5. ORNL Environmental Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted for air, water, and groundwater environmental media. These programs include regulatory and monitoring activities for ORNL site facilities and other locations in Bethel Valley, Melton Valley, and the ORR.

5.1 ORNL RADIOLOGICAL AIRBORNE EFFLUENT MONITORING

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the TDEC Division of Air Pollution Control. Radioactive emissions are regulated by EPA under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 CFR 61, Subpart H, and the rules of the TDEC Division of Air Pollution Control. (See Appendix G, Table G.1 for a list of radionuclides and their radioactive half-lives.) Nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control.

Radioactive airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. These airborne emissions are treated and then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases. The major radiological emission point sources for ORNL consist of the following five stacks located in Bethel and Melton Valleys (Fig. 5.1):

- 2026 High Radiation Level Analytical Laboratory;
- 3020 Radiochemical Processing Plant;
- 3039 central off-gas and scrubber system, which includes 3500 and 4500 areas cell ventilation system, isotope solid state ventilation system, and 3025 and 3026 areas cell ventilation system;
- 7512 Molten Salt Reactor Experiment remediation; and
- 7911 Melton Valley complex, which includes the High Flux Isotope Reactor (HFIR) and the Radionuclide Engineering Development Center (REDC).

In 1999, there were 27 minor point/group sources, and emission calculations/estimates were made for each of these sources.

5.1.1 Sample Collection and Analytical Procedure

Each of the five major point sources is equipped with a variety of surveillance instrumentation. Only data resulting from analysis of the continuous samples are used in this report. ORNL in-stack source sampling systems comply with ANSI N 13.1 (ANSI 1993) criteria. The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges, a silica-gel cartridge (if required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. In addition to that instrumentation, the system at Stack 7911 includes a high-purity germanium detector with a NOMAD analyzer, which allows continuous isotopic identification and quantification of radioactive noble gases (i.e., ^{41}Ar) in the effluent stream. The sample probes are annually removed, inspected, and cleaned.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at major and some minor sources. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system.

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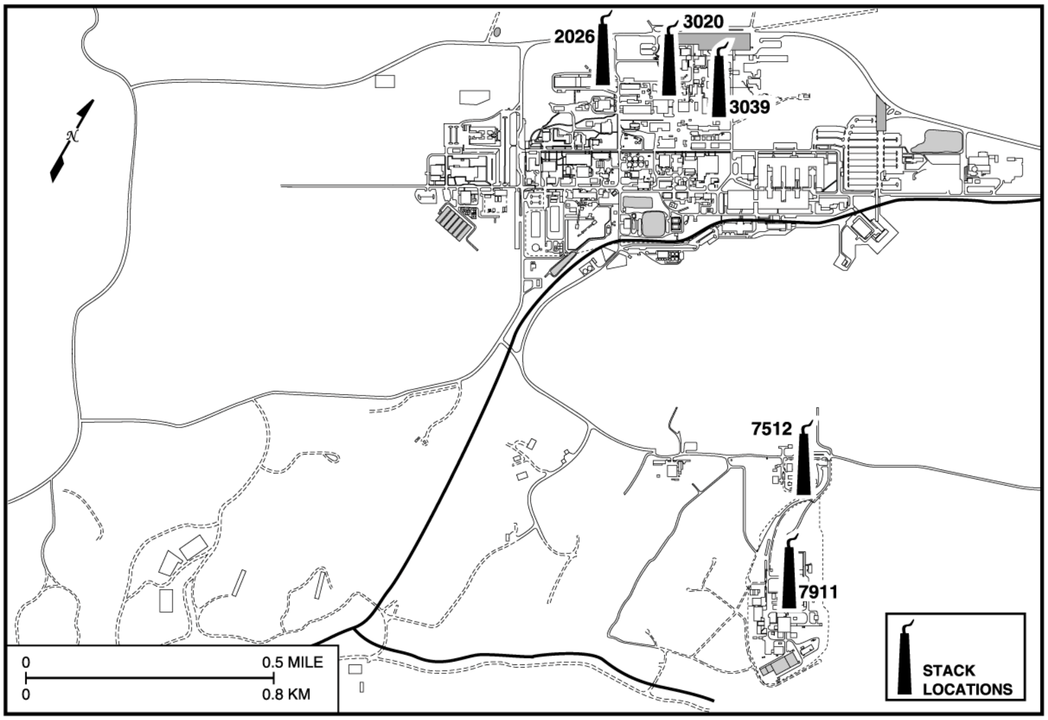

Fig. 5.1. Locations of major stacks (rad emission points) at ORNL.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any ventilation systems or components such as vents, laboratory hoods, room exhausts, and stacks that do not meet the approved regulatory criteria for a major source but are located in or vent from a radiological control area as defined by Radiological Protection. A variety of methods are used to determine the emissions from the various minor sources. Methods used for minor source emission calculations comply with criteria agreed upon by EPA. These minor sources are evaluated on a 1- to 3-year basis. Emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analysis is performed weekly. Particulate filters are held for 8 days prior to a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At Stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The weekly filters are then composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes. Compositing provides a better opportunity for quantification of these low-concentration isotopes. At the end of the year, each sample probe is rinsed, and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each major source and some minor sources.

5.1.2 Results

Annual radioactive airborne emissions for ORNL major sources in 1999 are presented in Table 5.1. All data presented were determined to be significantly different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emis-

Table 5.1. Major sources of radiological airborne emissions at ORNL, 1999 (in curies)[a]

Isotope	Stack				
	2026	3020	3039	7512	7911
^{241}Am	1.5E–07	1.6E–07	4.4E–07	7.6E–09	1.5E–08
^{41}Ar					1.3E+04
^{3}H	1.8E–01				
^{139}Ba					2.7E–01
^{140}Ba					1.7E–04
^{7}Be	6.6E–07	2.9E–07	2.5E–05	7.6E–08	2.0E–06
^{244}Cm	1.8E–06	7.8E–09	2.8E–07		1.5E–07
^{244}Cm				4.9E–08	
^{60}Co			6.8E–05		
^{137}Cs	3.4E–06	1.3E–06	1.6E–04	3.4E–08	9.7E–06
^{138}Cs					2.4E+03
^{152}Eu			4.5E–06		
^{3}H	1.8E–01		1.1E+01	7.4E+00	8.2E+01
^{131}I					5.8E–02
^{132}I					5.0E–01
^{133}I					3.7E–01
^{135}I					1.0E+00
^{85}Kr					4.8E+02
^{85m}Kr					1.1E+01
^{87}Kr					3.7E+01
^{88}Kr					6.6E+01
^{89}Kr					1.4E+01
^{140}La					1.4E–04
^{191}Os	1.3E–05	2.3E–05	4.5E+00		
^{212}Pb	1.6E–01	5.6E–01	1.5E+00	2.5E–01	2.3E–01
^{238}Pu	5.7E–08	2.2E–08	1.2E–07	1.9E–09	1.3E–08
^{239}Pu	1.7E–07	1.2E–07	1.4E–06	5.3E–09	8.3E–09
^{75}Se			1.2E–02		
^{228}Th	3.3E–08	5.2E–09	1.0E–08	9.0E–10	7.3E–09
^{230}Th	3.5E–09	3.0E–09	3.9E–09	7.4E–10	7.6E–09
^{232}Th	2.2E–09	3.1E–09	5.8E–09	4.6E–10	8.2E–09
Total Sr	5.7E–07	9.1E–07	1.2E–04	1.4E–08	1.9E–05
^{234}U	2.1E–07	6.5E–08	2.5E–07	1.5E–08	3.8E–08
^{235}U	7.5E–09	4.8E–09	4.0E–08	1.2E–09	4.2E–09
^{238}U	6.7E–09	6.6E–09	5.5E–08	2.2E–09	1.5E–08
^{131m}Xe					8.8E+00
^{133}Xe					4.6E+00
^{133m}Xe					3.1E+00
^{135}Xe					1.2E+02
^{135m}Xe					3.3E+01
^{137}Xe					1.1E+02
^{138}Xe					3.5E+02

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

sion calculation. Historical trends for ^{3}H and ^{131}I are presented in Figs. 5.2 and 5.3, respectively.

The tritium emissions for 1999 totaled approximately 103 Ci (Fig. 5.2), which is consistent with 1998. The ^{131}I emission for 1999 is essentially unchanged from that of the past years (Fig. 5.3). The major contributor to off-site doses at ORNL is ^{41}Ar, which totaled 12,500 Ci in 1999 (Fig. 5.4). This discharge has increased a little over 50% from the previous year.

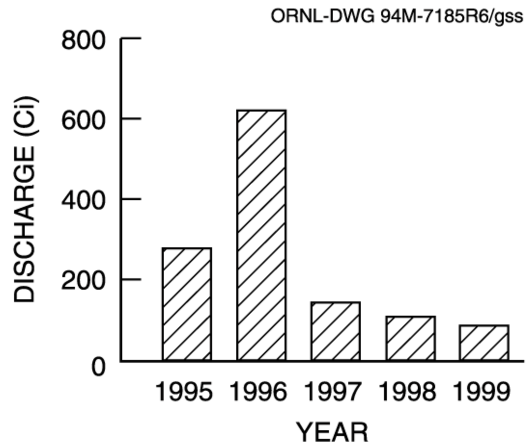

Fig. 5.2. Total discharges of ^{3}H from ORNL to the atmosphere, 1995–99.

5.2 ORNL NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

ORNL operates 25 permitted air emission sources. (See Appendix F, Table F.2.) Most of these sources are small-scale activities and result in very low emission rates. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of allowable emissions. The steam plant consists of six boilers. Four of these boilers are coal- and natural-gas-fired, two are natural-gas and fuel-oil-fired. As part of a 10-year plan to provide long-term reliability for the steam plant, the installation of a new 125-M Btu/h natural-gas-fired boiler was completed in December 1999. Also, as funding is made available, the four coal-fired boilers will be converted to natural gas and fuel oil firing, eliminating the use of coal at the steam plant.

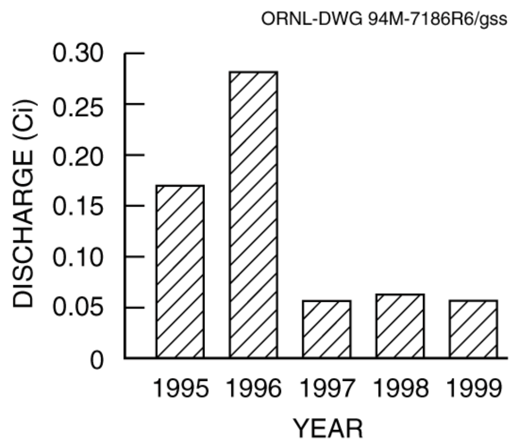

Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 1995–99.

The new 125-M Btu/h boiler is subject to 40 CFR 60, Subpart Db requirements, and therefore monitoring for NOx and opacity with quarterly reporting is required. Other TDEC air permits for ORNL's sources do not require stack sampling or monitoring; however, an opacity monitor is used at the steam plant to ensure compliance with visible emissions.

For the period from July 1, 1998, through June 30, 1999, ORNL paid $76,601.70 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). During 1999, TDEC inspected all permitted emission sources; all were found to be in compliance.

ORNL's Title V permit application was submitted to TDEC on May 5, 1997. In a letter dated June 5, 1997, TDEC indicated that the application

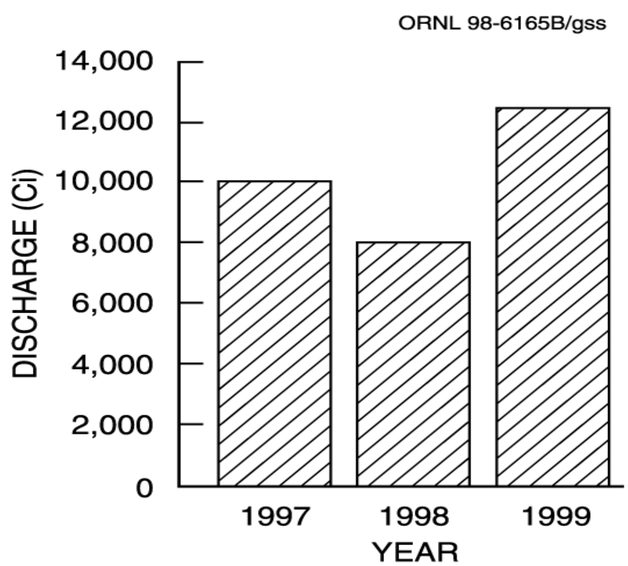

Fig. 5.4. Total discharges of ^{41}Ar from ORNL to the atmosphere, 1997–99.

was complete and that ORNL met the requirement to submit an application. ORNL will continue to operate with existing permits until the Title V permit is issued. TDEC anticipates that ORNL's Title V permit will be issued in 2000.

As required by Title VI of the CAA Amendments of 1990, actions have been implemented to comply with the prohibition against releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. In addition, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has implemented a plan to phase out the use of all Class I ozone-depleting substances. The most significant challenge is the replacement or retrofit of large chiller systems that require Class I refrigerants. This work is progressing on schedule as funding is available with no disruption of service.

5.2.1 Results

The primary sources of nonradioactive emissions at ORNL include the steam plant on the main ORNL site and two small boilers located in the 7600-area complex. These units use fossil fuels; therefore, criteria pollutants are emitted. Actual and allowable emissions from these sources are compared in Table 5.2. Actual emissions were calculated from fuel usage and EPA emission factors. The steam plant and the 7600-area boilers operated in compliance with visible emission standards during 1999.

5.3 ORNL AMBIENT AIR MONITORING

The objectives of the ORNL ambient air monitoring program are to collect samples at stations most likely to show impacts of airborne emissions from the operation of ORNL and to provide for emergency response capability. Four stations, identified as Stations 1, 2, 3, and 7 (Fig. 5.5) make up the ORNL network. Sampling is conducted at each ORNL station to quantify levels of adsorbable gases (e.g., iodine), and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.3).

The sampling system consists of a low-volume air sampler for particulate collection using a 47-mm glass-fiber filter. The filters are collected biweekly, composited annually, then submitted to the laboratory for analysis. Following the filter is a charcoal cartridge used to collect adsorbable gases (e.g., iodine). The charcoal cartridges are analyzed biweekly using gamma spectroscopy for adsorbable gas quantification. A silica-gel column is used for collection of tritium as tritiated water. These samples are collected biweekly or weekly. The silica gel from each station is composited each quarter and then submitted to the laboratory for tritium analysis.

5.3.1 Results

The ORNL PAM stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations

Table 5.2. Actual vs allowable air emissions from ORNL steam production, 1999

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	3	441	0.6
Sulfur dioxide	1565	9062	17.0
Nitrogen oxides	109	531	20.5
Volatile organic compounds	1	3	33.0
Carbon monoxide	86	336	26.0

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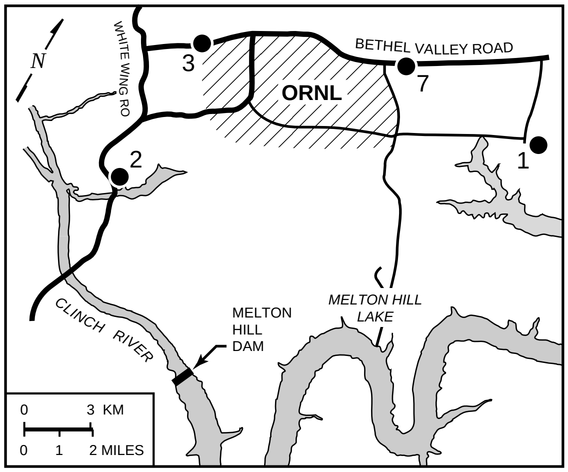

Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

Table 5.3. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 1999 (pCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{7}Be	1.7E–08	5.3E–09	7.4E–09	7.4E–09	5.4E–08
^{137}Cs	*c*	*c*	*c*	*c*	3.2E–11
^{60}Co	*c*	*c*	2.0E–11	*c*	*c*
^{3}H	3.5E–06	4.1E–05	5.6E–06	*c*	1.7E–06
^{131}I	*c*	*c*	*c*	*c*	*d*
^{133}I	*c*	*c*	*c*	*c*	*d*
^{135}I	*c*	*c*	*c*	*c*	*d*
^{40}K	1.9E–09	*c*	*c*	6.7E–10	*c*
^{191}Os	3.1E–08	*c*	*c*	*c*	*d*
^{234}U	3.6E–11	2.8E–11	5.3E–11	4.1E–11	*c*
^{235}U	*c*	*c*	*c*	*c*	*c*
^{238}U	3.3E–11	3.9E–11	6.7E–11	4.5E–11	*c*

[a]1 pCi = 3.7E–02 Bq.
[b]Reference location off site.
[c]Not detected.
[d]Not applicable.

(Table 5.3) are compared with air sampling data from the reference station (station 52) at Fort Loudoun.

5.4 LIQUID DISCHARGES—ORNL RADIOLOGICAL MONITORING SUMMARY

Since 1997, ORNL has sampled liquid discharges under the revised Radiological Monitoring Plan (RMP) approved by TDEC on July 1, 1997. The RMP is required by Part III, Section J, of the ORNL NPDES permit. The plan underwent major revision in 1999 with a new plan being implemented on November 1, 1999. Table 5.4 contains the details of the locations sampled, frequency, and target analyses. Monitoring of radioactivity occurred at the three treatment facilities: the STP, the Coal Yard Runoff Treatment Facility (CYRTF), and the Process Waste Treatment Complex (PWTC), three instream locations: X13 on Melton Branch, X14

Table 5.4. ORNL Radiological Monitoring Plan effective November 1, 1999

Location	Frequency	Gross alpha[a]	Gross beta[a]	Gamma scan	Tritium	Total rad Sr	Isotopic uranium
Outfall 001	Annually	X					
Outfall 080	Monthly	X	X	X	X	X	
Outfall 081	Annually		X				
Outfall 085	Quarterly	X	X				
Outfall 086	When discharges		X		X		
Outfall 087	Annually		X	X			
Outfall 203	Annually		X				
Outfall 204	Quarterly	X	X			X	
Outfall 205	Annually		X				
Outfall 207	Quarterly	X	X	X		X	
Outfall 211	Quarterly		X			X	
Outfall 217	Annually		X				
Outfall 219	Annually		X				
Outfall 234	Annually	X					
Outfall 241	Annually		X				
Outfall 265	Annually		X	X			
Outfall 281	Quarterly	X	X	X	X		
Outfall 282	Quarterly	X	X				
Outfall 284	Annually		X				
Outfall 290	Annually			X			
Outfall 302	Monthly	X	X	X	X	X	
Outfall 304	Monthly	X	X	X	X	X	
Outfall 365	Quarterly	X	X				
Outfall 368	Quarterly	X	X	X			
Outfall 381	Quarterly		X	X	X		
Outfall 382	Annually		X	X			
Outfall 383	Annually		X		X		
Sewage Treatment Plant (X01)	Monthly	X	X			X	
Coal Yard Runoff Treatment Facility (X02)	Monthly	X	X				
Process Waste Treatment Complex (X12)	Monthly	X	X	X	X	X	X
Melton Branch 1 (X13)	Monthly	X	X	X	X	X	
White Oak Creek (X14)	Monthly	X	X	X	X	X	
White Oak Dam (X15)	Monthly	X	X	X	X	X	

[a]Isotopic analyses will be performed to identify contributors to gross activities when results exceed screening criteria described in the Radiological Monitoring Plan, June 1999.

on White Oak Creek, and X15 at White Oak Dam (Fig. 5.6), and 27 category outfall locations. Data for those sites are included with the other ORNL radiological monitoring results.

The new plan includes requirements for monitoring radioactivity during storm conditions. There are 102 outfalls targeted for storm water sampling. These 102 outfalls were grouped into 8 different categories with the knowledge that outfalls may move from one category to another as storm water data are collected. The storm water categories are defined by the availability of historic data and the levels of radioactivity detected in past monitoring. Outfalls with limited historical data or higher levels of activity receive the most frequent monitoring. The goal is to perform monitoring at the rate of 20 outfalls per year. The RMP sets frequency goals for storm water monitoring, rather than hard requirements.

DOE-DCG values are used as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero. DCGs are not intended for comparison to instream values. However, they are useful as a frame of reference, so instream values are compared to DCGs in this section. The calculation of the percentage of the DCG for ingestion of water does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water.

For 1999, five radionuclides had an average concentration greater than 4% of the relevant DCG; they were total radioactive strontium (^{89}Sr + ^{90}Sr), ^{3}H, ^{137}Cs , ^{234}U, and total uranium. Of the locations sampled under the current RMP (i.e., effective November 1, 1999), the highest total radioactive strontium was at the STP (32% of the DCG, up from 15% in 1998); the highest ^{3}H was at Melton Branch monitoring station MB1 (20% of the DCG, up from 13% in 1998); the highest

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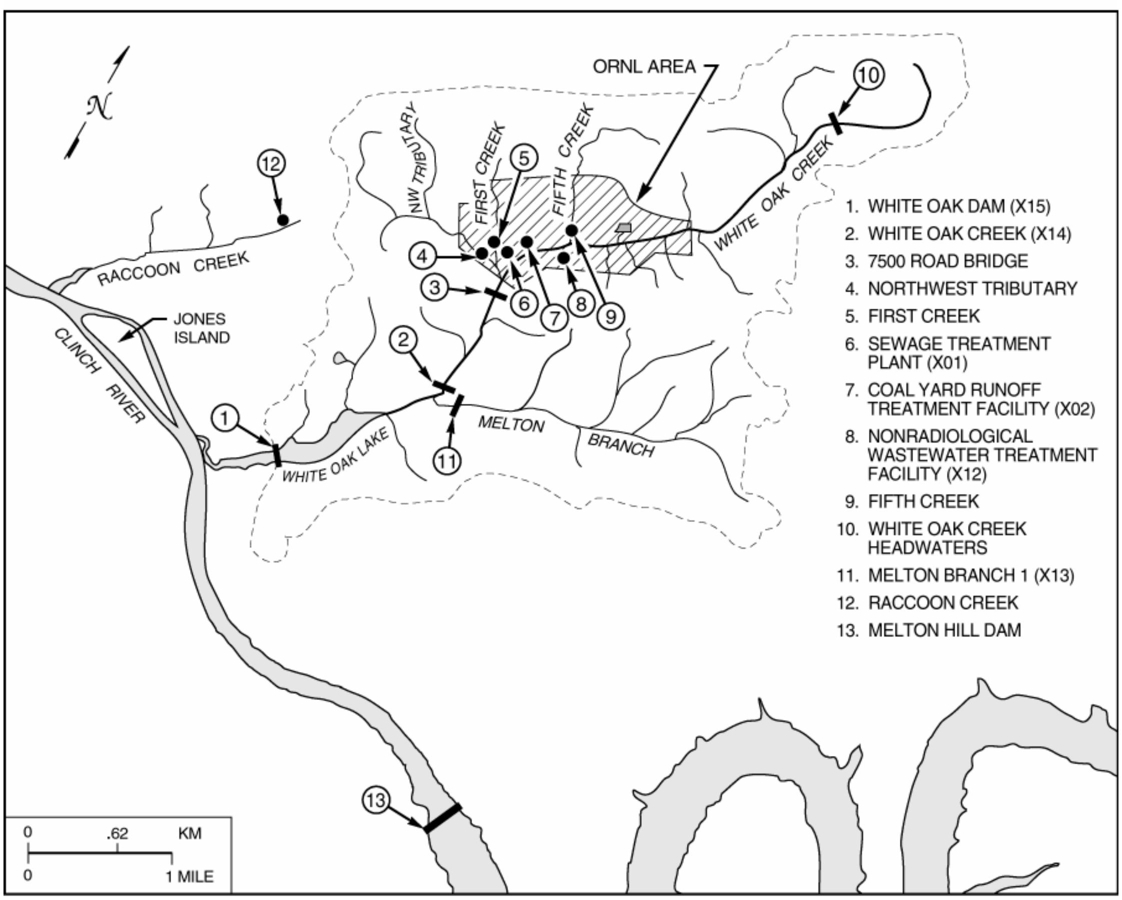

Fig. 5.6. ORNL surface water, NPDES, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

^{137}Cs was at the PWTC (38% of the DCG, up from 17% in 1998); ^{234}U was the highest at PWTC at 6% of the DCG; and total uranium was 6.9% of the DCG at PWTC (Fig. 5.7). Following guidelines given in DOE Order 5400.5, fractional DCG values for the radionuclides detected at each monitoring point are summed to determine whether radioactivity is within acceptable levels. In 1999, the sum of DCG percentages at each effluent point and ambient water station was less than 100% and therefore within acceptable levels. The largest sum of DCG percentages was 60% at PWTC (up from 27% at PWTC in 1998), and the next largest sum was 40% at MB1 (Fig. 5.7).

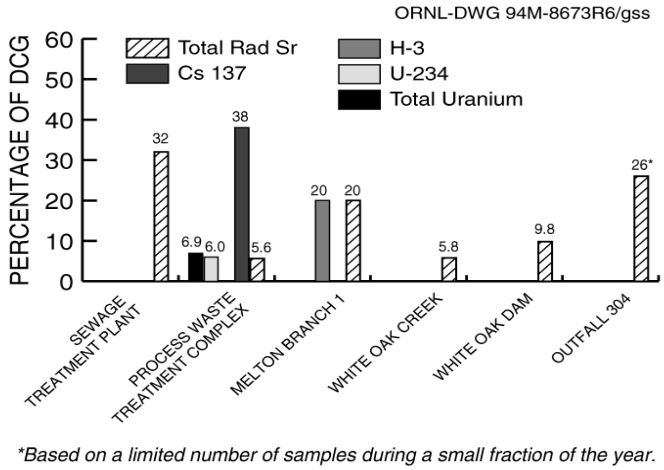

Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 1999.

Amounts of radioactivity released at White Oak Dam (WOD) are calculated from concentration and flow. As shown in Figs. 5.8, 5.9, 5.10, 5.11, 5.12, and 5.13, the total discharges (or amounts) of radioactivity released at WOD during the past 5 years have mainly remained in the same range of values. The one exception is ^{137}Cs. The 1999 value is higher than the previous four years; however, in 1994, ^{137}Cs discharge was 0.51 Ci.

In the last 2 months of 1999, four outfalls were monitored under the storm water portion of the RMP. Information about these four events will be reported next year with the 2000 data.

5.5 ORNL NPDES SUMMARY

5.5.1 NPDES Permit Monitoring

ORNL NPDES Permit TN0002941 was renewed on December 6, 1996, and became effective on February 3, 1997. Data collected for the NPDES permit are submitted to the state of Tennessee in the monthly Discharge Monitoring Report. The renewed permit includes 164 separate outfalls and monitoring points.

ORNL's NPDES permit requires that point-source outfalls be sampled before they are discharged into receiving waters or before they mix with any other wastewater stream (see Fig. 5.6). Under the renewed permit, numeric and aesthetic effluent limits have been placed on the following locations:

- X01—STP;
- X02—CYRTF;
- X12—PWTC;
- X13—Melton Branch (MB1);
- X14—WOC;
- X15—WOD;
- In-stream chlorine monitoring points (X16-X26);
- Steam condensate outfalls;
- Groundwater from building foundation drains;
- Category I outfalls (storm drains, water discharged under BMPs, groundwater, steam, and water condensate);
- Category II outfalls (storm drains, water discharged under BMPs, groundwater, steam, and water condensate);
- Category III outfalls (storm drains, water discharged under BMPs, groundwater, steam, and water condensate, cooling water, and cooling tower blowdown);
- Category IV outfalls (storm drains, water discharged under BMPs, groundwater, steam, and water condensate, cooling water, and cooling tower blowdown); and
- Cooling systems (cooling water, cooling tower blowdown).

Permit limits and compliance statistics are shown in Table 5.5. Instream data collection points X-13, X-14, and X-15 are not included in the table because only flow measurements and aesthetics are required under the NPDES permit. Permit limit exceedences in 1999 are shown in Fig. 5.14.

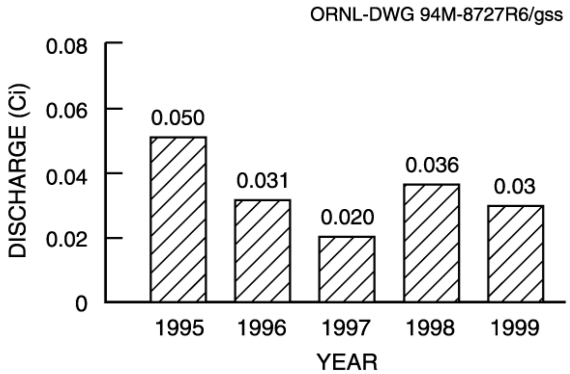

Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 1995–99.

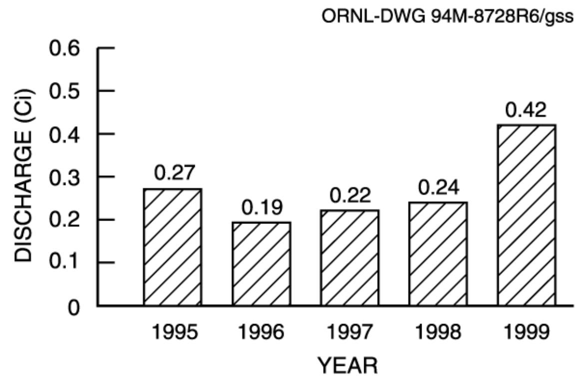

Fig. 5.9. Cesium-137 discharges at White Oak Dam, 1995–99.

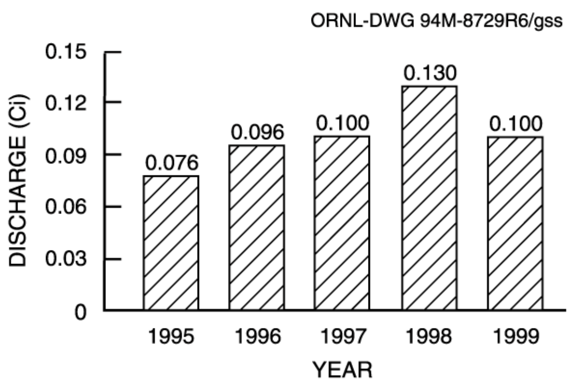

Fig. 5.10. Gross alpha discharges at White Oak Dam, 1995–99.

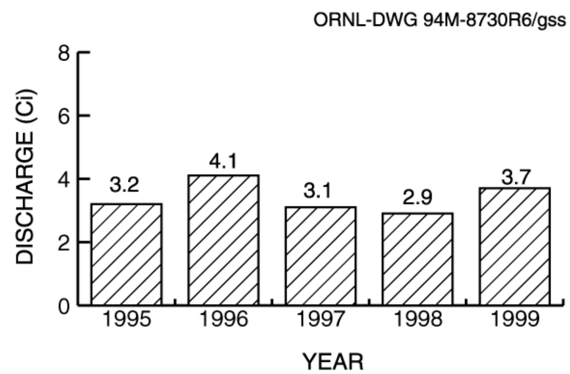

Fig. 5.11. Gross beta discharges at White Oak Dam, 1995–99.

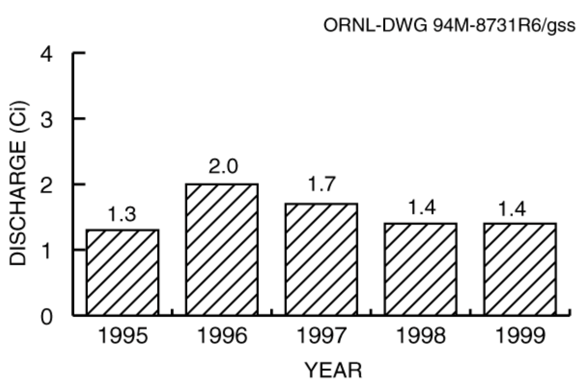

Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 1995–99.

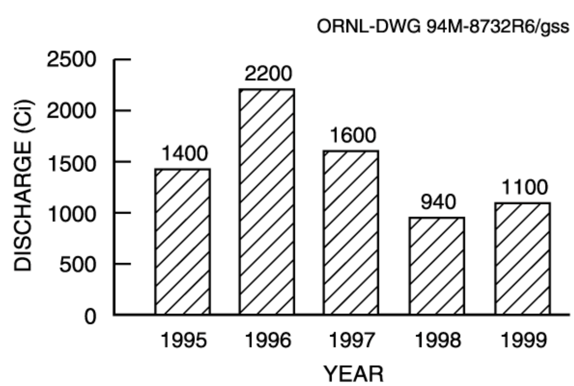

Fig. 5.13. Tritium discharges at White Oak Dam, 1995–99.

Table 5.5. 1999 NPDES compliance at ORNL (NPDES permit effective Feb. 3, 1997)

Discharge point	Effluent parameters	Permit limits: Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Permit compliance: Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	96-h LC_{50} for *Ceriodaphnia* (%)					41.1	0	4	100
	96-h LC_{50} for fathead minnows (%)					41.1	0	4	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	78	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		0	157	100
	Dissolved oxygen					6	0	156	100
	Fecal coliform (col/100 mL)			1000	5000		1	156	99
	No-observed-effect conc. for *Ceriodaphnia* (%)					12.3	0	4	100
	No-observed-effect conc. for fathead minnows (%)					12.3	0	4	100
	Oil and grease	8.7	13.1	10	15		4[b]	157	97
	pH (std. units)				9	6	0	156	100
	Total residual chlorine			0.038	0.066		0	156	99
	Total suspended solids	26.2	39.2	30	45		0	157	100
X02 (Coal Yard Runoff Treatment Facility)	96-h LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	96-h LC_{50} for fathead minnows (%)					4.2	0	4	100
	Copper, total			0.07	0.11		0	24	100
	Iron, total			1.0	1.0		1	24	96
	No-observed-effect conc. for *Ceriodaphnia* (%)					1.3	0	3	100
	No-observed-effect conc. for fathead minnows (%)					1.3	0	3	100
	Oil and grease			10	15		0	52	100
	pH (std. units)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	24	100
	Silver, total				0.008		0	24	100
	Total suspended solids				50		0	52	100
	Zinc, total			0.87	0.95		0	24	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X12 (Process Waste Treatment Complex)	96-h LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	96-h LC_{50} for fathead minnows (%)					100	0	4	100
	Cadmium, total	0.79	2.09	0.008	0.034		0	52	100
	Chromium, total	5.18	8.39	0.22	0.44		0	52	100
	Copper, total	6.27	10.24	0.07	0.11		0	52	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	52	100
	Nickel, total	7.21	12.06	0.87	3.98		0	52	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					30.9	0	4	100
	No-observed-effect conc. for fathead minnows (%)					30.9	0	4	100
	Oil and grease	30.3	45.4	10	15		1	52	98
	pH (std. units)				9.0	6.0	0	156	100
	Silver, total	0.73	1.3		0.008		0	52	100
	Temperature (°C)				30.5		0	156	100
	Total toxic organics		6.45		2.13		0	12	100
	Zinc, total	4.48	7.91	0.87	0.95		0	52	100
Instream chlorine monitoring points	Total residual oxidant			0.011	0.019		0	264	100
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	16	100
Groundwater/ pumpwater outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	6	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	4	100
Category I outfalls	pH (std. units)				9.0	6.0	0	19	100
Category II outfalls	pH (std. units)				9.0	6.0	0	19	100
Category III outfalls	pH (std. units)				9.0	6.0	0	57	100
Category IV outfalls	pH (std. units)				9.0	6.0	0	314	100
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	48	100
	Total residual oxidant			0.011	0.019		0	48	100

[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].
[b]The oil and grease measurement at X01 on September 7, 1999, resulted in calculated mass loading and monthly average limit exceedences.

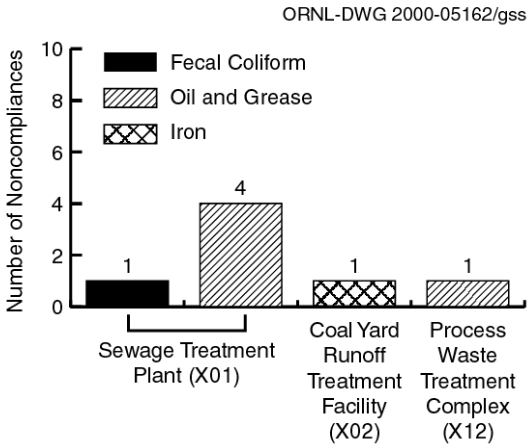

Fig. 5.14. ORNL NPDES permit limit exceedences in 1999 (total = 7).

Outfall X01, ORNL STP, exceeded its fecal coliform limit on June 30, 1999.

Outfall X01 also experienced one oil and grease limit exceedence on September 7, 1999. This value also caused several calculated NPDES limits to be exceeded, including mass loading and monthly average limits.

Outfall X02, ORNL CYRTF, exceeded its NPDES permit limit for iron on January 12, 1999.

Outfall X12, ORNL PWTC, exceeded its permit limit for oil and grease on November 4, 1999.

Under the NPDES permit, ORNL conducts several monitoring plans and programs. These include the RMP, the chlorine control strategy (CCS), and the Storm Water Pollution Prevention Plan (SWP3). These are discussed in the following sections.

5.5.1.1 Radiological Monitoring Plan

In 1999, ORNL continued to sample under the revised RMP approved by TDEC on July 1, 1997. Results for the 1999 monitoring are presented in the ORNL Radiological Monitoring Summary section, Sect. 5.4. Approved revisions to the RMP were implemented in November 1999.

5.5.1.2 Chlorine Control Strategy

The NPDES permit regulates the discharge of chlorinated water at ORNL by setting either total residual chlorine concentration limits or total residual oxidant (TRO) mass loading action levels on outfalls, depending on the outfall's location and the volume of its discharge. At ORNL, TRO measurements may include both chlorine and bromine residuals. Most outfalls with TRO mass-loading action levels are monitored semiannually with the balance of them being monitored either weekly, semimonthly, or quarterly. A number of outfalls were dropped from the CCS in July 1999 because they do not have dry weather TRO discharges. Outfalls included in the CCS have a mass-loading action level for TRO that requires ORNL to reduce or eliminate TRO in the discharge if it exceeds the action level. The action level is 1.2 g/d and is calculated by multiplying the instantaneous measured concentration by the instantaneous flow rate of the outfall. ORNL monitored 267 measurable dry weather discharges during 1999. Six outfalls exceeded the action level one or more times. Actions to reduce or eliminate chlorine in these effluents are being investigated for these outfalls. A report detailing monitoring results, corrective actions, and proposed modifications is submitted to TDEC annually.

5.5.1.3 Storm Water Pollution Prevention Plan

The SWP3 is a requirement of the ORNL NPDES Permit to document existing material management practices and evaluate the vulnerability of those practices in contributing pollutants to area streams via storm water runoff. The plan consists of four major components: (1) assessment and mapping of outdoor material storage/handling at ORNL; (2) characterization of storm water runoff by monitoring; (3) training of employees; and (4) implementation of measures to minimize storm water pollution in areas of ORNL that may be vulnerable. These four components of the plan were initiated in 1997 and are reviewed and updated by the facility at least annually. The ORNL SWP3 was last updated on August 1, 1999, to incorporate additional information and observations from the preceding year. The ORNL Storm Water Pollution Prevention (SWPP) Program, including the SWP3, SWPP training, and SWPP inspection program, is available to employees on the internal ORNL Web.

ORNL grouped its 164 NPDES outfalls into 11 groups based on the permit category and similar uses of the drainage areas (Table 5.6). Representative outfalls from each grouping were chosen for effluent sampling. The permit requires that Category I and II outfalls be characterized over a 5-year period and Category III and IV over a 3-year period. Storm water sampling and analysis continued in 1999 with five outfalls sampled.

While still in the early stages of information-gathering, storm water data collected to date were compared with water quality reference values for the purposes of better characterizing outfalls and for targeting additional actions such as focused studies, monitoring, and improved management practices. Copper at Outfall 217 and zinc at Outfall 113 were elevated above reference values. Follow-up investigations yielded no obvious wet-weather source for the copper, since this outfall drains storm water from a portion of an asphalt roof on Building 4500S. Dry-weather sources to this outfall are being investigated for sources of copper. Outfall 113 drains a high vehicle-traffic area where storm water runoff might be expected to contain parameters such as zinc. ORNL has continued to implement efforts, such as street sweeping and preventive maintenance of vehicles, to reduce the potential effect of vehicular traffic on storm water runoff.

5.5.2 ORNL Results and Progress in Implementing Programs and Corrective Actions

5.5.2.1 ORNL Mercury Investigation

Over the past three years, studies have been done by the ORNL Chemical Technology Divi-

Table 5.6. Storm Water Pollution Prevention Plan groups

Group	Description	Sampling frequency
A	Category I and II outfalls with potential discrete sources identified; however, none of the sources are potential hydrocarbon sources	Every 5 years
B	Category III and IV outfalls with potential discrete sources identified; however, none of the sources are potential hydrocarbon sources	Every 3 years
C	Category I and II outfalls with potential discrete sources identified, including potential hydrocarbon sources	Every 5 years
D	Category III and IV outfalls with potential discrete sources identified, including potential hydrocarbon sources	Every 3 years
E	Category I and II outfalls with impounded or collected storm water runoff	Every 5 years
F	Category III and IV outfalls with impounded or collected storm water runoff	Every 3 years
G	Category I and II outfalls with traffic and parking in their drainage areas but with no other discrete sources of potential storm water pollution in the drainage area	Every 5 years
H	Category III and IV outfalls with traffic and parking in their drainage areas but with no other point sources in the drainage area	Every 3 years
I	Category I and II outfalls without traffic and parking and with no other point sources identified in the drainage area	Every 5 years
J	Category III and IV outfalls without traffic and parking in their drainage areas but with no point sources in the drainage area	Every 3 years
K	Group K are excluded from storm water monitoring under the SWPP	Not applicable

sion to discover ways to maximize mercury removal by the ORNL Waste Treatment Complex-Nonradiological Wastewater Treatment Facility (NRWTF). Mercury sources have been investigated by measuring mercury concentrations and flow in process waste pipelines. Long-term studies have been done on the effectiveness of removing low concentrations of mercury in water by using various mercury sorbents (see Sect. 3.8.3.3) and complexing agents.

The Mercury Research Group in ORNL's Environmental Sciences Division continues to be involved in research on the air/surface exchange of mercury and its compounds. During the last decade, it has developed several new flux and speciation methods that are now used worldwide. Research has involved studies in Sweden and Germany and across North America. Current work involves studies of mercury deposition and speciation in Alaska, Canada, and Florida; studies of mercury emissions from the chlorine and other chemical industries in the Midwest and Southeast; studies of mercury releases from activities in municipal landfills in Florida; and natural mercury fluxes and re-emissions from geologically enriched soils in Nevada and California and background soils across North America.

During 1999, the Environmental Technology Partnership Group in ORNL's Environmental Sciences Division investigated mercury removal from wastewater using algal films in an experiment involving autotrophic biofilms for removing contaminants from industrial wastewater. The researchers found that biofilms are very effective in sorbing instream dissolved mercury and other metals.

5.6 ORNL WASTEWATER BIOMONITORING

Under the NPDES permit, wastewaters from the STP, the CYRTF, and the PWTC were evaluated for toxicity. The results of the toxicity tests of wastewaters from the three treatment facilities are given in Table 5.7. This table provides, for each wastewater, the month the test was conducted, the wastewater's no-observed-effect concentration (NOEC), and the concentration that kills 50% of the test organisms (LC_{50}) for fathead minnows and *Ceriodaphnia*. The NOEC is the highest concentration tested that does not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. The 96-h LC_{50} is the concentration of wastewater that kills 50% of the test organisms in 96 h. The NPDES permit effective February 3, 1997, defines the limits for the biomonitoring tests. For the X01 (STP) discharge, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 41.1% effluent (LC_{50}) or the NOEC is <12.3%. For the X02 discharge (CYRTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 4.2% effluent or the NOEC is <1.3%. Because of the batch mode of discharge at CYRTF, the limit for the NOEC only applies if the facility discharges for a sufficient length of time. For the X12 discharge (PWTC), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 100% effluent (LC_{50}) or the NOEC is <30.9%. In November 1998, the concentrations of wastewater evaluated for toxicity were reduced to only those required in the NPDES permit; thus, the 1999 NOEC and LC_{50} (Table 5.7) may appear lower than previous years' tests, but the values actually represent the highest concentration tested (i.e., 41.1% for Outfall X01).

During 1999, the STP, CYRTF, and PWTC were tested four times each. The biomonitoring limits for STP, CYRTF, and PWTC were not exceeded during 1999.

5.7 ORNL BIOLOGICAL MONITORING AND ABATEMENT PROGRAM

5.7.1 Bioaccumulation Studies

The bioaccumulation task addresses two NPDES permit requirements at ORNL: (1) to evaluate whether mercury at the site is contributing to a stream such that it will impact fish and aquatic life or violate the recreational criteria (instream water analyses for mercury should be part of this activity) and (2) to monitor the status of PCB contamination in fish tissue in the WOC watershed. These requirements are met by monitoring (1) mercury in water and game fish filets

Table 5.7. 1999 toxicity test results of ORNL wastewaters

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	January	*Ceriodaphnia*	12.3	>41.1
		Fathead minnow	41.1	>41.1
	April	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	August	*Ceriodaphnia*	<9.8[c]	>41.1
		Fathead minnow	41.1	>41.1
	November	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
Coal Yard Runoff Treatment Facility (X02)	February–March	*Ceriodaphnia*	4.2	>4.2
		Fathead minnow	4.2	>4.2
	May	*Ceriodaphnia*	*d*	>4.2[e]
		Fathead minnow	*d*	>4.2[e]
	August	*Ceriodaphnia*	4.2	>4.2
		Fathead minnow	4.2	>4.2
	November	*Ceriodaphnia*	4.2	>4.2
		Fathead minnow	4.2	>4.2
Nonradiological Wastewater Treatment Facility (X12)	March	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	April	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	August	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	November	*Ceriodaphnia*	100	>100
		Fathead minnow	80	>100

[a]NOEC = No-observed-effect concentration [the concentration (as percentage of full-strength wastewater) that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth].

[b]LC_{50} = the concentration (as percentage of full-strength wastewater) that kills 50% of the test species in 96 h.

[c]Not considered an exceedence, as the low NOEC was caused by unusually high reproduction in the controls rather than by reduced reproduction in the effluent.

[d]Insufficient discharge for chronic test and determination of NOEC.

[e]Test was terminated after 48 h due to batch discharge nature of facility, so value is a 48-h LC_{50}.

and (2) PCBs in game fish filet and whole-bodies of forage fish from WOC and White Oak Lake (WOL). Water samples were collected for mercury analysis from four WOC sites on five occasions in 1999. The mean mercury concentration in WOC at the weir upstream from ORNL (WCK 6.8) was below the analytical detection limit (<10 ng/L) on all sampling dates. Downstream from ORNL, average mercury concentrations in WOC surface water exceeded the Tennessee water quality criterion (51 ng/L) at all sites. The highest baseflow mercury concentrations were always found at MS 3619 (the flume upstream from the nonradiological wastewater treatment facility), where mercury concentrations averaged (± SD) 177 ± 71 ng/L, and ranged from 137 ng/L to 237 ng/L. The mean mercury concentration was 63 ± 25 ng/L at the weir below Melton Valley Road, with a range of 42 ng/L to 100 ng/L. Mean concentrations were lower below WOL, averaging 53 ± 23 ng/L total mercury, with a range of 23 ng/L to 81 ng/L.

Although aqueous mercury slightly exceeded the state water-quality standard in WOC, mean mercury concentrations in fish filets were below 0.5 mg/kg, which is the level typically used by the state of Tennessee in issuing fish consumption advisories. Two individual fish, a redbreast sunfish (*Lepomis auritus*) at WCK 2.9 (0.58 µg/g) and a largemouth bass (*Micropterus salmoides*) from WOL (0.69 µg/g), exceeded the 0.5-ppm level. The spatial pattern of mercury in WOC fish was consistent with the pattern for water. The highest concentrations in fish appear to be localized within WOC proper, where the mean mercury concentration (0.24 ± 0.07, µg/g ± SE) in redbreast sunfish was approximately three times higher than the mean concentration in fish from a local reference stream (0.08 ± 0.03). The mean mercury concentration in bluegill (*Lepomis macrochirus*) collected ~1.4 km downstream in WOL was similar to the reference stream value, averaging 0.06 ± 0.01. Mercury concentrations in WOL largemouth bass, averaging 0.21 ± 0.10 µg/g, were higher than in sunfish collected at the same site because of their higher position in the food chain.

Past studies of PCB bioaccumulation by the BMAP included the use of caged clams, whole-body fish sampling, and a larger number of sunfish sampling sites throughout WOC. These studies indicated that the major continuing source of PCBs to the system was from the main plant area (upstream of WCK 3.5). The PCB results in stonerollers (*Campostoma anomalum*) collected in 1999 from this area indicate that PCB levels in fish from upper WOC remain relatively high. Concentrations of PCBs in stonerollers averaged 2.46 ± 0.87 µg/g PCBs at a site near the main plant area (WCK 3.9). The mean PCB concentrations in sunfish filets from WCK 2.9 and WOL were 0.30 µg/g and 0.55 µg/g, respectively. Such PCB levels are high for relatively short-lived, lipid-poor fish such as sunfish. Concentrations of PCBs in sunfish collected from a reference site at the same time averaged < 0.01 µg/g. Because of their large size, position at the top of the food chain, and relatively high levels of intramuscular lipids, largemouth bass are sampled in WOL to evaluate the maximum PCB concentrations likely in the WOC watershed. The mean PCB concentration in WOL bass was lower than in past years, averaging 0.85 µg/g.

5.7.2 Ecological Surveys

Benthic macroinvertebrate communities have been monitored in streams of the WOC watershed since 1986 to help assess the condition of the streams and to document the effects of new pollution abatement facilities. Results for April sampling periods through 1998 show that ORNL operations adversely affect the benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC (Figs. 5.15, 5.16, and 5.17). Specifically, the total number of taxa (i.e., total taxonomic richness) and the number of pollution-intolerant taxa (i.e., Ephemeroptera, Plecoptera, and Trichoptera, or EPT richness) are markedly lower downstream of ORNL effluent discharges in all three streams. However, there have been some changes in the macroinvertebrate communities at all sites since April 1987, indicative of improvements in environmental conditions. The most substantial changes occurred after 1989 in the middle reaches of WOC at WCK 3.9 and at the downstream-most site on Fifth Creek (FFK 0.2). Both total taxonomic richness and EPT richness have increased considerably relative to initial conditions in 1987. More subtle improvements have occurred in lower First Creek (FCK 0.1) and lower WOC (WCK 2.3), where the number of pollution intolerant taxa has increased only slightly since the early 1990s.

Monitoring of the fish communities in WOC and its major tributaries continued in 1999. Samples were taken at 11 sites in the spring and 8 sites in the fall; sites closest to ORNL facilities were emphasized. In WOC, the fish community continued to display limited recovery, with sites closest to the outfalls having lower species richness (number of species), fewer sensitive species, and more pollution-tolerant species, but higher density (number of fish/m^2). The sites adjacent to Bldg. 4515 (WCK 4.3 and 4.4) had very high densities (10–13 fish/m^2) that were 2 to 30 times higher than the densities at WCK 3.9, a site near the PWTC treatment discharge. These densities were also much higher than those at area reference streams, suggesting some stimulation of production, perhaps from nutrient enrichment. However,

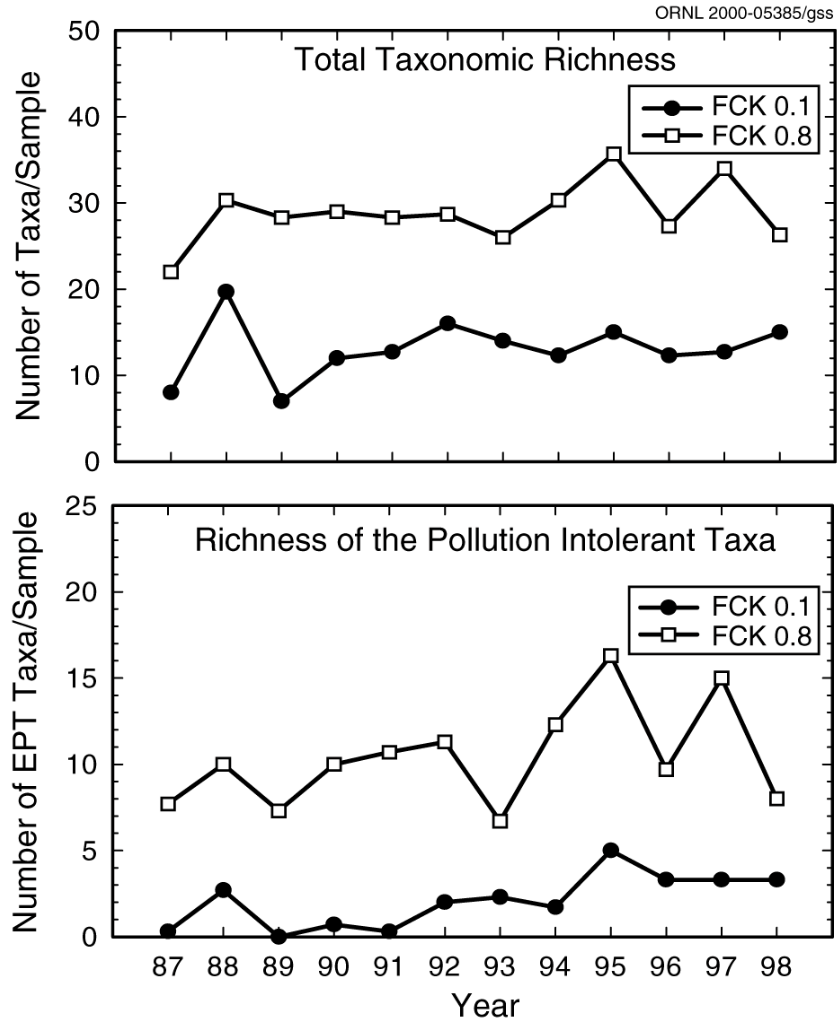

Fig. 5.15. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in First Creek during April sampling periods, 1987–1998. FCK = First Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

the high densities were countered by very low species richness, with these sites having only half as many species as similar-sized reference streams. The 1999 data continued to show a long-term positive trend, indicating that the fish communities at sites closest to the plant have improved over the 1985 to 1999 period. However, one especially noticeable change in the fish communities closest to the plant was a tenfold decline in fish densities at WCK 3.9 in fall 1999. The decline was almost totally due to reduced densities of one species, the central stoneroller (*Campostoma anomalum*). This is a schooling minnow that feeds on attached algae and normally occurs at high densities (e.g., 4 fish/m^2) at this site. It is unlikely that the decline of just one species would be related to a toxicant associated with nonradioactive wastewater discharges, but instead may just represent a short-term change in distribution of the primary stoneroller schools in this reach. Further sampling will indicate whether this is a continued problem or just an isolated event. Other main-stem WOC sites below all ORNL outfalls (WCK 3.4) and below the confluence with Melton Branch (WCK 2.3) show less recovery; species richness and density have more or less remained within similar ranges since 1985. Also, there has been a declining trend in density at WCK 3.4 since 1995, a trend not seen at upstream sites.

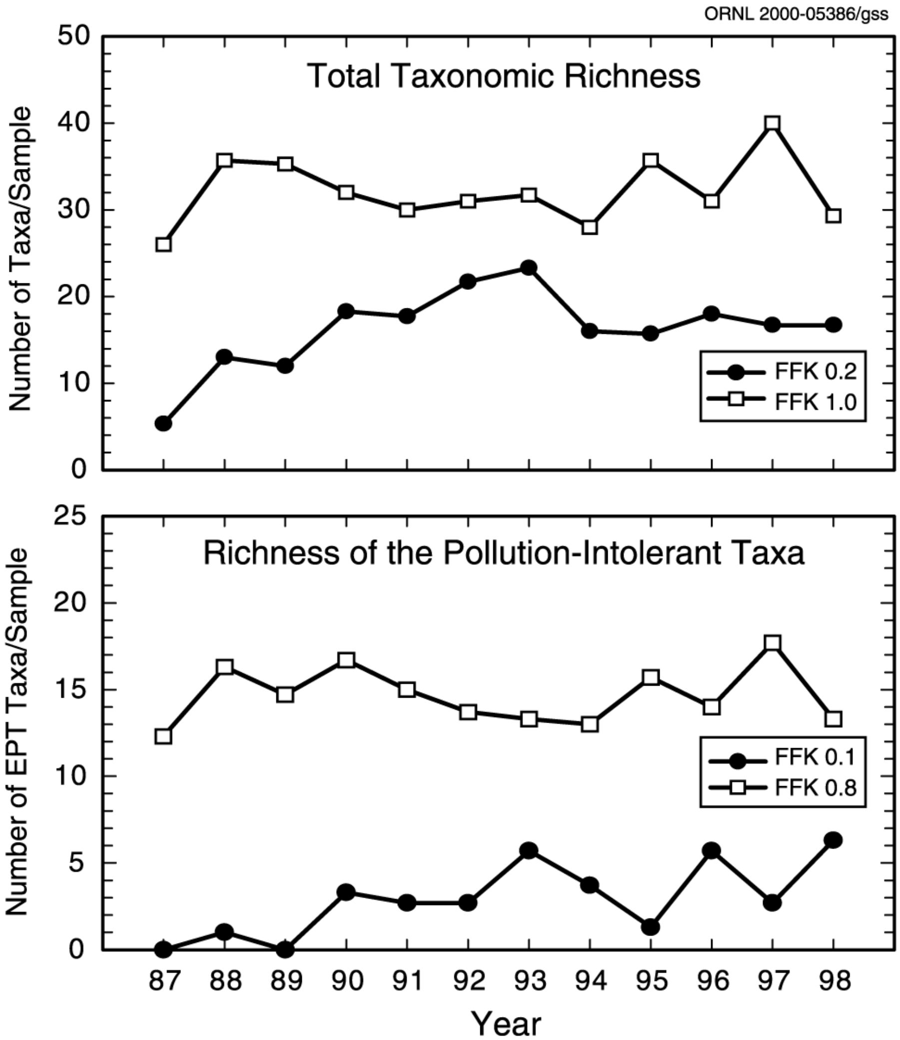

Fig. 5.16. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in Fifth Creek during April sampling periods, 1987–1998. FFK = Fifth Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

In the major tributaries, the fish communities also show some recovery but remain impacted relative to reference streams. Fifth Creek at FFK 0.2 has shown the most improvement. This site has changed from one that was incapable of supporting a fish community before 1992 to one having a fairly stable, three-species community in 1999. The densities have increased since 1992 even more rapidly and exceeded 6 fish/m^2 in fall 1999. High densities also have been measured at the reference site (FFK 1.0) since 1986. In Melton Branch, two new species of fish were found at MEK 1.4, the central stoneroller and the redbreast sunfish (*Lepomis auritus*); these two species had only been seen previously in Melton Branch at sampling sites located further downstream. Densities in Melton Branch have remained similar to those seen since 1988. In First Creek, the downstream site had high species richness (n = 7) but low density, which has declined since 1985. This site has experienced a noticeable increase in sedimentation, especially at the lower end of the sampling reach.

The low species richness seen in the WOC watershed is partially a result of isolation from the rest of the Clinch River drainage. The numerous weirs and dams in WOC watershed represent barriers to colonization by additional species, genera, and families. Historic impacts from poor water quality probably included elimination of

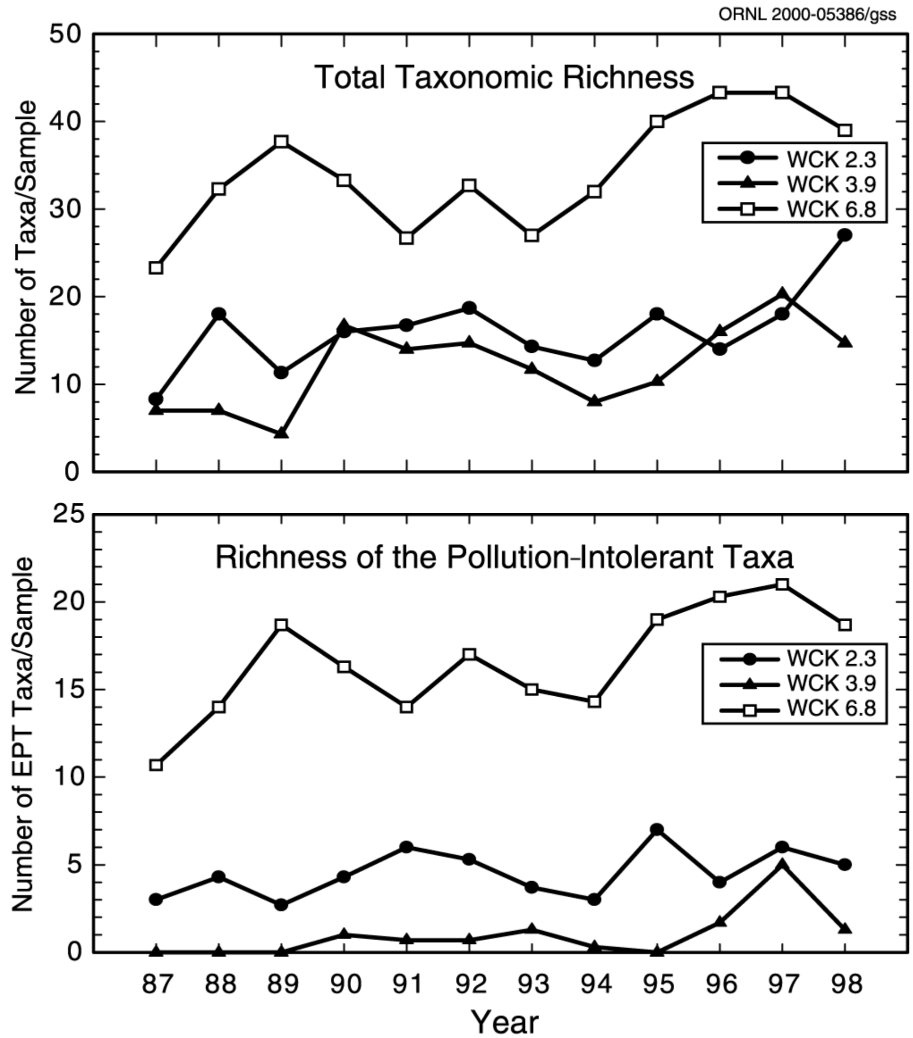

Fig. 5.17. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in White Oak Creek during April sampling periods, 1987–1998. WCK = White Oak Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

certain species and families from the watershed (e.g., darters, *Etheostoma*), and the weirs have prevented many of these species from returning, even with improvements in water quality. The construction of the WOC embayment dam altered flow release patterns at the WOC dam, especially during high flow conditions when pool elevation is high in the embayment. This change has allowed some additional species to colonize in the lower reaches of WOC (WCK 2.3), including the first occurrence of the golden redhorse (*Moxostoma erythrurum*), a moderately sensitive species, in the spring of 1999.

5.8 ORNL SURFACE WATER MONITORING AT REFERENCE LOCATIONS

The net impact of ORNL activities on surface waters is evaluated by comparing data from samples collected at background locations with information from samples collected downstream of the facility. This program was discontinued in the middle of 1999. Two months later, sampling was resumed at WOC headwaters to develop a baseline to assess impacts of the SNS project on

Table 5.8. 1999 analyses for ORNL reference surface waters

Parameter	No. detect/ No. total	Concentration Max[a]	Min[a]	Avg[b]	Standard error[c]	Reference value[d]	Percentage of reference value[e]
				Melton Hill Dam			
Anions (mg/L)							
Sulfate, as SO_4	6/6	26	16	22	1.6	*f*	*f*
Field measurements							
Conductivity (mS/cm)	6/6	0.25	0.15	0.23	0.015	*f*	*f*
Dissolved oxygen (mg/L)	6/6	10	6.2	8.8	0.57	*f*	*f*
pH (SU)	6/6	8.0	7.6	7.9	0.067	*f*	*f*
Temperature (°C)	6/6	20	8.5	13	1.9	*f*	*f*
Turbidity (NTU)	6/6	16	8.0	11	1.3	*f*	*f*
Metals (mg/L)							
Antimony, total	0/6	<0.0050	<0.00050	~0.00135	0.00075	0.006	*f*
Arsenic, total	1/6	0.0015	<0.0010	~0.0011	0.000083	0.05	2.2
Cadmium, total	0/6	<0.00010	<0.00010	~0.00010	0	0.005	*f*
Chromium, total	3/6	0.0010	0.00090	~0.00099	0.000018	0.1	0.99
Copper, total	6/6	0.0016	0.0011	0.0014	0.00066	*f*	*f*
Iron, total	0/6	<0.25	<0.25	~0.25	0	*f*	*f*
Lead, total	4/6	0.00032	<0.00010	~0.00015	0.000037	0.005	3.1
Nickel, total	1/6	0.0013	<0.0010	~0.0011	0.000050	0.1	1.1
Selenium, total	0/6	<0.0020	<0.0020	~0.0020	0	0.05	*f*
Silver, total	0/6	<0.00010	<0.00010	~0.00010	0	*f*	*f*
Zinc, total	6/6	0.0089	0.0040	0.0062	0.00064	*f*	*f*
Others (mg/L)							
Oil and grease	0/6	<5.6	<5.4	~5.5	0.037	*f*	*f*
Physical (mg/L)							
Total suspended solids	2/6	5.2	<1.0	~1.7	0.69	*f*	*f*
				White Oak Creek Headwaters			
Anions (mg/L)							
Sulfate, as SO_4	12/12	4.4	1.8	2.9	0.28	*f*	*f*
Field measurements							
Conductivity (mS/cm)	29/29	0.27	0.066	0.17	0.0092	*f*	*f*
Dissolved oxygen (mg/L)	29/29	11	7.0	8.6	0.16	*f*	*f*
pH (SU)	29/29	8.2	7.0	7.7	0.055	*f*	*f*
Temperature (°C)	29/29	18	5.6	12	0.74	*f*	*f*
Turbidity (NTU)	29/29	63	1.0	7.8	2.3	*f*	*f*
Metals (mg/L)							
Antimony, total	0/12	<0.00050	<0.00050	~0.00050	0	*f*	*f*
Arsenic, total	0/12	<0.0010	<0.0010	~0.0010	0	*f*	*f*
Cadmium, total	1/12	<0.00050	<0.00010	~0.00020	0.000052	0.0039	5.1
Chromium, total	6/12	0.0023	<0.0010	~0.0013	0.00012	*f*	*f*
Copper, total	5/12	0.014	<0.0010	~0.0023	0.0011	0.0177	13
Iron, total	4/12	1.2	<0.25	~0.39	0.-88	*f*	*f*
Lead, total	10/12	0.0025	<0.00010	~0.00062	0.00021	0.0817	0.76
Nickel, total	3/12	0.0022	<0.0010	~0.0011	0.00010	1.418	0.081
Selenium, total	0/12	<0.0020	<0.0020	~0.0020	0	0.02	*f*
Silver, total	1/12	0.00075	<0.00010	~0.00015	0.000054	0.0041	3.8
Zinc, total	12/12	0.049	0.0034	0.016	0.0035	0.117	13
Others (mg/L)							
Oil and grease	0/12	<8.3	<5.3	~5.8	0.23	*f*	*f*
Physical (mg/L)							
Total suspended solids	8/12	150	<1.0	~27	13	*f*	*f*

[a]Prefix "<" indicates the value of a parameter (excluding organics) was not quantifiable at the analytical detection limit.

[b]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

[c]Standard error of the mean.

[d]Tennessee General Water Quality Criteria for Domestic Water Supply is used as a reference value for Melton Hill Dam; Tennessee General Water Quality Criteria for Fish and Aquatic Life is used as a reference value for White Oak Creek headwaters.

[e]Average concentration as a percentage of the reference value, calculated when a reference exists, the parameter is a contaminant, and the parameter is detected.

[f]Not applicable.

the nearby surface waters. Under the old program, monthly surface water samples were collected at two reference sampling locations to determine contamination levels before the influence of WOC, the primary discharge point into Watts Bar Lake from the ORNL plant site. One sampling location is Melton Hill Dam above ORNL's main discharge point into the Clinch River. The other sampling location is WOC headwaters above any ORNL discharge points to WOC (Fig. 5.6). Since the program change in mid-year, WOC headwaters is the only reference location sampled.

Analyses were performed to detect radioactive, conventional, and inorganic pollutants in the water. Conventional pollutants are indicated by measurements of conductivity, temperature, turbidity, pH, total suspended solids (TSS), and oil and grease. Inorganic parameters are indicated by analyses for metals and anions (Table 5.8).

In an effort to provide a basis for evaluation of analytical results and for assessment of surface water quality, Tennessee General Water Quality Criteria (TWQC) have been used as reference values. The TWQC for domestic water supply have been used at Melton Hill, whereas TWQC for fish and aquatic life have been used at WOC headwaters (see Appendix D, Table D.2, for TWQC for all parameters in water and Table D.3 for surface water analyses).

A summary of the analyses at WOC headwaters and Melton Hill Dam is presented in Table 5.8. The average concentration is expressed as a percentage of the reference value when the parameter is a contaminant, the parameter is detected, and a reference value exists. The highest percentages of reference values were for copper and zinc at WOC headwaters. However, these values were only 13% of the reference values, indicating that these waters easily meet their respective TDEC WQC.

Radiological data are compared with DOE DCGs in Table 5.9. The average concentration for a radionuclide is expressed as a percentage of its DCG when a DCG exists and when the average concentration is significantly greater than zero. At the reference locations, three averages in 1999 met the criteria: ^{60}Co and ^{137}Cs at Melton Hill Dam and ^{60}Co at WOC headwaters. All three averages were less than 1% of their DCGs.

Table 5.9. 1999 radionuclide concentrations in surface waters around ORNL

Radionuclide	No. detect/ No. Total	Concentration (pCiL) Max[a]	Min[a]	Avg[b]	Standard error[c]	DCG[d]	Percent of DCG[e]
				Melton Hill Dam			
^{60}Co	4/5	15*	7.2*	11*	1.5	5,000	0.22
^{137}Cs	0/5	8.2	0.17	4.4*	1.3	3,000	0.15
Gross alpha	1/5	3.7*	–0.39	1.1	0.73	*f*	*f*
Gross beta	2/5	5.9*	–0.81	2.6*	1.1	*f*	*f*
				White Oak Creek Headwaters			
^{60}Co	3/10	22*	–6.4	5.3*	2.5	5,000	0.11
^{137}Cs	4/10	42*	–7.9	5.7	4.4	3,000	*f*
Gross alpha	4/10	4.9*	–1.3	1.2*	0.56	*f*	*f*
Gross beta	2/10	6.0*	–3.4	0.77	1.0	*f*	*f*

[a]Individual radionuclide concentrations significantly greater than zero are identified by an *.
[b]Average radionuclide concentrations significantly greater than zero are identified by an *.
[c]Standard error of the mean.
[d]Derived concentration guide for ingestion of water. From DOE Order 5400.5.
[e]Average concentration as a percentage of the derived concentration guide(DCG), calculated only when a DCG exists and the average concentration is significantly greater than zero.
[f]Not applicable.

5.9 OFF-SITE MONITORING

The ORNL program for assessing impacts to the Clinch and Tennessee rivers uses empirical data from samples taken at the Kingston and Gallaher potable water treatment plants (Fig. 5.18). This program was discontinued in 1999. In 1999, composite samples of treated water from Gallaher and untreated water from Kingston were collected January through March, and a composite was analyzed for specific radionuclides.

Federal and state drinking water standards (DWSs) (40 CFR Parts 141 and 143 and TWQC for domestic water supply) were used as reference values. If a DWS for a radionuclide has not been established, then 4% of the DOE DCG for that radionuclide is used as the reference value. The average radionuclide concentration is expressed as a percentage of the reference value when a reference exists and when the average is significantly greater than zero. In the one set of data from 1999, radionuclides at the Gallaher water treatment plant that met these criteria were ^{60}Co and ^{137}Cs, with the largest being ^{137}Cs at 17% of the reference value. At the Kingston water treatment plant, total uranium met these criteria, at 3.8% of the reference value.

5.10 GROUNDWATER MONITORING AT ORNL

5.10.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. The EMEF Program, formerly the ER Program, provides comprehensive

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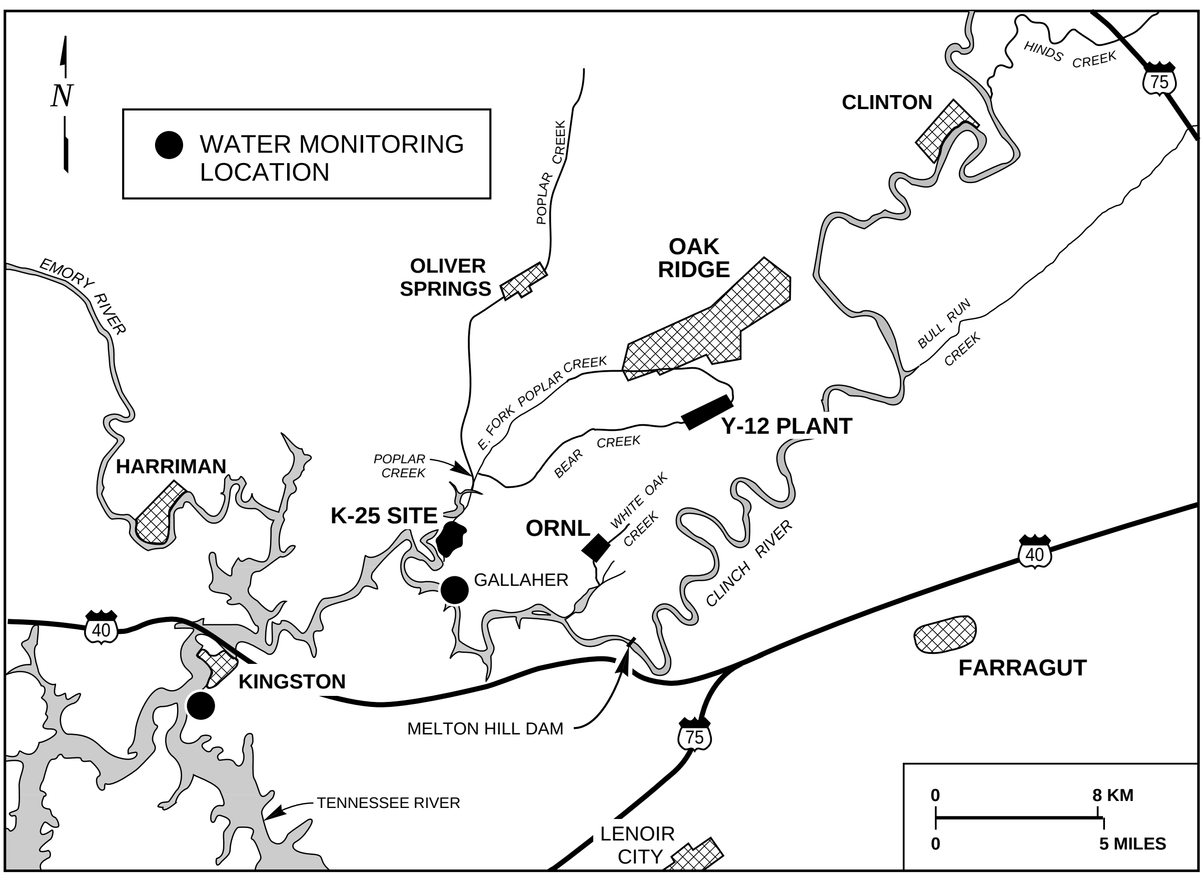

Fig. 5.18. ORNL off-site monitoring at the Gallaher and Kingston water treatment plants.

cleanup of sites where past and current research, development, and waste management activities may have resulted in residual contamination of the environment. Individual monitoring and assessment are assumed impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections among many of them. Consequently, the concept of waste area groupings (WAGs) was developed to facilitate evaluation of potential sources of releases to the environment. A WAG is a grouping of multiple sites that are geographically contiguous and/or that occur within hydrologically (geohydrologically) defined areas. WAGs allow establishment of suitably comprehensive groundwater and surface water monitoring and remediation programs in a far shorter time than that required to deal with every facility, site, or SWMU individually. Some WAGs share boundaries, but each WAG represents a collection of distinct small drainage areas, within which similar contaminants may have been introduced. Monitoring data from each WAG are used to direct further groundwater studies aimed at addressing individual sites or units within a WAG as well as contaminant plumes that extend beyond the perimeter of a WAG.

At ORNL, 20 WAGs were identified by the RCRA Facility Assessment (RFA) conducted in 1987. Thirteen of these have been identified as potential sources of groundwater contamination. Additionally, there are a few areas where potential remedial action sites are located outside the major WAGs. These individual sites have been considered separately (instead of expanding the area of the WAG). Water quality monitoring wells have been established around the perimeters of the WAGs determined to have a potential for release of contaminants. Figure 5.19 shows the location of each of the 20 WAGs.

Groundwater quality monitoring wells for the WAGs are designated as hydraulically upgradient or downgradient (perimeter), depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. There are no groundwater quality monitoring wells installed for the WAG 10 grout sheets.

In 1996, DOE established the IWQP (Sect. 3.10) to conduct long-term environmental monitoring throughout the ORR. The IWQP is the vehicle for the DOE to carry out the regulatory requirement from the FFA to conduct post-remedial action monitoring. Under the IWQP Plan (DOE 1998e), there was a shift away from the use of the WAG concept to more of a watershed approach to remediation, which resulted in the assignment of two watersheds to ORNL, Bethel Valley and Melton Valley. The WRRP succeeded the IWQP in fall 1999.

The ORNL groundwater program was reviewed in 1996, and modifications included transfer of monitoring responsibility for some of the WAGs to IWQP (now WRRP). ORNL retained monitoring responsibility for WAGs that have the potential for groundwater contamination because of ongoing ORNL activities. A summary of the ORNL groundwater surveillance program is

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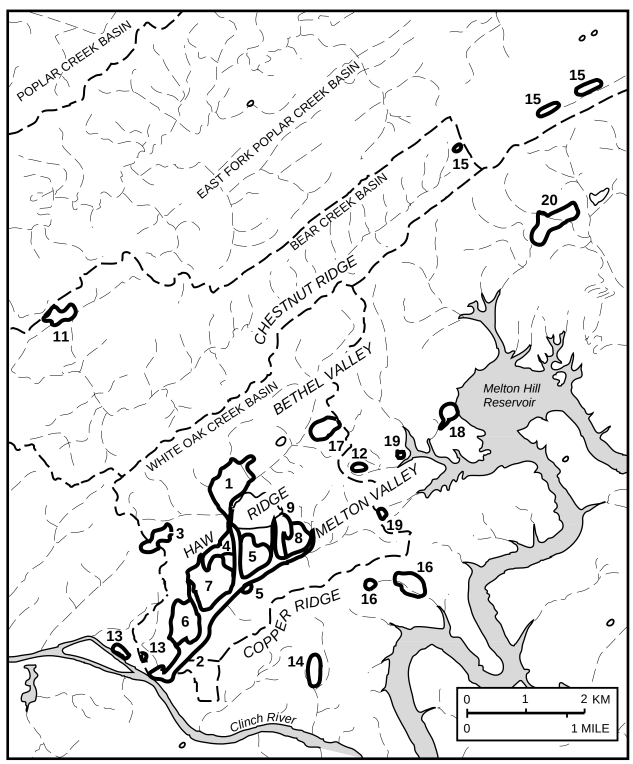

Fig. 5.19. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

presented in Table 5.10, which indicates whether WAGs are within Bethel Valley or Melton Valley. To provide continuity with previous Annual Site Environmental Reports (ASERs) and to allow comparison of activities and sampling results, the WAG concept is used in the following discussions. In the current ORNL program, groundwater quality wells are sampled on a rotational basis (Table 5.10).

Monitoring results for remedial actions (i.e., under WRRP purview) that are in progress or have been completed within specific WAGs are reported annually in the RER (BJC 2000a). Additionally, in the case of WAG 6, which is regulated under both RCRA and CERCLA, specific monitoring results and interpretations required by RCRA are reported in the annual Groundwater Quality Assessment Report for WAG 6, which is issued in February of each year (BJC 2000b).

The ORNL exit pathway program is designated to monitor groundwater at locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL. The program was initiated in 1993 and was reviewed in 1996, which resulted in WOC/Melton Valley being the focus of the program (Fig. 5.20). A summary of the current program is presented in Table 5.11.

Groundwater monitoring for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance during 1999 involved approximately 49 sampling events.

Four of the 10 wells identified by the ORR Environmental Monitoring Plan (EMP) (DOE 1998b) as ORNL's exit pathway monitoring program are also part of the WAG perimeter monitoring program. These four wells are located on WAG 2, and 1999 data from sampling conducted under the WAG perimeter program were used for the exit pathway monitoring plan program. The surface water location (WOC at WOD) was sampled in August 1999. The results of the plant perimeter monitoring program are discussed in part in the following sections.

Groundwater quality is regulated under RCRA by referring to the Safe Drinking Water Act (SDWA) standards. The standards are applied when a site undergoes RCRA permitting. None of the ORNL WAGs are under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, federal drinking water standards, and Tennessee WQC for domestic water supplies were used as reference values in the following discussions. When no federal or state standard had been established for a radionuclide, then 4% of the DOE DCG has been used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs. There are no groundwater wells furnishing drinking water to personnel at ORNL.

5.10.2 Bethel Valley

Bethel Valley, located in the southeastern portion of the ORR, lies between two prominent, parallel, northeast-southwest trending ridges, Chestnut Ridge to the north and Haw Ridge to the south. Research and development facilities have been located within it for 50 years, and it contains the main ORNL facilities complex, including buildings, reactors, surface impoundments, and buried waste tank farms with transfer pipelines. In most instances, groundwater in the valley flows northeast-southwest (i.e., parallel to the strike direction), and contaminant plumes generally enter the surface water system where contaminants can be readily monitored.

5.10.2.1 WAG 1 Area

WAG 1, the ORNL main plant area, contains about one-half of the RA sites identified to date by the EMEF Program. WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is about 2040 acres. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Many of the WAG 1 sites were used to collect and store LLW in tanks, ponds, and waste treatment facilities, but some sites also include landfills and contaminated sites resulting from spills and leaks occurring over the last 50 years. Because of the nature of cleanup and repair, it is not possible to determine which spill or leak sites still represent potential sources of release. Most of the

Table 5.10. Summary of the groundwater surveillance program at ORNL, 1999

WAG	Regulatory status	Wells		Frequency and last date sampled in 1999	Locations	Parameters
		Upgradient	Downgradient			
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Rotation Jun 1999	4 wells	Radionuclides[a] and field measurements[b]
3	DOE Orders 5400.1 and 5400.5	3	12	*c*	*c*	*c*
17	DOE Orders 5400.1 and 5400.5	4	4	Rotation Apr-May, Oct 1999[d]	All wells	Volatile organics, radionuclides,[a] and field measurements[b]
			Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Rotation Mar 1999	4 wells 16 wells	Full set[e] and field measurements[b] radionuclides[a] and field measurements[b]
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	*c*	*c*	*c*
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	*c*	*c*	*c*
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	*f*	*f*	*f*

Table 5.10 (continued)

WAG	Regulatory status	Wells		Frequency and last date sampled in 1999	Locations	Parameters
		Upgradient	Downgradient			
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	*c*	*c*	*c*
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Feb-Mar 1999	All wells	Radionuclides[a] and field measurements[b]
			White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	*c*	*c*	*c*

[a]Gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[b]Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.
[c]IWQP samples selected wells for various purposes; other wells are inactive.
[d]Sampling at one well was delayed due to RCRA activities.
[e]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[f]Sampled by EMEF and data reported in the *Groundwater Quality Assessment Report for Solid Waste Storage Area 6 at Oak Ridge National Laboratory, Oak Ridge, Tennessee CY 1999* (BJC 2000b).

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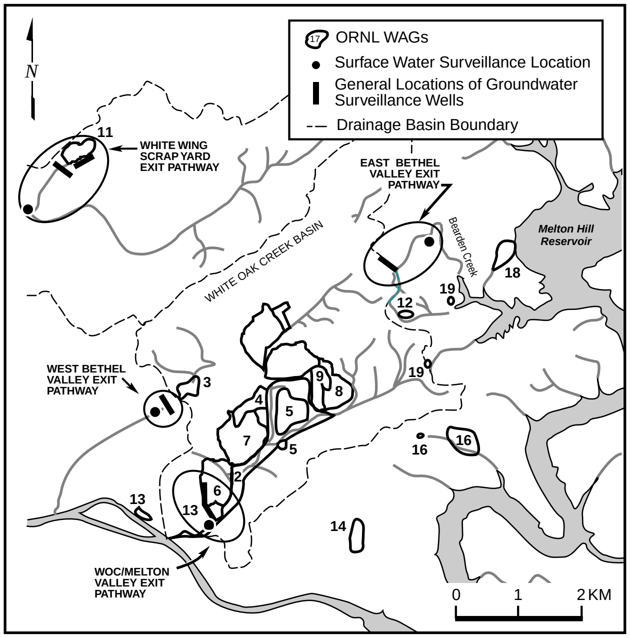

Fig. 5.20. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

Table 5.11. Summary of the plant perimeter surveillance program at ORNL, 1999

Exit pathway	WAG	Number of wells	Surface water locations	Parameters
White Oak Creek/ Melton Valley	6 and 2[a]	10	White Oak Creek at White Oak Dam	Volatile organics, ICP metals, tritium, total radioactive strontium, gross alpha and beta, ^{60}Co and ^{137}Cs

[a]Four wells are part of the ORNL WAG 2 perimeter network.

SWMUs are related to ORNL's waste management operations. Recent EMEF activities within WAG 1 include several CERCLA actions associated with sources of contamination (e.g., removal of liquids and sludge from the GAAT and the removal of liquids and sludge from the 190 ponds and subsequent backfilling with rocks and grout).

WAG 1 Results

In 1999, four WAG 1 wells potentially affected by current ORNL activities were sampled for radionuclides only. These four wells are in the southwest area of WAG 1. Tritium ranged from below detection to 7300 pCi/L, and total radioactive strontium ranged from below detection to 18 pCi/L. Total radioactive strontium at well 830 was 18 pCi/L, which is above the DWS of 8 pCi/L. All four wells' results were consistent with historical data.

5.10.2.2 WAG 3 Area

WAG 3 is located in Bethel Valley about 0.6 mile (1 km) west of the main plant area. WAG 3 is composed of three SWMUs: SWSA 3, the Closed Scrap Metal Area (1562), and the Contractors' Landfill (1554).

SWSA 3 and the Closed Scrap Metal Area are inactive landfills known to contain radioactive solid wastes and surplus materials generated at ORNL from 1946 to 1979. Burial of solid waste ceased at this site in 1951; however, the site continued to be used as an aboveground scrap metal storage area until 1979. Sometime during the period from 1946 to 1949, radioactive solid wastes removed from SWSA 2 were buried at this site. In 1979, most of the scrap metal stored aboveground at SWSA 3 was either transferred to other storage areas or buried on site in a triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this SWMU.

The Contractors' Landfill was opened in 1975 and is now closed. It was used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos was allowed to be buried at the site. ORNL disposal procedures required that only non-RCRA, nonradioactive solid wastes were to be buried in the Contractors' Landfill.

WAG 3 Results

Groundwater monitoring in WAG 3 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER (BJC 2000a).

5.10.2.3 WAG 17 Area

WAG 17 is located about 1 mile (1.6 km) directly east of the ORNL main plant area. This area has served as the major craft and machine shop area for ORNL since the late 1940s. The area includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead-melting facilities, garage facilities, welding facilities, and material storage areas needed to support ORNL's routine and experimental operations. WAG 17 is composed of 18 SWMUs. A former septic tank is now used as a sewage collection/pumping station for the area. Photographic waste tanks have been removed. Two relatively new USTs are currently registered to store diesel fuel and gasoline.

WAG 17 Results

WAG 17 is located on a northwest-facing slope, with its upgradient wells on the eastern border and downgradient wells on the western border. Although none of the wells had radiological levels above any DWSs, the data for wells along the eastern and western boundaries show evidence of radioactivity, including gross alpha activity and ^{3}H. In the past, gross alpha activity has exceeded the DWS at two wells; however, this has not occurred in the past five sampling events. The highest gross alpha activity was 2.7 pCi/L, the highest gross beta activity was 9.2 pCi/L, and ^{3}H was 5200 pCi/L. Total radioactive strontium was not detected.

The data for the wells along the southeastern and southwestern boundaries show evidence of VOCs. The contamination has consistently been located primarily in one well. The contaminants include trichloroethene, tetrachloroethene, 1,1-dichloroethene, benzene, and vinyl chloride, which is a degradation product of trichloroethene.

5.10.3 Melton Valley

Melton Valley is the second of the two valleys that comprise ORNL. Melton Valley is of primary importance on the ORR because it is one of the major waste storage areas on the Reservation. In addition to containing surface structures, it is the location of shallow waste burial trenches and auger holes, landfills, tanks, impoundments, seepage pits, hydrofracture wells and grout sheets, and waste transfer pipelines and associated leak sites. As with Bethel Valley, groundwater plumes within Melton Valley generally enter the surface water system, where contaminants are frequently encountered.

5.10.3.1 WAG 2 Area

WAG 2 is composed of WOC discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities.

In addition to natural drainage, WOC has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the PWTC, the STP, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 1, 4, 5, 6, 7, 8, and 9.

There is little doubt that WAG 2 represents a source of continuing contaminant release (radionuclides and/or chemical contaminants) to the Clinch River. Although it is known that WAG 2 receives groundwater contamination from other WAGs, the extent to which it may be contributing to groundwater contamination has yet to be determined. Recent EMEF activities to determine the extent of WAG 2 groundwater contamination include continued monitoring and support of the WAG 5 seeps removal action, as well as performing an RI of the WOC Watershed.

WAG 2 Results

At WAG 2, most of the downgradient wells are to the west and downstream. The upgradient wells are to the east and upstream. As a major drainage system, WAG 2 is influenced by other WAGs, and this seems to be reflected in the analytical results. Major contributors of ^{3}H and total radioactive strontium to WAG 2 (in order of contribution) are WAGs 5, 8, 9, 4, 1, 6, and 7 (see Fig. 5.19).

For example, four of the WAG 2 wells that exhibited high levels of ^{3}H are located south of and downgradient of WAGs 5, 6, and 8. All of the WAG 2 wells show evidence of radioactivity, including gross alpha and gross beta activity and ^{3}H. Gross beta activity above primary DWSs was detected at one well south of WAG 6 and slightly above DWS at one well along the eastern border of WAG 6. The elevated levels of ^{3}H and total radioactive strontium in the perimeter wells at WOD are believed to be the result of surface-water underflow at the dam, not groundwater contamination. Gross alpha activity at WAG 2 ranged from not detected to 4.9 pCi/L (the DWS is 15 pCi/L), beta activity ranged from not detected to 610 pCi/L (the DWS is 50 pCi/L), and total radioactive strontium ranged from not detected to 290 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 400,000 pCi/L (the DWS is 20,000 pCi/L).

Chromium was detected above the DWS at one well south of WAG 6. Chromium has been found to be above the DWS in the past six sampling events at this well.

5.10.3.2 WAG 4 Area

WAG 4 is located in Melton Valley about 0.5 mile (0.8 km) southwest of the main ORNL plant site. It comprises the SWSA 4 waste disposal area, LLLW transfer lines, and the experimental Pilot Pit Area (Area 7811).

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 1963, Oak Ridge was designated by the Atomic Energy Commission as the Southern Regional Burial Ground; as such, SWSA 4 received a wide variety of poorly characterized solid wastes (including radioactive waste) from about 50 sources. These wastes consisted of paper, clothing, equipment, filters, animal carcasses, and related laboratory wastes. About 50% of the waste was received from sources outside of Oak Ridge facilities. Wastes were placed in trenches, shallow auger holes, and in piles on the ground for covering at a later date.

From 1954 to 1975, LLLW was transported from storage tanks at the main ORNL complex to waste pits and trenches in Melton Valley (WAG 7), and later to the hydrofracture disposal sites through underground transfer lines. The Pilot Pit Area (Area 7811) was constructed for use in pilot-scale radioactive waste disposal studies from 1955 to 1959; three large concrete cylinders containing experimental equipment remain embedded in the ground. A removal action was conducted at WAG 4 during 1996 to grout in place sources of ^{90}Sr contamination emanating from selected trenches located within the WAG. A control building and asphalt pad have been used for storage through the years.

WAG 4 Results

Groundwater monitoring in WAG 4 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP RER (BJC 2000a).

5.10.3.3 WAG 5 Area

WAG 5 contains 33 SWMUs, 13 of which are tanks that were used to store LLLW prior to disposal by the hydrofracture process. WAG 5 also includes the surface facilities constructed in support of both the old and new hydrofracture facilities. The largest land areas in WAG 5 are devoted to TRU waste in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original PWTF. Currently, LLW tanks at the new hydrofracture facility are being used to store evaporator concentrates pending a decision regarding ultimate disposal of these wastes.

SWSA 5 South was used to dispose of solid LLW generated at ORNL from 1959 to 1973. During this time, the burial ground served as the Southern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site were set aside for the retrievable storage of TRU wastes.

The WAG 5 boundary includes the old (OHF) and new hydrofracture facilities (NHF). Because Melton Branch flows between these facilities, the NHF has a separate boundary. Studies of the contents of several tanks at the OHF were performed in preparation for a removal action. The scope of the removal action is to remove the contents of the tanks. The documentation for the non-time-critical removal action for the OHF tanks was completed in 1998. A CERCLA removal action was initiated in 1994 to remove ^{90}Sr from Seeps C and D located along the southern boundary of WAG 5 and continues through the present.

WAG 5 Results

Groundwater monitoring in WAG 5 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER (BJC 2000a).

5.10.3.4 WAG 6 Area

WAG 6 consists of four SWMUs: (1) SWSA 6, (2) Building 7878, (3) the explosives detonation trench, and (4) Building 7842. SWSA 6 is located in Melton Valley, northwest of WOL and southeast of Lagoon Road and Haw Ridge. The site is about 1.2 miles (2 km) south of the main ORNL complex. Waste burials at the 68-acre site were initiated in 1973 when SWSA 5 was closed. Various radioactive and chemical wastes were buried in trenches and auger holes. SWSA 6 is the only currently operating disposal area for LLW at ORNL. The emergency waste basin was constructed in 1961 to provide storage of liquid wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6 and has a capacity of 15 M gal, but has never been used. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 6 was among the first WAGs to be investigated at ORNL by the EMEF Program. WAG 6 is an interim-status RCRA unit because of past disposal of RCRA-regulated hazardous waste. Environmental monitoring is carried out under CERCLA and RCRA. A proposed CERCLA remedial action, which involved capping WAG 6, was abandoned after a public meeting in which members of the community objected to the high cost of capping. Groundwater monitoring continues to be carried out under the auspices of the EMP for WAG 6 at ORNL, which was implemented after abandonment of the RA chosen at WAG 6.

WAG 6 Results

Information about WAG 6 monitoring results in 1999 is available in the 1999 Groundwater Quality Assessment Report for ORNL's SWSA 6 (BJC 2000b).

5.10.3.5 WAG 7 Area

WAG 7 is located in Melton Valley about 1 mile (1.6 km) south of the ORNL main plant area. The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for disposal of LLLW. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose of acid solutions primarily containing enriched uranium from Homogeneous Reactor Experiment fuel. WAG 7 has been used to demonstrate the efficacy of in situ vitrification technology to immobilize radioactive waste streams buried in the WAG. However, because of a release of fission products (^{137}Cs) during testing of the in situ vitrification technology, the project was placed in shutdown mode.

WAG 7 Results

Groundwater monitoring in WAG 7 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER.

5.10.3.6 WAGs 8 and 9 Area

Because of the small number of groundwater monitoring wells in WAG 8 and WAG 9, they are sampled together. The analytical results for the two WAGs are also reported together.

WAG 8, located in Melton Valley, south of the main plant area, is composed of 36 SWMUs associated with the reactor facilities in Melton Valley. The SWMUs consist of active LLLW collection and storage tanks, leak/spill sites, a contractors' soils area, radioactive waste ponds and impoundments, and chemical and sewage waste treatment facilities. WAG 8 includes the MSRE facility, the HFIR, and the REDC. A removal action was initiated at the MSRE during 1995 to remove filtration devices contaminated with uranium.

Radioactive wastes from WAG 8 facilities are collected in on-site LLLW tanks and are periodically pumped to the main plant area (WAG 1) for storage and treatment. The waste includes demineralizer backwash, regeneration effluents, decontamination fluids, experimental coolant, and drainage from the compartmental areas of filter pits.

WAG 9 is located in Melton Valley about 0.6 mile (1 km) southeast of the ORNL main plant area and adjacent to WAG 8. WAG 9 is composed of eight SWMUs, including the Homogeneous Reactor Experiment pond, which was used from 1958 to 1961 to hold contaminated condensate and shield water from the reactor, and LLLW collection and storage tanks, which were used from 1957 to 1986.

WAGs 8 and 9 Results

The two upgradient wells are located north of the WAGs, two of the downgradient wells are located northwest of the WAGs, two are located south of WAG 8, and the remaining five are in WAG 8 west of WAG 9 and in WAG 9. The analytical results for 1999 are comparable to results from the previous years.

The two wells on the northwestern perimeter exceeded DWSs, one well with respect to tritium contamination and the other with respect to gross beta activity and total radioactive strontium contamination. The two wells in WAG 9 both exceeded the DWS for gross beta activity and total radioactive strontium. Gross alpha activity ranged from not detected to 5.7 pCi/L (the DWS is 15 pCi/L), beta activity ranged from not detected to 1400 pCi/L (the DWS is 50 pCi/L), and total radioactive strontium ranged from not detected to 1100 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 49,000 pCi/L (the DWS is 20,000 pCi/L).

5.10.3.7 WAG 10 Area

WAG 10 consists of the OHF grout sheets, the NHF, and NHF grout sheets. The surface facilities are associated with WAGs 5, 7, and 8.

Hydrofracture Experiment Site 1 is located within the boundary of WAG 7 (south of Lagoon Road) and was the site of the first experimental injection of grout (October 1959) as a testing program for observing the fracture pattern created in the shale and for identifying potential operating problems. Injected waste was water tagged with ^{137}Cs and ^{141}Ce. Grout consisted of diatomaceous earth and cement.

Hydrofracture Experiment Site 2 is located about 0.8 km (0.5 mile) south of the 7500 (experimental reactor) area (WAG 8). The second hydrofracture experiment was designed to duplicate, in scale, an actual disposal operation; however, radioactive tracers were used instead of actual waste. Cement, bentonite, and water tagged with ^{137}Cs were used in formulating the grout.

The OHF is located about 1.6 km (1.0 mile) southwest of the main ORNL complex near the southwest corner of WAG 5. The facility, commissioned in 1963, was used to dispose of liquid radioactive waste in impermeable shale formations at depths of 800 to 1000 ft by hydrofracture methods. Wastes used in the disposal operations included concentrated LLLW from the gunite tanks in WAG 2, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other, unidentified radionuclides.

The NHF is located 900 ft southwest of the OHF on the south side of Melton Branch. The facility was constructed to replace the OHF. Wastes used in the injections were concentrated LLLW and sludge removed from the gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other nuclides. Plans to plug and abandon several deep injection wells at WAG 10 were made in 1995.

WAG 10 Results

No groundwater monitoring wells were installed in WAG 10.

5.10.3.8 Exit Pathway Results

In the Melton Valley exit pathway, WOC at WOD had gross beta activity (240 pCi/L) and total radioactive strontium (75 pCi/L). One of the wells also had gross beta activity, total radioactive strontium, and ^{3}H concentrations detected above DWSs. This is consistent with historical data. No VOCs were detected above DWSs in either the wells or the surface-water location.

5.10.4 White Wing Scrap Yard

5.10.4.1 White Wing Scrap Yard (WAG 11) Area

The White Wing Scrap Yard (WAG 11), a largely wooded area of about 30 acres, is located in the McNew Hollow area on the western edge of East Fork Ridge. It is 1.4 km (0.9 mile) east of the junction of White Wing Road and the Oak Ridge Turnpike. Geologically, the White Oak thrust fault bisects WAG 11. Lower-Cambrian-age strata of the Rome Formation occur southwest of the fault and overlie the younger Ordovician-age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

The White Wing Scrap Yard was used for aboveground storage of contaminated material from ORNL, the ETTP, and the Y-12 Plant. The material stored at the site by ORNL consisted largely of contaminated steel tanks; trucks; earth-moving equipment; assorted large pieces of steel, stainless steel, and aluminum; and reactor cell vessels removed during cleanup of Bldg. 3019. An interim ROD was agreed to by TDEC, EPA, and DOE, requiring surface debris to be removed from the site. This work was completed in 1994.

The area began receiving material (primarily metal, glass, concrete, and trash with alpha, beta, and gamma contamination) in the early 1950s. Information regarding possible hazardous waste contamination has not been found. The precise dates of material storage are uncertain, as is the time when the area was closed to further storage. In 1966, efforts were begun to clean up the area by disposing of contaminated materials in ORNL's SWSA 5 and by the sale of uncontaminated material to an outside contractor for scrap. Cleanup continued at least into 1970, and removal of contaminated soil began in the same year. Some scrap metal, concrete, and other trash are still located in the area. Numerous radioactive areas, steel drums, and PCB-contaminated soil were identified during surface radiological investigations conducted during 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known.

White Wing Scrap Yard (WAG 11) Results

Groundwater monitoring in WAG 11 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER.

5.11 WELL PLUGGING AND ABANDONMENT AT ORNL

The purpose of the ORNL well plugging and abandonment program is to remove unneeded wells and boreholes as possible sources of crosscontamination of groundwater from the surface or between geological formations. Because of the complex geology and groundwater pathways at ORNL, it has been necessary to drill many wells and boreholes to establish the information base needed to predict groundwater properties and behavior. However, many of the wells established before the 1980s were not constructed satisfactorily to serve current long-term monitoring requirements. Where existing wells do not meet monitoring requirements, they become candidates for plugging and abandonment.

5.11.1 Wells Plugged During 1999

Eight wells used in monitoring former Subtitle I UST sites were plugged and abandoned per the Tennessee Division of Underground Storage Tank rules and guidance documents during 1999 (TDEC 1996).

5.11.2 Methods Used

Plugging and abandonment are accomplished by splitting the existing well casing and filling the casing and annular voids with grout or bentonite to create a seal between the ground surface and water-bearing formations and between naturally isolated, water-bearing formations.

Splitting and abandoning the well casing in place also minimizes the generation of waste that would be created if other methods were used. Special tools were developed to split the casings of different sizes and material. A down-hole camera was used during development of the splitting tools to evaluate their effectiveness.

Detailed procedures have been developed and documented regarding the use of specific grout materials in different well environments. These procedures were tested and evaluated during the 1993 plugging and abandonment activities.