6. Y-12 ENVIRONMENTAL MONITORING PROGRAMS

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. National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclides require continuous emission sampling of major sources [a "major source" is considered to be any emission point that potentially can contribute >0.1 mrem/year effective dose equivalent (EDE) to an off-site individual]. During 1998, 45 of the Y-12 Plant's 57 stacks were judged to be major sources. Five of these sources were not operational in 1998 because of work in progress on process or stack modifications. Eighteen of the stacks having 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, 1998, the Y-12 Plant had a total of 57 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 1998.

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. In addition, in 1996 an Analytical Chemistry Organization (ACO) laboratory was relocated from the DOE Y-12 Plant to a location approximately 1/3 mile east of the Y-12 Plant on Union Valley Road. The laboratory is operated in a leased facility that is not within the ORR boundary. The emissions from the ACO Union Valley laboratory are included in the Y-12 Plant source term. The releases from these laboratories are minimal, however, and have negligible impact on the total Y-12 Plant dose. Bechtel Jacobs Company LLC assumed operation of some waste management facilities at the Y-12 Plant in 1998. Two monitored stacks and two unmonitored emission points are included as minor sources in the Y-12 Plant source term.

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. No areas were identified in 1998 where room ventilation emissions exceeded 10% of the DAC worker protection guidelines.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods. In 1998, 50 minor emission points were identified from unmonitored radiological processes and laboratories. Twenty-eight minor emission points were identified from ORNL laboratory activities at facilities within the boundary of the Y-12 Plant. Seven minor emission points were identified at the ACO Union Valley laboratory.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on the operational process exhaust stacks in 1998. Particulate matter (including uranium) was filtered from the stack sample; 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 0.017 Ci (9.97 kg) of uranium was released into the atmosphere in 1998 as a result of Y-12 Plant activities (Table 6.1). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 71% of the curie release was composed of emissions of enriched uranium particulate, even though less than 2% of the total mass of uranium released was enriched material (Figs. 6.1 and 6.2).

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 that remove air contaminants from the workplace.

The Y-12 Plant has 40 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 nitrogen oxides emission monitoring beginning in 2003.

In 1998, Y-12 Plant personnel continued with implementation of a stratospheric ozone protection plan to comply with the limitations on the release of ozone-depleting chemicals and with the 1995 production ban on these chemicals. Significant actions completed in previous years resulted in greater than 90% emission reductions in Class I ozone-depleting substances between 1992 and 1995. In late1998, a line-item project, Retrofit Heating, Ventilating, and Air-Conditioning (HVAC) Systems and Chillers for Ozone Protection was completed, which will further reduce emissions of Class I ozone-depleting substances below the 2800 pounds released in 1998. Additionally, Y-12 Plant personnel have completed the

Table 6.1. Y-12 Plant airborne uranium emission estimates, 1998

Source of emissions	Quantity emitted	
	Ci[a]	kg
Enriched uranium		
Process exhaust (monitored)	0.012	0.184
Process and laboratory exhaust (unmonitored)	0.00009	0.0014
Room exhaust (from health physics data)	0.00	0.00
Depleted uranium		
Process exhaust (monitored)	0.0021	3.93
Process and laboratory exhaust (unmonitored)	0.0031	5.85
Room exhaust (from health physics data)	0.00	0.0
Total	0.017	9.97

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

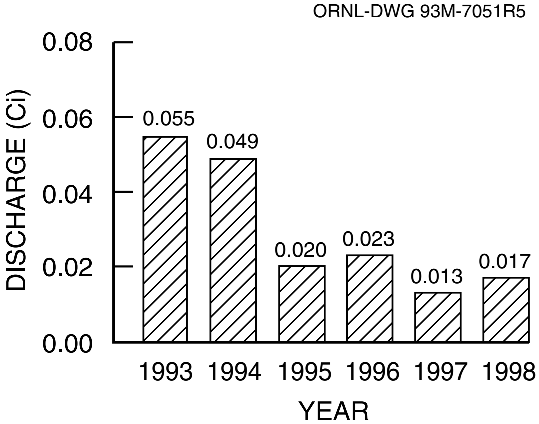

Fig. 6.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1993–98.

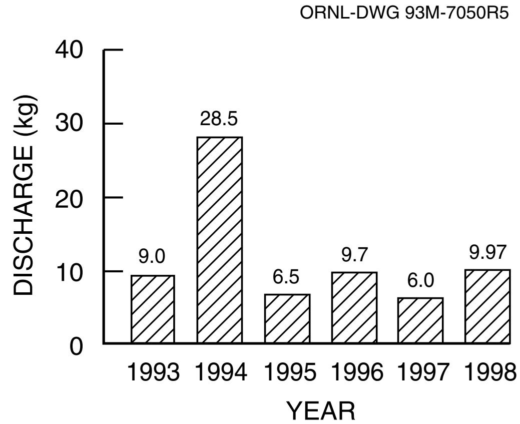

Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1993–98.

elimination of halon use in fire protection sys tems.

The 1998 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 $127,419.10. 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 hours per year). More than 90% of the Y-12 Plant pollutant emissions to the atmosphere are attributed to the operation of the steam plant. In calculating the annual emission fee, Schedule III of Chapter 26 of the TDEC regulations was used, in which carbon monoxide and exempt emissions are not included in total emissions and a 4000-ton cap is imposed for SO_2 and NO_x. The emission fee rate was based on $12.70 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 the fossil fuels coal and natural gas are burned. Information regarding actual versus allowable emissions from the steam plant is provided in Table 6.2. In addition, the annual Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313 Toxic Release Inventory report provides information on other significant nonradiological Y-12 Plant air emissions (Sect. 2.2.17).

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99 % of the time in 1998. Both systems were taken out of service for annual calibration/ certification on April 21 and 22, 1998. The annual opacity calibration error test reports were submitted to TDEC in July1998. During 1998, there were a total of 17 six-minute periods of excess emissions and one occasion 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 C.4 in Appendix C is a record of excess emissions and out-of-service conditions for the east and west stack opacity monitors for 1998.

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,

Table 6.2. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 1998

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particle	31	1,118	2.8
Sulfur dioxide	2,545	20,803	12.2
Nitrogen oxides[a]	1,386	9,741	14.2
Volatile organic compounds[a]	2.1	17	12.4
Carbon monoxide[a]	22	311	7.1

[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 8760 h/year).

state regulations, or DOE orders that require this monitoring. All ambient air monitoring systems at the Y-12 Plant are operated as a best management practice (BMP). With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly during the past several years. In addition, 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 ensure 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 fluoride, total suspended particulates (TSPs), and particulate matter less than 10 microns in diameter (PM10) sampling was discontinued, and all but 3 of the 12 uranium samplers were shut down. In 1998, three low-volume uranium particulate monitoring stations and 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. Prior to 1993, the samples were analyzed for gross alpha and beta and for activity levels of specific uranium isotopes; however, in 1993, the analysis program for radionuclides was revised as described in the Environmental Monitoring Plan (EMP) to obtain total uranium particulate and the percentage of ^{235}U. In this manner, uranium concentrations in ambient air could be better correlated to stack emission data, which are also measured as total uranium mass. For 1998, the average 7-day concentration of uranium at the three monitored locations ranged from a low of 0.00001 µg/m^{3}at Stations 5 and 8 to a high of 0.00044 µg/m^3 at Station 4 (Table 6.3).

6.3.2 Mercury

The Oak Ridge Y-12 Plant monitoring program for measuring on-site mercury vapor concentrations in ambient air was established in 1986 to

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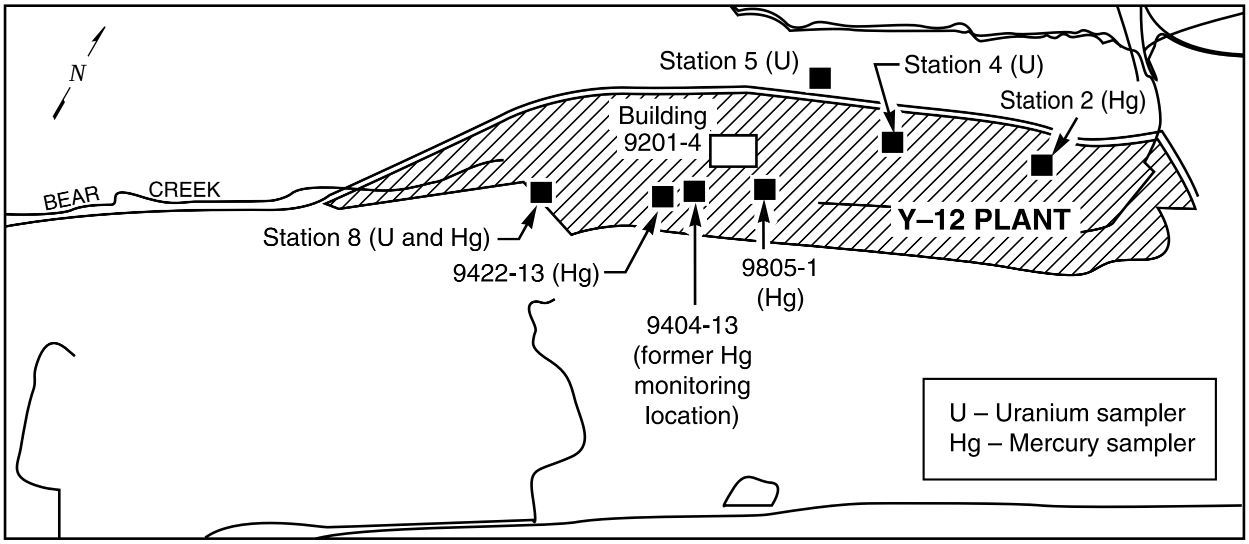

Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Plant.

Table 6.3. Uranium mass in ambient air at the Y-12 Plant, 1998

Station No.	No. of samples	7-day concentration (μg/m^3)		
		Max	Min	Av
4	51	0.00044	0.00002	0.00011
5	34	0.00026	0.00001	0.00008
8	52	0.00036	0.00001	0.000011

build a historical data base of mercury concentration in ambient air at the Y-12 Plant, identify spatial and temporal trends in mercury vapor concentrations at the Y-12 Plant, and demonstrate protection of the environment and human health from releases of mercury from the Y-12 Plant to the atmosphere. Outdoor airborne mercury vapor at the Y-12 Plant is primarily the result of vaporization from mercury-contaminated soils and drains, fugitive emissions from former mercury-use area buildings, and releases from coal burning at the Y-12 Steam Plant.

Four outdoor ambient mercury monitoring stations (boundary stations on the east and west ends of the plant and two stations near Building 9201-4, a former lithium isotope separation facility contaminated with mercury) are currently located at Y-12 (see Fig. 6.3). One of the original sites near Building 9201-4 was relocated in late 1995 approximately 30 meters south and west of the old location near Building 9404-13 to a site near Building 9422-13. A control or reference site was also 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.

Because no established or EPA-approved method for measuring mercury vapor in ambient air existed when the program was initiated in 1986, staff of the ORNL Environmental Sciences Division developed a method to meet the needs of the monitoring program for the Y-12 Plant. At each of the monitoring sites, airborne mercury vapor is pulled through a Teflon filter and flow-limiting orifice before being adsorbed onto iodated charcoal packed in a glass sampling tube. The flow-limiting orifice is used to restrict air flow through the collection system to approximately 1 liter per minute (L/min) or less. Actual flow rates through the system are measured with a calibrated rotameter. The charcoal sampling tubes are routinely changed every 7 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.

Tekran™ Model 2537A mercury vapor analyzers were operated at the two boundary locations, Ambient Station No. 2 and Ambient Station No. 8, simultaneously throughout most of 1997 with the older iodated charcoal trap monitoring system to verify comparability of the measurements. The Tekran analyzers are self-calibrating and include mass-flow controllers. A comparison of the results collected with the two different monitoring systems was presented in the 1997 ASER and showed very good agreement in results between the two. Because of its ease of use, reliability, and minimal downtime in instances of equipment malfunction or failure, the older charcoal trap method was the method selected in 1998 for monitoring mercury vapor at all four sites.

As reported in earlier ASERs, annual average mercury vapor concentrations at the Y-12 Plant have declined since the initial 3 years of the monitoring program (1986 through 1988) with average concentrations at the two boundary sites on the east and west ends of the Y-12 Plant currently comparable to those measured in 1988 and 1989 at the reference site on Chestnut Ridge (see Table 6.4). Of the three sites operational since 1986, all three continue to have significantly lower annual averages for mercury vapor concentration in 1998 when compared with the 1986 through 1988 average (Student's *t*-test at the 1% level). Average mercury vapor concentrations in 1998 for the four sites currently monitored are comparable to those reported previously in the 1996 and 1997 ASERs (see Table 6.4). As noted previously, the decrease in ambient vapor mercury recorded at the Y-12 sites since 1989 is thought to be related to the reductions in coal burning at the Y-12 Steam Plant beginning in 1989 and to the completion prior to 1990 of several major engineering projects that may have been responsible for temporarily elevating mercury vapor. More recently, mercury cleanup and closure activities have been conducted at several sites within the mercury-use areas, including Building 9201-4. Even though average mercury concentrations for 1998 at the four monitoring sites were not significantly different from the 1997 annual averages (Student's *t*-test), slight increases in annual concentration were noted at the two most westerly sites (i.e., Station No. 8 and Building 9422-13) during 1998 (see Table 6.4). This increase might be attributed to construction projects, including the excavation of soil, adjacent to and just east of Building 9422-13 and south of the old S-3 Pond site.

Figure 6.4 illustrates temporal trends in mercury concentrations for the four active ambient air mercury monitoring sites since the incep-

Table 6.4. Results of the Y-12 Plant ambient air mercury monitoring program
The 1998 averages are calculated from results of both charcoal trap and Tekran monitoring

Ambient air monitoring site	Mercury vapor concentration (μg/m³)			
	1998 Average	1997 Average[a]	1996 Average[a]	1986–1988 Average[a]
Station No. 2 (east end of Y-12 Plant)	0.0048	0.0048	0.0044	0.010
Station No. 8 (west end of Y-12 Plant)	0.0074	0.0068	0.0059	0.033
Bldg. 9422-13 (SW of Bldg. 9201-4)[b]	0.044	0.032[c]	0.030	N/A[b]
Bldg. 9805-1 (SE of Bldg. 9201-4)	0.057	0.064[c]	0.058	0.099
Reference Site, Rain Gage No.2 (1988[d])	N/A	N/A	N/A	0.006
(1989[e])	N/A	N/A	N/A	0.005

[a]ACGIH 8-h workday/40-h work week threshold limit equals 50 μg/m³.
[b]Site established in late 1995.
[c]Data for period from January 1 through September 30, 1997
[d]Data for period from February 9 through December 31, 1988.
[e]Data for period from January 1 through October 31, 1989.

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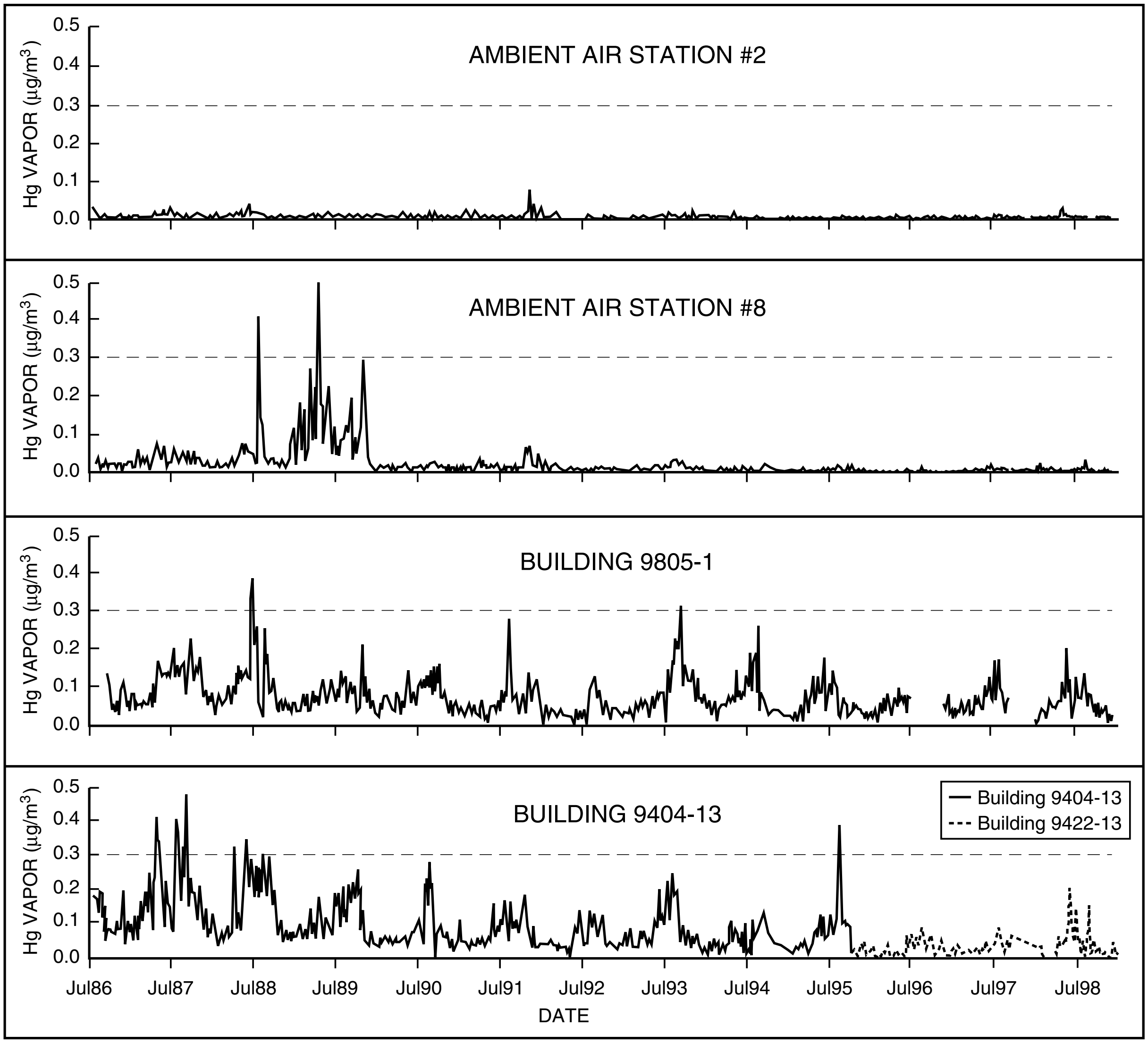

Fig. 6.4. Temporal trends in mercury vapor concentration for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Plant (1986 through 1998). The dashed line represents the EPA RfC of 0.3 µg/m^3.

tion of the program in 1986. Results for the newest site near Building 9422-13, which replaced the nearby site at Building 9404-13 in 1996, are overlain on the original plot for Building 9404-13. Seasonal increases in mercury concentrations in ambient air are recorded at all four sites during warm-weather months.

In conclusion, annual average ambient mercury concentrations during 1998 at the two monitoring sites southeast and southwest of Building 9201-4 remain elevated above natural background. However, results indicate that annual average concentrations are below the EPA reference concentration (0.3 µg/m^3) for mercury for chronic inhalation exposure (RfC). The RfC is an estimate of a daily inhalation exposure during a lifetime without appreciable risk of harmful effects to the general population, including sensitive subgroups. During the early years (1986–89) of this monitoring effort, the two sites located southeast and southwest of Building 9201-4 had annual average concentrations of mercury vapor approximately one-fourth to one-half the RfC and occasionally had spikes greater than the RfC (see Fig. 6.4). As mentioned previously, concentrations at all sites have declined since those early years of monitoring.

6.4 LIQUID DISCHARGES—Y-12 PLANT RADIOLOGICAL MONITORING SUMMARY

A Radiological Monitoring Plan (RMP) is in place at the Y-12 Plant to address compliance with DOE orders and the National Pollutant Discharge Elimination System (NPDES) permit (TN002968). The permit, issued in 1995, required that the Y-12 Plant reevaluate its Radiological Monitoring Plan 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 1995a) 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 1997e). Under the monitoring program, effluent monitoring is continued 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 have provided a basis for monitoring parameters routinely under the plan (Table 6.5). One new outfall (Outfall 551, the Central Mercury Treatment Facility) was added to the radiological monitoring program in 1998.

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 publicly owned treatment works (POTW) under Industrial and Commercial User Wastewater Discharge Permit No. 1-91. Radiological monitoring of this discharge is also conducted and is reported to the city of Oak Ridge. 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 ALARA goals of the Y-12 Plant. These data show that levels of radioactivity are orders of magnitude below levels established in DOE orders

Table 6.5. Radiological parameters monitored at the Y-12 Plant in 1998

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 parameter 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.

and are not thought to pose a safety or health risk. The radiological monitoring needs for the sanitary sewer were reviewed and summarized in the 1997 update to the RMP (LMES 1997e).

The following parameters are monitored routinely:

- alpha, beta, and gamma activity;
- plutonium (^{238}Pu and $^{239/240}$Pu); and
- uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U).

Furthermore, radiological monitoring of storm water is required by the NPDES permit, and 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 1998a), and this plan incorporates the radiological monitoring requirements. The NPDES permit requires characterization of a minimum of 25 storm-water outfalls per year, including both grab and composite sampling. There are 78 storm-water outfalls and monitoring points located at the Y-12 Plant.

6.4.1 Results

The Central Pollution Control Facility (Outfall 501) is the only treatment facility that has exceeded maximum allowable derived concentration guides (DCGs) in the past; however, improvements in the treatment process since 1989 have resulted in effluent data consistently well below DCGs.

RMP locations sampled in 1998 are noted in Fig. 6.5. Table 6.6 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1998. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the West End Treatment Facility. Radium (^{228}Ra) was the major contributor of radioactivity there, contributing 7.6% of the total 8.6% of the sum of the percentages of the DCGs.

In 1998, the total mass of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on

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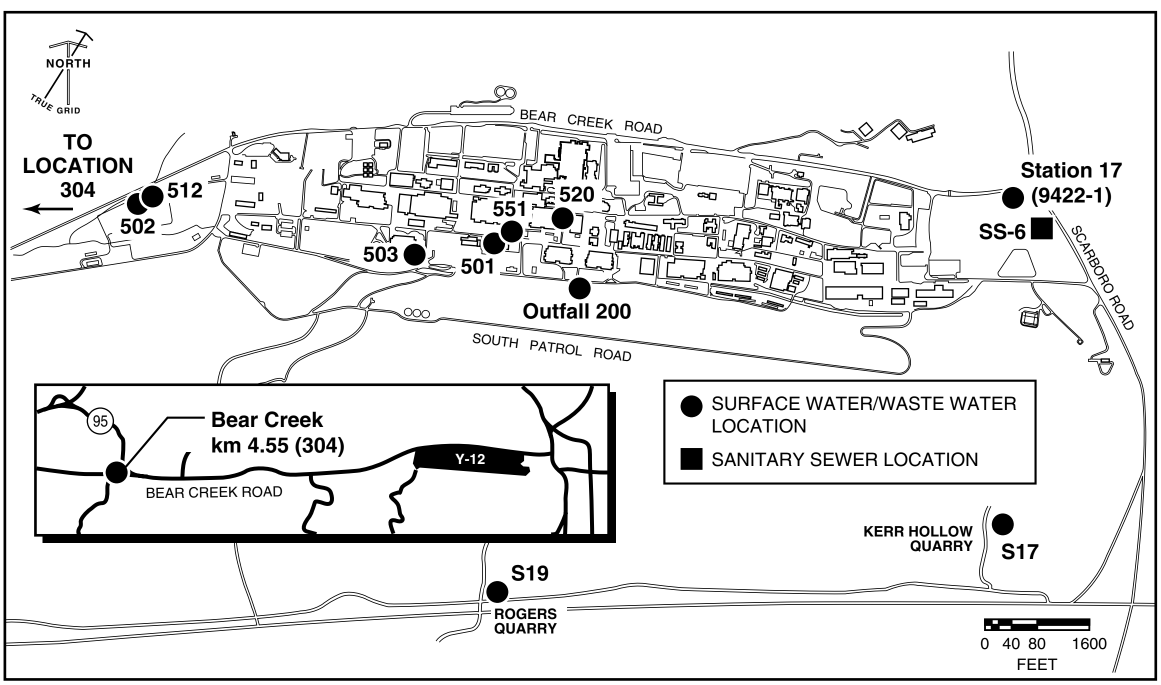

Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Plant.

Table 6.6. Summary of Y-12 Plant radiological monitoring plan sample requirements

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	1.6
502	West End Treatment Facility	1/week	24-hour composite	8.6
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	No flow
512	Groundwater Treatment Facility	1/week	24-hour composite	6.1
520 (402)[a]	Steam condensate	1/week	Grab	No flow
551	Central Mercury Treatment Facility	1/month	24-hour composite	4.6
	Other Y-12 Plant point and area source discharges			
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-hour composite	2.8
S19 (302)[a]	Rogers Quarry	1/month	24-hour composite	3.6
	Y-12 Plant instream locations			
BCK 4.55 (304)[a]	Bear Creek, plant exit (west)	1/week	7-day composite	5.0
Station 17	East Fork Poplar Creek, plant exit (east)	1/week	7-day composite	3.9
200	North/south pipes	1/week	24-hour composite	6.5

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

Upper East Fork Poplar Creek (UEFPC), and the westernmost monitoring station, at BCK 4.55 (former NPDES Outfall 304), was 375 kg, or 0.167 Ci (Table 6.7). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams/liter) by the average flow (million gallons/day). Converting units and multiplying by 365 days/year yields the calculated discharge.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 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 DCG listed in DOE Order 5400.5. Summed percentages of DCGs calculated from the Y-12 Plant contribution to the sewer are essentially zero. Results of radiological monitoring were reported to the city of Oak Ridge with the quarterly monitoring report and are summarized for 1998 in Table 6.8. Figure 6.7 illustrates the 5-year

Table 6.7. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1994–98

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
	Outfall 304	
1994	0.13	236
1995	0.066	105
1996	0.149	259
1997	0.116	199
1998	0.091	148

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

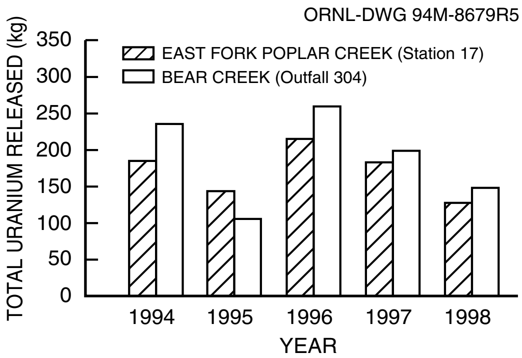

Fig. 6.6. Five-year trend of Y-12 Plant release of uranium to surface water.

trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

Radiological monitoring of storm water is consistent with past years' results. Uranium is the dominant constituent and increases during storm flow, likely because of surface sources as well as from increased groundwater flow. A request to discontinue grab sampling of storm water runoff for radiological analyses was approved by TDEC in January 1998 because collection of composite sampling has proven to be more effective for the purpose of radiological monitoring.

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 100 outfalls. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. In 1998, one outfall (Outfall 102) was added to the permit to help eliminate building flooding in peak storms. Over the past several years, approximately 100 outfalls were physically eliminated as part of a program to remove or consolidate outfall pipes on East Fork Poplar Creek (EFPC). Another 60 outfalls have been adminstratively eliminated by the latest permit. 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 infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permittted 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. In past years, discharge of coal bottom ash slurry to the McCoy Branch from the Y-12 Steam Plant occurred. This practice has been stopped, and coal ash is currently collected dry and is being used for recycle or for filler to support landfill operations. Bear Creek water quality is affected by area source runoff and groundwater discharges, and only storm water runoff is monitored under the NPDES permit.

In 1998, the Y-12 Plant operated for the third full calendar year under the permit that had been issued in 1995. The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit places emphasis on storm water runoff and biological, toxicological, and radiological monitoring. Some of the more significant 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 (see Sect. 6.6)
- a compliance schedule to reduce mercury in EFPC (see Reduction of Mercury in Plant Effluent in Sect. 6.5.5. Note: The mercury limitations have been appealed and the limits stayed pending resolution of the appeal.)

Table 6.8. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6 (1/1/98–12/31/98)

Parameter	Number of samples	Concentration (pCi/L)						Standard error	Percentage of DCG	Total curies
		Max	+/–	Min	+/–	Median	+/–			
Alpha activity	52	11.0[a]	16	–0.051[a]	3.4	3.5	*b*	0.35	*b*	3.8E–03
Beta activity	52	13.0[a]	4.4	–300.0[a]	290	5.9	*b*	5.9	*b*	–4.3E–04
Gamma activity	52	26.0[a]	57	–18.0[a]	27	4.9	*b*	1.4	*b*	3.8E–03
^{238}Pu	1	0.18[a]	0.16	0.18[a]	0.16	0.18[a]	0.16	*b*	0.45	1.9E–04
$^{239/240}$Pu	1	0.016[a]	0.092	0.016[a]	0.092	0.016[a]	0.092	*b*	0.053	1.7E–05
^{234}U	52	43.0	5	1.1	0.33	3.2	*b*	0.78	0.64	3.9E–03
^{235}U	52	2.3	0.62	0.0[a]	0	0.115[a]	*b*	0.043	0.019	1.7E–04
^{238}U	52	77.0	8.4	0.45	0.22	1.4	*b*	1.5	0.23	3.1E–03

[a]Result was below the minimum detectable activity.
[b]Not applicable.

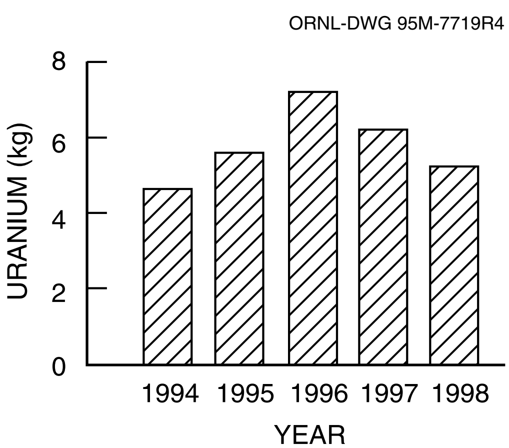

Fig. 6.7. Five-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

- a compliance schedule for chlorine limitations at outfalls containing cooling water (complete)
- chlorine limitations based on water quality criteria at the headwaters of EFPC (monitoring ongoing, chlorine limits are being met)
- a compliance schedule for correction of elevated ammonia concentrations discharged to EFPC from a groundwater spring (complete)
- 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 of storm water at a minimum of 25 locations per year (in second year of monitoring)
- a storm water pollution plan (plan updated in 1998), and
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge (monitoring ongoing)

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. A number of allowable discharge concentrations were modified in the new permit. 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 749,000 gal/day (2,830,000 L/day).

Compliance sampling is conducted at the EESSMS (SS-6, Fig. 6.5) on a weekly basis. In addition, throughout 1998 mercury composite samples were obtained daily, Monday through Thursday, and a 3-day composite was obtained for the weekend (Friday through Sunday). This monitoring station is also used for 24-hour flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel also use this monitoring station to perform compliance monitoring as required by pretreatment regulations.

Storm Water

The development and implementation of a Storm Water Pollution Prevention Plan for the Y-12 Plant is required by Part IV of the NPDES permit. The objective of the plan is to minimize the discharge of pollutants in storm water runoff at the Y-12 Plant by assessing the quality of storm water discharges from the site, determining potential sources of pollutants affecting storm water, and providing effective controls to reduce or eliminate these pollutant sources. The plan 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 in December 1998 (LMES 1998a) The NPDES permit requires sampling of a minimum of 25 storm water outfalls per year, including both grab and composite sampling. Each year approximately 1500 chemical analyses are conducted on storm water samples at the Y-12 Plant.

6.5.1 Results and Progress in Implementing Corrective Actions

In 1998, the Y-12 Plant experienced nine NPDES excursions as opposed to seven in 1997. Seven excursions resulted from a rise, and fluctuating changes, in the chlorine levels present in the raw water supplied to the Y-12 Plant. A change in Clinch River water chemistry over a period of several weeks, because of hot and dry weather, resulted in increased algae and natural organic matter in the water. Water from the Clinch River is the source of the local drinking water supply and is used as a raw water supplement to maintain the flow in EFPC. The increased algae content necessitated a change in the feed disinfectants by East Tennessee Mechanical Contractors, the operators of the water treatment plant, at the river pumping station to maintain clean and taste-free water for the city of Oak Ridge. This resulted in higher than expected and rapidly fluctuating quantities of residual chlorine in water received by the Y-12 Plant. As currently configured, the Y-12 Plant dechlorination systems could not handle the increased chlorine level nor respond adequately to the chlorine fluctuations. Short-term corrective actions were successfully implemented until normal rainfall returned in December and the Clinch River water quality improved such that the feed of disinfectants returned to normal. A long-term corrective action plan and request for funding have been developed.

Additional detail on all Y-12 Plant NPDES permit excursions recorded in 1998 and the associated corrective action are summarized in Appendix F, Table F.1. As in the past year, none of the Y-12 Plant NPDES excursions were attributable to administrative errors such as missing analytical sample holding times, loss of a sample, or improper sample preservation. Table 6.9 lists the NPDES compliance monitoring requirements and the 1998 compliance record.

During 1998, the Y-12 Plant experienced three exceedences of the Industrial and Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge POTW. There was one exceedence for cadmium and two for arsenic. On May 21, the cadmium default limit of 0.0045 mg/L was exceeded. The result obtained was 0.0049 mg/L. The arsenic default limit of 0.0045 mg/L was exceeded on June 16 (0.0077 mg/L) and November 11 (0.0095 mg/L).

Although no specific cause could be determined, there are a number of construction activities involving the sanitary sewer that may have contributed to these exceedences. The construction activities are part of an ongoing multi-million-dollar sanitary sewer upgrade project that is expected to continue through FY 1999. Table 6.10 summarizes Y-12 Plant monitoring of the discharge to the sanitary sewer during 1998.

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. Outfalls to EFPC are showing detectable levels of zinc, total suspended solids, phosphorus, copper, radium, uranium, manganese, iron, and mercury during storm events. However, some monitored

Table 6.9. NPDES compliance monitoring requirements and record for the Y-12 Plant, January through December 1998

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9.0	*b*	0
Outfall 068	pH, standard units			*a*	9.0	100	12
Outfall 117	pH, standard units			*a*	9.0	100	12
Outfall 073	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 077	pH, standard units			*a*	9.0	100	11
	Total residual chlorine				0.5	100	11
Outfall 122	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 125	pH, standard units			*a*	9.0	100	14
	Total residual chlorine				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9.0	100	57
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*a*	10.0	100	5
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	100	100
	Total residual chlorine				0.5	98	64
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10.0	100	20
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	158
	Total residual chlorine				0.5	100	122

Table 6.9 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.019	97	178
	Temperature, °C			*a*	30.5	100	157
	pH, standard units		8.5	*a*		100	157
Outfall 200 (North/ South pipes)	Oil and grease			10	15	100	157
Outfall 021	Total residual chlorine			0.080	0.188	98	160
	Temperature, °C			*a*	30.5	100	156
	pH, standard units				9.0	100	157
Outfall 017	pH, standard units			*a*	9.0	100	53
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*a*	9.0	100	104
	Mercury				0.004	100	104
	Total residual chlorine				0.5	100	104
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 551	pH, standard units				9.0	100	52
	Mercury				0.004	100	52
Outfall 051	pH, standard units			*a*	9.0	100	104
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	100	15
	Total suspended solids			31.0	40.0	100	15
	Total toxic organics				2.13	100	1
	Oil and grease			10	15	100	15
	Cadmium	0.16	0.4	0.075	0.15	100	15
	Chromium	1.0	1.7	0.5	1.0	100	15
	Copper	1.2	2.0	0.5	1.0	100	15
	Lead	0.20	0.4	0.1	0.2	100	15
	Nickel	1.4	2.4	2.38	3.98	100	15
	Nitrate/Nitrite				100	88	15
	Silver	0.14	0.26	0.05	0.05	100	15
	Zinc	0.9	1.6	1.48	2.0	100	15
	Cyanide	0.4	0.72	0.65	1.20	100	1
	PCB				0.001	100	1
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	100	46
	Total suspended solids	18.6	36.0	31.0	40.0	100	46
	Total toxic organics				2.13	100	8
	Nitrate/nitrite			100	150	100	46
	Oil and grease		10		15	100	46
	Cadmium	0.16	0.4	0.075	0.15	100	46
	Chromium	1.0	1.7	0.5	1.0	100	46
	Copper	1.2	2.0	0.5	1.0	100	46
	Lead	0.26	0.4	0.10	0.20	100	46
	Nickel	1.4	2.4	2.38	3.98	100	46
	Silver	0.14	0.26	0.05	0.05	100	46
	Zinc	0.9	1.6	1.48	2.0	100	46
	Cyanide	0.4	0.72	0.65	1.2	100	46
	PCB				0.001	100	8

Table 6.9 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (lb/d)	Daily max (lb/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids	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	140
	Iron				1.0	100	141
	PCB				0.001	100	12
Outfall 520	pH, standard units				9.0	*b*	0
Outfall 05A	pH				9.0	*b*	0

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

pollutants are not present at specific outfalls. It also has been established that for some parameters, grab and composite sample results are very similar. For these reasons, and with TDEC approval, the Storm Water Monitoring Plan was revised to reflect reduced storm water monitoring in 1998.

6.5.2 East Fork Poplar Creek Dechlorination and Fish Kill Summary

During 1998, as in the past 5 years, instream levels of total residual chlorine 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 two dechlorination systems and 42 tablet dechlorinators that were brought on line from 1992 through 1995. While reduced chlorine levels have contributed to ecological recovery of EFPC, a large, accidental release of a dechlorination chemical on July 24, 1997, killed approximately 24,000 fish in UEFPC. Fish count surveys in 1998 show that the fish population in UEFPC has almost fully recovered. There were no reported fish kills in 1998.

6.5.3 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). During October 1998, the monthly average daily flow at Station 17 was 6.1 million gallons per day. This was a result of a drier (less rainfall) than normal summer and fall, and the unavailability of the south raw water feed line because of the need to shut off the flow for a few days in response to the chlorine excursions.

Table 6.10. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, nonradiological summary (1/1/98–12/31/98)

Parameter	Number of samples	Concentration[a] Max	Min	Avg	Reference value[b]	Number of values exceeding reference
Flow, gpd[c]	365	2186818.0	433721.0	749357.6	*d*	*d*
pH, std unit	53	8.4	7.0	*d*	9/6[e]	0
Silver	52	0.03	<0.0002	<0.005	0.1	0
Arsenic	52	0.0095	<0.002	<0.004	0.0045	2
Boron	52	<0.1	<0.02	<0.05	*d*	*d*
Benzene	12	<0.010	<0.005	<0.008	0.015	0
Biochemical oxygen demand	53	53.6	20.9	34.8	300	0
Cadmium	53	0.0049	<0.0002	<0.001	0.0045	1
Chromium	52	0.0715	<0.001	<0.004	0.075	0
Copper	52	0.0746	0.014	0.027	0.092	0
Cyanide	12	0.02	<0.01	<0.01	0.062	0
Iron	52	2.25	<0.06	<0.8	15	0
Mercury	248	0.0161	<0.0002	<0.001	0.035	0
Kjeldahl nitrogen	53	14.4	3.15	10.1	90	0
Methylene chloride	12	0.033	<0.005	<0.010	0.041	0
Nickel	52	<0.01	<0.002	<0.006	0.032	0
Oil and grease	53	21.9	<5.0	<7.1	50	0
Lead	52	0.0067	<0.0002	<0.003	0.074	0
Phenols—total recoverable	53	0.029	<0.005	<0.01	0.5	0
Selenium	52	<0.2	<0.04	<0.1	*d*	*d*
Suspended solids	53	123	30.8	59.1	300	0
Toluene	12	<0.010	<0.005	<0.008	0.02	0
Trichloroethene	12	<0.010	0.001	<0.007	0.027	0
Zinc	52	0.174	0.08	0.1	0.75	0
Uranium	52	0.012	0.002	0.005	*d*	*d*
^{235}U, weight %	52	1.5	0.62	1.1	*d*	*d*

[a]Units in mg/L unless otherwise indicated.
[b]Industrial and Commercial User Waste Water Permit Limits.
[c]Flow during operations and/or discharging.
[d]Not applicable.
[e]Maximum value/minimum value.

6.5.4 Drain Modifications and Reroutes

Extensive drain surveys conducted on buildings at the Y-12 Plant were completed in early 1995. Drains incorrectly routed to the storm or sanitary sewer were identified for closure or correction, and many drains were eliminated or modified. In 1996, a validation program was initiated to confirm the completion of drain corrections, including the status of building floor drains. The validation process has continued through 1998 and is projected to continue into 1999. Permanent drain corrections that have not been completed have been identified for necessary corrective activities using an internal tracking program. Any drains found to be open are required to be plugged or "permitted" open by an internal process. New and updated building drain maps and drain status records are being generated in accordance with the NPDES permit.

6.5.5 Reduction of Mercury in Plant Effluent: Phase II

Significant progress continues to be made with the investigative and remedial actions aimed at reducing mercury releases to Upper East Fork Poplar Creek (UEFPC). All remedial actions required by the NPDES permit have been completed ahead of schedule. By September 1998, point sources of mercury accounted for only 50% of the baseflow mercury flux at Station 17, or roughly 7 to 8 g/day. Stormflow mercury transport averaged about 14 g/day. Two actions that were taken in late 1998, the permanent Lake Reality bypass and the capture and treatment of flow through the E3250 catch basin (see Fig. 6.8), have not been operational long enough to evaluate but hold the promise of further reducing baseflow mercury flux by up to 4 g/day. The startup of the Flow Management Project in July of 1996 resulted in an increase in mercury loading in the creek downstream of the North/South Pipe. This increase has offset some of the previous reductions achieved. As a result of studies conducted in 1998, it was found that the increased mercury inputs associated with Flow management disappeared when flow was reduced to pre–Flow management levels. The explicit mechanism for the increase was not determined but appears most likely to be caused by penetration of surface water into the streambed and into subsurface preferential flow pathways associated with the old streambed and floodplain. Increased flow through these pathways encounters deposits of metallic mercury, raising the dissolved mercury concentration in the shallow flows, which then reenter the surface flow in that reach. Increased erosion of bankside deposits of highly mercury-contaminated soil by the higher water level and velocity also acts to raise mercury concentrations in this reach.

Three main sources of mercury (see Fig. 6.8) account for virtually all of the observed baseflow mercury flux in UEFPC: (1) Outfalls 169, 163, and 160 originating in the historic mercury-use area upstream from the North/South Pipe; (2) Outfall 51, a natural spring surfacing near the historic mercury-use area downstream from the North/South Pipe, and (3) non-point inputs to the

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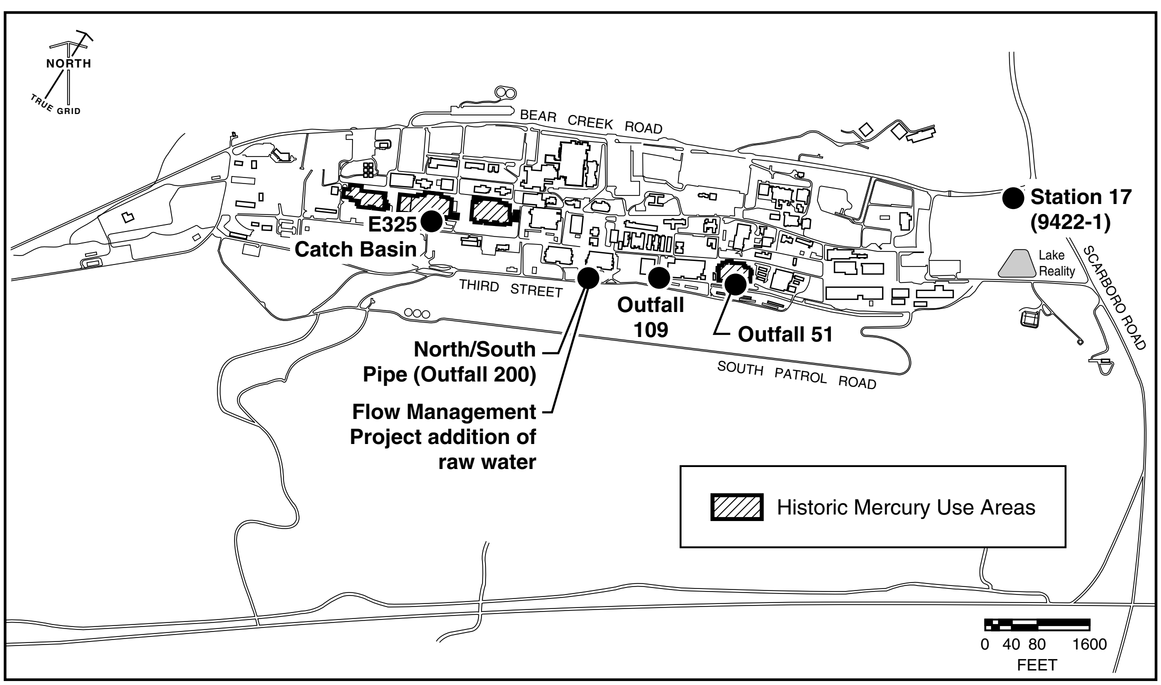

Fig. 6.8. Locations relevant to the Y-12 Plant's mercury abatement program.

reach of stream between the North/South Pipe and Outfall 109. The latter input is associated with increased flow from the Flow Management Project.

Erosion of mercury-contaminated particulate material from the streambed and banks downstream from the North/South Pipe was found to be the major source of stormflow mercury. The storm drain network upstream from the North/South Pipe contributed increased dissolved mercury during storms but was not the major contributor of particulate or total mercury flux during storm events. The discovery of metallic mercury deposits in the streambed in UEFPC raises questions about the extent of such deposits in UEFPC and the degree to which they act as continuing sources of contamination. Such deposits could readily act to replenish the inventory of particle-associated mercury eroded from the streambed by high flows. Reduction of stormflow mercury transport would be effected by actions that isolate streambed mercury deposits from the surface flow and by actions to protect or remove streambank deposits of mercury-contaminated soil. If removal and retention of waterborne mercury during periods between storms is a significant source of stormflow mercury, actions that reduce baseflow mercury (especially dissolved mercury) concentrations will also reduce stormflow transport.

Mercury concentrations in sunfish appear to be responding to decreased aqueous mercury concentrations in the headwaters of East Fork Poplar Creek (EFPC), where Flow management has had the greatest effect on waterborne mercury concentrations. Decreasing mercury in fish at what are still relatively high aqueous mercury concentrations is evidence that the site-specific relationship between mercury in water and mercury in fish is valid and that total mercury concentrations in the 0.1 to 0.2 mg/L (100–200 ng/L) range will ultimately result in concentrations of mercury in fish falling below 0.5 mg/g in upper EFPC. Mercury concentration in fish in lower EFPC have not yet decreased in response to decreased inputs from UEFPC.

Although progress continues to be made in reducing mercury concentrations in UEFPC, the Y-12 Plant did not meet the NPDES 5 g/day baseflow ($\leq$15 Mgd) mercury flux target by December 31, 1998. Non-point mercury inputs associated with Flow management continues to maintain baseflow mercury flux at a level well above the target .

The most cost-effective actions to reduce point-source mercury inputs have been taken. Additional incremental reductions in mercury inputs to EFPC are possible but generally involve treating high-volume, dilute flows such as Outfall 51, or relatively small individual contributors to the total mercury flux (Outfalls 160, 163, and 169). Treatment of these fluxes is likely to be substantially more costly per gram of mercury removed than actions taken to date. The non-point mercury input associated with Flow management is the largest single source of mercury to UEFPC under baseflow conditions. A number of possible actions might reduce or eliminate mercury inputs associated with Flow management. The nature of the mechanism behind this mercury source is not known well enough at the present time to guarantee success of any particular action.

Monitoring of mercury concentration and flow from key outfalls and instream locations will continue to be performed in 1999. Investigations leading to possible corrective actions to further reduce mercury inputs to UEFPC will be centered on resolving possible differences between mercury loading above and below Outfall 200 (i.e., the headwaters of UEFPC). Future long-range mercury remediation for EFPC will be driven by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process and the record of decision (ROD) for the UEFPC characterization area.

6.6 BIOMONITORING PROGRAM

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a Biomonitoring Program that evaluates an EFPC instream monitoring location (Outfall 201), wastewater treatment system discharges, and locations in the storm sewer system is required. Table 6.11 is a summary of the results of biomonitoring tests conducted on effluent samples from wastewater treatment systems and storm sewer effluents. 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-hour period. Thus, the lower the value, the more toxic an effluent. The LC_{50} is compared to the effluent's calculated

Table 6.11. Y-12 Plant Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 1998[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Central Pollution Control Facility (Outfall 501)	1/23	*Ceriodaphnia*	>100	0.09
Storm Sewer 9215/9204-2E Alley	2/5	*Ceriodaphnia*	32.0	*d*
Storm Sewer 9215/9204-2E Alley (dechlorinated)	2/5	*Ceriodaphnia*	75.9	*d*
Storm Sewer west of 9215	2/5	*Ceriodaphnia*	40.3	*d*
Storm Sewer west of 9215 (dechlorinated)	2/5	*Ceriodaphnia*	>100	*d*
Storm Sewer southeast of 9703-11	2/5	*Ceriodaphnia*	2.2	*d*
Storm Sewer southeast of 9703-11 (dechlorinated)	2/5	*Ceriodaphnia*	39.3	*d*
Groundwater Treatment Facility (Outfall 512)	2/6	*Ceriodaphnia*	72.3	0.1
Storm Sewer south of 9201-4	2/10	*Ceriodaphnia*	66.0	*d*
Central Mercury Treatment System (Outfall 551)	2/10	*Ceriodaphnia*	>100	0.12
West End Treatment Facility	4/10	*Ceriodaphnia*	42.4	0.13
Central Pollution Control Facility (Outfall 501)	4/17	*Ceriodaphnia*	>100	0.13
Storm Sewer southeast of 9703-11	4/23	*Ceriodaphnia*	17.3	*d*
Storm Sewer southeast of 9703-11 (dechlorinated)	4/23	*Ceriodaphnia*	70.7	*d*
Groundwater Treatment Facility (Outfall 512)	4/23	*Ceriodaphnia*	70.7	0.24
Central Pollution Control Facility (Outfall 501)	4/23	*Ceriodaphnia*	>100	0.11
Storm Sewer 9215/9204-2E Alley	4/23	*Ceriodaphnia*	66.7	*d*
Storm Sewer 9215/9204-2E Alley (dechlorinated)	4/23	*Ceriodaphnia*	70.7	*d*
Central Mercury Treatment System (Outfall 551)	4/24	*Ceriodaphnia*	>100	0.15
Storm Sewer south of 9201-4	4/28	*Ceriodaphnia*	70.7	*d*
West End Treatment Facility (Outfall 502)	4/28	*Ceriodaphnia*	55.9	0.23
Storm Sewer southeast of 9201-4	4/28	*Ceriodaphnia*	70.7	*d*
Storm Sewer southeast of 9201-4	7/9	*Ceriodaphnia*	>100	*d*
Storm Sewer south of 9201-4	7/9	*Ceriodaphnia*	70.7	*d*
Groundwater Treatment Facility (Outfall 512)	7/10	*Ceriodaphnia*	88.0	0.14
Central Mercury Treatment System (Outfall 551)	7/10	*Ceriodaphnia*	>100	0.04
Storm Sewer southeast of 9703-11	7/14	*Ceriodaphnia*	63.0	*d*
Storm Sewer southeast of 9703-11 (dechlorinated)	7/14	*Ceriodaphnia*	70.7	*d*
Storm Sewer 9215/9204-2E Alley	7/14	*Ceriodaphnia*	72.2	*d*
Storm Sewer 9215/9204-2E Alley (dechlorinated)	7/14	*Ceriodaphnia*	>100	*d*
West End Treatment Facility (Outfall 502)	7/29	*Ceriodaphnia*	41.4	0.19
Central Pollution Control Facility (Outfall 501)	9/29	*Ceriodaphnia*	>100	0.15
Groundwater Treatment Facility (Outfall 512)	10/8	*Ceriodaphnia*	90.3	0.03
Storm Sewer west of 9215	10/8	*Ceriodaphnia*	59.8	*d*
Storm Sewer southeast of 9703-11	10/8	*Ceriodaphnia*	15.8	*d*
Storm Sewer southeast of 9703-11 (dechlorinated)	10/8	*Ceriodaphnia*	39.7	*d*
West End Treatment Facility (Outfall 502)	10/9	*Ceriodaphni*	22.6	0.22
Central Mercury Treatment System (Outfall 551)	10/9	*Ceriodaphnia*	>100	0.32
Storm Sewer 9215/9204-2E Alley	10/13	*Ceriodaphnia*	71.0	*d*
Storm Sewer 9215/9204-2E Alley (dechlorinated)	10/13	*Ceriodaphnia*	75.8	*d*
Storm Sewer southeast of 9201-4	10/13	*Ceriodaphnia*	69.3	*d*
Central Pollution Control Facility (Outfall 501)	11/19	*Ceriodaphnia*	78.1	0.09

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

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

[c]IWC = instream waste concentration. The IWC is based on actual flows at Outfall 201 in East Fork Poplar Creek.

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

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 four times in 1998 using *Ceriodaphnia dubia*. Effluent samples from the Central Mercury Treatment System (CMTS) and Central Pollution Control Facility (CPCF) were nontoxic to *Ceriodaphnia* except for the CPCF test in November where the LC_{50} was 78%. The LC_{50}s for the Groundwater Treatment Facility (GWTF) ranged from 70.7 to 90.3% and for the West End Treatment Facility (WETF) ranged from 22.6 to 55.9%. In all cases the calculated IWCs of the effluent were less than the LC_{50}s . This provides some indication that the treated effluent from the treatment facilities would not be acutely toxic to the aquatic biota in EFPC.

Various storm sewer points 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 effluent than in the nontreated effluent. The improvement in survival varied from sample to sample (as indicated by an increase in the LC_{50}), thus indicating that the toxicity from chlorine varied from sample to sample. In most cases, the full-strength dechlorinated sample continued to reduce *Ceriodaphnia* survival. 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 6.12) demonstrated that when all discharges were combined (treated effluent, storm sewer contribution, plus flow management water) the samples were nontoxic in laboratory tests.

Table 6.12 is a summary of the no-observed-effect concentrations (NOECs) and 96-hour LC_{50}s for the instream monitoring location, Outfall 201. The NOEC is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms during a 6- or 7-day test. Thus, like the LC_{50}, the lower the value, the more toxic an effluent. Water from the instream monitoring point, Outfall 201, was tested four times in 1998 using fathead minnow larvae and *Ceriodaphnia dubia*. The NOECs were all 100% for both *Ceriodaphnia* and fathead minnows; the 96-hour 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, the ETTP in 1992, and ORNL in 1986 mandate Biological Monitoring and Abatement Programs (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 East fork Poplar Creek (EFPC); ETTP effluents discharge to Mitchell Branch, Poplar Creek, and the Clinch River; and ORNL effluents discharge to White Oak Creek (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.

During 1998, several actions having the potential to significantly affect the status of aquatic communities in EFPC were continued or initiated. Soil removal from the National Oceanic and Atmospheric Administration (NOAA) and Bruner sites in Oak Ridge was completed during the lower EFPC floodplain mercury remedial action. Mercury remediation at the Y-12 Plant site also continued during the year. Flow management, which was first fully implemented in the fall of 1996, operated except for short down-periods throughout 1998. The bypass of Lake Reality became permanent during the year.

The levels of exposure of EFPC biota to contaminants continued to decrease during 1998. No major fish kills were recorded during the year. Y-12 Plant activities still had some adverse effects on the biota of EFPC, as evidenced by the less-

Table 6.12. Y-12 Plant Biomonitoring Program summary information for Outfall 201 for 1998[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/8	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	4/9	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	7/9	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/1	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100

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

[b]No-observed-effect concentration (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.

than-optimal state of fish and invertebrate communities in upper EFPC. However, a relatively consistent trend of increases in species richness and diversity at upstream locations over the last decade, along with similar but more subtle trends in a number of other BMAP indicators, indicates that the overall ecological health of EFPC continues to improve.

6.7.1 Toxicity Monitoring

Toxicity monitoring employs U.S. Environmental Protection Agency (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 1998 for two sites upstream from Bear Creek Road [Lake Reality outfall or LR-o (EFK 23.8), LR inlet or LR-I (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 National Pollutant Discharge Elimination System (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 to conduct quarterly toxicity tests at the latter location.

The results of an October 1998 *Ceriodaphnia* toxicity test are shown in Table 6.13, as an example of the data produced by these tests. No evidence for toxicity was observed in any of the 1998 *Ceriodaphnia* (all three EFPC sites) or fathead minnow tests (only Outfall 201). These results are consistent with the results of previous *Ceriodaphnia* and fathead minnow tests conducted since flow management was instigated in the latter half of 1996. These results contrast, however, with the continuing toxicity evident in tests involving fish embryos, which appear more sensitive to water quality conditions in EFPC. Medaka (fish) embryo-larval test results are discussed in Section 6.7.4.

6.7.2 Bioaccumulation Studies

Fish in EFPC have historically had elevated amounts of mercury and PCBs relative to fish in uncontaminated reference streams. EFPC fish are monitored regularly for mercury and PCBs to assess spatial and temporal trends in bioaccumulation associated with ongoing reme-

Table 6.13. Results of *Ceriodaphnia dubia* toxicity tests of ambient sites from East Fork Poplar Creek and Outfall 201 conducted October 7–14, 1998

Sample	Concentration (%)	Survival (%)	Mean reproduction (offspring/surviving female ± SD)
		Ambient sites	
Control	100	100	27.7 ± 2.0
EFK 24.1	100	100	27.6 ± 2.3
EFK 23.8	100	90	25.3 ± 4.2
		Outfall 201	
Control	100	100	27.2 ± 2.5
Outfall 201	100	100	26.7 ± 1.3
	80	100	28.1 ± 2.3

Note: EFK = East Fork Poplar Creek kilometer. SD = standard deviation.

dial activities and plant operations. As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) were sampled twice during 1998 from six sites along EFPC and analyzed for tissue concentrations of these two environmental contaminants. Largemouth bass (*Micropterus salmoides*) were collected once from two sites in EFPC (Lake Reality and EFK 23.4) to monitor maximum bioaccumulation in larger piscivorous fish of the stream.

In spring 1998, the mean mercury concentrations in sunfish sampled from EFPC ranged from 9 to 13 times higher than the average concentrations in fish from the reference stream. High levels of bioaccumulation continue to occur upstream of Lake Reality, suggesting that Y-12 Plant discharges remain an important source of mercury to fish in the upper reaches of EFPC. However, mercury concentrations in the fish of upper EFPC have decreased significantly over the last few years in conjunction with similar decreases in water concentrations of mercury (Fig. 6.9).

PCB concentrations in sunfish sampled from EFPC during 1998 fell within ranges typical of past monitoring efforts at these sites (Fig. 6.10) . 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.

In a continuing effort to identify sources of PCBs to EFPC, semipermeable membrane devices (SPMDs) were again deployed during 1998 at several locations within upper EFPC (Fig. 6.11). SPMDs are passive sampling devices that provide a time-integrated measurement of dissolved (bioavailable) PCB concentrations. The use of these devices during 1998 led to the identification or confirmation of several point sources of PCBs entering upper EFPC from outfalls (with the N/S Pipe being the primary point source). As noted in a similar 1997 deployment of SPMDs in upper EFPC, significant non-point sources of dissolved PCBs were also observed along two specific reaches of the stream (N/S Pipe to 109 Bridge and Station 8 Bridge to East Patrol Road Bridge). These non-point sources could be historical contamination entering EFPC through shallow groundwater flow or may represent the remobilization of bioavailable PCBs from particle-bound PCBs in stream-bed sediments or outfall effluents.

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 (upstream of Lake Reality, EFK 23, EFK 19 and EFK 14) and from two reference streams (Brushy Fork and Hinds Creek) in the spring of 1998 prior to the onset of that year’s breeding season. The health and reproductive condition of sunfish from EFPC

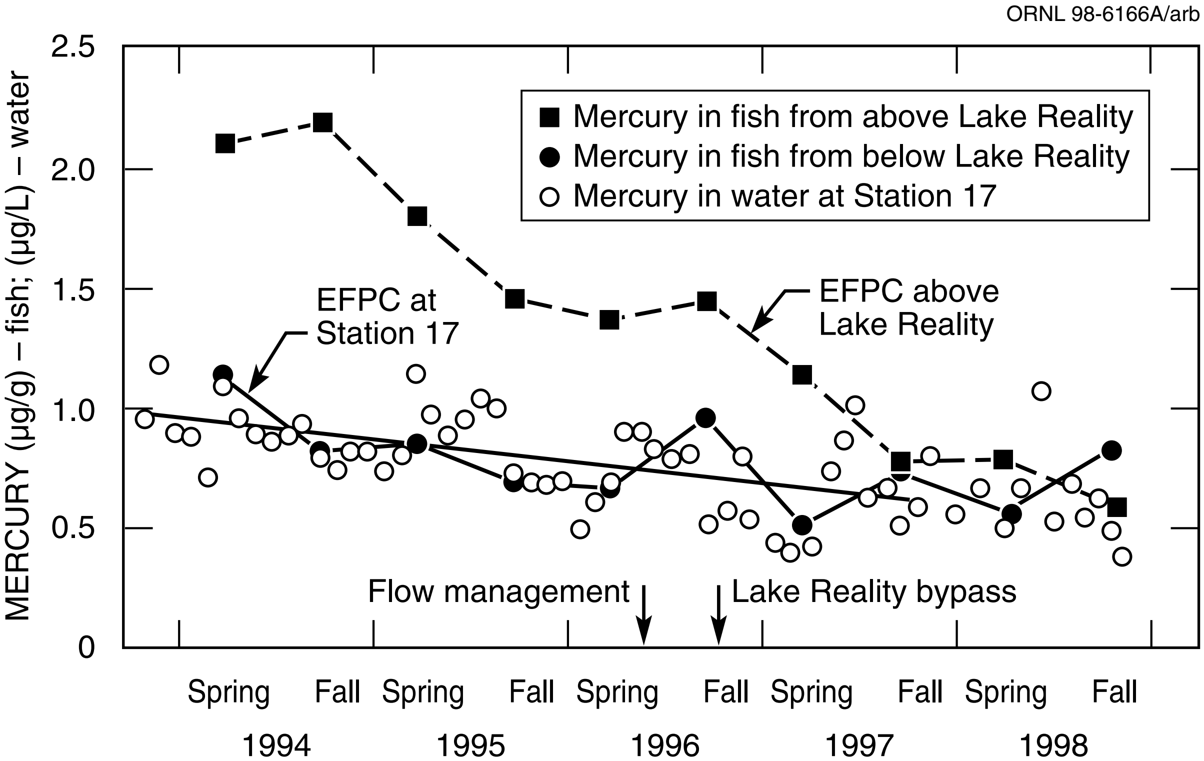

Fig. 6.9. Average mercury concentration in redbreast sunfish muscle fillets, East Fork Poplar Creek upstream and downstream of Lake Reality, and monthly average total mercury concentration in water at Station 17, 1994–98.

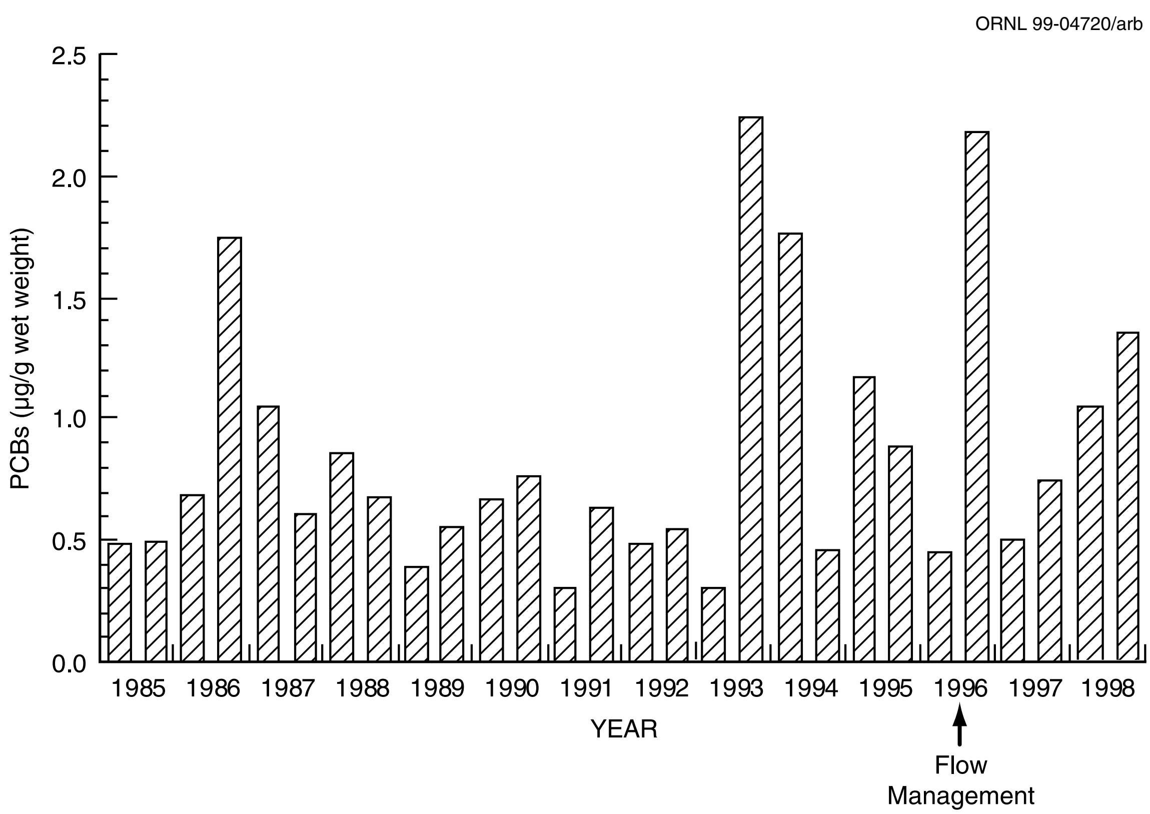

Fig. 6.10. Mean concentrations of PCBs in redbreast sunfish muscle fillets, East Fork Poplar Creek, upstream and downstream of Lake Reality, 1985–98.

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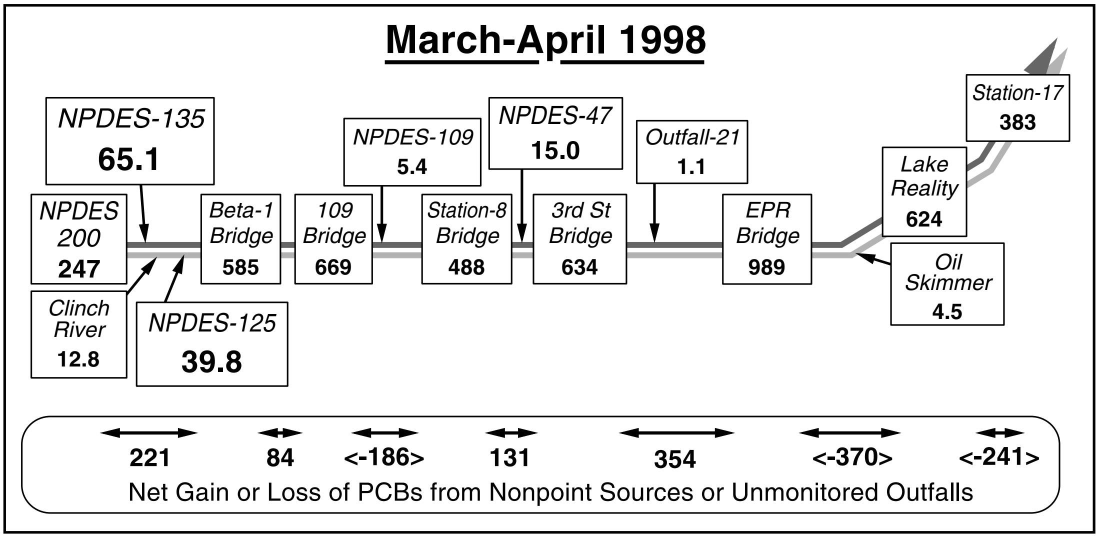

Fig. 6.11. The flux of bioavailable PCBs discharging from outfalls and within UEFPC, as measured in 1998 by SPMD technology. The bar at the bottom of each rectangle indicated the magnitude and location of PCB non-point sources or sinks (negative numbers).

sites upstream of Bear Creek Road continue to lag behind those of fish from reference sites and lower EFPC sites. One of the most widely used indicators of exposure to chemical contamination, the induction of detoxification enzyme systems in liver tissue, has shown little improvement in UEFPC over the last few years. However, overall trends in many other contamination-related bioindicators suggest that there has been a distinct improvement in overall fish health in UEFPC in recent years. For example, 1998 was the first year in ten years of sampling in which oocyte atresia (i.e., death of the developing immature eggs), although still occurring at a greater incidence in upper EFPC than in lower EFPC, did not significantly exceed atresia in fish from off-site reference streams.

It is clear from the results of toxicity testing and bioaccumulation studies that the exposure of aquatic organisms in upper EFPC to toxicants has been steadily decreasing as a result of remedial activities such as the implementation of flow management and continuing mercury reductions at the Y-12 Plant. However, flow management has had other measurable effects on EFPC in addition to decreasing concentrations of contaminants, including significantly increasing water flow and decreasing water temperatures. The apparent influences of these “non-pollution-related” consequences of flow management on the existing fish populations in upper EFPC are evident in the growth patterns of redbreast sunfish before and after flow management (Fig. 6.12). Growth, as indirectly represented in this figure by the mean lengths of fish in EFPC at several age categories, decreased significantly with the implementation of flow management, probably as a result of the decreased water temperatures altering the bioenergetics of the EFPC food chain. However, it should be noted that sunfish in EFPC remain larger than fish from reference sites, even after the decline associated with flow management.

Water sampled throughout the length of EFPC during 1998 remained toxic to developing fish embryos in the medaka embryo-larval test for developmental toxicity. The specific cause(s) for this toxicity has not 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 involved in or the by-products of chlorination/dechlorination water treatment procedures. Flow management has reduced, but not significantly removed, the toxicity of EFPC water to fish embryos as measured in the medaka developmental toxicity test (Fig. 6.13).

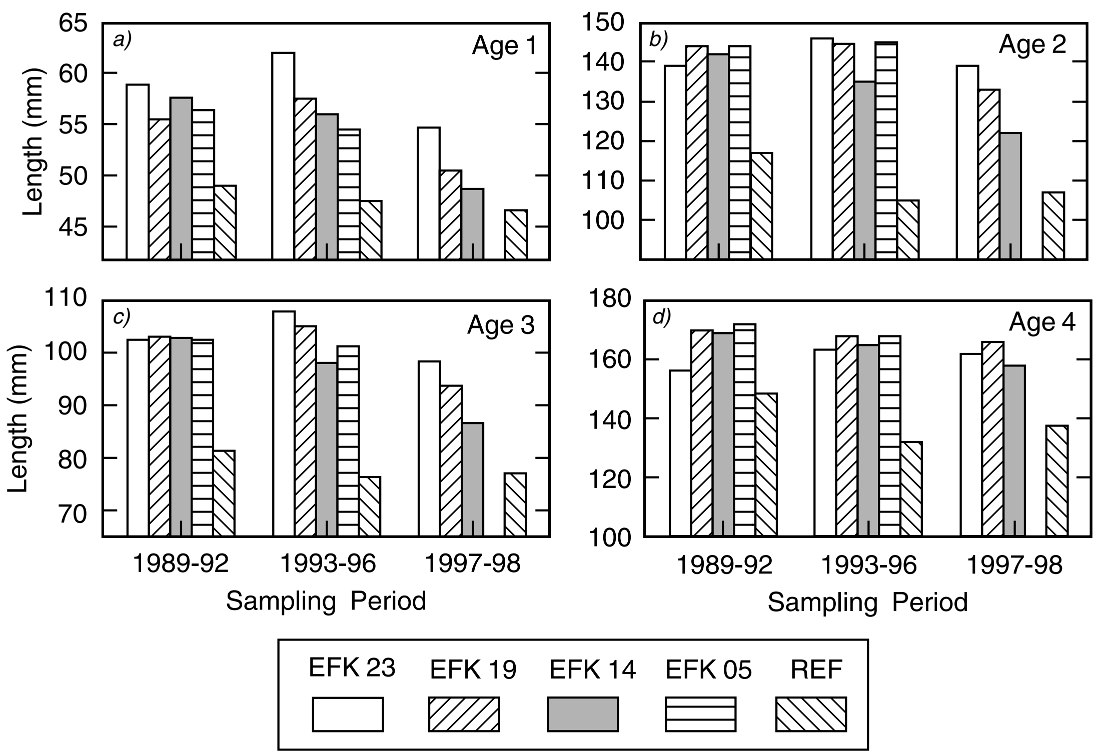

Fig. 6.12. The age-adjusted lengths of redbreast sunfish collected at various sites within EFPC and at a reference stream either before (1989–96) or after (1997–98) the implementation of flow management.

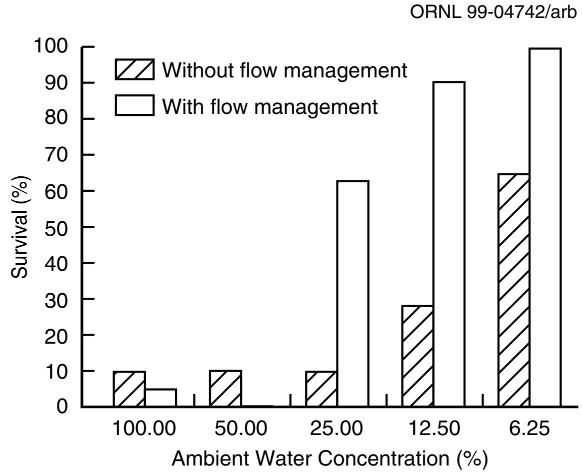

Fig. 6.13. Comparison of medaka embryo survival in grab samples of water collected from EFK 23.4 downstream of Lake Reality when flow management was either operational ("with flow management") or nonoperational ("without flow management"). "Without" sample collected on March 10, 1998; "with" sample collected on February 26, 1998.

6.7.4 Ecological Surveys and Fish Kill Results

Periphyton were monitored during 1998 at three sites along EFPC on a quarterly schedule. Algal biomass and photosynthetic rates measured remained elevated in EFPC in comparison with reference streams (Table 6.14). Concentrations of various nutrients measured concurrently with periphyton, including nitrate, ammonia, and phosphate, also continued to be higher in EFPC than in reference streams, although levels have dropped significantly at upstream sites (EFK 24.4 and EFK 23.4) from pre-flow-management levels. The chlorophyll-specific photosynthetic rate at EFK 23.4 was abnormally low throughout the year (Table 6.14), indicating an impairment of photosynthesis at this site. It is likely that this impairment is somehow related to the bypass of Lake Reality (i.e., from increased toxicity, sedimentation, water temperature, etc.).

Table 6.14. Means and standard errors for biomass, photosynthesis, and chlorophyll-specific photosynthesis rates of periphyton collected from East Fork Poplar Creek and Brushy Fork, July 16, 1998

Site	Algal biomass (μg chla/cm^2)	Photosynthesis (μgC/cm^2/h)	Chlorophyll-specific photosynthesis (μgC/μgchla/h)
EFK 24.4	41.2 ± 7.6	9.2 ± 0.9	0.24 ± 0.03
EFK 23.4	40.6 ± 5.1	6.6 ± 0.6	0.17 ± 0.01
EFK 6.3	15.3 ± 3.0	6.3 ± 0.4	0.44 ± 0.06
BFK 7.6	8.6 ± 1.7	2.4 ± 0.3	0.31 ± 0.07

Note: EFK = East Fork kilometer, BFK = Brushy Fork kilometer

Fish communities in EFPC were monitored twice in 1998 at six sites within EFPC and at two reference stream sites. Compared to previous years, the fish communities were significantly reduced at most locations within EFPC in the spring of 1998. Fish density values were down by as much as twofold at sites in upper EFPC (EFK 25.1 and EFK 23.4), with decreases being particularly evident in two of the dominant species, the central stoneroller (*Campostoma anomalum*) and the striped shiner (*Luxilus chrysocephalus*). Of particular concern were reductions in the numbers of sensitive fish species (Fig. 6.14) because their previously increasing numbers had documented a strong recovery of the fish communities in EFPC over the last several years. These declines were probably related to events of the summer of 1997, notably the fish kill and a record rainfall/flood event.

In contrast, upper EFPC fish communities appeared to be fully recovered from the recent population declines by fall 1998. Fish densities, in general, had returned to levels seen in the early 1990s in these fall monitoring results, with densities at EFK 24.4 being the highest ever measured. The recovery in the fish community in upper EFPC did involve a change in species dominance, with the blacknose dace (*Rhinichthys atratulus*) now the most common species. Whether this change in community structure is a result of the fish kill or just an acclimation of the fish community to the faster flows and cooler temperatures associated with flow management is uncertain. The fall density data also suggest that recovery of the benthic fish species, such as banded sculpin (*Cottus carolinae*) and snubnose darter (*Etheostoma simoterum*), is not progressing as quickly at most sites in EFPC.

Fish kill investigations are conducted in response to chemical spills, unplanned water releases, or when dead fish are observed in EFPC. The basic procedure for fish kill investigations is a survey of upper EFPC (above Bear Creek Road to the N/S Pipes), during which numbers and locations of dead, dying, and stressed fish are recorded. No significant fish kill occurred in EFPC during 1998.

Benthic macroinvertebrate communities were sampled for monitoring purposes from four sites in EFPC and from two reference streams in the fall and spring of 1998. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded through 1998 (Fig. 6.15). However, subtle but 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) appeared only minimally impacted relative to reference conditions.

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 best management practice (BMP). The Y-12 Environmental Compliance Organization staff monitor the sur-

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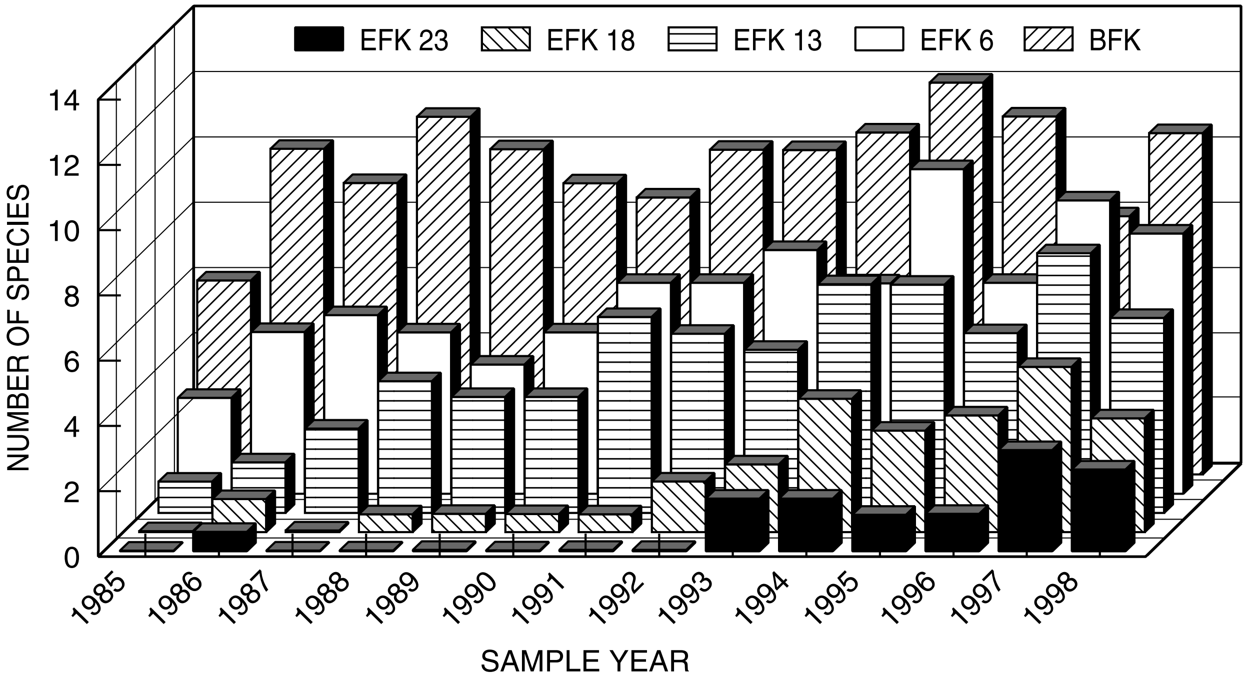

Fig. 6.14. Comparison of numbers of sensitive fish species collected during the spring of each year from 1985 through 1998 from four sites in EFPC and a reference site (Brushy Fork). EFK = East Fork Poplar Creek kilometer; BFK = Brushy Fork kilometer.

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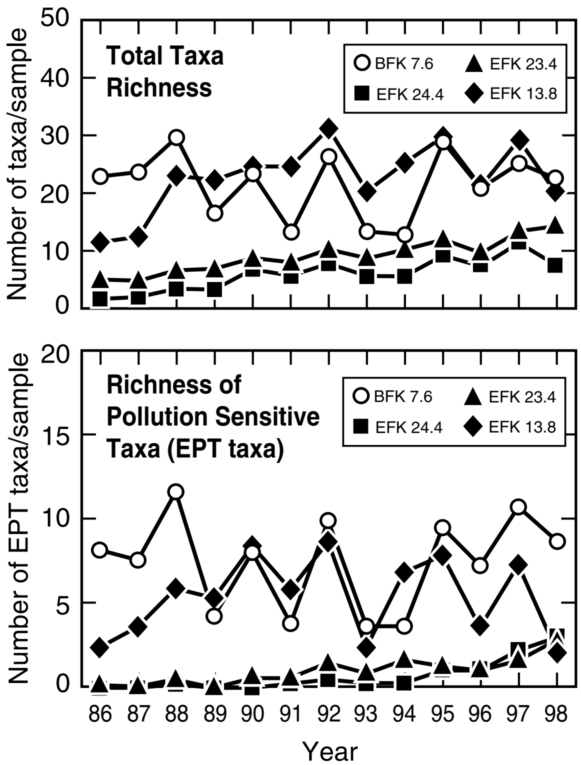

Fig. 6.15. Total taxonomic richness (mean number of taxa/sample, ± SE) and total taxonomic richness of the *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (mean number of EPT taxa/sample, ± SE) of the benthic macroinvertebrate communities in East Fork Poplar Creek (EFK) and a reference site (BFK 7.6) (EPT taxa include relatively pollution-sensitive species).

face water as it exits from each of the three hydrogeologic regimes that serve as an exit pathway for surface water (Fig. 6.16). The most recent modifications made to the routine BMP program (sampling frequency and number of parameters) were in the fall of 1996.

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-hour composites plus a 3-day weekend composite. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and total suspended solids (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 composite sample) is collected monthly for analysis for mercury, anions (sulfate, chloride, nitrate, nitrite), ICP metals, total phenols, and TSS.

The exit pathway from the Chestnut Ridge regime is monitored via NPDES location S19 (former NPDES Station 302) at Rogers Quarry. S19 is an instream location of McCoy Branch and is sampled monthly (a 24-hour composite) for ICP metals. The NPDES requirement for this location is to monitor and report metals data only. As part of the surface-water BMP surveillance activity, data from this location, as well as that from Station 17 and BCK 4.55, are compared with state water quality criteria.

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. 6.17. Not all stations are operated on a routine basis, but all are available as necessary.

For nonradiological parameters that are sampled, and detected above the analytical method reporting detection limit, the data are compared with Tennessee water quality criteria. 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

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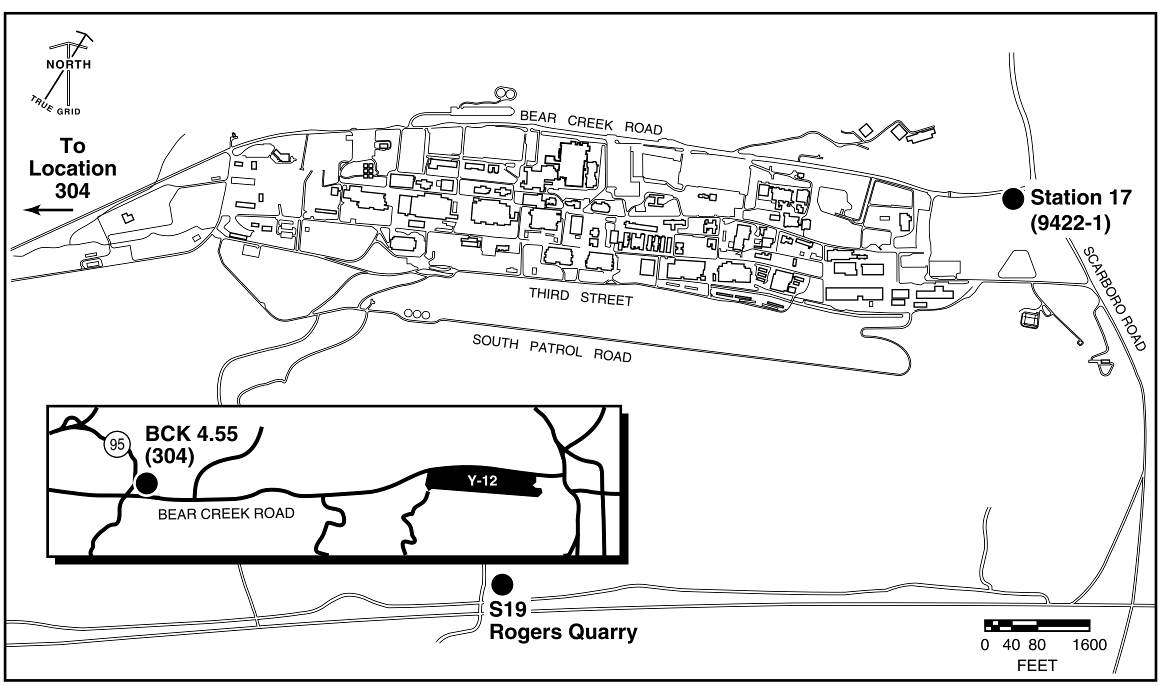

Fig. 6.16. Locations of Y-12 Plant surface water surveillance sampling stations.

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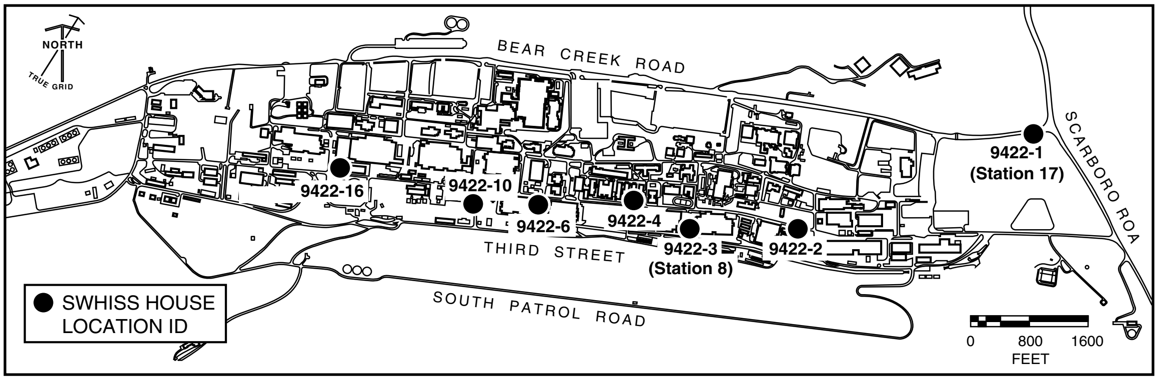

Fig. 6.17. Surface Water Hydrological Information Support System monitoring locations.

to achieve the lowest possible detection limit for all parameters.

More than 500 surface water surveillance samples were collected in 1998. Comparisons with Tennessee water quality criteria indicate that only silver, mercury, zinc, and copper from samples, collected at Station 17, were detected at values exceeding a criteria maximum. Results are shown in Table 6.15. Of all the parameters measured in the surface water as a BMP, mercury is the only demonstrated contaminant of concern (see "Reduction of Mercury in Plant Effluent: Phase II" in Sect. 6.5.5 for details on activities to reduce mercury discharges).

Additional surface-water sampling is conducted on Bear Creek in accordance with the Y-12 Plant Groundwater Protection Program (GWPP) to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 6.10).

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 best management practice, the Y-12 Plant maintains a 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 (December 1997) are given in Table 6.16. No samples were collected in calendar year 1998.

6.10 GROUNDWATER MONITORING AT THE Y-12 PLANT

6.10.1 Background and Regulatory Setting

Most of the groundwater monitoring at the Y-12 Plant is conducted within the scope of a single, comprehensive groundwater monitoring program, which included the following elements in 1998:

- monitoring to comply with requirements of Resource Conservation and Recovery Act (RCRA) Post-Closure regulations,
- compliance with TDEC solid waste management (SWM) regulations, and
- monitoring to support DOE Order 5400.1 requirements (exit pathway and surveillance monitoring).

Through incorporation of these multiple considerations, the comprehensive monitoring program at the Y-12 Plant addresses multiple regulatory considerations and technical objectives. It eliminates redundancy between different regulatory programs and ensures consistent data collection and evaluation.

Table 6.15. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Plant, 1998

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Av		
Mercury	Station 17	413	0.0002	0.0191	<0.001	0.00015	408
Silver	Station 17	148	0.02	<0.02	<0.008	0.0041	1
Copper	Station 17	148	0.02	0.0388	<0.01	0.0177[a]	13
Zinc	Station 17	148	0.05	0.15	0.04	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 6.16. Results of Y-12 Plant sediment monitoring

	Station 17	BCK 9.4
^{226}Ra (pCi/g)	2.8	2.4
^{228}Th (pCi/g)	0.97	0.70
^{230}Th (pCi/g)	1.2	0.41
^{232}Th (pCi/g)	0.73	0.68
^{234}U (pCi/g)	2.6	3.6
^{235}U (pCi/g)	0.13	0.20
^{238}U (pCi/g)	2.9	6.3
Mercury µg/g	9.5	0.3
Total PCBs µg/kg	370J	350J

J—The J flag of the PCB data indicates an estimated value below the analytical method reporting limit.

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. During the first quarter of 1998, these sites were being addressed by the Environmental Restoration (ER) Program and Y-12 Plant management (LMES). With the award by DOE-ORO of a management and integration (M&I) contractor, the responsibility for environmental management and groundwater issues under CERCLA and/or RCRA regulations and the Federal Facility Agreement (FFA) transitioned to Bechtel Jacobs for the remainder of 1998.

In 1992, a number of the inactive waste management sites were grouped into operable units (OUs) under CERCLA as part of an FFA negotiated between 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 remedial investigation/feasibility study (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. 6.18). 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 Bear Creek Valley (BCV) CA.

In addition, 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.

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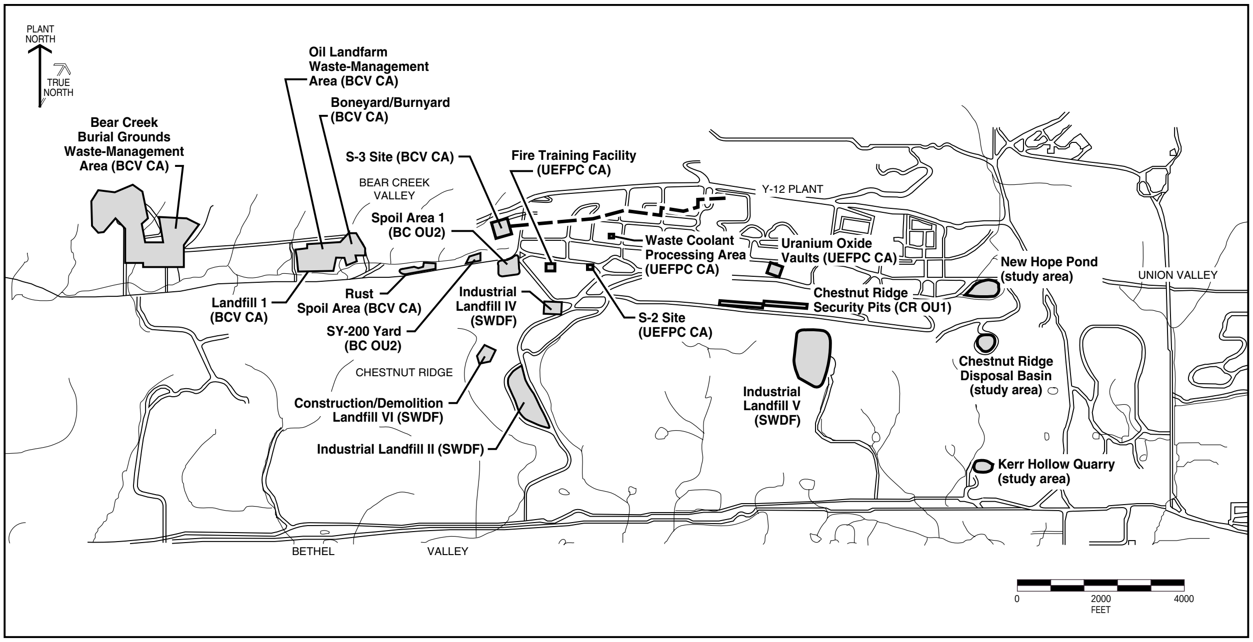

Fig. 6.18. Y-12 Plant inactive regulated units, study areas, and active facilities for which groundwater monitoring was conducted in CY 1998.

Post-Closure maintenance, monitoring, and reporting requirements of RCRA also apply to seven inactive CERCLA-regulated units that meet the definition of RCRA hazardous waste treatment, storage, disposal (TSD) facilities. These units include the S-3 Site, portions of the Bear Creek Burial Grounds, the Oil Landfarm, 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.

An additional primary regulatory driver for groundwater monitoring at the Y-12 Plant is the TDEC regulations governing nonhazardous solid waste disposal facilities (SWDFs). Two facilities (Centralized Sanitary 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). All of the active landfill sites are now under a semiannual detection monitoring program.

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.

6.10.2 Hydrogeologic Setting and Summary of Groundwater Quality

In the comprehensive monitoring program, 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 Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork regime), and the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge regime) (Fig. 6.19). Most of the Bear Creek and East Fork regimes are underlain by the ORR aquitards. The extreme southern portion of these two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer.

In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek and East Fork 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 Upper East Fork Poplar Creek 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 BCV to the north.

In BCV, 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 BCV 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 East Fork regime. In the Bear Creek regime, strike-parallel transport of some contaminants can occur within the ORR aquitards for significant distances. Continuous elevated levels of nitrate within the ORR aquitards are now known to extend west from the S-3 Site for a distance of about 3000 ft, approximately twice the previous estimates. Volatile organic compounds (VOCs) at source units in the ORR aquitards, however, tend to remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport for long distances can occur.

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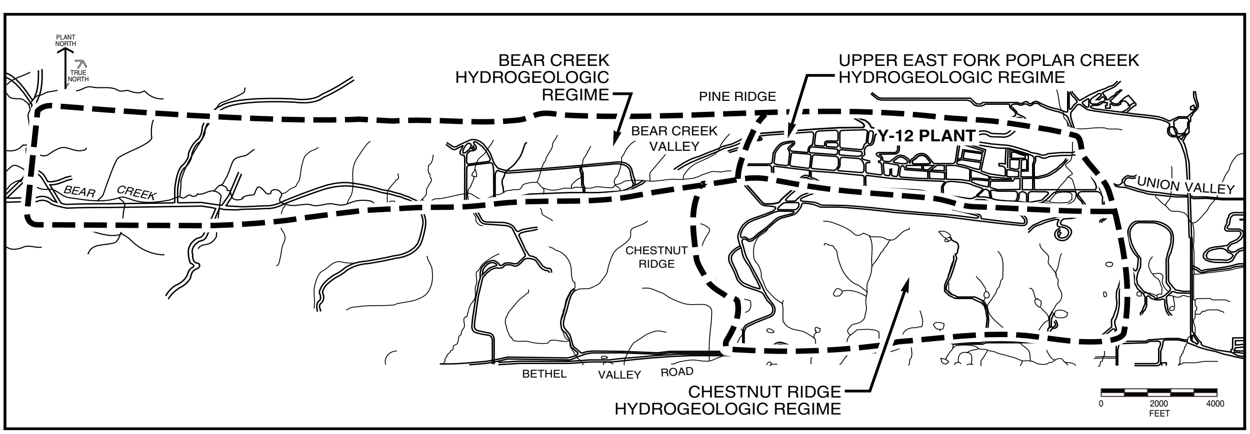

Fig. 6.19. Hydrogeologic regimes at the Y-12 Plant.

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

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, although data obtained since 1988 show that the extent of some radionuclides, particularly ^{99}Tc is also significant, particularly in the Bear Creek regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the west 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 possibly ^{99}Tc) are no longer easily associated with a single source.

6.10.3 1998 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices are routinely used for groundwater data collection at the Y-12 Plant. Monitoring wells are permanent devices used for collection of groundwater samples; these are installed according to established regulatory and industry specifications. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of polyvinyl chloride (PVC) or other low-cost materials. Other devices or techniques are sometimes employed to gather data, including well points and push probes.

No new monitoring wells were installed in CY 1998 for compliance monitoring. However, a total of 56 characterization wells and piezometers were installed or upgraded at the Y-12 Plant. In the Boneyard/Burnyard Area of the Bear Creek regime, 40 piezometers were installed as part of accelerated remedial actions (CERCLA). Eleven wells and piezometers were installed and two wells were upgraded near the Oil Landfarm Waste Management Area as part of the site characterization activity for the proposed Oak Ridge Reservation CERCLA waste disposal cell, the Environmental Management Waste Management Facility (EMWMF). One well (GW-845) was installed at the east end of the East Fork regime in support of a focused remedial action. Two wells were installed at the west end of the Bear Creek Regime to support hydrogeologic studies being performed by ORNL research personnel.

Under the Y-12 Plant Groundwater Protection Program (GWPP), well plugging and abandonment activities are conducted as part of an overall program to maintain the Y-12 Plant monitoring well network. Wells that are damaged beyond rehabilitation, that interfere with planned construction activities, or from which no useful data can be obtained are selected for plugging and abandonment. In 1998, 10 wells were plugged and abandoned.

6.10.4 1998 Monitoring Program

Groundwater monitoring in 1998 addressed multiple requirements from regulatory drivers and DOE orders. Table 6.17 contains a summary of monitoring activities conducted by the Y-12 Plant GWPP, as well as the programmatic requirements that apply to each monitored site. Figure 6.20 shows the locations of ORR perimeter groundwater monitoring stations as specified in the Environmental Monitoring Plan (EMP).

Detailed data reporting for monitoring activities conducted by the Y-12 Plant GWPP is contained within the annual groundwater monitoring report (LMES 1999b). Details of monitoring efforts performed outside the scope of the comprehensive monitoring program, specifically for CERCLA OUs, are published in remedial investigation (RI) reports. Other groundwater monitoring in support of CERCLA activities is performed by the Integrated Water Quality Program (IWQP) (DOE 1998e). Information about IWQP monitoring is reported in the annual Remediation Effectiveness Report (DOE 1999).

Table 6.17. Summary of the Comprehensive Groundwater Monitoring Program at the Y-12 Plant, 1998[a]

Hydrogeologic regime/waste disposal site	Requirements[b]	Number of wells/locations
Bear Creek Hydrogeologic Regime		
Bear Creek Springs	EXP	4
Bear Creek Surface Water	EXP	8
Maynardville Limestone	EXP/RCRA-CM	17
Oil Landfarm	RCRA-CM/SMP	5
Rust Spoil Area	SMP	1
S-3 Site	RCRA-CM	2
Spoil Area I	SMP	1
Y-12 Burial Grounds	RCRA-CM/SMP	5
East Fork Poplar Creek Hydrogeologic Regime		
Maynardville Limestone	EXP/RCRA-CM	17
Scarboro Road north of the Y-12 Plant	EXP	3
S-3 Site Eastern Plume	RCRA-CM	1
Y-12 Plant	SMP	29
–Active facilities		
–S-2 Site		
–Fire Training Facility		
–Beta-4 Security Pits		
–Grid Network		
–Coal Pile Trench		
–Building 9202		
–Building 9201-2		
–Waste Coolant Processing Facility		
New Hope Pond	EXP/SMP	5
UEFPC Diversion Channel	EXP	1
UST Tank T2331	RCRA-CM	1
Chestnut Ridge Hydrogeologic Regime		
Springs	EXP	5
Chestnut Ridge Security Pits	RCRA-CM	4
Kerr Hollow Quarry	RCRA-DM	5
Landfill II	SWDF	3
Landfill IV	SWDF	5
Landfill V	SWDF	5
Landfill VI	SWDF	4
Sediment Disposal Basin	RCRA-DM	4

[a]Baseline analytical parameters include ICP metals scan; U (total), thallium, Pb, Cd, Sb, Se and As by plasma mass spectroscopy; Hg; VOCs; major anions; gross alpha; gross beta; pH; conductance; TSS; TDS; turbidity; and standard field parameters, including dissolved oxygen, water level, pH, temperature, conductance, and redox potential. RCRA corrective action monitoring in the Bear Creek regime includes ^{241}Am, ^{129}I, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, total radium, total strontium, ^{99}Tc, ^{3}H, ^{234}U, ^{235}U, and ^{238}U. RCRA corrective action monitoring in the East Fork regime includes ^{99}Tc. Analyte lists for some sites were tailored to meet specific programmatic, technical, or regulatory requirements.

[b]EXP = exit-pathway or perimeter monitoring under DOE Order 5400.1; RCRA-DM = RCRA Detection Monitoring; RCRA-CM = RCRA postclosure corrective action monitoring; SMP = DOE Order 5400.1 surveillance monitoring; SWDF = monitoring for solid waste disposal facilities under TDEC Rule 1200-1-7.04

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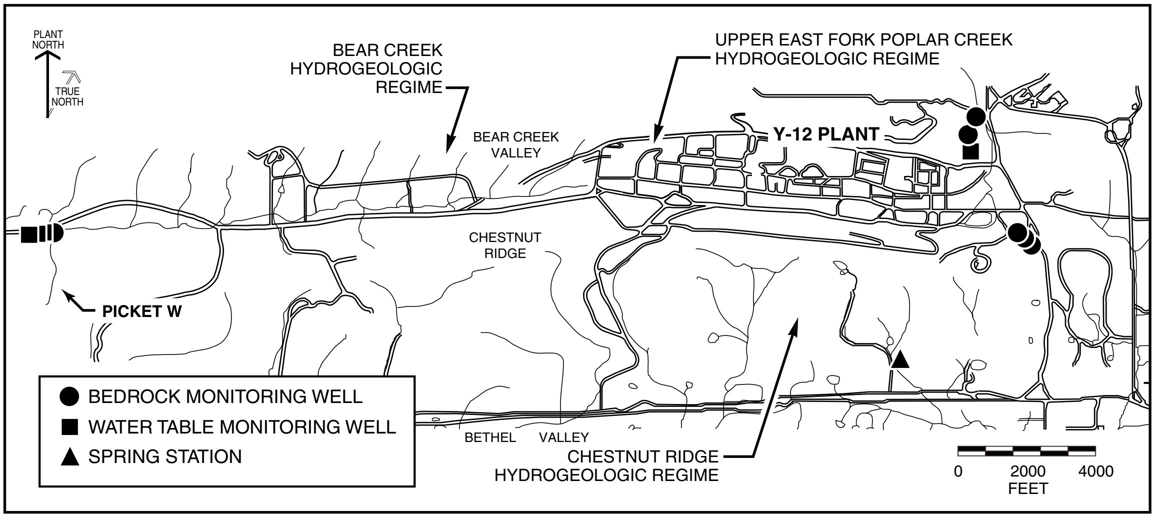

Fig. 6.20. Locations of ORR perimeter surveillance wells and multiport monitoring wells specified in the Environmental Monitoring Plan (Rev. 3).

In 1998, a change was made in groundwater monitoring well sampling methods. 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 stagnant water from the well casing. Concerns that the aggressive pumping required to perform this method of sampling [1.5 gallons per minute (5.7 liters per minute)] was inducing or accelerating contaminant transport, and a desire to minimize waste volumes, 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 milliliters per minute). 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. Where a marked decrease is observed, as with VOC concentrations in Well GW-763, the contaminants are no longer being pulled to the well by sampling-induced flow (Fig. 6.21). Where a marked increase in contaminant concentration is observed, as with VOC concentrations in Well GW-627 (Fig. 6.22), 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.

6.10.5 Y-12 Plant Groundwater Quality

6.10.5.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The 1998 monitoring locations and waste management sites in the East Fork regime that are addressed in this document are shown in Fig. 6.23. The regulatory status and a brief description of waste management sites in the East Fork regime are summarized in Table 6.18.

The East Fork regime contains the UEFPC CA, which consists of source units, surface water, and groundwater components of the hydrogeologic system within the East Fork regime and Union Valley to the east of the Y-12 Plant. Numerous sources of contamination to both surface water and groundwater exist within the plant area. Chemical constituents from the S-3 Site (primarily nitrate and technecium) dominate groundwater contamination in the western portion of the UEFPC CA. In addition to potential surface water and groundwater contamination sources identified

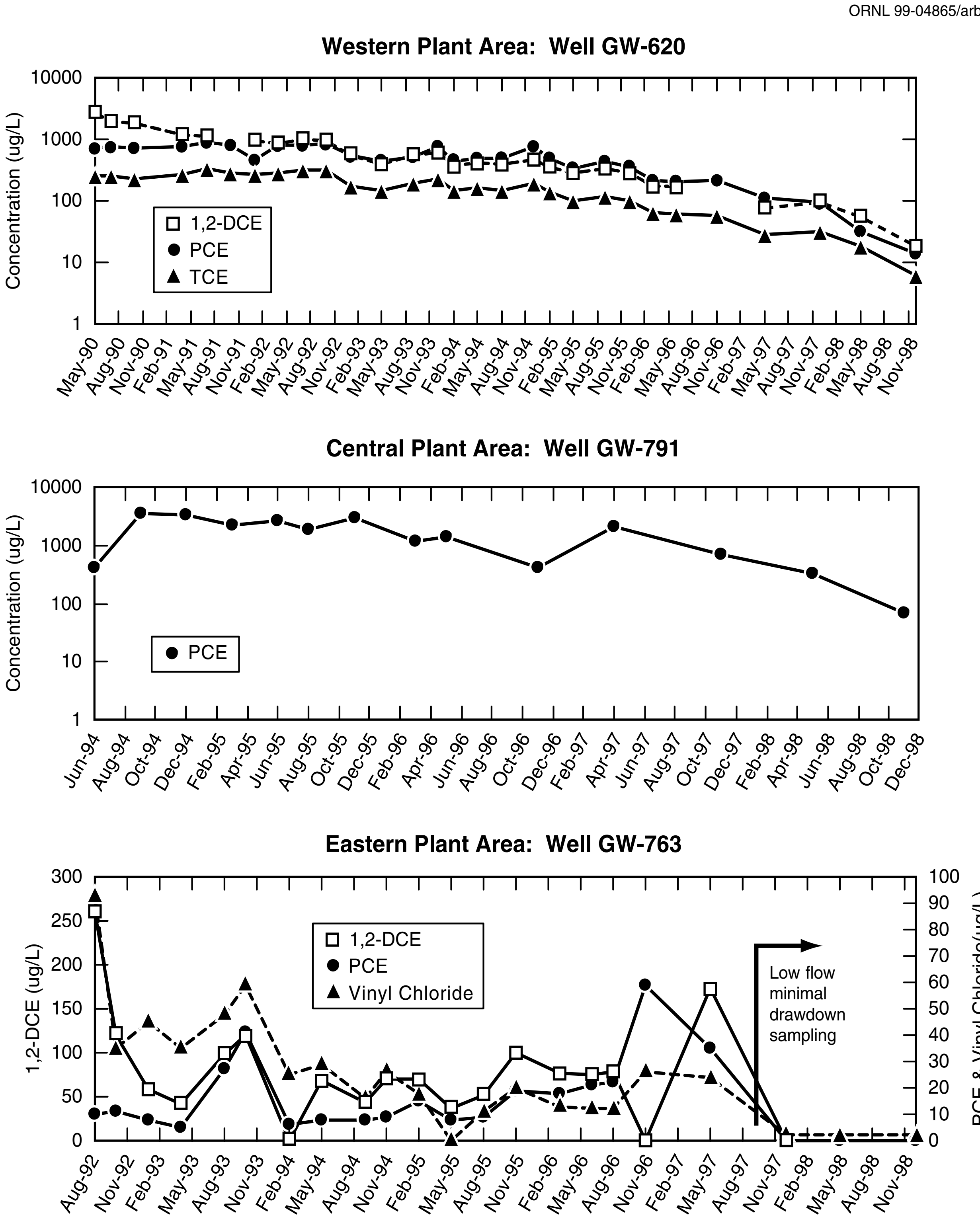

Fig. 6.21. VOC concentrations in groundwater in selected wells in the East Fork regime.

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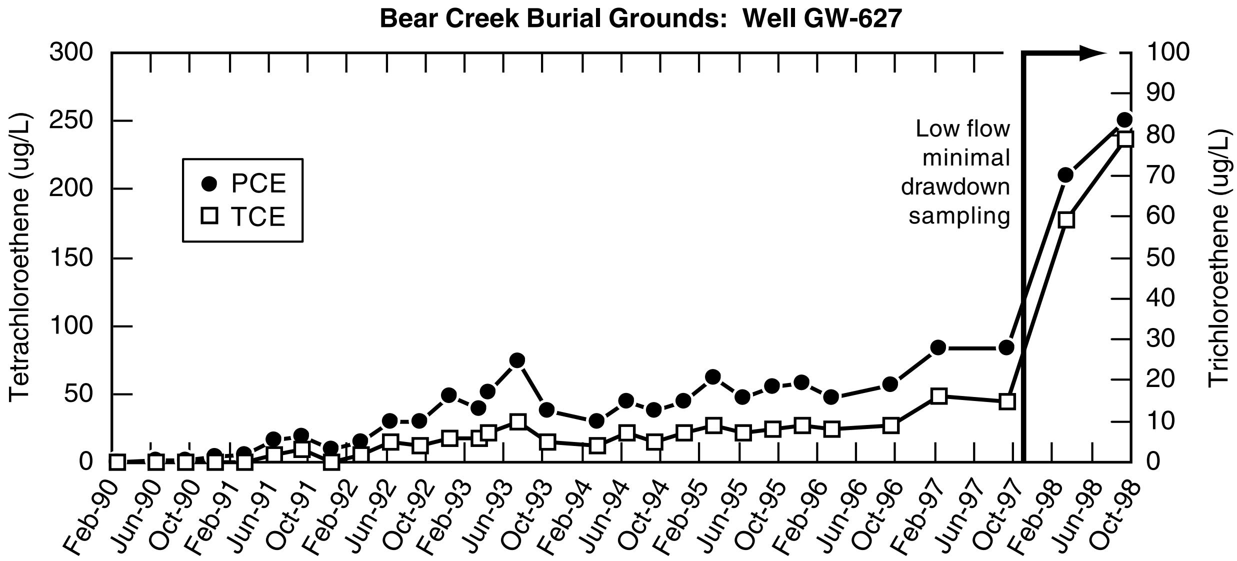

Notes: PCE and TCE MCL = 5 ug/L

Fig. 6.22. VOC concentrations in Bear Creek Burial Grounds Well GW-627.

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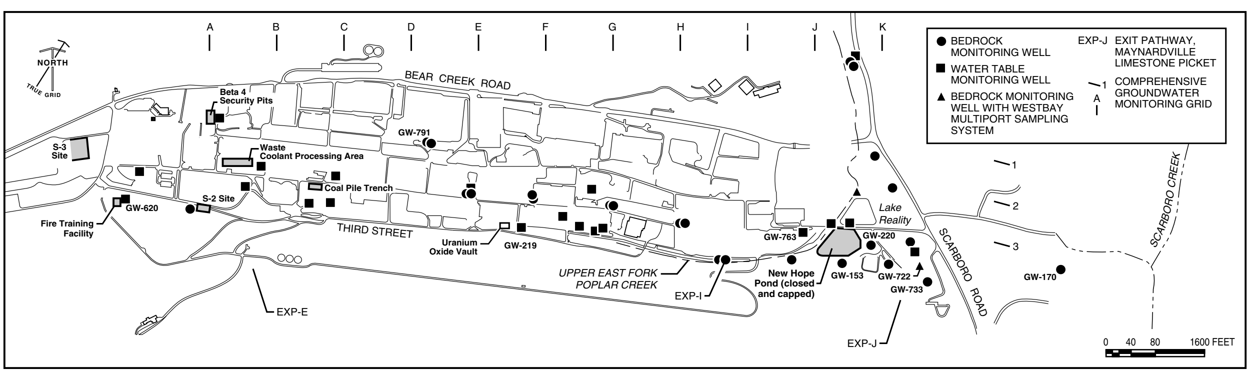

Fig. 6.23. Locations of waste management sites and monitoring wells sampled during 1998 in the Upper East Fork Poplar Creek Hydrogeologic Regime.

as OUs, a majority of the Y-12 Plant study areas are within the East Fork regime. Potential surface-water contamination associated with the storm sewer system and East Fork mercury-use areas is of primary interest and will also be addressed in the UEFPC CA RI/FS.

Discussion of Monitoring Results

The objectives of the 1998 groundwater monitoring program in the East Fork regime were to (1) further define contaminant nature and extent; (2) evaluate potential contaminant exit pathways for CERCLA, RCRA Post-Closure, and DOE order technical objectives; and (3) evaluate the trends of contaminant levels over time.

Plume Delineation

As denoted in previous ORR ASERs, the primary groundwater contaminants in the East Fork regime are nitrate, VOCs, trace metals, and radionuclides. Sources of these contaminants monitored during 1998 are the S-2 Site, the Fire Training Facility, the S-3 Site, the Waste Coolant Processing Facility, the 9418-3 Uranium Oxide

Table 6.18. Regulatory status and operational history of waste management units and underground storage tanks included in the 1998 Comprehensive Groundwater Monitoring Program; Upper East Fork Poplar Creek Hydrogeologic Regime

Site	Historical/current regulatory classification[a]	Historical data
New Hope Pond	TSD/Study Area	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	SWMU/UEFPC OU2	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	SWMU/UEFPC CA	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	SWMU/UEFPC CA	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	SWMU/UEFPC CA	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area.
Salvage Yard Drum Deheader Facility	SWMU/UEFPC CA	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	NA/UEFPC CA	Staging facility. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury.
Interim Drum Yard	SWMU/Study Area	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	UST/Study Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented.
Garage Underground Tanks	SWMU/Study Area	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.

Table 6.18 (continued)

Site	Historical/current regulatory classification[a]	Historical data
9418-3 Uranium Oxide Vault	NA/UEFPC CA	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of non-enriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism
Fire Training Facility	SWMU/UEFPC CA	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	SWMU/Study Area	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	UST/UEFPC CA	Used from 1973 to 1988. Tank removed in 1988. Tank used to store gasoline. Primary release mechanism to groundwater is infiltration.
S-2 Site	SWMU/UEFPC CA	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater.
Waste Coolant Processing Area	SWMU/UEFPC CA	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	SWMU/UEFPC CA	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater.

[a]Regulatory status before the 1992 Federal Facility Agreement: TSD-RCRA—regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; and UST—petroleum underground storage tank. Current regulatory status: study area—Y-12 Plant study area; UEFPC CA—Upper East Fork Poplar Creek Characterization Area.

Vault, petroleum underground storage tanks (USTs), and process/production buildings in the plant. Although it is located west of the current hydrologic divide that separates the East Fork regime from the Bear Creek regime, the S-3 Site has contributed to groundwater contamination in the western part of the regime during its operation.

Nitrate

Nitrate concentrations in groundwater at the Y-12 Plant exceed the 10 mg/L maximum drinking water contamination level [a complete list of drinking water standards (DWSs) is presented in Appendix D] in a large part of the western portion of the East Fork regime (Fig. 6.24). 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. In both zones of the aquitards, the nitrate plume extends about 4000 ft (1219 m)

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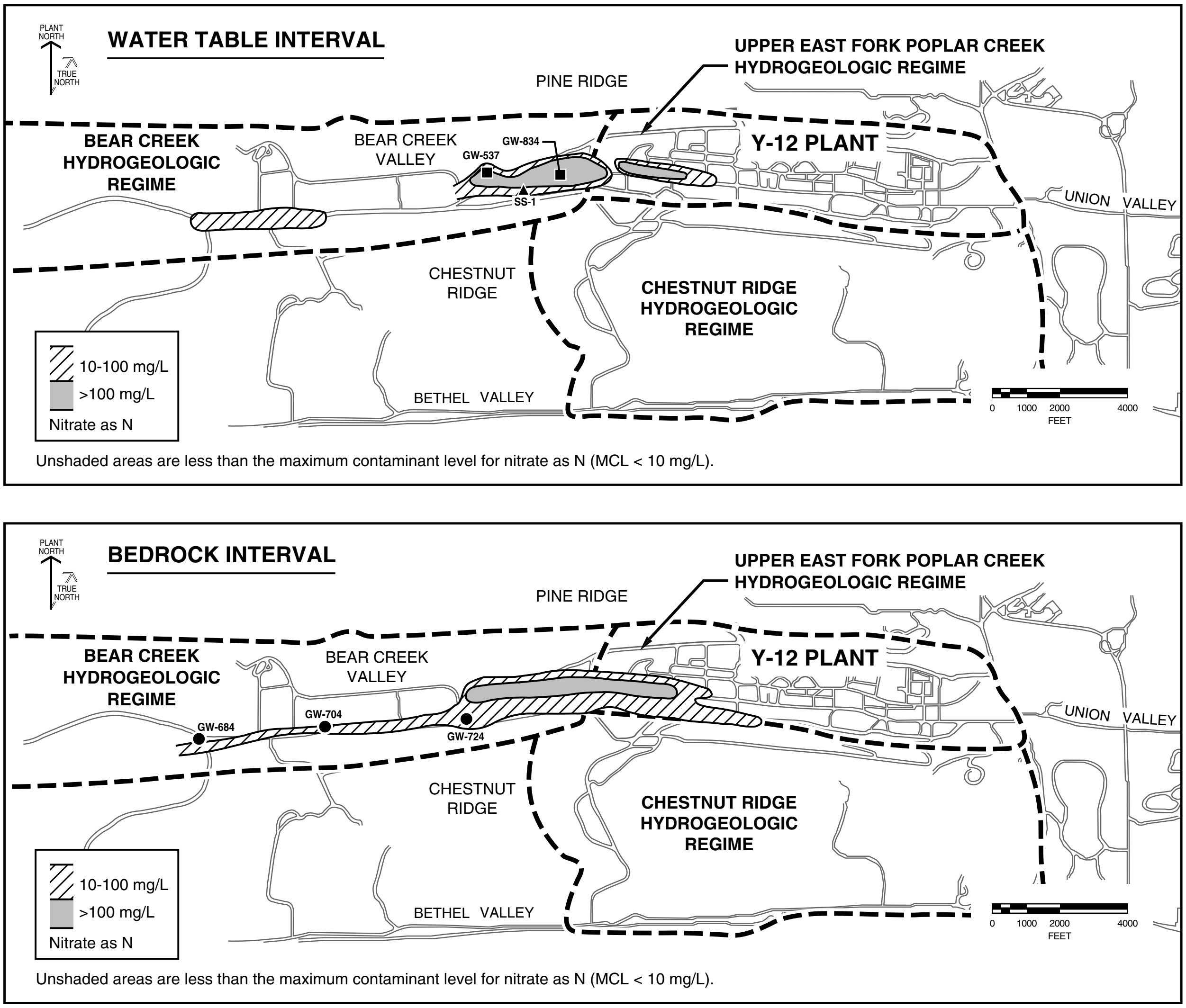

Fig. 6.24. Nitrate (as N) observed in groundwater at the Y-12 Plant.

eastward from the S-3 Site. Nitrate has traveled farthest, approximately 5000 ft (1524 m), in groundwater in the Maynardville Limestone. Although the nitrate plume is dispersing and moving eastward, concentrations near the source have been trending downward since disposal operations ceased and the site was closed and capped in the late 1980s.

Trace Metals

Concentrations of barium, cadmium, chromium, lead, nickel, and selenium exceeded DWSs during 1998 in samples collected from various monitoring wells at the S-2 Site, the S-3 Site, central and eastern plant grid locations, exit pathway wells, and upgradient of New Hope Pond. Elevated concentrations of these metals were most commonly reported for groundwater 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. The highest concentrations of dissolved chlorinated solvents (about 12 mg/L) are found at the Waste Coolant Processing Area and Y-12 Salvage Yard. The highest dissolved concentrations of petroleum hydrocarbons (about 60 mg/L) occur in groundwater near the Rust Garage Area.

Concentrations of chlorinated VOCs in the vicinity of source areas have remained relatively constant or have decreased since 1988 (Fig. 6.21). Within the exit pathway on the east end of the regime, some monitoring locations (e.g., GW-220) east of New Hope Pond have shown increasing VOC concentrations, indicative of an easterly movement of part of the plume (Fig. 6.25). Some wells south and west of New Hope Pond (e.g., GW-606 and GW-153) continue to show a shallow decreasing concentration trend, while wells located farther to the east (GW-733 and GW-170) show a static or stable trend. 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. 6.26).

The 1998 monitoring results generally confirm findings from the previous 7 years of monitoring. A continuous dissolved VOC plume in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime (Fig. 6.27). The primary sources are the

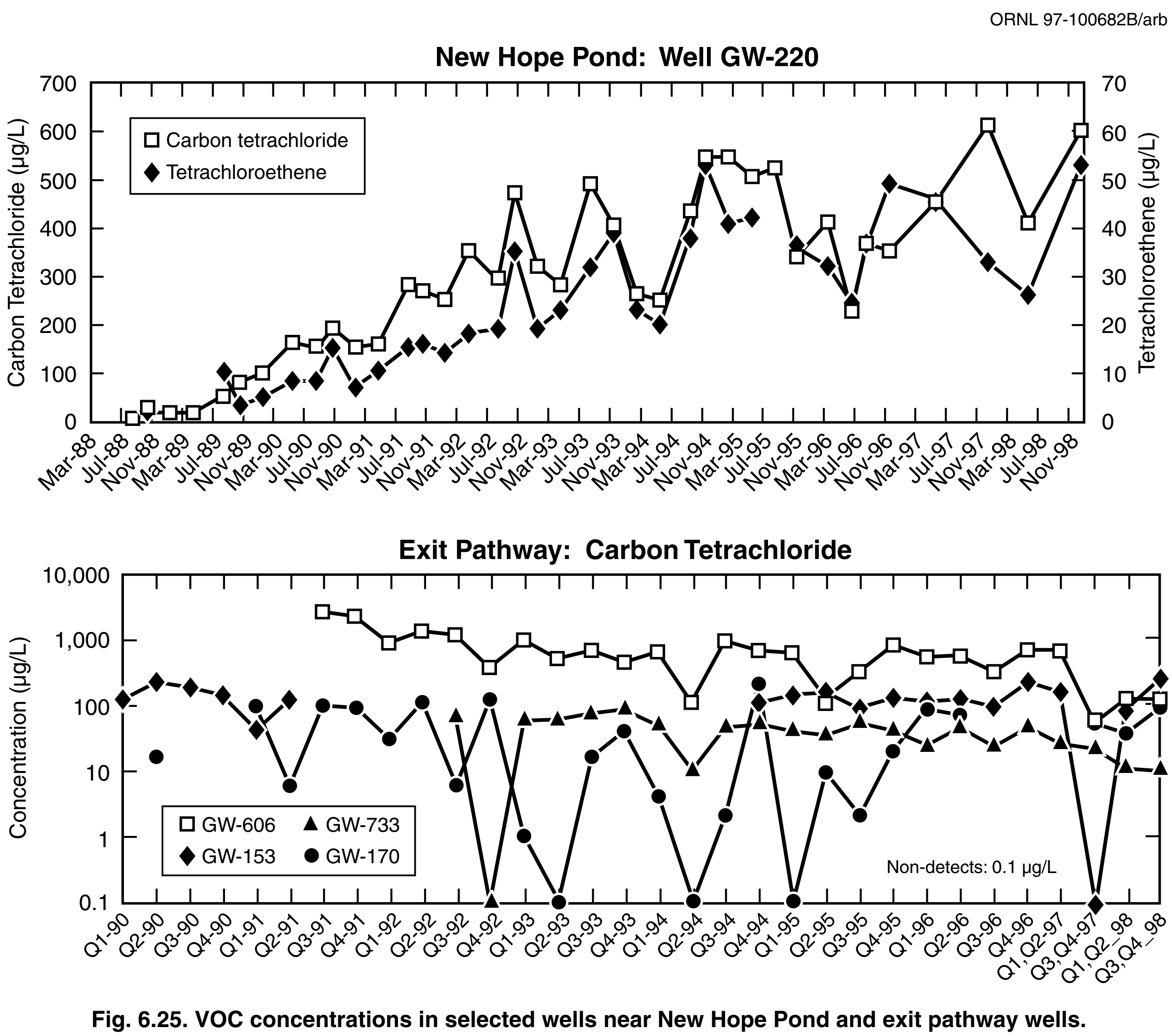

Fig. 6.25. VOC concentrations in selected wells near New Hope Pond and exit pathway wells.

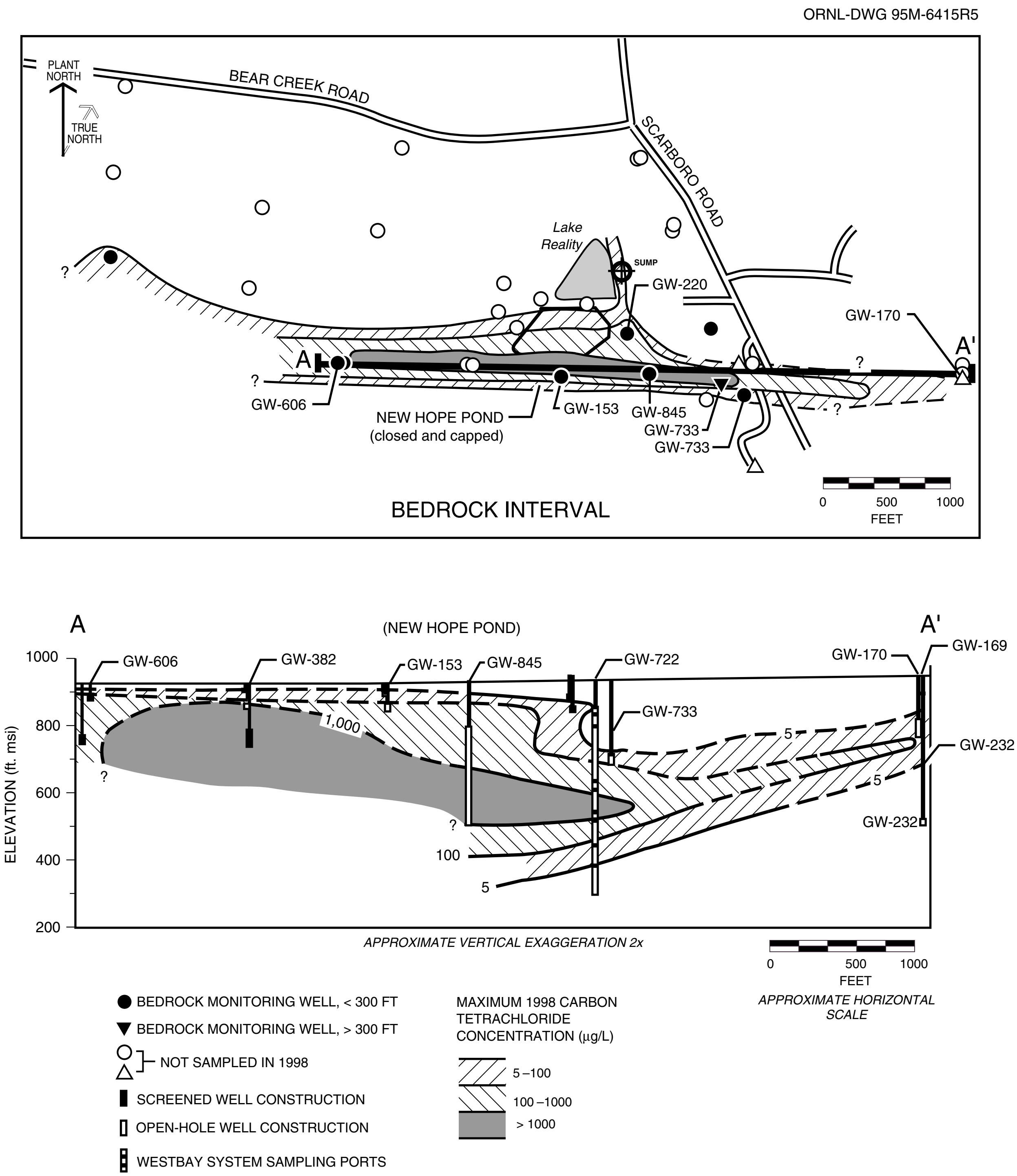

Fig. 6.26. Maximum carbon tetrachloride concentrations in Maynardville Limestone at depths between 200 and 500 ft, 1998.

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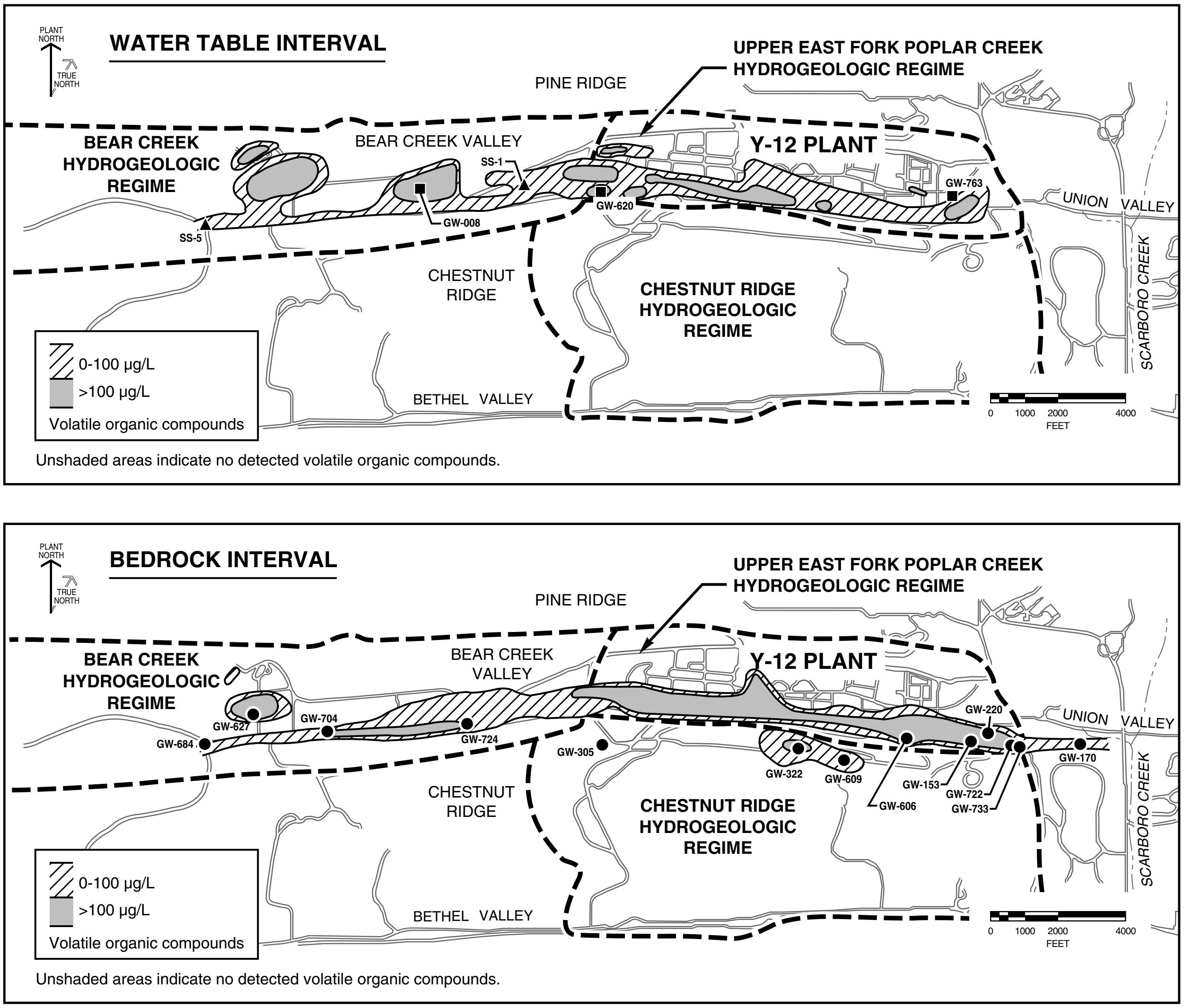

Fig. 6.27. Summed volatile organic compounds in groundwater at the Y-12 Plant.

Waste Coolant Processing Facility, the Building 9754 and 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 uranium, radium, neptunium, and americium. The primary beta-emitting radionuclide is technetium. Groundwater with gross alpha activity greater than 15 pCi/L occurs in scattered areas throughout the East Fork regime (Fig. 6.28). Historical data show that gross alpha activity that consistently exceeds the DWS (annual average activity level of 15 pCi/L) is most extensive in groundwater in the unconsolidated 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

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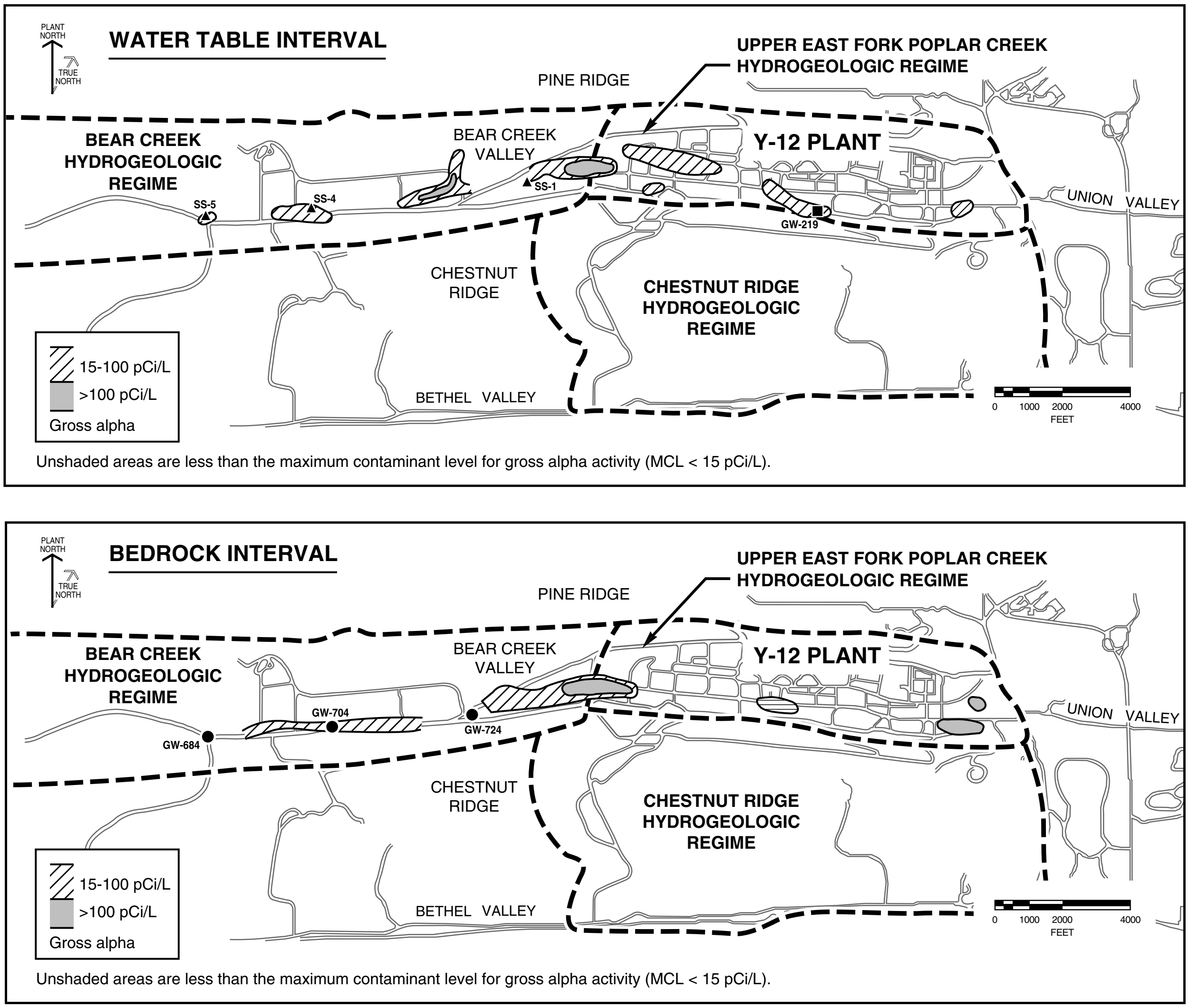

Fig. 6.28. Gross alpha activity in groundwater at the Y-12 Plant.

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. 6.29). 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.

Exit Pathway and Perimeter Monitoring

Exit pathway groundwater monitoring activities in the East Fork regime in 1998 involved continued collection and trending of data from exit pathway monitoring stations. In addition, data collected under the scope of the UEFPC RI were integrated into evaluations of contaminant exit pathways. The RI effort included sampling of springs, seeps, surface water, and wells in Union Valley and a few selected locations within the Y-12 Plant. Surface water quality in UEFPC is regularly monitored in accordance with NPDES permits.

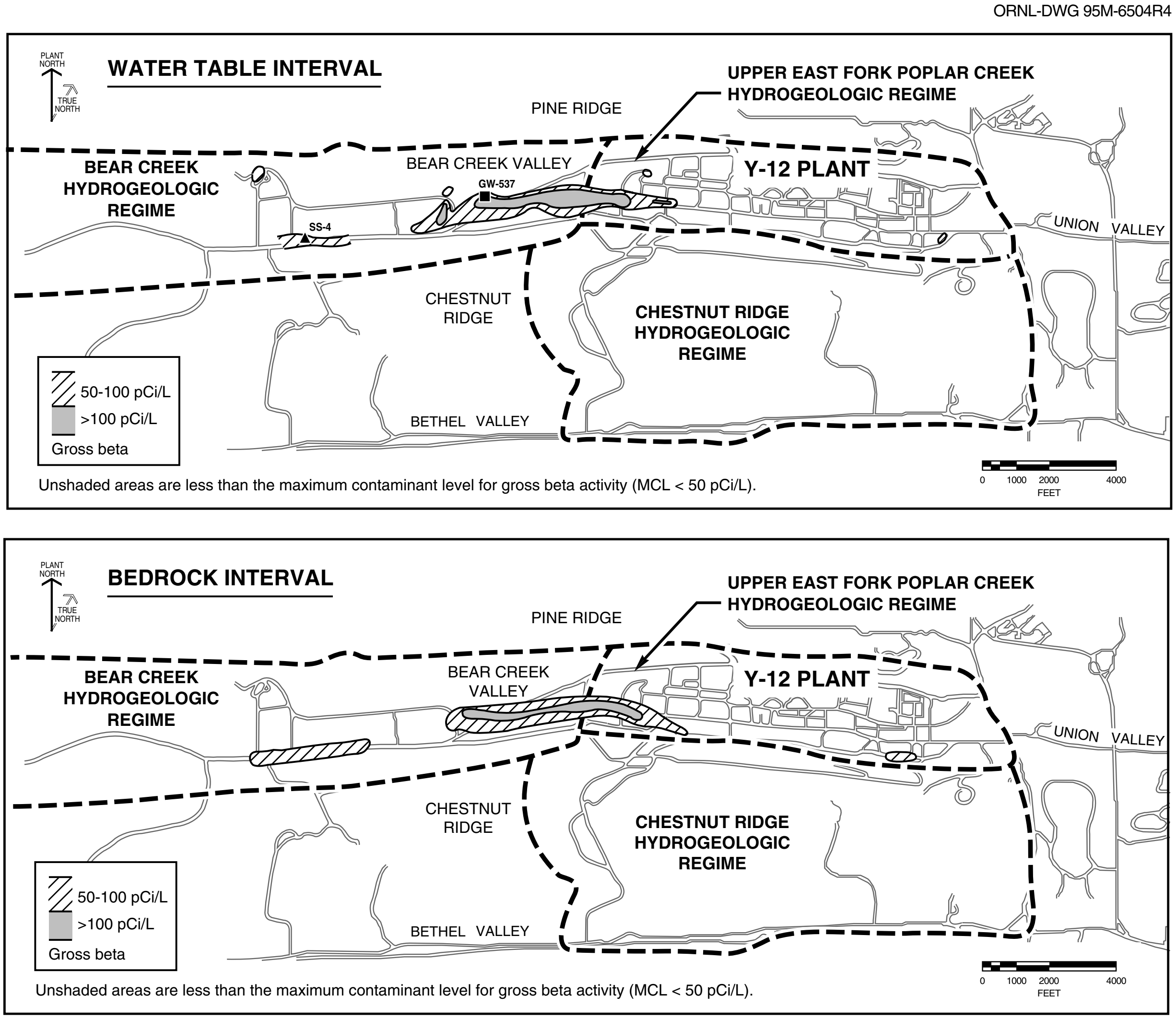

Fig. 6.29. Gross beta activity in groundwater at the Y-12 Plant.

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. 6.26. An aerial distribution of VOCs is shown in Fig. 6.27. 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, the majority of the VOCs are more dense than water; therefore, they tend to migrate downward within the subsurface. The deep fractures and solution channels that constitute flowpaths within the Maynardville Limestone appear to be well connected. The characteristics of the flowpaths 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 wells near the eastern ORR boundary for this exit pathway (Fig. 6.20).

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 Upper East Fork Poplar Creek.

Groundwater movement and contaminant migration along the diversion channel also appear to be accelerated by the effects of Lake Reality under-drain dewatering activities. At the dewatering sump (Fig. 6.26), 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 1998, the observed VOC concentrations at LRSPW were stable.

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.

6.10.5.2 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 1998, monitoring of locations in Union Valley continued under the IWQP (DOE 1998e). These 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. 6.27) 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 record of decision (IROD), administrative controls, such as restriction of 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.

6.10.5.3 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Plant in BCV, 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 6.30 and 6.31 show the Bear Creek regime, locations of stations sampled in 1998, and the locations of its waste management sites. The BCV CA lies within the regime and includes all source units, groundwater, surface water, and soils/sediments, with the exception of the SY-200 Yard and Spoil Area 1, which are addressed by a CERCLA ROD issued in 1996. The regulatory status and a brief description of waste management sites in the Bear Creek Regime are summarized in Table 6.19.

Characterization of the nature and extent of contamination in the regime is essentially complete. A CERCLA RI report has been finalized and approved by TDEC and EPA. The RI report contains a detailed description of site history, nature and extent of contamination, and human health and ecological risk assessments and is now available for public use.

As the next step in the CERCLA process, remedial actions under the scope of a feasibility study will be evaluated and initiated where sufficient data exist to identify acceptable alternatives. Where data gaps exist preventing full evaluation of remedial alternatives, focused studies with limited scopes and short durations will be completed to obtain the specific data required to fully evaluate potential remedial actions.

Currently, the focus of monitoring efforts is RCRA Post-Closure corrective action monitoring, exit pathway monitoring, and surveillance of contaminant plume boundaries. These objectives were met by sampling of a monitoring network of

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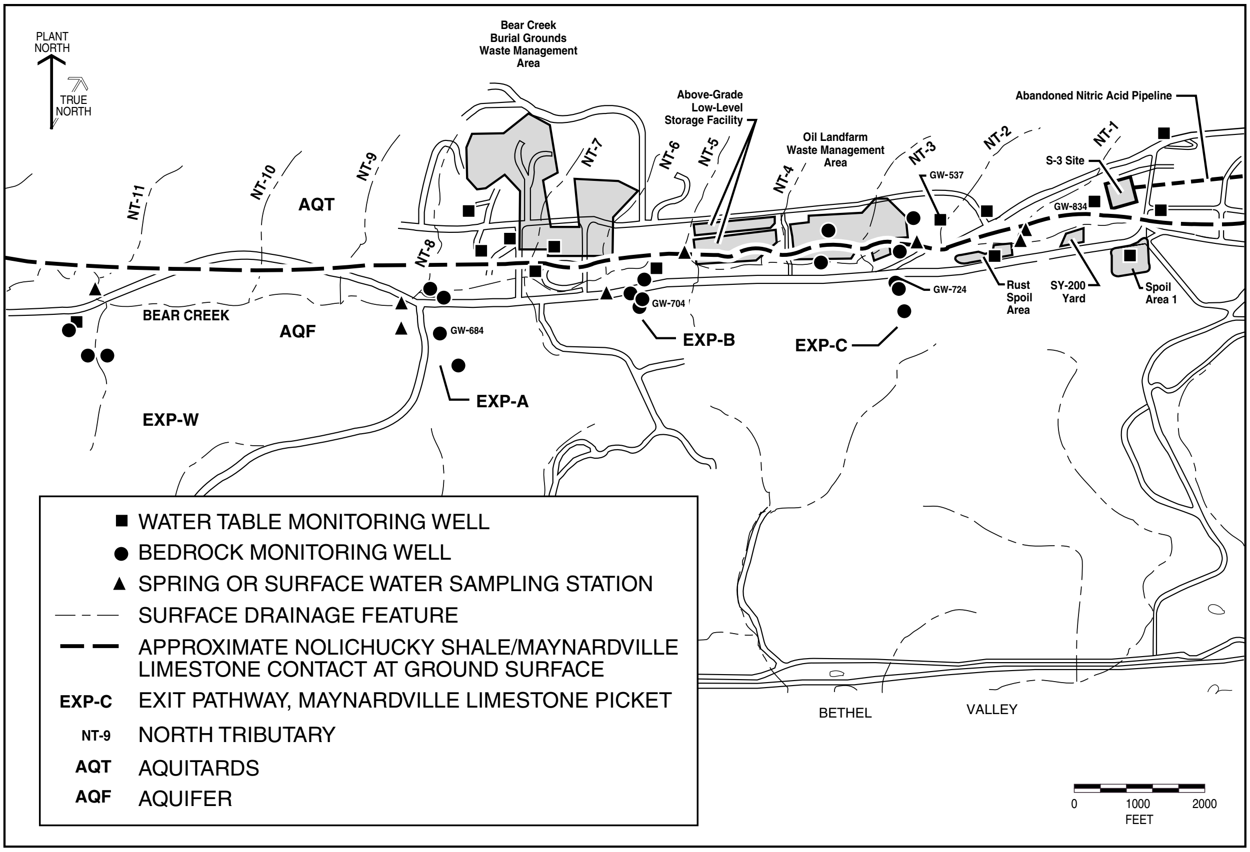

Fig. 6.30. Locations of waste management sites and monitoring wells sampled during 1998 in the Bear Creek Hydrogeologic Regime.

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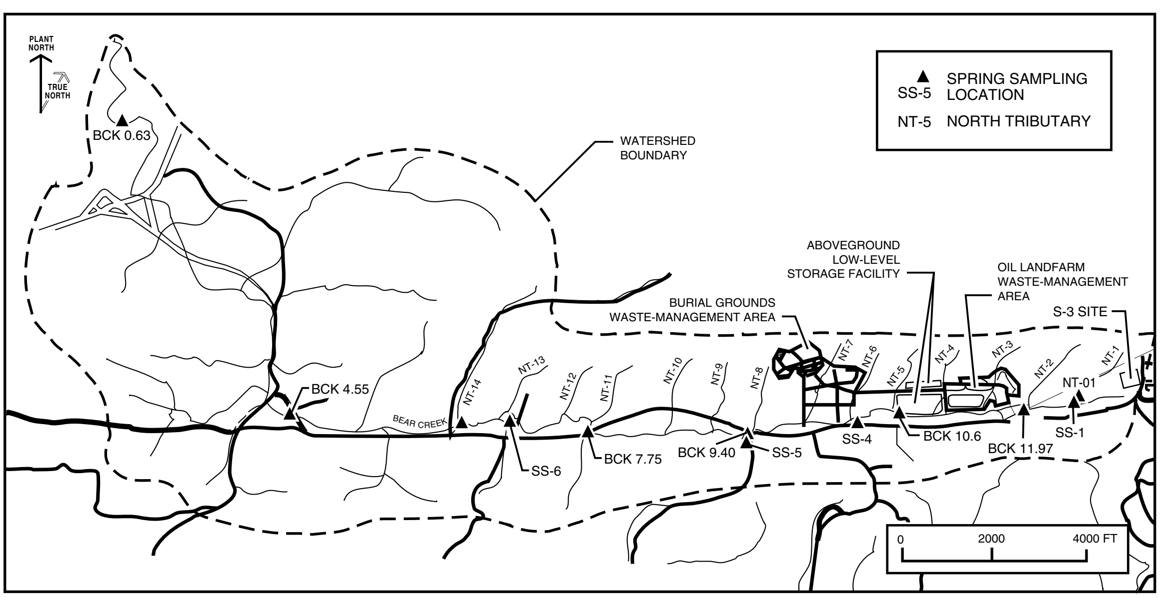

Fig. 6.31. Surface water and spring stations sampled during 1998 in the Bear Creek Hydrogeologic Regime.

Table 6.19. Regulatory status and operational history of waste management units included in the 1998 Comprehensive Groundwater Monitoring Program; Bear Creek Hydrogeologic Regime

Site	Historical/current regulatory classification[a]	Historical data
S-3 Site	TSD/TSD-BCV CA	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	TSD/TSD-BCV CA	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater.
Boneyard	SWMU/BCV CA	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood.
Burnyard	SWMU/BCV CA	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches.
Hazardous Chemical Disposal Area	SWMU/BCV CA	Used from 1975 to 1981. Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit.
Sanitary Landfill I	SWMU/BCV CA	Used from 1968 to 1982. TDEC-permitted, nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1985.
Bear Creek Burial Grounds: A, C, and Walk-in Pits	TSD/TSD-BCV CA	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	SWMUs/BCV CA	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.

Table 6.19 (continued)

Site	Historical/current regulatory classification[a]	Historical data
Rust Spoil Area	SWMU/BCV CA	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	SWMU/BC OU 2	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	SWMU/BC OU 2	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	Active	Constructed in 1993. Consists of six above-grade storage pads used to store inert, low-level radioactive debris and solid wastes packaged in steel containers.

[a]Regulatory status before the 1992 Federal Facilities Agreement: TSD—RCRA regulated, land-based treatment, storage, or disposal unit; SWMU—RCRA-regulated solid waste management unit; NA—not regulated. Current regulatory status: BCV CA—Bear Creek Valley Characterization Area; BC OU 02—Bear Creek Operable Unit 02; active—active waste storage facility.

31 wells, 4 springs, and 8 surface water locations specified by the RCRA Post-Closure permit, the ORR EMP, and primary exit pathway and surveillance-monitoring points. The network was sampled at a baseline semiannual frequency. Any future monitoring requirements dictated by CERCLA RODs issued for the BCV CA will be integrated into the long-term corrective action/surveillance-monitoring network for the regime.

Discussion of Monitoring Results

Groundwater monitoring in the Bear Creek regime during 1998 was conducted to (1) maintain surveillance of contaminant plumes (both extent and concentration of contaminants); (2) conduct trending within contaminant exit pathways in the Maynardville Limestone using existing monitoring locations; and (3) conduct corrective action monitoring at point-of-compliance sites, exit pathways, and background wells in accordance with the Bear Creek regime RCRA Post-Closure permit.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, VOCs, and radionuclides. The S-3 Site is the primary source of nitrate, radionuclides, and trace metals. Sources of VOCs include the S-3 Site, the Rust Spoil Area, the Oil Landfarm waste management area, and the Bear Creek Burial Grounds waste management area; the latter two sites are the principal sources. Dense nonaqueous phase liquids (DNAPLs) exist at a depth of 270 ft below the Bear Creek Burial Grounds. 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. However, one well west of the Bear Creek Burial Grounds, GW-627, has exhibited a shallow increase in VOCs, indicating some movement parallel to strike (Fig. 6.22). As detailed in previous ORR ASERs (LMES 1996, 1997g, 1998), certain contaminants at specific sites, such as nitrate levels adjacent to the S-3 site, have shown decreasing concentration trends. Other constituents, such as gross alpha, exhibit upward trends. In exit pathway wells located in the Bear Creek regime, slight increases or decreases are observed for selected contaminants (Fig. 6.32), depending on mobility of the contaminants and relative location of the monitoring station with respect to source areas.

Nitrate

Unlike most of the other groundwater contaminants, nitrate moves easily with the groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime.

Data obtained during 1998 indicate that nitrate concentrations in groundwater exceed the 10 mg/L DWS in an area that extends west from the S-3 Site for approximately 12,000 ft (3660 m) down BCV (Fig. 6.24). Nitrate concentrations greater than 100 mg/L extend about 3000 ft (915 m) west of the S-3 Site. Data obtained since 1986 suggest that the nitrate plume extends more than 600 ft (183 m) below the ground surface within the ORR aquitards at the S-3 Site. 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 the ground surface] in the Nolichucky Shale. During 1998, no monitoring was performed immediately adjacent, and downgradient of the S-3 Site. However, the IWQP sampled the well closest to the S-3 Site, GW-834, which monitors the water table interval of the Nolichucky Shale. This well did have the highest nitrate concentrations during 1998.

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 from exit pathway monitoring wells indicate that the nitrate plume in groundwater within bedrock in the Maynardville Limestone has not migrated appreciably during the past year and concentrations remain relatively constant or are slightly decreasing. Surface water nitrate concentrations exceed the DWS to approximately 16,000 ft (4877 m) west of the S-3 Site.

Trace Metals

Barium, cadmium, chromium, lead, and mercury have been identified from previous monitoring as the principal trace metal contaminants in groundwater in the Bear Creek regime. 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 beryllium, boron, cobalt, copper, nickel, strontium, and uranium. Concentrations of these metals have commonly exceeded background levels in groundwater near the S-3 Site, the Bear Creek Burial Grounds, and the Oil Landfarm waste management areas. Selected stream and spring locations and exit pathway study wells also have exhibited total uranium and strontium concentrations above background values.

Volatile Organic Compounds

Like nitrate, VOCs are widespread in groundwater in the Bear Creek regime (Fig. 6.27). 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,

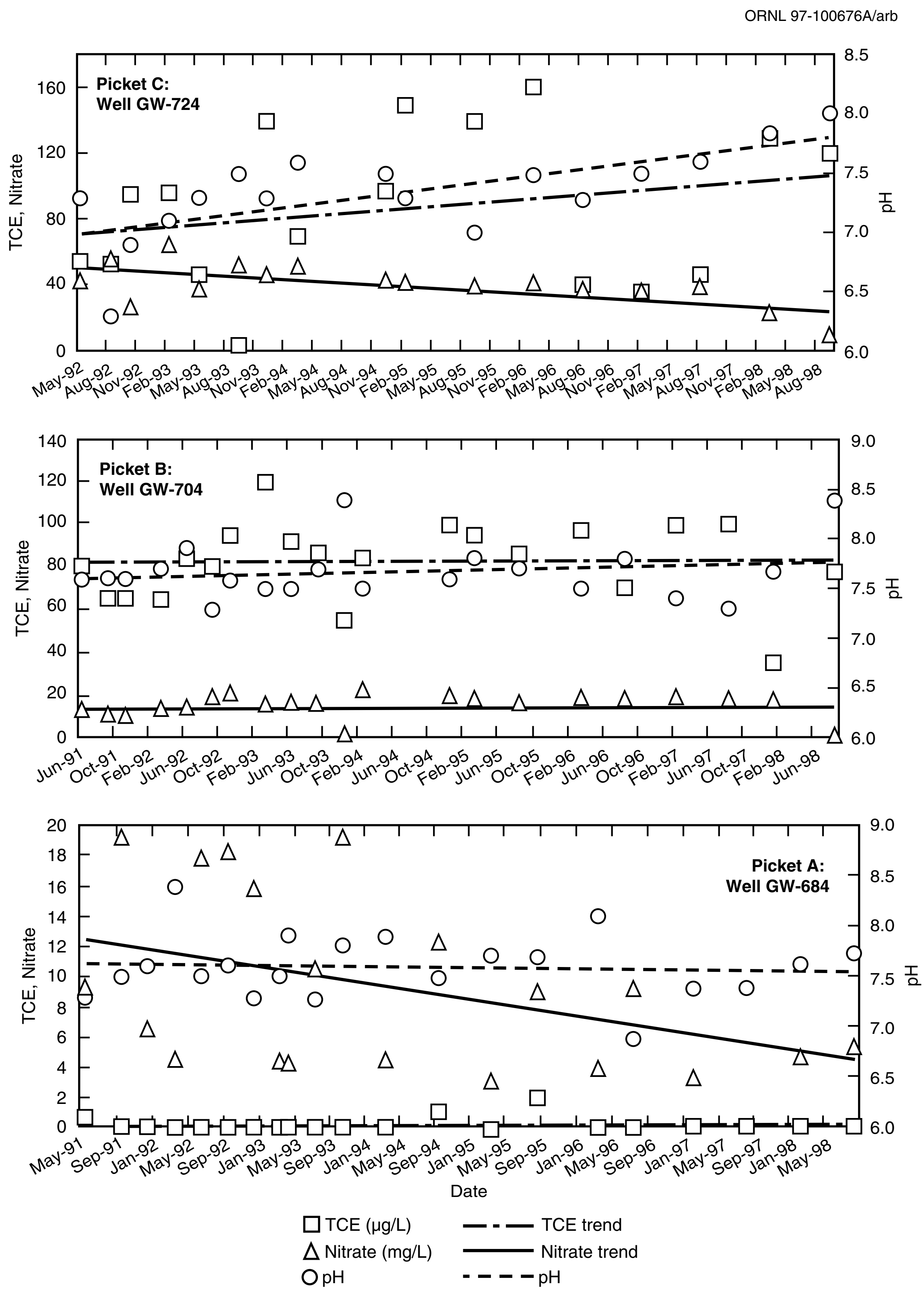

Fig. 6.32. Concentrations of selected contaminants in exit pathway monitoring wells GW-724, GW-704, and GW-684 in the Bear Creek Hydrogeologic Regime.

but nonaqueous phase accumulations of tetrachloroethene and trichloroethene occur in bedrock more than 250 ft (76 m) below the Bear Creek Burial Grounds 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 VOC concentrations (greater than 10,000 mg/L) in the unconsolidated zone occur at the Bear Creek Burial Grounds waste management area. The extent of the dissolved VOC plumes is slightly greater in the underlying bedrock. Well GW-627, which is downgradient of the Bear Creek Burial Grounds waste management area has exhibited an increase in VOC concentration (Fig. 6.22). This indicates that some strike parallel migration through the aquitards is occurring in the intermediate bedrock interval. The marked increase in VOC concentrations observed in 1998 is a result of the change in sampling methodology as discussed in Section 6.10.4.

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 Bear Creek Burial Grounds waste management area. The highest levels of VOCs in the Bear Creek regime occur in bedrock, just south of the Bear Creek Burial Grounds waste management area. Historical levels have been as high as 7000 mg/L in groundwater near the source area. Typical VOC levels in the exit pathway (Maynardville Limestone) range from about 160 µg/L in the eastern part of the regime to less than detectable levels in the western part of the regime.

During 1998, VOC concentrations have been highest in exit pathway transect Picket C (Fig. 6.32). Well GW-724 at this transect has exhibited a shallow increasing trend in trichloroethene since the early 1990s. All other exit pathway transect wells display static or decreasing VOC concentrations.

Radionuclides

As in the East Fork regime, uranium, neptunium, americium, and naturally occurring isotopes of radium have been identified as the primary alpha-particle-emitting radionuclides in the Bear Creek regime. Technetium is the primary beta-particle-emitting radionuclide in the regime, but tritium and isotopes of strontium are also present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during 1998 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the DWS for gross alpha activity), then one (or more) of the alpha-emitting radionuclides was assumed to be present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L.

As shown in Fig. 6.28, groundwater with elevated levels of gross alpha activity occurs in the water table interval in the vicinity of the S-3 Site, the Bear Creek Burial Grounds, and the Oil Landfarm waste management areas. In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the Nolichucky Shale near the S-3 Site, east of the Oil Landfarm waste management areas and the southern side of the Bear Creek Burial Grounds. 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. Gross alpha activities above the DWS in surface water samples were observed 25,000 ft (7620 m) west of the S-3 Site.

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 6.29). During 1998, 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 Oil Landfarm waste management area. Within the intermediate bedrock interval in the Maynardville Limestone, the elevated gross beta activity extends as far west as does gross alpha activity, just to the west of the Bear Creek Burial Grounds waste management area. 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 wells for the Bear Creek Regime (Fig. 6.20).

Exit pathway monitoring consisted of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during 1998 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 Bear Creek Burial Grounds waste management area. However, low levels of nitrate, gross alpha, and gross beta activities have been observed in surface water west of the burial grounds (LMES 1999b).

Surface water and spring samples collected during CY 1998 (Fig. 6.31) 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. 6.33).

6.10.5.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge 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. 6.19). 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 Centralized Sanitary Landfill II. Figure 6.34 shows the approximate boundaries of the regime and locations of waste management units and monitoring wells sampled in 1998.

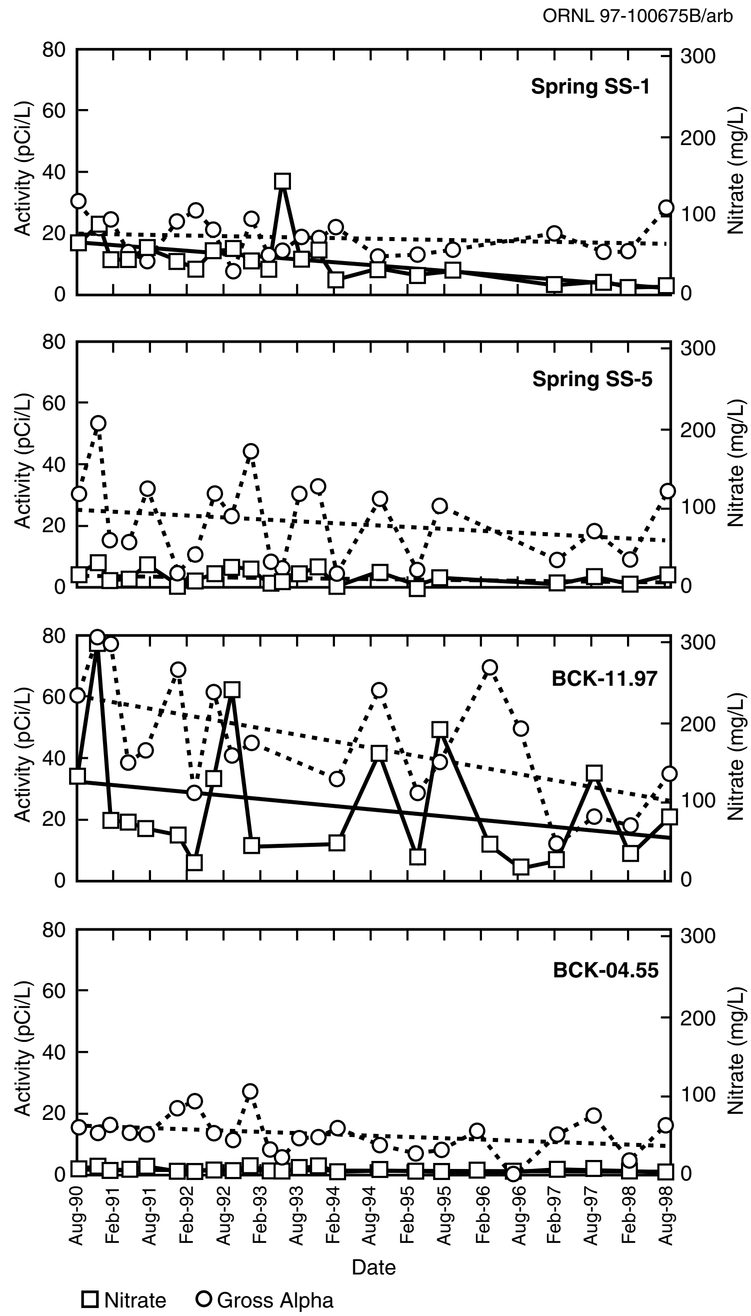

Fig. 6.33. Concentrations of selected groundwater contaminants in springs and surface water in the Bear Creek Hydrogeologic Regime (refer to Fig. 6.31 for sampling locations).

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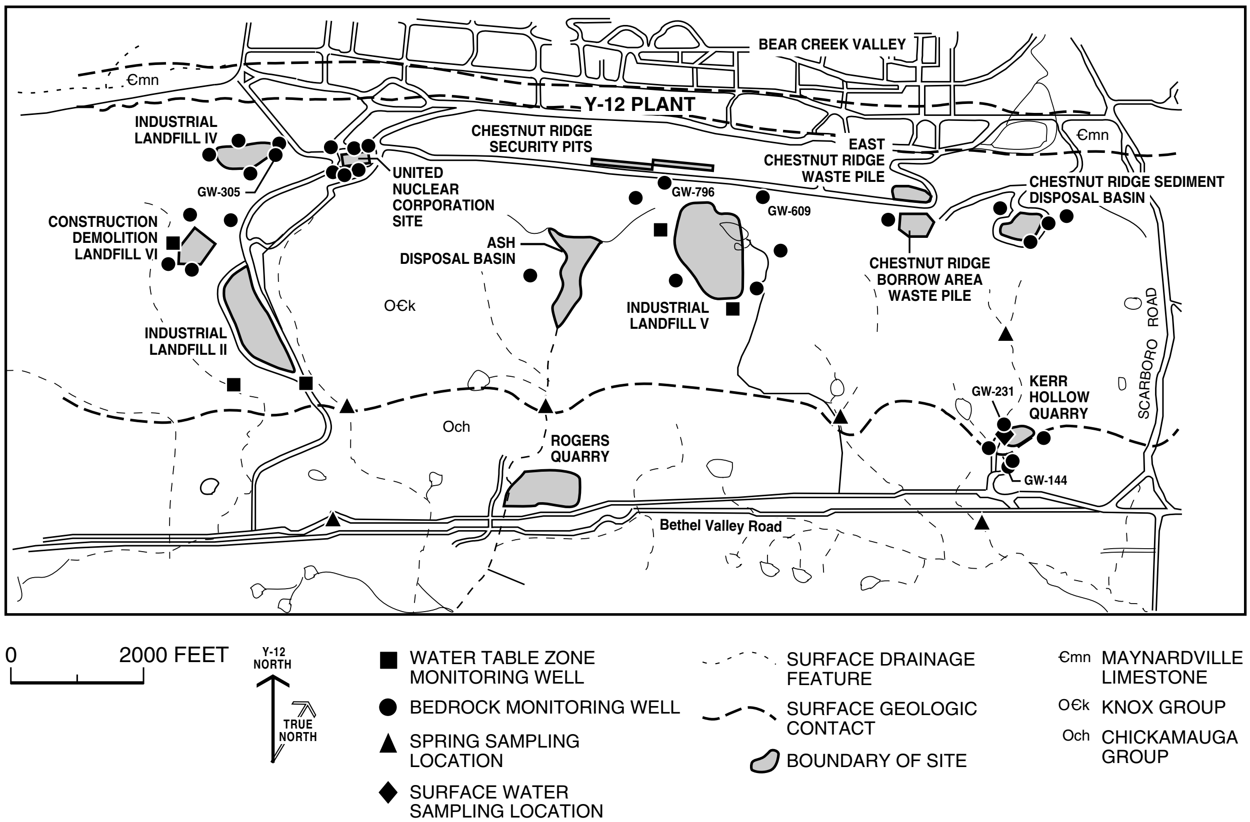

Fig. 6.34. Locations of waste management sites and monitoring wells during 1998 in the Chestnut Ridge Hydrogeologic Regime.

Four categories of sites are located within the Chestnut Ridge regime: (1) RCRA-regulated TSD units, (2) RCRA 3004(u) SWMUs and solid waste disposal units, (3) TDEC-permitted Solid Waste Disposal Facilities (SWDFs), and (4) CERCLA OUs. The Chestnut Ridge Security Pits 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 6.20 summarizes the regulatory status and operational history of waste management units in the regime.

Discussion of Monitoring Results

Monitored units in the Chestnut Ridge regime, with the exception of the Chestnut Ridge Security Pits and the United Nuclear Site, are under a regulatory detection monitoring program. The Chestnut Ridge Security Pits are monitored in accordance with RCRA Post-Closure corrective action requirements. The United Nuclear Site is monitored under the provisions of a CERCLA ROD. No observable changes of groundwater quality relative to past years were noted for units under surveillance exit pathway, detection, or post-closure monitoring.

Plume Delineation

The horizontal extent of the VOC plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones (Fig. 6.27). Groundwater quality data obtained during 1998 continue to indicate that the lateral extent of the VOC plume at the site is increasing slightly, 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.

Table 6.20. Regulatory status and operational history of waste management units included in the 1998 Comprehensive Groundwater Monitoring Program; Chestnut Ridge Hydrogeologic Regime

Site	Historical/current regulatory classification[a]	Historical data
Chestnut Ridge Sediment Disposal Basin	TSD/TSD-Study Area	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	TSD/TSD-Study Area	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	TSD/TSD-CR OU 1	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	SWMU/CR OU 3	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	TDEC-permitted Class II industrial SWDF	Central sanitary landfill for the ORR. Detection monitoring under postclosure plan has been ongoing since 1996.
Industrial Landfill V	TDEC-permitted Class II industrial SWDF	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	TDEC-permitted Class II industrial SWDF	Permitted to receive only, nonhazardous industrial solid wastes. Detection monitoring under TDEC-SWM regulations has been ongoing since 1988.
Construction/Demolition Landfill VI	TDEC-permitted Class IV construction/demolition SWDF	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.

Table 6.20 (continued)

Site	Historical/current regulatory classification[a]	Historical data
Construction/Demolition Landfill VII	TDEC-permitted Class IV construction/demolition SWDF	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	SWMU/Study Area	Contains soils from off-site locations in Oak Ridge bearing low levels of mercury and other metals.
Filled Coal Ash Pond	SWMU/CR OU 2	Site received Y-12 Steam Plant coal ash slurries. A CERCLA ROD has been issued. Remedial action complete.

[a]Regulatory classification before the 1992 Federal Facilities Agreement: TSD—RCRA regulated, land-based treatment, storage, or disposal facility; SWMU—RCRA-regulated solid waste management unit. Current regulatory status: study area—Y-12 Plant study area; CR OU 1—Chestnut Ridge Operable Unit 1; SWDF—solid waste disposal facility (active landfill).

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. However, an increasing trend in nitrate concentrations was noted in groundwater samples from monitoring Well GW-144 (LMES 1998b). This well is located downgradient of the Kerr Hollow Quarry (KHQ). Upgradient of the KHQ are several active sewage sludge land application areas. Because nitrates are a common non-point source contaminant from this type of activity, additional samples from all KHQ wells and the quarry itself were collected during 1998 for other indicator parameters [fecal coliform, ammonia, and phosphate (as phosphorus)]. The resulting analytical data did not conclusively provide evidence of groundwater contamination from land applications of sewer sludges upgradient of KHQ. However, further evaluation of historical data revealed an increasing trend in nitrate concentration from upgradient Well GW-231 indicating an upgradient source of this contaminant. Additionally, nitrate concentrations have been observed in a spring 1500 ft (457 m) north and upgradient of the KHQ. This spring discharges into a surface water tributary that flows south and adjacent to the KHQ.

Trace Metals

Groundwater concentrations of trace metals did not exceed DWSs during 1998.

Volatile Organic Compounds

In early 1998, Well GW-305 located immediately to the east of Industrial Landfill IV continues to exhibit an increasing trend in VOCs (Fig. 6.35) since the first quarter of 1992 (exclusively 1,1,1-trichloroethane until the fourth quarter of 1996). In July 1998, concentrations decreased dramatically, and it is uncertain as to the cause of these results. Concentrations of the VOCs in Well GW-305 have remained below applicable DWSs. Continued monitoring will provide data for further

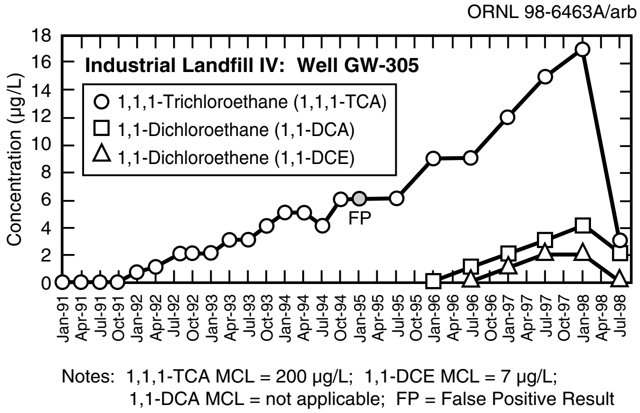

Fig. 6.35. VOC concentrations in Industrial Landfill IV Well GW-305.

evaluation. The source of the VOCs in this well has not yet been determined; however, it was originally thought to be the Chestnut Ridge Security Pits, located east of Industrial Landfill IV. Evaluation of water table levels in wells in the area have shown that the water table at Industrial Landfill IV is typically about 10 feet higher than that at the Security Pits, and the overall hydraulic gradient indicates that groundwater flows predominantly from west to east. Therefore, a connection with the Security Pits is not likely.

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 suggests that VOC concentrations in groundwater at the site have generally decreased since 1988 (Fig. 6.36). Low levels of VOCs have also been observed at a few additional monitoring locations in 1998. Of particular note, trace levels of VOCs continued to be observed in Kerr Hollow Quarry monitoring wells.

Radionuclides

Only one sample exceeded the gross alpha DWS of 15 pCi/L (LMES 1999b); no well has demonstrated consistent radiological contamination. Gross beta activities were below the DWS of 50 pCi/L 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 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. Tennessee Department of Environment and Conservation/DOE Oversight Division (TDEC/DOE-O) conducted a small-scale tracer study east of the Sediment Disposal Basin in 1995; 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).

Monitoring of one large spring south of Industrial Landfill V and Construction/Demolition Landfill VII was continued in 1998 as required under the EMP. Periodically, additional springs within the Chestnut Ridge regime will be sampled as part of overall exit pathway monitoring for the regime.

6.10.5.5 Environmental Management Activities

Planning, initiation, and implementation of a number of CERCLA projects related to groundwater occurred in 1998. These projects were implemented by the Lockheed Martin Energy Systems, Inc., Environmental Restoration Organization during the first quarter and Bechtel Jacobs Company LLC during the rest of the year.

East Fork Regime

Planning and evaluation activities began in 1996 to select and design a system to remediate the VOC plume emanating from the plant and moving eastward along exit pathways as far as Union Valley. One phase of this activity performed in 1998 was the installation of a deep well on the ORR near the east end of the Y-12 Plant. This well, GW-845, is 438 ft (134 m) deep and has a 271 ft (83 m) open interval located to intercept the primary mass of VOC contamination (carbon tetrachloride) in the intermediate and deep intervals of the Maynardville Limestone.

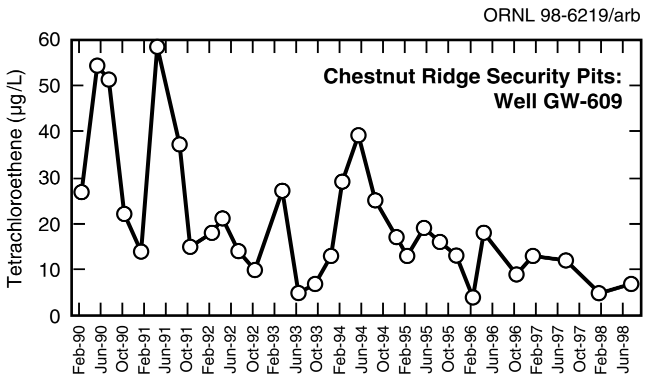

Fig. 6.36. Tetrachloroethene concentrations in Chestnut Ridge Security pits Well GW-609.

Pumping and tracer tests were performed, with Well GW-845 performing as the pumping well, to assess geologic and hydrologic characteristics of the bedrock for system design and feasibility determinations. The information gathered during these activities will be used in an Engineering Evaluaton/Cost Analysis (EE/CA) to determine the best focused remedial actions possible to reduce the off-site migration of contaminants (BJC 1998).

Bear Creek Regime

In the Bear Creek Regime, a multiphase treatability study continued in 1998. This effort involved evaluation of remedial technologies for contaminated groundwater and surface water, with particular focus on the primary S-3 Site contaminants. The initial phase of the feasibility study was conducted in 1996 and early 1997 and involved laboratory-scale testing of various types of treatment methods for contaminated groundwater. Remediation of contaminants in surface water using wetlands and biological uptake methods was tested using field-scale experiments. In 1998, the data from the field-scale experiments were evaluated and reported.

The second phase, which began in 1997, involved the collection of focused hydrologic data around the S-3 Site and the installation of capture trenches and wells for shallow groundwater extraction and treatment. One well was drilled at approximately 45% from vertical (200 linear feet) to intersect a permeable flow zone beneath north tributary 1. In 1998, testing of these two groundwater treatment systems was performed to evaluate hydraulic influences and performance. Preliminary monitoring results show that ferrous iron placed in the trench is removing uranium, nitrate, and technetium. Evaluation of the performance of the treatment media is required over time to better understand the long-term effectiveness and maintenance issues (BJC 1999a).

The funnel and gate technology demonstration involved the installation of a trench capture and treatment system for shallow groundwater contamination. This technology consists of a treatment cell located between two subsurface impermeable barrier walls downgradient of a collection trench. The treatment cell contains experimental treatment media housed in removable cartridges for easy maintenance. The entire system is approximately 300 ft (91 m) long and 25 ft (7.6 m) deep (or to bedrock), and installation was completed in late 1997. Monitoring of treatment effectiveness continued through 1998.

At the Boneyard/Burnyard (BY/BY), contaminants, primarily uranium, contained in soils and in waste materials leach into groundwater, which subsequently discharges to surface water in a tributary of Bear Creek. Contaminants in groundwater that have leached from buried waste and fill material in BY/BY likely migrated directly to the Maynardville Limestone and to Bear Creek via shallow groundwater flow. Excavation of contaminated soils and waste materials that are leaching uranium to groundwater and surface water will significantly reduce flux of this contaminant. During 1998, predesign site characterization was performed to support the remedial action design effort. Preliminary results from this sampling indicate that approximately 35,000 yd^3 of buried waste contribute to off-site migration of uranium. During the BY/BY Accelerated Action, this material will be excavated along with the installation of hydraulic controls to mitigate movement of water into the remaining buried waste. The action is scheduled to begin in mid-1999 (DOE 1999).

The construction of an on-site facility, the Environmental Management Waste Management Facility, (EMWMF), has been proposed for the disposal of ORR CERCLA-generated wastes. The proposed facility will have the capability to safely isolate wastes from the environment. During 1998, site characterization activities were performed to support facility design. The EMWMF is scheduled to be constructed and ready to receive wastes in 2001.