6. Y-12 Environmental Monitoring Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted 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 PLANT RADIOLOGICAL AIRBORNE EFFLUENT MONITORING

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 Plant occurs almost exclusively as a result of plant production, maintenance, and waste management activities. NESHAP regulations for radionuclides require continuous emission sampling of major sources (a "major source" is considered to be any emission point that potentially can contribute >0.1 mrem/year EDE to an off-site individual). During 1999, 45 of the Y-12 Plant's 57 monitored stacks were judged to be major sources. Five of these sources were not operational in 1999 because of work in progress on process or stack modifications. Eighteen of the stacks with the greatest potential to emit significant amounts of uranium are equipped with alarmed breakthrough detectors, which alert operations personnel to process-upset conditions or to a decline in filtration-system efficiencies, allowing them to investigate and correct the problem before a significant release occurs. As of January 1, 1999, the Y-12 Plant had a total of 57 monitored stacks, 51 active and 6 temporarily shut down. No stacks were permanently shut down in 1998. Thus, 51 active stacks were being monitored at the end of 1999.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods. In 1999, there were 11 unmonitored processes in operation at the Y-12 Plant. These are included as minor sources in the Y-12 Plant source term.

Uranium and other radionuclides are handled in millicurie quantities at facilities within the boundary of the Y-12 Plant as part of ORNL and Y-12 Plant laboratory activities. Thirty-two minor emission points were identified from laboratory activities at facilities within the boundary of the Y-12 Plant. In addition, an 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 Plant on Union Valley Road. The emissions from the ACO Union Valley laboratory are included in the Y-12 Plant 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 Plant dose.

Emissions from Y-12 Plant 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. Eight emission points were identified in 1999 where room ventilation emissions exceeded 10% of the DAC worker-protection guidelines.

Two monitored stacks and two unmonitored emission points are included as minor sources in the Y-12 Plant source term.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 57 operational process exhaust stacks in 1999. Particulate matter (including uranium) was filtered from the stack effluent. Filters at each location were changed routinely, from one to three times per week, and analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and washed with nitric acid; the washing was analyzed for total uranium. At the end of the year, the probe-wash data were included in the final calculations in determining total emissions from each stack.

6.1.2 Results

An estimated 0.015 Ci (3.9 kg) of uranium was released into the atmosphere in 1999 as a result of Y-12 Plant activities. The specific activity of enriched uranium is much greater than that of depleted uranium, and about 87% of the curie release was composed of emissions of enriched uranium particulate, even though less than 5% of the total mass of uranium released was enriched material (Figs. 6.1 and 6.2).

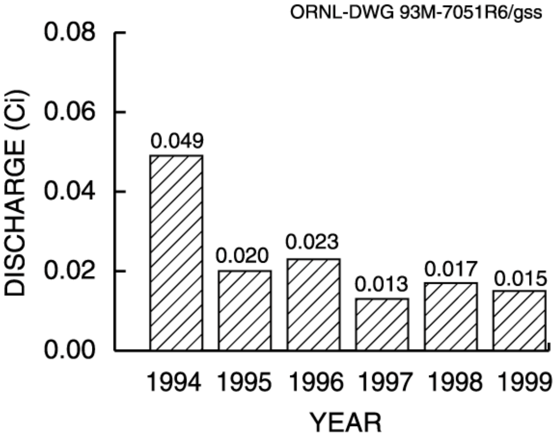

Fig. 6.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1994–1999.

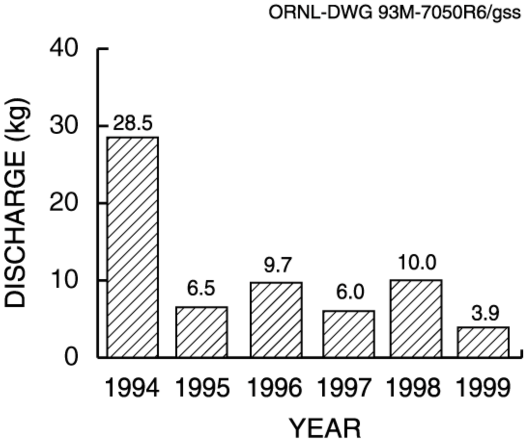

Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1994–1999.

6.2 Y-12 PLANT NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

The release of nonradiological contaminants into the atmosphere at the Y-12 Plant 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 Plant has 36 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. 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 Plant 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 2003.

The 1999 Y-12 Plant annual emission fee was calculated based on 10,033 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $147,485. 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 Plant pollutant emissions to the atmosphere are attributed to the operation of the steam plant. The emission fee rate was based on $14.70 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 fee 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 Plant 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 Plant 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 1999. Both systems were taken out of service for annual calibration/certification on April 20 and 21, 1999. The annual opacity calibration error test reports were submitted to TDEC in July 1999. During 1999, there were nine 6-minute periods of excess emissions and two occasions where 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 1999.

6.3 Y-12 PLANT AMBIENT AIR MONITORING

In 1994, Y-12 Plant personnel issued *Evaluation of the Ambient Air Monitoring Program at the Oak Ridge Y-12 Plant* (MMES 1994) 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 Plant are operated as a 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.

With agreement from TDEC personnel, the ambient air sampling program at the Y-12 Plant was significantly reduced, effective at the end of 1994. All sampling for fluoride, total suspended

Table 6.1. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 1999

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particle	23	1,118	2.1
Sulfur dioxide	2,354	20,803	11.3
Nitrogen oxides[a]	1,148	7,718	14.9
Volatile organic compounds[a]	1.57	17	9.2
Carbon monoxide[a]	23	543	4.2

[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 were calculated based on the latest AP-42 emission factors.

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 where TDEC personnel took over responsibility for sampling and analysis of the three remaining uranium samplers at the Y-12 Plant. The uranium samplers were operated by the Y-12 Plant only during the first quarter of 1999. In 1999, four mercury monitoring stations were operated by the Y-12 Plant. The locations of these monitoring stations are shown in Fig. 6.3.

6.3.1 Uranium

Samples for routine measurement of uranium particulate were collected by pulling ambient air through a 14-cm- (5.5-in.-) square filter, which was analyzed by the Y-12 Plant Analytical Chemistry Organization for total uranium and for the percentage of ^{235}U. For first quarter 1999, the average 7-day concentration of uranium at the three monitored locations ranged from a low of 0.00002 ug/m^3 at stations 4, 5, and 8 to a high of 0.00038 ug/m^3 at station 4 (Table 6.2).

6.3.2 Mercury

Four outdoor monitoring stations for mercury in ambient air (boundary stations on the east and west ends of the Y-12 Plant and two stations near Bldg. 9201-4, a former lithium isotope separation facility contaminated with mercury) are presently located at the Y-12 Plant (see Fig. 6.3). The four mercury monitoring stations were established in 1986 and have been monitoring mercury in

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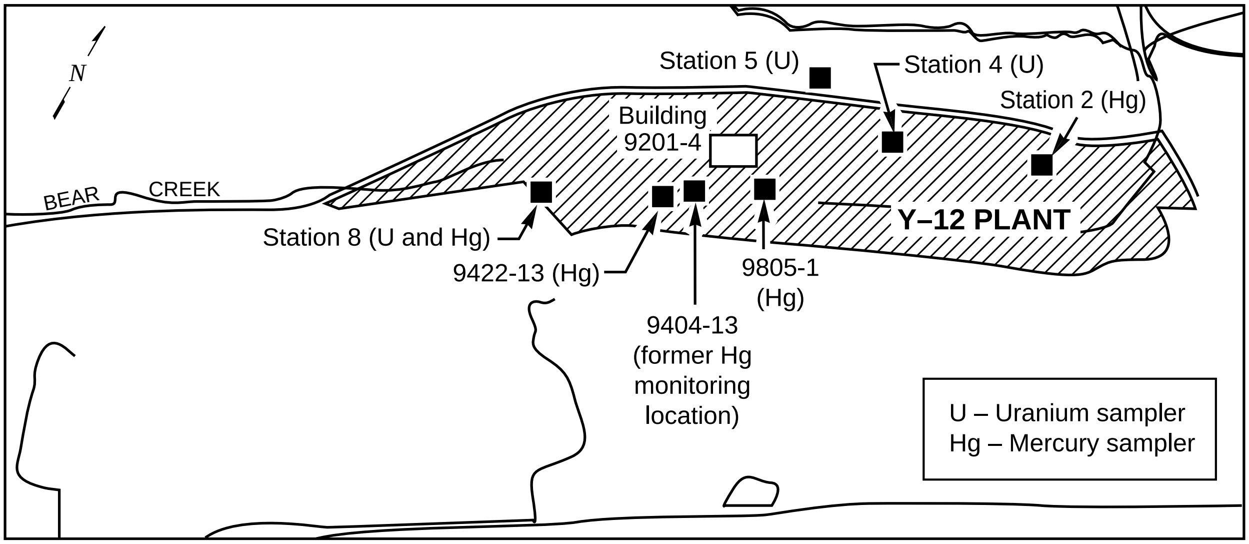

Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Plant.

Table 6.2. Uranium mass in ambient air at the Y-12 Plant, first quarter 1999

Station No.	No. of samples	7-day concentration (µg/m^3)		
		Max	Min	Avg
4	14	0.00038	0.00002	0.00008
5	2	0.00008	0.00002	0.00005
8	11	0.00020	0.00002	0.00008

ambient air continuously since their establishment with the exception of short periods for power or equipment outages. A control or reference site was established in 1988 at Rain Gage No. 2 on Chestnut Ridge in the Walker Branch Watershed and monitored for a period of 20 months during 1988 and 1989 to establish background concentrations. One of the original sites near Bldg. 9201-4 was relocated 30 m south and west in late 1995 to a site near Bldg. 9422-13. In 1999, the four monitoring stations were upgraded by repositioning the sampling train at each site so that the minimum height was 3 m, thus, conforming to 40 CFR 58, Subpart E for other gaseous pollutants.

At each of the monitoring sites, airborne mercury vapor is pulled through a Teflon filter and flow-limiting orifice before adsorbing onto iodated charcoal packed in a glass sampling tube. The iodated charcoal sampling tubes are changed routinely every seven days. The charcoal in each trap is then analyzed 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.

Over the approximately 14 years of the monitoring program, average annual mercury vapor concentrations at the Y-12 Plant have shown a decline since the initial three years of the monitoring program (1986 through 1988). Recent average concentrations at the two boundary stations located at the east and west ends of the Y-12 Plant are comparable to those measured in 1988 and 1989 at the reference site (i.e., background site) situated on Chestnut Ridge. Average mercury vapor concentrations during the first eight months of 1999 for the two sites located near the former mercury-use building, Bldg. 9201-4, are lower in comparison to those reported in previous years (see Table 6.3). The large drop in average concentration measured at 9422-13 may be related to the placement of a solid plate over a mercury-contaminated catchbasin located nearby. Figure 6.4 illustrates temporal trends in mercury concentrations for the four active ambient air mercury monitoring sites since the inception of the program in 1986 through early September 1999. Monitoring was also conducted through the last four months of 1999 at the four monitoring sites, but samples have been temporarily archived and await future analysis.

In conclusion, annual average ambient mercury concentrations during the first eight months of 1999 at the monitoring sites located at the east or west boundary of the Y-12 Plant are comparable to background levels measured on Chestnut Ridge. The average mercury concentrations at the two sites located southeast and southwest of Bldg. 9201-4 remain elevated above natural background (see Table 6.3) but are lower than the concentra-

Table 6.3. Results of the Y-12 Plant ambient air mercury monitoring program from 1996 through September 8, 1999

Ambient air monitoring site	Mercury vapor concentration (µg/m^3)			
	1999 Average	1998 Average	1997 Average	1986–1988 Average[a]
Station No. 2 (east end of Y-12 Plant)	0.0037	0.0048	0.0048	0.010
Station No. 8 (west end of Y-12 Plant)	0.0054	0.0074	0.0068	0.033
Bldg. 9422-13 (SW of Bldg. 9201-4)[b]	0.021	0.044	0.032[e]	N/A
Bldg. 9805-1 (SE of Bldg. 9201-4)	0.053	0.057	0.064[e]	0.099
Reference Site, Rain Gage No. 2 (1988[c])	N/A	N/A	N/A	0.006
(1989[d])	N/A	N/A	N/A	0.005

[a] The 1986 through 1988 average is shown for reference.
[b] Site established in late 1995.
[c] Data for period from February 9 through December 31, 1988.
[d] Data for period from January 1 through October 31, 1989.
[e] Data for period from January 1 through September 30, 1997.

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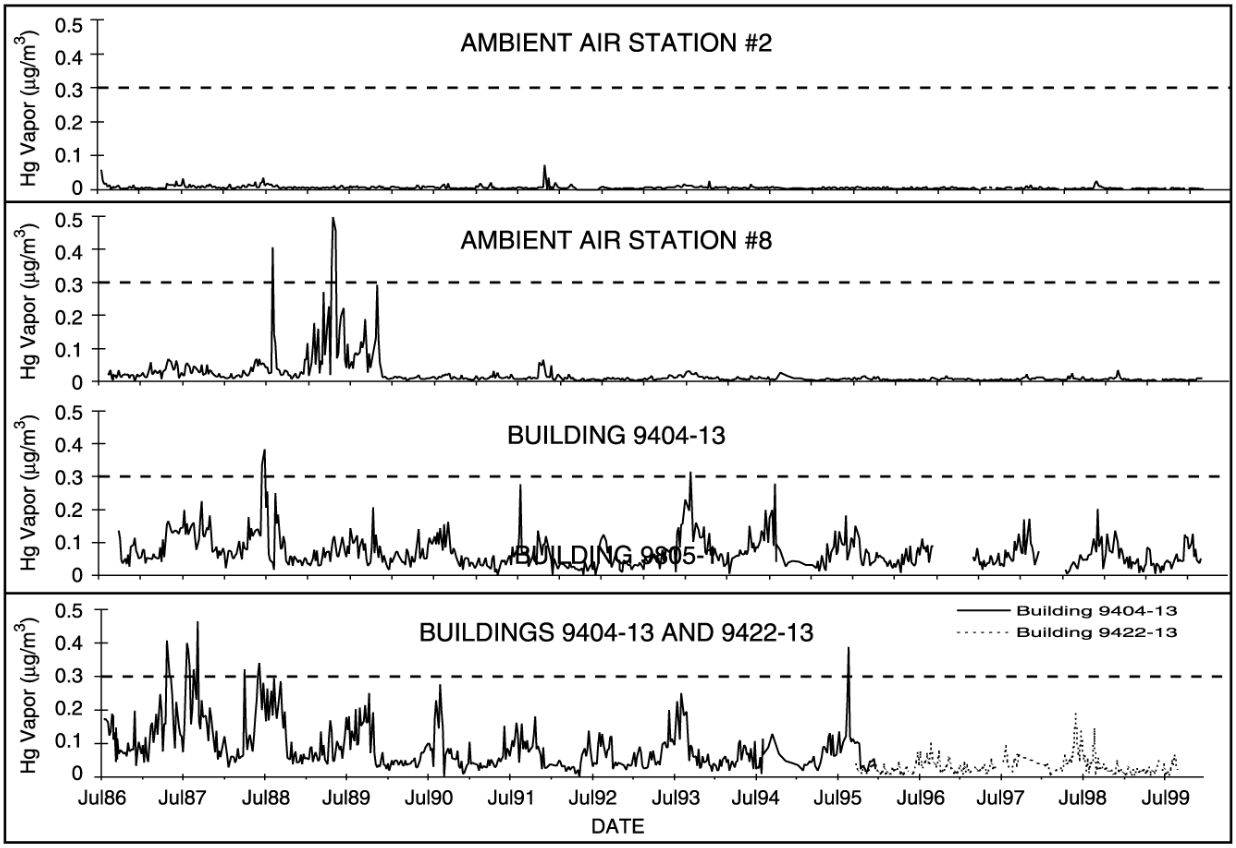

Fig. 6.4. Temporal trends in mercury vapor concentration for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Plant, July 1986 through July 1999. The dashed line represents the EPA RfC of 0.3 µg/m^3.

tions measured during the first 3 years of the monitoring program and are below regulatory levels. Concentrations at the two Bldg. 9201-4 sites are below the American Conference of Governmental Industrial Hygienists (ACGIH) workplace threshold limit value of 25 µg/m^3 (time-weighted average for a normal 8-h workday and 40-h work week) and the EPA reference concentration (RfC) (0.3 µg/m^3) for mercury for chronic inhalation exposure.

6.4 LIQUID DISCHARGES—Y-12 PLANT RADIOLOGICAL MONITORING SUMMARY

An RMP is in place at the Y-12 Plant to address compliance with DOE orders and the NPDES permit (TN002968). The permit, issued in 1995, required that the Y-12 Plant reevaluate its RMP and 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 only 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 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 1997b). Under the existing RMP, effluent monitoring is conducted at three types of locations: (1) treatment facilities, (2) other point and area source discharges, and (3) instream locations. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan (Table 6.4).

The RMP also addresses monitoring of the sanitary sewer. The Y-12 Plant is permitted to discharge domestic wastewater to the city of Oak Ridge 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 Plant as part of an initiative to meet the plant's 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 1997b).

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 1998c) and incorporates radiological monitoring requirements. There are 79 storm water outfalls and monitoring points located at the Y-12 Plant and the NPDES permit requires characterization of a minimum of 25 storm water outfalls per year.

6.4.1 Results

RMP locations sampled in 1999 are noted in Fig. 6.5. Table 6.5 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1999. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from Bear Creek. Radium (^{228}Ra) was the major contributor of radioactivity in Bear Creek, contributing 5.0% of the total 9.3% of the sum of the percentages of the DCGs.

In 1999, the total mass of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek (UEFPC), and the westernmost monitoring station, at BCK 4.55 (former NPDES Outfall 304), was 306 kg, or 0.166 Ci (Table 6.6). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentra-

Table 6.4. Radiological parameters monitored at the Y-12 Plant in 1999

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 the Y-12 Plant 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

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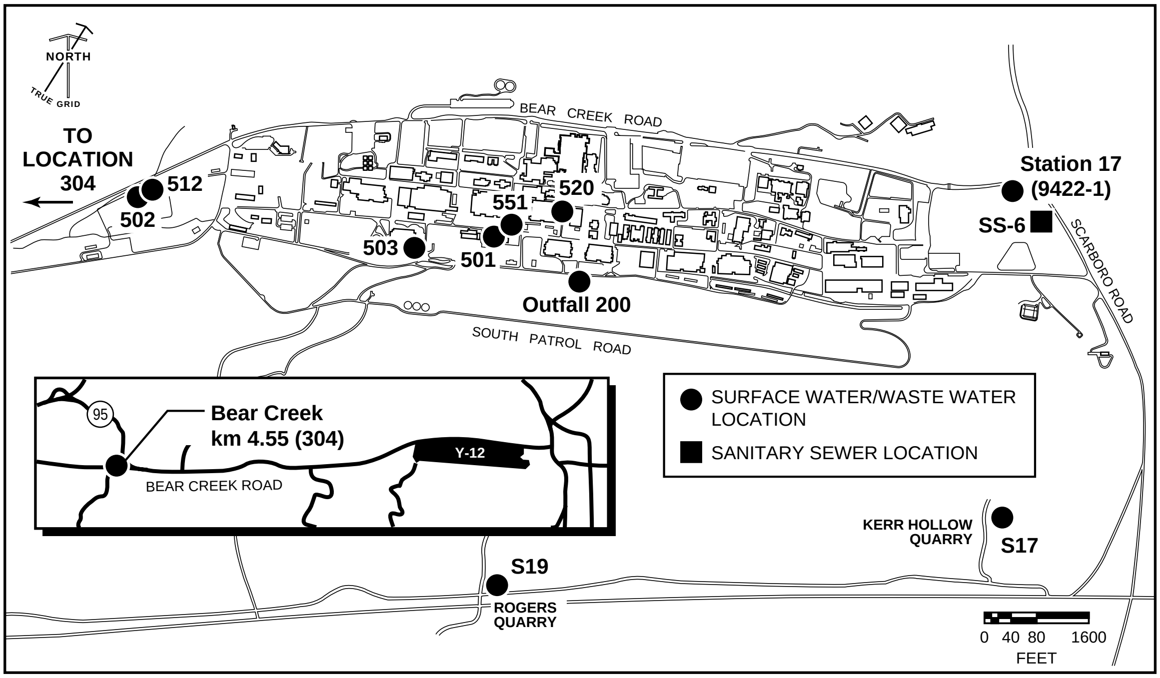

Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Plant.

Table 6.5. Summary of Y-12 Plant radiological monitoring plan sample requirements and results

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
		Y-12 Plant wastewater treatment facilities		
501	Central Pollution Control Facility	1/week	Composite during batch operation	5.9
502	West End Treatment Facility	1/week	24-h composite	5.7
503	Steam Plant Wastewater Treatment Facility	1/week	24-h composite	No flow
512	Groundwater Treatment Facility	1/week	24-h composite	5.2
520 (402)[a]	Steam condensate	1/week	Grab	1.8
551	Central Mercury Treatment Facility	1/month	24-h composite	4.1
		Other Y-12 Plant point and area source discharges		
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-h composite	3.6
S19 (302)[a]	Rogers Quarry	1/month	24-h composite	3.3
		Y-12 Plant instream locations		
BCK 4.55 (304)[a]	Bear Creek, plant exit (west)	1/week	7-day composite	9.3
Station 17	East Fork Poplar Creek, plant exit (east)	1/week	7-day composite	3.1
200	North/south pipes	1/week	24-h composite	4.3

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

Table 6.6. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1994–99

Year	Quantity released	
	Ci[a]	kg
	Station 17	
1994	0.11	185
1995	0.069	143
1996	0.135	215
1997	0.098	184
1998	0.076	127
1999	0.070	123
	Outfall 304	
1994	0.13	236
1995	0.066	105
1996	0.149	259
1997	0.116	199
1998	0.091	148
1999	0.096	183

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

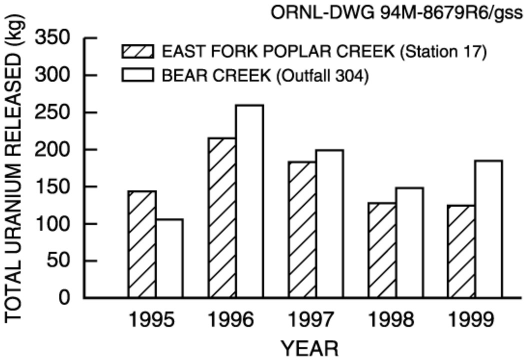

Fig. 6.6. Five-year trend of Y-12 Plant release of uranium to surface water.

tion (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 Plant 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 Plant contribution to the sanitary sewer exceeded 1% of the DCGs listed in DOE Order 5400.5. Summed percentages of DCGs calculated from the Y-12 Plant 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 6.7 presents a summary of 1999 storm water data that exceeded screening levels. More detailed results are given in Environmental Monitoring on the Oak Ridge Reservation: 1999 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. Table 6.7 indicates that ^{228}Ra is above the screening level (5% of its DCG); however, this is a worse case since the analytical method used did not have a low enough minimum detection limit to evaluate the sample. Because of the apparent increased level of ^{228}Ra, duplicate samples were taken and analyzed using a different analytical method.

6.5 NONRADIOLOGICAL LIQUID DISCHARGES—Y-12 PLANT SURFACE WATER AND LIQUID EFFLUENTS

The current Y-12 Plant NPDES permit, issued on April 28, 1995, and effective on July 1, 1995, requires sampling, analysis, and reporting at approximately 95 outfalls. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, the Y-12 Plant 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

Table 6.7. Summary of storm water data above screening levels

Parameter	Outfalls													
	10	15	21	45	63	83	102	113	200	S02	S08	S20	S24	S26
Fecal coliform	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					
Copper			X	X	X	X	X	X	X					
Mercury				X	X		X	X	X		X			
Phosphorus		X	X	X			X	X	X	X				X
PCB								X						
Nitrate as (N)													X	
Alpha activity		X								X	X	X	X	
Radium-228	X		X			X	X					X		X
Uranium-238										X	X		X	
Uranium-234										X	X		X	

infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared to NPDES limits, where 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 Plant is affected by current and historical legacy operations. Discharges from Y-12 Plant processes affect water quality and flow in EFPC before the water exits the Y-12 Plant 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 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 (monitoring ongoing, chlorine limits are being met);
- 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 (complete, see Sect. 6.5.3);
- sampling and characterization of storm water at a minimum of 25 locations per year;
- implementation of a 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.

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 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.

6.5.1 Sanitary Wastewater

Sanitary wastewater from the Y-12 Plant 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 1999, 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-hour 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 Plant 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 Plant 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 water discharged 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 Plant. By assessing the quality of storm water discharges from the site and 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 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 2000.

6.5.3 Results and Progress in Implementing Corrective Actions

In 1999, the Y-12 Plant experienced four NPDES excursions as opposed to nine in 1998. Additional details on all Y-12 Plant NPDES permit excursions recorded in 1999 and the associated corrective actions are summarized in Appendix E, Table E.1. Table 6.8 lists the NPDES compliance monitoring requirements and the 1999 compliance record.

During 1999, the Y-12 Plant experienced one exceedence of the Industrial and Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge POTW. The copper limit of 0.092 mg/L was exceeded on December 16 (0.093 mg/L). No specific cause was determined.

Construction activities associated with the multi-million-dollar project to rehabilitate the Y-12 Plant Sanitary Sewer collection system was 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 6.9 summarizes Y-12 Plant monitoring of the discharge to the sanitary sewer during 1999.

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, outfalls are showing detectable levels of TSS, Zn, P, Cu, Ra, U, Mn, Fe, and Hg during storm events. However, some monitored pollutants are not present at specific outfalls. A detailed data summary table is given in Environmental Monitoring on the Oak Ridge Reservation: 1999 Results (see http://www.ornl.gov/aser).

6.5.4 East Fork Poplar Creek Dechlorination and Fish Kill Summary

During 1999, as in the past 6 years, instream levels of TRC were about 0.01 mg/L (outfall discharge levels prior to 1993 were about 0.3 to 1.0 mg/L). This reduction is a result of dechlorination systems that were brought on line from 1992 through 1995. There were no reported fish kills in 1999.

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 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

Table 6.8. NPDES compliance monitoring requirements and record for the Y-12 Plant, January through December 1999

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	83	6
Outfall 117	pH, standard units			*a*	9.0	100	6
Outfall 073	pH, standard units			*a*	9.0	100	13
	TRC				0.5	100	12
Outfall 077	pH, standard units			*a*	9.0	100	14
	TRC				0.5	100	13
Outfall 122	pH, standard units			*a*	9.0	*b*	0
	TRC				0.5	*b*	0
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	TRC				0.5	*b*	0
Outfall 125	pH, standard units			*a*	9.0	100	15
	TRC				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9.0	100	79
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	128
	TRC				0.5	100	86
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10.0	100	27
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	173
	TRC				0.5	100	131
Outfall 201 (below the North/South pipes)	TRC			0.011	0.019	100	156
	Temperature, °C			*a*	30.5	100	157
	pH, standard units		8.5	*a*		99	157
Outfall 200 (North/South pipes)	Oil and grease			10	15	100	157
Outfall 021	TRC			0.080	0.188	100	157
	Temperature, °C			*a*	30.5	100	157
	pH, standard units				9.0	100	158
Outfall 017	pH, standard units			*a*	9.0	100	55
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*a*	9.0	100	105
	Mercury				0.004	100	104
	TRC				0.5	100	105

Table 6.8 (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 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	52
Outfall 051	pH, standard units			*a*	9.0	100	105
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	100	21
	TSS			31.0	40.0	100	20
	Total toxic organics				2.13	100	1
	Oil and grease			10	15	100	20
	Cadmium	0.16	0.4	0.075	0.15	100	21
	Chromium	1.0	1.7	0.5	1.0	100	21
	Copper	1.2	2.0	0.5	1.0	100	21
	Lead	0.26	0.4	0.1	0.2	100	21
	Nickel	1.4	2.4	2.38	3.98	100	21
	Nitrate/Nitrite				100	88	20
	Silver	0.14	0.26	0.05	0.05	100	21
	Zinc	0.9	1.6	1.48	2.0	100	20
	Cyanide	0.4	0.72	0.65	1.20	100	20
	PCB				0.001	100	1
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	100	55
	TSS	18.6	36.0	31.0	40.0	100	55
	Total toxic organics				2.13	100	7
	Nitrate/nitrite			100	150	100	55
	Oil and grease			10	15	100	55
	Cadmium	0.16	0.4	0.075	0.15	100	56
	Chromium	1.0	1.7	0.5	1.0	100	56
	Copper	1.2	2.0	0.5	1.0	100	56
	Lead	0.26	0.4	0.10	0.20	100	56
	Nickel	1.4	2.4	2.38	3.98	100	56
	Silver	0.14	0.26	0.05	0.05	100	56
	Zinc	0.9	1.6	1.48	2.0	100	55
	Cyanide	0.4	0.72	0.65	1.20	100	56
	PCB				0.001	100	7
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	TSS	125	417	30.0	40.0	*b*	0
	Oil and grease	62.6	83.4	10	15	*b*	0
	Iron	4.17	4.17	1.0	1.0	*b*	0
	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 (Groundwater Treatment Facility)	pH			*a*	9.0	100	141
	Iron				1.0	100	142
	PCB				0.001	100	14
Outfall 520	pH, standard units				9.0	100	12
Outfall 05A	pH				9.0	*b*	0

[a]Not applicable.
[b]No discharge.
TRC = total residual chlorine.
TSS = total suspended solids.

Table 6.9. Y-12 Plant Discharge Point sanitary sewer station 6 (SS6)

From January through December 1999

	No. of samples	Concentration[a]			Reference value[b]	Number of values exceeding reference
		Max	Min	Avg		
Flow, gpd[c]	365	1969725.0	388349.0	677899.2	*d*	*d*
pH, Std Unit	53	8.5	6.8	*d*	9/6[e]	0
Silver, mg/L	53	0.0614	<0.0002	<0.004	0.1	0
Arsenic, mg/L	53	0.0042	<0.002	<0.002	0.0045	0
Boron, mg/L	53	<0.1	<0.1	<0.1	*d*	*d*
Beryllium, mg/L	53	<0.001	<0.0002	<0.0009	*d*	*d*
Benzene, mg/L	13	0.01U	0.005U	0.01U	0.015	0
Biochemical oxygen demand	53	61.0	10.0	34.4	300	0
Cadmium, mg/L	53	<0.001	<0.0002	<0.0005	0.0045	0
Chromium, mg/L	53	0.0162	<0.001	<0.002	0.075	0
Copper, mg/L	53	0.0926	0.0086	0.031	0.092	1
Cyanide, mg/L	13	<0.01	<0.01	<0.01	0.062	0
Iron, mg/L	53	2.27	0.225	0.686	15	0
Mercury, mg/L	84	0.0054	<0.0002	<0.0009	0.035	0
Kjeldahl nitrogen, mg/L	53	16.3	0.362	<9.36	90	0
Methylene chloride, mg/L	13	0.01U	0.005U	0.01U	0.041	0
Manganese, mg/L	53	0.0838	0.0204	0.0398	*d*	*d*
Nickel, mg/L	53	0.0114	<0.002	<0.004	0.032	0
Oil and grease, mg/L	53	14.4	<5.6	<6.4	50	0
Lead, mg/L	53	0.0042	<0.0002	<0.001	0.074	0
Phenols—total recoverable	53	0.0196	<0.005	<0.01	0.5	0
Selenium, mg/L	53	<0.2	<0.004	<0.05	*d*	*d*
Suspended solids, mg/L	53	107.0	12.8	52.7	300	0
Toluene, mg/L	13	0.01U	0.005U	0.01U	0.02	0
Trichloroethene, mg/L	13	0.01U	0.001	0.009U	0.027	0
Zinc, mg/L	53	0.302	0.0381	0.117	0.75	0

[a] Units in mg/L unless otherwise indicated.
[b] Industrial and commercial user waste water discharge permit limits.
[c] Flow during operations and/or discharging.
[d] Not applicable.
[e] Maximum value/minimum value.

Outfall 201), wastewater treatment system discharges, and locations in the storm sewer system is required. Table 6.10 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 1999 using *Ceriodaphnia dubia*. Effluent samples from the Central Mercury Treatment System (CMTS) were consistently nontoxic throughout Central Pollution Control Facility (CPCF) samples were nontoxic to *Ceriodaphnia* in one test and had LC_{50}s of 84% and 72% in two other tests. The LC_{50}s for the Groundwater Treatment Facility (GWTF) ranged from 33% to 78% and from 17 to 19% for the West End Treatment Facility (WETF). In all cases, the calculated IWCs of the effluent were less than the LC_{50}s. This indicates that the treated effluent 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-sewer 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-sewer 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 6.11) demonstrated that when all discharges were combined (treated effluent, storm sewer contribution, plus flow management water) and dechlorinated the samples were nontoxic in laboratory tests.

Table 6.11 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 1999 using 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 permits issued to the Y-12 Plant in 1995, ETTP in 1992, and ORNL in 1986 mandate BMAPs with the objective of demonstrating that the effluent limitations established for each facility protect the classified uses of the receiving streams. The Y-12 Plant effluents discharge to EFPC; ETTP effluents discharge to Mitchell Branch, Poplar Creek, and the Clinch River; and ORNL effluents discharge to WOC and its tributaries. Each of the BMAPs is unique and consists of three or four major tasks that reflect different but complementary approaches to evaluating the effects of the effluent discharges on the aquatic integrity of the receiving streams. Tasks present in one or more of the BMAPs include (1) toxicity monitoring; (2) bioaccumulation studies; (3) biological indicator studies; (4) waterfowl surveys; and (5) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

Exposure of EFPC biota to contaminants continued to decrease during 1999. Fish and invertebrate communities in upper EFPC continue to be degraded in comparison with similar communities in reference streams. However, relatively consistent trends of increases in species richness

Table 6.10. Y-12 Plant Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 1999[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Groundwater Treatment Facility (GWTF)	1/21/99	*Ceriodaphnia*	77.93	0.23
Central Mercury Treatment System (CMTS)	1/22/99	*Ceriodaphnia*	>100	0.23
Storm Sewer 9215/9204-2E Alley (dechlorinated)	1/26/99	*Ceriodaphnia*	>100	*d*
Storm Sewer 9215/9204-2E Alley	1/26/99	*Ceriodaphnia*	36.14	*d*
Storm Sewer Southeast of 9201-4	1/26/99	*Ceriodaphnia*	70.71	*d*
Storm Sewer Southeast of 9703-11 (dechlorinated)	1/27/99	*Ceriodaphnia*	70.71	*d*
Storm Sewer Southeast of 9703-11	1/27/99	*Ceriodaphnia*	6.68	*d*
Storm Sewer West of 9212	1/27/99	*Ceriodaphnia*	9.05	*d*
Storm Sewer West of 9212 (dechlorinated)	1/27/99	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (CPCF)	1/29/99	*Ceriodaphnia*	84.46	0.16
Outfall 135	4/22/99	*Ceriodaphnia*	60.8	*d*
Storm Sewer Southeast of 9204-2 (dechlorinated)	4/22/99	*Ceriodaphnia*	>100	*d*
GWTF	4/22/99	*Ceriodaphnia*	33.1	0.05
Storm Sewer Southeast of 9204-2	4/22/99	*Ceriodaphnia*	38.5	*d*
CMTS	4/23/99	*Ceriodaphnia*	>100	0.15
CPCF	4/24/99	*Ceriodaphnia*	>100	0.14
Surface Water Hydrological Information Support System (SWHISS) South of 9204-2 (dechlorinated)	4/27/99	*Ceriodaphnia*	57.3	*d*
SWHISS South of 9204-2	4/27/99	*Ceriodaphnia*	35.4	*d*
Storm Sewer West of 9204-2	4/27/99	*Ceriodaphnia*	70.7	*d*
Storm Sewer West of 9204-2 (dechlorinated)	4/27/99	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (WETF)	6/15/99	*Ceriodaphnia*	19.4	0.23
Storm Sewer Southeast of 9204-2 (dechlorinated)	7/24/99	*Ceriodaphnia*	73.1	*d*
Storm Sewer Southeast of 9204-2	7/24/99	*Ceriodaphnia*	69.9	*d*
Outfall 135	7/24/99	*Ceriodaphnia*	67.7	*d*
GWTF	7/24/99	*Ceriodaphnia*	78.5	0.17
CMTS	7/25/99	*Ceriodaphnia*	>100	0.02
WETF	7/25/99	*Ceriodaphnia*	17.3	0.08
SWHISS South of 9204-2 (dechlorinated)	7/29/99	*Ceriodaphnia*	>100	*d*
SWHISS South of 9204-2	7/29/99	*Ceriodaphnia*	66.6	*d*
Storm Sewer West of 9204-2	7/29/99	*Ceriodaphnia*	45.9	*d*
Storm Sewer West of 9204-2 (dechlorinated)	7/29/99	*Ceriodaphnia*	>100	*d*
CPCF	9/27/99	*Ceriodaphnia*	>100	0.13
WETF	10/16/99	*Ceriodaphnia*	17.3	0.08
GWTF	10/16/99	*Ceriodaphnia*	57.2	0.09
SWHISS South of 9201-4 (dechlorinated)	10/16/99	*Ceriodaphnia*	90.4	*d*
Storm Sewer South of 9201-4	10/16/99	*Ceriodaphnia*	81.0	*d*
SWHISS South of 9201-4	10/16/99	*Ceriodaphnia*	<6	*d*
CMTS	10/17/99	*Ceriodaphnia*	>100	0.13
CPCF	10/20/99	*Ceriodaphnia*	71.8	0.15
Storm Sewer North of 9723-25 (dechlorinated)	10/21/99	*Ceriodaphnia*	91.2	*d*
Storm Sewer South of 9409-24	10/21/99	*Ceriodaphnia*	>100	*d*
Storm Sewer South of 9409-24 (dechlorinated)	10/21/99	*Ceriodaphnia*	>100	*d*
Storm Sewer North of 9723-25	10/21/99	*Ceriodaphnia*	11.6	*d*

[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.

Table 6.11. Y-12 Plant Biomonitoring Program summary information for Outfall 201 for 1999[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	2/2	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	4/21	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	7/29	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/20	*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 percent of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

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 1999 for one site upstream from 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 Plant's NPDES permit. Because of the close proximity of Outfall 201 (an instream NPDES location in upper EFPC) 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 1999 *Ceriodaphnia* (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 1999 from the mid to upper reaches of EFPC and analyzed for tissue concentrations of these two environmental contaminants. Largemouth bass (*Micropterus salmoides*) were collected once in 1999 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 much higher in EFPC than in fish from reference streams. High levels of mercury bioaccumulation continue to occur upstream of Lake Reality, indicating that the Y-12 Plant remains an important source of mercury to fish in the upper reaches of EFPC. Following significant decreases in the mid-1990s, mercury concentrations in the fish and water of upper EFPC have remained relatively constant over the last two years (Fig. 6.7).

PCB concentrations in EFPC sunfish continued during 1999 within ranges typical of past monitoring efforts at these sites (Fig. 6.8) . Mean PCB concentrations remained highest in Lake Reality and in the upper reaches of EFPC above Lake Reality, indicating a continuing source or sources within the Y-12 Plant.

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 four sites in EFPC and from two reference streams in the spring of 1999 prior to the onset of that year's breeding season. The health and reproductive condition of sunfish from EFPC sites upstream of Bear Creek Road continue to 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 upper EFPC in recent years.

EFPC water remained toxic during 1999 to developing 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 many other species of fish, are quite sensitive to many of the chemical constituents originating within the Y-12 Plant, including various metals (particularly mercury), ammonia and other nitrogenous wastes, and even the chemicals that are involved in or are the by-products of chlorination/dechlorination water treatment procedures.

6.7.4 Ecological Surveys

Periphyton were monitored quarterly during 1999 from three sites along EFPC. Algal biomass and photosynthetic rates remained higher in EFPC

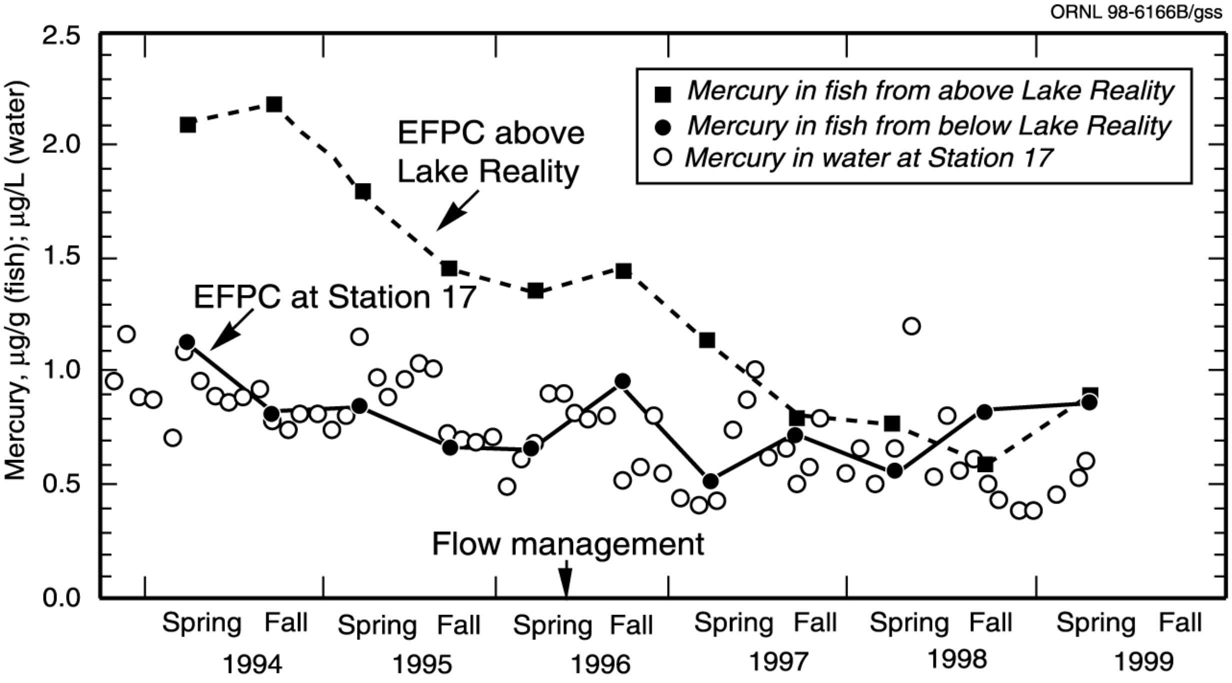

Fig. 6.7. Average mercury concentration in redbreast sunfish muscle filets, East Fork Poplar Creek upstream and downstream of Lake Reality, and monthly average total mercury concentration in water at Station 17, 1994 through spring 1999.

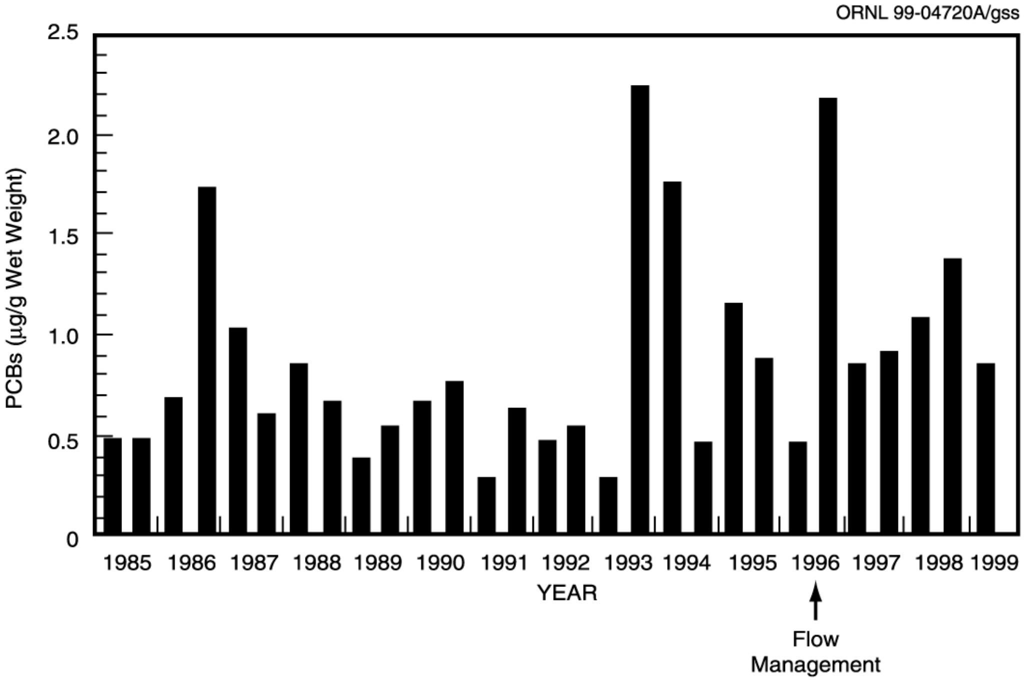

Fig. 6.8. Mean concentrations of PCBs in redbreast sunfish muscle filets, East Fork Poplar Creek, upstream and downstream of Lake Reality, 1985–1999.

than in reference streams. Concentrations of various metals measured in periphyton showed steady decreases for all EFPC sites through 1999, although concentrations remain elevated in comparison with reference streams.

Fish communities in EFPC were monitored twice in 1999 at six sites along EFPC and at two reference streams. Fish communities in EFPC were seen to have recovered nearly completely from population declines related to a fish kill and record rainfall/flood event in the summer of 1997. Sensitive fish species continued to increase in the upper reaches of the stream below Lake Reality (Fig. 6.9).

Benthic macroinvertebrate communities were monitored at four sites in EFPC and from two reference streams in the fall and spring of 1999. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded through 1999 (Fig. 6.10). However, persistent increases in total richness and the richness of pollution-tolerant taxa at these sites indicated continuing improvement in water quality. The benthic macroinvertebrate communities at sites farther downstream (i.e., EFK 13.8) appear to be responding to urban development in this reach of the stream.

The effects of in situ exposure on clam growth and survival was tested during 1999 at three sites in EFPC and at sites in three reference streams (Fig. 6.11). As in previous such tests, clam survival and growth continued to be severely impacted in EFPC, especially at upstream sites closest to the Y-12 Plant.

6.8 Y-12 PLANT 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

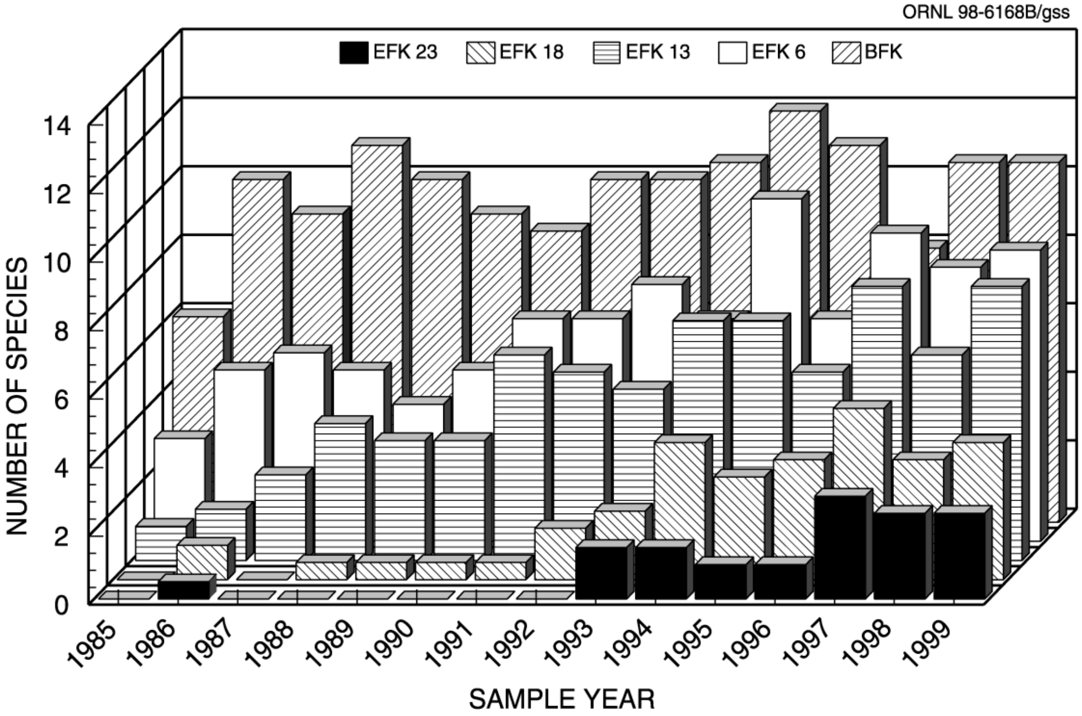

Fig. 6.9. Comparison of numbers of sensitive fish species collected during the spring of each year from 1985 through 1999 from four sites in EFPC and a reference site (Brushy Fork). EFK = East Fork kilometer; BFK = Brushy Fork kilometer.

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 Plant area of responsibility. A surveillance sample (a 7-day omposite 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) houses are 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 stations 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 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 480 surface water surveillance samples were collected in 1999. Comparisons with Tennessee WQC indicate that only mercury and zinc from samples collected at Station 17 were detected at values exceeding a criteria maximum. Results are shown in Table 6.12. 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 Plant Groundwater Protection Program (GWPP)

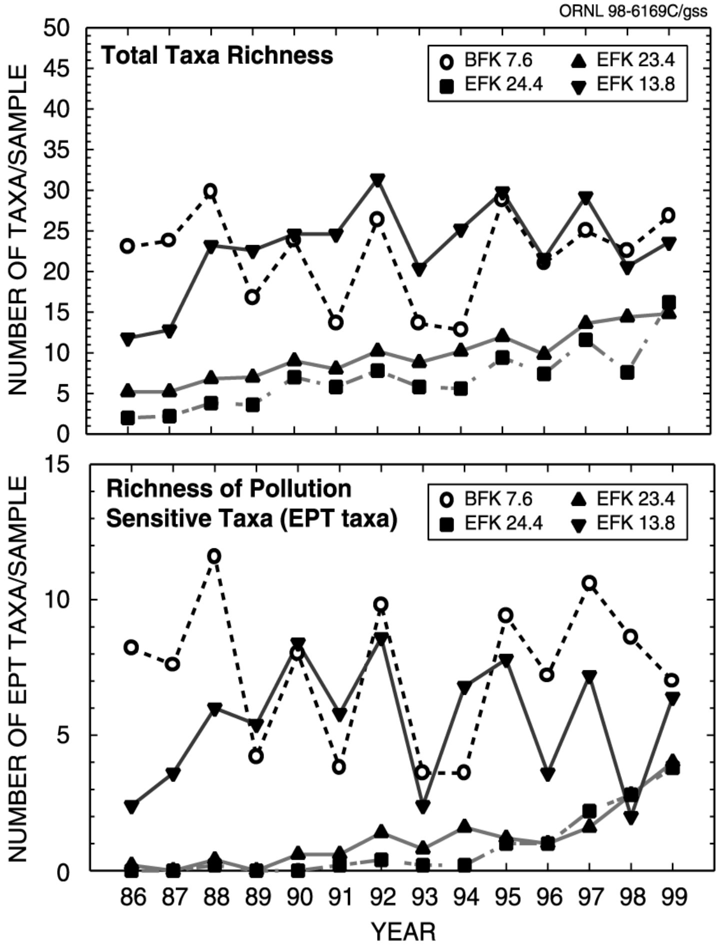

Fig. 6.10. Total taxonomic richness (mean number of taxa/sample, ± SE) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (mean number of EPT taxa/sample ± SE) of the benthic macroinvertebrate communities in East Fork Poplar Creek (EFK) and a reference site (BFK 7.6), spring data only. (EPT taxa include relatively pollution-sensitive species.)

to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 6.10.5.3).

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 Plant 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 Plant maintains an annual sampling program to determine if these constituents are accumulating in the sediments of EFPC and Bear Creek as a result of Y-12 Plant discharges. Results of the most recent monitoring activity (May 1999) are given in Table 6.13. 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 water stream to natural waterways. The Order limits the amount of activity that may be present in released settleable solids. Because Y-12 Plant waste streams have very low settleable solids contents, this sampling program to measure activity in the sediments of EFPC and Bear Creek is used to determine if a buildup of radionuclide concentrations is occurring.

6.10 GROUNDWATER MONITORING AT THE Y-12 PLANT

More than 200 sites have been identified at the Y-12 Plant that represent known or potential sources of contamination to the environment as a result of past waste management practices. Because of this, extensive groundwater monitoring is required to comply with federal, state, and local regulations and DOE orders.

6.10.1 Background and Regulatory Setting

Groundwater monitoring at the Y-12 Plant is conducted by two programs, the Y-12 Plant GWPP, managed by Lockheed Martin Energy Systems, Inc., and the IWQP, managed by Bechtel Jacobs Company LLC. Each program is responsible for monitoring groundwater to meet specific

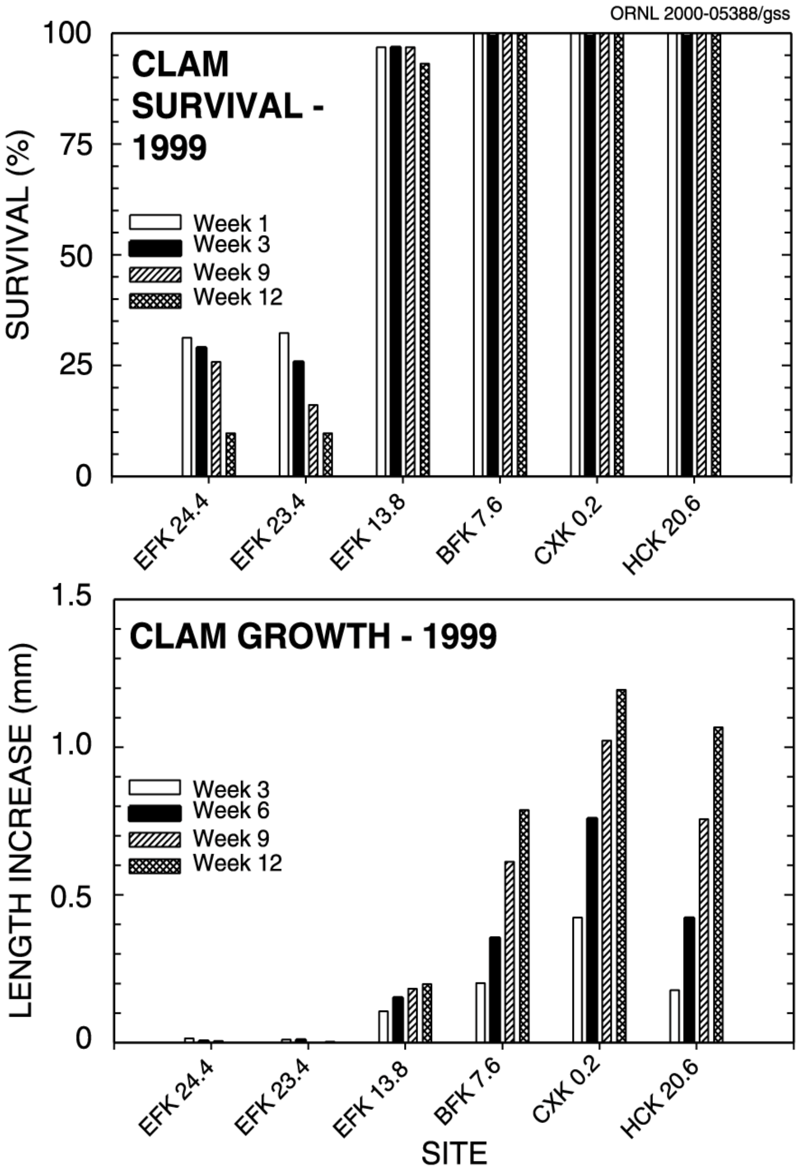

Fig. 6.11. Mean survival and growth of fingernail clams (*Sphaerium fabale*) in in situ bioassays in EFPC, June through September 1999.

compliance requirements. In 1999, the GWPP performed detection monitoring of solid waste disposal facilities (SWDFs) and monitoring for compliance with DOE orders, while the IWQP performed groundwater monitoring in compliance with RCRA and CERCLA regulations.

In 1999, four SWDFs (landfills) located on Chestnut Ridge at the Y-12 Plant and permitted and regulated by the Tennessee Department of Environment and Conservation Solid Waste Management were under semiannual detection monitoring. Two facilities (Industrial Landfill II and Industrial Landfill IV) have been subject to groundwater monitoring under the SWDF regulations since the late 1980s. Construction of three additional landfill facilities was completed between 1993 and 1994 (Industrial Landfill V, Construction/Demolition Landfill VI, and Construction/Demolition Landfill VII). Transition of all landfill monitoring responsibilities from Energy Systems to Bechtel Jacobs was completed at the end of 1999.

Specific regulatory requirements do not address all groundwater monitoring concerns at the Y-12 Plant. 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 the Y-12 Plant. 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 management issues under CERCLA and RCRA regulations and the FFA. In January 1999, the transition from the GWPP to the IWQP of all responsibilities for groundwater monitoring to comply with RCRA post-closure permit (PCP) requirements was completed. In addition to RCRA PCP monitoring, the IWQP monitored groundwater to meet CERCLA requirements. Under CERCLA, the IWQP performed groundwater monitoring to comply with RODs, Interim RODs, or AMs and to continue to accumulate baseline data against

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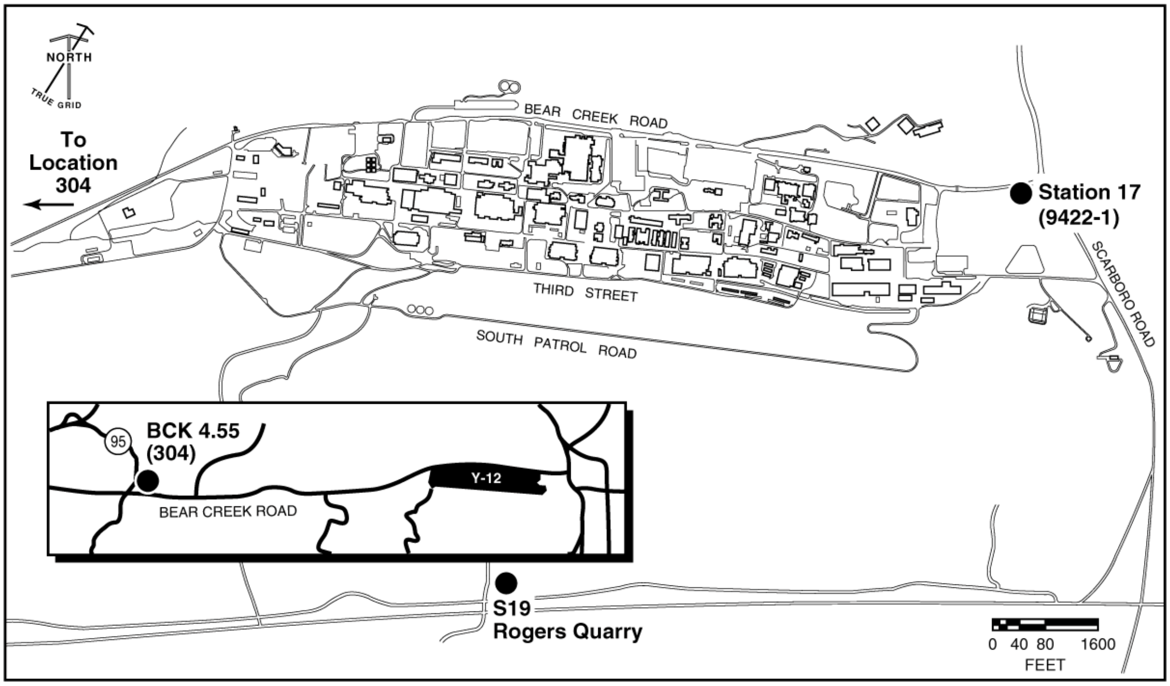

Fig. 6.12. Locations of Y-12 Plant surface water surveillance sampling stations.

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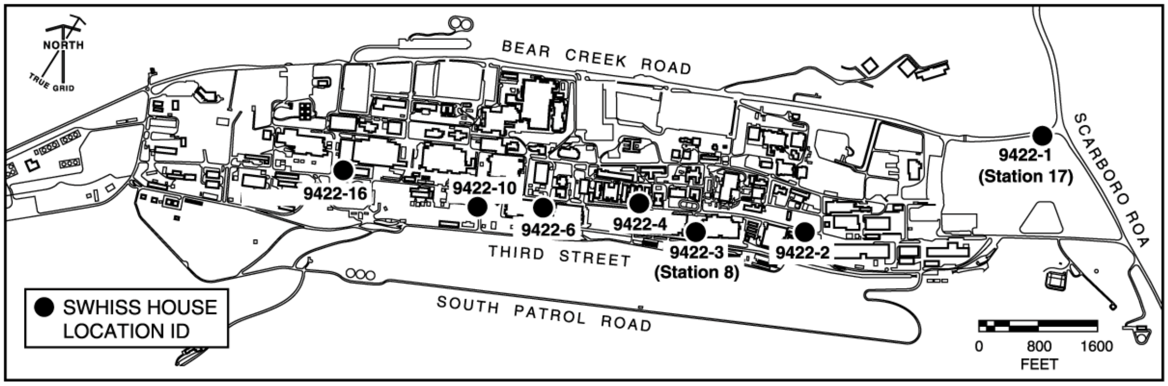

Fig. 6.13. Surface Hydrological Information Support System monitoring locations.

Table 6.12. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1999

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Avg		
Mercury	Station 17	400	0.0002	0.0152	<0.0007	0.00015	398
Zinc	Station 17	152	0.05	0.147	<0.06	0.117[a]	21

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

Table 6.13. Results of Y-12 Plant sediment monitoring

	Station 17		BCK 9.4	
	1997	1999	1997	1999
^{226}Ra (pCi/g)	2.8	2.4	2.4	2.5
^{228}Th (pCi/g)	0.97	0.57	0.70	0.52
^{230}Th (pCi/g)	1.2	0.50	0.41	0.24
^{232}Th (pCi/g)	0.73	0.48	0.68	0.41
^{234}U (pCi/g)	2.6	2.7	3.6	3.6
^{235}U (pCi/g)	0.13	0.11	0.20	0.20
^{238}U (pCi/g)	2.9	2.8	6.3	7.6
Mercury µg/g	9.5	14.6	0.3	0.215
Total PCBs µg/kg	370J	280	350J	350

which the effects of pending remedial actions can be measured.

In 1992, a number of the inactive waste management sites were grouped into operable units (OUs) under CERCLA as part of an FFA negotiated among EPA, TDEC, and DOE. Two types of OUs were identified: (1) source OUs consisting of sites or groups of sites that were known sources of contamination to the environment and (2) integrator OUs consisting of media, such as groundwater, soils, and/or surface water, that had been impacted by the source OUs. An agreement was reached among regulatory agencies and DOE in 1994 to proceed with an integrated RI/FS strategy. In the integrated strategy, former source OUs and integrator OUs are addressed concurrently in a characterization area (CA) defined by physical limits, such as watershed boundaries and/or groundwater flow regimes (Fig. 6.14). Specific sites or locations of high risk or concern within the CA are targeted for focused, rapid remedial actions, while a general remedial strategy and/or administrative controls for other sites in the CA progress. Individual focused action sites are designated as OUs and documented under separate RODs.

Two CAs incorporating 27 known source units have been established for the Y-12 Plant, the UEFPC CA and the BCV CA.

Additionally, four individual source OUs remain on Chestnut Ridge where available data indicate that contamination from each unit is distinct and separable. The remaining sites have been grouped into Y-12 Plant study areas that constitute lower-priority units that will be investigated under CERCLA. Post-closure maintenance, monitoring, and reporting requirements of RCRA also apply to seven inactive CERCLA-regulated units that meet the definition of a RCRA hazardous waste TSD facility. These units include the S-3 Site, portions of the BCBG, the OLF, New Hope Pond, the Chestnut Ridge Security Pits, the Chestnut Ridge Sediment Disposal Basin, and Kerr Hollow Quarry. Post-closure requirements are now outlined in RCRA post-closure permits issued by TDEC. These requirements are integrated with CERCLA programs. Corrective actions addressing contaminant releases will be deferred to the CERCLA RI/FS process. While corrective actions are progressing, the permits require focused monitoring of selected exit pathways and compliance boundaries.

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

6.10.2 Hydrogeologic Setting

The Y-12 Plant is divided into three hydrogeologic regimes delineated by surface water drainage patterns, topography, and groundwater flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime (Bear Creek regime), the UEFPC Hydrogeologic Regime (UEFPC regime), and the Chestnut 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.

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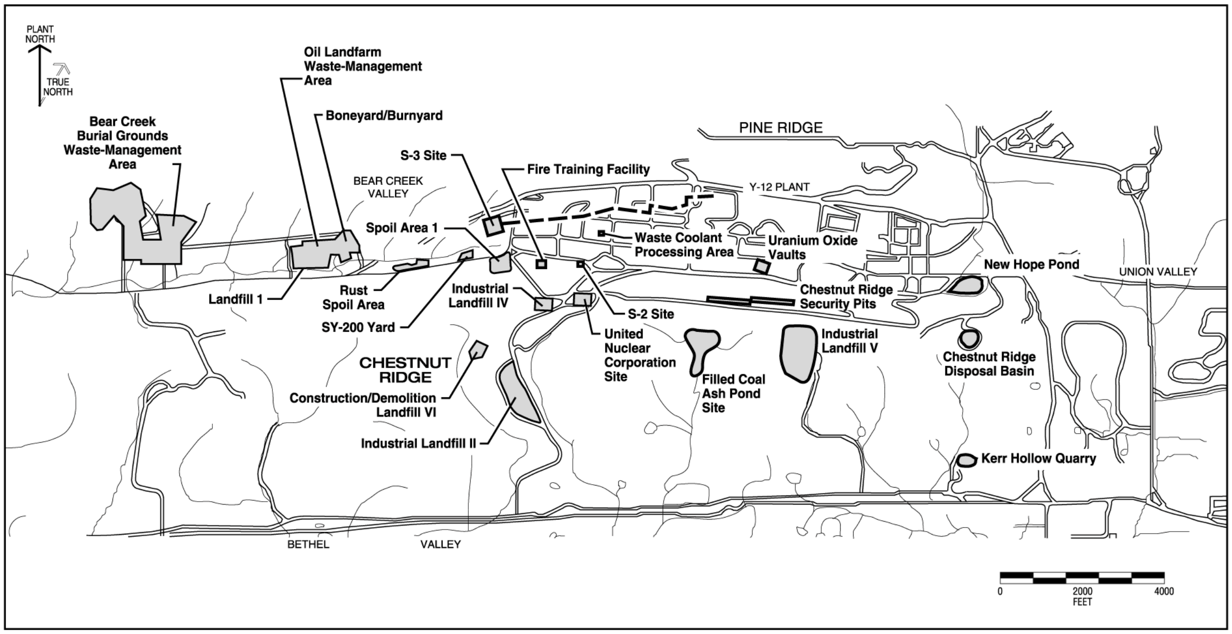

Fig. 6.14. Y-12 Plant inactive regulated units, study areas, and active facilities for which groundwater monitoring was conducted in CY 1999.

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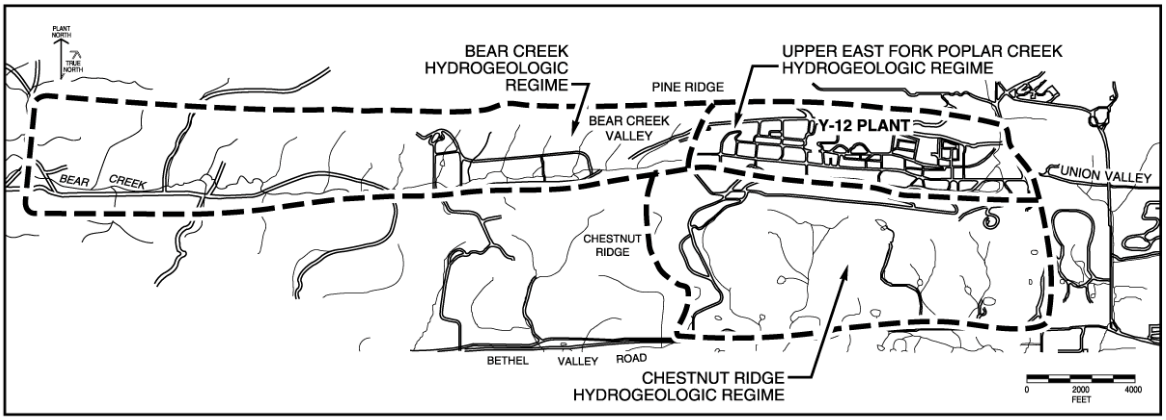

Fig. 6.15. Hydrogeologic regimes at the Y-12 Plant.

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 the Y-12 Plant. 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 to the north and Chestnut Ridge to the south of the Y-12 Plant. 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 predominantly through fractures in the ORR aquitards, converging toward and moving through fractures and solution conduits in the Maynardville Limestone. Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels 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 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, approximately twice the previous estimates. 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 BCV to the north and Bethel Valley (BV) 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 toeast, demonstrating an overall easterly trend in groundwater flow.

6.10.3 1999 Monitoring Program

Groundwater monitoring in 1999 was performed to comply with multiple requirements from state and federal regulations and DOE orders by the GWPP and IWQP. Compliance requirements were met by the monitoring of 149 wells, 19 springs, 29 surface water locations and 5 building sumps (Table 6.14). Figure 6.16 shows the locations of ORR perimeter/exit pathway groundwater monitoring stations as specified in the EMP (DOE 1998b).

Detailed data reporting of monitoring activities conducted by both the Y-12 Plant GWPP and the IWQP is in the annual groundwater monitoring report (LMES 2000). Details of monitoring efforts performed specifically for CERCLA OUs are published in four documents (DOE 1997a, 1997b, 1998b, and 1998f) and in the Annual RER (DOE 2000). Groundwater monitoring compliance reporting to meet RCRA post-closure care requirements can be found in the RCRA annual reports (BJC 2000c, BJC 2000d, and BJC 2000e).

A number of devices and natural hydrogeologic features are routinely used for groundwater data collection at the Y-12 Plant including wells, piezometers, building sumps, springs, and surface water. Monitoring wells are permanent devices used to collect groundwater samples; these are installed according to established regulatory and industry specifications and are predominantly sampled using the low-flow sampling method. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of polyvinyl chloride (PVC) or other low-cost material. Other devices or techniques are sometimes employed to gather data, including well points and push probes. Springs are naturally occurring groundwater discharge points where the saturated zone intersects the land surface (Freeze and Cherry 1979). Surface water bodies such as streams, rivers, ponds, and lakes are highly interactive with the saturated groundwater zone.

In 1998, a change was made in groundwater monitoring well sampling methods by the GWPP. Prior to 1998, well sampling was performed by purging three casing volumes from a well prior to sampling to ensure that groundwater indicative of natural conditions was being collected and not

Table 6.14. Types and numbers of groundwater monitoring stations at the Y-12 Plant, 1999

	Bear Creek	Chestnut Ridge	UEFPC	Total
Conventional wells	53	36	53	142
Multiport wells	5	0	2	7
Surface water	13	3	13	29
Springs	7	8	4	19
Building sumps	0	0	5	5
Total number of monitoring stations	78	47	77	202

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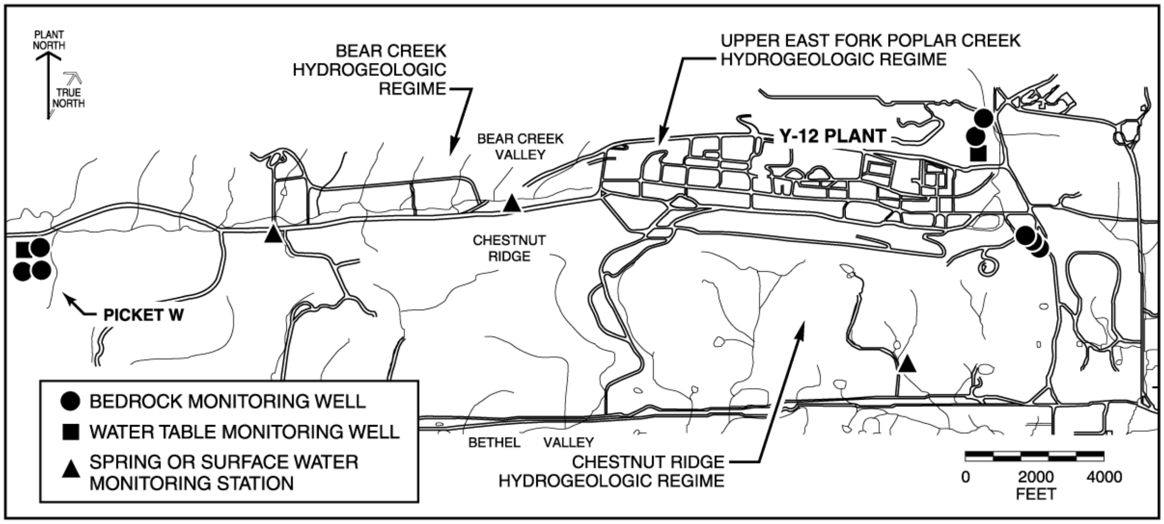

Fig. 6.16. Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring station in the *Environmental Monitoring Plan* (DOE 1998b).

stagnant water from the well casing. Concerns that the aggressive pumping required to perform this method of sampling [1.5 gpm (5.7 L/min)] was inducing or accelerating contaminant transport and generating a significant volume of waste water have resulted in the adoption and implementation of the low-flow minimal draw-down sampling (low-flow) method. By this method, a well is purged at very low rates (less than 300 mL/min). Water levels and field parameters (specific conductance, temperature, pH, dissolved oxygen, and reduction/oxidation potential) within a well are monitored during the low-flow purging. The stabilization of all parameters indicates that the discharging water from the well is groundwater indicative of the natural flow system, and sampling can commence.

The use of the low-flow method has resulted in fewer sampling artifacts; however, some changes in observed contaminant concentrations have occurred. In some wells, a marked decrease in contaminants (since the implementation of the low-flow method) from a well is observed, indicating that groundwater contaminants are no longer being pulled to the well by sampling-induced flow. Other wells have a significant increase in contaminant concentrations. In this case, speculation is that the decreased flux of groundwater into the well using the low-flow method minimizes the dilution of the contaminants with a large volume of “clean” groundwater as in the conventional sampling method. In either case, the low-flow sampling method is still considered an appropriate and cost-effective method of obtaining representative samples from monitoring wells.

6.10.4 Y-12 Plant Groundwater Quality

Historical monitoring efforts have shown that groundwater quality at the Y-12 Plant has been affected by four types of contaminants: nitrate, VOCs, metals, and radionuclides. Of these, nitrate and VOCs are the most widespread, and some radionuclides, particularly ^{99}Tc are also significant, particularly in the Bear Creek regime and the western portion 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 the Y-12 Plant, in the vicinity of the 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 1999 monitoring locations and waste management sites in the UEFPC regime that are addressed in this document are shown in Fig. 6.17. A brief description of waste management sites in the UEFPC regime is given in Table 6.15.

The UEFPC regime, which includes the UEFPC CA, consists of contaminant source areas, surface water, and groundwater components of the hydrogeologic system within the UEFPC regime and Union Valley to the east of the Y-12 Plant and off the DOE ORR. Among the three hydrogeologic regimes at the Y-12 Plant, the UEFPC regime contains most of the known and potential sources of surface and groundwater contamination. Chemical constituents from the S-3 Site (primarily nitrate and ^{99}Tc) dominate groundwater contamination in the western portion of the UEFPC regime, while groundwater in the eastern portion, including Union Valley, is predominantly contaminated with VOCs.

Plume Delineation

The primary groundwater contaminants in the UEFPC regime are nitrates, VOCs, trace metals, and radionuclides. Sources of these contaminants monitored during 1999 are 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, and process/production buildings in the plant. 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 the Y-12 Plant exceed the 10 mg/L maximum drinking water contamination level (a complete list of DWSs is presented in Appendix D) in a large part of the western portion of the UEFPC regime

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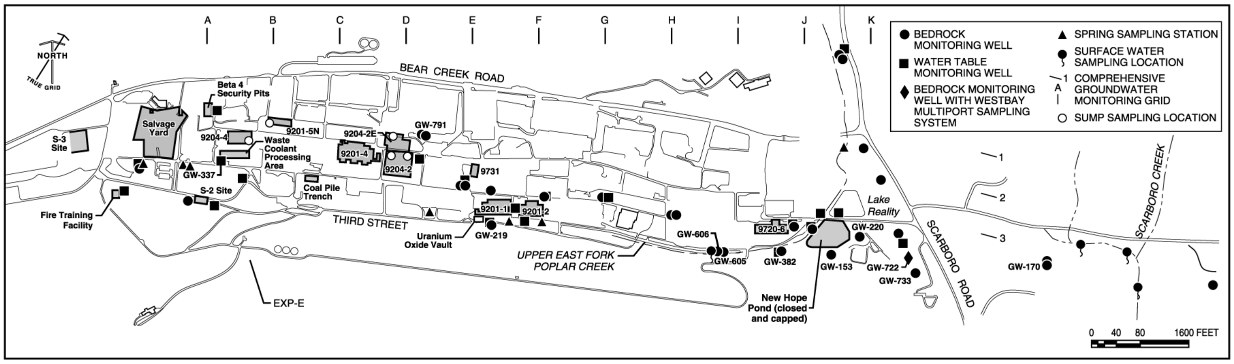

Fig. 6.17. Locations of waste management sites and monitoring wells sampled during 1999 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Table 6.15. History of waste management units and underground storage tanks included in 1999 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 Plant grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. Closed under RCRA in 1990
Abandoned Nitric Acid Pipeline	Used from 1951 to 1983. Transported liquid nitric acid wastes and dissolved uranium from Y-12 Plant process areas to the S-3 Site. Leaks were the release mechanisms to groundwater. A CERCLA ROD has been issued
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
Interim Drum Yard	Diked outdoor storage area once used to store drums of liquid and solid wastes. Partially closed under RCRA in 1988 and 1996. Further action deferred to CERCLA
Rust Garage Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented
Garage Underground Tanks	Fuel USTs used from 1944 to 1978. Converted to waste oil storage in 1978; removed in 1989. Petroleum and waste oil leaks represent probable releases to groundwater. The unit was clean-closed under RCRA in 1995
9418-3 Uranium Oxide Vault	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of nonenriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism
Fire Training Facility	Used for hands-on fire-fighting training. Sources of contamination to soil include flammable liquids and chlorinated solvents. Infiltration is the primary release mechanism to groundwater
Beta-4 Security Pits	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration
Tank 2331-U	Used from 1973 to 1988. Tank removed in 1988. Tank used to store gasoline. 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

(Fig. 6.18). The two primary sources of nitrate contamination are the S-3 and S-2 sites. Groundwater containing nitrate concentrations as high as 10,000 mg/L 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, surface water outfalls, and building sumps during 1999 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 1998b, 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 continue to trend downward since disposal operations ceased and the site was closed and capped in the late 1980s.

Trace Metals

Concentrations of Sb, Ba, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, and Tl exceeded DWSs during 1999 in samples collected from various monitoring wells, surface water locations, and building sumps downgradient of the S-2 Site, the S-3 Site, the Scrap Yard, and throughout the plant upgradient of New Hope Pond. Other metals with significant concentrations observed were uranium and strontium. Elevated concentrations of these metals were most commonly reported for groundwater

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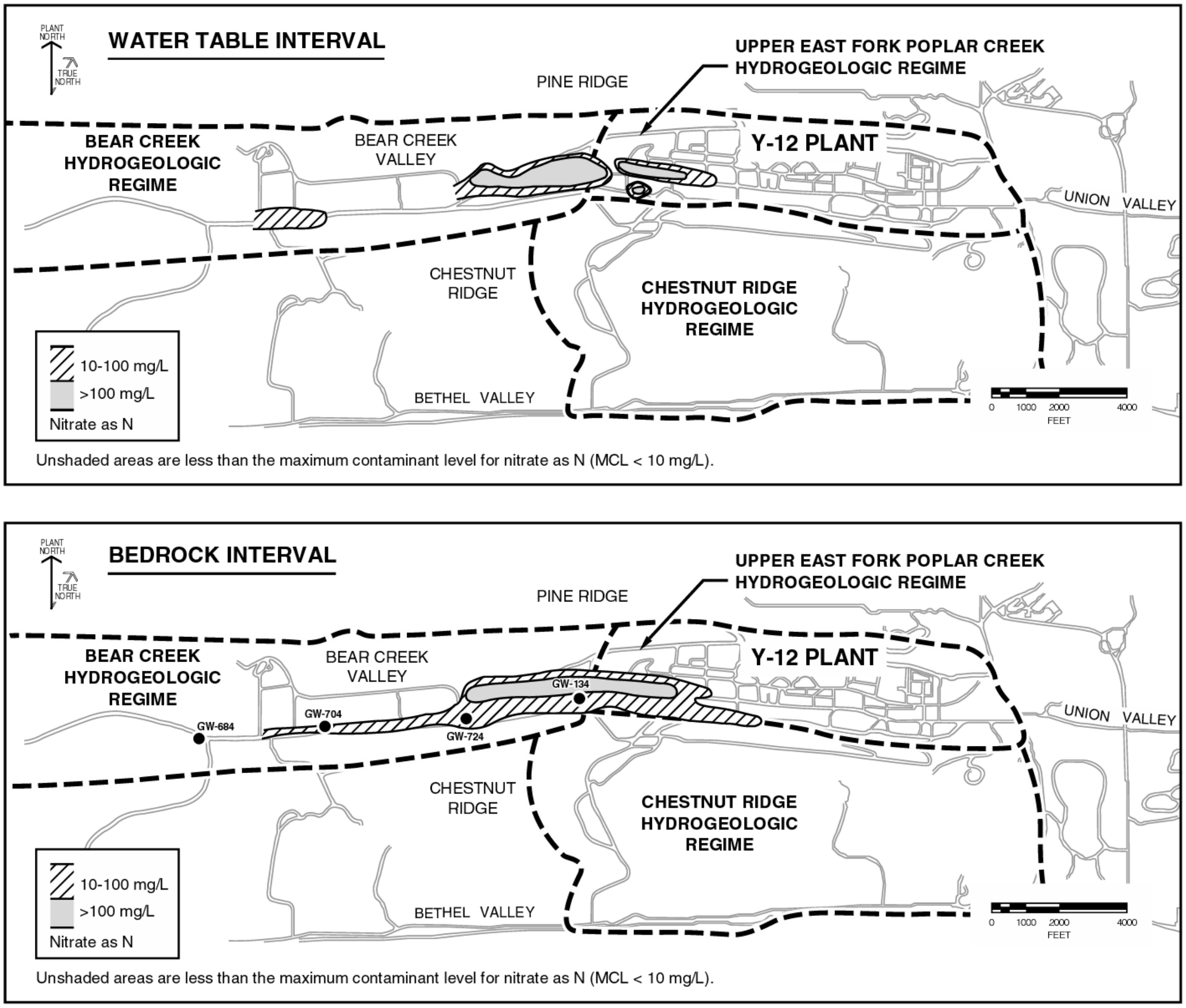


Unshaded areas are less than the maximum contaminant level for nitrate as N (MCL < 10 mg/L).

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

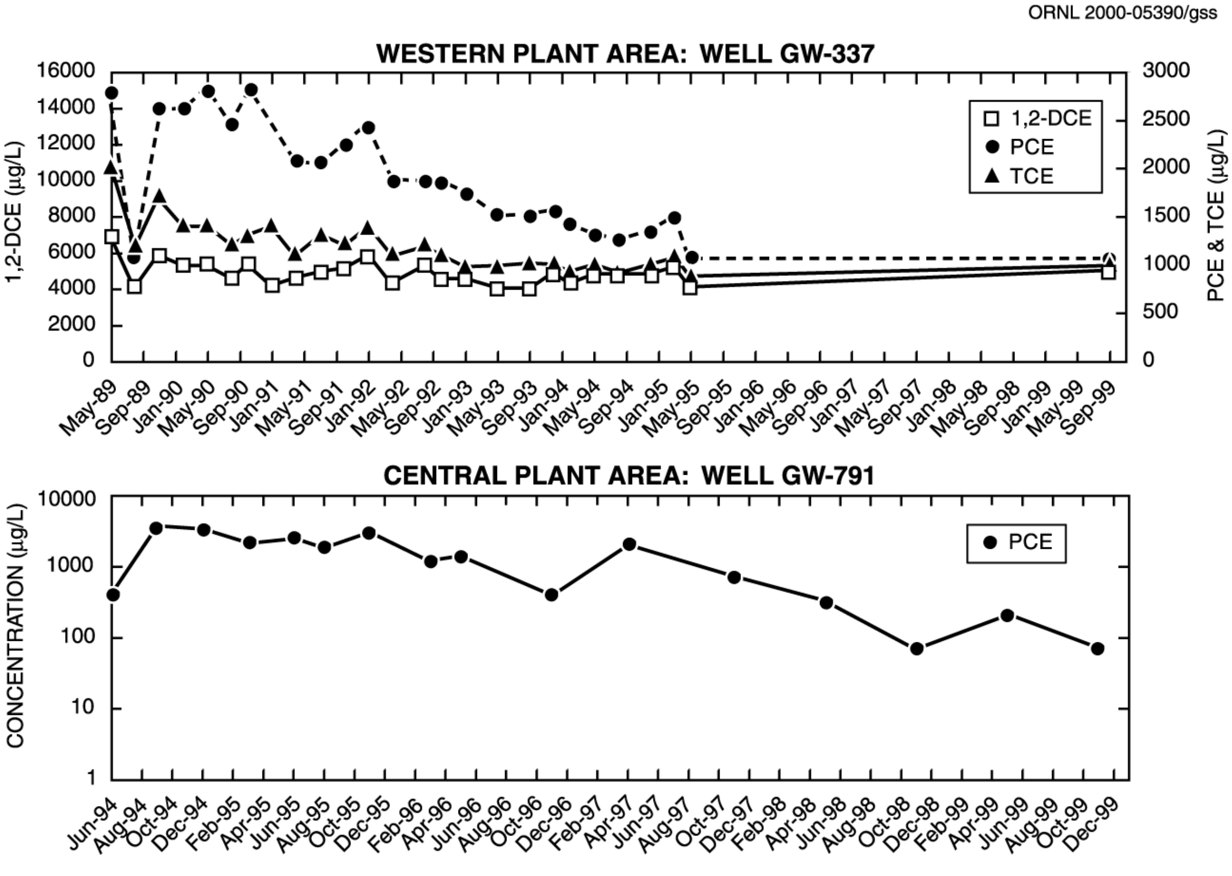
samples collected from monitoring wells in the unconsolidated zone. A definable plume of elevated metals contaminants is not present; metals above maximum contaminant levels tend to occur adjacent to the source units.

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 1999, the highest concentrations of dissolved chlorinated solvents (about 7.7 mg/L) are found at the Waste Coolant Processing Area. The highest dissolved concentrations of petroleum hydrocarbons (about 76 μg/L) occur in groundwater at a closed UST (2331-U) east of Bldg. 9201-1.

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. Evaluation 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 the Y-12 Plant (Fig. 6.21).

The 1999 monitoring results generally confirm findings from the previous seven years of monitoring. A continuous dissolved VOC plume in groundwater in the bedrock zone extends east-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WESTERN PLANT AREA: WELL GW-337

CENTRAL PLANT AREA: WELL GW-791

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

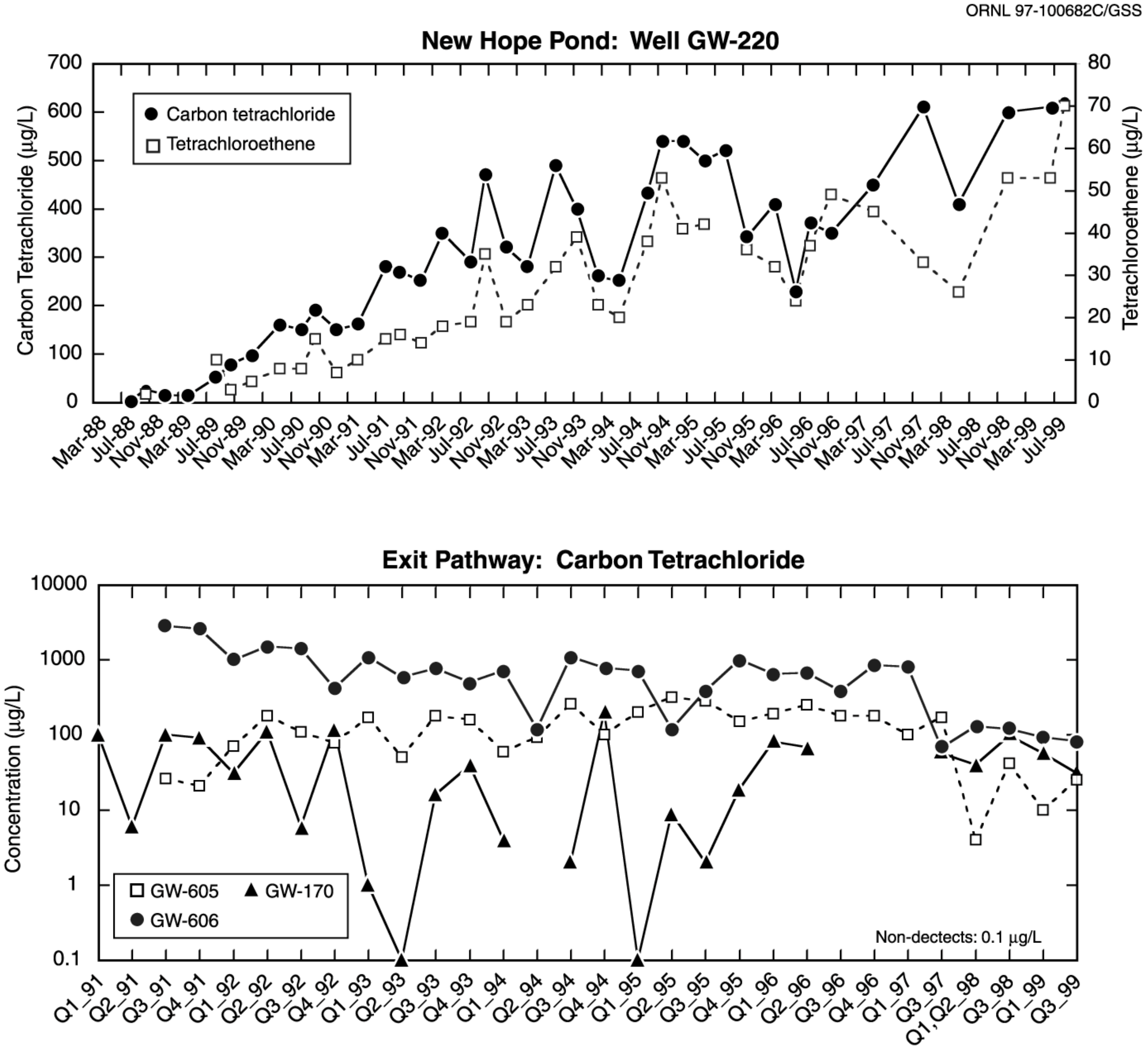

Fig. 6.20. VOC concentrations in selected wells near New Hope Pond and exit pathway wells.

ward from the S-3 Site over the entire length of the regime (Fig. 6.22). The primary sources are the Waste Coolant Processing Facility, the Bldg. 9754 and Bldg. 9754-2 fuel facilities, and process areas in the central portion of the plant.

Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the VOC plume composition in the western and central portions of the Y-12 Plant. 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 and southeastern portions of the plant.

Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime are isotopes of U, Ra, Np, and Am; the primary beta-emitting radionuclide is ^{99}Tc. 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 alpha activity that consistently exceeds the DWS is most extensive in groundwater in the unconsoli-

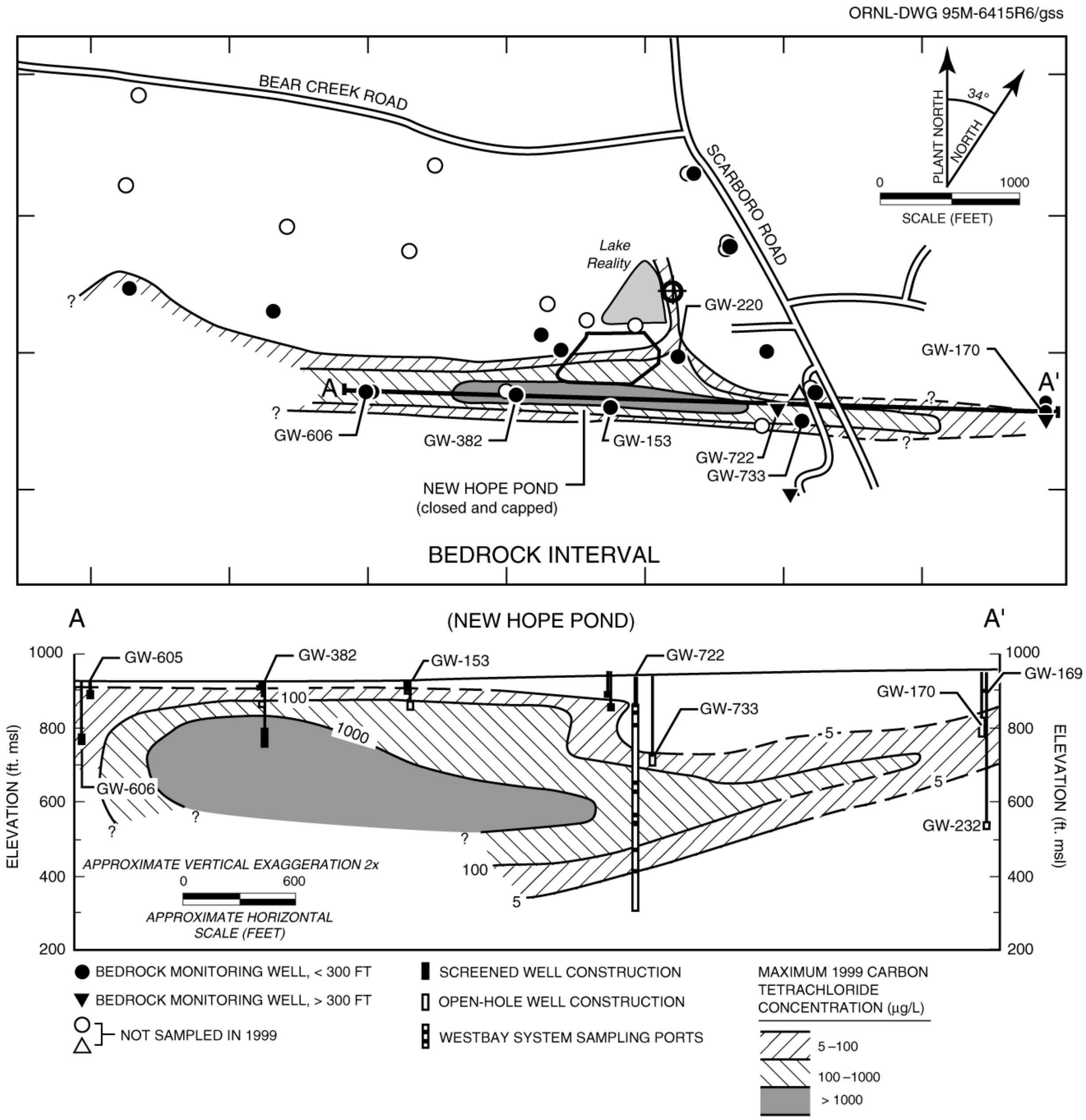

Fig. 6.21. Maximum carbon tetrachloride concentrations in Maynardville Limestone at depths between 200 and 500 ft, 1999.

dated zone in the western portion of the Y-12 Plant near the S-3 Site. Surveillance data also show that gross beta activity levels remained elevated well above the DWS in the western portion of the plant. An area of elevated gross alpha activity is also present west of New Hope Pond. Gross alpha activity from Well GW-219 indicates that uranium from the 9418-3 Uranium Oxide Vault is infiltrating into the unconsolidated zone.

Elevated gross beta activity in groundwater 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 DWS of 50 pCi/L in groundwater in the western portion of the regime, with the primary source being the S-3 Site. Due to the volatility of ^{99}Tc, the analytical method used to determine gross beta activity does not include the ^{99}Tc activity. A gross beta activity result does

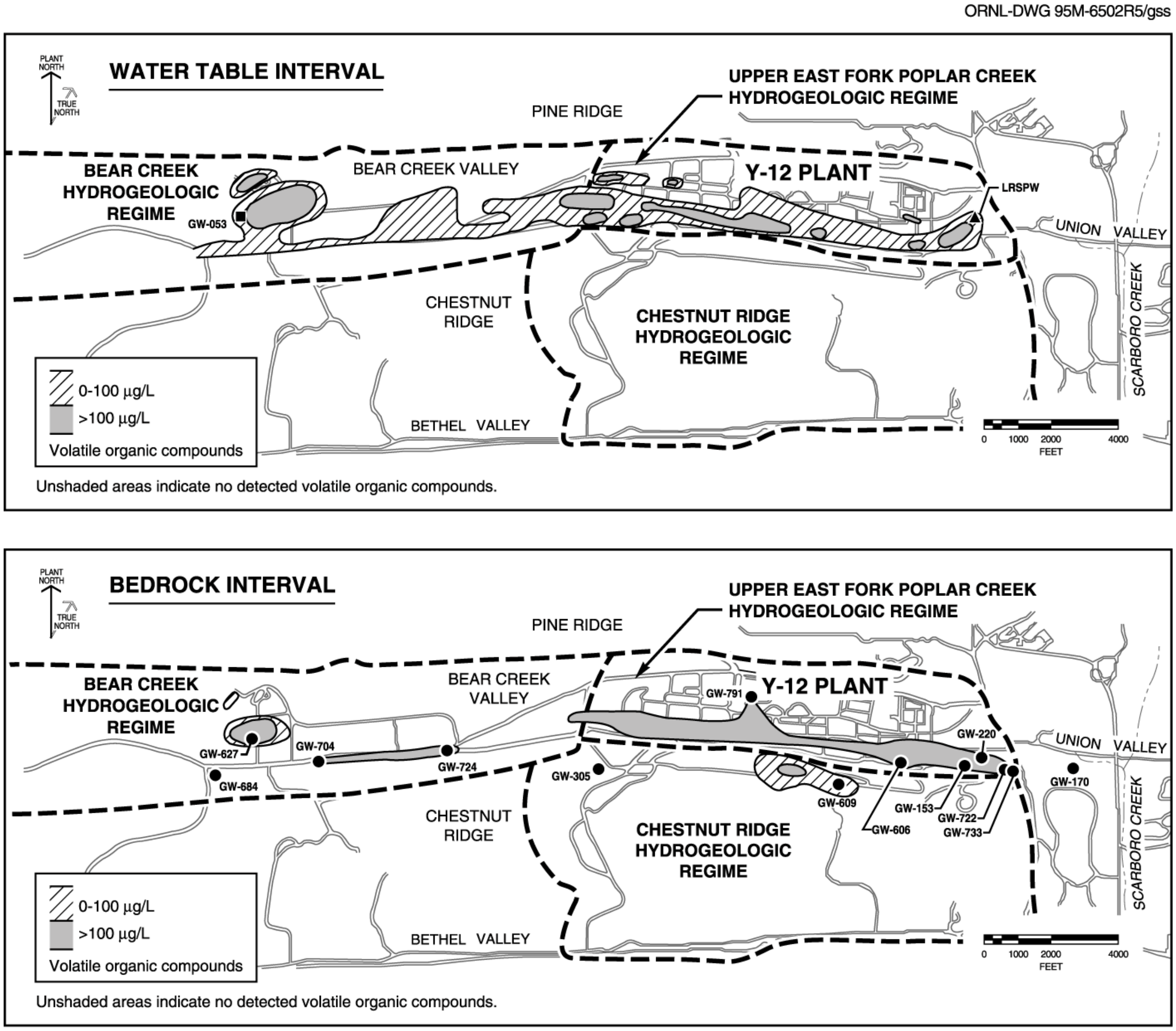

Fig. 6.22. Summed volatile organic compounds in groundwater at the Y-12 Plant.

represent the combined activity of uranium daughter products and naturally occurring radionuclides.

Exit Pathway and Perimeter Monitoring

Exit pathway groundwater monitoring activities in the East Fork regime in 1999 involved continued collection and trending of data from exit pathway monitoring stations. Data collected to date indicate that VOCs are the primary class of 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. A vertical profile of VOC contamination is depicted in Fig. 6.21. An aerial distribution of VOCs is shown in Fig. 6.22. Concentrations of VOCs are typically higher at depth because most dilution and mixing with rainfall occurs in the shallow portions of the Maynardville limestone. In addition, most VOCs 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 the Y-12 Plant. The EMP specifies monitoring of three

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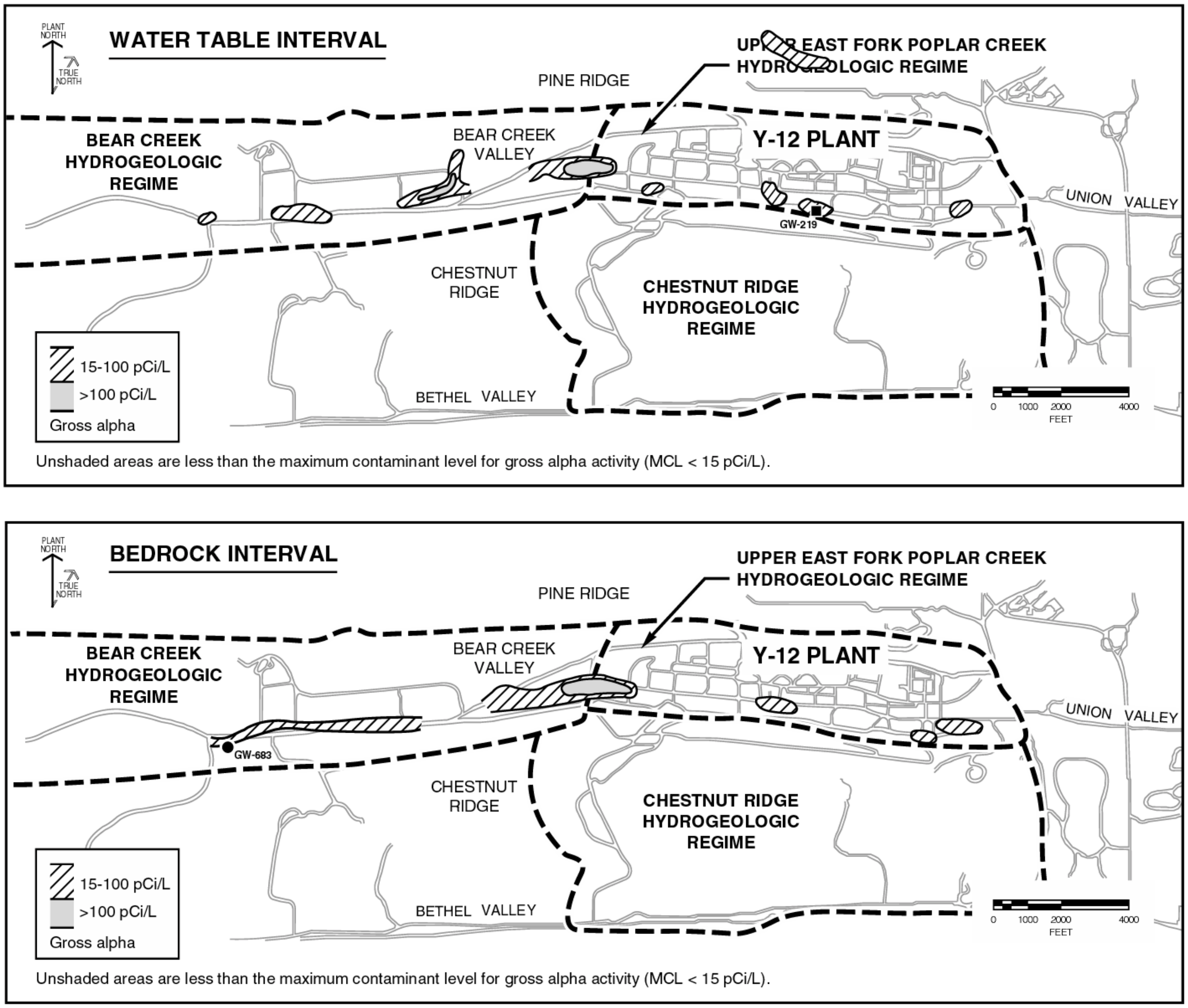

Fig. 6.23. Gross alpha activity in groundwater at the Y-12 Plant.

wells near the eastern ORR boundary for this exit pathway (Fig. 6.16).

In addition to the deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval in the vicinity of New Hope Pond, Lake Reality, and Upper East Fork Poplar Creek 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.

Groundwater movement and contaminant migration along the diversion channel also appeared to be accelerated by the effects of Lake Reality underdrain dewatering activities. At the dewatering sump (Fig. 6.21), groundwater is pumped from a drainage layer to relieve hydraulic pressure that periodically raises the synthetic liner in Lake Reality. Past studies have shown that when the dewatering sump is activated, groundwater table levels are lowered over a large area, and contaminant levels in the sump discharge increase over time. Thus, operation of the dewatering sump has been kept to minimal levels with monitoring of discharge when operation is required.

During 1999, the observed VOC concentrations at LRSPW notably increased. This is due to a change in the sampling procedures for this

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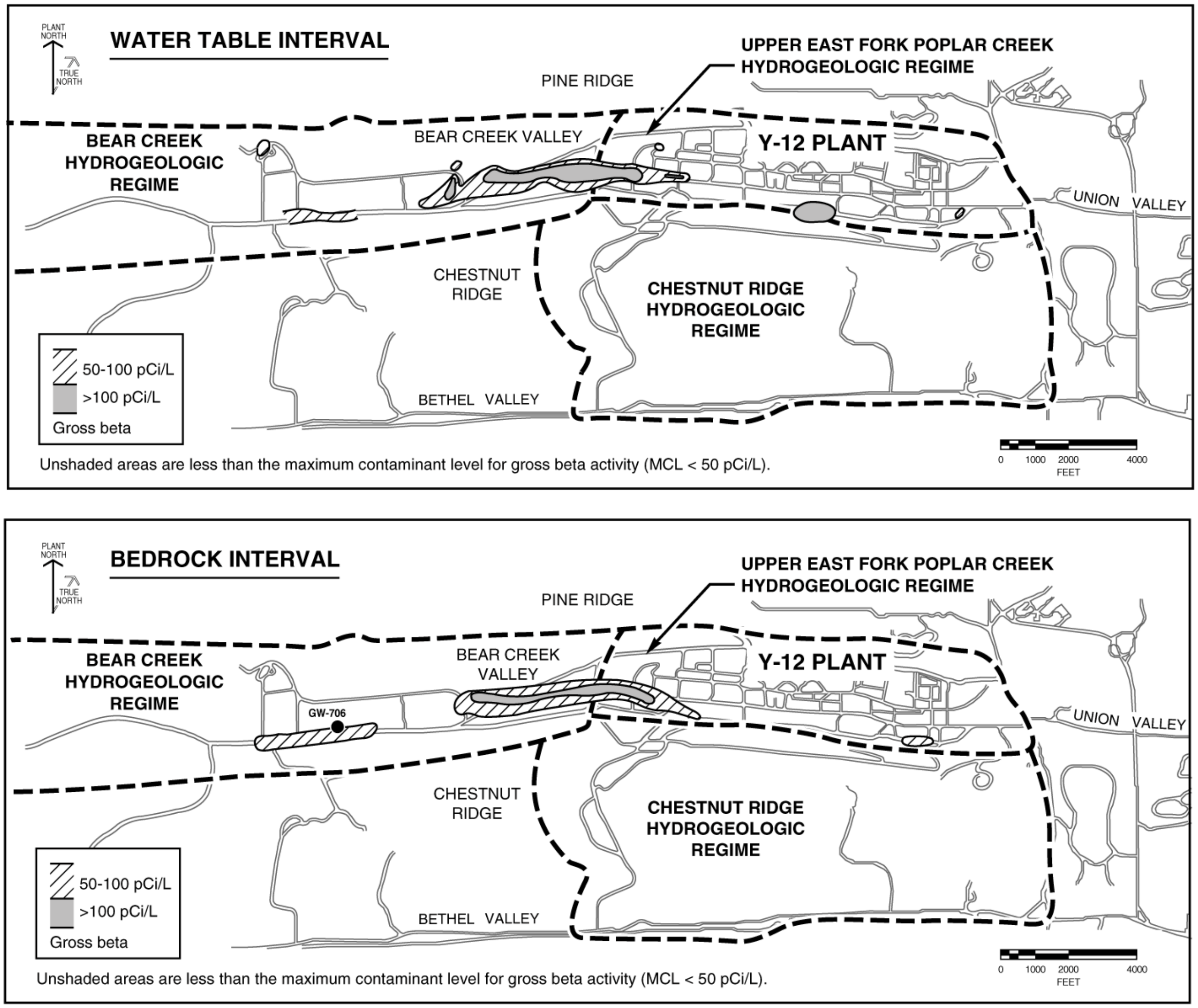

Fig. 6.24. Gross beta activity in groundwater at the Y-12 Plant.

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. In 1998 and 1999, 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 previously reported decreasing trend in carbon tetrachloride concentrations appears to have reversed, now showing an increase.

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

In September 1999, five new sampling locations were established north and northwest of the Y-12 Plant to evaluate possible contaminant transport from the ORR (Fig. 6.25). These locations have been considered unlikely groundwater or surface water contaminant exit pathways, so they had not been identified previously. These locations were monitored due to recent concerns regarding potential health impacts to nearby

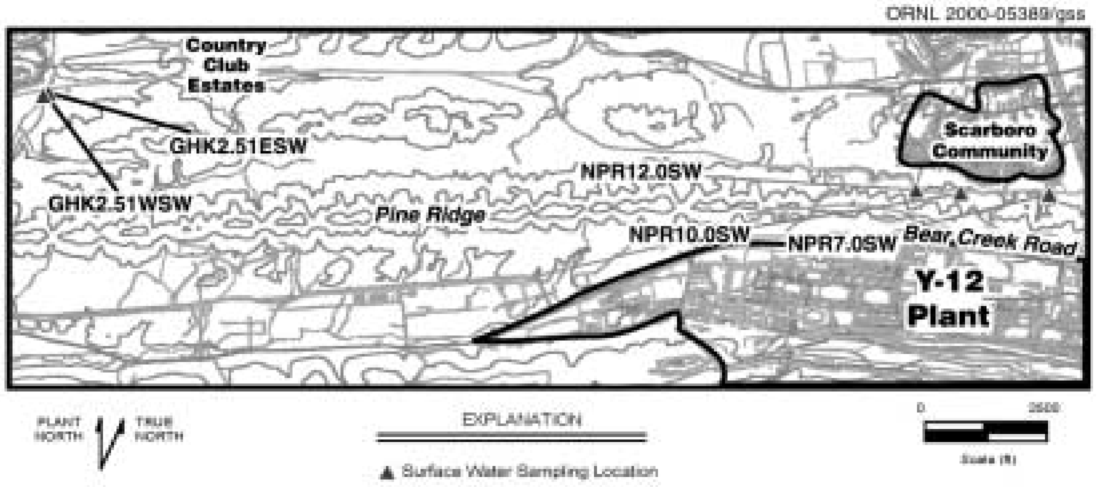

Fig. 6.25. Surface water sampling locations north of Pine Ridge, 1999.

residence from Y-12 Plant 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, volatile organics, and gross alpha and gross beta activities. There were no results that exceeded a DWS, nor were there any indications (results above background) that contaminants were being discharged from the ORR into these communities. These locations will continue to be monitored in 2000.

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 1999, monitoring of locations in Union Valley continued under the IWQP (DOE 2000). 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. Long-term remedial actions in this area will be addressed along with those for the entire UEFPC CA in conjunction with DOE, TDEC, EPA, and the public (see Chap. 3 for more details). During the 1999 Union Valley monitoring, VOCs above the DWSs were observed only in well GW-170 (Fig. 6.20).

6.10.4.3 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Plant 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 BCV extending from the west end of the Y-12 Plant to Highway 95. Figures 6.26 and 6.27 show the Bear Creek regime, locations of monitoring stations sampled in 1999, and the locations of its waste management sites. Table 6.16 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

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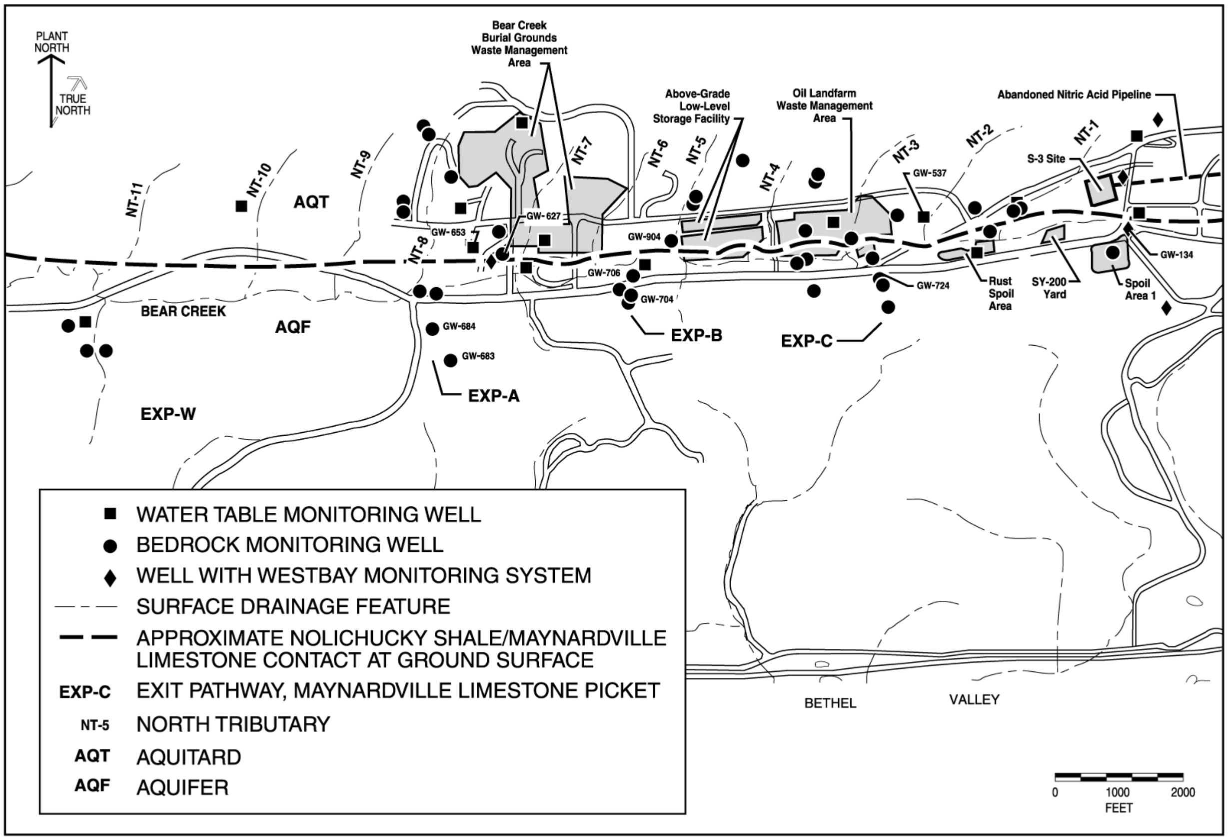

Fig. 6.26. Locations of waste management sites and monitoring wells sampled during 1999 in the Bear Creek Hydrogeologic Regime.

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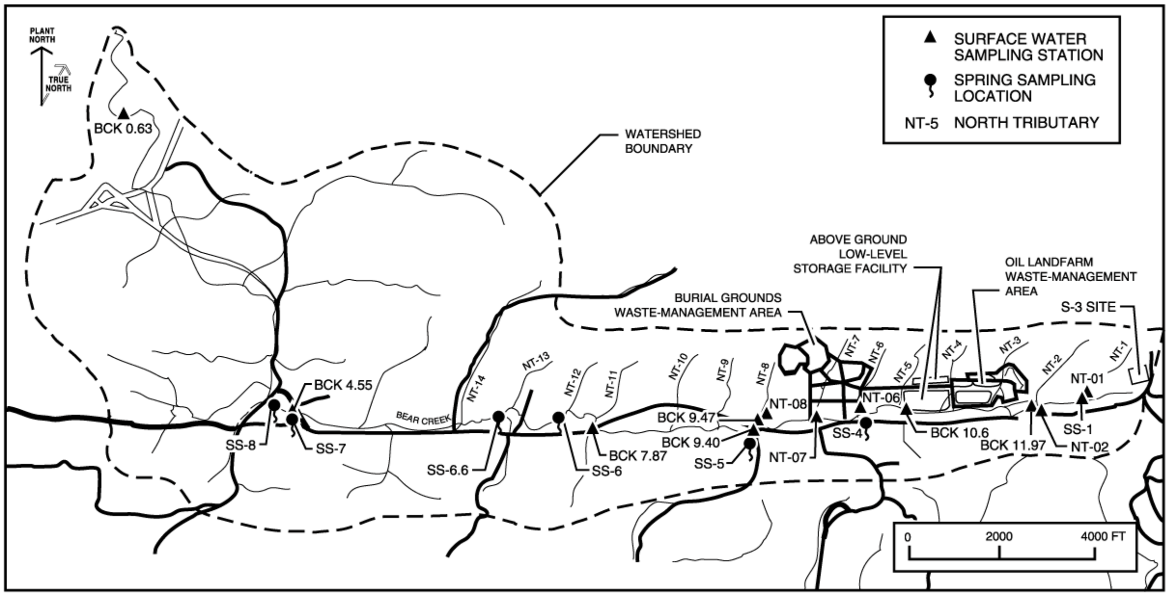


Fig. 6.27. Locations of surface water and spring stations sampled during 1999 in the Bear Creek Hydrogeologic Regime.

Table 6.16. History of waste management units and underground storage tanks included in 1999 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

primary source of nitrate, radionuclides, and trace metals. The OLF waste management area consisting of the OLF, BY/BY, HCDA, and Landfill I is a significant source of uranium and other metals and VOCs. Other sources of VOCs include the S-3 Site, the Rust Spoil Area, and the 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 a depth of 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 most of the other 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 1999 indicate that nitrate concentrations in groundwater exceed the DWS in an area that extends west from the S-3 Site for approximately 7,800 ft (2377 m) down BCV (Fig. 6.18) to exit pathway picket B wells. In previous years, the nitrate concentrations above the DWS extended to about 12,000 ft (3660 m) to exit pathway picket A wells, so a reduction in the fringe areas of the nitrate plume was indicated in 1999. This reduction may indicate the permanent 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 may result in future increases 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 significant change from previous years. In 1999, the north-south trending transect of five multiport monitoring wells at the S-3 Site were monitored for a number of chemical constituents including nitrate. In the multiport well GW-134 (configured with 11 vertically discrete monitoring zones), on geologic strike with the S-3 site, the concentrations of nitrate were observed in monitoring zones within the ORR aquitards at least 740 ft (226 m) below ground surface and at concentrations lower than those observed in 1991 (Dreier et al. 1993). Historically, the highest nitrate concentrations are observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths [less than 100 ft (30.5 m) below ground surface] in the Nolichucky Shale. During 1999, monitoring performed immediately adjacent to and down-gradient of the S-3 Site within the Bear Creek regime was limited to Well GW-134. Shallow monitoring interval nitrate results from this well were relatively low and increased with depth. A comparison of nitrate concentrations from multiport well GW-134 groundwater samples obtained during 1991 and 1999 reveal a marked decrease with time in all monitoring zones.

Surface water nitrate results exceeding the DWS during 1999 were observed as far away as State Highway 95, approximately 24,000 ft (7315 m) west of the S-3 Site. However, consistent observations of these concentrations during the year were seen only up to 2,800 ft (850 m) from the S-3 Site at surface water station BCK 11.97. Other locations further away showed fluctuations in nitrate concentrations that were consistently higher (above the DWS) during the wet season (winter and spring) and lower (below the DWS) during the dry season (summer and fall). One location in a losing reach of Bear Creek dried up and could not be sampled during the summer months.

Trace Metals

In the Bear Creek regime groundwater, Ba, Cd, Cr, Pb, and Hg have been identified from previous monitoring as the principal trace metal contaminants. Historically, the concentrations of these metals exceeded DWSs or natural (background) levels primarily in low-pH groundwater 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 relatively high pH conditions prevail, only sporadic occurrences of elevated trace metal concentrations are evident.

Other trace metal contaminants in the Bear Creek regime are Be, B, Co, Cu, Ni, Sr, and U. Concentrations of these metals have commonly exceeded background levels in groundwater near the S-3 Site, the BCBG, and the OLF waste management areas. Selected stream and spring locations and exit pathway wells also have exhibited total uranium and strontium concentrations above background values.

During 1999, the most prolific trace metal contaminant observed within the Bear Creek regime was uranium. It was observed in monitoring wells, springs, and surface water locations adjacent to all of the waste areas above the background value of 0.012 mg/L. It was also observed in surface water monitoring station BCK 04.55 which is located over 6500 ft (2000 m) from BCBG, the westernmost waste area. Concentrations of uranium were observed at monitoring location BCK 00.63 above background levels; however, this location is far removed from BCV, and contributions from sources (naturally occurring and anthropogenic) other than Bear Creek regime waste areas are likely. The highest uranium concentrations observed in groundwater in the Bear Creek regime during 1999 were observed at a spring location, SS-4 (0.239 mg/L), and in well GW-706 (0.113 mg/L). These two locations are downgradient of the OLF waste management area, a primary source of uranium within the regime.

Other trace metals observed above their respective DWSs during 1999 were Ba, Sr, Se, Be, Cd, Ni, and Cr. Ba, Sr, Be, and Cd are observed in close proximity to waste areas. Selenium is observed in deep monitoring zones of two multiport monitoring wells [>400 ft (170m) and 1200 ft (500 m), respectively]. The selenium is most likely naturally occurring in evaporite mineral deposits within the deep subsurface. Nickel and chromium are trace metals observed in samples from shallow wells that may be contaminants from nearby sources. However, there is some evidence that the presence of these two contaminants from wells may be caused by the minor corrosion and subsequent dissolution of stainless steel well materials. Investigations into the source of nickel and chromium will continue into 2000.

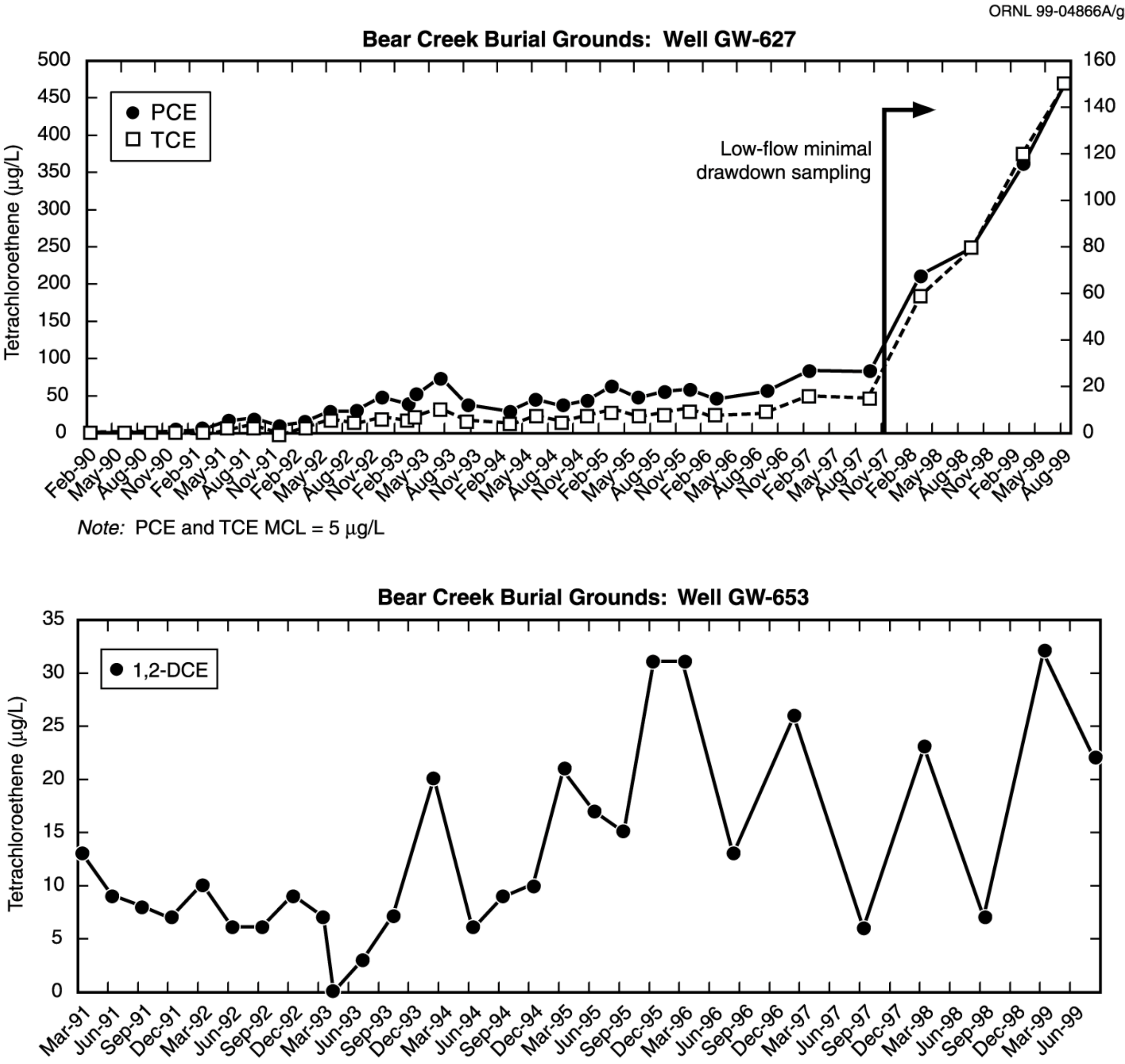
Volatile Organic Compounds

Like nitrate, 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 tetrachloroethene and trichloroethene occur in bedrock more than 250 ft (76 m) below the BCBG waste management area.

Groundwater in the unconsolidated zone overlying the aquitards that contains detectable levels of VOCs occurs primarily within about 1000 ft (305 m) of the source areas. The highest historical VOC concentrations (greater than 10,000 mg/L) in the unconsolidated zone occur at the BCBG waste management area. The extent of the dissolved VOC plumes is slightly greater in the underlying bedrock. Wells GW-627 and GW--653, which are downgradient of the BCBG waste management area, have continued to exhibit an increase in VOC concentration (Fig. 6.28). This indicates that some migration through the aquitards parallel to the valley axis is occurring in the intermediate bedrock and unconsolidated 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. 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 7000 mg/L in groundwater near the source area.

Typical VOC concentrations observed in 1999 in the exit pathway (Maynardville Limestone) range from about 120 µg/L in the eastern part of



Note: PCE and TCE MCL = 5 µg/L

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

the regime (Well GW-724) to less than detectable levels in the western part of the regime. Concentrations of VOCs have been highest in exit pathway transect picket C (Fig. 6.29). The 1999 concentrations of trichloroethene observed in Well GW-724 (120 µg/L on February 22 and 110 µg/L on August 9, respectively) are consistent, if not slightly lower, with the 1998 results. This may indicate a stabilizing of the historically increasing VOC concentrations in the groundwater at this transect since the early 1990s. All other exit pathway transect wells display static or decreasing VOC concentrations.

Radionuclides

The primary radionuclides identified in the Bear Creek regime are U and ^{99}Tc, with local occurrence of Np, Am, Ra, Sr, and ^{3}H as secondary and less widespread radionuclides present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during 1999 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

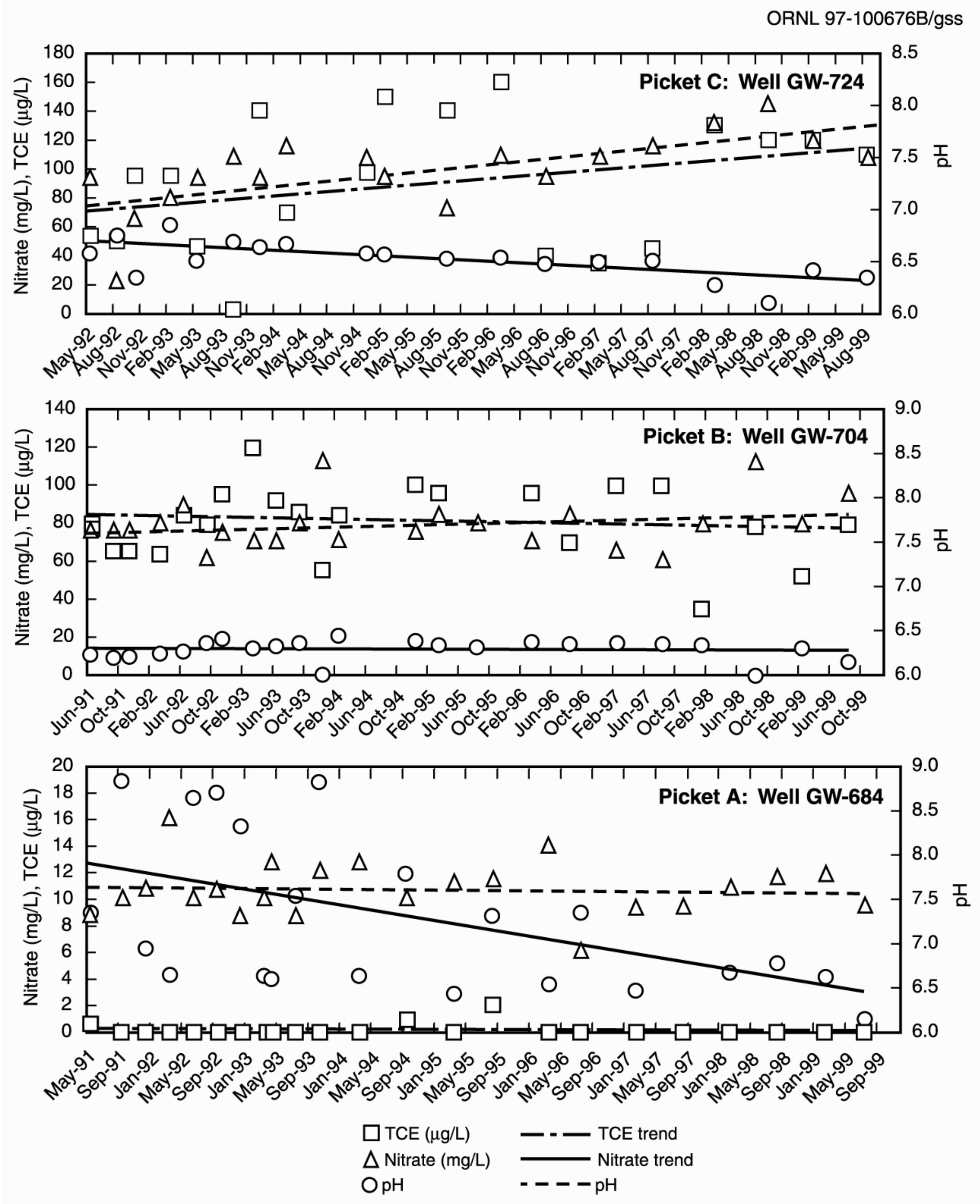


Fig. 6.29. Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-704, and GW-684 in the Bear Creek Hydrogeologic Regime.

one (or more) of the alpha-emitting radionuclides was assumed present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L. As previously mentioned, more volatile radionuclides (^{99}Tc, ^{3}H) are not screened in the gross beta activity analysis.

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 1999, no observed gross alpha activity results from shallow or bedrock wells in the BCBG 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 11,400 ft (3474 m) west of the S-3 Site (e.g., GW-683). Gross alpha activities above the DWS in surface water samples were observed 25,000 ft (7620 m) west of the S-3 Site (i.e., BCK-04.55).

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 6.24). During 1999, 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 DWS were observed 16,000 ft (4877m) west of the S-3 Site.

Exit Pathway and Perimeter Monitoring

Exit pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek Regime, is the principal exit pathway for surface water. Various studies have shown that surface water in Bear Creek, springs along the valley floor, and groundwater in the Maynardville Limestone are hydraulically connected. The western exit pathway well transect (Picket W) serves as the ORR perimeter well for the Bear Creek regime (Fig. 6.16).

Exit pathway monitoring consisted of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during 1999 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, low levels of nitrate, gross alpha, and gross beta activities, and uranium have been observed in surface water west of the burial grounds (LMES 2000).

Surface water and spring samples collected during 1999 (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 discharges decrease rapidly with distance downstream of the waste disposal sites (Fig. 6.30).

6.10.4.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge Hydrogeologic Regime is south of the Y-12 Plant 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 the Y-12 Plant to an unnamed drainage basin on the ridge located just west of Industrial Landfill II. Figure 6.31 shows the approximate boundaries of the regime and locations of waste management units and monitoring wells sampled in 1999.

The Chestnut Ridge Security Pits area is the only documented source of groundwater contamination in the regime. No integrating CA has been established for the regime because contamination from the Security Pits is distinct and is not mingled with plumes from other sources. Table 6.17 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 is reasonably

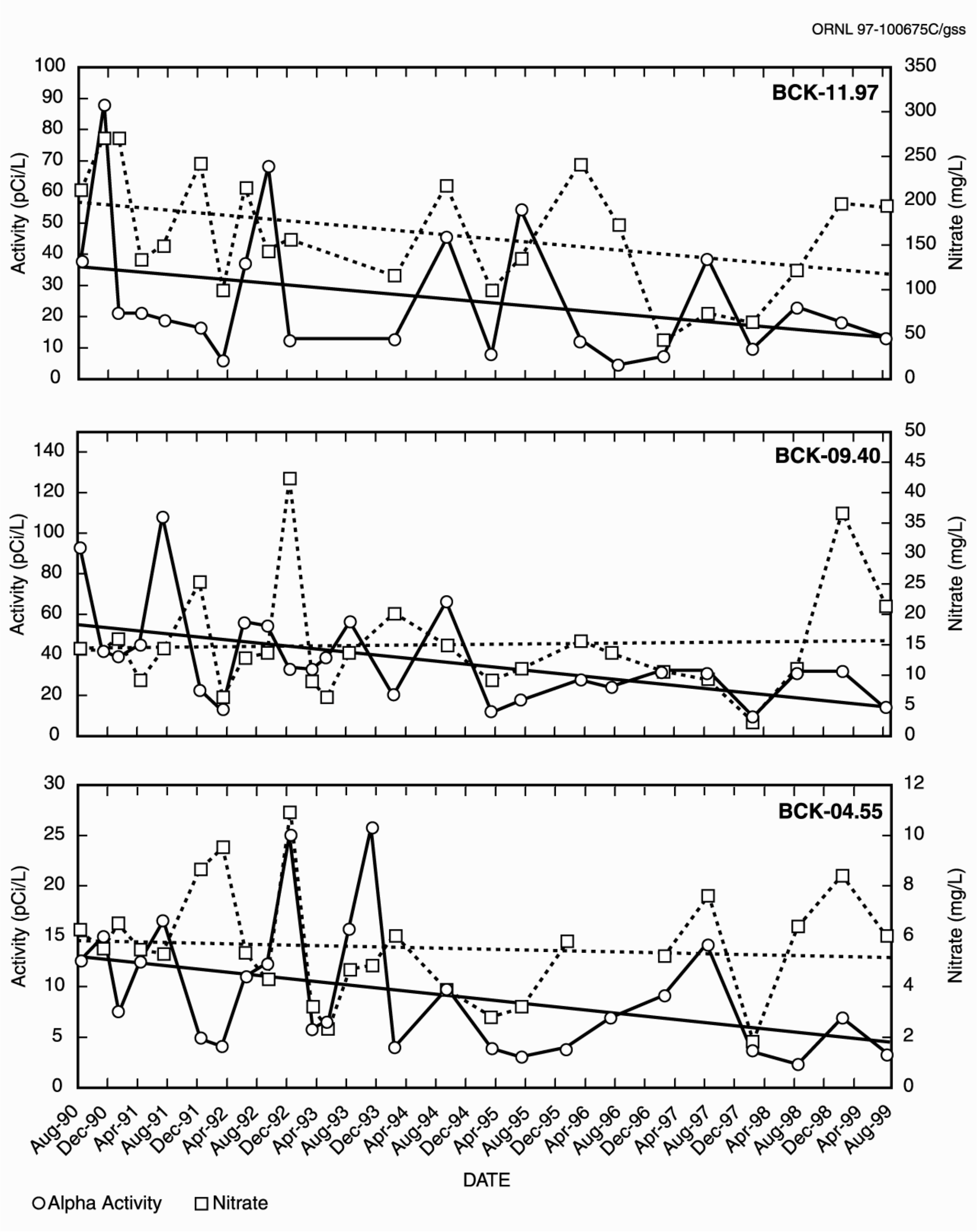


Fig. 6.30. Concentrations of selected groundwater contaminants in Bear Creek (refer to Fig. 6.26 for sampling locations).

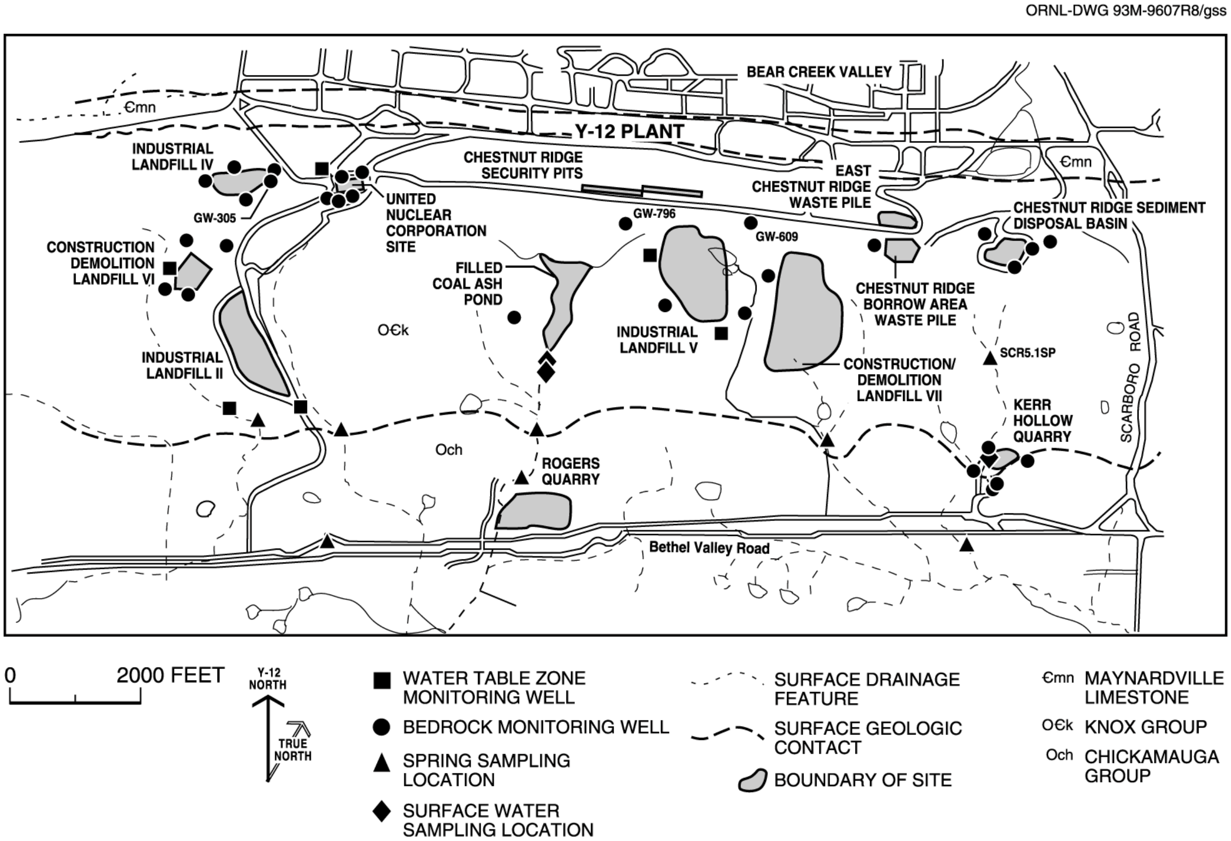


Fig. 6.31. Locations of waste management sites and monitoring wells sampled during 1999 in the Chestnut Ridge Hydrogeologic Regime.

well defined in the water table and shallow bedrock zones (Fig. 6.22). Groundwater quality data obtained during 1999 indicates that the lateral extent of the VOC plume at the site is not increasing, as evidenced by detectable signature VOCs in wells GW-609 and GW-796. 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. In 1998, elevated levels of nitrate were observed in groundwater samples from monitoring locations within the vicinity of Kerr Hollow Quarry (KHQ). It was also noted that upgradient of KHQ are several active sewage sludge land application areas that may be contributing to the observed nitrate results, but no definitive evidence of this was indicated. During 1999, a spring (SCR5.1SP) 1500 ft (457 m) north and upgradient of the KHQ and a surface water monitoring station (Outfall 301) discharging from KHQ were sampled. This spring and surface water monitoring station discharge into a surface water tributary that flows south and adjacent to KHQ. The nitrate concentrations observed in SCR5.1SP and Outfall 301 (2.89 mg/L and 2.5 mg/L, respectively) were comparable to those observed in 1998.

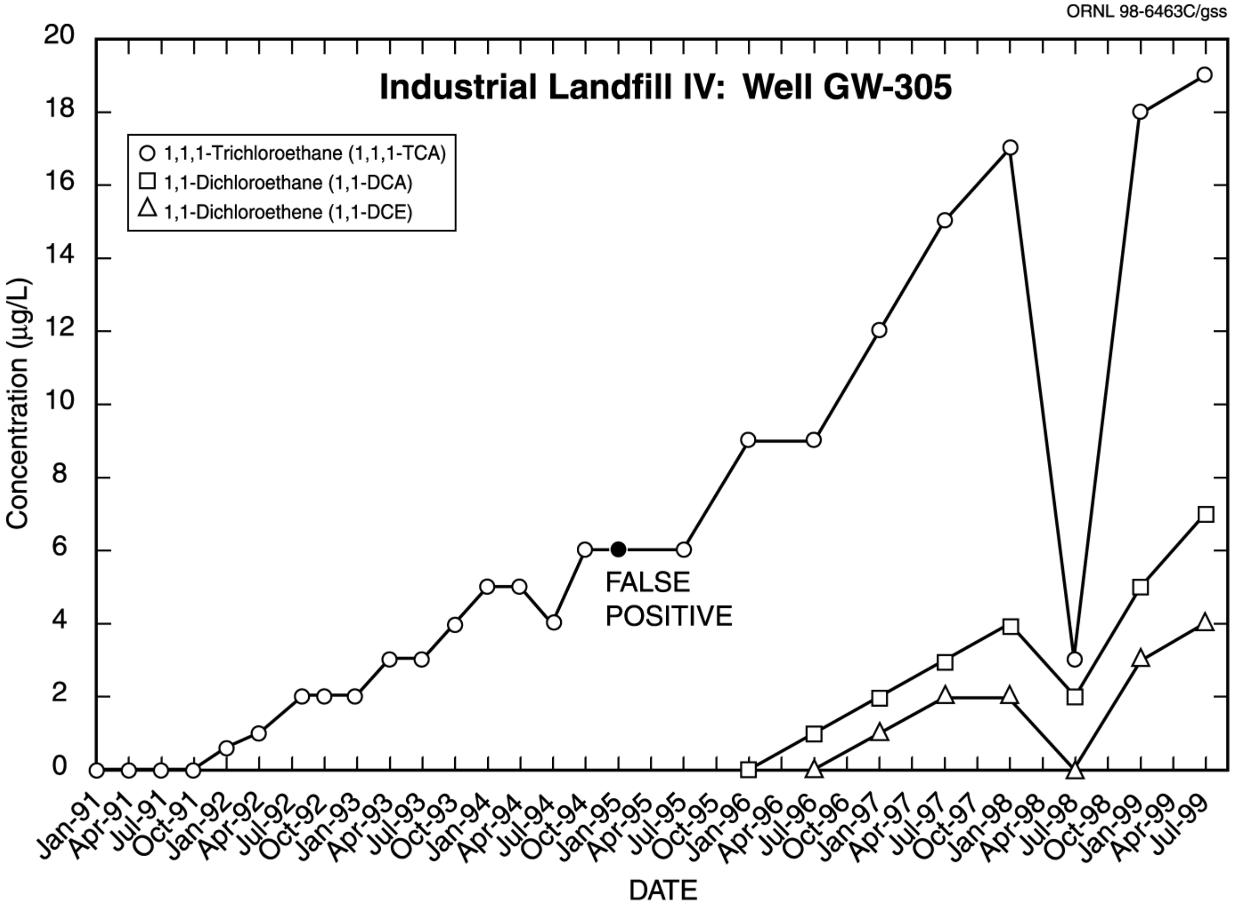
Table 6.17. History of waste management units and underground storage tanks included in 1999 groundwater monitoring activities; Chestnut Ridge Hydrogeologic Regime

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
Centralized Sanitary 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
Chestnut Ridge Borrow Area Waste Pile	Contains soils from off-site locations in Oak Ridge bearing low levels of mercury and other metals
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries. A CERCLA ROD has been issued. Remedial action complete

Trace Metals

Groundwater concentrations of trace metals exceeded regulatory standards during 1999 at four locations. Concentrations above the DWS for nickel were observed in samples from one monitoring well. Concentrations of antimony above the DWS were observed in samples from two surface water monitoring stations and one well.

Nickel concentrations above the DWS were observed from well GW-305 during the second semiannual detection monitoring event for Industrial Landfill IV. Follow-up sampling was performed during the fourth quarter of 1999 that confirmed the detection of nickel in the well. As previously described (in Sect. 6.10.5.3), there is some evidence that the presence of this contaminant from wells may be caused by the minor corrosion and subsequent dissolution of stainless-steel well materials. Elevated concentrations of nickel were also detected in two wells at the United Nuclear Corporation Site (UNCS). This



Notes: 1,1,1-TCA MCL = 200 μg/L; 1,1-DCA MCL = not applicable; 1,1-DCE MCL = 7 μg/L

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

site is monitored under a CERCLA ROD, and nickel is not a COC (DOE 2000). The source of nickel within the UNCS wells is probably also due to minor corrosion of well casing.

Antimony was detected at concentrations above the DWS at two surface water locations and one spring at the Filled Coal Ash Pond under CERCLA ROD Monitoring (DOE 2000).

Volatile Organic Compounds

During 1999, Well GW-305, located immediately to the east of Industrial Landfill IV, continues to exhibit an increasing trend in VOCs (Fig. 6.32) since the first quarter of 1992. 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 1999, trace levels of VOCs (less than DWS) were observed at a downgradient monitoring well at Industrial Landfill II and a spring location south of Bethel Valley Road and downgradient of KHQ.

Radionuclides

Only one sample exceeded the gross beta DWS (LMES 2000); no well has demonstrated consistent radiological contamination. Gross alpha activities were below the DWS at all locations.

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

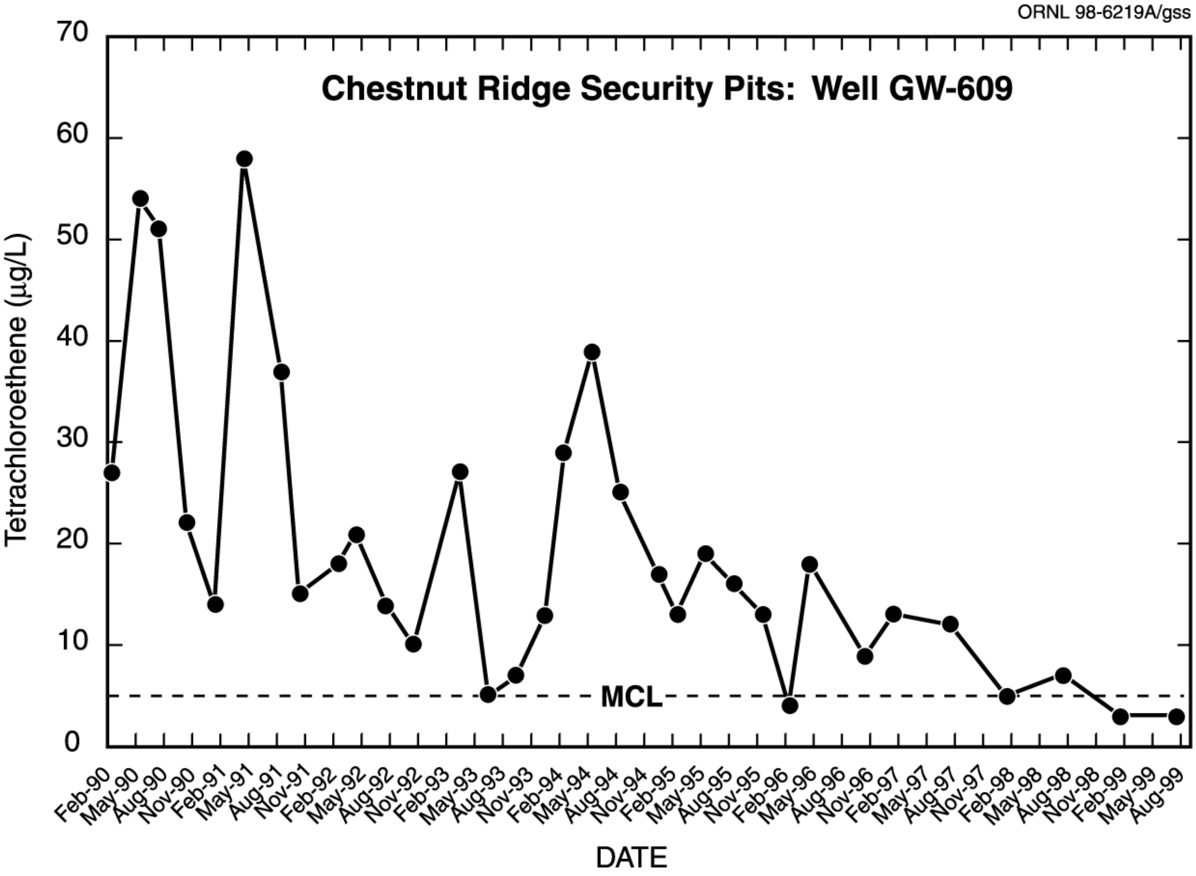


Fig. 6.33. Tetrachloroethene concentrations in Chestnut Ridge Security Pits well GW-609.

conventional monitoring techniques. Dye-tracer studies have been used in the past to attempt to identify exit pathways. Based on the results of dye-tracer studies to date, no springs or surface streams that represent discharge points for groundwater have been conclusively identified for water quality monitoring. Future dye-tracer studies are possible.

TDEC/DOE-O has conducted several tracer studies at the Y-12 Plant. In 1995, it conducted a small-scale tracer study east of the Sediment Disposal Basin; the results indicated preferential migration of groundwater along strike with discharge to a spring located off the ORR along Scarboro Creek in Union Valley. Off-site locations, including the spring, are monitored by the IWQP (Sect. 6.10.5.2). In 1999, two tracer tests were performed on Chestnut Ridge. One dye injection location was in a sinkhole north of Construction/Demolition Landfill VII, while the other was in a tributary southeast of Industrial Landfill II. Even though the final results of these tracer studies have not been formally reported, preliminary results indicate direct connectivity of the karst network over significant distances and directions. The first tracer test performed in 1999 with a sinkhole injection point resulted in long-distance strike parallel migration with detection of the dye at a spring at Scarboro Creek, approximately 7200 ft (2194 m) to the east. The second tracer test resulted in both strike parallel and cross-strike migration of the dye toward Melton Hill Lake at McCoy Branch (Gilmore 1999).

Monitoring of one large spring south of Industrial Landfill V and Construction/ Demolition Landfill VII was continued in 1999 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 1999. These projects are discussed in Chap. 3.