5. ORNL Environmental Programs

Compliance and environmental monitoring programs required by federal and state regulations, and by DOE orders, are conducted for air, water, and groundwater environmental media. These programs include regulatory and monitoring activities for facilities located on the ORNL site, 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, the TDEC Division of Air Pollution Control, and DOE orders. Radioactive emissions are regulated by EPA under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 CFR 61, Subpart H. (See Appendix A 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.

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, then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge to ensure that any radioactivity released is as low as possible. Radiological gaseous 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; and
- 7512 Molten Salt Reactor Experiment remediation; and
- 7911 Melton Valley complex, which includes the High Flux Isotope Reactor (HFIR) and the Radiochemical Engineering Development Center (REDC).

In 1998, there were 27 minor point/group sources, and emission calculations/estimates were made for each of these sources. Some of these sources are continuously sampled along with the four major sources.

5.1.1 Sample Collection and Analytical Procedure

Each of the four major point sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report because the other equipment does not provide data of sufficient accuracy and precision to support the quantification of emission source terms. All ORNL in-stack source sampling systems comply with American National Standards Institute N 13.1 (ANSI 1969) 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) present in the effluent stream. To ensure that all radioactive particulates are accounted for, end-of-the-year samples are collected and analyzed by cleaning the in-stack sampling probes. This program re quires annual removal, inspection, and cleaning of sample probes.

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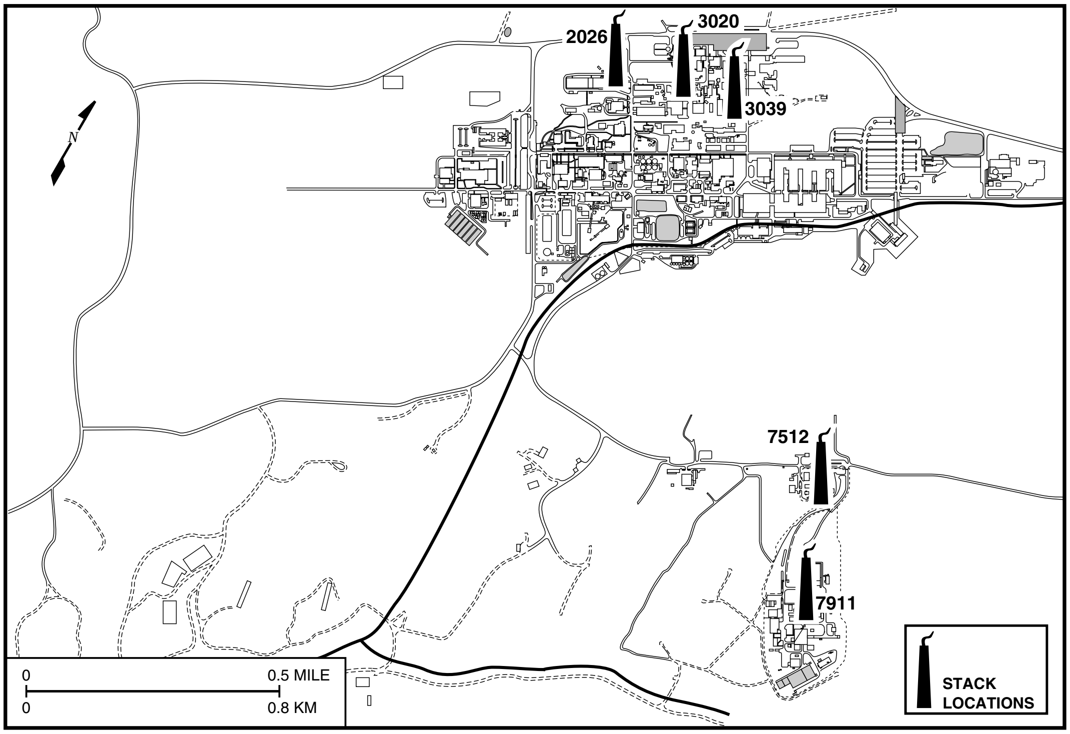

Fig. 5.1. Locations of major stacks (rad emission points) at ORNL.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at all major and at 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.

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 criteria for a major source but are located in or vent from a radiological control area. A variety of methods are used to determine the emissions from the various minor sources. All methods used for minor source emission calculations comply with criteria agreed upon by EPA and/or are included in the NESHAP Compliance Plan for the ORR. These minor sources are evaluated on a 1- to 3-year basis, depending on the source type. All 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 bi-weekly. 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 1998 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 emission calculation. Historical trends for ^{3}H and ^{131}I are presented in Figs. 5.2 and 5.3, respectively.

The tritium emissions for 1998 totaled approximately 110 Ci (Fig. 5.2), which is down approximately 30% from 1997. The ^{131}I emission for 1998 is essentially unchanged from that of the past years (Fig. 5.3). The major contributor to off-site dose at ORNL is ^{41}Ar, which totaled 7950 Ci in 1998 (Fig. 5.4). This discharge has been reduced by 20% over the previous year.

5.2 ORNL NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

ORNL operates 21 permitted air emission sources. Most of these sources are small-scale activities and result in very low emission rates. TDEC air permits for ORNL sources do not require stack sampling or monitoring; however, an opacity monitor is used at the steam plant to ensure compliance with visible emissions. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of all allowable emissions.

Implementation of a 10-year plan to provide long-term reliability for the steam plant will eliminate the use of coal and will employ the use of natural gas. In keeping with this long-term project, installation of a new 125 million Btu/h natural-gas-fired boiler was started in 1999. The new boiler will be available for the 1999–2000 heating season. Additional components of the 10-year plan will be installed over the next few years.

For the period from July 1, 1997, through June 30, 1998, ORNL paid $66,179 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). During 1998, TDEC inspected all permitted emission sources, which were all found to be in compliance.

The ORNL Title V permit application was submitted to TDEC on May 5, 1997. In a letter dated June 5, 1997, TDEC indicated that the application was complete and that ORNL met the requirement to submit an application. TDEC anticipates that the ORNL Title V permit will be issued in 1999 or 2000.

Actions have been implemented to comply with the prohibition against releasing ozone-depleting substances under Title VI. Also, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has taken actions to phase out the use of Class I ozone-depleting substances. The most significant challenge, the replacement or retrofit of large chiller systems that require Class I refrigerants, is progressing on schedule.

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, and 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 1998.

5.3 ORNL AMBIENT AIR MONITORING

The objectives of the ORNL ambient air monitoring program are to collect samples at stations that are 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).

Table 5.1. Major sources of radiological airborne emissions at ORNL, 1998 (in curies)[a]

Isotope	Stack				
	2026	3020	3039	7512	7911
^{3}H	3.0E-001		1.2E+001		9.6E+001
^{7}Be	6.5E-007	6.1E-007	3.2E-005	4.09E-07	6.9E-007
^{41}Ar					8.0E+003
^{141}Ce					5.5E-006
^{60}Co			2.8E-005		9.1E-006
^{203}Hg			5.7E-005		
^{85}Kr					2.6E+002
^{85m}Kr					1.6E+001
^{87}Kr					3.8E+001
^{88}Kr					6.6E+001
^{89}Kr					4.4E+001
Total Sr	4.8E-007	2.3E-006	9.2E-005		1.8E-004
^{125}I					9.3E-007
^{129}I					3.8E-004
^{131}I			7.3E-005		6.2E-002
^{132}I					3.9E-001
^{132m}I					1.5E+000
^{133}I		6.5E-006	3.3E-005		2.3E-001
^{135}I			5.9E-005		9.5E-001
^{192}Ir			4.8E-006		
^{194}Ir					1.2E-005
^{105}Ru					1.1E-002
^{90}Sr				8.52E-08	
^{131m}Xe					2.7E+001
^{133}Xe	2.1E-005	3.1E-005			3.2E+002
^{133m}Xe		2.1E-005			2.3E+000
^{135}Xe			1.2E-004		1.9E+002
^{135m}Xe					1.2E+002
^{137}Xe					3.0E+002
^{138}Xe					7.7E+002
^{137}Cs	3.2E-006	3.0E-006	5.8E-004	4.28E-09	8.3E-001
^{138}Cs					4.7E+003
^{137m}Ba				4.28E-09	
^{139}Ba			9.4E-005		6.7E-003
^{140}Ba			9.8E-006		4.8E-004
^{191}Os		1.6E-003	4.8E-001		
^{212}Pb	1.7E-001	6.8E-001	9.1E-001	1.65E-01	1.7E-001
^{228}Th	1.9E-008	9.5E-009	8.6E-006	3.21E-09	5.9E-008
^{230}Th		-6.2E-010	1.5E-008	6.80E-10	3.5E-008
^{232}Th	3.1E-009	4.9E-009	2.0E-008	7.86E-10	6.3E-008
^{234}U	3.3E-007	2.3E-007	2.5E-007	2.63E-08	3.1E-007
^{235}U	3.1E-008	3.2E-008	2.1E-008		7.9E-008
^{238}U	6.4E-008	3.7E-008	3.4E-008		9.0E-008
^{238}Pu	4.6E-008	1.1E-008	1.8E-007	7.71E-09	7.0E-009
^{239}Pu	1.5E-007	3.2E-007	3.3E-007	2.60E-08	6.8E-009
^{241}Am	1.2E-007	4.1E-007	1.7E-007	2.23E-08	2.4E-008
^{244}Cm	1.5E-006	4.1E-008	1.2E-007	1.71E-07	4.9E-007
^{152}Eu			1.1E-006		
^{154}Eu			3.2E-007		
^{140}La					2.8E-005

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

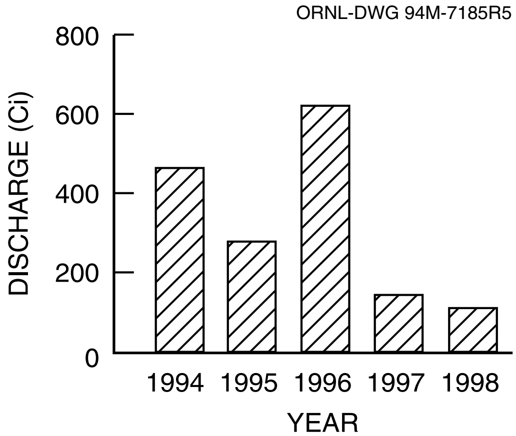

Fig. 5.2. Total discharges of ^3H from ORNL to the atmosphere, 1994–98.

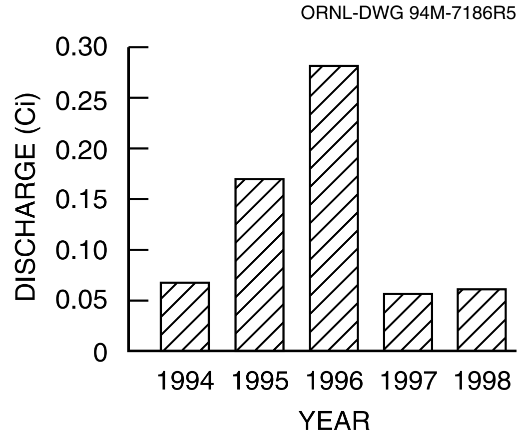

Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 1994–98.

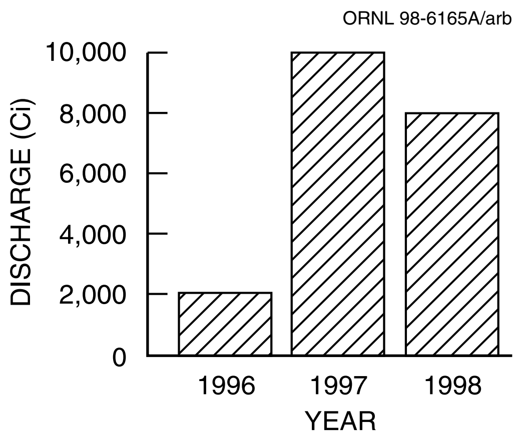

Fig. 5.4. Total discharges of ^{41}Ar from ORNL to the atmosphere, 1996–98.

Table 5.2. Actual vs allowable air emissions from ORNL steam production, 1998

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	2	481	0.4
Sulfur dioxide	1091	9062	12.0
Nitrogen oxides	100	535	18.7
Volatile organic compounds	1	3	33.0
Carbon monoxide	80	336	23.8

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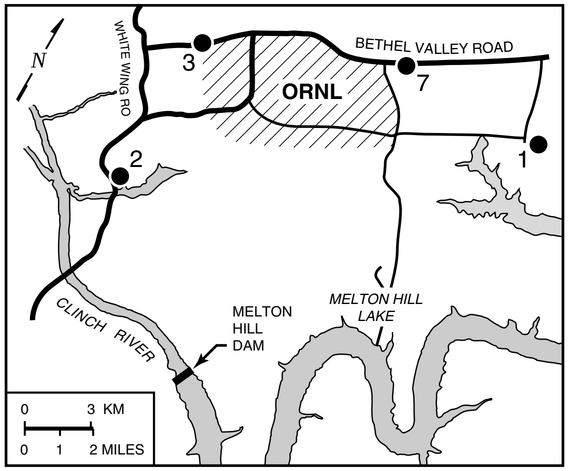

Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

Table 5.3. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 1998 (pCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{7}Be	2.5E-08	3.0E-08	2.3E-08	2.3E-08	3.1E-08
^{137}Cs	c	c	c	c	3.6E-11
^{60}Co	2.3E-10	c	1.6E-10	c	2.8E-12
^{3}H	4.32E-06	3.64E-05	*c*	*c*	3.30E-06
^{131}I	*c*	*c*	*c*	*c*	*d*
^{133}I	*c*	*c*	*c*	*c*	*d*
^{135}I	*c*	*c*	*c*	*c*	*d*
^{40}K	3.0E-09	*c*	*c*	3.0E-09	4.7E-10
^{234}U	4.0E-11	2.9E-11	4.4E-11	4.1E-11	5.0E-12
^{235}U	*c*	*c*	*c*	4.1E-12	7.5E-13
^{238}U	4.7E-11	3.3E-11	6.1E-11	5.8E-11	4.6E-12
Gross alpha	1.5E-08	1.4E-08	1.4E-08	1.3E-08	2.4E-09
Gross beta	2.9E-08	2.5E-08	2.2E-08	2.3E-08	7.0E-09

[a]1 pCi = 3.7E−02 Bq.
[b]Reference location offsite.
[c]Not detected.
[d]Not applicable.

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 then submitted to the laboratory for tritium analysis.

5.3.1 Results

The ORNL perimeter air monitoring (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 5.3) are compared with air sampling data from the reference station (station 52) at Fort Loudoun.

5.4 LIQUID DISCHARGES—ORNL RADIOLOGICAL MONITORING SUMMARY

In 1998, ORNL continued to sample liquid discharges under the revised Radiological Monitoring Plan (RMP) approved by TDEC on July 1, 1997. Monitoring of radioactivity occurred at the three treatment facilities: the Sewage Treatment Plant (STP), the Coal Yard Runoff Treatment Facility (CYRTF), and the Nonradiological Wastewater Treatment Facility (NRWTF), as well as at three instream locations: X13 on Melton Branch, X14 on White Oak Creek, and X15 at White Oak Dam. Additional sites that were monitored under the previous RMP, namely, First Creek, Fifth Creek, Northwest Tributary, 7500 Road Bridge, Raccoon Creek, White Oak Creek Headwaters, and Melton Hill Dam (Fig. 5.6), continued to be monitored by the National Pollutant Discharge Elimination System (NPDES) program through 1998 to ensure continuity of data during transition to another monitoring program. Data for those sites are included with all the other ORNL radiological monitoring results. An assessment of radiological liquid effluents, including numerous category outfalls, was conducted in the summer of 1997. Data gathered during the assessment will be used to complete another revision of the RMP due to be approved in 1999.

DOE derived concentration guide (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. The calculation of 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 1998, five radionuclides had an average concentration greater than 4% of the relevant DCG; they were total radioactive strontium (^{89}Sr + ^{90}Sr) with the highest value at STP (15% of the DCG, down from 18% in 1997); ^{3}H with the highest value at Melton Branch monitoring station MB1 (13% of the DCG, down from 23% in 1997), ^{137}Cs at NRWTF (17% of the DCG, up from 13% in 1997), ^{234}U at White Oak Dam (WOD) at 6% of the DCG, and total uranium at WOD at 6.3% of the DCG (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 1998, 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 27% at MB1 (down from 42% at NRWTF in 1997), and the next largest sum was 21.5% at WOD (Fig. 5.7).

Amounts of radioactivity released at 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 remained in the same range of values.

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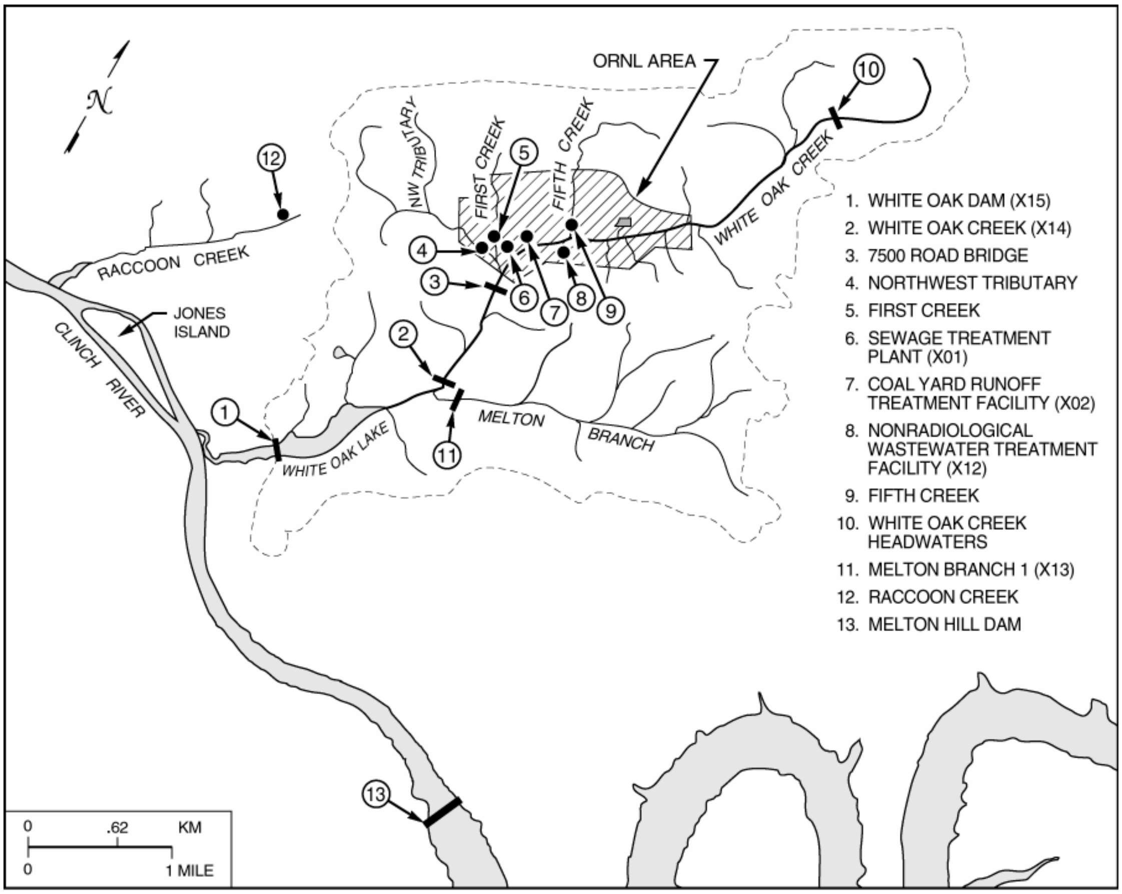

Fig. 5.6. ORNL surface water, NPDES, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

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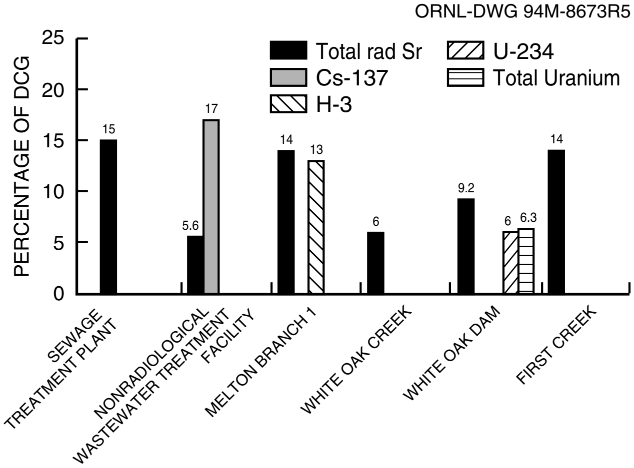

Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 1998.

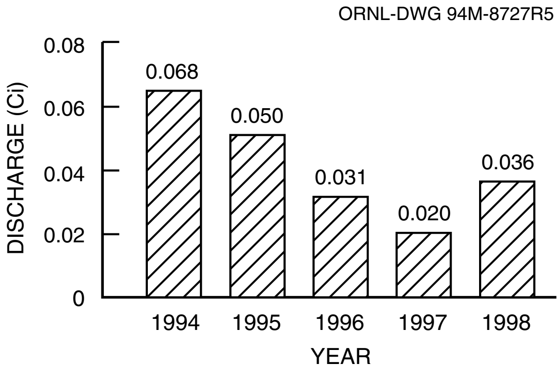

Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 1994–98.

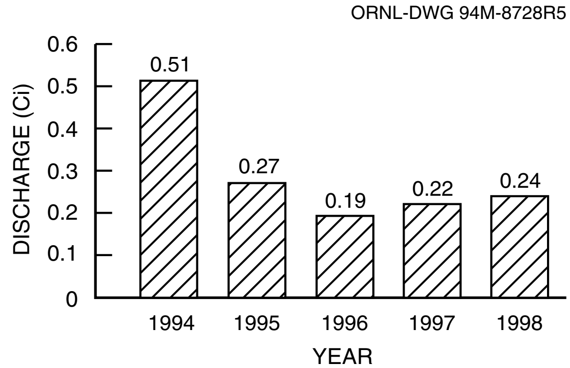

Fig. 5.9. Cesium-137 discharges at White Oak Dam, 1994–98.

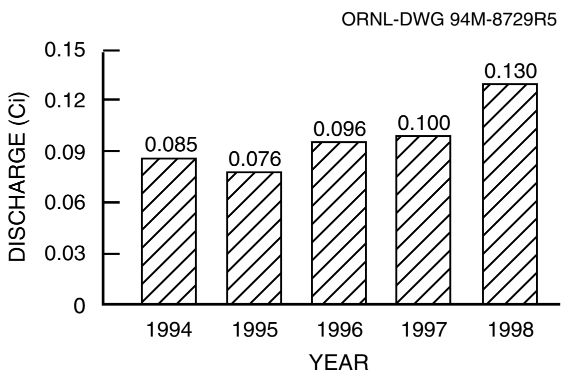

Fig. 5.10. Gross alpha discharges at White Oak Dam, 1994–98.

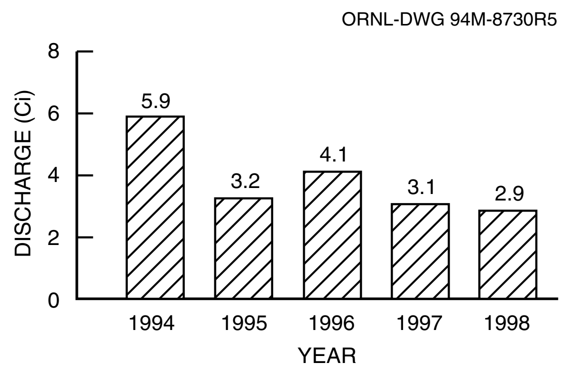

Fig. 5.11. Gross beta discharges at White Oak Dam, 1994–98.

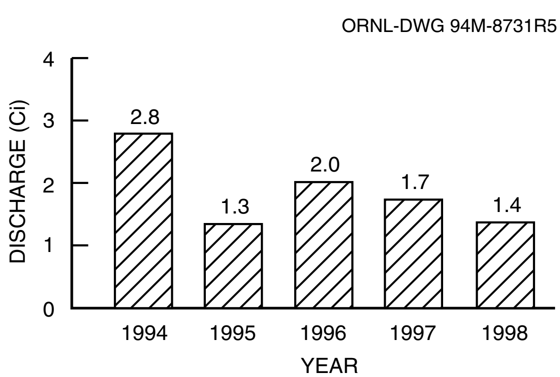

Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 1994–98.

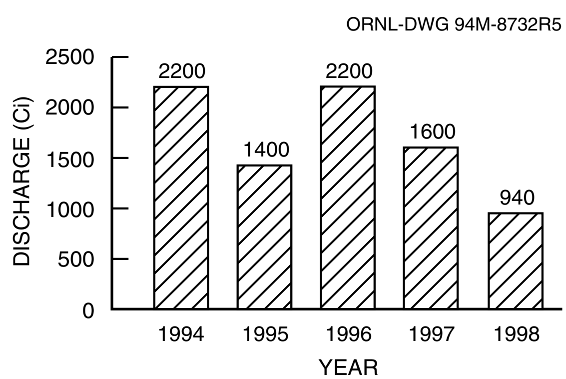

Fig. 5.13. Tritium discharges at White Oak Dam, 1994–98.

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—Sewage Treatment Plant;
- X02—Coal Yard Runoff Treatment Facility;
- X12—Nonradiological Wastewater Treatment Facility;
- X13—Melton Branch (MB1);
- X14—White Oak Creek;
- X15—White Oak Dam;
- Instream chlorine monitoring points (X16-X26);
- Steam condensate outfalls;
- Groundwater from building foundation drains;
- Category I outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate);
- Category II outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate);
- Category III outfalls (storm drains, water discharged under best management practices, groundwater, steam and water condensate, cooling water, and cooling tower blowdown);
- Category IV outfalls (storm drains, water discharged under best management practices, 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 5.4. 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 1998 are shown in Fig. 5.14. In 1998, ORNL significantly improved its NPDES compliance record with regard to NPDES chlorine discharge limits. A Cooling Systems Working Group was established to provide a forum for technical exchange, lessons learned, and team problem solving to facilitate compliance with chlorine limits.

ORNL Outfall 081 did exceed maximum and average total residual oxidant limits on May 18, 1998, as a result of additional cooling-water flows being temporarily redirected to an existing dechlorination unit. The unit was filled with additional dechlorination chemical, which corrected the situation.

One Category IV outfall, 302, experienced one pH limit exceedence (pH of 9.6 measured on January 13, 1998). The corrective action taken to mitigate the exceedence was to plug an abandoned underground pipe that was the source of a small flow of higher pH water to Outfall 302. The pH of Outfall 302 effluent returned to normal as a result of the corrective action.

ORNL experienced one NPDES nonconformance resulting from a late submittal of an NPDES report in April 1998 and one nonconformance because of a visible sheen at storm water drain Outfall 341 on November 12, 1998. Oil residue in a parking lot catch basin was identified as the source and was promptly cleaned, eliminating the sheen.

Under the renewed NPDES permit, ORNL has initiated several new monitoring plans and programs. These include the Radiological Monitoring Plan (RMP), the Chlorine Control Strategy (CCS), and the Storm Water Pollution Prevention (SWPP) Plan. Each of these is discussed in the following sections.

5.5.1.1 Radiological Monitoring Plan

In 1998, ORNL continued to sample under the revised RMP approved by TDEC on July 1, 1997. Results for the 1998 monitoring are presented in the ORNL Radiological Monitoring Summary section, Sect. 5.4.

Table 5.4. 1998 NPDES compliance at ORNL (NPDES permit effective Feb. 3, 1997)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	96-hour LC_{50} for *Ceriodaphnia* (%)					41.1	0	4	100
	96-hour LC_{50} for fathead minnows (%)					41.1	0	4	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	78	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	79	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		0	157	99
	Dissolved oxygen					6	0	156	100
	Fecal coliform (col/100 mL)			1000	5000		0	156	100
	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		0	156	100
	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-hour LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	96-hour 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		0	24	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					1.3	0	2	100
	No-observed-effect conc. for fathead minnows (%)					1.3	0	2	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 5.4 (continued)

Discharge point	Effluent parameters	Permit limits: Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Permit compliance: Number of noncompliances	Number of samples	Percentage of compliance[a]
X12 (Nonradiological Wastewater Treatment Facility)	96-hour LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	96-hour 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	5	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		0	52	100
	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	13	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	99
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	7	100

Table 5.4 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly av (kg/d)	Daily max (kg/d)	Monthly av (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	2	100
Category I outfalls	pH (std. units)				9.0	6.0	0	27	100
Category II outfalls	pH (std. units)				9.0	6.0	0	23	100
Category III outfalls	pH (std. units)				9.0	6.0	0	58	100
Category IV outfalls	pH (std. units)				9.0	6.0	1	326	99.7
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	48	100
	Total residual oxidant			0.011	0.019		2	48	95.8

[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].

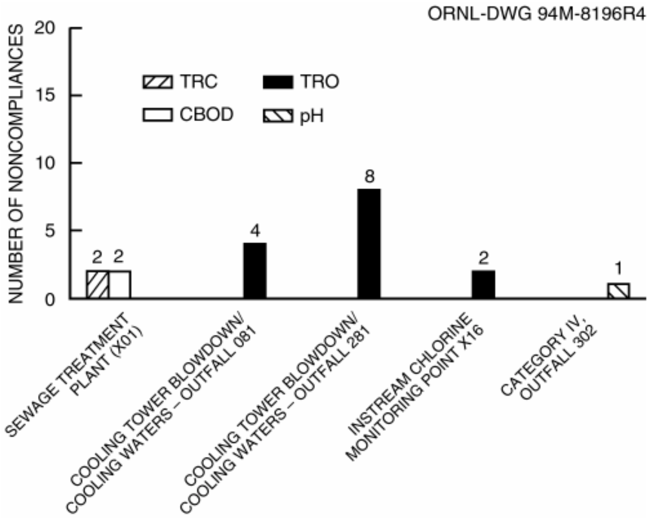

Fig. 5.14. ORNL NPDES permit limit exceedences in 1998 (total = 19).

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 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 1998 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 grams per day (g/d) and is calculated by multiplying the instantaneous measured concentration by the instantaneous flow rate of the outfall. ORNL monitored 368 measurable dry-weather discharges during 1998. Eleven outfalls exceeded the mass-loading limit one or more times. Corrective actions to reduce or eliminate chlorine in these effluents are currently under way at most of these outfalls.

5.5.1.3 Storm Water Pollution Prevention Plan

The SWPP Plan requires (1) assessment of storm water quality at ORNL, (2) characterization of storm water by monitoring, (3) training of employees, and (4) implementation of measures to minimize storm water pollution in areas of ORNL that may be affected. These four components of the plan were initiated in 1997. The plan is reviewed and updated, if necessary, by the facility at least annually. The ORNL SWPP Plan was updated and submitted to the DOE on July 31, 1998, to incorporate additional information and observations from the preceding year. The ORNL SWPP Program, including the SWPP Plan, Awareness Training, and Inspection Program, is available to ORNL employees via an online internal web application at http://oecdwsrv .oecd.ornl.gov/ water/ wqphome. htm.

For the first year, ORNL grouped its 165 NPDES outfalls into 11 groups based on the permit category and similar uses of the drainage areas (Table 5.5). Outfalls to be sampled first in each grouping were chosen. The permit required that Category I and Category II outfalls be characterized over a 5-year period, and the Category III and Category IV outfalls be characterized within a 3-year period. Five outfalls were characterized in 1998:

- Category I Outfall 209 (Group A), which discharges street, area, and roof runoff from the area around Buildings 3501 and 3523. Grab and flow-proportional composite (FPC) samples were collected on 2/11/98.
- Category III Outfall 219 (Group B), which discharges roof and area runoff from the south side of Building 5500. Grab and FPC samples were collected on 1/22/98.
- Category II Outfall 232 (Group C), which discharges runoff from the 6000 Area. Grab and FPC samples were collected on 2/11/98.
- Category I Outfall 113 (Group G,) which drains a very small section of road west of ORNL's east portal. During working hours, this portal is open to two-way official-use vehicular traffic and sees a constant stream of

Table 5.5. 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	Once every 5 years
B	Category III and IV outfalls with potential discrete sources identified; however, none of the sources are potential hydrocarbon sources	Once every 3 years
C	Category I and II outfalls with potential discrete sources identified, including potential hydrocarbon sources	Once every 5 years
D	Category III and IV outfalls with potential discrete sources identified, including potential hydrocarbon sources	Once every 3 years
E	Category I and II outfalls with impounded or collected storm water runoff	Once every 5 years
F	Category III and IV outfalls with impounded or collected storm water runoff	Once 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	Once 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	Once every 3 years
I	Category I and II outfalls without traffic and parking and with no other point sources identified in the drainage area	Once 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	Once every 3 years
K	Group K are excluded from storm water monitoring under the SWPP	Not applicable

traffic. Grab and FPC samples were collected on 1/27/98.

- Category IV Outfall 217 (Group J), which primarily discharges roof runoff from the south center section of the Building 4500S roof; however, it also discharges some dry-weather flow. Grab and FPC samples were collected on 1/22/98.

Of the five outfalls that were characterized, the concentrations of two parameters, copper at Outfall 217 and zinc at Outfall 113, were elevated above the comparative water quality reference values. All other parameters measured at the five outfalls were within the expected ranges of the reference values. Follow-up investigations yielded no obvious wet-weather source for the elevated copper value; therefore, Outfall 217 is being investigated for dry-weather sources. The Outfall 113 drainage area is exclusively made up of a high-vehicle-traffic area where storm water runoff might be expected to contain parameters such as zinc. ORNL has continued to implement efforts (best management practices) 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 and Mitigation

ORNL is currently investigating sources of mercury in process waste piping within the ORNL main plant area and technologies to maximize the mercury removal capabilities of the ORNL Process Waste Treatment Complex wastewater treatment facilities. The Process Waste Treatment Complex consists of two facilities, the Process Waste Treatment Plant (PWTP), Building 3544, and the Nonradiological Wastewater Treatment Facility (NRWTF), Building 3608.

During 1998, the ORNL Chemical Technology Division conducted two sampling programs on Process Waste Treatment Complex influent looking at mercury and other metals regulated under the NPDES permit and conducted bench-scale treatment tests using different sorbents and complexing agents for removing mercury and other heavy metals from wastewater. These projects were funded by ORNL Waste Management and DOE's Environmental Management Office of Science and Technology.

Wastewater grab samples were taken from influent to the PWTP (Building 3544) to compare with the influent at the NRWTP (Building 3608) and process manholes in the Buildings 4501/4505 area where mercury spills occurred historically. Five manholes, essentially in series, transport process nonradiological wastewater from Buildings 4501, 4505, and 4508 and then on to the NRWTP. These manholes were characterized over a 5-month period by sampling and analysis, visual observation for solids, flow monitoring, and correlation of flows with rainfall. The results were than ranked according to mercury loading, flow rates, and the extent of mercury associated with particulates, to facilitate remedial action and prioritization decisions.

Tests of several sorbents showed that the mercury removal efficiency of the sorbents varied considerably over time. Possible causes are being investigated, including the tendency of a significant portion of the mercury to become chemically complexed or bound to very small particulates, which impairs the ability of the sorbents to permanently remove the mercury from the waste stream.

ORNL's Environmental Sciences Division plans to investigate mercury removal from wastewater in 1999 using algal films in the experiment "Autotrophic biofilms for removing contaminants from industrial wastewater."

5.5.2.2 Cooling Systems Working Group

The ORNL Cooling Systems Working Group, which includes ORNL staff from environmental protection, utilities, and several research divisions, was formed in 1998 and met periodically to develop strategies to reduce or eliminate the chlorine component of cooling-water effluents from cooling systems outfalls. Many of these systems have dechlorinator units installed to control effluent chlorine concentrations. During 1998, the group addressed issues such as Y2K compliance, adequacy of alarm systems, and alarm response for automated dechlorination systems. The group also assessed the potential for dechlorination chemical overfeeding and cooling systems overflowing into surface streams across the ORNL site and shared lessons learned from cooling-system operating experiences. The Cooling Systems Working Group is considered a success in terms of improvement in the ORNL NPDES permit compliance rate for the cooling systems effluents that occurred from 1997 to 1998.

5.5.2.3 ORNL Sink and Drain Survey Program

In 1997, ORNL completed a comprehensive verification of the routing of all wastewater discharges from points of entry such as sinks and floor drains. As a result, over 9000 sink and drain records were produced and are stored in a central database. ORNL continued its efforts in 1998 to ensure that sinks and drains discharge to the proper wastewater collection systems by initiating a division-by-division recertification of ORNL sinks and drains. An intranet web interface is available for facility personnel to record corrections and updates to sink and drain data.

5.6 ORNL WASTEWATER BIOMONITORING

Under the NPDES permit, wastewaters from the STP, the CYRTF, and the NRWTF were evaluated for toxicity. The results of the toxicity tests of wastewaters from the three treatment facilities are given in Table 5.6. This table provides, for each wastewater, the month the test was conducted, and 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 hours. 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 hours 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 hours 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

Table 5.6. 1998 toxicity test results of ORNL wastewaters

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	January	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	May	*Ceriodaphnia*	12.3	>100
		Fathead minnow	100	>100
	July	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	November	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
Coal Yard Runoff Treatment Facility (X02)	January	*Ceriodaphnia*	3.36	>100
		Fathead minnow	100	>100
	April	*Ceriodaphnia*	4.2	>100
		Fathead minnow	100	>100
	August	*Ceriodaphnia*	*c*	>100
		Fathead minnow	*c*	>100
	November	*Ceriodaphnia*	*c*	>4.2
		Fathead minnow	*c*	>4.2
Nonradiological Wastewater Treatment Facility (X12)	January	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	May	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	July	*Ceriodaphnia*	80	>100
		Fathead minnow	100	>100
	October	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>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]Insufficient discharge for chronic test and determination of NOEC.

(NRWTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 hours 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 NOEC and LC_{50} may appear lower than earlier tests (Table 5.6) but the values actually represent the highest concentration tested (i.e., 41.1% for Outfall X01).

During 1998, the STP, CYRTF, and NRWTF were tested four times each. The biomonitoring limits for STP, CYRTF and NRWTF were not exceeded during 1998.

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 polychlorinated biphenyl (PCB) contamination in fish tissue in the White Oak Creek (WOC) watershed.

On six occasions in 1998, water samples were collected for mercury analysis from four WOC sites. The mean mercury concentration in WOC at the weir upstream from ORNL (WCK 6.8) was <10 ng/L, with only a single sample (15 ng/L) exceeding the detection limit. The highest baseflow mercury concentrations were always found at MS 3619 (the flume upstream from the NRWTF), where mercury concentrations averaged (± SD) 199 ± 124 ng/L. Mercury concentrations at this site ranged from 40 ng/L in wet weather to 362 ng/L in June 1998. The mean mercury concentration was 90 ± 43 ng/L at the weir below Melton Valley Road, with a range of 27 to 123 ng/L. Mean concentrations were lower below White Oak Lake (WOL), averaging 68 ± 19 ng/L total mercury, with a range of 44 to 96 ng/L. Downstream from ORNL, average mercury concentrations in WOC surface water exceeded the pending revised Tennessee water quality criterion (51 ng/L) at all sites.

To evaluate human health concerns associated with mercury in WOC, filet tissue in game fish was analyzed for total mercury in the spring of 1998. The spatial pattern of mercury in WOC fish is consistent with the mercury in water results. The highest concentrations in fish appear to be localized within WOC-proper, where the mean mercury concentration in redbreast sunfish (*Lepomis auritus*) was approximately three times higher than the mean concentration in fish from a local reference stream. Mercury concentrations in bluegill (*Lepomis macrochirus*) collected ~1.4 kilometers downstream in White Oak Lake were not much different from reference stream values. As expected however, mercury concentrations in largemouth bass (*Micropterus salmoides*) were higher than in sunfish collected at the same site because of their higher position in the food chain. Concentrations in some bass approached, but did not exceed, 0.50 µg/g (the level typically used by the state of Tennessee in issuing fish consumption advisories).

The mean PCB concentrations in sunfish from WCK 2.9 (a site in WOC-proper) and WCK 1.5 (a site in WOL) were 0.49 and 0.53 µg/g, respectively. Such PCB levels are high for relatively short-lived, lipid-poor fish such as sunfish. Sunfish from a local uncontaminated stream analyzed at the same time averaged < 0.01 µg/g PCBs. Largemouth bass, a species that achieves a large size, is at the top of the food chain and contains relatively high levels of intramuscular lipids, were sampled at WCK 1.5 to evaluate the maximum PCB concentrations likely in the WOC system. The mean PCB concentration in WCK 1.5 bass exceeded the Food and Drug Administration (FDA) threshold limit of 2 µg/g. A high degree of variation was evident in the collection; the range of values was 1.63 to 5.90 µg/g.

5.7.2 Ecological Surveys

Monitoring of the fish communities in WOC and major tributaries continued in 1998. Spring and fall samples were taken at ten sites in the spring and at seven sites in the fall, with an emphasis on sites closest to the facilities.

In WOC, the communities continued to display limited recovery, with sites closest to the outfalls having lower species richness (number of species) but higher density (number of fish/m^2). The sites adjacent to Building 4515 (WCK 4.3 and 4.4) had very high densities (10–25 fish/m^2), two to three times higher than the densities at WCK 3.9, near the non-rad wastewater treatment release. These densities are much higher than area reference streams, suggesting some sort of enhancement of production, perhaps through nutrient enrichment. However, the high densities are countered by very low numbers of species, with these sites containing only half as many species as similar sized reference streams. The 1998 data do continue to show a long-term positive trend that indicates that the fish communities have improved over the 1985 to 1998 period. 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 is a declining trend in density at WCK 3.4 since 1995, a pattern not seen at upstream sites. Overall, the fish communities in WOC continue to show impacts, compared with reference streams, by having fewer species, fewer sensitive species, and more tolerant species.

In the major tributaries, the fish communities also show some recovery but not up to levels exhibited by reference streams. Fifth Creek has shown the most improvement, from being incapable of supporting a fish community before 1992, to having a fairly stable four-species community in 1998. The densities have increased even more rapidly and reached nearly 8 fish/m^2 in fall 1998, the highest density ever measured at this site. Although high densities can indicate problems, this pattern in Fifth Creek also extends to the upstream reference site, where high densities (up to 8 fish/m^2) have been measured since 1985. In Melton Branch, the fish community remained substantially unchanged in 1998 with density levels similar to those seen since 1988. In First Creek, the downstream site had a high species richness (n=7), but density was low, with a declining trend since 1985. This site has seen a noticeable increase in sedimentation, especially at the lower end, which might be responsible for the decline in density.

The patterns of low species richness seen in the WOC watershed are partially a result of isolation from the rest of the Clinch drainage. The numerous weirs and dams on the creek represent barriers to colonization of WOC by additional species, genera, and families. Historic impacts from poor water quality probably included elimination of certain species and families from the watershed (e.g., darters, *Etheostoma*), and the weirs prevented many of these species from returning even when water quality improved. The construction of the WOC embayment dam did alter flow release patterns at the WOC dam, especially under high flow conditions when pool elevation is high in the embayment. This change resulted in some additional species at the lower end of WOC (WCK 2.3), but further recovery of fish communities at sites closer to the ORNL facilities will be limited unless active measures are taken to enhance species richness above the weirs.

Benthic macroinvertebrate communities have been monitored in streams of the WOC watershed at ORNL since 1986 to help assess their ecological condition and to assist in the identification and documentation of the effects of new pollution abatement facilities. Results for April sampling periods through 1997 show that ORNL operations adversely affect the benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC (Figs. 5.15, 5.16, 5.17). The number of taxa (i.e., total taxonomic richness) and 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 community at most sites since 1986 suggesting that improvements have occurred in environmental conditions. The most significant changes have occurred in the middle reaches of WOC at WCK 3.9, most notably since 1994, and at the downstream site in Fifth Creek (FFK 0.2). Both total taxonomic richness and taxonomic richness of the pollution-intolerant taxa have increased considerably relative to initial conditions in 1987. Only subtle improvement has been observed in lower First Creek (FCK 0.1), where the number of pollution intolerant taxa increased slightly after 1991. In lower WOC at WCK 2.3 on the other

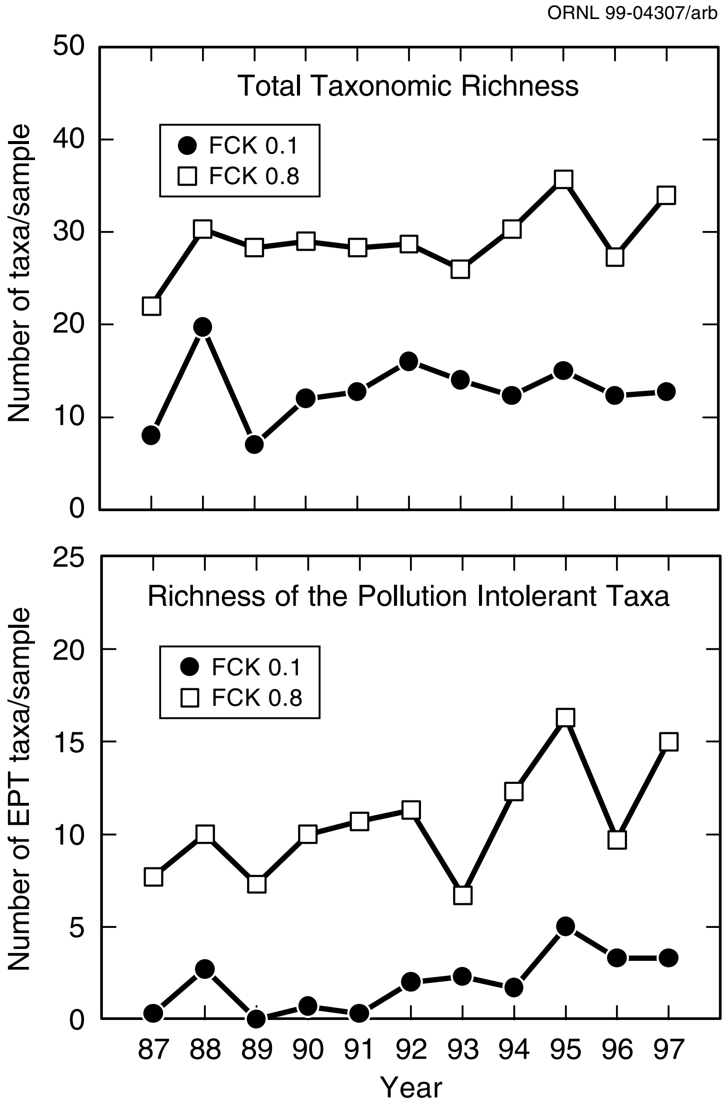

Fig. 5.15. Mean total taxonomic richness (number of taxa/sample) and taxonomic richness of pollution intolerant taxa [number of Ephemeroptera, Plecoptera, and Trichoptera (EPT)/sample] of the benthic macroinvertebrate community in First Creek for April sampling periods in 1987–1997. FCK = First Creek kilometer.

hand, there have been no persistent changes indicating that conditions have notably improved.

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. Monthly surface water samples are 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).

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 5.7).

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).

There is reasonably good agreement between parameters measured at WOC headwaters and those at Melton Hill Dam, the two reference locations. 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 (Table 5.7). Eight metals met these criteria; the largest percentage of reference value was copper at WOC headwaters at 62% of the reference value.

Radiological data are compared with DOE DCGs in Table 5.8. 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

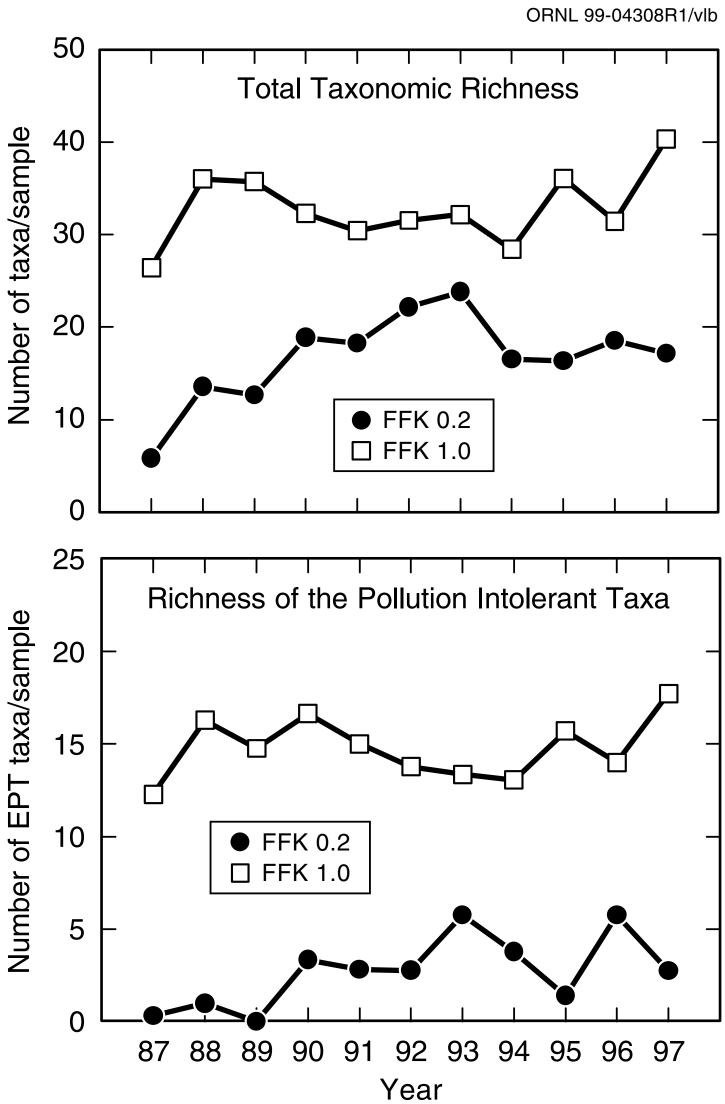

Fig. 5.16. Mean total taxonomic richness (number of taxa/sample) and taxonomic richness of pollution intolerant taxa [number of Ephemeroptera, Plecoptera, and Trichoptera (EPT)/sample] of the benthic macroinvertebrate community in Fifth Creek for April sampling periods in 1987–1997. FFK = Fifth Creek kilometer.

the reference locations, three averages in 1998 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.

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 (Figure 5.18). In 1998, composite samples of treated water from Gallaher and untreated water from Kingston were collected monthly and analyzed quarterly 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 1998, radionuclides at the Gallaher Water Treatment Plant that met these criteria were gross beta, ^{3}H, and total uranium, with the largest being gross beta at 3.5% of the reference value. At the Kingston Water Treatment Plant, ^{238}Pu and total uranium met these criteria, with the largest being ^{238}Pu at 2.3% of the reference value.

5.10 GROUNDWATER MONITORING AT THE OAK RIDGE NATIONAL LABORATORY

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 Resource Conservation and Recovery Act (RCRA) specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. The Environmental Management and Enrichment Facilities (EMEF) Program, formerly the Environmental Restoration (ER) Program, provides comprehensive cleanup of sites where past and current research, develop-

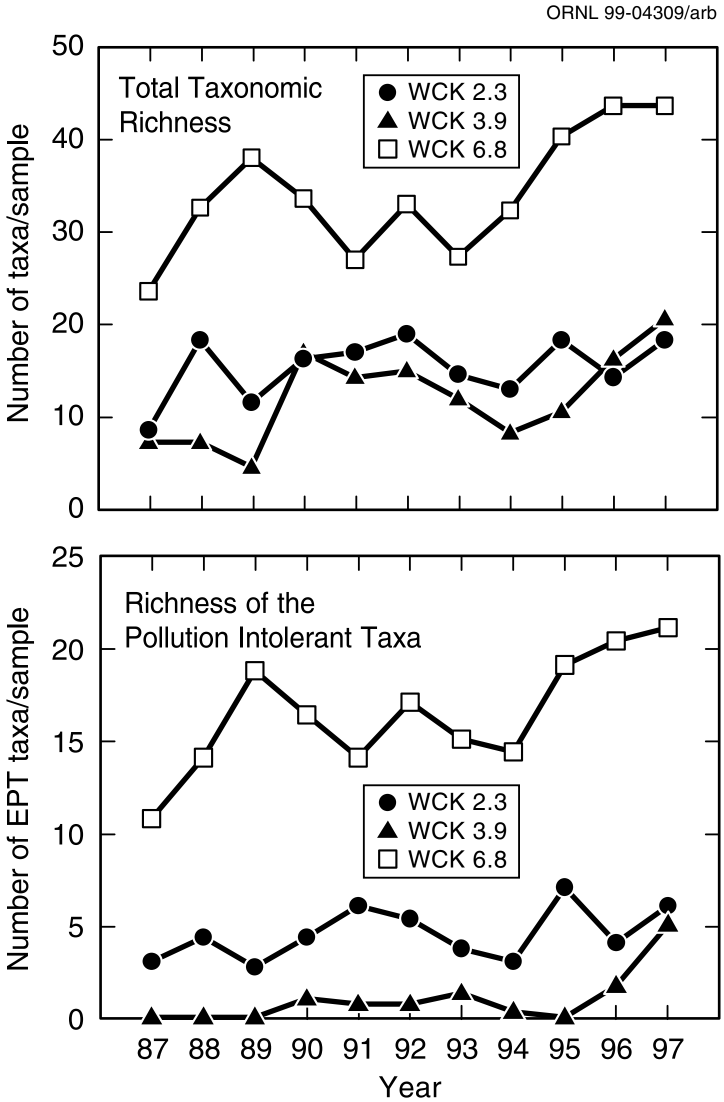

Fig. 5.17. Mean total taxonomic richness (number of taxa/sample) and taxonomic richness of pollution intolerant taxa [number of Ephemeroptera, Plecoptera, and Trichoptera (EPT)/sample] of the benthic macroinvertebrate community in White Oak Creek for April sampling periods in 1987–1997. WCK = White Oak Creek kilometer.

ment, and waste management activities may have resulted in residual contamination of the environment. Individual monitoring and assessment are assumed to be impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections between 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 Solid Waste Management Unit (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 ground water 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 Integrated Water Quality Program (IWQP) (Sect. 3.3) to conduct long-term environmental monitoring throughout the ORR. The IWQP is the vehicle for the DOE to carry out the regulatory requirement

Table 5.7. 1998 analyses for ORNL reference surface waters

Parameter	No. detect/ No. total	Concentration Max[a]	Min[a]	Av[b]	Standard error[c]	Reference value[d]	Percentage of reference value[e]
			Melton Hill Dam				
Anions (mg/L)							
Sulfate, as SO_4	12/12	23	17	20	0.67	*f*	*f*
Field measurements							
Conductivity (mS/cm)	12/12	0.36	0.13	0.22	0.016	*f*	*f*
Dissolved oxygen (mg/L)	12/12	12	6.1	8.1	0.50	*f*	*f*
pH (SU)	12/12	8.3	7.2	7.8	0.075	*f*	*f*
Temperature (°C)	12/12	22	8.6	16	1.4	*f*	*f*
Turbidity (NTU)	12/12	46	2.0	14	3.3	*f*	*f*
Metals (mg/L)							
Antimony, total	9/12	0.00080	<0.00010	~0.00045	0.000076	0.006	7.5
Arsenic, total	3/12	0.0015	<0.0010	~0.0011	0.000047	0.05	2.2
Cadmium, total	0/12	<0.00010	<0.00010	~0.00010	0	0.005	*f*
Chromium, total	7/12	0.0013	<0.00050	~0.00064	0.000073	0.1	0.64
Copper, total	11/12	0.0035	<0.0010	~0.0021	0.00018	*f*	*f*
Iron, total	1/12	0.25	<0.25	~0.25	0	*f*	*f*
Lead, total	10/12	0.0010	<0.00010	~0.00030	0.000077	0.005	6.0
Nickel, total	5/12	0.0021	<0.0010	~0.0011	0.000092	0.1	1.1
Selenium, total	0/12	<0.0020	<0.0020	~0.0020	0	0.05	*f*
Silver, total	0/12	<0.00010	<0.00010	~0.00010	0	*f*	*f*
Zinc, total	12/12	0.011	0.0048	0.0072	0.00049	*f*	*f*
Others (mg/L)							
Oil and grease	0/12	<6.0	<5.4	~5.6	0.042	*f*	*f*
Physical (mg/L)							
Total suspended solids	7/12	10	<1.0	~2.4	0.74	*f*	*f*
			White Oak Creek Headwaters				
Anions (mg/L)							
Sulfate, as SO_4	12/12	4.6	1.7	2.7	0.26	*f*	*f*
Field measurements							
Conductivity (mS/cm)	12/12	0.26	0.033	0.18	0.021	*f*	*f*
Dissolved oxygen (mg/L)	12/12	9.7	7.9	8.8	0.14	*f*	*f*
pH (SU)	12/12	8.2	7.0	7.7	0.091	*f*	*f*
Temperature (°C)	12/12	18	8.3	14	0.89	*f*	*f*
Turbidity (NTU)	12/12	210	0	40	19	*f*	*f*
Metals (mg/L)							
Antimony, total	7/12	0.00080	<0.00010	~0.00036	0.000067	*f*	*f*
Arsenic, total	0/12	<0.0010	<0.0010	~0.0010	0	*f*	*f*
Cadmium, total	2/12	0.0016	<0.00010	~0.00023	0.00013	0.0039	5.8
Chromium, total	6/12	0.0026	<0.00050	~0.00094	0.00019	*f*	*f*
Copper, total	4/12	0.12	<0.0010	~0.011	0.0097	0.0177	62
Iron, total	8/12	1.7	<0.25	~0.55	0.13	*f*	*f*
Lead, total	11/12	0.0038	<0.00010	~0.0011	0.00032	0.0817	1.4
Nickel, total	2/12	0.0040	<0.0010	~0.0014	0.00027	1.418	0.096
Selenium, total	0/12	<0.0020	<0.0020	~0.0020	0	0.02	*f*
Silver, total	0/12	<0.00010	<0.00010	~0.00010	0	0.0041	*f*
Zinc, total	12/12	0.069	0.0063	0.016	0.0051	0.117	13
Others (mg/L)							
Oil and grease	0/12	<6.0	<5.4	~5.6	0.048	*f*	*f*
Physical (mg/L)							
Total suspended solids	11/12	130	<1.0	~38	11	*f*	*f*

[a]Prefix "<" indicates that 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.

Table 5.8. 1998 radionuclide concentrations for ORNL reference surface waters

Parameter	No. detect/ No. total	Concentration (pCi/L)			Standard error[c]	DCG[d]	Percentage of DCG[e]
		Max[a]	Min[a]	Av[b]			
			Melton Hill Dam				
^{60}Co	5/12	26*	–1.7	8.0*	2.5	5,000	0.16
^{137}Cs	2/12	20*	–6.4	4.3*	2.0	3,000	0.14
Gross alpha	4/12	3.0*	–0.83	1.2*	0.34	*f*	*f*
Gross beta	4/12	6.9*	–3.7	2.7*	0.81	*f*	*f*
			White Oak Creek Headwaters				
^{60}Co	4/12	22*	–0.10	8.8*	2.2	5,000	0.18
^{137}Cs	1/12	18	–7.2	3.3	1.9	3,000	*f*
Gross alpha	6/12	3.3*	–0.49	1.2*	0.33	*f*	*f*
Gross beta	3/12	7.9*	–0.87	2.4*	0.73	*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 (DCG) 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.

ORNL-DWG 93M-6313

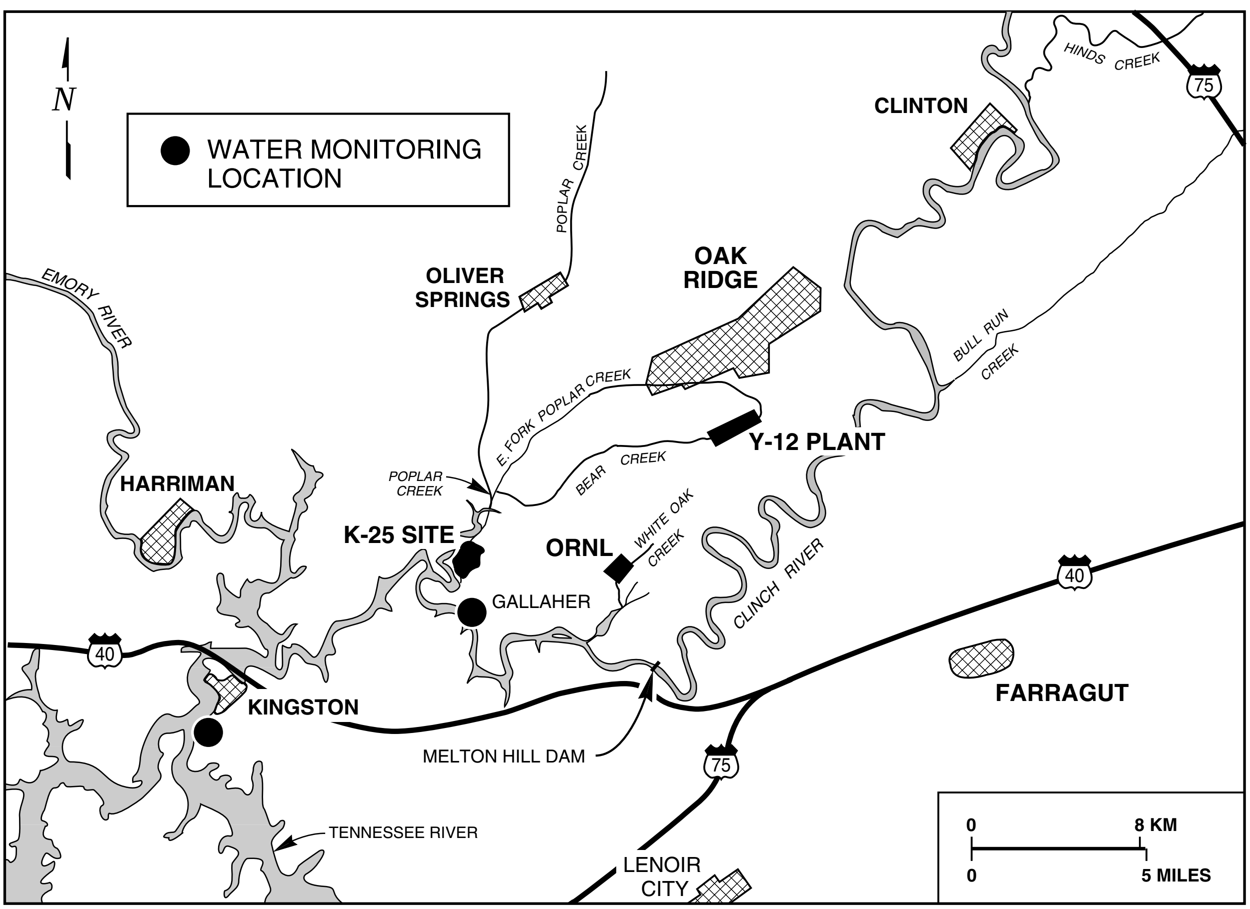

Fig. 5.18. ORNL off-site monitoring at the Gallaher and Kingston water treatment plants.

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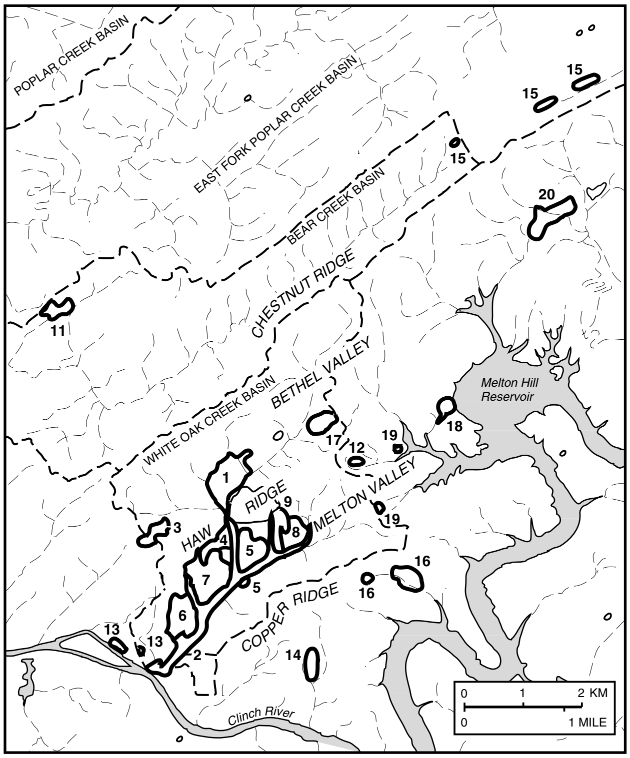

Fig. 5.19. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

from the Federal Facilities Agreement (FFA) to conduct postremedial action monitoring. Under the IWQP (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 Watershed and Melton Valley Watershed.

The ORNL groundwater program was reviewed in 1996, and modifications included transfer of monitoring responsibility for some of the WAGs to IWQP. 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 presented in Table 5.9, which indicates whether WAGs are within Bethel or Melton valley. To provide continuity with previous ASER reports 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 5.9).

Monitoring results for remedial actions (i.e., under IWQP purview) that are in progress or have been completed within specific WAGS are reported annually in the Remediation Effectiveness Report, which is issued in March of each year (DOE 1999). Baseline monitoring results and interpretations for both watersheds at ORNL were reported in the IWQP Annual Report for 1997 (DOE 1998b). Additionally, in the case of WAG 6, which is regulated under both RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), specific monitoring results and interpretations required by RCRA are reported in the annual Groundwater Quality Assessment Report for Waste Area Grouping 6, which is issued in February of each year (DOE 1998f).

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 5.10.

Groundwater monitoring for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance during 1998 involved approximately 49 sampling events. In a few cases, no samples could be collected because the wells were dry.

Four of the 10 wells identified by the ORR Environmental Monitoring Plan (EMP) (DOE 1998e) 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 1998 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 the fall of 1998. The results of the plant perimeter monitoring program are discussed as part of the discussions below.

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

Table 5.9. Summary of the groundwater surveillance program at ORNL, 1998

WAG	Regulatory status	Wells: Upgradient	Wells: Downgradient	Frequency and last date sampled in 1998	Locations	Parameters
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Rotation Mar 1998	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 Feb 1998	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 Jan–Feb 1998	4 wells 16 wells	Full set[d] 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	*e*	*e*	*e*

Table 5.9 (continued)

WAG	Regulatory status	Wells		Frequency and last date sampled in 1998	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	Jan 1998	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]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[e]Sampled by EMEF and data reported in the 1998 Groundwater Quality Assessment Report for ORNL's Solid Waste Storage Area 6.

ORNL-DWG 93M-10468

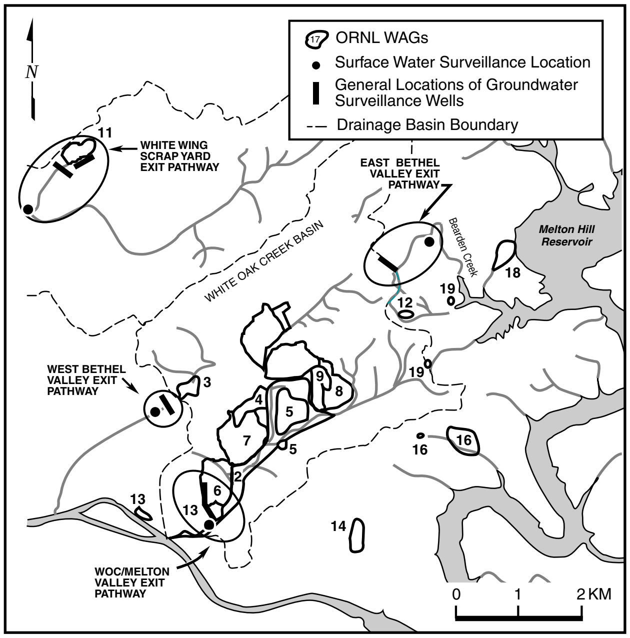

Fig. 5.20. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

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 water quality criteria 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, which is 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. It has been an industrial site for 50 years and 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 remedial action 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 to store low-level waste (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 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., a treatability study associated with the Gunite and Associated Tanks (GAAT) remedial action, the demolition of the Waste Evaporator Facility (Building 3506) via a CERCLA removal action, and completion of the non-time-critical removal action for stabilization of the Building 3001 canal].

WAG 1 Results

In 1998, under the revised program, four wells on WAG 1 that are 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 11,000 pCi/L and total radioactive strontium ranged from below detection to 5.1 pCi/L. None of the targeted radionuclides were detected above DWSs. All four wells' results were consistent with historical data.

Table 5.10. Summary of the plant perimeter surveillance program at ORNL, 1998

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.

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: Solid Waste Storage Area (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 IWQP in 1996. The IWQP Annual Report issued in April 1998 contains all published information from IWQP monitoring activities in 1997 (DOE 1998b).

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 that are needed to support ORNL's routine and experimental operations. It 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 underground storage tanks 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 ^3H. 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 6.2 pCi/L, the highest total radioactive strontium was 4.4 pCi/L, and ^3H was 5500 pCi/L. Gross beta was not detected.

The data for the wells along the southeastern and southwestern boundaries show evidence of volatile organic compounds (VOCs). The contamination has consistently been located primarily in one well. The pollutants include trichloroethene, tetrachloroethene, 1,1-dichloroethene, and benzene.

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 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 Nonradioactive Wastewater Treatment Facility (NRWTF), the Sewage Treatment Plant (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 a Remedial Investigation (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 ^3H 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 ^3H 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 ^3H. Gross beta activity above primary DWSs was detected at one well south of WAG 6. The elevated levels of ^3H 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 7.6 pCi/L (the DWS is 15 pCi/L); beta activity ranged from not detected to 600 pCi/L (the DWS is 50 pCi/L); and total radioactive strontium ranged from not detected to 310 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 390,000 pCi/L (the DWS is 20,000 pCi/L).

Chromium and lead were detected above 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.

5.10.3.3 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, liquid low-level waste (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 IWQP in 1996. The IWQP Annual Report (DOE 1998b) contains all published monitoring results for 1997 IWQP activities. No annual report was issued for 1998; however, future results will be merged into the RER report (DOE 1999).

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 transuranic (TRU) waste in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL’s hydrofracture operations, two low-level waste (LLW) pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original Process Waste Treatment Facility. 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. From 1959 to 1963, the burial ground served as the Southeastern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site was set aside for the retrievable storage of TRU wastes.

The WAG 5 boundary includes the old and new hydrofracture facilities. Because Melton Branch flows between the old and new hydrofracture facilities, the new hydrofracture facility has a separate boundary. Studies of the contents of several tanks at the old hydrofracture facility 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 old hydrofracture facility 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 continued during 1997.

WAG 5 Results

Groundwater monitoring in WAG 5 was transferred to IWQP in 1996. The IWQP Annual Report (DOE 1998b) contains all published monitoring results for 1997 IWQP activities. No annual report was issued for 1998; however, in the future monitoring results will be merged into the RER report (DOE 1999).

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 White Oak Lake (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 million 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 remedial action chosen at WAG 6.

WAG 6 Results

Information about WAG 6 monitoring results in 1998 is available in the 1998 Groundwater Quality Assessment Report for ORNL's Solid Waste Storage Area 6 (DOE 1998f).

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 IWQP in 1996. The IWQP Annual Report (DOE 1998b) contains all published monitoring results for 1997 IWQP activities. In the future, these results will be merged into the RER report (DOE 1999).

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 that are 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 Molten Salt Reactor Experiment (MSRE) facility, the High Flux Isotope Reactor (HFIR), and the Radionuclide Engineering Development Center (REDC). A removal action was initiated at the MSRE during 1995 to remove filtration devices contaminated with uranium. The CERCLA actions (time-critical removal action, non-time critical removal action, and remedial action) for MSRE continued in 1998 (see Sect. 3.5 for details).

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 miles (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 1998 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. Gross alpha activity ranged from not detected to 6.7 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 630 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 53,000 pCi/L (the DWS is 20,000 pCi/L).

5.10.3.7 WAG 10 Area

WAG 10 consists of the Old Hydrofracture Facility (OHF) grout sheets, the New Hydrofracture Facility, and New Hydrofracture 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 New Hydrofracture Facility 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 (150 pCi/L) and total radioactive strontium (64 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 miles) 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 Building 3019. An interim Record of Decision (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 Scrapyard (WAG 11) Results

Groundwater monitoring in WAG 11 was transferred to IWQP in 1996. The IWQP Annual Report (DOE 1998b) contains all published monitoring results for 1997 IWQP activities. No annual report was issued for 1998 activities.

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 cross-contamination 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 that were 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 1998

No wells were plugged and abandoned at ORNL during 1998. A total of 232 wells have been recommended for plugging and abandonment as soon as funds are available.

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 minimize 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.