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. These programs include regulatory and monitoring activities for Y-12 site facilities and Bear Creek.

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. National Emission Standards for Hazardous Air Pollutants (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 >0.1 mrem/year effective dose equivalent (EDE) to an off-site individual). During 2000, 45 of the Y-12 Complex's 57 monitored stacks were judged to be major sources. Nineteen 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 them to investigate and correct the problem before a significant release occurs. As of January 1, 2000, the Y-12 Complex had continuous monitoring capability on a total of 57 stacks, 48 of which were active and 9 which were temporarily shut down. No stacks were permanently shut down in 2000.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to calculation methods approved by the U.S. Environmental Protection Agency (EPA). In 2000, there were twelve 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 Bechtel Jacobs Company, LLC (BJC), ORNL, and BWXT Y-12 laboratory activities. Thirty-one minor emission points were identified from laboratory activities at facilities within the boundary of the Y-12 Complex as being operated by the BWXT Y-12. In addition, the BWXT Y-12 Analytical Chemistry Organization (ACO) laboratory is operated in a leased facility that is not within the ORR boundary and is located approximately 1/3 mile east of the Y-12 Complex on Union Valley Road. The emissions from the ACO Union Valley laboratory are included in the Y-12 Complex source term. Eight minor emission points were identified at the ACO Union Valley laboratory. The releases from these laboratories are minimal, however, and have 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 (DAC) worker-protection guidelines are included in the annual emission estimate. One emission point was identified in 2000 where room ventilation emissions exceeded 10% of the DAC worker-protection guidelines.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on monitored operating process exhaust stacks in 2000. 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 9.16E–3 Ci (2.2 kg) of uranium was released into the atmosphere in 2000 as a result of Y-12 activities. The specific activity of enriched uranium is much greater than that of depleted uranium, and about 89% of the curie release was composed of emissions of enriched uranium particulate, even though approximately 6% of the total mass of uranium released was enriched material (Figs. 6.1 and 6.2).

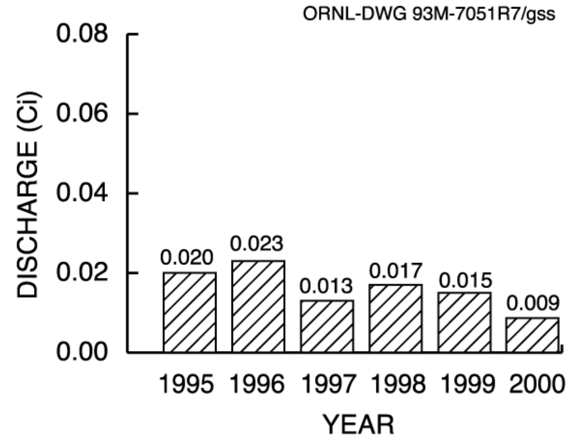

Fig. 6.1. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 1995–2000.

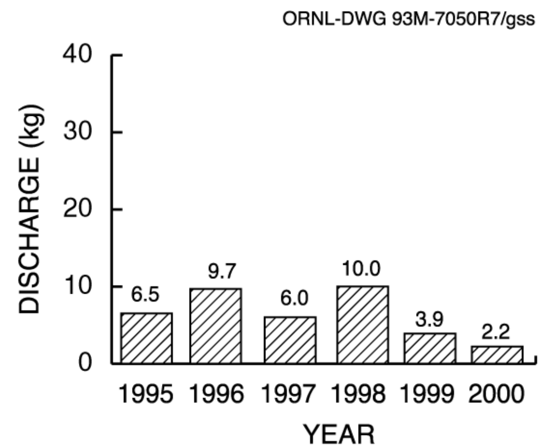

Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 1995–2000.

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.

The Y-12 Complex has 37 individual air permits. Approximately two-thirds of the permitted air sources release primarily nonradiological contaminants. The remaining one-third of the permitted sources process primarily radiological materials. Tennessee Department of Environment and Conservation (TDEC) air permits for the nonradiological sources do not require stack sampling or monitoring except for the opacity monitors used at the steam plant to ensure compliance with visible emission standards. 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. In the future, when the Y-12 Complex is issued its first-ever major source (Title V) operating permit, reporting of key process parameters is expected to increase. Also, it is anticipated that a future permit condition for the steam plant will require continuous emission monitoring for nitrogen oxides beginning in 2004.

The 2000 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 $130,429. 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 $13 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 versus allowable emissions from the steam plant is provided in Table 6.1. In addition, the annual EPCRA Sect. 313 TRI report provides information on other nonradiological Y-12 Complex air emissions (Sect. 2.2.16).

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99% of the time in 2000. Both systems were taken out of service for annual calibration/certification on April 18 and 19, 2000. The annual opacity calibration error test reports were submitted to TDEC in July 2000. During 2000, there were nine 6-min periods of excess emissions and two occasions when the monitors were out of service. 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 out-of-service conditions for the east and west stack opacity monitors for 2000.

6.3 Y-12 COMPLEX AMBIENT AIR MONITORING

In 1994, Y-12 Complex personnel issued *Evaluation of the Ambient Air Monitoring Program at the Oak Ridge Y-12 Plant* (MMES 1994b) and worked with DOE and TDEC in reviewing the ambient air program for applicability and usefulness of the data. There are no federal regulations, state regulations, or DOE orders that require this monitoring. All ambient air monitoring systems at the Y-12 Complex are operated as a best management practice (BMP). 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, operated by ORNL 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.

Table 6.1. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2000

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	22	931	2.4
Sulfur dioxide	2,338	20,803	11.2
Nitrogen oxides[a]	1,098	7,718	14.2
Volatile organic compounds[a]	1.67	37	4.5
Carbon monoxide[a]	21.5	543	4.0

[a]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 TDEC Rule 1200-3-26-.02(2)(d)3 (maximum design capacity for 8,760 h/year). The emissions for both the actual and allowable emissions were calculated based on the latest AP-42 emission factors.

With agreement from TDEC personnel, the ambient air-sampling program at the Y-12 Complex was significantly reduced, effective at the end of 1994. All sampling for fluoride, total suspended particulates (TSPs), and particulate matter less than 10 microns in diameter (PM10) was discontinued, and all but 3 of the 12 uranium samplers were shut down. Effective April 1, 1999, an agreement was reached according to which TDEC personnel took over responsibility for sampling and analysis of the three remaining uranium samplers at the Y-12 Complex. The uranium samplers were operated by the TDEC during 2000. On December 6, 1999, DOE submitted to TDEC a letter providing justification for reducing the number of on-site mercury-monitoring stations from four to two. Effective, January 1, 2000, operation of the two monitors located in the interior of the Complex (near Buildings 9805-1 and 9422-13) was discontinued. The two boundary mercury-monitoring stations (stations 2 and 8) remain in operation. The locations of these monitoring stations are shown in Fig. 6.3. Also, during 2000, planning was initiated for future on-site ambient air monitoring for fluorides. This monitoring will be started prior to the restart of the hydrogen fluoride system at Building 9212. A sampling plan will be prepared for submission to TDEC in 2001.

6.3.1 Mercury

The Y-12 Complex ambient air monitoring program for mercury was established in 1986 as a BMP. The objectives of the program were to establish a historical database of mercury concentration in ambient air at Y-12, identify spatial and temporal trends in mercury vapor concentrations at Y-12, and demonstrate protection of the environment and human health from releases of mercury from the Y-12 Complex to the atmosphere. In 2000 this program operated two stations for monitoring mercury in ambient air, down from the four sites previously operated (see Sect. 6.3). These two stations, Ambient Air Station No. 2 (AAS2) and Ambient Air Station No. 8 (AAS8), are located near the east and west boundaries of the Y-12 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 due to power or equipment outages. In addition to the Complex monitoring stations, a control or reference site was operated on Chestnut Ridge in the Walker Branch Watershed (Rain Gauge No. 2) for a 20-month period in 1988 and 1989 to establish background concentrations.

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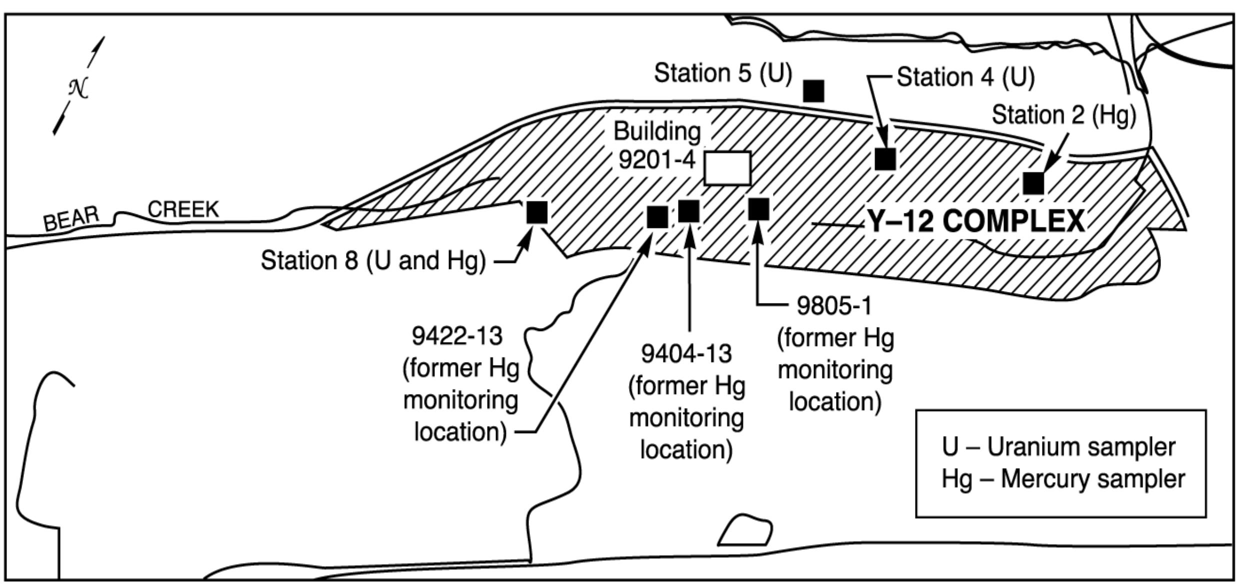

Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Complex.

At each of the monitoring sites, airborne mercury vapor is monitored by pulling ambient air through a sampling train consisting of a Teflon filter, a flow-limiting orifice, and an iodated charcoal glass sampling tube. The flow-limiting orifice is used to restrict air flow through the sampling train to ~1L/min, although actual flow rates are measured with a calibrated flowmeter. The iodated charcoal sampling tubes are changed out routinely every seven days. The charcoal in each trap is then analyzed for mercury by using cold vapor atomic fluorescence. Average air concentration of mercury vapor 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 over the 7-day period. During the early days of the program, the Teflon filters in the sampling train were analyzed for particulate mercury, but this practice was discontinued in 1989 after results revealed very low to undetectable levels of particulate mercury.

As reported in previous ASERs, over the 15 years of the monitoring program, average annual mercury vapor concentrations at the Y-12 Complex mercury monitoring sites have declined, especially since the initial three years of the monitoring program (1986 through 1988). Recent average annual concentrations at the two boundary stations located at the east and west ends of the Y-12 Complex are comparable to those measured in 1988 and 1989 at the Chestnut Ridge reference site and only slightly elevated above concentrations reported for continental background (i.e., ~0.002 $\mu g/m^3$). Annual average mercury concentration during 2000 at AAS2 was 0.0037 $\mu g/m^3$ (N = 51; S.E. = ±0.0005) and at AAS8, 0.0046 $\mu g/m^3$ (N = 51; S.E. = ±0.0004). Table 6.2 summarizes the CY 2000 mercury results and provides the results from the 1986–1988 period for comparison. Figure 6.4 illustrates temporal trends in mercury concentrations for the two active ambient air mercury-monitoring sites since the inception of the program in 1986 through December 2000.

In conclusion, annual average ambient mercury concentrations during 2000 at the Y-12 east and west boundary monitoring sites are comparable to reference levels measured on Chestnut Ridge in 1988 and 1989 and approaching the average values reported for continental background. These concentrations are well below the American Conference of Governmental Industrial Hygienists (ACGIH) workplace threshold limit value of 25 $\mu g/m^3$ (time-weighted average for a normal 8-h workday and 40-h work week) and the EPA reference concentration (RfC) of 0.3 $\mu g/m^3$ for mercury for chronic inhalation exposure.

6.4 LIQUID DISCHARGES—Y-12 COMPLEX RADIOLOGICAL MONITORING SUMMARY

A radiological monitoring plan (RMP) is in place at the Y-12 Complex to address compliance with DOE orders and the NPDES permit (TN002968). The permit, issued in 1995, required

Table 6.2. Results of the Y-12 ambient air mercury monitoring program for calendar year 2000

The 1986 through 1988 average is shown for reference.

Ambient air monitoring site	Mercury vapor concentration ($\mu g/m^3$)			
	2000 Avg	2000 Max	2000 Min	1986–1988 Avg
Station No. 2 (east end of Y-12)	0.0037	0.0267	0.0011	0.010
Station No. 8 (west end of Y-12)	0.0046	0.0169	0.0006	0.033
Reference site, Rain Gage No. 2 (1988[a])	N/A	N/A	N/A	0.006
Reference site, Rain Gage 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.

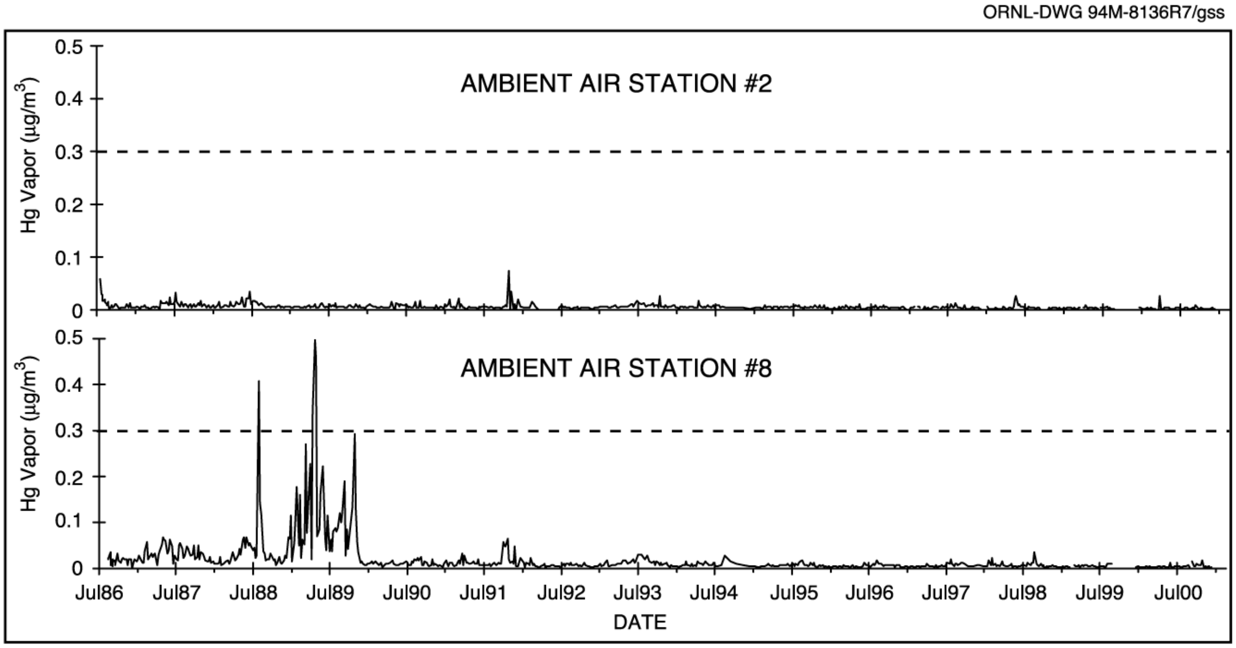

Fig. 6.4. Temporal trends in mercury vapor concentration for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Complex, July 1986 through July 2000. The dashed line represents the EPA RfC of 0.3 µg/m^3.

Y-12 to reevaluate its RMP and 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. A revised plan (LMES 1995) was fully implemented in 1995. The RMP was expanded at that time to allow sufficient collection of data such that an assessment of alpha, beta, and gamma emitters could be made. The intent was to more appropriately identify parameters to be monitored and to establish analytical detection limits necessary for dose evaluations.

Based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results, the plan was updated again in October 1997 (LMES 1997a). Under the existing RMP, 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 6.3).

The RMP 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 (POTW) 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” (ALARA) goals. The radiological monitoring needs for the sanitary sewer were reviewed and summarized in the 1997 update to the RMP (LMES 1997a).

Radiological monitoring of storm water is also required by the NPDES permit. A comprehensive monitoring plan has been designed to fully characterize pollutants in storm water runoff. The most recent revision of this plan was issued in December 1998 (LMES 1998) and incorporates radiological-monitoring requirements. There are 77 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.

Table 6.3. Radiological parameters monitored at Y-12 in 2000

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 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

6.4.1 Results

RMP locations sampled in 2000 are noted in Fig. 6.5. Table 6.4 identifies the monitored locations, the frequency of monitoring, and the sum of derived concentration guide (DCG) percentages for radionuclides measured in 2000. Except for the Central Pollution Control Facility (outfall 501) radiological data were well below the allowable DCGs. The summed percentage of DCG for outfall 501 of 92.0% was due to the elevated level of uranium measured from a sample taken during a February discharge. Following this discharge, equipment and pipelines in the facility were cleaned and flushed. A change was also made in the type of chemical precipitant used in treatment operations. These actions greatly improved treatment efficiency and reduced uranium levels in the discharge to normal.

In 2000, the total mass of uranium and associated curies released from the Y-12 Complex at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek (UEFPC), and the westernmost monitoring station, at BCK 4.55 (the former NPDES Outfall 304), was 294 kg, or 0.156 Ci (Table 6.5). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams/liter) by the average flow (million gallons/day). Converting units and multiplying by 365 days/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 POTW through the East End Sanitary Sewer Monitoring Station (EESSMS), also identified as SS-6 (Fig. 6.5). Compliance samples are collected at this location. No single radionuclide in the Y-12 contribution to the sanitary sewer exceeded 4% of the DCGs listed in DOE Order 5400.5. Summed percentages of DCGs calculated from the Y-12 contribution to the sewer are less than one. Results of radiological monitoring were reported to the city of Oak Ridge in quarterly monitoring reports.

Table 6.6 presents a summary of 2000 storm water data that exceeded screening levels. More detailed results are given in *Environmental Monitoring on the Oak Ridge Reservation: 2000 Results* (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.

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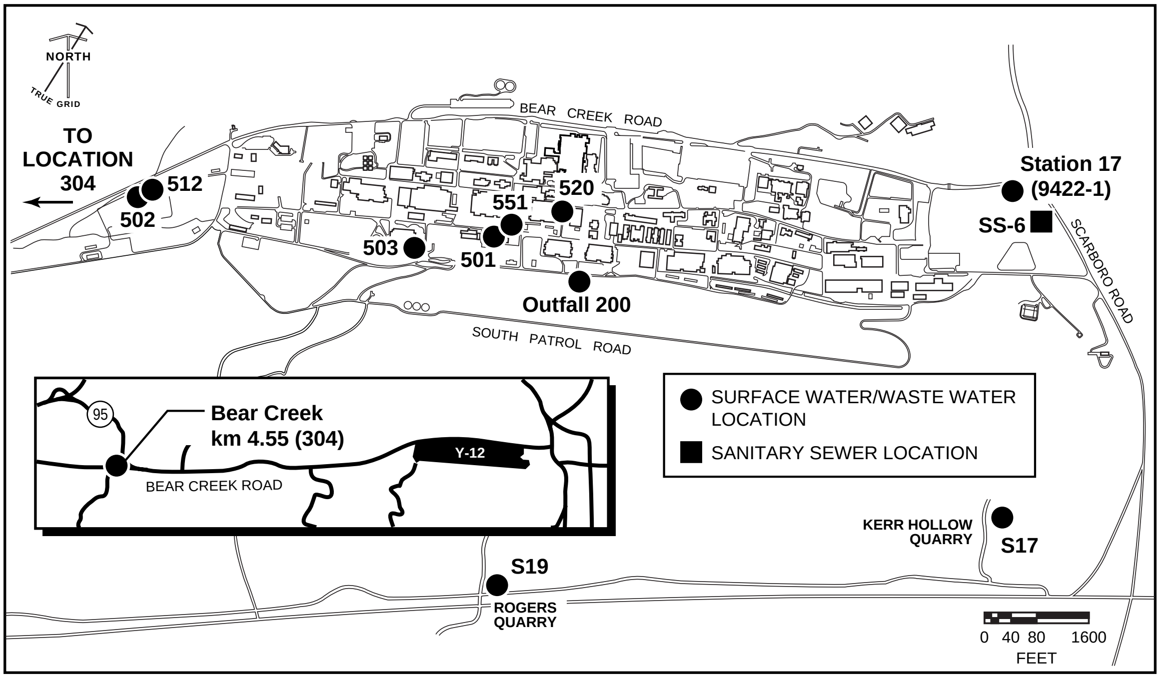

Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Table 6.4. Summary of Y-12 radiological monitoring plan sample requirements and results, 2000

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
	Y-12 wastewater treatment facilities			
501	Central Pollution Control Facility	1/week	Composite during batch operation	92
502	West End Treatment Facility	1/week	24-h composite	9.8
503	Steam Plant Wastewater Treatment Facility	1/week	24-h composite	No flow
512	Groundwater Treatment Facility	1/week	24-h composite	4.0
520 (402)[a]	Steam condensate	1/week	Grab	2.2
551	Central Mercury Treatment Facility	1/month	24-h composite	5.4
	Other Y-12 point and area source discharges			
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-h composite	2.5
S19 (302)[a]	Rogers Quarry	1/month	24-h composite	1.1
	Y-12 instream locations			
BCK 4.55 (304)[a]	Bear Creek, plant exit (west)	1/week	7-day composite	4.5
Station 17	East Fork Poplar Creek, plant exit (east)	1/week	7-day composite	2.2
200	North/south pipes	1/week	24-h composite	4.4

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

Table 6.5. Release of uranium from Y-12 to the off-site environment as a liquid effluent, 1996–2000

Year	Quantity released	
	Ci[a]	kg
	Station 17	
1996	0.135	215
1997	0.098	184
1998	0.076	127
1999	0.070	123
2000	0.063	126
	Outfall 304	
1996	0.149	259
1997	0.116	199
1998	0.091	148
1999	0.096	183
2000	0.093	168

[a]1 Ci = 3.7E+10 Bq.

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 at approximately 95 outfalls (see Fig. 6.7). The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, Y-12 has outfalls and monitoring points in the following water drainage areas: EFPC, 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

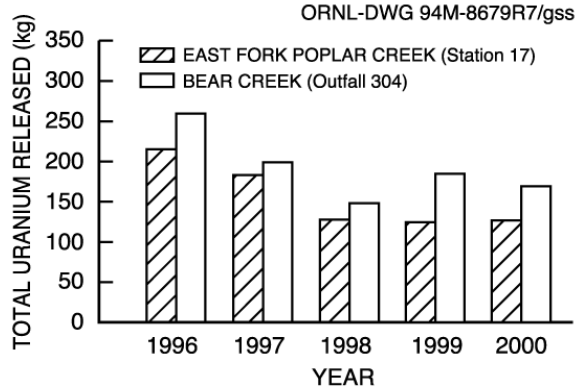

Fig. 6.6. Five-year trend of Y-12 Complex release of uranium to surface water.

data collected by the sampling and analysis of permitted discharges are compared to NPDES limits if a limit exists for each parameter. Some parameters are monitor only, with no limits specified.

The water quality of surface streams in the vicinity of the Y-12 Complex is affected by current and historical legacy operations. Discharges from Y-12 Complex processes flow in EFPC before the water exits the Y-12 Complex and eventually flow 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:

- toxicity limitation for the headwaters of East Fork Poplar Creek (EFPC) (see Sect. 6.6);
- quarterly toxicity testing at the wastewater treatment facilities and storm drain locations (see Sect. 6.6);
- chlorine limitations based on water quality criteria (WQC) at the headwaters of EFPC;
- a requirement to manage the flow of EFPC such that a minimum flow of 7 million gal/day is guaranteed by adding raw water from the Clinch River to the headwaters of EFPC (see Sect. 6.5.3);

Table 6.6. Summary of storm water data above screening levels

Parameter	Outfalls																						
	2	9	16	17	21	47	54	64	87	102	109	114	134	135	200	S02	S04	S07	S08	S10	S14	S17	S24	S26
Fecal coliform	x	x			x	x		x	x		x	x	x		x		x		x			x		x
TSS	x													x						x	x	x		x
Zinc	x		x		x	x		x	x	x	x	x		x	x									
Copper						x	x	x	x			x		x										
Mercury		x	x			x		x				x		x	x									
Magnesium												x												
Phosphorus			x		x	x			x		x	x	x	x	x		x					x	x	x
Titanium																								x
PCB																					x			
Nitrate (nitrogen)					x					x			x						x					
Alpha activity													x	x		x			x		x		x	
Beta activity		x														x			x		x			
^{228}Ra																						x		
^{230}Th																						x		
^{238}U																x			x		x		x	
^{234}U																x			x				x	

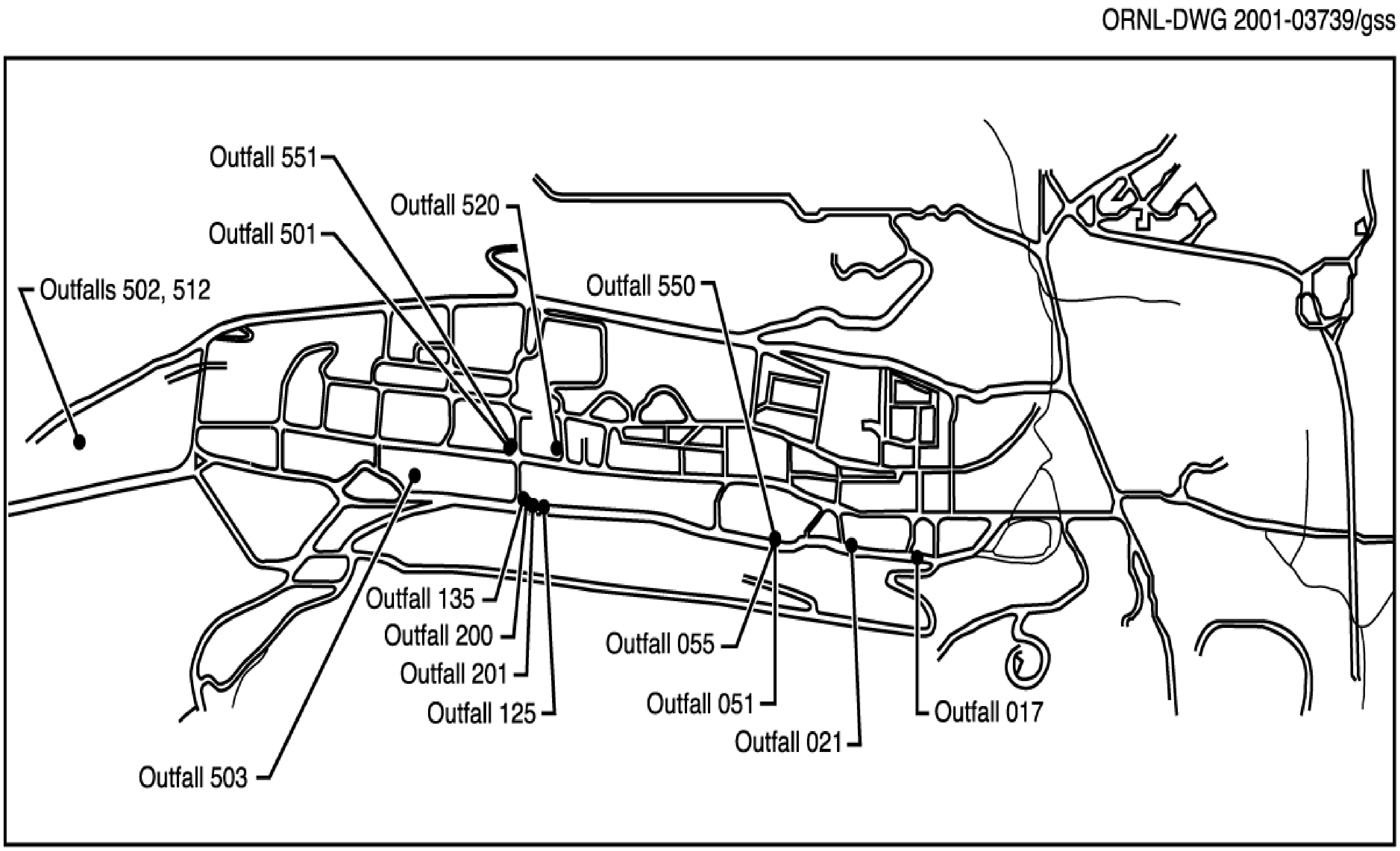

Fig. 6.7. Major Y-12 Complex NPDES outfalls.

- sampling and characterization of storm water at a minimum of 25 locations per year;
- implementation of a storm water pollution prevention plan (SWP3) (updated in 1998);
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge (monitoring ongoing); and
- a radiological monitoring plan requiring monitoring and reporting of uranium and other isotopes at pertinent locations (see Sect. 6.4).

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 CERCLA program. The CERCLA record of decision (ROD) will define any mercury requirements for EFPC. As required, a NPDES permit application was submitted in October 1999, six months prior to the expiration date (April 28, 2000) of the current permit. Since April 28, 2000 the Y-12 Complex has continued operation under the current permit.

6.5.1 Sanitary Wastewater

Sanitary wastewater from the Y-12 Complex is discharged to the city of Oak Ridge POTW 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 2000, the wastewater flow in this system averaged about 670,000 gal/day (2,536,000 L/day).

Compliance sampling is conducted at the EESSMS (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 an SWP3 at the Y-12 Complex is designed to minimize the discharge of pollutants in storm water runoff. 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.

Each year approximately 1500 chemical analyses are conducted on 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 these pollutant sources.

The SWP3 is reviewed at least annually and updated, as necessary, to reflect changes in plant operations and to incorporate revised monitoring strategies based on data from past years. The most recent revision of this plan was issued December 1998. The next revision is anticipated to be released in the CY 2001.

6.5.3 Results and Progress in Implementing Corrective Actions

In 2000, the Y-12 Complex experienced five NPDES excursions. There were four excursions in 1999 and nine in 1998. Additional details on all Y-12 NPDES permit excursions recorded in 2000 and the associated corrective actions are summarized in Appendix E, Table E.1. Table 6.7 lists the NPDES compliance monitoring requirements and the 2000 compliance record.

During 2000, the Y-12 Complex experienced one exceedence of the Industrial and Commercial

Table 6.7 NPDES compliance monitoring requirements and record for Y-12, January through December 2000

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9.0	*b*	0
Outfall 068	pH, standard units			*a*	9.0	*b*	0
Outfall 117	pH, standard units			*a*	9.0	*b*	0
Outfall 073	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 077	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 122	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 125	pH, standard units			*a*	9.0	100	14
	Total residual chlorine				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9.0	97	67
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*a*	10.0	100	6
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	99	123
	Total residual chlorine				0.5	100	33
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10.0	97	38
Outfall S19 (Rogers Quarry)	pH, standard units			*a*	9.0	100	14
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			*a*	9.0	100	162
	Total residual chlorine				0.5	99	120
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.01	100	156
	Temperature, °C			*a*	9	100	156
	pH, standard units		8.5	*a*	30.5	100	156

Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 200 (North/ South pipes)	Oil and grease			10	15	100	158
Outfall 021	Total residual chlorine			0.080	0.188	100	156
	Temperature, °C			*a*	30.5	100	158
	pH, standard units				9.0	100	158
Outfall 017	pH, standard units			*a*	9.0	100	52
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*a*	9.0	100	105
	Mercury				0.004	100	105
	Total residual chlorine				0.5	100	105
Outfall 55A	pH, standard units			*a*	9.0	*b*	0
	Mercury				0.004	*b*	0
Outfall 550	pH, standard units			*a*	9.0	100	52
	Mercury			0.002	0.004	100	53
Outfall 551	pH, standard units				9.0	100	52
	Mercury			0.002	0.004	100	52
Outfall 051	pH, standard units			*a*	9.0	100	105
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	100	18
	Total suspended solids			31.0	40.0	100	18
	Total toxic organics				2.13	100	1
	Oil and grease			10	15	100	18
	Cadmium	0.16	0.4	0.075	0.15	100	18
	Chromium	1.0	1.7	0.5	1.0	100	18
	Copper	1.2	2.0	0.5	1.0	100	18
	Lead	0.26	0.4	0.1	0.2	100	18
	Nickel	1.4	2.4	2.38	3.98	100	18
	Nitrate/nitrite				100	100	18
	Silver	0.14	0.26	0.05	0.05	100	18
	Zinc	0.9	1.6	1.48	2.0	100	18
	Cyanide	0.4	0.72	0.65	1.20	100	18
	PCB				0.001	100	1
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	100	60
	Total suspended solids	18.6	36.0	31.0	40.0	100	62
	Total toxic organics				2.13	100	8
	Nitrate/nitrite			100	150	100	62
	Oil and grease			10	15	100	61
	Cadmium	0.16	0.4	0.075	0.15	100	62
	Chromium	1.0	1.7	0.5	1.0	100	62
	Copper	1.2	2.0	0.5	1.0	100	62
	Lead	0.26	0.4	0.10	0.20	100	62
	Nickel	1.4	2.4	2.38	3.98	100	62
	Silver	0.14	0.26	0.05	0.05	100	62
	Zinc	0.9	1.6	1.48	2.0	100	62
	Cyanide	0.4	0.72	0.65	1.20	100	61
	PCB				0.001	100	8

Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall 503	pH, standard units			*a*	9.0	*b*	0
(Steam Plant	Total suspended solids	125	417	30.0	40.0	*b*	0
Wastewater	Oil and grease	62.6	83.4	10	15	*b*	0
Treatment	Iron	4.17	4.17	1.0	1.0	*b*	0
Facility)	Cadmium			0.075	0.15	*b*	0
	Chromium	0.83	0.83	0.20	0.20	*b*	0
	Copper	4.17	4.17	0.20	0.40	*b*	0
	Lead			0.10	0.20	*b*	0
	Zinc	4.17	4.17	1.0	1.0	*b*	0
Outfall 512	pH			*a*	9.0	100	144
(Groundwater	Iron				1.0	100	144
Treatment	PCB				0.001	100	12
Facility)							
Outfall 520	pH, standard units				9.0	100	10
Outfall 05A	pH				9.0	100	2

[a]Not applicable.
[b]No discharge.

Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge POTW. The zinc limit of 0.75 mg/L was exceeded on January 5 (0.93 mg/L). No specific cause was determined. Construction activities associated with the multimillion-dollar project to rehabilitate the Y-12 Complex Sanitary Sewer collection system were completed during 1999. This project was undertaken to upgrade the sewer collection infrastructure and to reduce the amount of storm water inflow and groundwater infiltration into the system. Table 6.8 lists the Industrial and Commercial Users Wastewater Permit compliance monitoring requirements and the 2000 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 (TSS), Zn, P, Cu, U, Mn, Nitrate, and Hg during storm events (see Table 6.6). However, some monitored pollutants are not present at specific outfalls. A detailed storm water data summary table is given in *Environmental Monitoring on the Oak Ridge Reservation: 2000 Results* (see http://www.ornl.gov/aser).

6.5.4 East Fork Poplar Creek Fish Kill Summary

During the evening of January 29, 2000, a small number of dead fish were observed on EFPC near outfall 200. An investigation determined that a potable water line break resulted in flooding of the basement of Building 9815 and discharge of water to the surface drains. The flooding caused two tanks to float from the support cradles. One tank apparently spilled some acidic solution, which was inadvertently discharged to the drain system, briefly lowering the pH in the stream near outfall 200. Fifty-two minnow sized fish were collected following this short event.

6.5.5 Flow Management (or Raw Water) Project

Because of concern about maintaining water quality and stable flow in the upper reaches of EFPC, the NPDES permit requires addition of Clinch River water to the headwaters of EFPC (North/South Pipe-Outfall 200 area) so that a minimum flow of 7 million gal/day (26.5 million L/day) is maintained at the point where EFPC

Table 6.8. Y-12 Discharge Point SS6, Sanitary Sewer Station 6
January through December 2000

Effluent parameter	Number of samples	Daily average value (effluent limit)[a]	Daily maximum value (effluent limit)[b]	Percentage of compliance
pH, standard units	54	*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
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	50	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	98

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

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 this project, instream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters).

6.6 BIOMONITORING PROGRAM

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a Biomonitoring Program that evaluates an EFPC instream monitoring location (Outfall 201, see Fig. 6.7), wastewater treatment system discharges, and locations in the storm sewer drain is required. Table 6.9 summarizes the results of biomonitoring tests conducted on effluent samples from wastewater treatment and storm drainage systems. The results of the 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 to the effluent's calculated instream waste concentration (IWC) to determine the likelihood that the discharged effluent would be harmful to aquatic biota in the receiving stream. If the LC_{50} is much greater than the IWC, it is less likely that there is an instream impact. Effluent samples from the wastewater treatment system discharges were tested at least three times in 2000 on *Ceriodaphnia dubia*. Effluent samples from the Central Mercury Treatment System (CMTS) were consistently nontoxic. Central Pollution Control Facility (CPCF) samples were nontoxic to *Ceriodaphnia* in two tests and had LC_{50}s of 71% and 65% in two other tests. The LC_{50}s for the Groundwater Treatment Facility (GWTF) was nontoxic in one test and ranged from 41% to 46% in three additional tests. The West End Treatment Facility (WETF) ranged from 17 to 50% for three tests. In all cases, the calculated IWCs of the effluent were less than the LC_{50}s. This indicates that the treated effluent

Table 6.9. Y-12 Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 2000[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
West End Treatment Facility (WETF)	1/19/00	*Ceriodaphnia*	17.3	0.09
SWHISS South of 9201-4	1/20/00	*Ceriodaphnia*	17.2	*d*
Storm Sewer South of 9201-4	1/20/00	*Ceriodaphnia*	65.6	*d*
Groundwater Treatment Facility (GWTF)	1/20/00	*Ceriodaphnia*	>100	0.12
SWHISS South of 9201-4 (dechlorinated)	1/20/00	*Ceriodaphnia*	68.7	*d*
Central Mercury Treatment System (CMTS)	1/21/00	*Ceriodaphnia*	>100	0.24
Central Pollution Control Facility (CPCF)	1/25/00	*Ceriodaphnia*	64.8	0.13
Storm Sewer North of 9723-25 (dechlorinated)	1/25/00	*Ceriodaphnia*	>100	*d*
Storm Sewer North of 9723-25	1/25/00	*Ceriodaphnia*	17.3	*d*
Storm Sewer South of 9409-24	1/25/00	*Ceriodaphnia*	>100	*d*
SWHISS South of 9201-4	4/13/00	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (GWTF)	4/13/00	*Ceriodaphnia*	45.5	0.20
SWHISS South of 9204-2 (dechlorinated)	4/13/00	*Ceriodaphnia*	64.8	*d*
SWHISS South of 9204-2	4/13/00	*Ceriodaphnia*	9.0	*d*
West End Treatment Facility (WETF)	4/14/00	*Ceriodaphnia*	48.9	0.10
Central Mercury Treatment System (CMTS)	4/14/00	*Ceriodaphnia*	>100	0.21
SWHISS South of 9201-5, 9201-4	4/18/00	*Ceriodaphnia*	43.3	*d*
SWHISS South of 9201-5, 9201-4 (dechlorinated)	4/18/00	*Ceriodaphnia*	89.9	*d*
SWHISS South of 9204-4, 9201-5	4/18/00	*Ceriodaphnia*	>100	*d*
Lithium Process Steam Condensate	5/12/00	*Ceriodaphnia*	26.1	*d*
Central Pollution Control Facility (CPCF)	6/28/00	*Ceriodaphnia*	70.7	0.07
Groundwater Treatment Facility (GWTF)	7/13/00	*Ceriodaphnia*	40.9	0.11
SWHISS South of 9201-4 (dechlorinated)	7/13/00	*Ceriodaphnia*	>100	*d*
SWHISS South of 9201-4	7/13/00	*Ceriodaphnia*	49.7	*d*
West End Treatment Facility (WETF)	7/14/00	*Ceriodaphnia*	50.6	0.11
Central Mercury Treatment System (CMTS)	7/14/00	*Ceriodaphnia*	>100	0.17
Lithium Process Steam Condensate	7/17/00	*Ceriodaphnia*	42.3	*d*
SWHISS South of 9204-2	7/18/00	*Ceriodaphnia*	36.4	*d*
SWHISS South of 9204-2 (dechlorinated)	7/18/00	*Ceriodaphnia*	57.0	*d*
SWHISS South of 9201-5, 9201-4 (dechlorinated)	7/18/00	*Ceriodaphnia*	>100	*d*
SWHISS South of 9204-4, 9201-5	7/18/00	*Ceriodaphnia*	78.7	*d*
SWHISS South of 9204-4, 9201-5 (dechlorinated)	7/18/00	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (CPCF)	9/9/00	*Ceriodaphnia*	>100	0.10
SWHISS South of 9204-2 (dechlorinated)	10/19/00	*Ceriodaphnia*	>100	*d*
SWHISS South of 9201-4	10/19/00	*Ceriodaphnia*	16.8	*d*
SWHISS South of 9201-4 (dechlorinated)	10/19/00	*Ceriodaphnia*	61.1	*d*
SWHISS South of 9204-2	10/19/00	*Ceriodaphnia*	70.7	*d*

Table 6.9 (continued)

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Central Mercury Treatment System (CMTS)	10/20/00	*Ceriodaphnia*	>100	0.07
Central Pollution Control Facility (CPCF)	10/24/00	*Ceriodaphnia*	76.4	*d*
SWHISS South of 9201-5, 9201-4	10/24/00	*Ceriodaphnia*	68.7	*d*
SWHISS South of 9201-5, 9201-4 (dechlorinated)	10/24/00	*Ceriodaphnia*	>100	*d*
SWHISS South of 9204-4, 9201-5	10/24/00	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (GWTF)	10/25/00	*Ceriodaphnia*	40.5	0.09

[a]Summarized are the effluents and their corresponding 48-h LC_{50}s and instream waste concentrations (IWCs). 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. The IWC is based on actual flows at Outfall 201 in East Fork Poplar Creek.

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

from the treatment facilities would not alone be acutely toxic to the aquatic biota in EFPC.

Various locations in the storm drainage system upstream of outfalls 200 and 201 were monitored during the year. When chlorine was detected in a storm-drain sample, side-by-side tests were conducted with a sample that was dechlorinated. In all cases, survival was higher in the dechlorinated sample than in the nontreated sample. The improvement in survival varied from sample to sample (as indicated by an increase in the LC_{50}), indicating that the toxicity from chlorine varied from sample to sample. In most cases, the full-strength dechlorinated sample continued to reduce *Ceriodaphnia* survival, indicating the presence of toxicity other than chlorine. 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 IWC). It is notable, however, that the results of the biomonitoring tests at Outfall 201 (Table 6.10) demonstrated that when all discharges were combined (treated effluent, storm drain contribution, plus Flow Management water) and dechlorinated, the samples were nontoxic in laboratory tests.

Table 6.10 summarizes the NOECs and 96-h 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 an effluent. Water from Outfall 201 was tested four times in 2000 on fathead minnow larvae and *Ceriodaphnia dubia*. The NOECs were all 100% for both *Ceriodaphnia* and fathead minnows; the 96-h LC_{50}s were all >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, EFPC. The BMAP consists of four major tasks that reflect complementary approaches to evaluating the effects of the Y-12 Complex discharges on the aquatic integrity of EFPC. 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.

Fish and invertebrate communities in UEFPC continue to be degraded in comparison with similar communities in reference streams. However, relatively consistent trends of increases in

Table 6.10. Y-12 Biomonitoring Program summary information for Outfall 201 for 2000[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/19	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	4/12	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	7/12	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/18	*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 percent 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.

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, indicate that the overall ecological health of EFPC continues to improve.

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 biological water quality of EFPC at intervals throughout the year. *Ceriodaphnia* tests were conducted quarterly in 2000 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 (see Sect. 6.6). Because of the close proximity of Outfall 201 (an instream NPDES location in UEFPC) to EFK 25.1, the tests of water from Outfall 201 also met the intent of the *Y-12 BMAP Sampling Plan* (Adams et al. 1998) to conduct quarterly toxicity tests at the latter location.

No evidence for toxicity was observed in any of the 2000 *Ceriodaphnia* tests (both EFPC sites) or fathead minnow tests (only Outfall 201). These results are consistent with the findings of previous *Ceriodaphnia* and fathead minnow tests conducted since flow management began in the latter half of 1996. These results contrast, however, with the continuing toxicity evident in chronic tests involving fish embryos and clams, which appear more sensitive to water quality conditions in EFPC. 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

Fish in EFPC historically had elevated mercury and PCBs relative to fish in uncontaminated reference streams. Fish are monitored regularly in EFPC 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*) were sampled twice during 2000 from the mid to upper reaches of EFPC and were analyzed for tissue concentrations of these two environmental contaminants. Largemouth bass (*Micropterus salmoides*) were collected once in 2000 from two sites in EFPC (Lake Reality and EFK 23.4) to monitor maximum bioaccumulation in larger piscivorous fish of the system.

Mercury concentrations remained higher during 2000 in fish from EFPC than in fish from reference streams. Accelerated mercury bioaccumulation in UEFPC indicates that the Y-12 Complex remains an important source of mercury to fish in the stream. Following significant decreases in the mid-1990s, mercury concentrations in the fish and water of UEFPC have remained relatively constant over the last 3 years (Fig. 6.8).

PCB concentrations in EFPC sunfish during 2000 fell within ranges typical of past monitoring efforts at these sites (Fig. 6.9) . Mean PCB concentrations were again highest in Lake Reality and in the upper reaches of EFPC above Lake Reality, indicating a continuing PCB source or sources within the Y-12 Complex.

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 populations in EFPC. Redbreast sunfish were sampled from three sites in EFPC and from two reference streams in the spring of 2000 prior to the onset of the breeding season. The health and reproductive condition of sunfish from EFPC sites upstream of Bear Creek Road still lag behind those of fish from reference sites and downstream EFPC sites. However, overall trends in many contamination-related bioindicators suggest that there has been a distinct improvement in overall fish health in UEFPC in recent years.

EFPC water remained toxic during 2000 to fish embryos in the medaka embryo-larval test for developmental toxicity. No specific cause for this toxicity has yet been identified, but medaka embryos, like the embryos of other fish species, are quite sensitive to many of the chemical constituents originating within the Y-12 Complex, including various metals (particularly mercury), ammonia and other nitrogenous wastes, and even the chemicals involved in or the by-products of chlorination/dechlorination water treatment procedures.

6.7.4 Ecological Surveys

Periphyton were monitored quarterly during 2000 from three sites along EFPC. Algal biomass and photosynthetic rates remained higher in EFPC

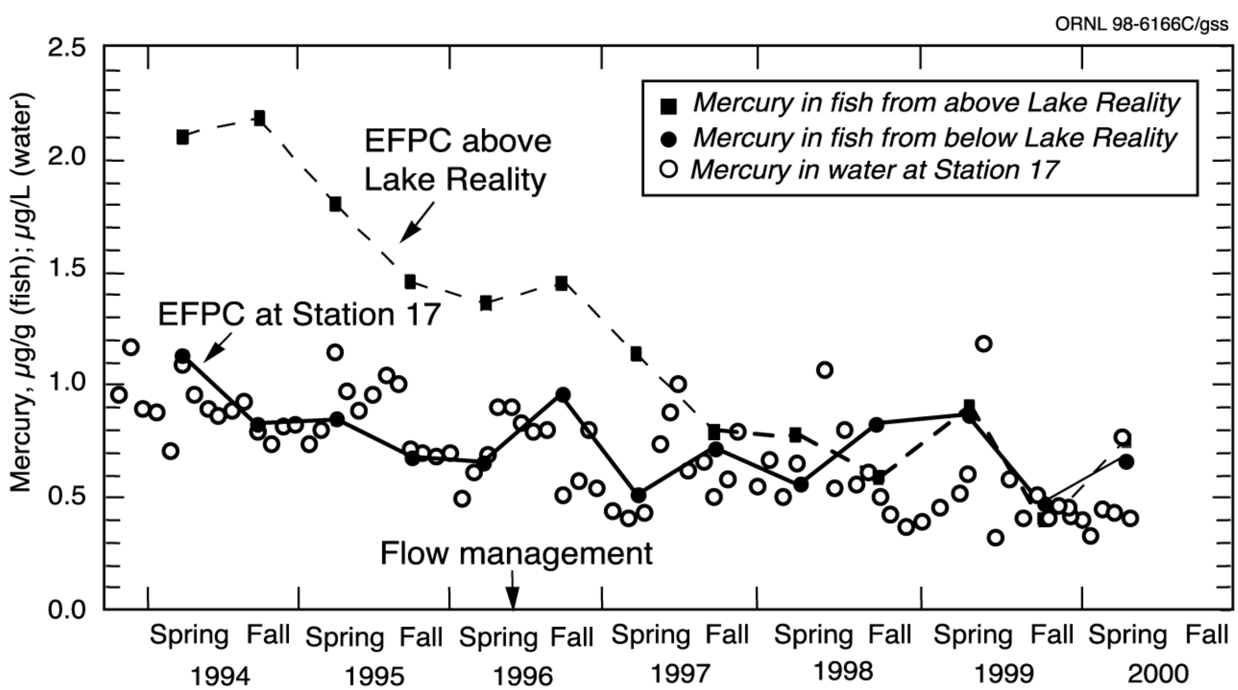

Fig. 6.8. Average mercury concentration in redbreast sunfish muscle filets, East Fork Poplar Creek upstream and downstream of Lake Reality, and monthly average total mercury concentration in water at Station 17, 1994 through spring 2000.

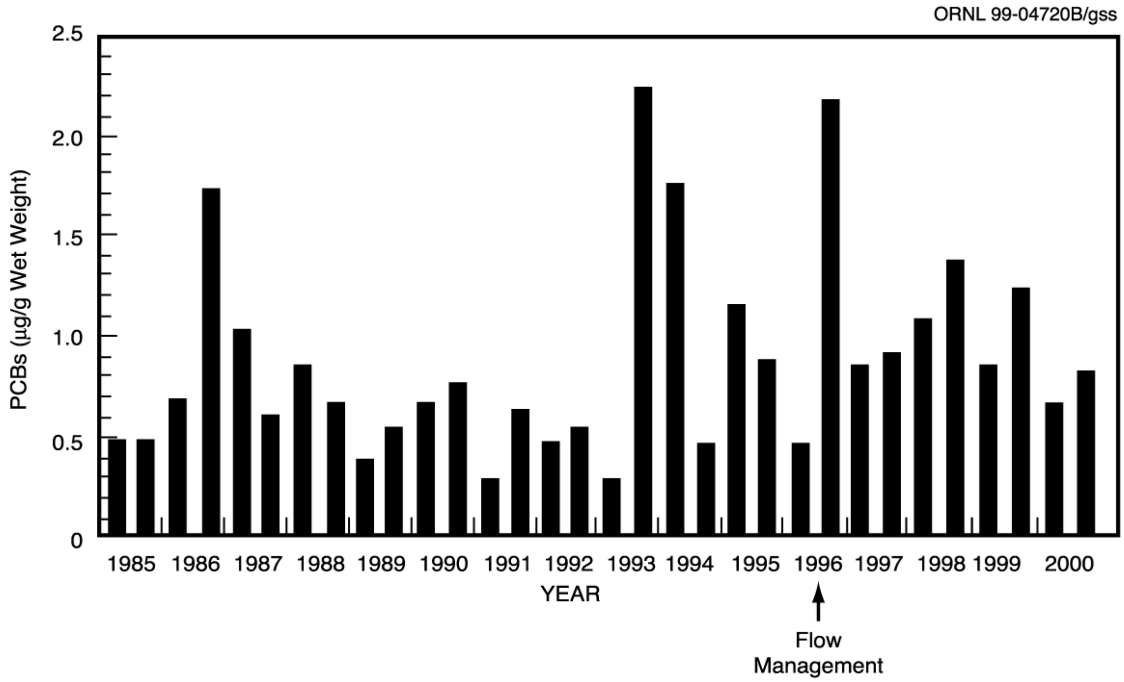

Fig. 6.9. Mean concentrations of PCBs in redbreast sunfish muscle filets, East Fork Poplar Creek, upstream and downstream of Lake Reality, 1985–2000.

than in reference streams. Concentrations of various metals continued to be elevated in EFPC periphyton.

Fish communities in EFPC were monitored twice in 2000 at six sites along EFPC and at two reference streams. In recent years, overall species richness and the number of pollution-sensitive fish species have increased at all sampling locations below Lake Reality (Fig. 6.10). However, fish communities in EFPC still lagged behind reference stream communities in these and other important metrics of community health.

Benthic macroinvertebrate communities were monitored at four sites in EFPC and at two reference streams in the fall and spring of 2000. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded as compared with reference communities (Fig. 6.11). However, persistent increases in total richness and the richness of pollution-tolerant taxa at these sites indicated continuing improvement in EFPC benthic macroinvertebrate communities.

The effects of in situ exposure on clam growth and survival were tested during 2000 at three sites in EFPC and at three reference streams. As in previous such tests, clam survival and growth were severely impacted at all tested EFPC locations, especially upstream sites near the Y-12 Complex.

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 BMP. The Y-12 Environmental Compliance Department staff monitor the surface water as it exits from each of the three hydrogeologic regimes that serve as an exit pathway for surface water (Fig. 6.12).

Monitoring is conducted in EFPC at Station 17 (9422-1) near the junction of Scarboro and Bear Creek roads. The current sampling program consists of two 48-h composites plus a 3-day weekend composite. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and TSS.

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

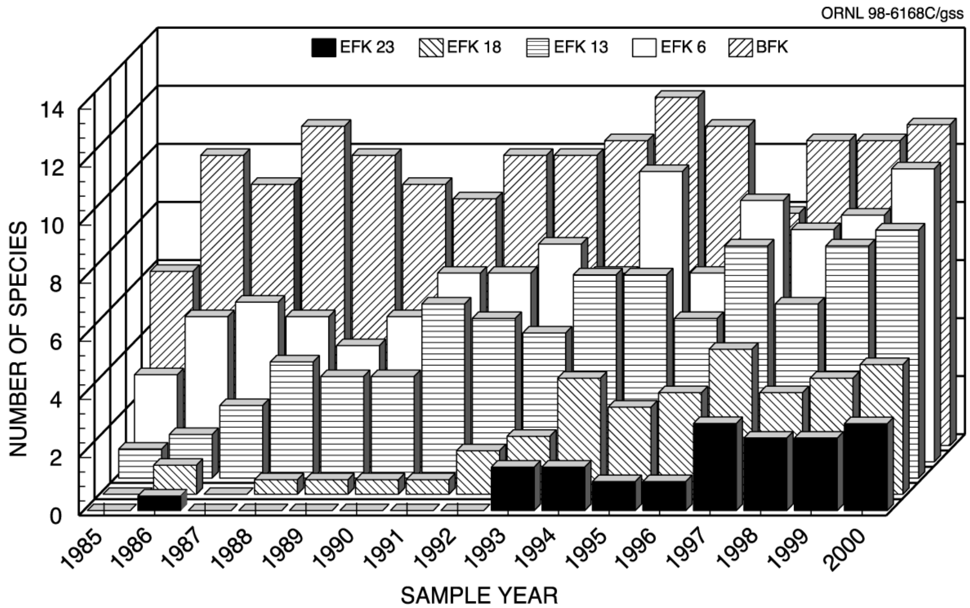

Fig. 6.10. Comparison of numbers of sensitive fish species collected during the spring of each year from 1985 through 2000 from four sites in EFPC and a reference site (Brushy Fork). EFK = East Fork kilometer; BFK = Brushy Fork kilometer.

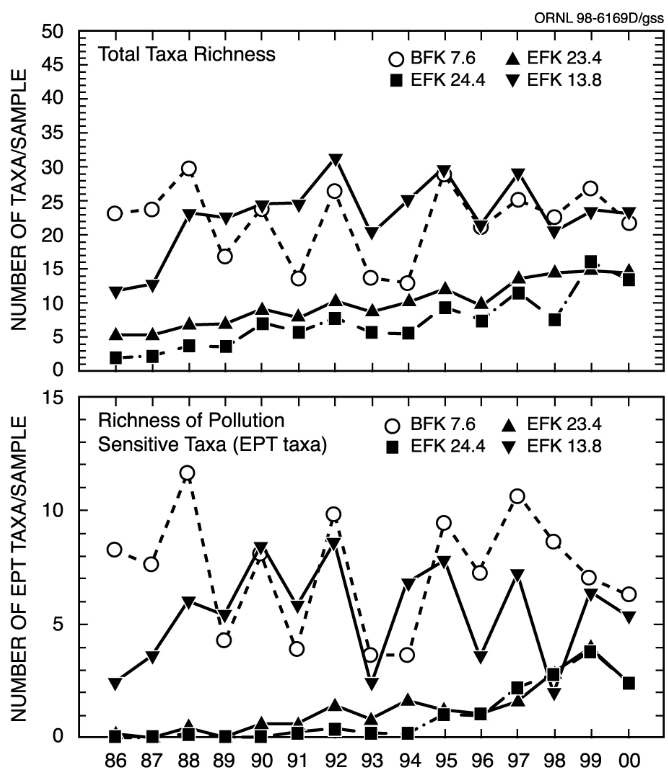

Fig. 6.11. Total taxonomic richness (mean number of taxa/sample, ± SE) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (mean number of EPT taxa/sample ± SE) of the benthic macroinvertebrate communities in East Fork Poplar Creek (EFK) and a reference site (BFK 7.6), spring data only. (EPT taxa include relatively pollution-sensitive species.)

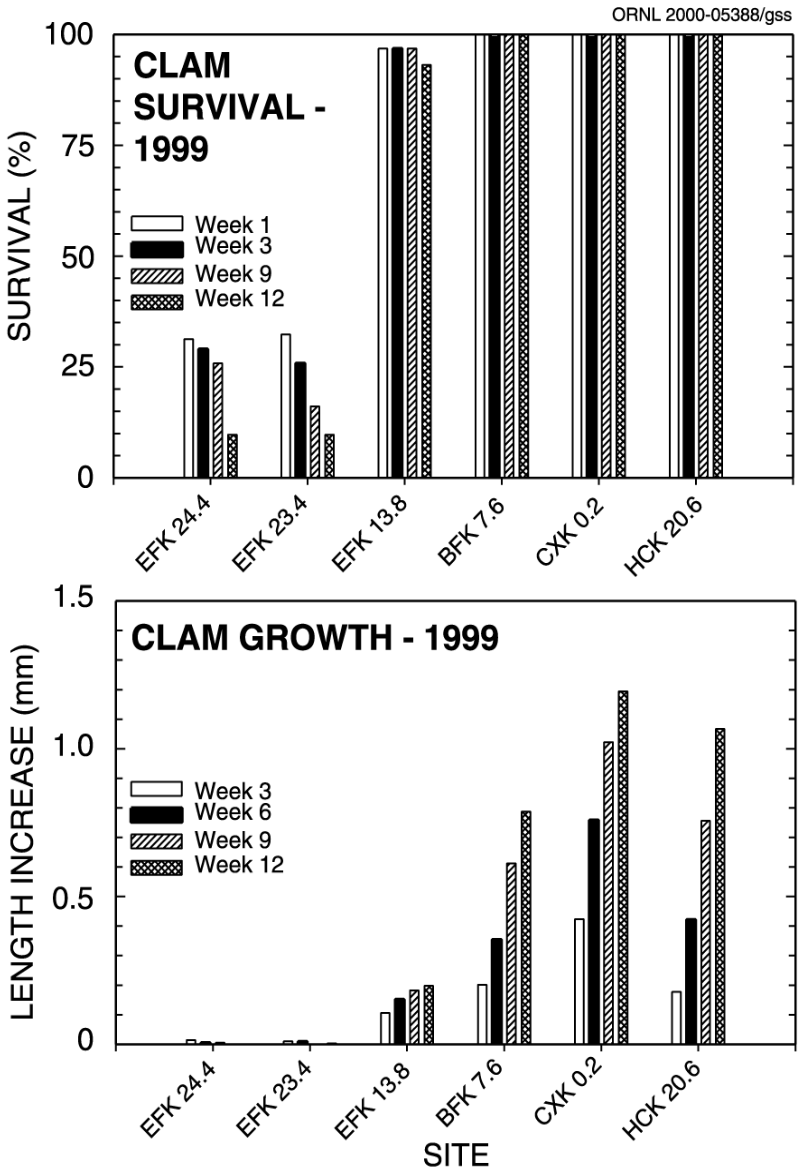

Fig. 6.12. Mean survival and growth of fingernail clams (*Sphaerium fabale*) in in situ bioassays in EFPC, June through September 1999.

composite sample) is collected monthly for analysis for mercury; anions (sulfate, chloride, nitrate, nitrite); ICP metals; total phenols; and TSS.

The exit pathway from the Chestnut Ridge 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 requirement for this location is to monitor and report metals data only.

In addition to these exit pathway locations, a network of real-time monitors is located at instream locations along UEFPC and at key points on the storm drain system that flows to the creek. The Surface Water Hydrological Information Support System (SWHISS) is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 6.13. 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 (WQC). The most restrictive of either the freshwater fish and aquatic life criterion maximum concentration (CMC) or the recreation concentration for organisms only standard (10^5 risk factor for carcinogens) 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 5400 surface water surveillance samples were collected in 2000. Comparisons with Tennessee WQC indicate that only mercury, copper and zinc from samples collected at Station 17 were detected at values exceeding a criteria maximum. Results are shown in Table 6.11. Of all the parameters measured in the surface water as a BMP, 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 (GWPP) to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 6.10.4.3).

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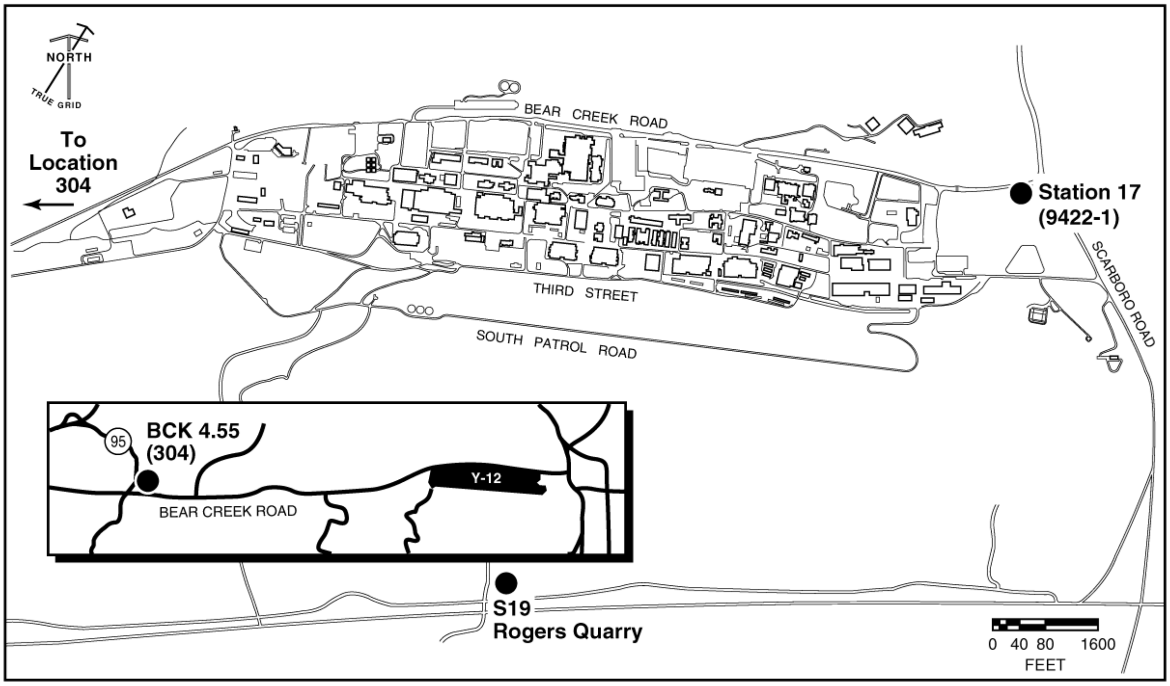

Fig. 6.13. Locations of Y-12 Complex surface water surveillance sampling stations.

Table 6.11. Surface water surveillance measurements exceeding Tennessee water quality criteria at Y-12, 2000

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Avg		
Copper	Station 17	151	0.02	0.0251	<0.02	0.0177	1
Mercury	Station 17	401	0	0.0053	<0.0005	0.000051	393
Zinc	Station 17	151	0.05	0.193	<0.06	0.117[a]	5

[a]The standard is a function of total hardness. This value corresponds to a total hardness value of 100 mg/L.

6.9 Y-12 SEDIMENT SAMPLING

In 1997, revisions to the ORR Environmental Monitoring Plan and the scope of ORR surveillance monitoring conducted by ORNL resulted in discontinuation of sediment sampling at the Y-12 Complex in EFPC and Bear Creek. However, historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in the sediment. Therefore, as a BMP, the Y-12 Complex maintains an annual sampling program to determine whether these constituents are accumulating in the sediments of EFPC and Bear Creek as a result of Y-12 Complex discharges. Results of the most recent monitoring activity (May 2000) are given in Table 6.12. The monitoring results indicate that the levels of mercury, PCBs, and isotopes of uranium and thorium have not significantly changed since 1997.

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 stream to natural waterways. The order limits the amount of activity that may be present

Table 6.12. Results of Y-12 sediment monitoring, 1997–2000

	Station 17			BCK 9.4		
	1997	1999	2000	1997	1999	2000
^{226}Ra (pCi/g)	2.8	2.4	–0.67	2.4	2.5	0.92
^{228}Th (pCi/g)	0.97	0.57	0.072	0.70	0.52	0.54
^{230}Th (pCi/g)	1.2	0.50	0.79	0.41	0.24	0.38
^{232}Th (pCi/g)	0.73	0.48	0.10	0.68	0.41	0.28
^{234}U (pCi/g)	2.6	2.7	1.4	3.6	3.6	3.5
^{235}U (pCi/g)	0.13	0.11	0.078	0.20	0.20	0.16
^{238}U (pCi/g)	2.9	2.8	3	6.3	7.6	6.7
Mercury (µg/g)	9.5	14.6	18.5	0.3	0.215	0.262
Total PCBs (µg/kg)	370J	280	180	350J	350	340

in released settleable solids. Because waste streams from the Y-12 Complex have very low settleable solids contents, this sampling program to measure activity in the sediments of EFPC and Bear Creek is used to determine whether a buildup of radionuclide concentrations is occurring.

6.10 GROUNDWATER MONITORING AT Y-12

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. Because of this contamination, extensive groundwater monitoring is required to comply with regulations and DOE orders.

6.10.1 Background and Regulatory Setting

During CY 2000, routine groundwater monitoring at Y-12 was conducted by two programs: (1) the Y-12 Groundwater Protection Program (GWPP), managed by Lockheed Martin Energy Systems, Inc. (January through October 2000) and BWXT Y-12, L.L.C. (November through December 2000), and (2) the Water Resources Restoration Program (WRRP), formerly the Integrated Water Quality Program (IWQP), managed by Bechtel Jacobs Company LLC. Each program is responsible for monitoring groundwater to meet specific compliance requirements. In CY 2000, the GWPP performed monitoring to comply with DOE orders, while the WRRP performed groundwater monitoring in compliance with CERCLA, the Resource Conservation and Recovery Act (RCRA), and Tennessee Department of Environment and Conservation Division of Solid Waste Management (TDEC-DSWM) regulations.

Specific regulatory requirements do not address all groundwater-monitoring concerns at Y-12. Selected areas, from which contamination is most likely to migrate to potential exposure points off the ORR, are monitored as part of DOE Order 5400.1 requirements for exit pathway monitoring. Also, monitoring is performed as part of DOE 5400.1 surveillance monitoring in areas not specifically regulated and not representing specific exit pathways off the reservation, such as a large part of the industrialized portion of Y-12. Surveillance monitoring is conducted to monitor contaminant plume boundaries and to trend contaminant concentrations specifically to augment regulatory and exit pathway monitoring programs.

Bechtel Jacobs is responsible for addressing environmental and waste management issues under RCRA, CERCLA, and TDEC-DSWM. The WRRP performed groundwater monitoring to comply with RCRA post-closure permit (PCP) requirements at the seven sites identified in Table 2.6. Under CERCLA, the WRRP performed groundwater monitoring to comply with RODs, Interim RODs, or action memoranda (AMs) to determine and evaluate the effectiveness of remedial actions. Also, baseline CERCLA monitoring is performed to accumulate data against which the effects of pending remedial actions can be measured. Groundwater detection monitoring was performed semiannually or quarterly at five solid waste disposal facilities (SWDFs) located on Chestnut Ridge at Y-12 and permitted and regulated by the TDEC-DSWM. Figure 6.14 depicts the major facilities considered as known and/or potential contaminant source areas for which groundwater monitoring was performed during CY 2000.

Due to the multiple considerations and the differing technical objectives and responsibilities of the GWPP and the WRRP, considerable effort is made to maintain efficiencies in groundwater-monitoring activities at Y-12. Communication between the two programs has been crucial in eliminating any redundancies in monitoring activities. In addition, communication and mutual cooperation provided for more consistent data collection, evaluation, and overall quality.

6.10.2 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes delineated by surface water drainage patterns, topography, and ground-water flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime (Bear Creek regime), the UEFPC Hydro-geologic Regime (UEFPC regime), and the Chest-nut Ridge Hydrogeologic Regime (Chestnut Ridge regime) (Fig. 6.15). Most of the Bear Creek and UEFPC regimes are underlain by the ORR aquitards. The extreme 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.

In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek and UEFPC regimes is divergent from a topographic and groundwater table divide located near the western end of Y-12. The flow directions of shallow groundwater east and west of the divide are predominantly easterly and westerly, respectively. This divide defines the boundary between the Bear Creek and UEFPC regimes. In addition, flow converges toward the primary surface streams from Pine Ridge and Chestnut Ridge. In the Chestnut Ridge regime, a groundwater table divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow, therefore, 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 predomi-nantly through fractures in the ORR aquitards, converging toward and moving through fractures

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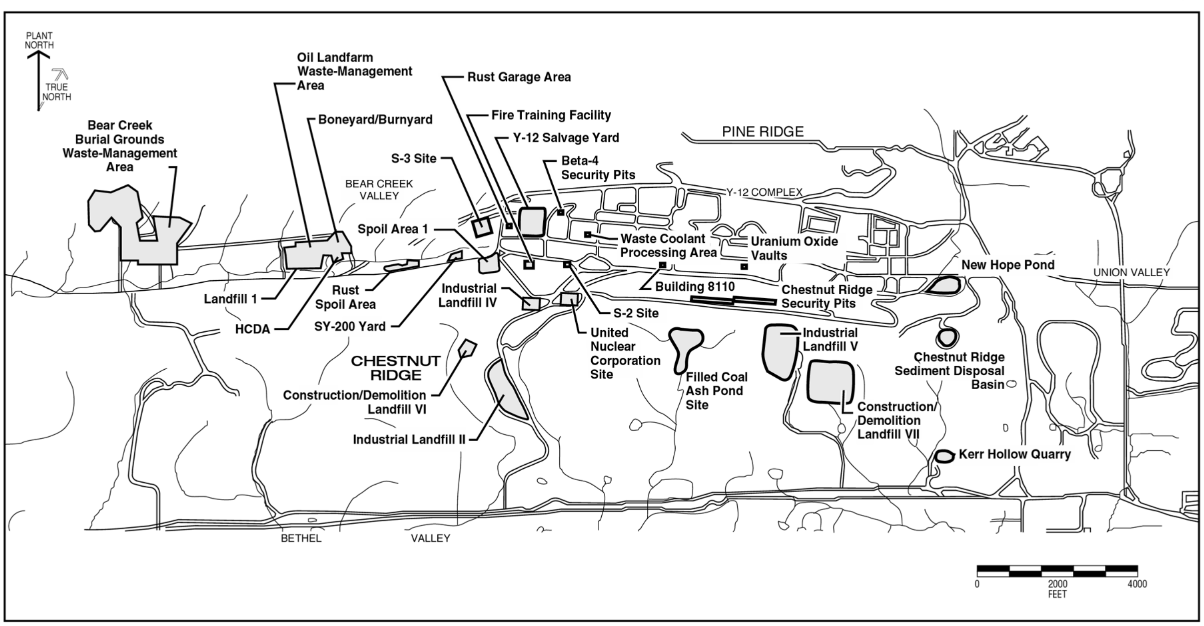

Fig. 6.14. Y-12 Complex inactive regulated units, study areas, and active facilities for which groundwater monitoring was conducted in CY 2000.

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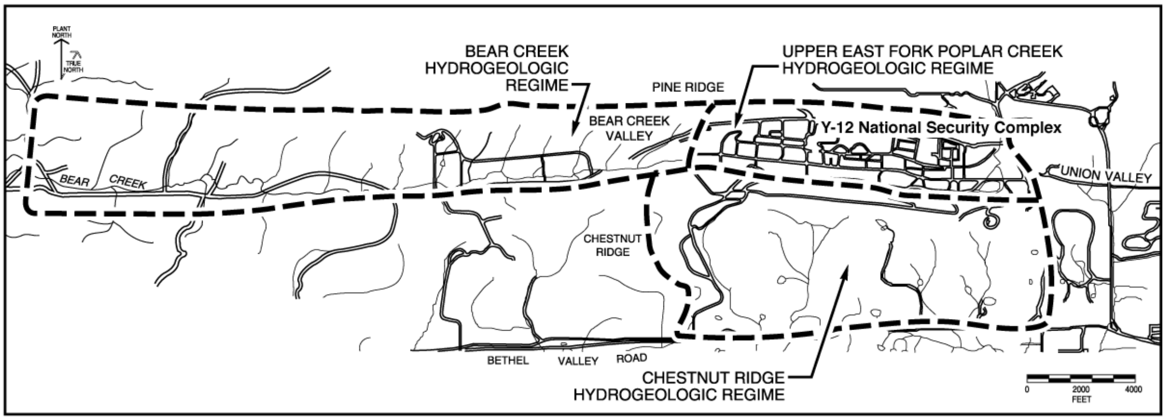

Fig. 6.15. Hydrogeologic regimes at the Y-12 Complex.

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 geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the ORR aquitards but can be quite rapid within solution conduits in the Maynardville Limestone.

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 subsurface utility traces and buried tributaries in the UEFPC 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 now known to extend west from the S-3 Site for a distance of about 3000 ft. Volatile organic compounds (VOCs) at source units in the ORR aquitards, however, tend to remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport for long distances can occur.

Groundwater flow in the Chestnut Ridge regime is almost exclusively 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 the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Along the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

6.10.3 CY 2000 Monitoring Program

Groundwater monitoring in CY 2000 was performed to comply with regulations and DOE orders by the GWPP and WRRP. Compliance requirements were met by the monitoring of 148 wells, 19 springs, 25 surface water locations and 2 building sumps (Table 6.13). Figure 6.16 shows the locations of ORR perimeter/exit pathway groundwater monitoring stations as specified in the *ORR Environmental Monitoring Plan* (DOE 1998b).

Detailed results of monitoring activities at Y-12 in CY 2000 are presented in the annual groundwater monitoring report (BWXT Y-12 2001). Details of monitoring efforts performed specifically for CERCLA OUs are published in four documents (DOE 1997a, 1997b, 1998b, and 1998c) and in the *2001 Remediation Effectiveness Report* (DOE 2001). Groundwater monitoring compliance reporting to meet RCRA post-closure permit requirements can be found in the RCRA annual reports (BJC 2001a, BJC 2001b, and BJC 2001c).

Table 6.13. Types and numbers of groundwater monitoring stations sampled at the Y-12 Complex, during 2000

	Bear Creek	Chestnut Ridge	UEFPC	Total
Conventional wells	45	40	58	143
Multiport wells	4	0	1	5
Surface water	10	3	12	25
Springs	7	8	4	19
Building sumps	0	0	2	2
Total number of monitoring stations	66	51	77	194

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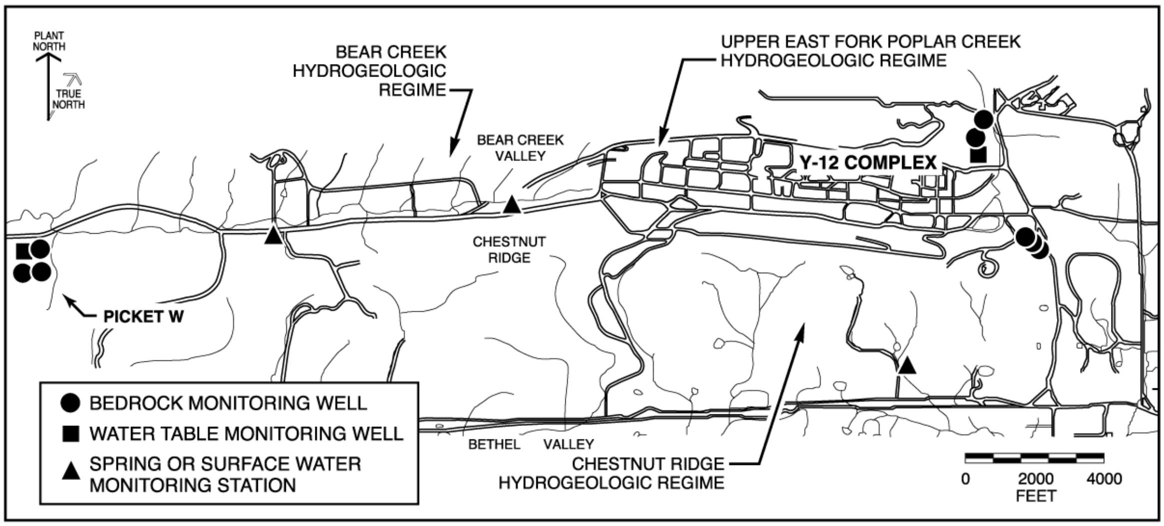

Fig. 6.16. Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring station in the *Environmental Monitoring Plan* (DOE 1998b).

6.10.4 Y-12 Groundwater Quality

Historical monitoring efforts have shown that four types of contaminants have affected groundwater quality at Y-12: nitrate, VOCs, metals, and radionuclides. Of these, nitrate and VOCs are the most widespread, and some radionuclides, particularly uranium and ^{99}Tc are significant, principally in the Bear Creek regime and the western and central portions of the UEFPC regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the western end of Y-12, near the S-2 and S-3 Site. 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 CY 2000 monitoring locations and waste management sites in the UEFPC regime that are addressed in this document are shown in Fig. 6.17. Brief descriptions of waste management sites in the UEFPC regime are given in Table 6.14.

The UEFPC regime consists of contaminant source areas, surface water, and groundwater components of the hydrogeologic system within the manufacturing complex and Union Valley to the east and off the DOE ORR. Among the three hydrogeologic regimes at Y-12, the UEFPC regime contains most of the known and potential sources of surface water and groundwater contamination. Chemical constituents from the S-3 Site

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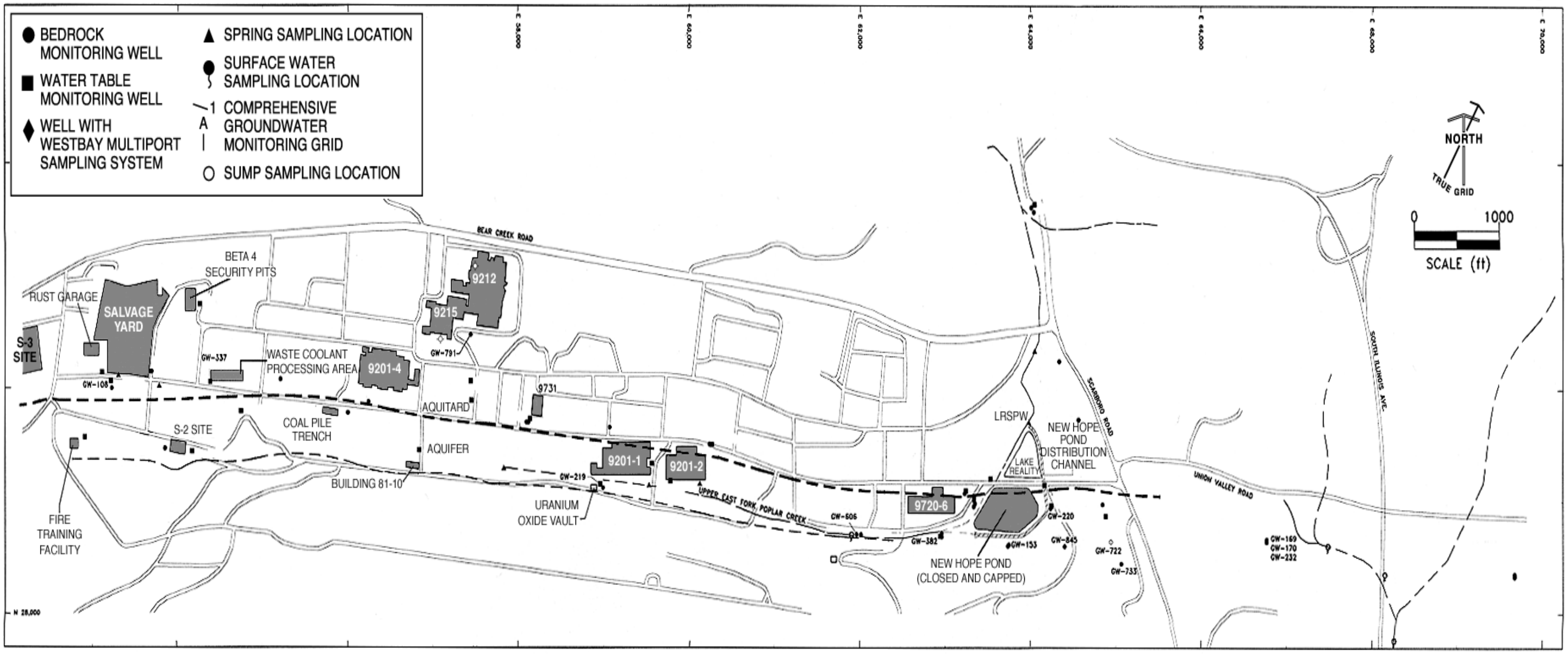

Fig. 6.17. Locations of waste management sites and monitoring wells sampled during 2000 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Table 6.14. History of waste management units and underground storage tanks included in CY 2000 groundwater monitoring activities; Upper East Fork Poplar Creek Hydrogeologic Regime

Site	Historical data
New Hope Pond	Built in 1963. Regulated flow of water in UEFPC before exiting the Y-12 Complex. 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 Facility	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	Staging facility. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury
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 firefighting 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
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
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

(primarily nitrate and ^{99}Tc) dominate groundwater contamination in the western portion of the UEFPC regime; groundwater in the eastern portion, including Union Valley, is predominantly contaminated with VOCs.

Plume Delineation

The principal groundwater contaminants in the UEFPC regime are nitrates, VOCs, trace metals, and radionuclides. Sources of these contaminants monitored during CY 2000 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, Beta-4 Security Pits, Salvage Yard, and process/production buildings in the Y-12 Complex. Although it is located west of the current hydrologic divide that separates the UEFPC regime from the Bear Creek regime, the S-3 Site, now closed under RCRA, has contributed to groundwater contamination in the western part of the regime.

Nitrate

Nitrate concentrations in groundwater at Y-12 exceed the 10 mg/L maximum drinking water contamination level [a complete list of drinking water standards (DWSs) is presented in Appendix D] in a large part of the western portion of the UEFPC regime (Fig. 6.18). The two principal sources of nitrate contamination are the S-3 and S-2 sites. In CY 2000, groundwater containing nitrate concentrations as high as 13,300 mg/L (Well GW-108) occurs in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site.

The extent of the nitrate plume is essentially defined in the unconsolidated zone and the shallow bedrock zone. From data collected from monitoring wells, and surface water outfalls during CY 2000 in both zones of the aquitards, nitrate concentrations above the DWS are observed about 2600 ft (792 m) eastward from the S-3 Site. This is as compared with data presented in DOE 1998c, where the plume was observed approximately 4000 ft (1219 m) from the S-3 site. Although the nitrate plume is dispersing and moving eastward, concentrations near the source have continued to trend downward since disposal operations ceased and the site was closed and capped in the late 1980s.

Trace Metals

Concentrations of barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, and uranium exceeded DWSs during CY 2000 in samples collected from various monitoring wells, surface water locations, and building sumps downgradient of the S-2 Site, the S-3 Site, the Salvage Yard, and throughout the complex. In December 2000, the U.S. EPA promulgated a primary DWS of 0.03 mg/L for uranium. Even though this DWS will not go into effect until 2003, it was used to evaluate uranium concentrations in groundwater and surface water at Y-12. Concentrations of uranium exceed this DWS in a number of source areas (e.g., Salvage Yard, the 9212 Manufacturing Complex, and the Uranium Oxide Vaults) and contribute this trace metal to UEFPC. Another metal observed with statistically significant concentrations was strontium. (There is no DWS for metallic strontium.) Elevated concentrations of these metals were most commonly observed from monitoring wells in the unconsolidated zone. Trace metals above DWSs

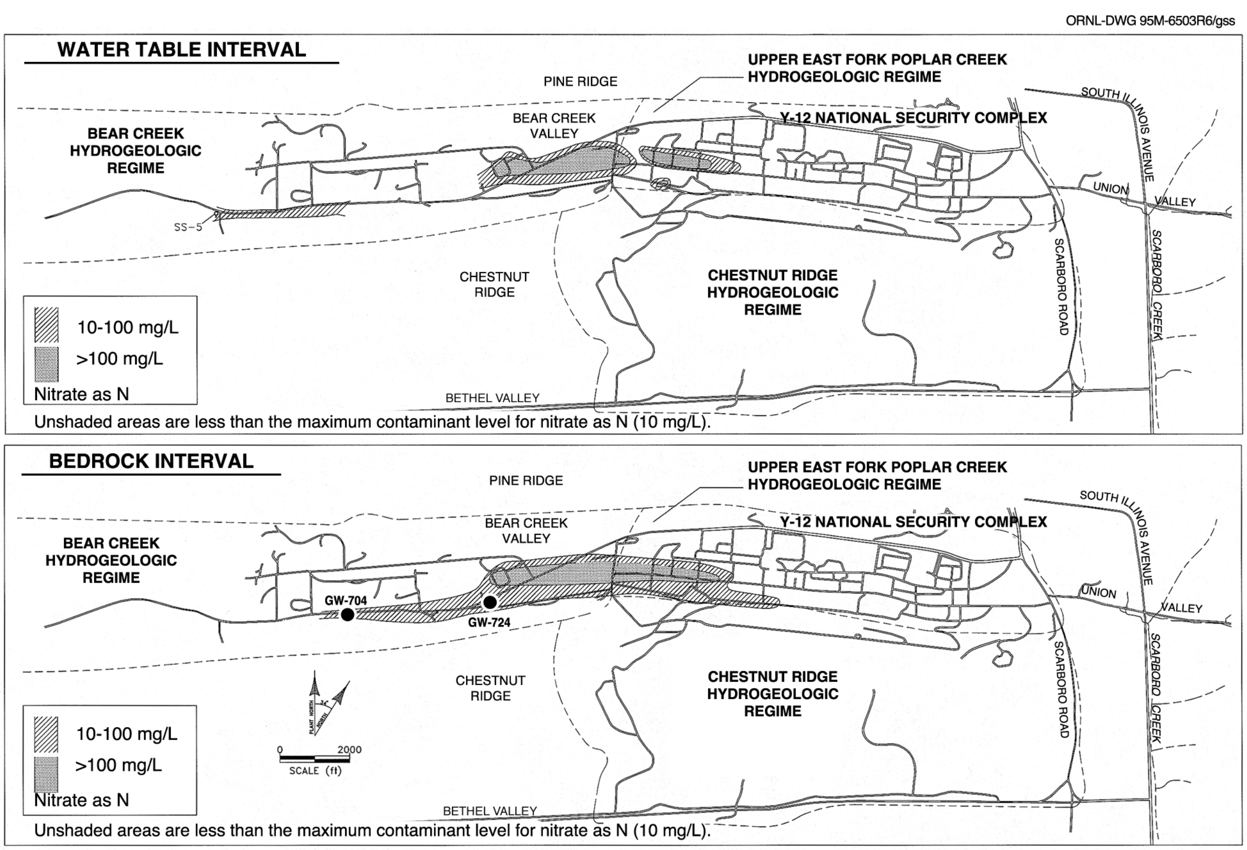

Fig. 6.18. Nitrate (as N) observed in groundwater at the Y-12 Complex.

tend to occur adjacent to the source areas due to low solubility in natural water systems on the ORR.

Volatile Organic Compounds

Because of the many source areas, VOCs are the most widespread groundwater contaminants in the East Fork regime. Dissolved VOCs in the regime generally consist of two types of compounds: chlorinated solvents and petroleum hydrocarbons. In CY 2000, the highest concentrations of dissolved chlorinated solvents (about 7300 µg/L) were found at the Waste Coolant Processing Area. The highest dissolved concentrations of petroleum hydrocarbons (about 1100 µg/L) occur in groundwater at a closed UST south of the former Rust Garage Area.

Concentrations of chlorinated VOCs in the vicinity of source areas have remained relatively constant or have decreased since 1988 (Fig. 6.19). Within the exit pathway on the east end of the regime, some monitoring locations (e.g., GW-153 and GW-220) south and east of New Hope Pond have shown increasing VOC concentrations, indicative of an easterly movement of part of the plume (Fig. 6.20). Some wells west of New Hope Pond (e.g., GW-605, GW-606) continue to show a shallow decreasing concentration trend, while those farther to the east (GW-170) show a static trend. Evaluations of all of these concentration trends indicate a center of mass of the carbon tetrachloride plume south of Bldg. 9720-6. Data show that VOCs are the most extensive in shallow groundwater. However, when contaminants migrate into the Maynardville Limestone, they tend to concentrate at depths between 100 and 500 ft. The highest VOC concentrations appear to be between 200 and 500 ft, as exemplified by vertical carbon tetrachloride distribution at the east end of Y-12 (Fig. 6.21).

The CY 2000 monitoring results generally confirm findings from the previous seven years of

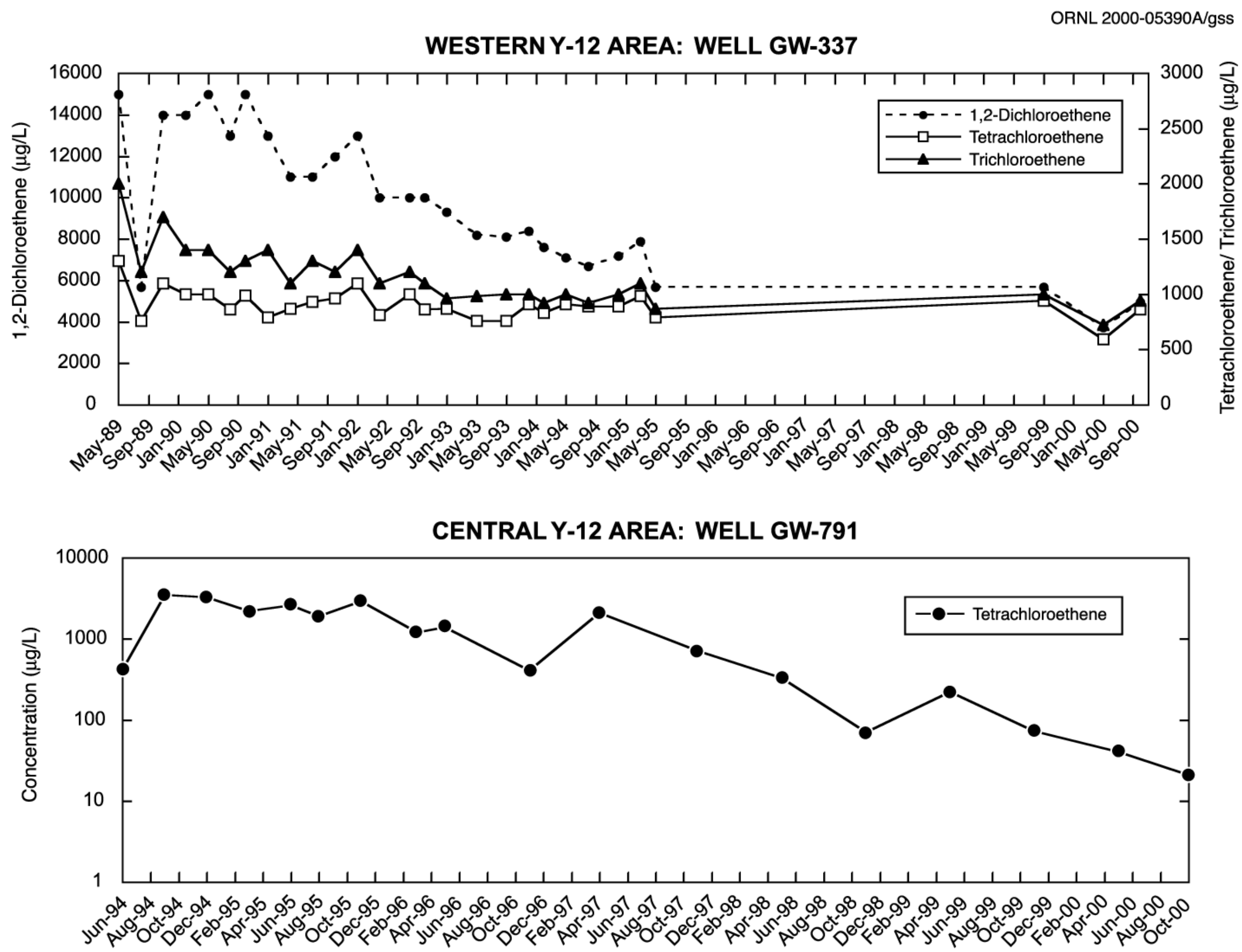

Fig. 6.19. VOC concentrations in groundwater in selected wells near source areas in the East Fork regime.

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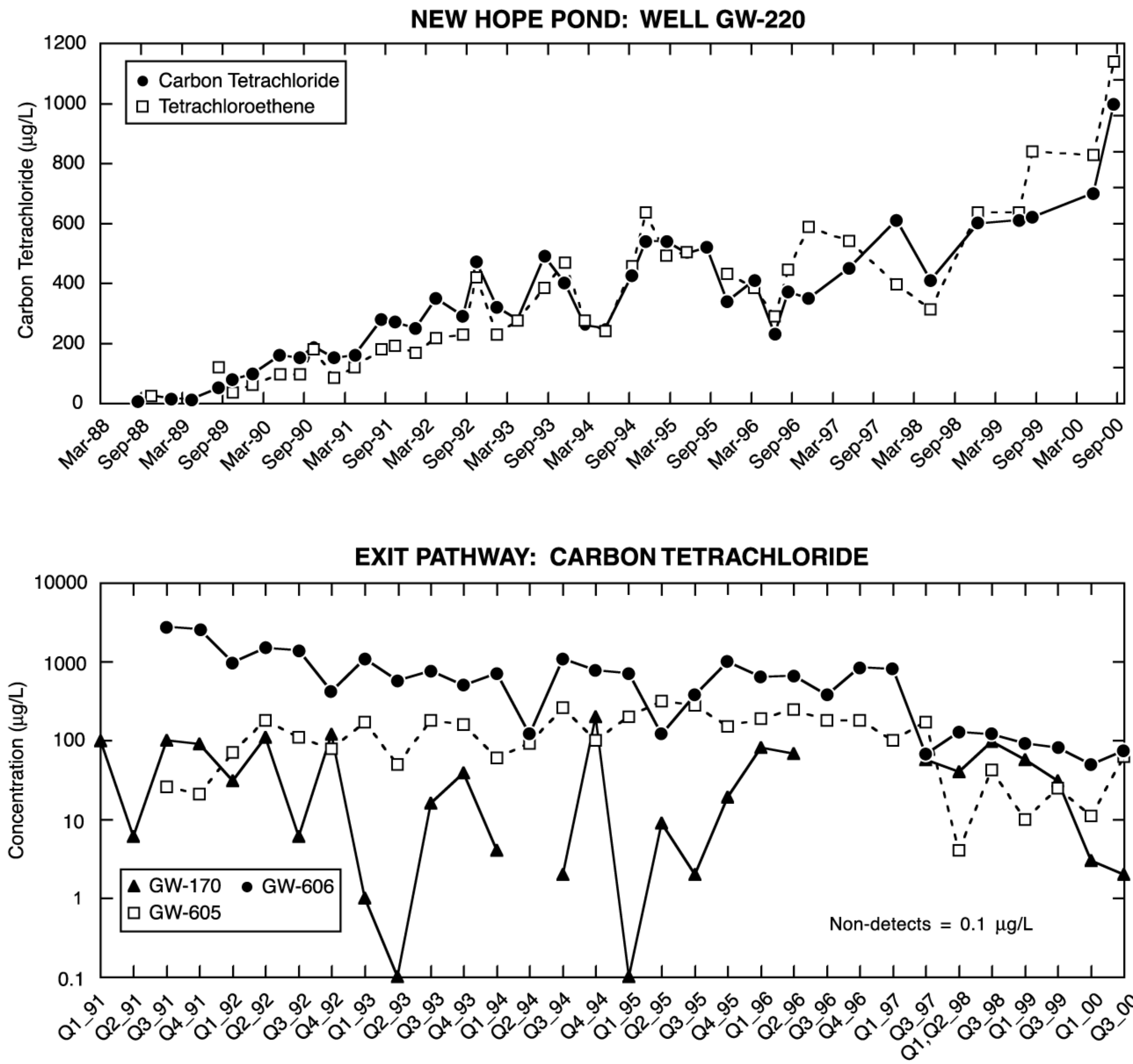

Note: The wells were sampled during different months,
Q1_91 = the first quarter of calendar year 1991

Fig. 6.20. VOC concentrations in selected wells near New Hope Pond and exit pathway wells.

monitoring. A continuous dissolved VOC plume 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 and process areas in the central and eastern portions of Y-12.

Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the VOC plume composition in the western and central portions of Y-12. However, tetrachloroethene and isomers of dichloroethene are almost ubiquitous throughout the extent of the VOC plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant VOCs in the eastern portion of Y-12.

Radionuclides

The principal alpha-emitting radionuclides found in the East Fork regime during CY 2000 were isotopes of uranium. Groundwater with gross alpha activity greater than 15 pCi/L (the DWS) occurs in scattered areas throughout the East Fork regime (Fig. 6.23). Historical data show that gross

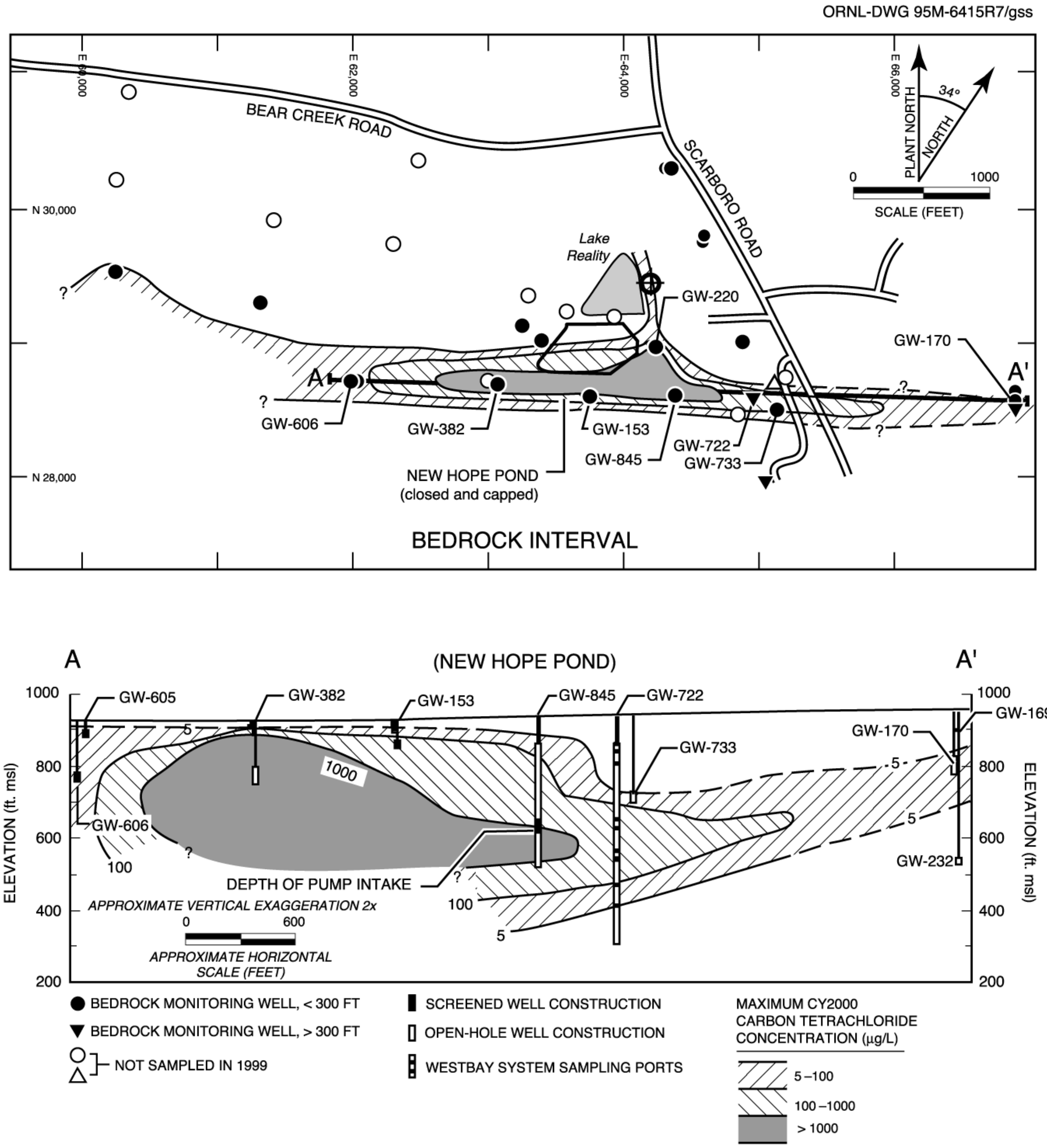

Fig. 6.21. Maximum carbon tetrachloride concentrations in Maynardville Limestone at depths between 200 and 500 ft, 2000.

alpha activity that consistently exceeds the DWS is most extensive in groundwater in the unconsolidated zone in the western portion of Y-12 near the S-3 Site. The highest level of gross alpha activity observed during CY 2000 (5100 pCi/L) was from a single water sample from the Building 9215 facility in the central portion of Y-12. This measurement was collected from water associated with a below-grade basin. This basin is part of a ventilation system in the facility and is being evaluated as to its impact to the surrounding groundwater and surface water. Other areas of elevated gross alpha activity are present west of New Hope Pond and east of the 9418-3 Uranium Oxide Vault.

The primary beta-emitting radionuclide observed in the East Fork Regime during CY 2000 was ^{99}Tc. Elevated gross beta activity in ground-

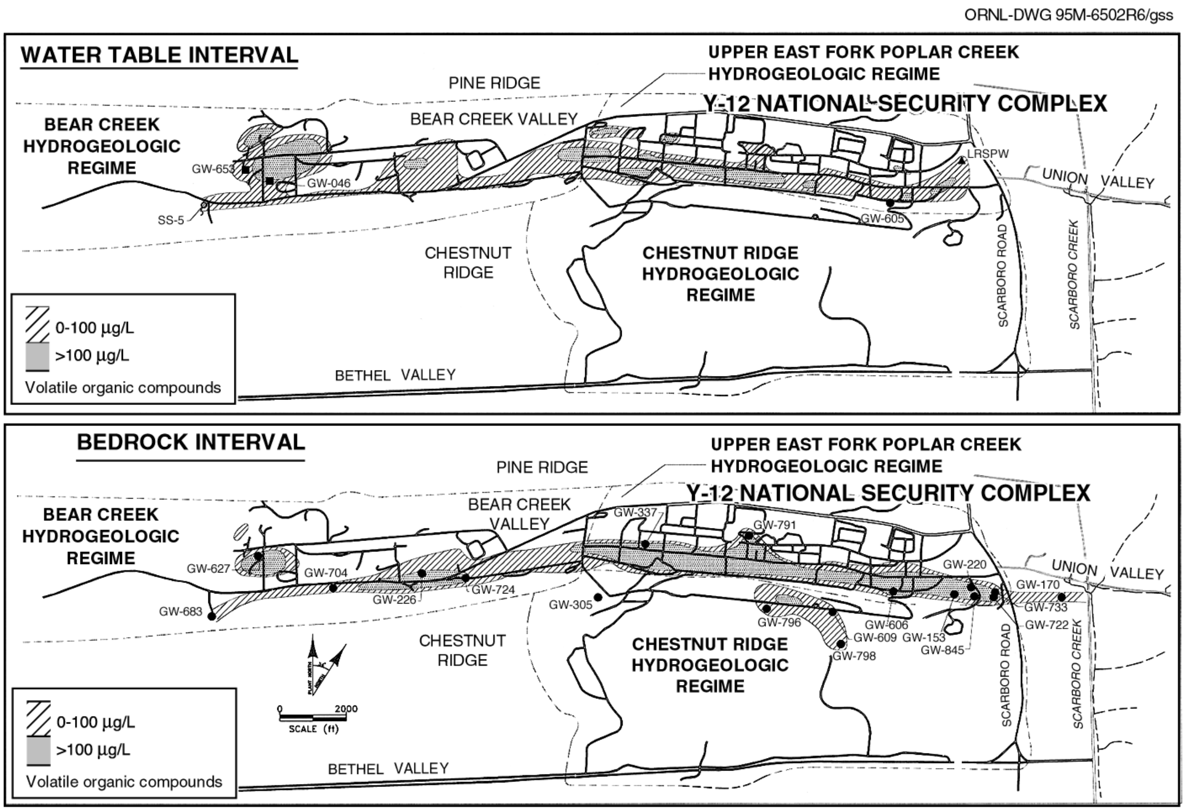

Fig. 6.22. Summed volatile organic compounds in groundwater at the Y-12 Complex.

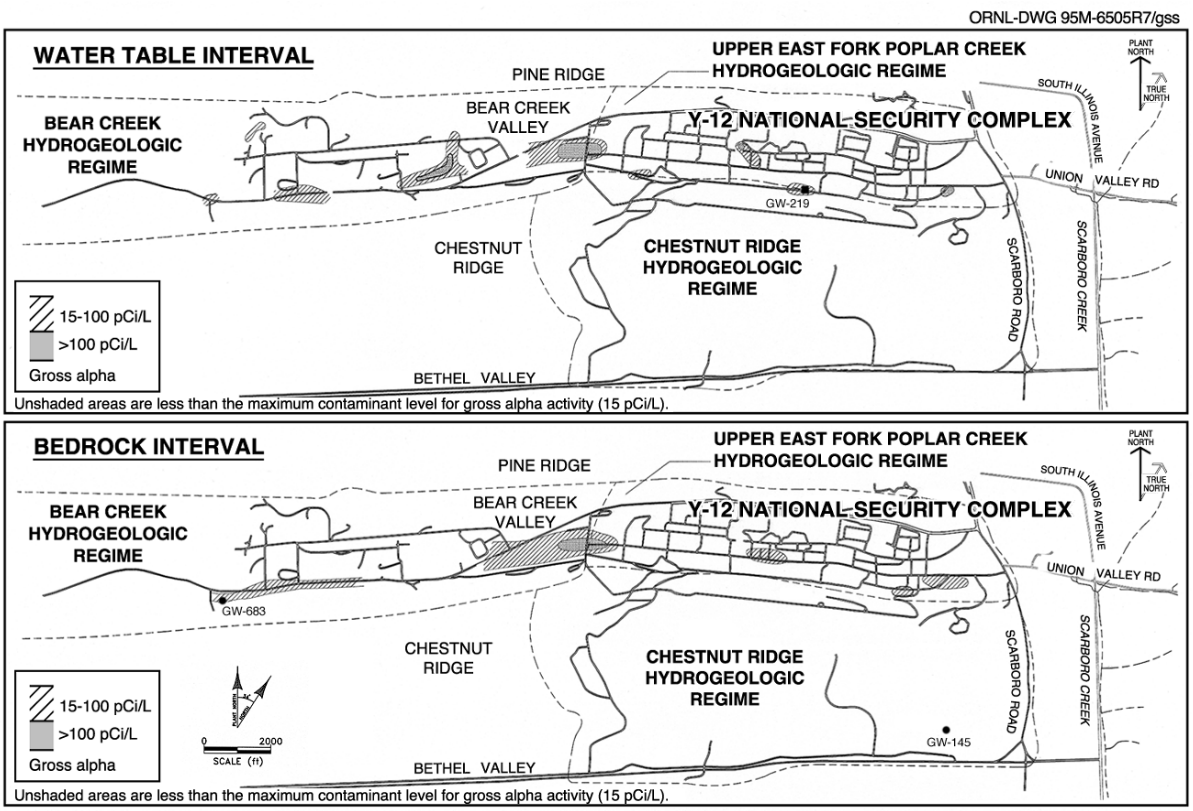

Fig. 6.23. Gross alpha activity in groundwater at the Y-12 Complex.

water in the East Fork regime shows a pattern similar to that observed for gross alpha activity (Fig. 6.24).

In general, gross beta activity consistently exceeds the annual average screening level of 50 pCi/L in groundwater in the western portion of the regime, with the primary source being the S-3 Site. Per the discussion in 40 CFR 141.26(b), compliance with the 4 mrem/year standard can be assumed if the average annual gross beta particle activity is less than 50 pCi/L and if the average annual concentrations of ^{3}H and strontium-90 are less than 20,000 pCi/L and 8 pCi/L, respectively, provided that, if both radionuclides are present, the sum of their annual dose equivalents to bone marrow is less than 4 mrem/year.

The S-3 waste disposal unit is the only known source of ^{99}Tc at Y-12. Due to the volatility of ^{99}Tc, the analytical method used to determine gross beta activity does not wholly or predictably include ^{99}Tc activity; however, general trends in gross beta and ^{99}Tc tend to correlate well. East of the S-3 Site ^{99}Tc appears to be increasing in the shallow bedrock and unconsolidated zones and decreasing in the intermediate bedrock zone. This may indicate an influence of the deep-to-shallow flow of groundwater that is transporting ^{99}Tc into the shallower zones.

Exit Pathway and Perimeter Monitoring

Exit pathway groundwater monitoring activities in the East Fork regime in CY 2000 involved continued collection and trending of data from exit pathway monitoring stations. Data collected to date indicate that VOCs are the primary class of

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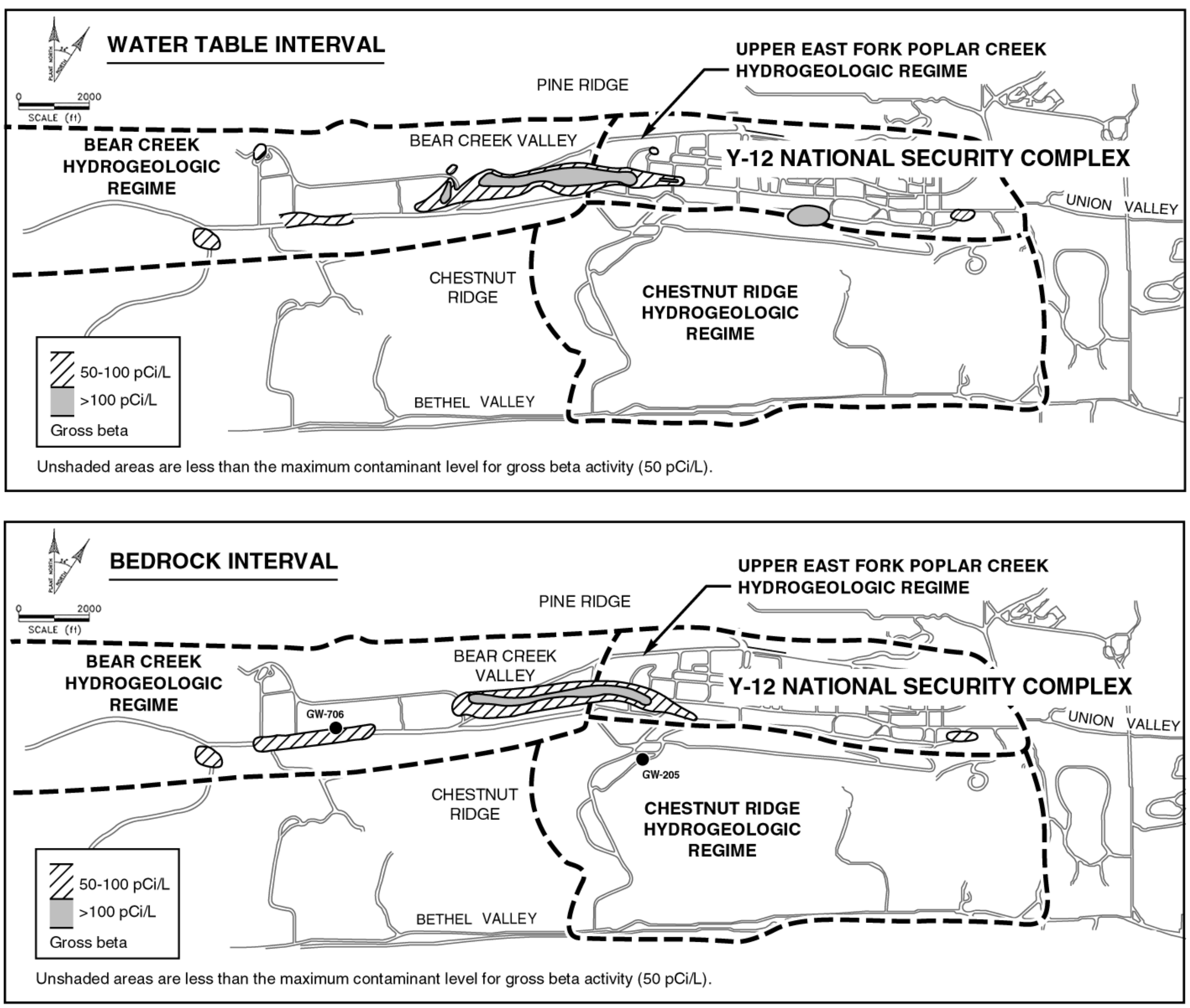

Fig. 6.24. Gross beta activity in groundwater at the Y-12 Complex.

contaminants that are migrating through the exit pathways in the East Fork regime. The VOCs are migrating predominantly at depths between 200 and 500 ft and appear to be restricted to the Maynardville Limestone, the primary intermediate to deep groundwater exit pathway on the east end of Y-12. A vertical profile of VOC contamination is depicted in Fig. 6.21. The distribution of VOCs is shown in Fig. 6.22. Concentrations of VOCs are typically higher at depth because most dilution and mixing with rainfall occur in the shallow portions of the Maynardville limestone. In addition, most of the VOC contaminants at Y-12 are denser than water; therefore, they tend to migrate downward within the subsurface. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected. The characteristics of the flow paths combined with the chemical characteristics of the contaminants have resulted in migration for substantial distances off the ORR into Union Valley to the east of Y-12. The EMP specifies monitoring of three wells near the eastern ORR boundary for this exit pathway (Fig. 6.16).

In addition to the intermediate to deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval in the vicinity of New Hope Pond, Lake Reality, and UEFPC is also monitored. Historically, VOCs have been observed in the vicinity of Lake Reality from wells, a dewatering sump, and the Lake Reality Spillway (LRSPW). In this area, shallow groundwater flows north-northeast through the water table interval east of New Hope Pond and Lake Reality, following the path of a diversion channel for UEFPC.

During CY 2000, the observed VOC concentrations at LRSPW decreased to concentrations consistent with those observed prior to CY 1999. The increase in VOCs observed from LRSPW during 1999 was conjectured to be due to a change in the sampling procedures for this location. Prior to 1998, grab samples were obtained at the exit point of the spillway pipes. This provided a diluted sample consisting of surface water and underdrain contributions. Beginning in 1998, sampling of this location was performed by temporarily shutting off the flow through the spillway, thereby isolating surface water while permitting exclusive discharge and sampling of the underdrain. This allowed sampling personnel to obtain a sample of undiluted groundwater. Consequently, the pre-1999 reported decreasing trend in carbon tetrachloride concentrations appeared to have reversed in 1999, now showing an increase. In CY 2000, two samples were obtained from the LRSPW (April and December). The April sample indicated that the VOC concentrations (carbon tetrachloride = 35 µg/L) were still elevated and consistent with the increased levels observed in 1999. The December sample showed a return to VOC concentrations (carbon tetrachloride = 11 µg/L) consistent with pre-1999 levels. This may be due to the start-up of a groundwater pump-and-treat system in well GW-845 (Fig. 6.21) between July and October south of the LRSPW, which may be reducing VOC levels in the area. The installation of this system by Bechtel Jacobs was completed in June 2000. This groundwater plume capture system pumps groundwater from the intermediate bedrock depth to mitigate off-site migration of VOCs. The well continuously pumps groundwater from the Maynardville Limestone at about 25 gpm, passes the pumped water through a water treatment system to remove the VOCs, and then discharges to UEFPC.

Well GW-722, a multi-port monitoring well downgradient of well GW-845, has shown some response to the pumping activities. The multi-port system installed in well GW-722 permits sampling of 10 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 VOC plume and is critical in the evaluation of the effectiveness of the plume capture system. Monitoring results from GW-722 indicate possible reductions in VOCs due to groundwater pumping upgradient at well GW-845. Until more water quality results have been gathered from the multiport well, any evaluations of effectiveness are preliminary.

Three wells, located in the large gap in Pine Ridge through which UEFPC exits Y-12, are used to monitor shallow, intermediate, and deep groundwater intervals. 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). Monitoring of these wells since about 1990 has not shown that any contaminants are moving via this exit pathway.

Surface water sampling results at Station 17, the point at which UEFPC exits the ORR, generally indicate concentrations of uranium below the DWS. Even though the UEFPC is not a drinking water source, the DWSs are applied as general criteria. Results of weekly monitoring performed to comply with the Y-12 NPDES permit indicate that uranium concentrations at Station 17 were below the DWS. The WRRP obtained three CERCLA baseline samples from this location during CY 2000, one of which exceeded the DWS for uranium with a concentration of 0.04 mg/L. This sample was obtained after a significant rain event during March (the wet season).

In CY 2000, five sampling locations were monitored north and northwest of Y-12 to evaluate possible contaminant transport from the ORR (Fig. 6.25). These locations are considered unlikely groundwater or surface water contaminant exit pathways; however, monitoring was performed due to recent concerns regarding potential health impacts to nearby residences from Y-12 operations. Three of the stations monitored tributaries draining the north slope of Pine Ridge on the ORR and discharged into the adjacent Scarboro Community. The remaining two locations monitored Gum Hollow Branch as it discharged from the ORR and adjacent to the Country Club Estates Community. Samples were obtained and analyzed for metals, inorganics, VOCs, and gross alpha and gross beta activities. There were no results that exceeded a DWS, or, for gross beta activity, that exceeded the screening level, nor were there any indications that contaminants were being discharged from the ORR into these communities.

6.10.4.2 Union Valley Monitoring

Groundwater monitoring data obtained in 1993 provided the first strong indication that VOCs were being transported off the ORR through the deep Maynardville Limestone exit pathway. The 1995 ASER (LMES 1996) provided a discussion of the nature and extent of the VOCs and short-term response actions taken. In CY 2000, monitoring of locations in Union Valley continued under the WRRP (DOE 2001) Data showed no significant changes in the types and concentrations of contaminants forming the groundwater contaminant plume in Union Valley.

The current conceptual model for Union Valley suggests that Scarboro Creek (Fig. 6.22) functions as a shallow (and possible intermediate) groundwater divide. Contaminants appear to be upwelling under the influence of vertical gradients and discharging at low concentrations to several springs and possibly within the creek channel itself. Under the terms of an interim ROD, administrative controls, such as restriction on potential future groundwater use, have been established. The plume capture system previously discussed was installed and initiated to reduce VOCs in Union Valley (see Chap. 3 for more details).

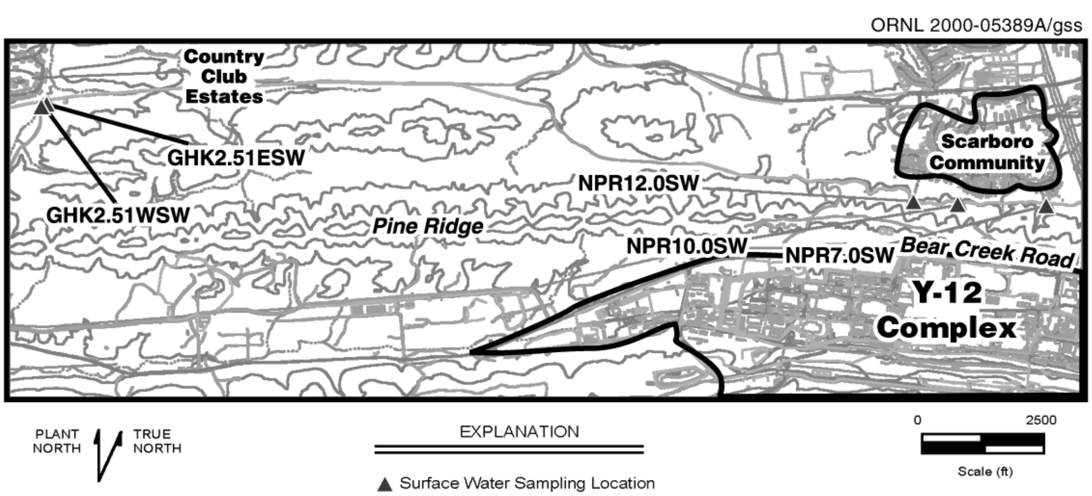

Fig. 6.25. Surface water sampling locations north of Pine Ridge, 2000.

6.10.4.3 Bear Creek Hydrogeologic Regime

Located west of Y-12 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 Y-12 to Highway 95. Figures 6.26 and 6.27 show the Bear Creek regime, locations of monitoring stations sampled in CY 2000, and the locations of its waste management sites. Table 6.15 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, VOCs, and radionuclides. The S-3 Site is the primary source of nitrate, radionuclides, and trace metals. The Oil Landfarm (OLF) waste management area, consisting of the OLF, the Bone Yard/Burn Yard (BY/BY), the Hazardous Chemical Disposal Area (HCDA), and Landfill I is a statistically significant source of uranium, other trace metals, and VOCs. Other sources of VOCs include the S-3 Site, the Rust Spoil Area, and the Bear Creek Burial Grounds (BCBG) waste management area; the latter two sites are the principal sources. Dense nonaqueous phase liquids (DNAPLs), heavier-than-water solvents that have a low water solubility, exist at depths as great as or greater than 270 ft below the BCBG. The DNAPLs consist primarily of tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs.

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. 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. A review of historical data suggests that contaminant concentrations near source areas within the ORR aquitards have remained relatively constant since 1986.

Nitrate

Unlike many groundwater contaminants, nitrate 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 (91 m) below the ground surface].

Data obtained during CY 2000 indicate that nitrate concentrations in groundwater exceed the DWS in an area that extends west from the S-3 Site for approximately 12,000 ft (3,660 m) down Bear Creek Valley (Fig. 6.18). The nitrate concentrations of monitoring locations fluctuate so that the groundwater plume appears to shrink or expand between exit pathway picket B [7,800 ft (2,380 m)] and exit pathway A [12,000 ft (3,660 m)]. Therefore, a reduction in the fringe areas (furthest from source areas) of the nitrate plume indicated in 1999 was offset by an expansion in CY 2000. Reductions may indicate the shrinking of contaminant plumes due to the capping and closure of the S-3 Ponds in 1988; however, seasonal fluctuations and corresponding influences on groundwater and contaminant migration probably account for some variability in nitrate concentrations. Nitrate concentrations greater than 100 mg/L persist out to about 3000 ft (915 m) west of the S-3 Site, indicating no statistically significant change from concentrations measured in previous years. Historically, the highest nitrate concentrations have been observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths [less than 100 ft (30.5 m) below ground surface] in the Nolichucky Shale. However, concentrations of nitrate have been observed 740 ft (226 m) below ground surface. Surface water nitrate results exceeding the DWS during CY 2000 were observed as far away as exit pathway picket W (BCK-07.87), 15,400 ft (4,694 m) west of the S-3 Site (Fig. 6.27).

Trace Metals

In the Bear Creek regime during CY 2000, uranium, barium, cadmium, chromium, lead, and

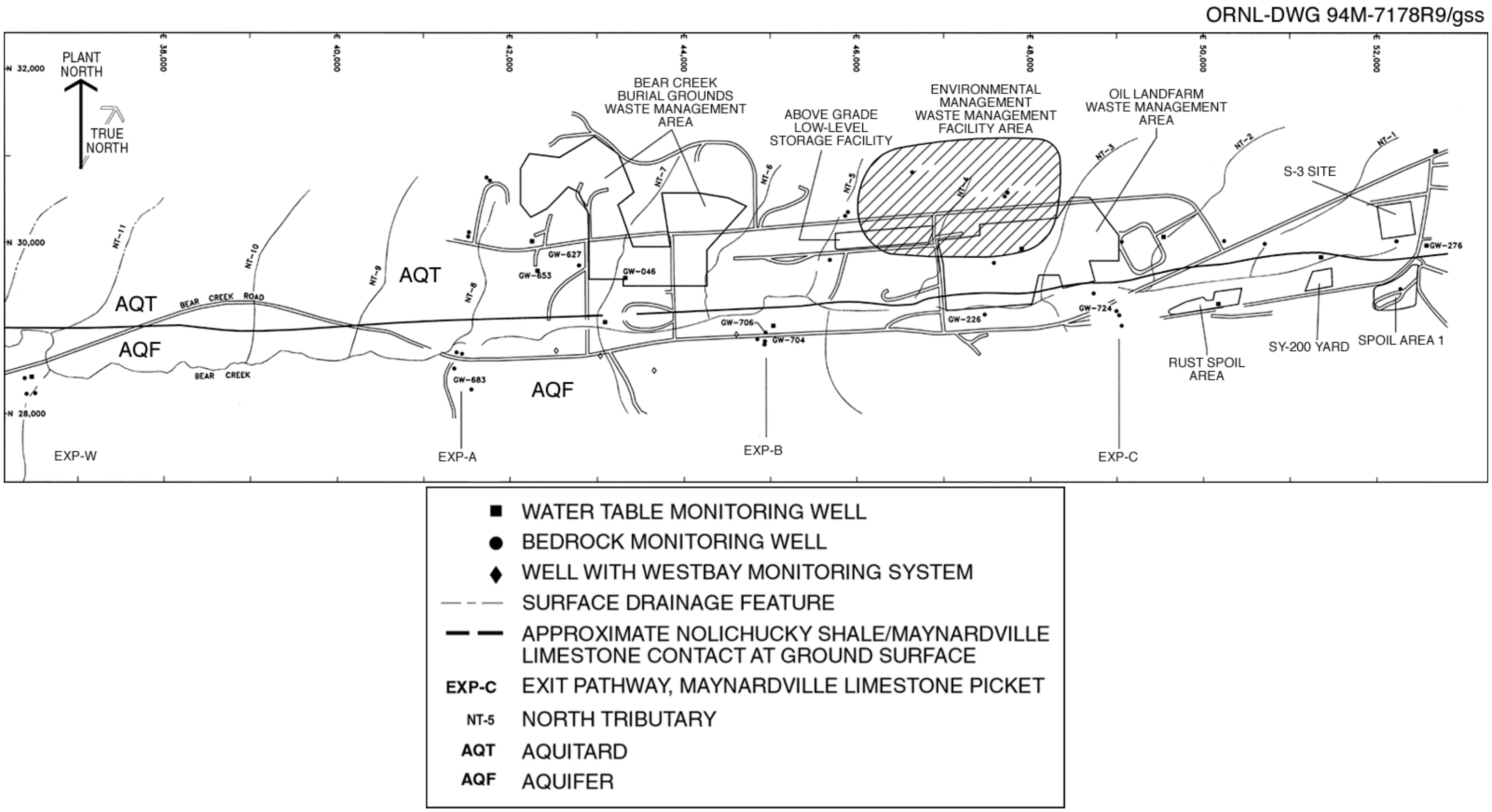

Fig. 6.26. Locations of waste management sites and monitoring wells sampled during 2000 in the Bear Creek Hydrogeologic Regime.

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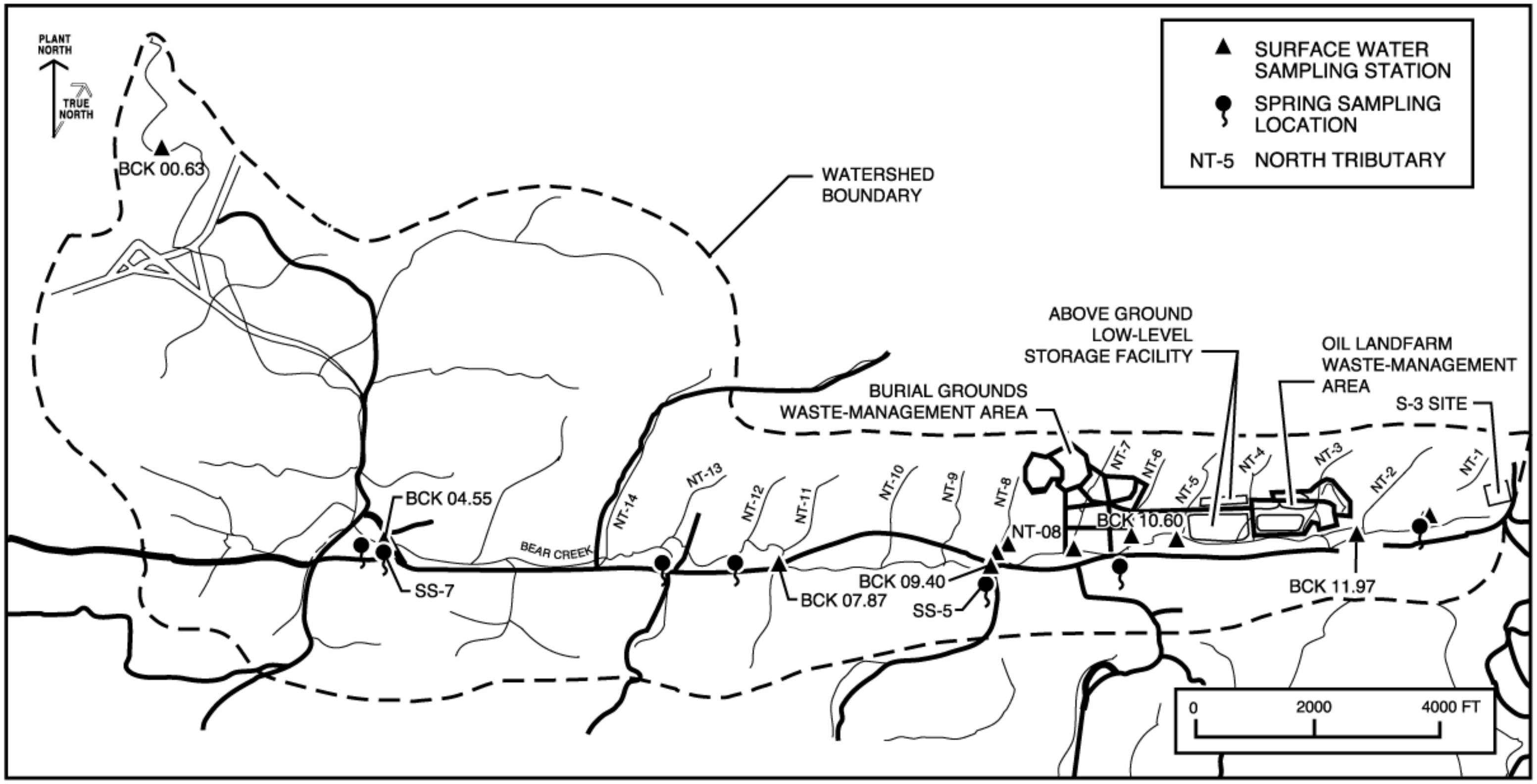

Fig. 6.27. Locations of surface water and spring stations sampled during 2000 in the Bear Creek Hydrogeologic Regime.

Table 6.15. History of waste management units and underground storage tanks included in CY 2000 groundwater monitoring activities; Bear Creek Hydrogeologic Regime

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. Part of the Oil Landfarm waste management area
Boneyard	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood. Part of the Oil Landfarm waste management area
Burnyard	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches. Part of the Oil Landfarm waste management area
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. Part of the Oil Landfarm waste management area
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. Part of the Oil Landfarm waste management area
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 amounts 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 2/95
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 VOCs to shallow groundwater according to CERCLA RI
Spoil Area I	Used from 1980 to 1988 for disposal of construction debris and other stable, nonrad wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern. CERCLA ROD 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 ROD 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

nickel have been identified from groundwater monitoring as the principal trace metal contaminants. Historically, the concentrations of these metals exceeded DWSs at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at this 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, these trace metals may occur sporadically and in close association with source areas because conditions are typically not favorable for dissolution and migration. In CY 2000, these trace metals are evident at elevated concentrations within the surface water and groundwater of the Maynardville Limestone downgradient of the S-3 Site, the BCBG, and the OLF waste management areas.

During CY 2000, the most prevalent trace metal contaminant observed within the Bear Creek regime was uranium. This indicates that geochemical conditions are favorable for the leaching and migration of uranium from waste areas to the surface water and groundwater. The Boneyard/Burnyard site has been identified as the primary source of uranium contamination of surface water and groundwater. Uranium is typically observed in shallow monitoring wells, springs, and surface water locations downgradient from all of the waste areas at concentrations exceeding the DWS of 0.03 mg/L. Uranium concentrations above the DWS were observed in surface water monitoring station BCK-00.63 which is located more than 5.5 miles (8.8 km) from BCBG, the westernmost waste area. Location BCK-00.63 is far removed from Bear Creek Valley and contributions from sources (naturally occurring and anthropogenic) other than Bear Creek regime waste areas are possible.

Other trace metal contaminants that have been observed in the Bear Creek regime are beryllium, boron, cobalt, copper, selenium, and strontium. Concentrations of these metals have commonly exceeded background and regulatory levels in groundwater near contaminant source areas.

Volatile Organic Compounds

Like nitrates, VOCs are widespread in groundwater in the Bear Creek regime (Fig. 6.22). The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1-dichloroethane. In most areas, the VOCs are dissolved in the groundwater, but nonaqueous phase accumulations of these VOCs occur in bedrock more than 250 ft (76 m) below the BCBG waste management area.

Groundwater in the aquitards that contains detectable levels of VOCs occurs primarily within about 1000 ft (305 m) of the source areas. The highest VOC concentrations in the unconsolidated zone in the Bear Creek Regime occur at the BCBG waste management area in monitoring well GW-046. Furthermore, an increasing long-term concentration trend is apparent in this shallow well, where VOCs as high as 11,000 µg/L were observed (Fig. 6.28). The extent of the dissolved VOC plumes is greater in the underlying bedrock. The highest levels of VOCs in the Bear Creek regime occur in bedrock, just south of the BCBG waste management area. Historical levels have been as high as 7,000,000 µg/L in groundwater near the source area. Well GW-627, which is downgradient of the BCBG waste management area, has continued to exhibit an increase in VOC concentration (Fig. 6.28). The increasing trends observed in wells GW-046, GW-627, and GW-653 indicates that some VOC migration through the aquitards parallel to the valley axis and towards the exit pathway (Maynardville Limestone) is occurring in the unconsolidated and intermediate bedrock intervals.

Significant transport of VOCs 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 VOC plume extends for about 12,000 ft (3660 m) westward from the S-3 Site to just west of the BCBG waste management area. Typical VOC concentrations observed in CY 2000 in the Maynardville Limestone range from 164 µg/L in the central part of the regime (Well GW-226) to less than detectable levels in the western part of the regime (at exit pathway picket A).

Radionuclides

The principal radionuclides identified in the Bear Creek regime are uranium and ^{99}Tc, with local occurrence of ^{237}Np, ^{241}Am, radium, strontium, and ^{3}H as secondary and less widespread

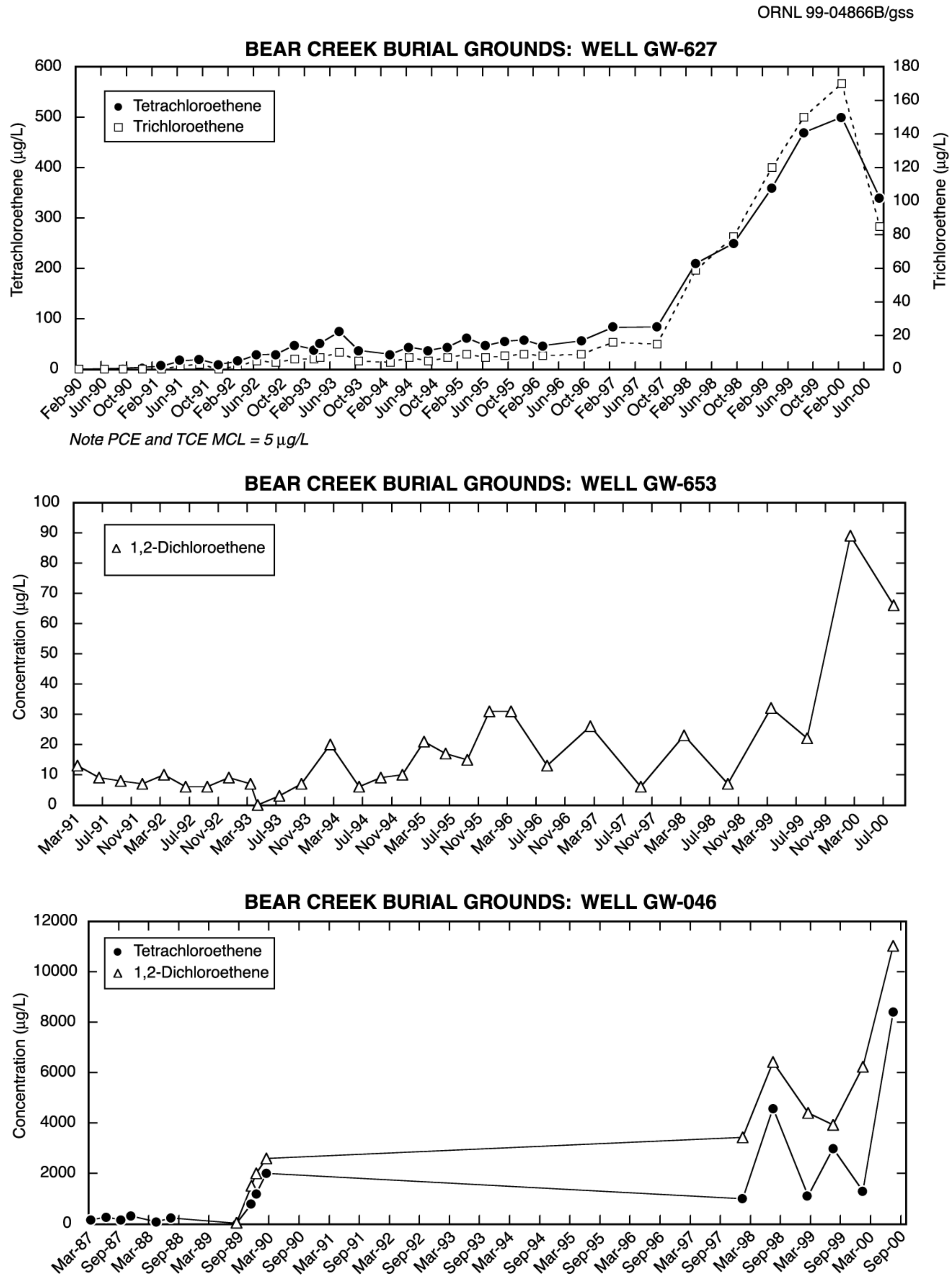

Fig. 6.28. VOC concentrations in Bear Creek Burial Grounds wells GW-627 and GW-653.

radionuclides present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during CY 2000 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 DWS for gross alpha activity), then one (or more) of the alpha-emitting radionuclides (e.g., uranium) was assumed present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded the screening level of 50 pCi/L. More volatile radionuclides (i.e., ^{99}Tc, ^{3}H) are qualitatively screened by gross beta activity analysis, and at certain monitoring locations are evaluated isotopically.

As shown in Fig. 6.23, groundwater with elevated levels of gross alpha activity occurs in the water table interval in the vicinity of the S-3 Site and the OLF waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the Nolichucky Shale only near the S-3 Site. During CY 2000, no observed gross alpha activity results from shallow or bedrock wells in the BCBG or OLF WMA exceeded the DWS. Data obtained from exit pathway monitoring stations show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the DWS for 12,000 ft (3660 m) west of the S-3 Site (e.g., GW-683). Gross alpha activities above the DWS in surface water samples were observed over 7.5 miles (12.1 km) west of the S-3 Site (i.e., BCK-00.63). This is further away than previously reported. Location BCK-00.63 is far removed from BCV, and contributions from sources (naturally occurring and anthropogenic) other than Bear Creek Regime waste areas are possible. However, an east to west decrease in uranium concentrations and gross alpha activity between monitoring stations SS-4 and BCK-00.63 indicate that these contaminants are likely to originate from the Bear Creek Regime source areas.

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 6.24). During CY 2000, gross beta activity exceeded 50 pCi/L within the water table interval in the Maynardville Limestone from south of the S-3 Site to the OLF waste management area. Within the intermediate bedrock interval in the Maynardville Limestone, the elevated gross beta activity extends approximately 7,800 ft (2377 m) from the S-3 Site (Fig. 6.24) to exit pathway picket B (i.e., well GW-706). Surface water gross beta activities above the screening level were observed 16,000 ft (4877 m) west of the S-3 Site (BCK-07.87).

Technetium-99 activities mimicked the gross beta activity distribution across the Bear Creek Regime in CY 2000. The highest ^{99}Tc activity observed was 735 pCi/L at the S-3 site (well GW-276). No monitoring results during CY 2000 exceeded the DWS (4000 pCi/L).

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. 6.16).

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 2000 from the exit pathway monitoring wells confirmed previous data indicating that contaminated groundwater does not seem to occur much beyond the western side of the BCBG waste management area (Fig. 6.29). However, levels of nitrate, gross alpha activity, and uranium exceeding their respective DWSs have been observed in surface water west of the burial grounds (BWXT Y-12 2001).

Surface water and spring samples collected during CY 2000 (Fig. 6.27) indicate that spring discharges and water in upper reaches of Bear Creek contain many of the compounds found in the groundwater. However, the concentrations in the creek and spring discharge decrease with distance downstream of the waste disposal sites

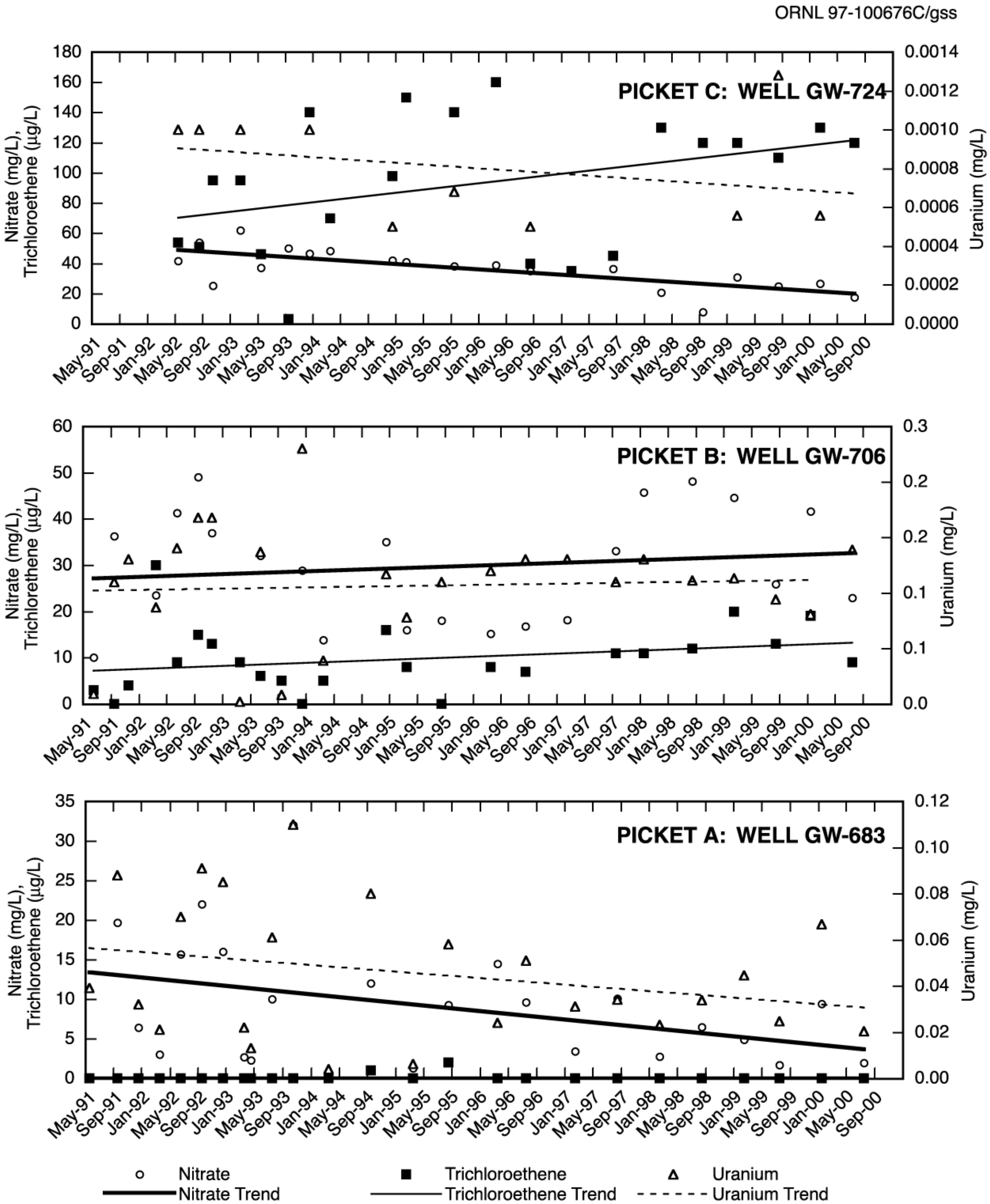

Fig. 6.29. Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-704, and GW-684 in the Bear Creek Hydrogeologic Regime.

(Fig. 6.30). Uranium concentrations and corresponding gross alpha activities appear to be increasing at BCK-09.40 and BCK-04.55, while a decrease in these parameters is observed in BCK-11.97. This indicates that the OLFWMA is the primary uranium source to Bear Creek.

6.10.4.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge Hydrogeologic Regime is south of Y-12 and is flanked to the north by BCV and to the south by Bethel Valley Road (Fig. 6.15). The regime encompasses the portion of Chestnut Ridge extending from Scarboro Road east of Y-12 to an unnamed drainage basin on the ridge located just west of Industrial Landfill II. Figure 6.31 shows the approximate extents of the regime and locations of waste management units and monitoring locations sampled in CY 2000.

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 is not mingled with plumes from other sources. Table 6.16 summarizes the operational history of waste management units in the regime.

Plume Delineation

The horizontal extent of the VOC plume at the Chestnut Ridge Security Pits (Security Pits) is reasonably well defined in the water table and shallow bedrock zones (Fig. 6.22). Groundwater quality data obtained during CY 2000 indicate that the lateral extent of the VOC plume at the site may be increasing, as evidenced by detectable signature VOCs in wells GW-609, GW-796, and GW-798. Concentrations of tetrachloroethene have been steadily decreasing in Well GW-609 since monitoring began in 1990.

There are two distinct VOCs in groundwater at the Security Pits. In the western portion of the site, the VOC plume is characterized by high concentrations of 1,1,1-trichloroethane. Tetrachloroethene is a principal component of the VOC plume in the eastern portion of the site. The distinct difference in the composition of the plume is probably related to differences in the types of wastes disposed of in the eastern and western trench areas.

Nitrate

Nitrate concentrations were well below the DWS of 10 mg/L at all monitoring stations.

Trace Metals

Groundwater concentrations of trace metals exceeded regulatory standards during CY 2000 at four locations. Concentrations above the DWS for nickel were observed in samples from three monitoring wells. Concentrations of antimony above the DWS were observed in samples from one monitoring well. One surface water monitoring station showed elevated concentrations of arsenic.

Nickel concentrations above the DWS were observed from well GW-305 during the third- and fourth-quarter detection monitoring events for Industrial Landfill IV. There is some evidence that the presence of this contaminant from wells may be caused by the corrosion and subsequent dissolution of stainless-steel well materials (Jones 1999). Elevated concentrations of nickel above the DWS were also detected in two wells at the United Nuclear Corporation Site (UNCS). The source of nickel within the UNCS wells is possibly also due to corrosion of well casing.

Antimony was detected at concentrations above the DWS at monitoring well GW-305. The detection of this trace metal, historically, has been sporadic and may not indicate groundwater contamination.

Elevated (above the DWS) concentrations of arsenic were observed in one surface water monitoring location downstream from the Filled Coal Ash Pond (FCAP) which is under CERCLA ROD Monitoring (BWXT Y-12 2001). A constructed wetlands is being utilized to prevent surface water contamination from FCAP effluent. The location where elevated arsenic levels were detected is upgradient of this wetland area. Downgradient of the wetlands, concentrations are noticeably lower and below the DWS for arsenic.

Volatile Organic Compounds

During CY 2000, Well GW-305, located immediately to the southeast of Industrial Landfill IV, continues to exhibit an increasing trend in VOCs (Fig. 6.32) since the first quarter of 1992.

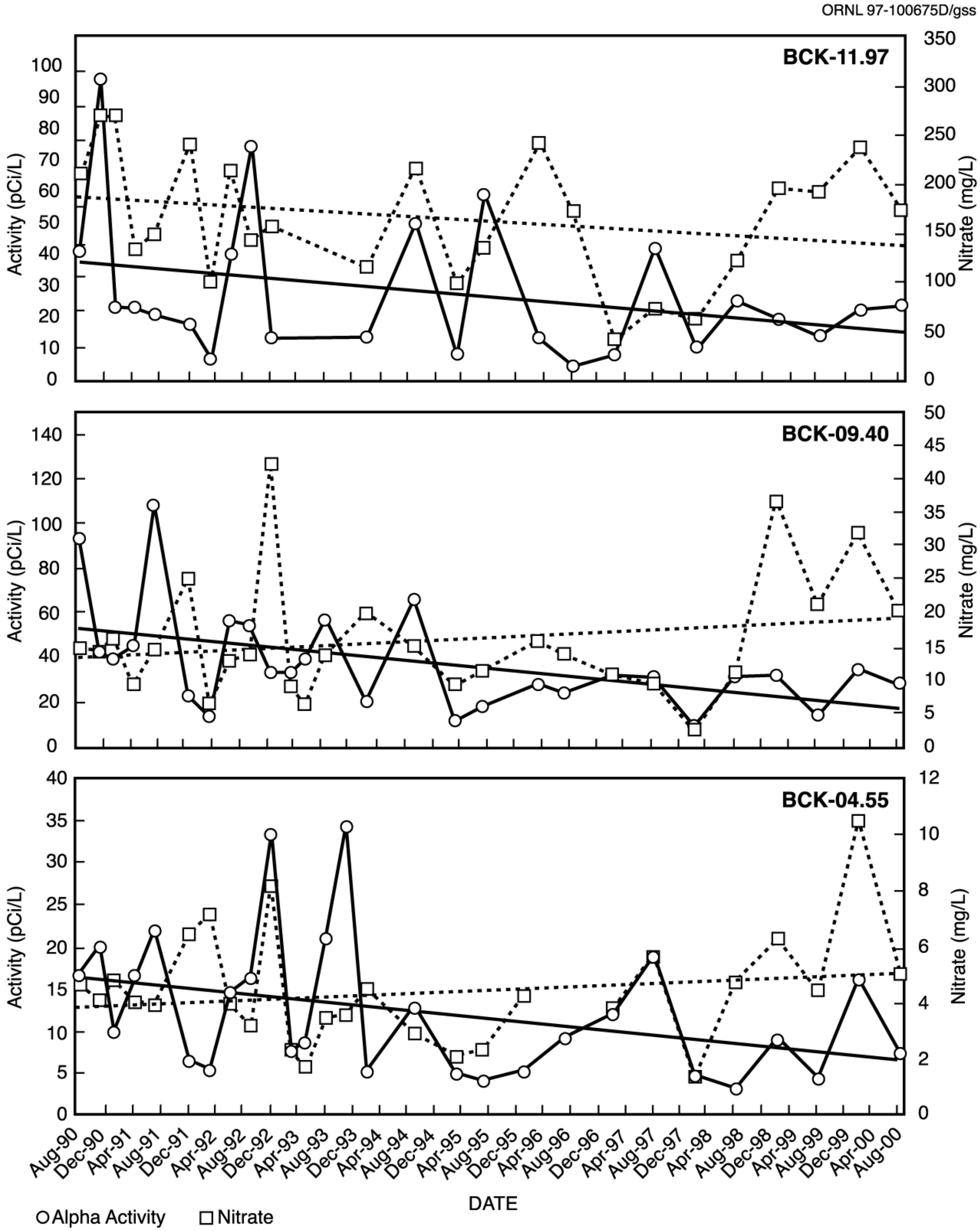

Fig. 6.30. Concentrations of selected groundwater contaminants in Bear Creek (refer to Fig. 6.27 for sampling locations).

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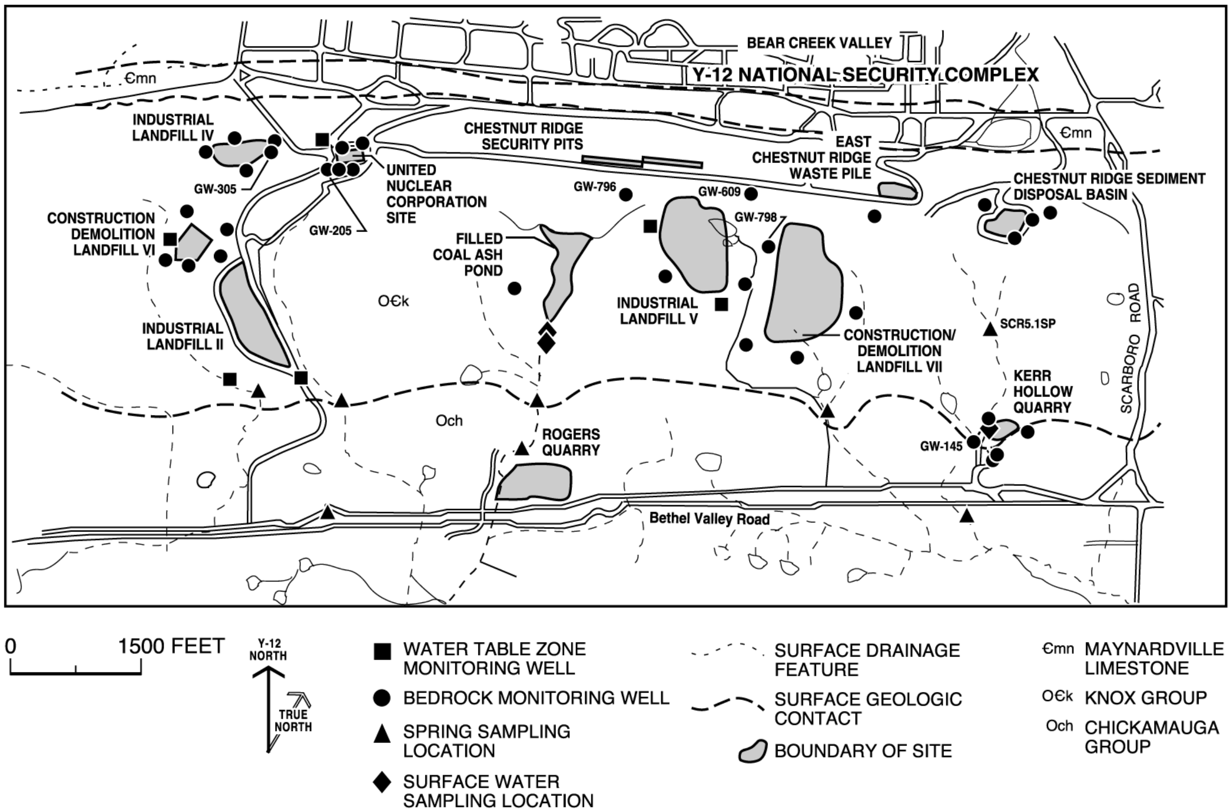

Fig. 6.31. Locations of waste management sites and monitoring wells sampled during 2000 in the Chestnut Ridge Hydrogeologic Regime.

Concentrations of the VOCs in Well GW-305 have remained below applicable DWSs.

Efforts to delineate the extent of VOCs in groundwater attributable to the Security Pits (previously discussed) have been in progress since 1987. A review of historical data indicates that VOC concentrations in groundwater at the site have generally decreased since 1988 (Fig. 6.33). In CY 2000, trace levels of VOCs (less than the DWS) were observed for the first time at downgradient monitoring well GW-798 east of Industrial Landfill V. The VOCs detected are characteristic of the Security Pits plume constituents, indicating that the contaminant plume may be migrating slowly to the southeast.

Radionuclides

In CY 2000, two locations exceeded gross radiological activity DWSs (BWXT Y-12 2001). Gross alpha activities were below the DWS at all locations except for Kerr Hollow Quarry downgradient monitoring well GW-145. Two out of the four samples obtained during each of the semiannual detection monitoring events exceeded the DWS for gross alpha activity. The well was resampled, and a statistical evaluation of the results did not indicate a groundwater contaminant release (BJC 2001a).

Monitoring well GW-205 at the UNCS has consistently exceeded the screening level for gross beta activity since August 1999 (the last three samples), indicating a possible increasing trend. However, isotopic analyses did not show a correlative increase in known beta- emitting radionuclide contaminant of concern at the UNCS (e.g., strontium-90). More comprehensive radiological monitoring is proposed for 2001.

Exit Pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized using

Table 6.16. History of waste management units and underground storage tanks included in CY 2000 groundwater monitoring activities; Chestnut Ridge Hydrogeologic Regime

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 Plant. 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 2/95
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 ROD has been issued
Industrial Landfill II	Central sanitary landfill for the ORR. Detection monitoring under postclosure plan has been ongoing since 1996
Industrial Landfill V	New facility completed and initiated operations 4/94. Baseline groundwater monitoring began 5/93 and was completed 1/95. Currently under TDEC-SWM detection monitoring
Industrial Landfill IV	Permitted to receive only nonhazardous industrial solid wastes. Detection monitoring under TDEC-SWM regulations has been ongoing since 1988
Construction/Demolition Landfill VI	New facility completed and initiated operations 12/93. Baseline groundwater quality monitoring began 5/93 and was completed 12/93. Currently under permit-required detection monitoring per TDEC
Construction/Demolition Landfill VII	New facility; construction completed in 12/94. TDEC granted approval to operate 1/95. Baseline groundwater quality monitoring began in 5/93 and was completed in 1/95. Permit-required detection monitoring per TDEC was temporarily suspended 10/97 pending closure of construction/demolition Landfill VI
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries. A CERCLA ROD has been issued. Remedial action complete

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 identified for water quality monitoring.

Monitoring of one large spring south of Industrial Landfill V and Construction/Demolition Landfill VII was continued in CY 2000 as required under the EMP. Seven other springs within the Chestnut Ridge regime were sampled as part of overall exit pathway monitoring for the regime. No contaminants were detected at these natural discharge points.

6.10.4.5 Environmental Management Activities

Continuation or planning, initiation, and implementation of a number of CERCLA activities related to groundwater occurred in CY 2000. These projects are discussed in Chap. 3.

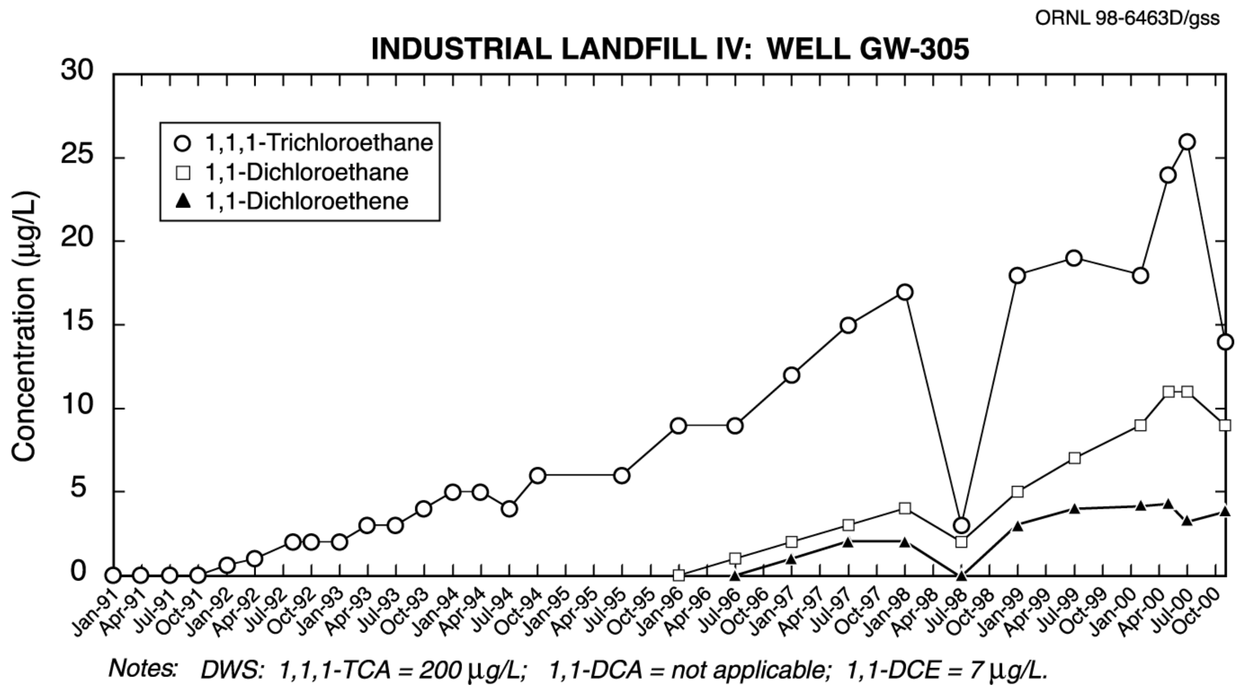

Fig. 6.32. VOC concentrations in Industrial Landfill IV well GW-305.

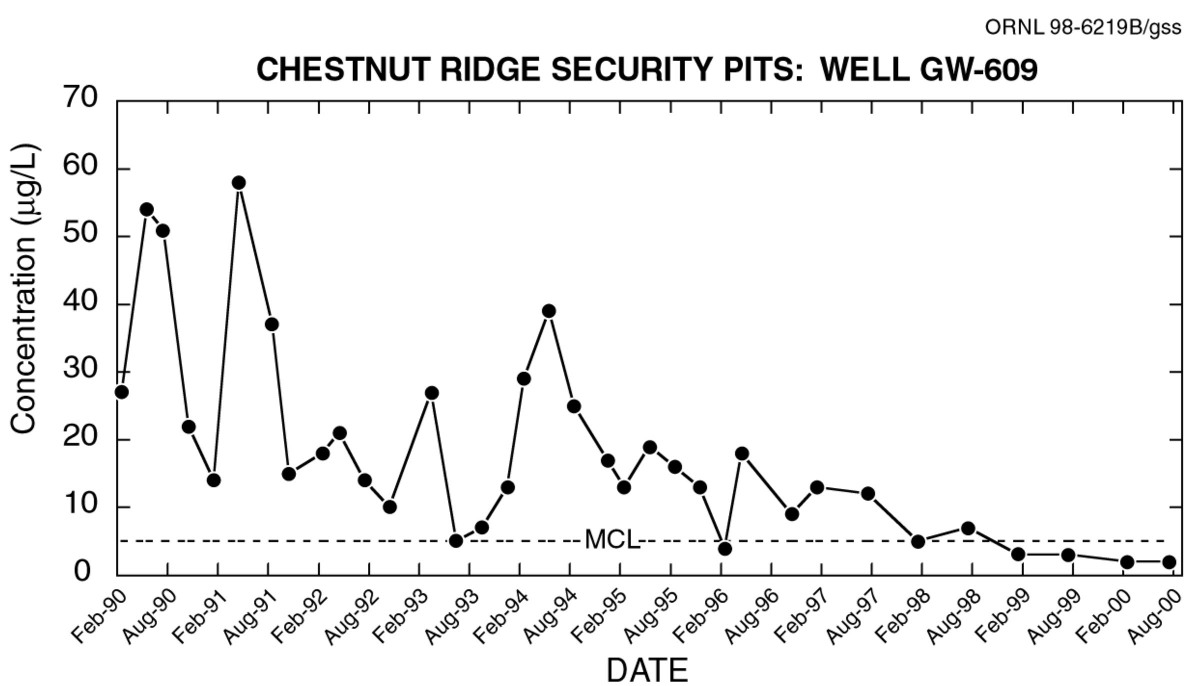

Fig. 6.33. Tetrachloroethene concentrations in Chestnut Ridge Security Pits well GW-609.