2	0.45	0.16	2
^{228}Th (pCi/g)	0.51	0.13	0.038	0.51	0.07	0.0075	0.52	0.17	0.10	0.51	0.15	0.071
^{230}Th (pCi/g)	0.21	0.075	0.016	0.21	0.038	0.0074	0.39	0.2	0.088	0.25	0.11	0.098
^{232}Th (pCi/g)	0.41	0.11	0.016	0.37	0.055	0.0043	0.25	0.11	0.069	0.37	0.12	0.040
^{234}U (pCi/g)	1.1	0.21	0.083	2.1	0.21	0.0043	3.9	0.53	0.056	0.19	0.077	0.058
^{235}U (pCi/g)	0.11	0.061	0.022	0.10	0.022	0.0051	0.25	0.11	0.047	0.063	0.037	0.013
^{238}U (pCi/g)	2.5	0.37	0.042	4.1	0.4	0.0045	8.2	0.96	0.050	9	0.96	0.052
Mercury (μg/g)	0.187			0.277			0.167			0.169		
Total PCBs (μg/kg)	550			590			490			640		

[a]MDA = minimum detectable activity.

1 pCi = 3.7×10^{-2} Bq.

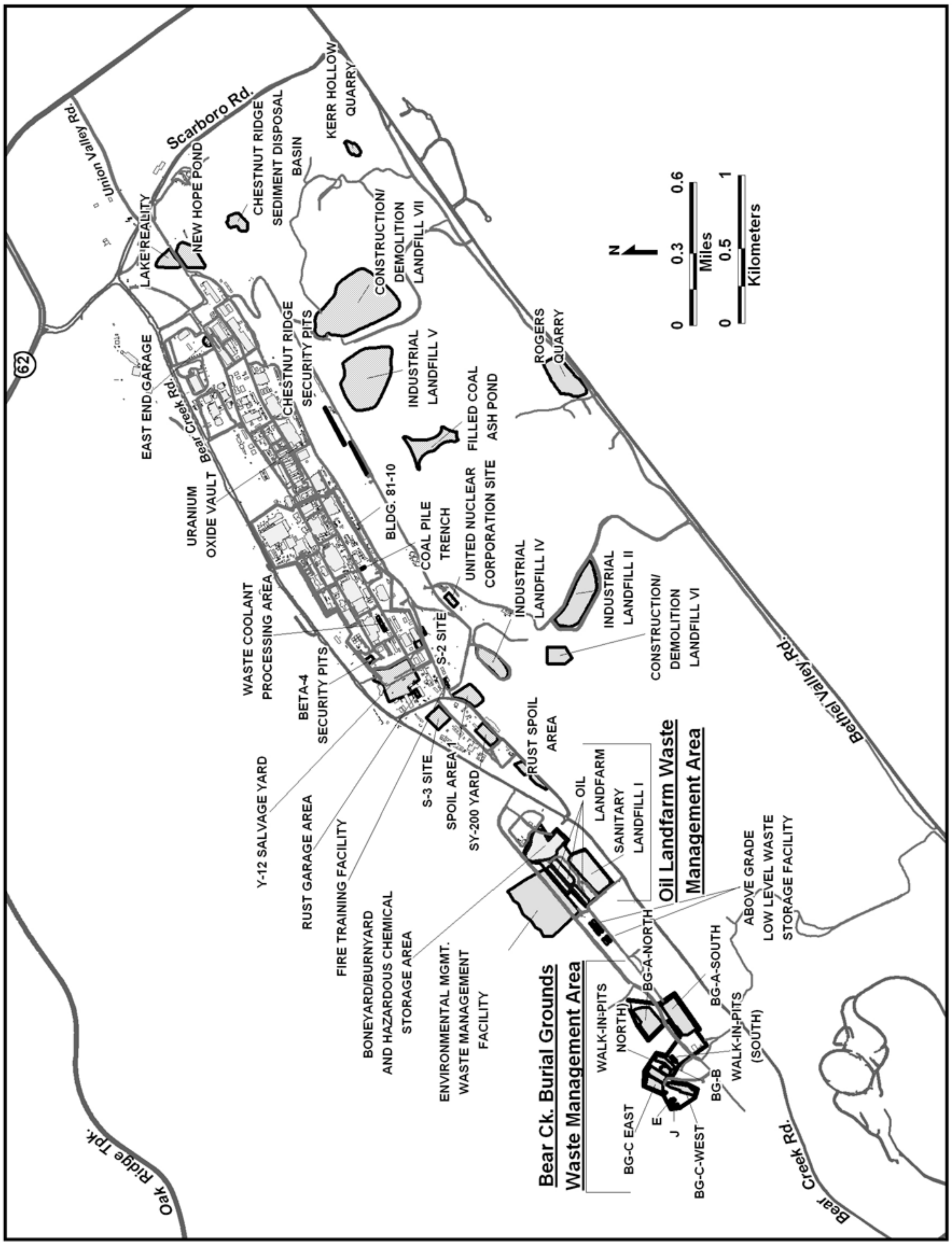

Fig. 6.18. Known or potential contaminant sources for which groundwater monitoring was performed on the Y-12 Complex during CY 2005.

toring was performed during CY 2005. Because of that contamination, extensive groundwater monitoring is performed to comply with regulations and DOE orders.

During CY 2005, routine groundwater monitoring at Y-12 was conducted primarily by two programs, the Y-12 Groundwater Protection Program, managed by BWXT Y-12 LLC, and the Water Resources Restoration Program, managed by BJC. Each program is responsible for monitoring groundwater to meet specific compliance requirements. In CY 2005, the Groundwater Protection Program performed monitoring to comply with DOE orders, while the Water Resources Restoration Program performed groundwater monitoring in compliance with CERCLA and the Resource Conservation and Recovery Act (RCRA). In addition to the monitoring performed by the Water Resources Restoration Program, BJC monitors groundwater at the solid waste disposal landfills on Chestnut Ridge and the EMWMF, in Bear Creek Valley.

Although the Groundwater Protection Program, the Water Resources Restoration Program, and other projects have differing technical objectives and responsibilities, considerable efforts are made to maintain consistency in groundwater monitoring activities at the Y-12 Complex. Communication among the programs has been crucial in eliminating any redundancies in monitoring activities. In addition, communication and cooperation provided for more consistent and efficient data collection, evaluation, and overall quality. All groundwater monitoring data obtained by all programs are evaluated to provide a comprehensive view of groundwater quality at the Y-12 Complex.

6.10.1 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes, which are delineated by surface water drainage patterns, topography, and groundwater flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime, the Upper East Fork Poplar Creek Hydrogeologic Regime, and the Chestnut Ridge Hydrogeologic Regime (Fig. 6.19). Most of the Bear Creek and Upper East Fork Poplar Creek regimes are underlain by the ORR Aquitards. The southern portion of these two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer (Fig. 1.6). In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek regime and the Upper East Fork regime is divergent from a topographic and groundwater divide located near the western end of the Y-12 Complex that defines the boundary between the two regimes (Fig. 6.19). In addition, flow converges on the primary surface streams (Bear Creek and Upper East Fork Poplar Creek) from Pine Ridge and Chestnut Ridge. In the Chestnut Ridge regime, a groundwater divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs located in Bethel Valley to the south and Bear Creek Valley to the north.

In Bear Creek Valley, groundwater in the intermediate and deep intervals moves predominantly through fractures in the ORR Aquitards, converging on and then moving through fractures and solution conduits in the Maynardville Limestone. Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels the valley and geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the ORR Aquitards (< 1 ft/year) but can be quite rapid within solution conduits in the Maynardville Limestone (tens to thousands of feet per day).

The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has been estimated to be very slow below the water table interval. Most contaminant migration appears to be via surface tributaries to Bear Creek or along utility traces and buried tributaries in the Upper East Fork regime. In the Bear Creek regime, strike-parallel transport of some contaminants can occur within the ORR aquitards for significant distances. Continuous elevated levels of nitrate within the ORR Aquitards are known to extend east and west from the S-3 Site for thousands of feet. Volatile organic compounds at source units in the ORR Aquitards, however, tend to remain close to source areas because they tend to adsorb

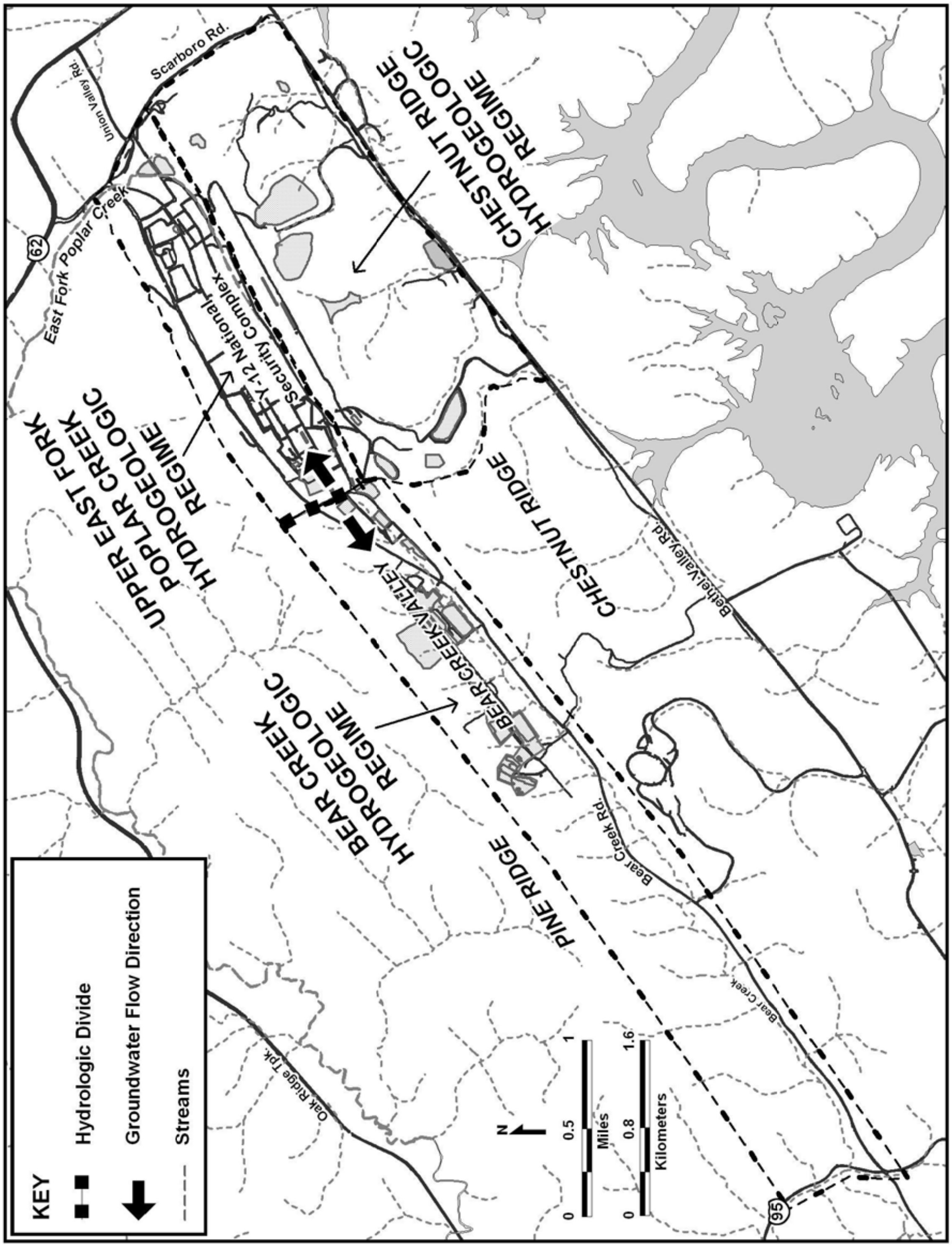

Fig. 6.19. Hydrogeologic regimes at the Y-12 Complex.

to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport occurs for long distances. Regardless, extensive volatile organic compound contamination occurs throughout the groundwater system in both the Bear Creek and Upper East Fork regimes.

Groundwater flow in the Chestnut Ridge regime is primarily through fractures and solution conduits in the Knox Group. Discharge points for intermediate and deep flow are not well known. Groundwater is currently presumed to flow primarily toward Bear Creek Valley to the north and Bethel Valley to the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Following the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

6.10.2 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices are routinely used for groundwater data collection at the Y-12 Complex. Monitoring wells are permanent devices used for the collection of groundwater samples; they are installed according to established regulatory and industry specifications. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of polyvinyl chloride or other low-cost materials. Other devices or techniques are sometimes employed to gather data, including well points and push probes. In CY 2005, eight surveillance monitoring wells were installed. One was of a conventional design. The remaining seven wells consist of two coreholes with three and four dedicated BarCad™ pump systems, respectively, for vertical delineation of groundwater quality. Also, 65 piezometers/wells were installed in support of activities by the Natural and Accelerated Bioremediation Research Field Research Center at the S-3 Site. The purpose of the field research center is to provide the fundamental science that will serve as the basis for development of cost-effective bioremediation of contaminant radionuclides and metals in the subsurface at DOE sites.

Well plugging and abandonment activities are conducted to protect human health and the environment, maintain the Y-12 monitoring well network, and meet operational needs. Wells that are damaged beyond rehabilitation, that interfere with planned construction activities, or from which no useful data can be obtained, are selected for plugging and abandonment. In 2005, no wells or piezometers were plugged and abandoned.

6.10.3 CY 2005 Monitoring Program

Groundwater monitoring in CY 2005 was performed to comply with DOE orders and regulations by the Groundwater Protection Program, the Water Resources Restoration Program, and other BJC projects. Compliance requirements were met by the monitoring of 194 wells and 48 surface water locations and springs, and one building sump (Table 6.16). Figure 6.20 shows the locations of ORR perimeter/exit pathway groundwater monitoring stations as specified in the *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE 2003).

Comprehensive water quality results of monitoring activities at Y-12 in CY 2005 are presented in the annual *Groundwater Monitoring Report* (BWXT Y-12 2006).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the fiscal year (FY) 2005 and FY 2006 water resources restoration program sampling and analysis plans (BJC 2004a and BJC 2005), and the 2005 *Remediation Effectiveness Report* (DOE 2006b).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the RCRA annual reports (BJC 2006a, BJC 2006b, BJC 2006c).

6.10.4 Y-12 Groundwater Quality

Historical monitoring efforts have shown that four types of contaminants have affected groundwater quality at the Y-12 Complex: nitrate, volatile organic compounds, metals, and radionuclides. Of those, nitrate and volatile organic compounds are the most widespread. Some radionuclides, particularly uranium and ^{99}Tc, are significant, principally in the Bear Creek regime and the western and central portions of the Upper East Fork regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of

Table 6.16. Summary of CY 2005 groundwater monitoring at the Y-12 Complex

	Purpose for which monitoring was performed				
	Restoration[a]	Waste management[b]	Surveillance[c]	Other[d]	Total
Number of active wells	63	34	97	65	259
Number of other monitoring stations (e.g., springs, seeps, surface water)	27	5	16	7	55
Number of samples taken[e]	190	112	230	250	782
Number of analyses performed	9,956	8,711	26,555	3,730	48,952
Percentage of analyses that are non-detects	70.3	74.6	65.1	59.7	67.4
Ranges of results for positive detections, VOCs (μg/L)[f]					
Chloroethenes	1–4,500	0.19–7.6	1–71,000	1–1,500	
Chloroethanes	2–680	0.47–20	1–2,600	5–5	
Chloromethanes	1–2,000	7.2–12	1–1,300	6–24	
Petroleum hydrocarbons	1–10,000	0.1–0.3	1–1,700	3–3	
Uranium (mg/L)	0.00466–0.627	0.00095–0.0013	0.0005–0.338	0.05–60.36	
Nitrates (mg/L)	0.02–8,650	0.024–1.7	0.0339–4,350	2.4–23,000	
Ranges of results for positive detections, radiological parameters (pCi/L)[g]					
Gross alpha activity	1.15–775	1.8–4.9	2.2–106	NA	
Gross beta activity	2.34–13,700	1.57–18.3	4.4–5,500	NA	

[a]Monitoring to comply with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements and with Resource Conservation and Recovery Act postclosure detection and corrective action monitoring.

[b]Solid waste landfill detection monitoring and CERCLA landfill detection monitoring.

[c]DOE Order 450.1 surveillance monitoring.

[d]Research related groundwater monitoring associated with activities of the DOE Natural and Accelerated Bioremediation Research Field Research Center.

[e]The number of unfiltered samples, excluding duplicates.

[f]These ranges reflect concentrations of individual contaminants (not summed VOC concentrations):

Chloroethenes—includes tetrachloroethene, trichloroethene, 1,2-dichloroethene (*cis* and *trans*), 1,1-dichloroethene, and vinyl chloride.

Chloroethanes—includes 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane.

Chloromethanes—includes carbon tetrachloride, chloroform, and methylene chloride.

Petroleum hydrocarbon—includes benzene, toluene, ethylbenzene, and xylene.

[g]1 pCi = 3.7×10^{-2} Bq.

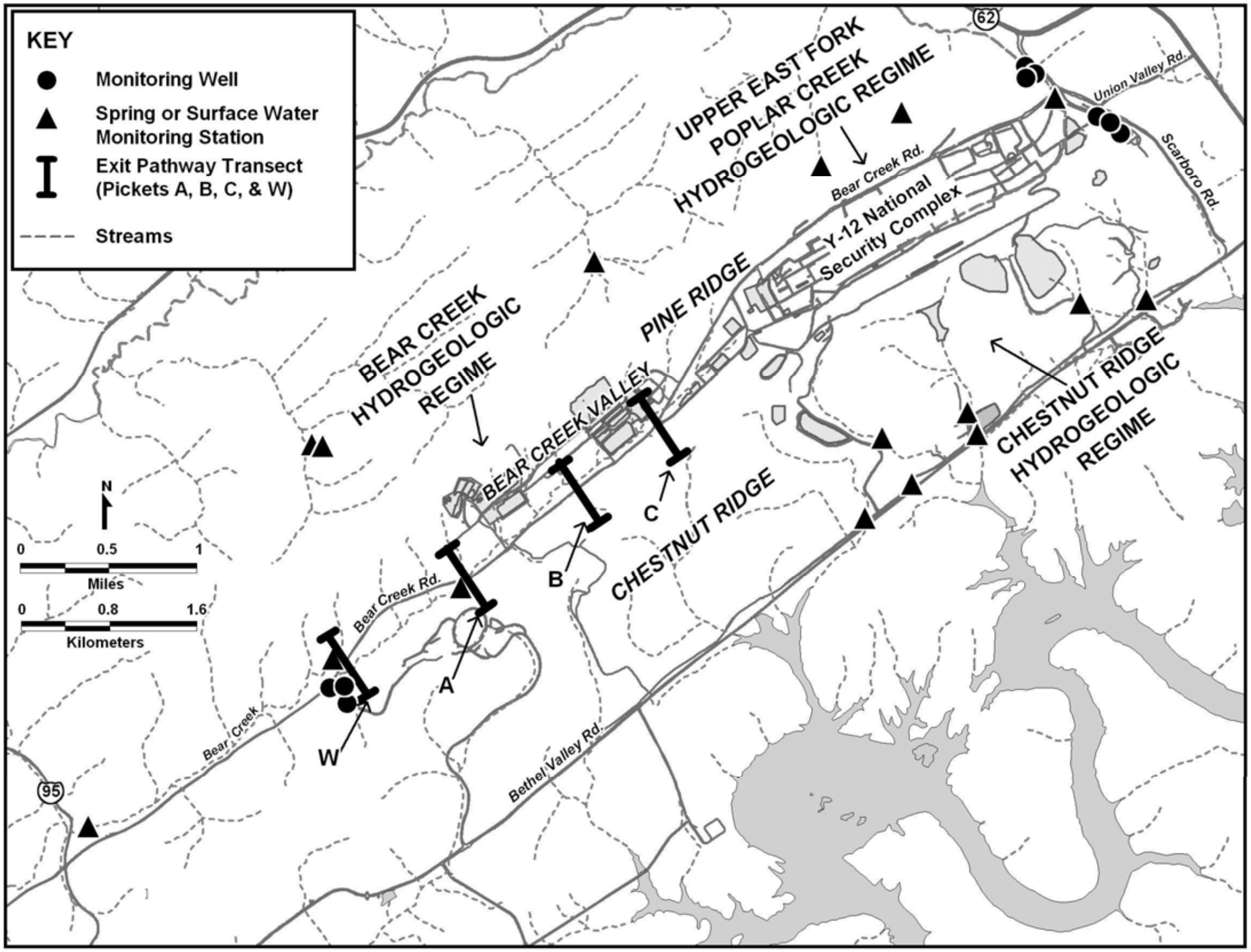

Fig. 6.20. Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring stations in the *Environmental Monitoring Plan for the Oak Ridge Reservation.* (Department of Energy Oak Ridge Office, DOE/OR/011066/R5, 2003.)

low-pH groundwater at the western end of the complex, near the S-2 and S-3 sites. Historical data have shown that plumes from multiple-source units have mixed with one another and that contaminants (other than nitrate and ^{99}Tc) are no longer easily associated with a single source.

6.10.4.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The Upper East Fork regime contains contaminant source areas and surface water and groundwater components of the hydrogeologic system within the Y-12 Complex and Union Valley to the east and off the ORR. Among the three hydrogeologic regimes on the Y-12 Complex, the Upper East Fork regime encompasses most of the known and potential sources of surface water and groundwater contamination. A brief description of waste management sites is given in Table 6.17. Chemical constituents from the S-3 Site (primarily nitrate and ^{99}Tc) dominate groundwater contamination in the western portion of the Upper East Fork regime, while groundwater in the eastern portion, including Union Valley, is predominantly contaminated with volatile organic compounds.

Table 6.17. History of waste management units and underground storage tanks included in CY 2005 groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime[a]

Site	Historical data
New Hope Pond	Built in 1963. Regulated flow of water in Upper East Fork Poplar Creek before exiting the Y-12 Complex grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. Closed under RCRA in 1990
Salvage Yard Scrap Metal Storage Area	Used from 1950 to present for scrap metal storage. Some metals contaminated with low levels of depleted or enriched uranium. Runoff and infiltration are the principal release mechanisms to groundwater
Salvage Yard Oil/Solvent Drum Storage Area	Primary wastes included waste oils, solvents, uranium, and beryllium. Both closed under RCRA. Leaks and spills represent the primary contamination mechanisms for groundwater
Salvage Yard Oil Storage Tanks	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area
Salvage Yard Drum Deheader	Used from 1959 to 1989. Sump tanks 2063-U, 2328-U, and 2329-U received residual drum contents. Sump leakage is a likely release mechanism to groundwater
Building 81-10 Area	Mercury recovery facility operated from 1957 to 1962. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury. The building structure was demolished in 1995
Rust Garage Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented
9418-3 Uranium Oxide Vault	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of nonenriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism
Fire Training Facility	Used for hands-on fire-fighting training. Sources of contamination to soil include flammable liquids and chlorinated solvents. Infiltration is the primary release mechanism to groundwater
Beta-4 Security Pits	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration
S-2 Site	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater

Table 6.17. (continued)

Site	Historical data
Waste Coolant Processing Area	Used from 1977 to 1985. Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988
East End Garage	Used from 1945 to 1989 as a vehicle fueling station. Five USTs used for petroleum fuel storage were excavated, 1989 to 1993. Petroleum releases to the groundwater are documented
Coal Pile Trench	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater

[a]Abbreviations
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
UST = underground storage tank

Plume Delineation

Sources of groundwater contaminants monitored during CY 2005 include the S-2 Site, the Fire Training Facility, the S-3 Site, the Waste Coolant Processing Facility, the 9418-3 Uranium Oxide Vault, petroleum USTs, New Hope Pond, the Beta-4 Security Pits, the Salvage Yard, and process/production buildings throughout the Y-12 Complex. Although the S-3 Site, now closed under RCRA, is located west of the current hydrologic divide that separates the Upper East Fork regime from the Bear Creek regime, it has contributed to groundwater contamination in the western part of this regime.

Nitrate

Nitrate concentrations in groundwater at the Y-12 Complex exceed the 10 mg/L drinking water standard in a large part of the western portion of the Upper East Fork regime (a complete list of national drinking water standards is presented in Appendix D). The two primary sources of nitrate contamination are the S-3 and S-2 sites. In CY 2005, groundwater containing nitrate concentrations as high as 8650 mg/L (Well GW-108) occurred in the unconsolidated zone and in shallow bedrock just east of the S-3 Site (Fig. 6.21). These results are consistent with results in previous years. The extent of the nitrate plume is essentially defined in the unconsolidated and shallow bedrock zones. An increasing trend in nitrate concentrations at monitoring wells in the eastern portion of Y-12 has been observed. This increase indicates that the nitrate plume in the Maynardville Limestone is migrating into the eastern area of the Y-12 Complex from the S-2 and/or the S-3 sites. Historical results from monitoring wells in near source areas indicate generally decreasing trends.

Trace Metals

Concentrations of barium, beryllium, cadmium, chromium, lead, mercury, nickel, thallium, and uranium exceeded drinking water standards during CY 2005 in samples collected from various monitoring wells and surface water locations downgradient of the S-2 Site, the S-3 Site, the Salvage Yard, and throughout the complex. Elevated concentrations of these metals in groundwater were most commonly observed from monitoring wells in the unconsolidated zone. Trace metal concentrations above standards tend to occur only adjacent to the source areas due to their low solubility in natural water systems. However, some metals, such as uranium and mercury, are being transported through the surface water and groundwater systems and have been observed in concentrations above the drinking water standards. Concentrations of uranium exceed the standard (0.03 mg/L) in a number of source areas (e.g., production areas, the Uranium Oxide Vault, and the Former Oil Skimmer Basin) and contribute to the uranium concentration in Upper East Fork Poplar Creek.

Volatile Organic Compounds

Because of the many legacy source areas, volatile organic compounds are the most widespread groundwater contaminants in the East

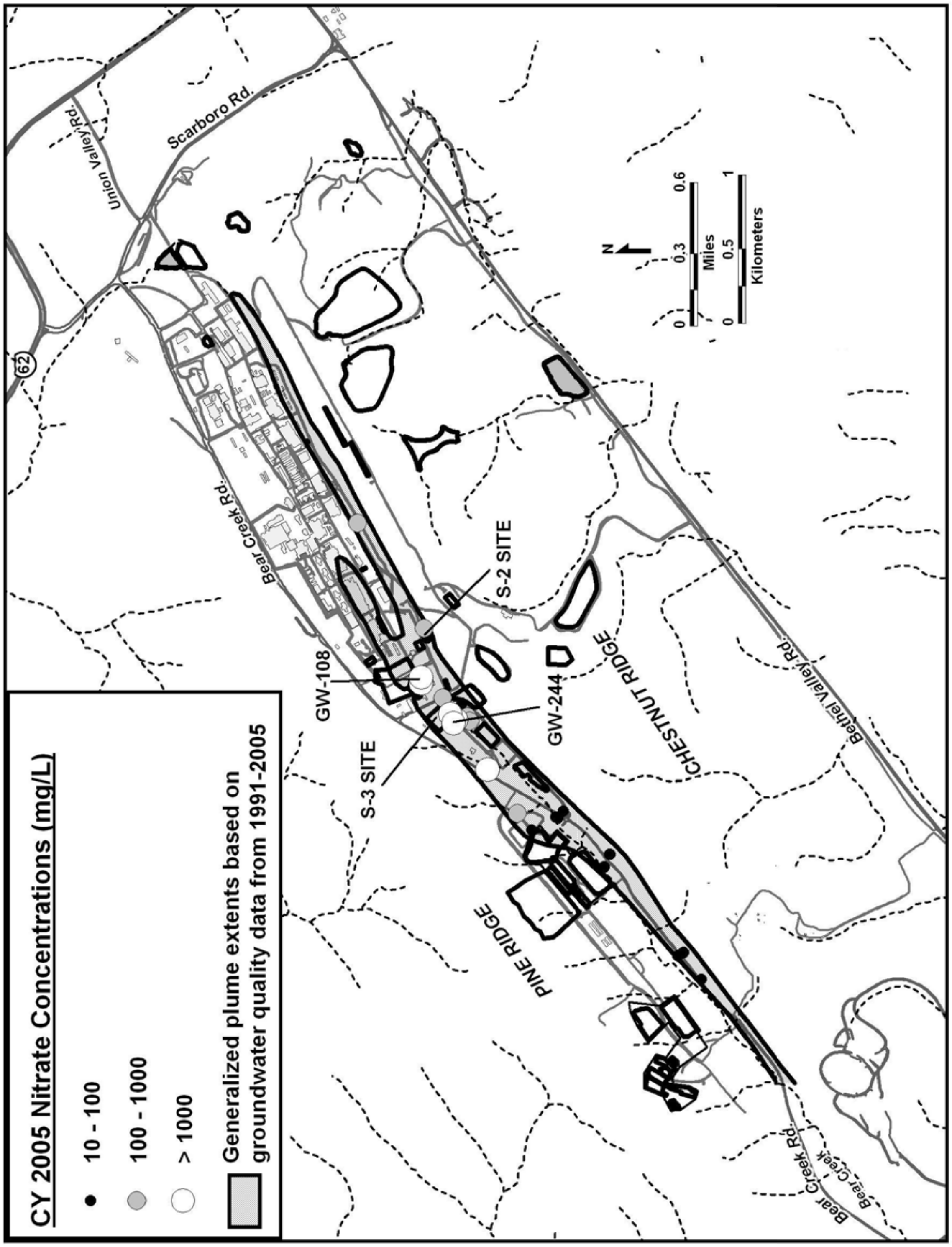

Fig. 6.21. Nitrate (as Nitrogen) observed in groundwater at the Y-12 Complex, 2005.

Fork regime. Dissolved volatile organic compounds in the regime primarily consist of chlorinated solvents and petroleum hydrocarbons. In CY 2005, the highest concentration of dissolved chlorinated solvents (78,100 µg/L) was found in groundwater at Well 55-3B in the western portion of the Y-12 Complex adjacent to manufacturing facilities. The highest dissolved concentration of petroleum hydrocarbons (24,000 µg/L) was obtained from Well GW-658 at the closed East End Garage.

The CY 2005 monitoring results generally confirm findings from the previous years of monitoring. A continuous dissolved plume of volatile organic compounds in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime (Fig. 6.22). The primary sources are the Waste Coolant Processing Facility, fuel facilities (Rust Garage and East End) and other waste-disposal and production areas throughout the Y-12 Complex. Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the volatile organic plume composition in the western and central portions of the Y-12 Complex. However, tetrachloroethene and isomers of dichloroethene are almost ubiquitous throughout the extent of the plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant volatile organic compounds in the eastern portion of the complex.

Variability in concentration trends of chlorinated volatile organic compounds near source areas is seen within the East Fork regime. As seen in previous years, data from most of the monitoring wells have remained relatively constant (i.e., stable) or have decreased since 1988. Increasing trends are observed in monitoring wells associated with the Waste Coolant Processing Facility, some production/process facilities, and the East End volatile organic compound plume, indicating that some portions of the plume are still mobile. Within the exit pathway the general trends are also stable or decreasing. These trends west of New Hope Pond are indicators that the contaminants from source areas are attenuating due to factors such as (1) dilution by surrounding uncontaminated groundwater, (2) dispersion through a complex network of fractures and conduits, (3) degradation by chemical or biological means, or (4) adsorption by surrounding bedrock and soil media. Wells to the southeast of New Hope Pond are displaying the effects of the pumping well (GW-845) operated to capture the plume prior to migration off of the ORR into Union Valley. Wells east of the New Hope Pond and north of Well GW-845 exhibit an increasing trend in volatile organic compound concentrations, indicating that little impact or attenuation from the plume capture system is apparent across lithologic units (perpendicular to strike). However, no subsequent downgradient detection of these compounds is apparent, so migration seems to be limited.

Monitoring wells at two former petroleum hydrocarbon contaminant sources (the Rust Garage Area and the East End Garage) were sampled to evaluate the present condition of groundwater. A well at the Rust Garage has shown a significant increase in concentration since the early 1990s. A well at the East End Garage shows petroleum hydrocarbon concentrations consistent with those observed during the early 1990s. These observations indicate that there is still an accumulation of hydrocarbon contaminants within and surrounding each well.

Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime during CY 2005 are isotopes of uranium. Groundwater with gross alpha activity greater than 15 pCi/L (the drinking water standard) occurs in scattered areas throughout the East Fork regime (Fig. 6.23). Historical data show that gross alpha activity consistently exceeds the drinking water standard and that it is most extensive in groundwater in the unconsolidated zone in the western portion of the Y-12 Complex near source areas such as the S-3 Site, the S-2 Site, and the Y-12 Salvage Yard. However, the highest gross alpha activity (775 pCi/L) in groundwater in Well GW-154 was observed during CY 2005 east of the Former Oil Skimmer Basin.

The primary beta-emitting radionuclides observed in the East Fork regime during CY 2005 are technetium-99 and uranium. Elevated gross beta activity in groundwater in the East Fork regime shows a pattern similar to that observed for gross alpha activity, where technetium-99 is the primary contaminant exceeding the screening level of 50 pCi/L in

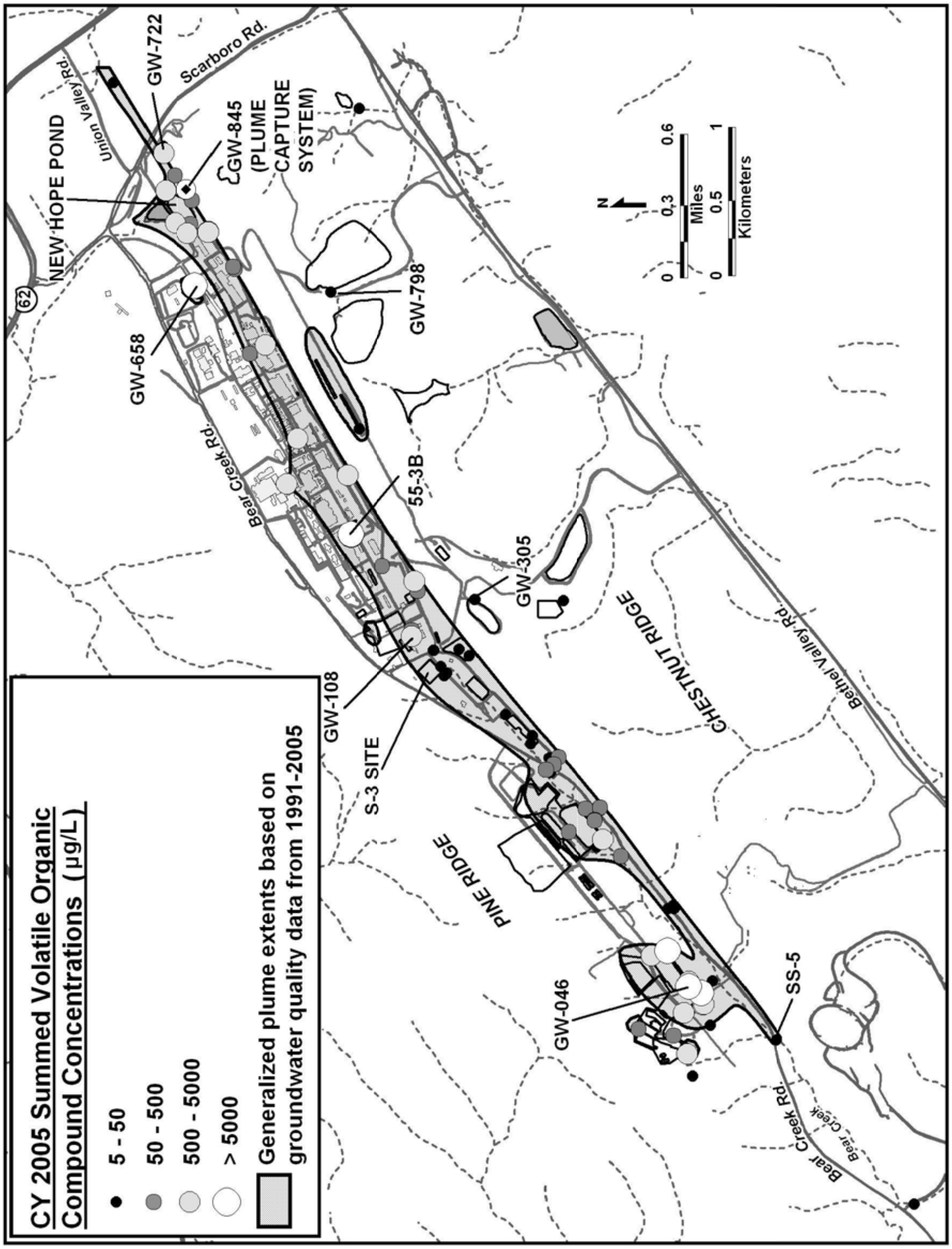

Fig. 6.22. Summed volatile organic compounds observed in groundwater at the Y-12 Complex, 2005.

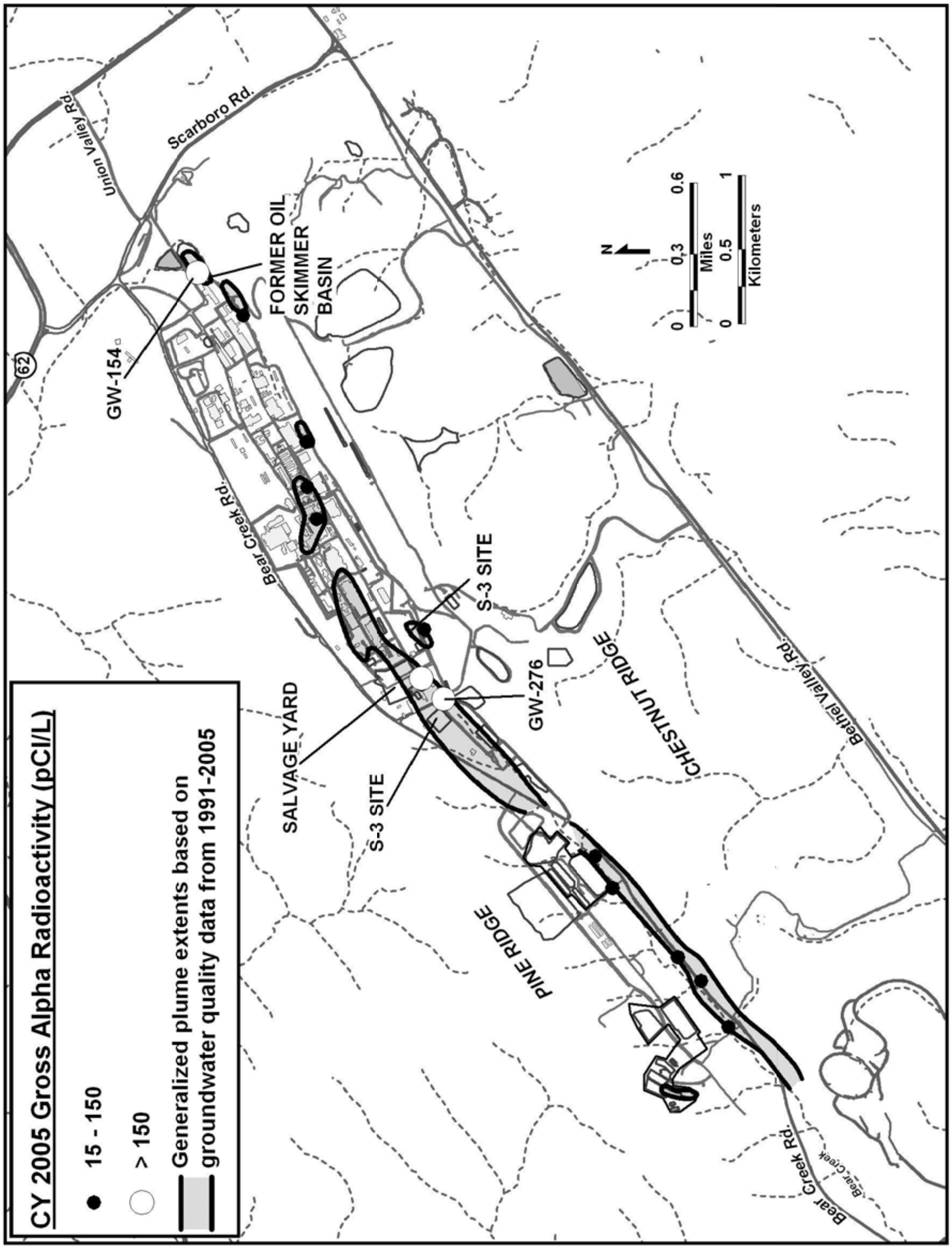

Fig. 6.23. Gross alpha radioactivity observed in groundwater at the Y-12 Complex, 2005. 1 pCi = 3.7×10^{-2} Bq.

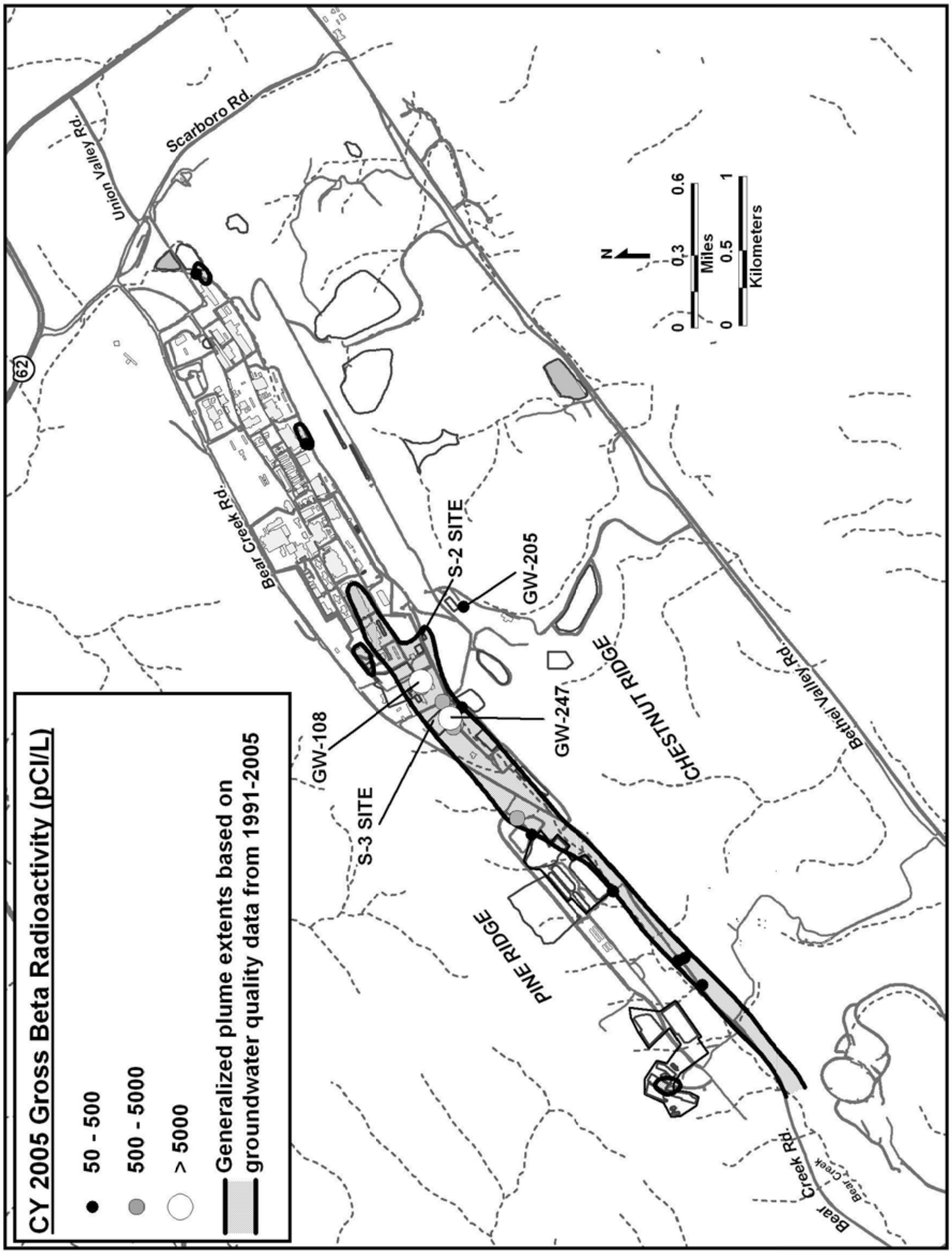

Fig. 6.24. Gross beta radioactivity observed in groundwater at the Y-12 Complex, 2005. 1 pCi = 3.7 × 10^{-2} Bq.

groundwater in the western portion of the regime, with the primary source being the S-3 Site (Fig. 6.24). The highest gross beta activity in groundwater was observed during CY 2005 from well GW-108 (13,700 pCi/L), east of the S-3 site.

Exit Pathway and Perimeter Monitoring

Data collected to date indicate that volatile organic compounds are the primary class of contaminants that are migrating through the exit pathways in the East Fork regime. The compounds are migrating at depths of almost 500 ft in the Maynardville Limestone, the primary intermediate to the deep groundwater exit pathway on the east end of the Y-12 Complex. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected, resulting in contaminant migration for substantial distances off the ORR into Union Valley to the east of the complex.

In addition to the intermediate to deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval near New Hope Pond, Lake Reality, and Upper East Fork Poplar Creek is also monitored. Historically, volatile organic compounds have been observed near Lake Reality from wells, a dewatering sump, and the New Hope Pond distribution channel underdrain. In that area, shallow groundwater flows north-northeast through the water table interval east of New Hope Pond and Lake Reality, following the path of the distribution channel for Upper East Fork Poplar Creek.

During CY 2005, the observed concentrations of volatile organic compounds at the New Hope Pond distribution channel underdrain continue to remain low. This may be because the continued operation of the groundwater plume-capture system in Well GW-845 southeast of the New Hope Pond may be reducing the levels of volatile organic compounds in the area. BJC completed the installation of the system in June 2000. This system pumps groundwater from the intermediate bedrock depth to mitigate off-site migration of volatile organic compounds. Groundwater is continuously pumped from the Maynardville Limestone at about 25 gal/min, passes through a treatment system to remove the volatile organic compounds, and then discharges to Upper East Fork Poplar Creek.

As previously mentioned, monitoring wells near Well GW-845 have shown some encouraging response to pumping activities. The multiport system installed in Well GW-722, approximately 500 ft east and downgradient of Well GW-845, permits sampling of ten discrete zones within the Maynardville Limestone between 87 and 560 ft below ground surface. This well has been instrumental in characterizing the vertical extent of the east-end plume of volatile organic compounds and is critical in the evaluation of the effectiveness of the plume capture system. Monitoring results from some sampled zones in Well GW-722 indicate reductions in volatile organic compounds due to groundwater pumping upgradient at Well GW-845. Other wells also show decreases that may be attributable to the plume capture system operation. These indicators show that operation of the plume capture system is decreasing volatile organic compounds upgradient and downgradient of Well GW-845.

Three wells, located in the large gap in Pine Ridge through which Upper East Fork Poplar Creek exits the Y-12 Complex, are used to monitor shallow, intermediate, and deep groundwater intervals (Fig. 6.20). Shallow groundwater moves through this exit pathway, and very strong upward vertical flow gradients exist; two of the three wells located in this area are artesian (water flows from the well casing due to unusually high naturally occurring water pressure). Continued monitoring of the wells since about 1990 has not shown that any contaminants are moving via this exit pathway.

Five sampling locations continue to be monitored north and northwest of the Y-12 Complex to evaluate possible contaminant transport from the ORR. These locations are considered unlikely groundwater or surface water contaminant exit pathways; however, monitoring was performed due to previous public concerns regarding potential health impacts from Y-12 operations to nearby residences. Two of the stations monitored tributaries that drain the north slope of Pine Ridge on the ORR and that discharge into the adjacent Scarboro Community. One location monitors an upper reach of Mill Branch, which discharges into the residential areas along Wiltshire Drive. The remaining two locations monitor Gum Hollow Branch as it discharges from the ORR and flows adjacent to the Country Club Estates community. Samples were obtained and analyzed for metals, inorganic parameters, volatile organic compounds, and gross alpha and gross beta activities. No results exceeded a drinking water standard, nor were there any indications that contaminants were being discharged from the ORR into those communities.

6.10.4.2 Union Valley Monitoring

Groundwater monitoring data obtained in 1993 provided the first strong indication that volatile organic compounds were being transported off the ORR through the deep Maynardville Limestone exit pathway. The Upper East Fork Poplar Creek remedial investigation (DOE 1998) provided a discussion of the nature and extent of the volatile organic compounds.

In CY 2005, monitoring of locations in Union Valley continued, showing an overall decreasing trend in the concentrations of contaminants forming the groundwater contaminant plume in Union Valley.

Under the terms of an interim record of decision, administrative controls, such as restriction on potential future groundwater use, have been established. Additionally, the previously discussed plume capture system (Well GW-845) was installed and initiated to mitigate the migration of groundwater contaminated with volatile organic compounds into Union Valley (DOE 2006).

6.10.4.3 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Complex in Bear Creek Valley, the Bear Creek regime is bounded to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of Bear Creek Valley extending from the west end of the Y-12 Complex to State Highway 95. Table 6.18 describes each of the waste management sites within the Bear Creek regime.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, volatile organic compounds, and radionuclides. The S-3 Site is a source of all four of these contaminants. The Oil Landfarm waste management area, consisting of the Oil Landfarm, the Boneyard/Burnyard, the Hazardous Chemical Disposal Area, and Landfill I, is a significant source of uranium, other trace metals, and volatile organic compounds. Other sources of volatile organic compounds include the Rust Spoil Area, and the Bear Creek Burial Grounds waste management area. Volatile organic compounds such as tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs have been observed as deep as 270 ft below the Bear Creek Burial Grounds.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. This aquitard unit is positioned north of and adjacent to the exit pathway unit, the Maynardville Limestone. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike in both the Knox Aquifer and the ORR Aquitards.

Nitrate

Unlike many groundwater contaminants, nitrate is highly soluble and moves easily with groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime. The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper to intermediate part of the aquitard and aquifer (less than 300 ft below the ground surface).

Data obtained during CY 2005 indicate that nitrate concentrations in groundwater exceed the drinking water standard in an area that extends west from the S-3 Site for approximately 8000 ft down Bear Creek Valley, which is consistent with the nitrate observations from CY 2004. During CY 2003 the western extent was reported at about 11,000 ft, indicating that some variability in the plume in the Maynardville Limestone is occurring due to the reduction in contaminants as well as attenuation by uncontaminated groundwater. Nitrate concentrations greater than 100 mg/L continue to persist out to about 2500 ft west of the S-3 Site, indicating little significant change from previous years in the

Table 6.18. History of waste management units included in CY 2005 groundwater monitoring activities, Bear Creek Hydrogeologic Regime[a]

Site	Historical data
S-3 Site	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium-bearing wastes via the Nitric Acid Pipeline until 1983. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater
Oil Landfarm	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater
Boneyard	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood. Excavated and restored in 2002
Burnyard	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches. Excavated and restored in 2002
Hazardous Chemical Disposal Area	Used from 1975 to 1981. Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit. The northwest portion was excavated and restored in 2002 as part of Boneyard/Burnyard remedial activities
Sanitary Landfill I	Used from 1968 to 1982. TDEC-permitted, nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1985
Bear Creek Burial Grounds: A, C, and Walk-in Pits	A and C received waste oils, coolants, beryllium and uranium, various metallic wastes, and asbestos into unlined trenches and standpipes. Walk-in Pits received chemical wastes, shock-sensitive reagents, and uranium saw fines. Activities ceased in 1981. Final closure certified for A (1989), C (1993), and the Walk-in Pits (1995). Infiltration is the primary release mechanism to groundwater
Bear Creek Burial Grounds: B, D, E, J, and Oil Retention Ponds 1 and 2	Burial Grounds B, D, E, and J, unlined trenches, received depleted uranium metal and oxides and minor a mounts of debris and inorganic salts. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of Burial Grounds B and part of C was granted February 1995
Rust Spoil Area	Used from 1975 to 1983 for disposal of construction debris, but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of volatile organic compounds to shallow groundwater according to CERCLA remedial investigation
Spoil Area I	Used from 1980 to 1988 for disposal of construction debris and other stable, non-rad wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern. CERCLA record of decision issued in 1996
SY-200 Yard	Used from 1950 to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns. CERCLA record of decision issued in 1996
Above-Grade LLW Storage Facility	Constructed in 1993. Consists of six above-grade storage pads used to store inert, low-level radioactive debris and solid wastes packaged in steel containers

[a]Abbreviations

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
LLW = low-level radioactive waste
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation

Nolichucky Shale. Historically, the highest nitrate concentrations are observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths (less than 100 ft below ground surface) in the aquitard. This was observed in CY 2005 with the highest nitrate concentration (4,350 mg/L) at Well GW-244 adjacent to the S-3 Site at a depth of 47 ft below ground surface (Fig. 6.21). In previous years, elevated concentrations of nitrate have been observed as deep as 740 ft below ground surface. Surface water nitrate results exceeding the drinking water standard during CY 2005 were observed as far as 11,000 ft west of the S-3 Site. The extent of nitrate contamination in the surface waters of the Bear Creek regime appears to be similar to the extents observed in CY 2004.

Trace Metals

During CY 2005, uranium, barium, cadmium, lead, beryllium, nickel, arsenic, and selenium were identified from groundwater monitoring as the trace metal contaminants in the Bear Creek regime that exceeded drinking water standards. Historically, elevated concentrations of many of the trace metals were observed at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at the S-3 Site reduced the pH of the groundwater, which allows the metals to remain in solution. Elsewhere in the Bear Creek regime, where natural geochemical conditions prevail, the trace metals may occur sporadically and in close association with source areas because conditions are typically not favorable for dissolution and migration. In CY 2005, the listed trace metals were evident at elevated concentrations within the surface water and groundwater downgradient of the S-3 Site, the Bear Creek Burial Ground, and the Oil Landfarm waste management areas.

The most prevalent trace metal contaminant observed within the Bear Creek regime is uranium, indicating that geochemical conditions are favorable for its migration. The Boneyard/Burnyard site was identified as the primary source of uranium contamination of surface water and groundwater. Historically, uranium is observed at concentrations exceeding the drinking water standard of 0.03 mg/L in shallow monitoring wells, springs, and surface water locations downgradient from all of the waste areas. In 2003, BJC performed the final remedial actions at the Boneyard/Burnyard with the objective of removing materials contributing to surface water and groundwater contamination to meet existing record-of-decision goals. Approximately 86,000 yd^3 of waste materials were excavated and placed in the EMWMF (DOE 2006b). There has been a 99% decrease in uranium in the surface water tributary immediately downstream of the Boneyard/Burnyard, which indicates that the remedial actions performed from 2002 to 2003 were successful in removing much of the primary source of uranium in Bear Creek Valley. In CY 2005, a corresponding decrease in uranium concentrations was observed downstream in Bear Creek (Table 6.19); however, the decreases were not as dramatic as that observed immediately downstream of the Boneyard/Burnyard due to other contributing ungauged sources. Other trace metal contaminants that have been observed in the Bear Creek regime are antimony, boron, chromium, cobalt, manganese, strontium, and thallium. Concentrations have commonly exceeded background values in groundwater near contaminant source areas.

Table 6.19. Nitrate and uranium concentrations in Bear Creek

Bear Creek Monitoring Station (distance from S-3 site)	Contaminant	Average concentration (mg/L)				
		1990–93	1994–97	1998–2001	2002–04	2005
BCK-11.84 to 11.97	Nitrate	119	80	80	84	63.3
(~0.5 miles downstream)	Uranium	0.196	0.134	0.139	0.119	0.088
BCK-09.20 to 09.47	Nitrate	16.4	9.6	10.6	11.9	6.6
(~2 miles downstream)	Uranium	0.091	0.094	0.171	0.099	0.038
BCK-04.55	Nitrate	4.6	3.6	2.6	3.5	1.1
(~5 miles downstream)	Uranium	0.034	0.031	0.036	0.029	0.017
BCK-00.63	Nitrate	NS[a]	1.8	1.5	1.4	0.63
(~7.5 miles downstream)	Uranium	NS[a]	0.024	0.022	0.013	0.0097

[a]NS—not sampled.

Volatile Organic Compounds

Volatile organic compounds are widespread in groundwater in the Bear Creek regime. The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1-dichloroethane, and vinyl chloride. In most areas, they are dissolved in the groundwater and can occur in bedrock at depths greater than 270 ft below the Bear Creek Burial Ground waste management area. Groundwater in the aquitards that contains detectable levels of volatile organic compounds occurs primarily within about 1000 ft of the source areas. The highest concentrations observed in CY 2005 in the Bear Creek regime occurred in the unconsolidated zone at the Bear Creek Burial Ground waste management area, with a maximum summed volatile organic compound concentration of 10,838 µg/L in Well GW-046 (Fig 6.22). This result is consistent with the maximum summed concentration observed in CY 2004. The extent of the dissolved plumes of volatile organic compounds is greater in the underlying bedrock. The highest levels in bedrock, in the Bear Creek regime, occur just south of the Bear Creek Burial Ground waste management area. Historical levels have been as high as 7,000,000 µg/L in groundwater near the source area. Downgradient of the Bear Creek Burial Ground waste management area in the aquitards, increasing trends indicate that some migration of volatile organic compounds is occurring. This migration through the aquitards parallel to the valley axis and toward the exit pathway (Maynardville Limestone) is occurring in both the unconsolidated and bedrock intervals.

Significant transport of volatile organic compounds has occurred in the Maynardville Limestone. Data obtained from exit pathway monitoring locations show that in the vicinity of the water table, an apparently continuous dissolved plume extends at least 7400 ft westward from the S-3 Site to just southeast of the Bear Creek Burial Ground waste management area.

Radionuclides

The primary radionuclides identified in the Bear Creek regime are isotopes of uranium and ^{99}Tc. Neptunium-237, ^{241}Am, radium, strontium, thorium, plutonium, and tritium are secondary and less widespread radionuclides, primarily present in groundwater near the S-3 Site. Evaluations of their extent in groundwater in the Bear Creek regime during CY 2005 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the drinking water standard for gross alpha activity), then one (or more) of the alpha-emitting radionuclides (e.g., uranium) was assumed to be present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L. Technetium-99, a more volatile radionuclide, is qualitatively screened by gross beta activity analysis and, at certain monitoring locations, is evaluated isotopically.

Groundwater with elevated levels of gross alpha activity occurs near the S-3 Site and the Oil Landfarm and Bear Creak Burial Grounds waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the aquitards only near source areas (Fig. 6.23). Data obtained from exit pathway monitoring stations show that gross alpha activity in groundwater in the Maynardville Limestone and in the surface waters of Bear Creek exceeds the drinking water standard for over 9,000 ft west of the S-3 Site. The highest gross alpha activity observed in CY 2005 was 268 pCi/L in Well GW-276 located adjacent to the S-3 Site.

The distribution of gross beta radioactivity in groundwater is similar to that of gross alpha radioactivity. During CY 2005, it appears that the lateral extent of gross beta activity within the exit pathway groundwater interval and surface water above the drinking water standard has not changed from those observed in recent years. Gross beta activities exceeded 50 pCi/L within the Maynardville Limestone exit pathway for 8,000 to 10,000 ft from the S-3 Site (Fig. 6.24). The highest gross beta activity in groundwater in the Bear Creek Regime this year was 5,500 pCi/L at Well GW-247 located immediately downgradient of the S-3 Site.

Exit Pathway and Perimeter Monitoring

Exit pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime.

The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek regime, is the principal exit pathway for surface water. Various studies have shown that surface water in Bear Creek, springs along the valley floor, and groundwater in the Maynardville Limestone are hydraulically connected. The western exit pathway well transect (Picket W) serves as the ORR perimeter well location for the Bear Creek regime (Fig. 6.20).

Exit pathway monitoring consists of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during CY 2005 from the exit pathway monitoring wells indicate that groundwater between Pickets A and B is not consistently contaminated above drinking water standards in the Maynardville Limestone. However, nitrate and uranium concentrations and gross alpha and gross beta activities exceeding their respective drinking water standards have been observed in surface water west of the burial grounds (BWXT 2006).

Surface water samples collected during CY 2005 indicate that water in Bear Creek contains many of the compounds found in the groundwater. The concentrations in the creek decrease with distance downstream of the waste disposal sites (Table 6.19). Individual monitoring locations along Bear Creek also show a decrease in concentration with respect to time, reflecting the positive steps toward remediation of legacy wastes and active mitigating practices of pollution prevention.

6.10.4.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge Hydrogeologic Regime is south of the Y-12 Complex and is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road (Fig. 6.19). The regime encompasses the portion of Chestnut Ridge extending from Scarboro Road, east of the complex, to Dunaway Branch, located just west of Industrial Landfill II.

The Chestnut Ridge Security Pits area is the only documented source of groundwater contamination in the regime. Contamination from the Security Pits is distinct and does not mingle with plumes from other sources. Table 6.20 summarizes the operational history of waste management units in the regime.

Plume Delineation

The horizontal extent of the volatile organic compound plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones. With one exception, historical monitoring indicates that the volatile organic compound plume from the Chestnut Ridge Security Pits has not migrated very far in any direction (< 1000 ft). Groundwater quality data obtained during CY 2005 indicate that the western lateral extent of the plume of volatile organic compounds at the site has not changed significantly from previous years. An increase in volatile organic compound contaminants over the past several years at a well approximately 1500 ft southeast of the Chestnut Ridge Security Pits shows that some migration of the eastern plume is occurring.

Nitrate

Nitrate concentrations were below the drinking water standard of 10 mg/L at all monitoring stations in the Chestnut Ridge Hydrogeologic Regime.

Trace Metals

Groundwater concentrations of trace metals exceeded regulatory standards during CY 2005 at three locations. Concentrations above the drinking water standard for nickel were observed in samples from one monitoring well. Two surface water monitoring stations showed elevated concentrations of arsenic.

Nickel concentrations above the drinking water standard (0.1 mg/L) were observed from one well at the Industrial Landfill IV (Fig. 6.18). The presence of nickel in groundwater samples from monitoring wells at the Y-12 Complex, with the exception of the S-3 Site, is not due to historical waste disposal, but is probably due to corrosion of well casings. Nickel is a primary component of stainless steel, and its presence indicates the occurrence of corrosion and subsequent dissolution of stainless steel well casing and screen materials due to chemical or biochemical processes (LMES 1999).

Elevated concentrations of arsenic above the drinking water standard (0.01 mg/L) were

Table 6.20. History of waste management units included in CY 2005 groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime[a]

Site	Historical data
Chestnut Ridge Sediment Disposal Basin	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Complex. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination
Kerr Hollow Quarry	Operated from 1940s to 1988. Used for the disposal of reactive materials, compressed gas cylinders, and various debris. RCRA closure (waste removal) was conducted between 1990 and 1993. Certification of closure with some wastes remaining in place was approved by TDEC February 1995
Chestnut Ridge Security Pits	Operated from 1973 to 1988. Series of trenches for disposal of classified materials, liquid wastes, thorium, uranium, heavy metals, and various debris. Closed under RCRA in 1989. Infiltration is the primary release mechanism to groundwater
United Nuclear Corporation Site	Received about 29,000 drums of cement-fixed sludges and soils demolition materials, and low-level radioactive contaminated soils. Closed in 1992; CERCLA record of decision has been issued
Industrial Landfill II	Central sanitary landfill for the Oak Ridge Reservation. Detection monitoring under postclosure plan has been ongoing since 1996
Industrial Landfill IV	Permitted to receive only nonhazardous industrial solid wastes. Detection monitoring under TDEC solid-waste-management regulations has been ongoing since 1988
Industrial Landfill V	Facility completed and initiated operations April 1994. Baseline groundwater monitoring began May 1993 and was completed January 1995. Currently under TDEC solid-waste-management detection monitoring
Construction/Demolition Landfill VI	Facility completed and initiated operations December 1993. Baseline groundwater quality monitoring began May 1993 and was completed December 1993. Currently under permit-required detection monitoring per TDEC
Construction/Demolition Landfill VII	Facility construction completed in December 1994. TDEC granted approval to operate January 1995. Baseline groundwater quality monitoring began in May 1993 and was completed in January 1995. Permit-required detection monitoring per TDEC was temporarily suspended October 1997 pending closure of construction/demolition Landfill VI. Reopened and began waste disposal operations in April 2001
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries. A CERCLA record of decision has been issued. Remedial action complete

[a]Abbreviations
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
RCRA = Resource Conservation and Recovery Act.
TDEC = Tennessee Department of Environment and Conservation.

observed in two surface water monitoring location downstream from the Filled Coal Ash Pond, which is monitored under a CERCLA record of decision (DOE 2005). A constructed wetland area is being utilized to prevent surface water contamination by effluent from the Filled Coal Ash Pond. During CY 2005, the locations where elevated arsenic levels were detected are both upgradient and downgradient of this wetland area. Downgradient of the wetlands, concentrations are noticeably lower and surface water samples obtained approximately 2000 ft downstream (Rogers Quarry) exhibit no detectable arsenic.

Volatile Organic Compounds

Efforts to delineate the extent of volatile organic compounds in groundwater attributable to the Chestnut Ridge Security Pits have been in progress since 1987. A review of historical data indicates that concentrations of volatile organic compounds in groundwater at the site have generally decreased since 1988. However, a general increasing trend in volatile organic compounds in groundwater samples from monitoring well GW-798 to the southeast and downgradient of the Chestnut Ridge Security Pits has been developing since CY 2000 (Fig 6.22). This trend seems to have peaked at the beginning of CY 2003 and has stabilized between 15 and 20 μg/L. The volatile organic compounds detected in CY 2005 are characteristic of the Chestnut Ridge Security Pits plume; none of the detected compounds were observed to exceed their respective drinking water standards. These results indicate that there is some migration occurring through the developed fracture and conduit system of the karst dolostone to the southeast of the Chestnut Ridge Security Pits.

At Industrial Landfill IV, a number of volatile organic compounds have been observed since 1992. Monitoring well GW-305, located immediately to the southeast of the facility, has historically displayed concentrations of compounds below applicable drinking water standards, but the concentrations have been on a shallow increase. In CY 2005, the fourth-quarter result for one of the compounds, 1, 1-dichloroethene, was 7.6 μg/L, which exceeded the drinking water standard (7 μg/L) for the first time.

Radionuclides

In CY 2005, there was no gross alpha activity above the drinking water standard of 15 pCi/L. Gross beta activities were below the screening level of 50 pCi/L at all monitoring stations except at monitoring well GW-205 (Fig. 6.24) at the United Nuclear Corporation site (the maximum detected activity was 68.7 pCi/L). This location has consistently exceeded the screening level since August 1999. Isotopic analyses show a correlative increase in the beta-emitting radionuclide potassium-40, which is not a known contaminant of concern at the United Nuclear site. The source of the radioisotope is not known.

Exit Pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized by conventional monitoring techniques. Tracer studies have been used in the past to attempt to identify exit pathways. Based on the results of tracer studies to date, no springs or surface streams that represent discharge points for groundwater have been conclusively correlated to a waste management unit that is a known or potential groundwater contaminant source.

Monitoring of natural groundwater exit pathways is a basic monitoring strategy in a karst regime such as that of Chestnut Ridge. Perimeter springs and surface water tributaries were monitored to determine whether contaminants are exiting the downgradient southern side of the regime. Five springs and three surface water monitoring locations were sampled during CY 2005. No contaminants were detected at these natural discharge points.

6.11 Modernization Activities at the Y-12 National Security Complex

The National Nuclear Security Administration (NNSA) has embarked on a significant facility and infrastructure modernization program at the Y-12 Complex. The objectives of the program are to

- consolidate operations to reduce footprint and maintenance cost,

- upgrade facilities and site infrastructure systems to be used in the future,
- replace obsolete, ineffective facilities with new modernized structures designed for their intended use, and
- demolish or disposition surplus facilities and materials no longer required to perform missions.

Overall implementation of the modernization program is consistent with the current site-wide environmental impact statement for the Y-12 Complex and its associated record of decision. NNSA is presently updating the site-wide environmental impact statement. Key considerations of the modernization strategy include maintaining compliance with regulatory requirements and coordinating NNSA's modernization activities with CERCLA requirements. The construction of new NNSA facilities has begun prior to completion of remediation of the soils and groundwater of the Upper East Fork Poplar Creek characterization areas.

6.11.1 Infrastructure Reduction

The Facility and Infrastructure Recapitalization Program, an NNSA initiative to revitalize the physical infrastructure, includes funding for the demolition of non-process contaminated excess facilities across the nuclear weapons complex. By removing excess buildings and equipment, the program is helping reduce NNSA liabilities and costs. The Y-12 Complex's infrastructure reduction effort focuses on removing excess buildings and infrastructure to support reduction in maintenance and operating cost and to provide real estate for future modernization needs. The efforts help support the strategic goal of reducing the active footprint at the complex by 50% in the next decade.

BWXT Y-12's infrastructure reduction activities have already significantly changed the face of the Y-12 Complex. In FY 2005, an additional 214,424 ft^2 of floor space was demolished, bringing Y-12's total to more than 885,000 ft^2 demolished since the program was initiated in 2001.

6.11.2 New Construction

As part of the modernization of the Y-12 Complex, numerous construction projects are under way or are planned for the future. Some are refurbishments or upgrades to plant systems, such as those for potable water, compressed air, and the steam plant. Others involve construction of new buildings, such as the following.

- Purification Facility—Construction was completed in 2005, and operations have started. This is the first major production facility built at the Y-12 Complex in more than 30 years.
- New Garage Office Building—Construction was completed in 2004, and the service bays are expected to be completed in FY 2006. The new garage will replace the existing garage, which is scheduled to be demolished in FY 2006.
- New East End Records Storage Facility and Technical Support Facility—Construction is complete on the Technical Support Facility, and the building is occupied. The records facility will be completed in 2006.
- Highly Enriched Uranium Materials Facility—The new, state-of-the-art storage facility will replace multiple aging facilities. Construction is under way and completion is scheduled in FY 2007. Full-scale operations are slated to start in 2008.
- Uranium Processing Facility—The Uranium Processing Facility, cornerstone of the Y-12 Complex's enriched uranium modernization strategy, will replace current enriched-uranium and other processing operations. NNSA published a notice of intent in the Federal Register (70 FR 71270) on November 28, 2005, announcing its intent to prepare a site-wide environmental impact statement to analyze alternatives. Completion of the Uranium Processing Facility is projected for 2015.
- Beryllium Capability Project—This project will provide new equipment within existing facilities to support ongoing beryllium operations at the Y-12 Complex. The project will address modern technologies and engineered controls for beryllium operations. Construction is expected to be completed by FY 2008.

6.11.3 Operating Lease Project

Staff at the Y-12 Complex are working with a private-sector entity to provide for the construction of two new technical and administrative support facilities: the Jack Case Center and the New Hope Building.

The Jack Case Center, to be built north of the recently demolished Y-12 Administration Building, will house administrative, technical, and scientific functions now scattered across the site. The Jack Case Center is named in honor of Jack M. Case, a former Y-12 Plant Manager who rose through the ranks to become plant manager and had the longest tenure—15 years.

The New Hope Building will be located where the small community of New Hope once stood at the east end of the complex. The structure will house a visitor's center and other functions requiring frequent interaction with the public.

Together, these new facilities will replace about 1 million ft^2 of obsolete workspace with about 540,000 ft^2 of modern office and laboratory space for about 1,500 employees. To accommodate the construction, NNSA transferred two parcels of land at the Y-12 Complex to a private developer, who will finance, design, and build the facilities for long-term lease by NNSA to support Y-12 missions. Construction has started, and occupancy is scheduled for late 2007.