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 a variety of environmental media. These programs include regulatory and monitoring activities for ORNL site facilities and other locations in Bethel Valley, Melton Valley, and the ORR.

5.1 ORNL RADIOLOGICAL AIRBORNE EFFLUENT MONITORING

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the TDEC Division of Air Pollution Control. Radioactive emissions are regulated by EPA under NESHAP regulations in 40 CFR 61, Subpart H, and by the rules of the TDEC Division of Air Pollution Control, 1200-3-11.08. (See Appendix F, Table F.1 for a list of radionuclides and their radioactive half-lives.)

Radioactive airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. These airborne emissions are treated and then filtered with high-efficiency particulate air filters and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates; adsorbable gases (e.g., iodine); tritium (^{3}H); and nonadsorbable gases (i.e., noble 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, 3025 and 3026 areas' cell ventilation system, 3042 ventilation system, and 3092 central off-gas system;
- 7503 (formerly 7512) Molten Salt Reactor Experiment remediation; and
- 7911 Melton Valley complex, which includes the HFIR and the Radionuclide Engineering Development Center.

In 2002, there were 24 minor point/group sources, and emission calculations/estimates were made for each of these sources.

5.1.1 Sample Collection and Analytical Procedure

Each of the five major point sources is equipped with a variety of surveillance instrumentation. Only data resulting from analysis of the continuous samples are used in this report. ORNL in-stack source sampling systems comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1 (ANSI 1969). 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 (e.g., ^{41}Ar) in the effluent stream. The sample probes are annually removed, inspected, and cleaned.

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

In addition to the major sources, ORNL has a number of minor sources that have the potential to

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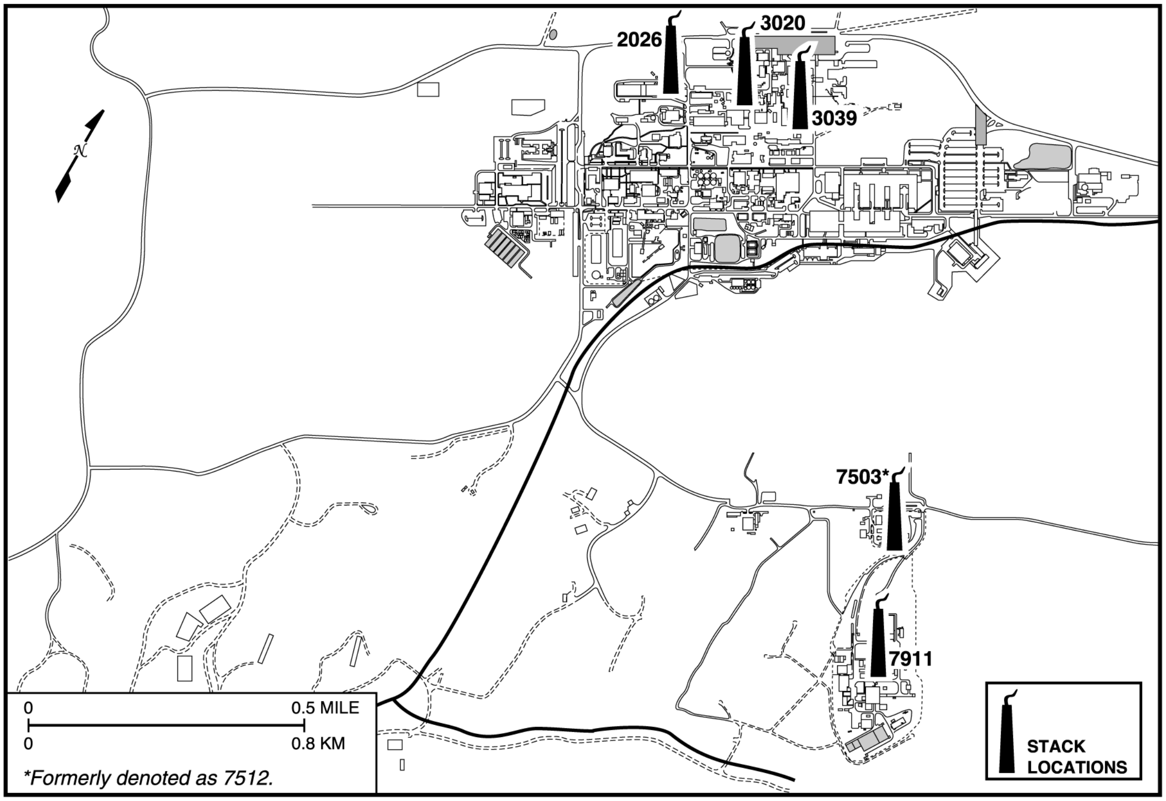

Fig. 5.1. Locations of major stacks (rad emission points) at ORNL.

emit radionuclides to the atmosphere. A minor source is composed of any ventilation system or component such as a vent, a laboratory hood, room exhaust, or stack that does not meet the approved regulatory criteria for a major source but that is located in or vents from a radiological control area as defined by Radiological Support Services of the ORNL Operational Safety Services Division. A variety of methods are used to determine the emissions from the various minor sources. Methods used for minor source emission calculations comply with criteria agreed upon by EPA. These minor sources are evaluated on a 1- to 5-year basis. Emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analysis is performed weekly to biweekly. 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 to biweekly filters are then composited quarterly and are analyzed for alpha-, beta-, and gamma-emitting isotopes. Compositing provides a better opportunity for quantification of these low-concentration isotopes. Silica-gel traps are used to capture tritium water vapor. Analysis is performed weekly to biweekly. At the end of the year, each sample probe is rinsed, and the rinsate is collected and submitted 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 2002 are presented in Table 5.1. All data presented were determined to be statistically different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the same result may not be obtained if the sample is analyzed repeatedly. This deviation is referred to as the "counting uncertainty." Statistical significance at the 95% confidence level means that there is a 5% chance that the results could be in error. Historical trends for ^{3}H and ^{131}I are presented in Figs. 5.2 and 5.3, respectively.

The ^{3}H emissions for 2002 totaled approximately 86 Ci (Fig. 5.2), which is almost double the value of 2001 but still lower than the values for 1998 through 2000. The ^{131}I emission for 2002 decreased from that for 2001 to 0.09 Ci (Fig. 5.3). The major contributor to off-site doses at ORNL is usually ^{41}Ar, which is emitted as a nonadsorbable gas from the HFIR facility stack (7911). However, 2001 was a nonoperating year for HFIR due to a long maintenance period. In 2002, full operational capacity was not yet achieved. Therefore, for 2002, ^{138}Cs, which totaled 1590 Ci, was the major contributor to the off-site dose at ORNL as it was in 2001(Fig. 5.4).

5.2 ORNL NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

ORNL has a total of 12 CAA permits (11 operating permits and 1 construction permit; see Appendix E, Table E.2). The ORNL Steam Plant and two small oil-fired boilers account for 98% of allowable emissions. The steam plant consists of six boilers that are fired by natural gas and fuel oil. As part of a 10-year plan to provide long-term reliability for the steam plant, the installation of a new 125-MBtu/h natural-gas-fired boiler was completed in December 1999. During 2001, coal was phased out.

Boiler 6, a 125-MBtu/h boiler, is subject to 40 CFR 60, Subpart Db requirements, and therefore monitoring and quarterly reporting are required for NO_x and opacity. During 2002, no exceedances of NO_x or opacity limits occurred. Other TDEC air permits for ORNL's sources do not require stack sampling or monitoring.

For the period from July 1, 2001, through June 30, 2002, ORNL paid $67,743 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). During 2002, TDEC inspected all permitted emission sources; all were found to be in compliance.

ORNL's CAA 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. ORNL will continue to operate with existing permits until the Title V permit is issued. TDEC anticipates that ORNL's Title V permit will be issued in 2003.

As required by Title VI of the CAA Amendments of 1990, actions have been implemented to comply with the prohibition against releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. In addition, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has implemented a plan to phase out the use of all Class I ozone-depleting substances. All critical applications of Class I ozone-depleting substances have been eliminated, replaced, or retrofitted with other materials. Work is progressing as funding becomes available for small, noncritical applications with no disruption of service.

5.2.1 Results

The primary sources of nonradioactive emissions at ORNL include the steam plant on the main ORNL site and two small boilers located in the 7600-area complex. These units use fossil fuels; therefore, criteria pollutants are emitted. Actual and allowable emissions from these sources are compared in Table 5.2. Actual emissions were calculated from fuel usage and EPA emission factors. The steam plant and the 7600-area boilers operated in compliance with visible emission standards during 2002.

Table 5.1. Major sources of radiological airborne emissions at Oak Ridge National Laboratory, 2002 (Ci)[a]

Isotope	Stack				
	X-2026	X-3020	X-3039	X-7503[b]	X-7911
^{241}Am	1.60E–07	1.26E–06	4.45E–07	5.37E–10	4.28E–09
^{41}Ar					1.49E+03
^{139}Ba			3.14E–03		3.38E–01
^{140}Ba					8.95E–05
^{7}Be	7.18E–07	7.86E–07	2.11E–05	1.25E–07	
^{252}Cf					1.25E–08
^{244}Cm	1.47E–06	3.32E–08	1.20E–07	5.60E–09	7.02E–08
^{60}Co			3.18E–05		
^{137}Cs	6.72E–06	1.77E–06	8.43E–05	2.40E–06	4.18E–06
^{138}Cs					1.59E+03
^{152}Eu			1.50E–06		
^{3}H	3.48E–01		1.93E+01	2.48E+00	6.16E+01
^{131}I			3.76E–04		8.96E–02
^{132}I					9.10E–01
^{133}I			1.26E–03		4.68E–01
^{134}I					1.53E+00
^{135}I			4.21E–04		1.31E+00
^{85}Kr					3.14E+02
^{85m}Kr					2.55E+01
^{87}Kr					1.28E+02
^{88}Kr					1.07E+02
^{89}Kr					5.55E+01
^{140}La			1.28E–05		2.92E–04
^{191}Os			3.48E–01		3.80E–03
^{212}Pb	1.93E–01		1.15E+00	1.08E–01	1.19E–01
^{238}Pu	5.15E–08	1.46E–06	2.63E–08		1.53E–09
^{239}Pu	1.70E–07	1.30E–06	9.69E–07	4.42E–10	3.46E–09
^{90}Sr	8.25E–07	1.87E–06	1.48E–03	1.23E–08	9.28E–06
^{228}Th	3.29E–08	1.49E–08	1.23E–08	7.77E–10	9.69E–09
^{230}Th	2.64E–09	4.26E–09	2.40E–08	5.75E–10	6.09E–09
^{232}Th	1.57E–09	2.09E–09	6.67E–09	5.36E–10	8.54E–09
^{234}U	3.03E–07	4.77E–07	4.63E–07	1.99E–09	2.21E–08
^{235}U	6.15E–09	1.28E–08	3.92E–08	5.62E–11	5.06E–09
^{238}U	4.47E–09	1.12E–08	5.87E–08	1.13E–09	1.36E–08
^{131m}Xe					1.47E+02
^{133}Xe			3.09E–09		5.88E+00
^{133m}Xe					1.22E+01
^{135}Xe			2.09E–03		1.01E+02
^{135m}Xe					7.04E+02
^{137}Xe					1.34E+02
^{138}Xe					2.91E+02
^{90}Y	8.25E–07	1.87E–06	1.48E–03	1.23E–08	9.28E–06

[a] 1 Ci = 3.7E+10 Bq.
[b] Formerly 7512.

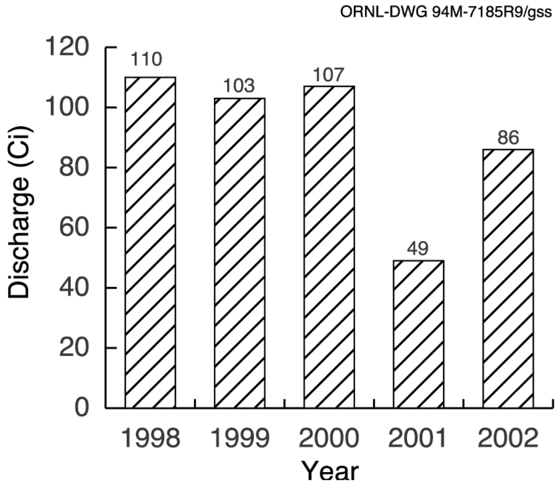

Fig. 5.2. Total discharges of ^{3}H from ORNL to the atmosphere, 1998–2002.

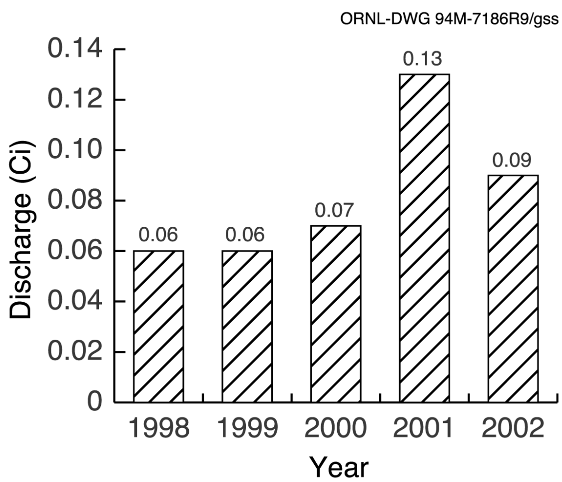

Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 1998–2002.

5.3 ORNL AMBIENT AIR MONITORING

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

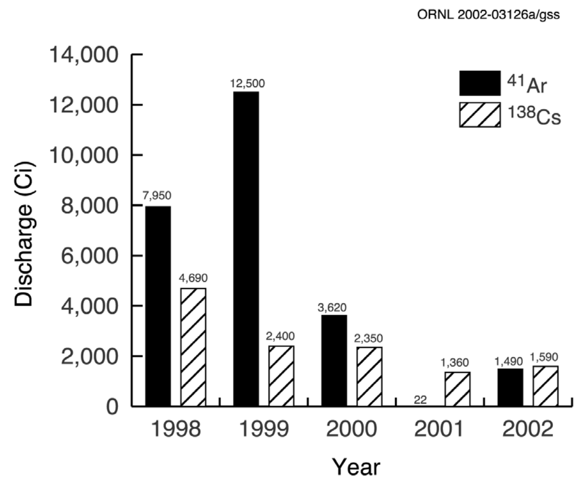

Fig. 5.4. Total discharges of ^{41}Ar and ^{138}Cs from ORNL to the atmosphere, 1998–2002.

The sampling system consists of a low-volume air sampler for particulate collection in 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 by gamma spectroscopy for adsorbable gas quantification. A silica-gel column is used for collection of ^{3}H as tritiated water. These samples are collected biweekly or weekly. The silica gel from each station is composited each quarter and is then submitted to the laboratory for ^{3}H analysis.

5.3.1 Results

The ORNL PAM stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations (Table 5.3) are compared with air-sampling data from the reference station (Station 52) and with the DCGs for air and water established by DOE as reference values for conducting radiological environmental protection programs at DOE sites. (DCGs are listed in DOE Order 5400.5.) Average radionuclide concentrations measured for the ORNL network were less than 1% of the applicable DCG in all cases. The average concentration of tritium for the ORNL network was statistically different from the average concentrations measured at the reference location. Measuring a radionuclide requires a process of counting random

Table 5.2. Actual vs allowable air emissions from Oak Ridge National Laboratory steam production, 2002

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulates	3	696	0.4
Sulfur dioxide	7	9102	0.1
Nitrogen oxides	56	600	9.3
Volatile organic compounds	1	18	5.6
Carbon monoxide	30	381	7.9

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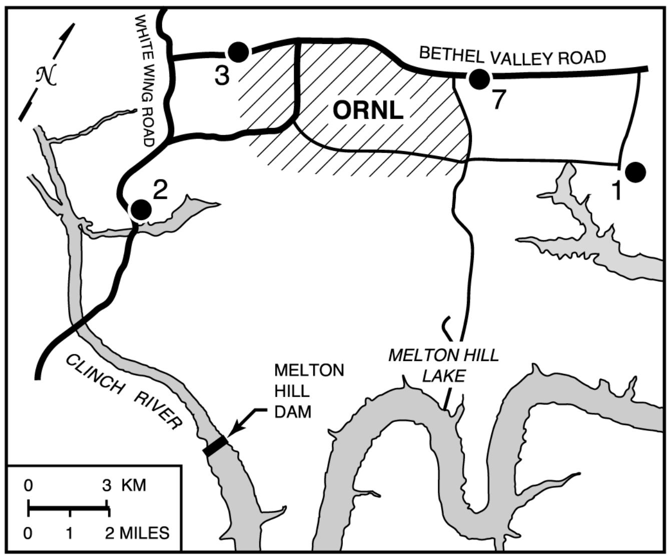

Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

Table 5.3. Radionuclide concentrations measured at Oak Ridge National Laboratory perimeter air monitoring stations, 2002 (pCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{7}Be	1.69E–08[c]	1.79E–08[c]	1.65E–08[c]	1.71E–08[c]	*d*
^{137}Cs	6.86E–09[c]	2.54E–09[c]	5.15E–09	*e*	*d*
^{3}H	4.09E–06	2.99E–05[c]	3.58E–06	3.23E–06	–4.26E–07
^{40}K	2.53E–07[c]	2.26E–07[c]	2.11E–07[c]	3.12E–07[c]	*d*
^{234}U	1.12E–11[c]	1.59E–11[c]	1.09E–11[c]	1.57E–11[c]	1.24E–11[c]
^{235}U	4.73E–13	1.15E–11[c]	5.63E–13[c]	2.68E–12[c]	9.26E–13[c]
^{238}U	6.09E–12[c]	1.22E–11[c]	1.29E–11[c]	6.62E–12[c]	8.20E–12[c]

[a]1 pCi = 3.7E–02 Bq.

[b]Reference location off-site.

[c]Statistically significant average at 95% confidence level.

[d]Comparison of gamma scan results not applicable due to differences in collection media and analytical frequencies.

[e]Not reported.

radioactive emissions from a sample. Therefore, the same result may not be obtained if the sample were analyzed repeatedly. This deviation is referred to as the "counting uncertainty." Statistical significance at the 95% confidence level means that there is a 5% chance that the results could be in error, and does not necessarily indicate environmental significance.

5.4 LIQUID DISCHARGES—ORNL RADIOLOGICAL MONITORING SUMMARY

ORNL monitors radioactivity at NPDES outfalls that have a potential to discharge radioactivity and at three instream monitoring stations under a radiological monitoring plan that is required by Part III, Section J, of the ORNL NPDES permit. The current version of the plan was implemented on November 1, 1999. Table 5.4 contains the details of the locations, frequency, and target analyses for monitoring of dry-weather discharges and instream monitoring locations. Monitoring of radioactivity occurs at the three ORNL treatment facilities: the Sewage Treatment Plant, the Coal Yard Runoff Treatment Facility, and the Process Waste Treatment Complex. Other effluents monitored in 2002 included 21 smaller discharges (category outfalls). Wastewaters discharged through category outfalls are primarily storm water runoff, cooling water, groundwater, and steam condensate. Some category outfalls listed in Table 5.4 were not sampled in 2002, either because they are no longer in service or because they were not discharging or were otherwise unsamplable during sampling attempts. The three instream locations monitored under the Radiological Monitoring Plan are X13 on Melton Branch, X14 on White Oak Creek, and X15 at White Oak Dam (Fig. 5.6).

The DOE DCG values are used in this section 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 at the 95% confidence level. For analyses that cannot differentiate between two isotopes (e.g., $^{89/90}$Sr) and for isotopes that have more than one DCG for different gastrointestinal tract absorption factors, the most restrictive (lowest) DCG is used in calculations. DCGs are not intended for comparison to instream values. However, they are useful as a frame of reference, so instream values are also compared to DCGs in this section. The calculation of the percentage of the DCG for ingestion of water does not imply that effluent points or that ambient-water-sampling stations at ORNL are sources of drinking water. Four percent of the relevant DCG is used as a screening value because it is roughly equivalent to the 4-mrem dose limit on which the EPA radionuclide drinking water standards are based.

For 2002, three radionuclides had an average concentration greater than 4% of the relevant DCG in at least one location; they were total radioactive strontium ($^{89/90}$Sr), ^{3}H, and ^{137}Cs. Of the locations sampled, the highest total radioactive strontium and tritium activities were at NPDES location X13 on Melton Branch (respectively, 24% and 15% of the DCGs), and the highest ^{137}Cs activity was at Outfall X12, the discharge from the Process Waste Treatment Complex (43% of the DCG). 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 2002, the sum of DCG percentages in dry-weather discharges at each effluent point and ambient water station was less than 100% (Fig. 5.7).

Amounts of radioactivity in stream water passing White Oak Dam, the final monitoring point on White Oak Creek before the stream flow leaves ORNL, are calculated from concentration and flow. The total annual discharges (or amounts) of radioactivity released at White Oak Dam during each of the past 5 years are shown in Figs. 5.8 through 5.13. The amounts of radioactivity passing this monitoring station were similar to previous years with the exception of ^{137}Cs. The increase in transport of ^{137}Cs was also reflected in the discharge of gross beta activity.

Data collected under the NPDES Radiological Monitoring Plan does not indicate that the higher transport of ^{137}Cs measured at the White Oak Dam monitoring station was caused by an individual NPDES permitted outfall. One potential explanation for the increase is contributions from environmental remediation activities within the White

Table 5.4. Oak Ridge National Laboratory Radiological Monitoring Plan, effective November 1, 1999

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

[a]Isotopic analyses are performed to identify contributors to gross activities when results exceed screening criteria described in the *Radiological Monitoring Plan*, June 1999.
[b]No discharge present.
[c]No longer discharges (underwater).
[d]No longer discharges (plugged).

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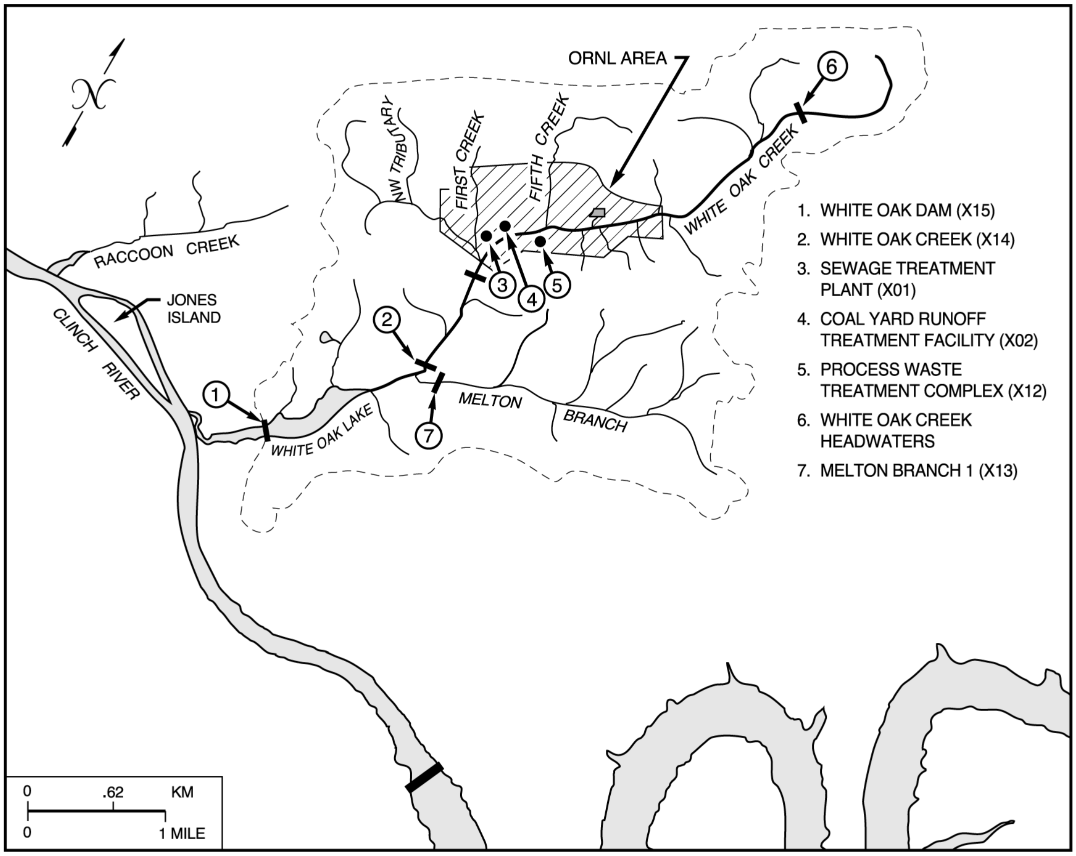

Fig. 5.6. ORNL surface water, National Pollutant Discharge Elimination System, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

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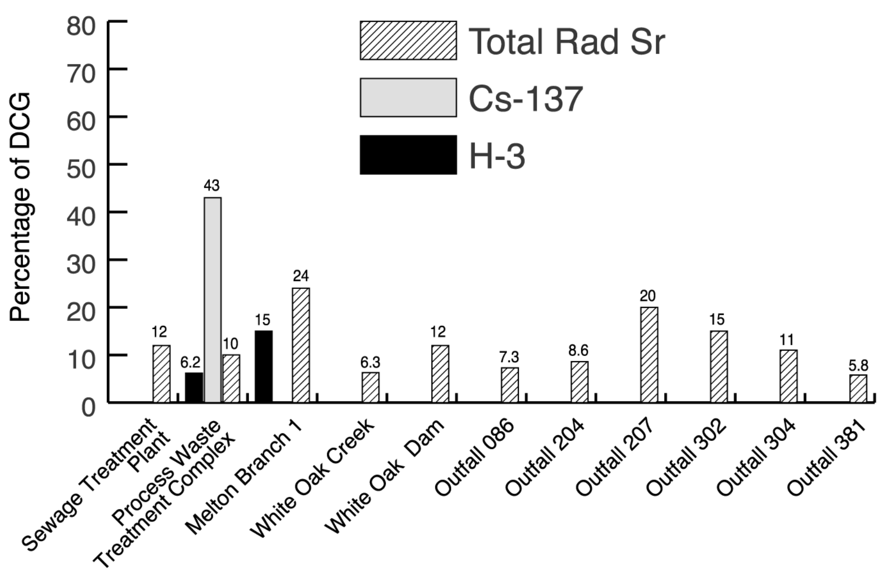

Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2002.

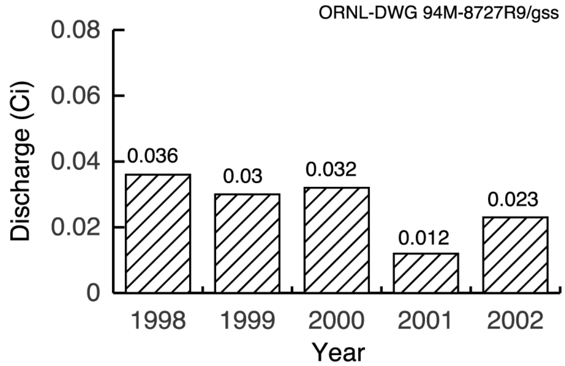

Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 1998–2002.

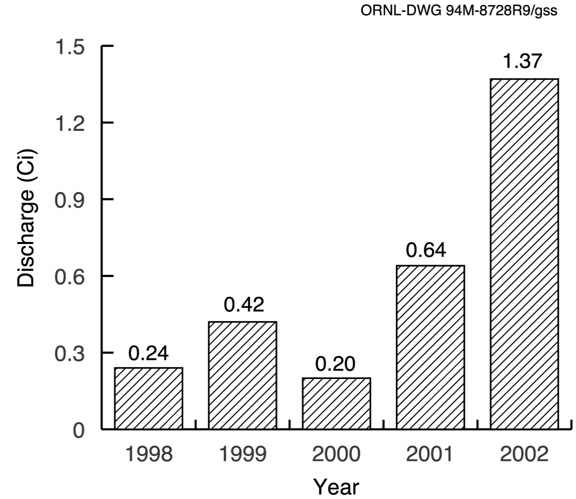

Fig. 5.9. Cesium-137 discharges at White Oak Dam, 1998–2002.

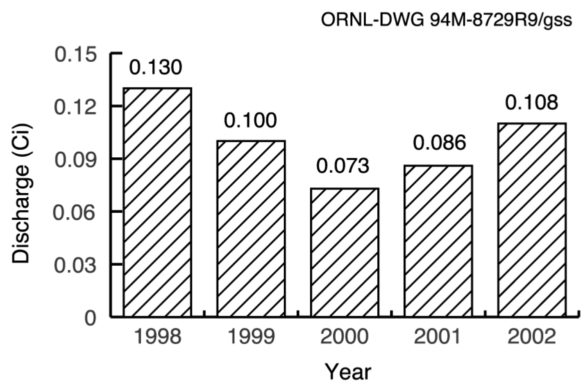

Fig. 5.10. Gross alpha discharges at White Oak Dam, 1998–2002.

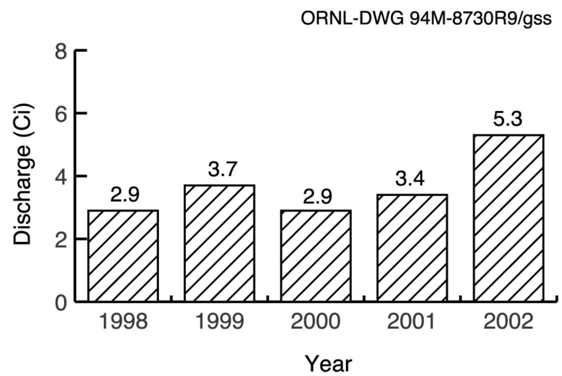

Fig. 5.11. Gross beta discharges at White Oak Dam, 1998–2002.

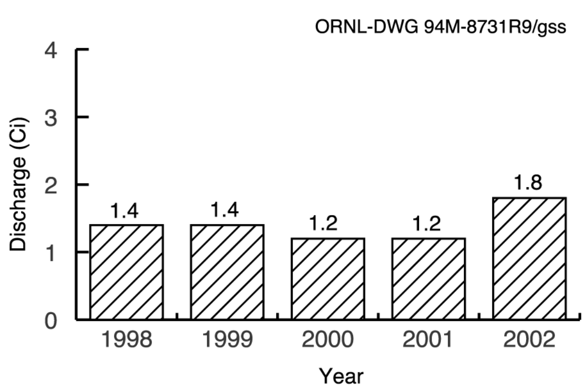

Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 1998–2002.

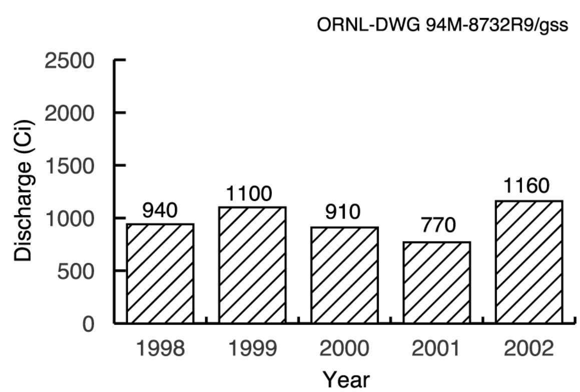

Fig. 5.13. Tritium discharges at White Oak Dam, 1998–2002.

Oak Creek watershed. The remediation project that is most likely to have contributed to the increase is the remediation of the area adjacent to White Oak Creek that was formerly the Intermediate Holding Pond. This project, which was started in 2002, included the clearing and excavation of a large area of contaminated White Oak Creek floodplain. It is logical that disturbance of this area would result in increased contaminant transport in White Oak Creek. If this is the case, the higher ^{137}Cs transport should be temporary. In addition, the restoration project's removal of this source of ^{137}Cs from the environment should presumably reduce the post-remediation transport of ^{137}Cs in White Oak Creek.

The Radiological Monitoring Plan also includes requirements for monitoring radioactivity at category outfalls during storm conditions. There were 102 outfalls targeted for storm water sampling when the plan was developed. Since that time, one of those outfalls was physically removed (Outfall 115) and another was plugged (Outfall 382). The storm water outfalls were grouped into eight different categories with the knowledge that outfalls may move from one category to another as storm water data are collected. The storm water categories were defined by the availability of historic data, and when data were available, by the levels of radioactivity detected in past monitoring. The goal set for storm water monitoring in the Radiological Monitoring Plan is to perform monitoring at the rate of 20 outfalls per NPDES permit year (February 3 to February 2). The plan set frequency goals rather than strict requirements because opportunities for storm water sampling are weather dependent.

Monitoring of storm water runoff through NPDES-permitted outfalls for radioactivity is conducted on an NPDES permit-year basis; however, storm water results are discussed on a calendar-year basis in this report. A total of 12 storm water outfalls were monitored in calendar year 2002.

When storm water monitoring locations are selected, outfalls are chosen so that various areas of the ORNL site are represented. Storm water samples are analyzed for gross alpha, gross beta, and ^{3}H activities. A gamma scan is also routinely performed. Under the Radiological Monitoring Plan, additional analyses are added when there is enough gross alpha and/or gross beta activity at an outfall to indicate that DCG levels may be exceeded. In 2002, no storm water discharges required additional analyses.

Of the 60 individual storm water sample results collected in 2002, 45 (75%) were less than the minimum detectable activities of the tests. None of the isotope-specific measurements (^{3}H, ^{60}Co, and ^{137}Cs) were greater than 4% of DCG levels.

5.5 ORNL NPDES SUMMARY

5.5.1 NPDES Permit Monitoring

ORNL submitted the application for renewal of NPDES Permit TN0002941 on June 1, 2001, fulfilling the requirement that an application be made six months prior to permit expiration. The December 6, 1996, ORNL NPDES Permit expired in December 2001, and the limits and conditions of that permit remain in effect until renewal by TDEC. Data collected as required by the permit are submitted to the state of Tennessee in the monthly *NPDES Discharge Monitoring Report*. The 1996 NPDES permit includes 164 separate outfalls and monitoring points.

The ORNL 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 existing permit, there are numeric and narrative effluent limits on the following locations:

- X01—Sewage Treatment Plant;
- X02—Coal Yard Runoff Treatment Facility;
- X12—Process Waste Treatment Complex;
- X13—Melton Branch (MB1);
- X14—White Oak Creek;
- X15—White Oak Dam;
- in-stream 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, water condensate, cooling water, and cooling tower blowdown);
- Category IV outfalls (storm drains, water discharged under best management practices, groundwater, steam, water condensate, cooling water, and cooling tower blowdown); and
- cooling systems (cooling water and cooling tower blowdown).

Permit limits and compliance statistics are shown in Table 5.5. Instream data collection points X-13, X-14, and X-15 are not included in the table because only flow measurements and narrative conditions are required under the ORNL NPDES Permit at those three points. Permit nonconformances in 2002 are discussed below and are shown in Appendix D.

During 2002, ORNL experienced eight instances of noncompliance with numeric NPDES permit limits and one instance where an instream temperature criterion was exceeded. Based on approximately 8300 compliance measurements and analyses, the rate of compliance with the ORNL NPDES permit was approximately 99.9%. Five of the instances of nonconformances occurred at the ORNL Sewage Treatment Plant due to extenuating circumstances caused by heavy rainfall events on January 25 and March 17–18, 2002. Heavy rainwater inflow into the Sewage Treatment Plant forced temporary incomplete treatment of a portion of the effluent from the plant, and resulted in exceedances of permit limits for the parameters carbonaceous biochemical oxygen demand and total suspended solids. The ORNL sewage treatment plant experienced an indication of effluent toxicity in required NPDES testing in May 2002. No cause for the indication of toxicity was determined, and no adverse environmental or operational effects were observed. Required confirmatory testing indicated a nontoxic condition; therefore, no corrective actions were available or required. Other permit limit exceedances occurred in 2002: exceedance of a pH limit at Outfall 235, which was caused by steam plant boiler-blowdown leakage past a valve during maintenance on a heat exchanger, and two exceedances of a total residual oxidant limit at Outfall 281 due to inadequate dechlorination during a scheduled system outage. Operational improvements were made to guard against recurrence of these two incidents. Figure 5.14 shows the number and types of noncompliances at each respective location.

Thermal impacts from ORNL discharges were assessed in August 2002 in accordance with the ORNL BMAP. All sections of receiving streams that were monitored were found to be compliant with the state of Tennessee's water quality criteria for temperature with the exception of one small tributary to Melton Branch. Cooling water discharges from NPDES Outfall 082 are being investigated as a possible contributor to the instream temperature, which was 31.1°C; the acceptable maximum is 30.5°C. No impacts on the aquatic environment or species were noted as a result of this exceedance.

Under the NPDES permit, ORNL conducts several monitoring plans and programs. These include the Radiological Monitoring Plan, the Chlorine Control Strategy, and the Storm Water Pollution Prevention Plan. These are discussed in the following sections.

5.5.1.1 Radiological Monitoring Plan

In 2002, ORNL continued to sample and analyze under the revised Radiological Monitoring Plan implemented on November 1, 1999. Results for the 2002 monitoring are presented in Sect. 5.4.

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 mass-loading action levels on outfalls, depending on the outfall's location and the volume of its discharge. At ORNL, total residual oxidant measurements may include both chlorine and bromine residuals. Most outfalls with total residual oxidant mass-loading action levels are monitored semiannually, and the remainder of them are monitored either weekly, semimonthly, or quarterly. A number of outfalls that do not have dry-weather total residual oxidant discharges were dropped from the Chlorine Control Strategy during the duration of the NPDES permit. However, no additional outfalls were dropped in 2002.

Table 5.5. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2002 (NPDES permit effective February 3, 1997)

Discharge point	Effluent parameters[a]	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[b]
X01	LC_{50} for *Ceriodaphnia* (%)					41.1	0	4	100
(Sewage	LC_{50} for fathead minnows (%)					41.1	1	4	75
Treatment	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	80	100
Plant)	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	78	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		1	158	99.3
	Dissolved oxygen					6	0	158	100
	Fecal coliform (col/100 mL)			1000	5000		0	158	100
	NOEC for *Ceriodaphnia* (%)					12.3	0	4	100
	NOEC for fathead minnows (%)					12.3	0	4	100
	Oil and grease	8.7	13.1	10	15		0	158	100
	pH (std. units)				9	6	0	158	100
	Total residual chlorine			0.038	0.066		0	158	100
	Total suspended solids	26.2	39.2	30	45		4	158	97.4
X02	LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
(Coal Yard	LC_{50} for fathead minnows (%)					4.2	0	4	100
Runoff	Copper, total			0.07	0.11		0	24	100
Treatment	Iron, total			1.0	1.0		0	24	100
Facility)	NOEC for *Ceriodaphnia* (%)					1.3	0	0[c]	100
	NOEC for fathead minnows (%)					1.3	0	0[c]	100
	Oil and grease			10	15		0	52	100
	pH (std. units)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	24	100
	Silver, total				0.008		0	24	100
	Total suspended solids				50		0	52	100
	Zinc, total			0.87	0.95		0	24	100

Table 5.5 (continued)

Discharge point	Effluent parameters[a]	Permit limits: Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Permit compliance: Number of noncompliances	Number of samples	Percentage of compliance[b]
X12 (Process Waste Treatment Complex)	LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	LC_{50} for fathead minnows (%)					100	0	4	100
	Cadmium, total	0.79	2.09	0.008	0.034		0	53	100
	Chromium, total	5.18	8.39	0.22	0.44		0	53	100
	Copper, total	6.27	10.24	0.07	0.11		0	53	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	53	100
	Nickel, total	7.21	12.06	0.87	3.98		0	53	100
	NOEC for *Ceriodaphnia* (%)					30.9	0	4	100
	NOEC for fathead minnows (%)					30.9	0	4	100
	Oil and grease	30.3	45.4	10	15		0	53	100
	pH (std. units)				9.0	6.0	0	158	100
	Silver, total	0.73	1.3		0.008		0	53	100
	Temperature (°C)				30.5		0	158	100
	Total toxic organics		6.45		2.13		0	12	100
	Zinc, total	4.48	7.91	0.87	0.95		0	53	100
Instream chlorine monitoring points	Total residual oxidant			0.011	0.019		0	264	100
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	11	100
Groundwater/ pumpwater outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	4	100

Table 5.5 (continued)

Discharge point	Effluent parameters[a]	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[b]
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	4	100
Category I outfalls	pH (std. units)				9.0	6.0	0	19	100
Category II outfalls	pH (std. units)				9.0	6.0	0	22	100
Category III outfalls	pH (std. units)				9.0	6.0	0	48	100
Category IV outfalls	pH (std. units)				9.0	6.0	1	312	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]LC_{50} = the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 96 h. NOEC = no-observed-effect concentration; the concentration as a percentage of full-strength wastewater that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

[b]Percentage compliance = 100 – [(number of noncompliances/number of samples) * 100].

[c]Insufficient discharge for chronic test and determination of no-observed-effect concentration for each of the quarterly tests.

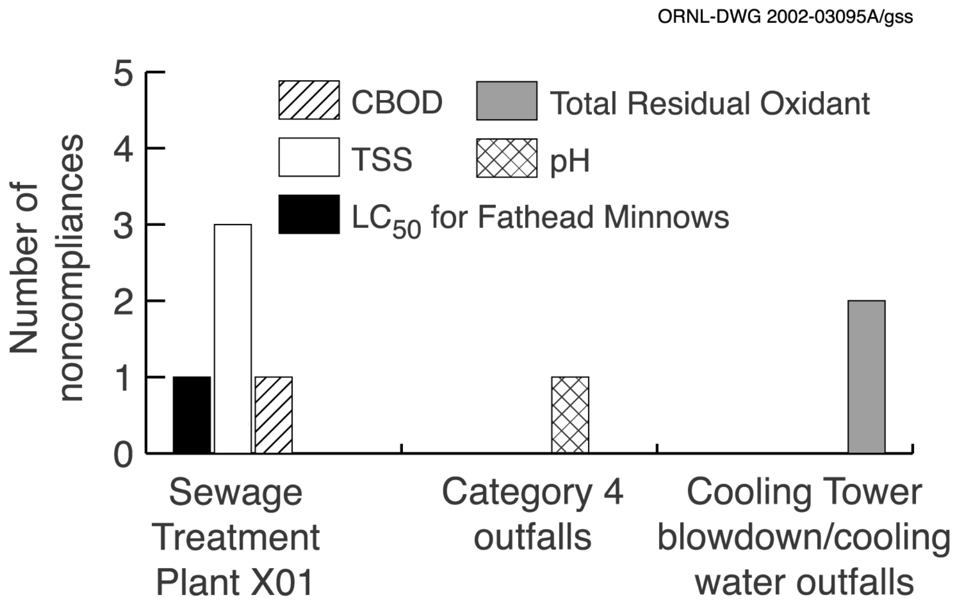

Fig. 5.14. ORNL National Pollutant Discharge Elimination System permit limit noncompliances in 2002.

Outfalls included in the Chlorine Control Strategy have a mass-loading action level for total residual oxidants that requires ORNL to reduce or eliminate total residual oxidants in the discharge if they exceed the action level. The action level is 1.2 g/d and is calculated by multiplying the instantaneously measured concentration by the instantaneous flow rate of the outfall.

ORNL monitored 152 measurable dry-weather discharges during 2002. Two outfalls exceeded the action level one or more times. Actions to reduce or eliminate chlorine in these effluents are being investigated. A report detailing monitoring results, corrective actions, and proposed modifications is submitted to TDEC annually.

5.5.1.3 Storm Water Pollution Prevention Plan

The Storm Water Pollution Prevention Plan is a requirement of the ORNL NPDES Permit to document existing material management practices and to evaluate the vulnerability of those practices in contributing pollutants to area streams via storm water runoff. The plan consists of four major components:

1. assessment and mapping of outdoor material storage/handling at ORNL,
2. characterization of storm water runoff by monitoring,
3. training of employees, and
4. implementation of measures to minimize storm water pollution in areas of ORNL that may be vulnerable.

These four components of the plan were initiated in 1997 and are reviewed and updated by the facility at least annually. The plan was last updated on August 1, 2002. This update includes observations and data from the previous year. ORNL has a storm water pollution prevention program that includes an inspection program, the analysis of storm water data collected as part of the NPDES program, training for ORNL employees and contractors, and annual review and revision of the program document. (The document is available to personnel on the ORNL site via the ORNL internal web.)

For sampling purposes, ORNL categorizes its storm water outfalls into four broad groups based on common land uses or pollutant sources, and storm water pollutant potential. These four groups are further subdivided based on permit categorizations that have different monitoring schedule requirements. The permit requires that Category I and II outfalls be characterized over a 5-year period and that Category III and IV outfalls be characterized over a 3-year period. The outfalls chosen to be sampled were thought to be representative of the group or were thought to be more vulnerable to runoff pollution than other outfalls in the group. Other factors considered in selecting representative outfalls from each group include interest in a particular runoff quality at an outfall and ease of obtaining a representative sample. A rotation of representative outfalls occurs each sampling period as directed by the permit. The results of the storm water outfall effluent sampling as of 2002 are provided in Attachment 6.0 of the *Storm Water Pollution Prevention Plan*.

The EPA Nationwide Urban Runoff Program was developed to expand the understanding of urban runoff pollution by instituting data collection and applied research projects in the urban areas of the United States. Urban storm water runoff pollutant loading factors for ten standard water quality constituents, called "event mean concentrations" (EMCs), were developed for the 1983 program's final report. Program findings were again updated in 1999 by using results of storm water data collected by the U.S. Geological Survey and the NPDES Storm Water Program to refine the EMCs.

In a comparison of recent ORNL data with data from the Nationwide Urban Runoff Program, most values for the ten water quality constituents are well below the EMCs. Patterns of values exceeding the EMCs can be generalized by exceedances of copper or zinc occurring at Outfalls 006, 165, 216, 217, 235, 249, 302, and 343. Outfalls 006 and 235 also exceeded the chemical oxygen demand level. Copper is found naturally in the soils and could also occur from coal-burning activities or corrosion of copper pipes. Zinc can be attributed to vehicular degradation. The Outfall 006 drainage area includes the High Temperature Materials Laboratory (Building 4515). The drainage area for Outfall 235 is much larger by comparison and includes the Steam Plant (Building 2519), a fuel oil tank, a substation, craft support/offices (Building 2567), and a machine shop (Building 2547). This drainage area may show marked improvement in pollutant concentrations with the recent conversion of fuel at the Steam Plant from coal to natural gas. While the adjacent coal yard did not drain directly to this outfall, coal dust was always evident along this outfall's natural conveyance. The coal yard has been reclaimed and evidence of coal dust in the surrounding environs has noticeably declined.

5.5.2 ORNL Results and Progress in Implementing Programs and Corrective Actions

5.5.2.1 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, more than 9000 sink and drain records were produced and are stored in a central database. ORNL has continued its efforts annually and in 2002 continued an annual division-by-division recertification of ORNL sinks and drains to ensure that sinks and drains continue to discharge to the proper wastewater collection systems. Program management continues to communicate sink and drain responsibilities to the ORNL site population.

5.6 ORNL WASTEWATER BIOMONITORING

Under the NPDES permit, wastewaters from the Sewage Treatment Plant, the Coal Yard Runoff Treatment Facility, and the Process Waste Treatment Complex 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, the wastewater's no-observed-effect concentration (NOEC), and the concentration that kills 50% of the test organisms (LC_{50}) for fathead minnows (*Pimephales promelas*) and daphnia (*Ceriodaphnia dubia*). The NOEC is the highest concentration tested that does not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. The 96-h LC_{50} is the concentration of wastewater that kills 50% of the test organisms in 96 h. The NPDES permit defines the limits for the biomonitoring tests. For the X01 (Sewage Treatment Plant) discharge, toxicity is demonstrated if more than 50% lethality of

Table 5.6. Toxicity test results of Oak Ridge National Laboratory wastewaters, 2002

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	February	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	May	*Ceriodaphnia*	12.3	>41.1
		Fathead minnow	12.3	21.6
	June[c]	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	August	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	November	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
Coal Yard Runoff Treatment Facility (X02)	February	*Ceriodaphnia*	NA[d]	>4.2[e]
		Fathead minnow	NA[d]	>4.2[e]
	May	*Ceriodaphnia*	NA[d]	>4.2[e]
		Fathead minnow	NA[d]	>4.2[e]
	August	*Ceriodaphnia*	NA[d]	>4.2[e]
		Fathead minnow	NA[d]	>4.2[e]
	November	*Ceriodaphnia*	NA[d]	>4.2[e]
		Fathead minnow	NA[d]	>4.2[e]
Process Waste Treatment Complex (X12)	February	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	May	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	August	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	November	*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]Confirmatory test.

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

[e]48-h LC_{50}.

the test organisms occurs in 96 h in 41.1% effluent or if the NOEC is less than 12.3%. For the X02 discharge (Coal Yard Runoff Treatment Facility), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 4.2% effluent or if the NOEC is less than 1.3%. Because of the batch mode of discharge at the Coal Yard Runoff Treatment Facility, the limit for the NOEC only applies if the facility discharges for a sufficient length of time. For the X12 discharge (Process Waste Treatment Complex), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 100% effluent (LC_{50}) or if the NOEC is less than 30.9%.

During 2002, the Sewage Treatment Plant, Coal Yard Runoff Treatment Facility, and Process Waste Treatment Complex were each tested four times. Numeric biomonitoring limits in the NPDES permit were not exceeded with the exception of the May fathead minnow LC_{50} for X01, the Sewage Treatment Plant. Biomonitoring limits for the Sewage Treatment Plant were met during a subsequent confirmatory test conducted in June.

5.7 ORNL BIOLOGICAL MONITORING AND ABATEMENT PROGRAM

As a condition of the NPDES permit issued to ORNL in April 1986, the BMAP was set forth to assess the condition of aquatic life in White Oak Creek, the Northwest Tributary of White Oak Creek, Melton Branch, Fifth Creek and First Creek (Loar et al. 1991); the BMAP continued as a condition of the most recent NPDES permit that was effective February 3, 1997 (Kszos et al. 1997). The program addresses the following objectives as described in the NPDES permit part III (I).

- Temperature loadings shall be within state water criteria for protection of fish and aquatic life for warm summer conditions. This should be verified and reported annually (see Sect. 5.5.1).
- Instream water analysis for mercury shall be part of the BMAP so that it can be determined whether mercury at the site is being contributed to the stream and, if so, whether it will impact fish and aquatic life or violate the recreation criteria.
- Sediment and oil and grease from storm discharges shall not create stream impacts.
- The status of PCB contamination in fish tissue in the White Oak Creek watershed shall be determined.
- The Chlorine Control Strategy's protection of the stream in the main plant area shall be assessed.

In addition, the BMAP shall continue studies evaluating the receiving streams' biological communities throughout the duration of the permit.

5.7.1 Bioaccumulation Studies

The bioaccumulation task for the BMAP addresses two NPDES permit requirements at ORNL: (1) 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) monitor the status of PCB contamination in fish tissue in the White Oak Creek watershed.

5.7.1.1 Mercury in water

Water samples were collected for mercury analysis from four White Oak Creek sites on six occasions in 2002. Stream conditions were representative of seasonal baseflow (dry weather) conditions at the time of the sampling on all dates except January and September, which were influenced by wet-weather flow. The mean mercury concentration in White Oak Creek at the weir upstream from ORNL [White Oak Creek kilometer (WCK) 6.8] was below the routine analytical detection limit (<10 ng/L) on all sampling dates. High-sensitivity analysis (Zeeman effect cold vapor atomic absorption spectrometry) of water from this site in August, September, and November 2002 found total mercury to range from 2.1 to 6.8 ng/L, typical of uncontaminated waters in the southeastern United States. Average concentrations (± standard error) of waterborne mercury in White Oak Creek in 2002 clearly exceeded the Tennessee Water Quality Standard (51 ng/L) at WCK 4.1/MS3619 (89 ± 11 ng/L), but at the downstream sites (WCK 3.4; 36 ± 5 ng/L and White Oak Lake; 37 ± 9 ng/L) mean mercury concentrations were below the standard. Aqueous mercury concentrations from 1998 to 2002 are shown in Fig. 5.15. High temporal variability is characteristic of waterborne mercury in White Oak Creek, with highest concentrations and greatest variability in upper White Oak Creek (WCK 4.1).

5.7.1.2 Bioaccumulation

Sunfish are ideally suited organisms for evaluating changes in contaminant accumulation because they are a relatively short-lived species and are limited in their stream movements, thus, providing a recent measure of exposure at the specific site of collection. In spring 2002, redbreast sunfish (*Lepomis auritus*) from WCK 2.9 were approximately fourfold higher in their average mercury concentration (0.30 ± 0.02 mg/kg ± SE) than redbreast sunfish (0.08 ± 0.01 mg/kg) from the Hinds Creek reference site. Concentrations of mercury in bluegill (*Lepomis macrochirus*) collected further downstream in White Oak Lake (WCK 1.5) were similar to concentrations in reference-site fish (0.09 ± 0.01 mg/kg) and far lower than in redbreast sunfish from WCK 2.9. Largemouth bass (*Micropterus salmoides*) mercury concentrations at WCK 1.5 reflected their higher position in the food chain, averaging 0.35 ± 0.02 mg/kg (± SE). No fish from White Oak Creek exceeded 0.5 mg Hg/kg, a level currently used by the state of Tennessee in issuing fish consumption advisories. Five of six redbreast sunfish from WCK 2.9 and five of six bass from WCK 1.5 exceeded EPA's criterion for mercury in fish tissue of 0.3 mg methylmercury/kg (ppm); no bluegill collected from WCK 1.5 exceeded this level.

The mean PCB concentrations in redbreast sunfish from WCK 2.9 and bluegill from WCK 1.5 were 0.24 ± 0.04 mg/kg (± SE) and 0.39 ± 0.07 mg/kg, respectively. Redbreast sunfish from the reference stream (Hinds Creek) analyzed at the same time averaged <0.02 mg PCB/kg. PCB levels in White Oak Creek sunfish are relatively high for such short-lived, lipid-poor fish. Largemouth bass are better indicators of the maximum PCB concentrations likely in the White Oak Creek system because of their high lipid content and higher position in the food chain. The mean PCB concentration in WCK 1.5 bass in the spring of 2002 was 1.43 ± 0.43 mg/kg; a substantial decrease from the average in 2001 (4.87 mg/kg). Only two individual bass in 2002 exceeded the U.S. Food and Drug Administration threshold limit (for fish sold commercially) of 2 mg/kg (ppm). As a comparison, the state of Tennessee typically issues an advisory when PCB concentrations in fish approach 0.8–1 mg/kg (ppm).

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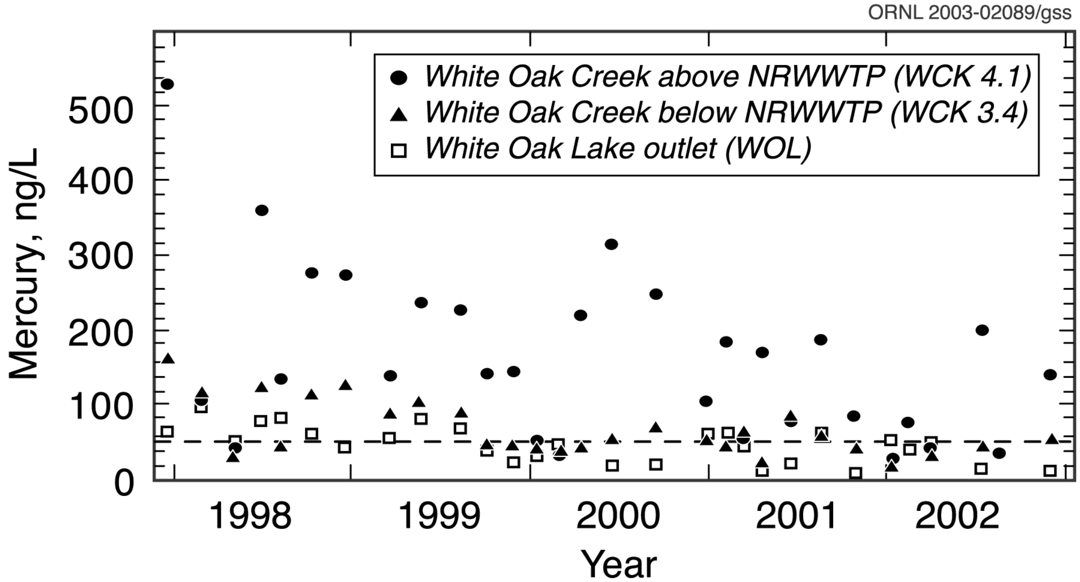


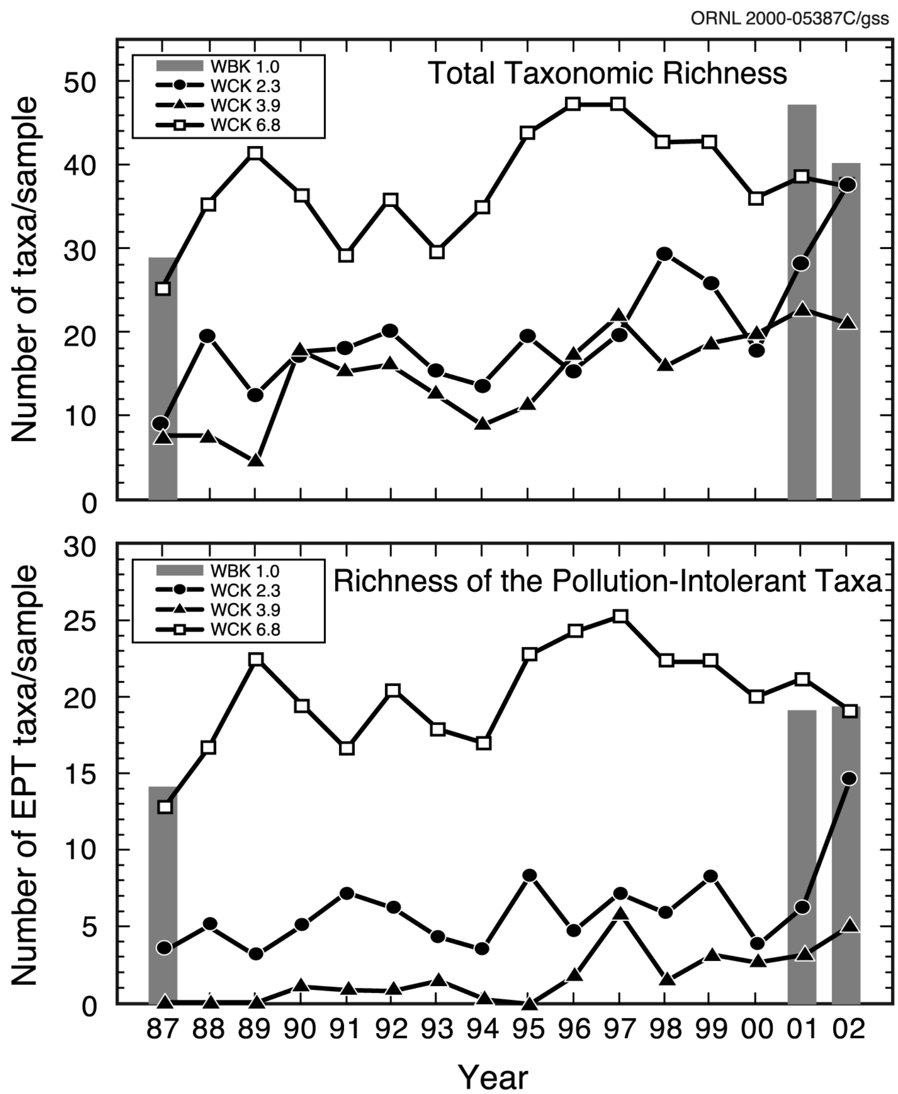
Fig. 5.15. Total mercury in water vs time, 1998–2002, at three sites in the White Oak Creek watershed downstream from ORNL. Dashed line is the TDEC water quality standard of 51 ng/L (NRWWTP = Nonradiological Wastewater Treatment Plant).

5.7.2 Ecological Surveys

5.7.2.1 Benthic Macroinvertebrate Communities

The benthic macroinvertebrate communities of several streams in the White Oak Creek watershed have been monitored as part of the ORNL BMAP since 1986. The objective of this task is to help assess ORNL's compliance with the current NPDES permit requirements by evaluating the ecological condition of and temporal trends in the macroinvertebrate communities of these streams. An additional objective is to evaluate and verify the effectiveness of pollution abatement and other actions taken at ORNL. This is accomplished by following temporal trends in the macroinvertebrate communities of the streams.

Results for April sampling periods through 2002 show that the benthic macroinvertebrate communities in First Creek, Fifth Creek, and White Oak Creek continue to exhibit characteristics of some degradation from ORNL operations, although results from 2002 suggest that further improvements may have occurred at some sites (Figs. 5.16, 5.17, and 5.18). Impacts were most



WBK - Walker Branch kilometer
WCK - White Oak Creek kilometer
EPT - Ephemeroptera, Plecoptera, and Trichoptera

Fig. 5.16. Taxonomic richness and richness of the pollution-intolerant taxa in the benthic macroinvertebrate communities in White Oak Creek during April sampling periods, 1987–2002.

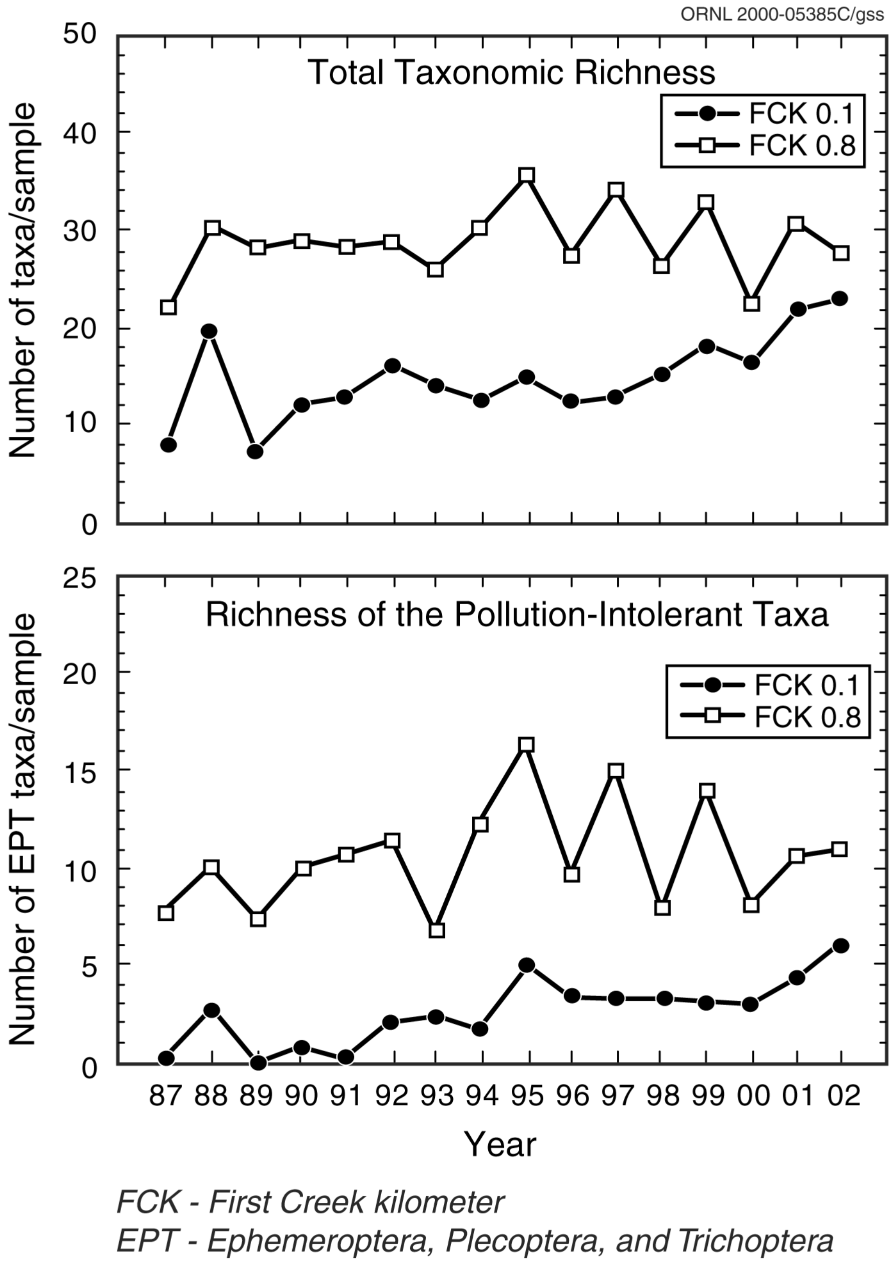


Fig. 5.17. Taxonomic richness and richness of the pollution-intolerant taxa in the benthic macroinvertebrate communities in First Creek during April sampling periods, 1987–2002.

evident in White Oak Creek just upstream of the coal yard, where at WCK 3.9 taxonomic richness of the pollution-intolerant taxa was approximately three times lower than at the Walker Branch [Walker Branch kilometer (WBK) 1.0] reference site and the most upstream site in White Oak Creek (WCK 6.8; Fig. 5.16). Differences between WCK 2.3 and the reference site in the total number of taxa and the number of pollution-intolerant taxa were smaller in 2002 than in previous years, but this site continues to be numerically dominated by pollution-tolerant species such as the non-biting midges (Chironomidae). In First Creek, differences in total richness between the downstream [First Creek kilometer (FCK) 0.1] and reference sites (FCK 0.8) continue to be small as has been true since 2000, but the number of pollution-intolerant taxa at FCK 0.1 continued to be about 50% lower than at FCK 0.8 (Fig. 5.17). Although the differrences in 2002 between the downstream [Fifth Creek kilometer (FFK) 0.2] and reference sites (FFK 1.0) in Fifth Creek were less than in previous years (Fig. 5.18), as in lower White Oak Creek, pollution-tolerant taxa (e.g., Chironomidae) continued to numerically dominate FFK 0.2, which is a typical characteristic of degraded environmental conditions. While these results do indicate that the benthic macroinvertebrate communities remain somewhat degraded, they also show that the improvements observed in these streams in recent years are persisting.

5.7.2.2 Fish Communities

Monitoring of the fish communities in White Oak Creek and its major tributaries continued in 2002. Samples were taken at 11 sites in the spring and 9 sites in the fall; sites closest to ORNL facilities were emphasized. In the main stream of White Oak Creek the fish community continued to display characteristics of degraded conditions, with sites closest to the outfalls having lower species richness (number of species), fewer pollution-sensitive species, more pollution-tolerant species, and higher densities (number of fish

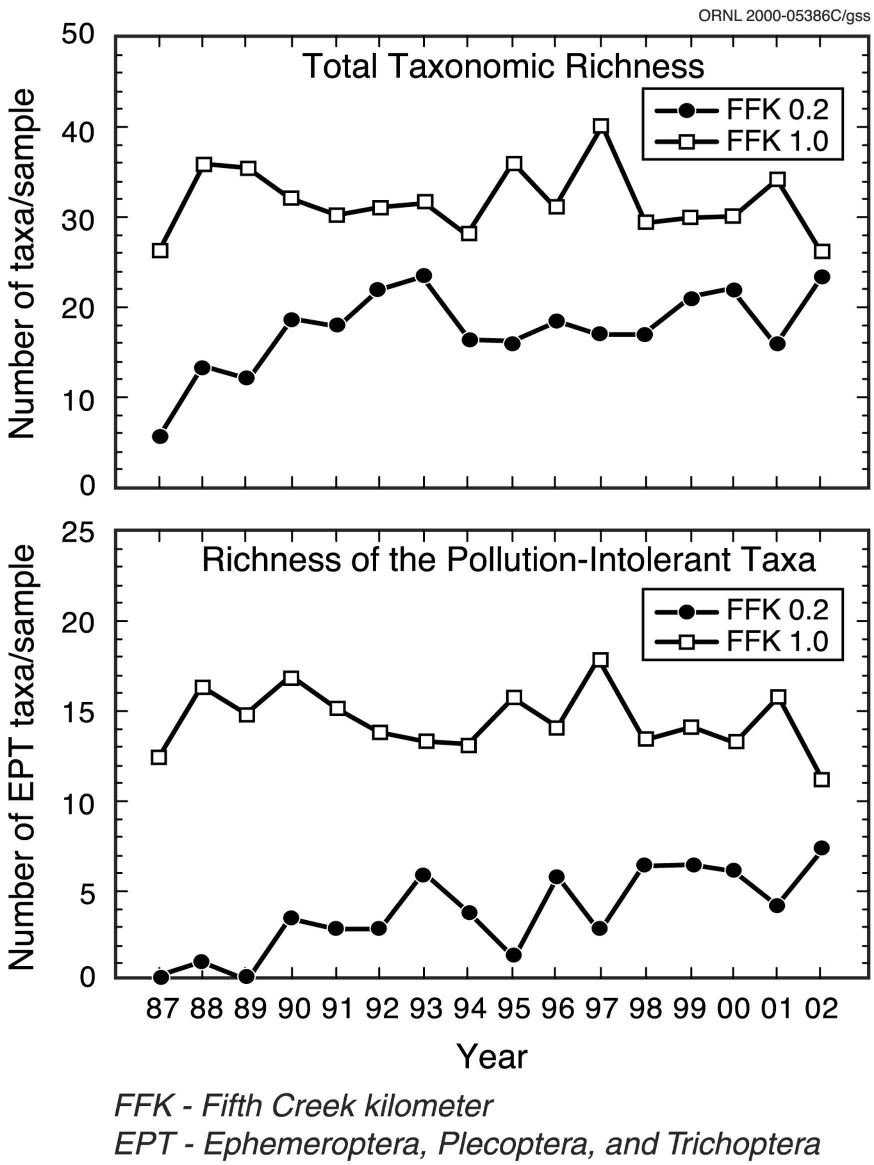


Fig. 5.18. Taxonomic richness and richness of the pollution-intolerant taxa in the benthic macroinvertebrate communities in Fifth Creek during April sampling periods, 1987–2002.

per square meter) than similar-sized reference streams. Density at the White Oak Creek sites generally declined during 2002 compared with 2001, especially at sites adjacent to Building 4515 (WCKs 4.3 and 4.4), where densities in 2002 declined to half those levels seen previously. In the past, these sites had very high densities (~14–17 fish/m^2), at least tenfold higher than at the larger reference sites.

In the major tributaries to White Oak Creek, the fish communities showed some recovery, but they remained impacted relative to reference streams. Lower Fifth Creek at site FFK 0.2 has shown the most improvement. This site has changed from one that was incapable of supporting fish before 1992 to one having a fairly stable, four-species community in 2002. However, the density at the upstream site (FFK 1.0) continued a trend of declining that began in 1998. In Melton Branch, the fish community changed little in 2002. Although density in Melton Branch was slightly lower in 2002 than in the 1990s, species richness was slightly higher. In First Creek, the fish community exhibited no notable changes in 2002.

5.8 ORNL SURFACE WATER MONITORING AT REFERENCE LOCATION

White Oak Creek headwaters were monitored in 2002 as a background or reference location for ORNL surface water monitoring.

In an effort to provide a basis for evaluation of analytical results and for assessment of nonradiological surface water quality, Tennessee General Water Quality Criteria have been used as reference values. The criteria for fish and aquatic life have been used at White Oak Creek headwaters (see Appendix C, Table C.2, for Tennessee General Water Quality Criteria for all parameters in water and Appendix C, Table C.3, for surface water analyses).

5.9 GROUNDWATER MONITORING AT ORNL

5.9.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. The Environmental Management and Enrichment Facilities Program, formerly the Environmental Restoration Program, provides comprehensive cleanup of sites where past R&D and waste management activities have resulted in residual contamination of the environment. The Environmental Management and Enrichment Facilities Program is managed by BJC. Impacts of current R&D activities on groundwater at ORNL are monitored by UT-Battelle via the exit pathway monitoring program. Individual monitoring and assessment programs are impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections among many of them. Consequently, the concept of waste area groupings (WAGs) was developed to facilitate evaluation of potential sources of releases to the environment. A WAG is a grouping of multiple sites that are geographically contiguous and/or that occur within geohydrologically defined areas. WAGs and a watershed-based remediation approach established by BJC 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 individually.

At ORNL, 20 WAGs were identified by the RCRA Facility Assessment conducted in 1987. 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

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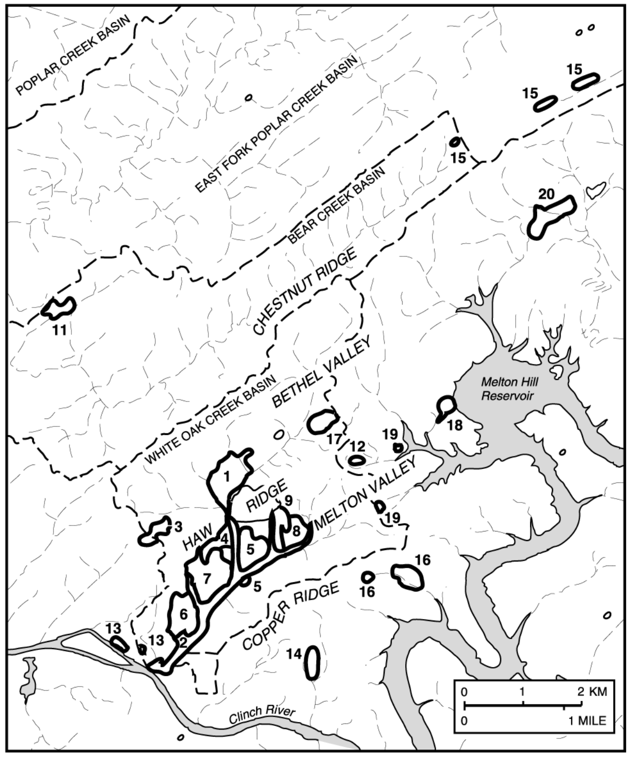

Fig. 5.19. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5).

location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible ground-water 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 to conduct long-term environmental monitoring throughout the ORR. The Water Resources Restoration Program succeeded the Integrated Water Quality Program in fall 1999.

The Water Resources Restoration Program is managed by the BJC Environmental Management and Enrichment Facilities Program and is the vehicle for the DOE to carry out the regulatory requirement from the Federal Facility Agreement to conduct postremedial action monitoring. The Water Resources Restoration Program has shifted away from the use of the WAG concept to more of a watershed approach to remediation, which resulted in the assignment of two watersheds to ORNL, Bethel Valley and Melton Valley.

The ORNL groundwater program was reviewed in 1996, and modifications included transfer of monitoring responsibility for some of the WAGs to the Water Resources Restoration Program. A summary of the ORNL groundwater surveillance program is presented in Table 5.7, which indicates whether WAGs are within Bethel Valley or Melton Valley. To provide continuity with previous annual site environmental 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 an annual basis (Table 5.7).

Monitoring results for remedial actions (under Water Resources Restoration Program purview) that are in progress or that have been completed within specific WAGs are reported annually in the Environmental Management and Enrichment Facilities Program *Remediation Effectiveness*

Table 5.7. Summary of the groundwater surveillance program at Oak Ridge National Laboratory, 2002[a]

WAG	Regulatory status	Wells		Frequency and last date sampled in 2002	Locations	Parameters
		Upgradient	Downgradient			
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	Annually, May 2002	4 wells	Radionuclides[b] and field measurements[c]
3	DOE Orders 5400.1 and 5400.5	3	12	*d*	*d*	*d*
17	DOE Orders 5400.1 and 5400.5	4	4	Annually, May 2002	All wells	Volatile organics, radionuclides,[b] and field measurements[c]
			Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Annually, June–July 2002	4 wells 16 wells	Full set[e] and field measurements[c] Radionuclides[b] and field measurements[c]
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	*d*	*d*	*d*
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	*d*	*d*	*d*
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	*f*	*f*	*f*
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	*d*	*d*	*d*
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	Annually, May–June 2002	All wells	Radionuclides[b] and field measurements[c]
			White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	*d*	*d*	*d*

[a]Abbreviations
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
DOE = U.S. Department of Energy
RCRA = Resource Conservation and Recovery Act
WAG = waste area grouping.

[b]Gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.

[c]Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.

[d]Water Resources Restoration Program (formerly Integrated Water Quality Program) samples selected wells for various purposes; other wells are inactive.

[e]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.

[f]Sampled by Environmental Management and Enrichment Facilities and data reported in the *Groundwater Quality Assessment Report for Solid Waste Storage Area 6 at Oak Ridge National Laboratory, Oak Ridge, Tennessee CY 2002,* February 2003, Bechtel Jacobs Company, LLC (BJC 2003d).

Report (DOE 2003a). Additionally, in the case of WAG 6, which is regulated under both RCRA and CERCLA, specific monitoring results and interpretations required by RCRA are reported in the annual *Groundwater Quality Assessment Report for Solid Waste Storage Area 6* (BJC 2003d), which is issued in February of each year.

UT-Battelle's WAG perimeter monitoring network and the ORNL plant perimeter groundwater surveillance program involved 49 wells in 2001. 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 White Oak Creek and Melton Valley being the focus of the program (Fig. 5.20). A summary of the current program is presented in Table 5.8.

Four of the ten wells that make up ORNL's exit pathway monitoring program are also part of the WAG perimeter monitoring program. These four wells are located on WAG 2, and 2002 data from sampling conducted under the WAG perimeter program were used for the exit pathway monitoring program. The surface water location (White Oak Creek at White Oak Dam) was sampled in October 2002. The results of the plant perimeter monitoring program are discussed in part in the following sections.

None of the ORNL WAGs are regulated under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality monitored by UT-Battelle at the ORNL WAGs, federal drinking water standards, and Tennessee Water Quality Criteria for domestic water supplies are used as reference values in the following discussions. When no federal or state standard has been established for a radionuclide, then 4% of the DOE DCG is used. Although drinking water standards are used, it is important to realize that no members of the public drink groundwater from ORNL WAGs, nor do any groundwater wells furnish drinking water to personnel at ORNL.

Trend analyses were performed on exit pathway wells or other wells monitoring areas actively managed by UT-Battelle whose organic and radiological contaminants exceeded their respective reference values during 2002. Inorganic contaminants exceeding their reference values did not undergo trend analysis because the inorganics (metals such as aluminum, iron, lead, manganese, and zinc) are commonly found in the soil and rock

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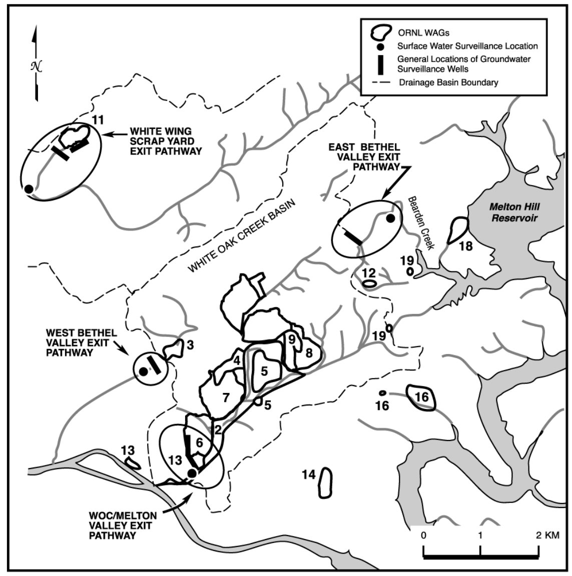

Fig. 5.20. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

Table 5.8. Summary of the plant perimeter surveillance program at Oak Ridge National Laboratory, 2002[a]

Exit pathway	WAG	Number of wells	Surface water locations	Parameters
White Oak Creek/ Melton Valley	6 and 2[b]	10	White Oak Creek at White Oak Dam	Volatile organics, ICP metals, ^{3}H, total radioactive strontium, gross alpha and beta, ^{60}Co, and ^{137}Cs

[a]Abbreviations
ICP = inductively coupled plasma.
WAG = waste area grouping.
[b]Four wells are part of the ORNL WAG 2 perimeter network.

composing the earth's crust. Sen's Slope/Mann-Kendall trend analysis was used to detect trends. The trend analysis was performed using historical data collected through 2002.

5.9.2 Bethel Valley

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

5.9.2.1 WAG 1 Area

WAG 1, the ORNL main plant area, contains about one-half of the remedial action sites identified to date by the Environmental Management and Enrichment Facilities Program. WAG 1 lies within the Bethel Valley portion of the White Oak Creek 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 composed of limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Many of the WAG 1 sites were used to collect and store low-level waste in tanks, ponds, and waste treatment facilities, but some sites also include landfills and contaminated sites resulting from spills and leaks that have occurred 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 solid waste management units are related to ORNL's past waste management operations.

WAG 1 Results

UT-Battelle activities to monitor groundwater discharging from WAG 1 include sampling four wells (807, 808, 809, and 830) in the southwest area of WAG 1, near the water gap in Haw Ridge that separates Bethel Valley from Melton Valley. These four wells are located downgradient of the main plant facilities in WAG 1. Shallow groundwater flow within WAG 1 is southward toward White Oak Creek. In 2002, these wells were sampled for radiological contaminants (gross alpha, gross beta, total radioactive strontium, tritium, and gamma-emitting-radionuclides). The radiological contaminant concentrations in these wells in 2002 did not exceed reference values used for comparison. Recent Environmental Management and Enrichment Facilities Program activities in WAG 1 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.2.2 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 solid waste management units: 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 triangle-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 solid waste management unit.

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 is performed under the Water Resources Restoration Program. Any activities to be reported are published in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.2.3 WAG 17 Area

WAG 17 is located about 1 mile (1.6 km) directly east of the ORNL main plant area and is situated on a relatively flat limb of the northwest facing slope of Haw Ridge. This area has served as the major craft and machine shop area for ORNL since the late 1940s. The area includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead-melting facilities, garage facilities, welding facilities, and material storage areas needed to support ORNL's routine and experimental operations. WAG 17 is composed of 18 solid waste management units. A former septic tank is now used as a sewage collection/pumping station for the area. Photographic waste tanks have been removed. Four old petroleum USTs were removed during the period from 1987 to 1990, and closure approval for these four USTs was received from TDEC in 1997. Two relatively new USTs are currently registered to store diesel fuel and gasoline.

WAG 17 Results

Upgradient and downgradient wells surround WAG 17; the upgradient wells (1196, 1197, 1198, and 1199) are located on the eastern boundary of WAG 17, and the downgradient wells (1200, 1201, 1202, and 1203) are located on its western boundary. General groundwater flow is to the north and west toward White Oak Creek. In 2002, these wells were sampled for radiological contaminants (gross alpha, gross beta, total radioactive strontium, tritium, and gamma-emitting radionuclides) and volatile organic compounds. The radiological contaminant concentrations in 2002 were below their respective reference values. Several volatile organic contaminants were observed to exceed their respective reference values in Well 1201. Included in this suite were 1,1-dichloroethene, benzene, tetrachloroethene, trichloroethene, and vinyl chloride. Trichloroethene was observed to exceed its reference value in Well 1202.

Trend analysis was performed on those organic contaminants that exceeded their respective reference values during 2002. Sen's Slope/ Mann-Kendall trend analysis was used to detect trends. The trend analysis was performed using historical data collected through 2002. No statistically significant trends were observed for 1,1-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride in Well 1201. A statistically significant downward trend was observed for benzene in Well 1201 (at a level of significance of 0.01). A statistically significant upward trend was detected for trichloroethene in Well 1202 (at a significance level of 0.2). The presence of the organic contaminants at the periphery of WAG 17 is related to continued discharges of legacy contamination associated with past usage of cleaning solvents and operation of garage facilities within WAG 17.

5.9.3 Melton Valley

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

5.9.3.1 WAG 2 Area

WAG 2 is composed of White Oak Creek 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, White Oak Creek has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the Process Waste Treatment Complex, the Sewage Treatment Plant, and a variety of process waste holding 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 (see Fig. 5.19).

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.

WAG 2 Results

Many of the wells sampled within WAG 2 monitor discharges to White Oak Creek and are therefore classified as downgradient wells. These wells are generally located to the southwest and downstream of the main plant area of ORNL. Downgradient wells monitored during 2002 include 1152, 1154, 1155, 1156, 1185, 1186, 1187, 1188, 1189, 1190, 1191, 1192, 1193, 1194, 1195, 1244, and 1245. Upgradient wells are located upslope and to the south of the main plant area of ORNL. Upgradient wells monitored during 2002 include 1150, 1151, and 1153. In 2002, the following wells were sampled for metals, volatile organic compounds, and radiological contaminants (gross alpha, gross beta, total radioactive strontium, tritium, and gamma-emitting radionuclides): 1189, 1190, 1191, and 1192; all other WAG 2 wells were sampled for radiological contaminants only. Four radiological contaminant concentrations exceeded their respective reference values in 2002 (tritium in Well 1152 and gross beta, total radioactive strontium, and tritium in Well 1191).

Trend analysis was performed on those organic contaminants that exceeded their respective reference values during 2002. Sen's Slope/Mann-Kendall trend analysis was used to detect trends. The trend analysis was performed using historical data collected through 2002. A statistically significant upward trend was observed for tritium in Well 1152 (at a level of significance of 0.01). Well 1152 is located downgradient of the HFIR; the upward trend is most likely due to the tritium leak from the process waste drain line. Statistically downward trends were also observed for gross beta, total radioactive strontium, and tritium in Well 1191 (at a significance level of 0.01).

The presence of the radiological contaminants is related to continued discharges of legacy contamination associated with past waste disposal activities within the WAGs that drain into WAG 2. Several metal contaminants exceeded their respective reference values during 2002, but these metals (e.g., aluminum, iron, manganese, zinc) are commonly found in the soil and rock composing the earth's crust. No volatile organic compounds were present above their respective detection limits in 2002. Recent Environmental Management and Enrichment Facilities Program activities in WAG 2 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.3.2 WAG 4 Area

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

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 1959, ORNL's SWSA 4 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.

WAG 4 Results

Groundwater monitoring in WAG 4 was transferred to the Integrated Water Quality Program (now the Water Resources Restoration Program) in 1996. Any activities to be reported are published in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.3.3 WAG 5 Area

WAG 5 contains 33 solid waste management units, 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 waste in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original Process Wastewater 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 1964. During this time, the burial ground served as the Southern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site were set aside for the retrievable storage of transuranic wastes.

The WAG 5 boundary includes the Old Hydrofracture Facility and the New Hydrofracture Facility. Because Melton Branch flows between these facilities, the New Hydrofracture Facility has a separate boundary.

WAG 5 Results

Groundwater monitoring in WAG 5 was transferred to the Water Resources Restoration Program in 1996. Any activities to be reported are published in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.3.4 WAG 6 Area

WAG 6 consists of four solid waste management units: (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 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 this 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 White Oak Creek. The basin, located northwest of SWSA 6, 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 Environmental Management and Enrichment Facilities Program. Several RCRA interim status units (having received RCRA-regulated hazardous waste) are located in WAG 6. Environmental monitoring is carried out under CERCLA and RCRA.

WAG 6 Results

Information about WAG 6 monitoring results in 2002 is available in the 2002 *Groundwater Quality Assessment Report for Solid Waste Storage Area 6* (BJC 2003d).

5.9.3.5 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 Results

Groundwater monitoring in WAG 7 was transferred to the Integrated Water Quality Program (now the Water Resources Restoration Program) in 1996. Any activities to be reported are published in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.3.6 WAG 8 and 9 Areas

Because of the small number of groundwater monitoring wells in WAGs 8 and 9, they are sampled together. The analytical results for the two WAGs are also reported together. Wells monitored within WAG 8 and 9 include 1087, 1088, 1090, 1089, 1090, 1091, 1092, 1093, 1094, and 1095. Wells monitored within WAG 9 include 1096 and 1097.

WAG 8, located in Melton Valley south of the main plant area, is composed of 36 solid waste management units associated with the reactor facilities in Melton Valley. The solid waste management units 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 facility, the HFIR, and the Radionuclide Engineering Development Center. A removal action was initiated at the Molten Salt Reactor Experiment during 1995 to remove filtration devices contaminated with uranium.

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

An abnormally high tritium concentration was reported in October 2000 in the foundation drain system associated with the HFIR building (Building 7900). As a result, characterization monitoring was conducted to determine the location of the leak site and the extent of contamination. This monitoring included sampling a number of wells, drains, outfalls, and a groundwater seep located in the immediate vicinity of Building 7900. The characterization effort revealed a leak in the process waste drain system for HFIR. Characterization efforts continued throughout 2001 and revealed a general drop in tritium concentrations during the winter and spring of 2001. Using the data generated during the characaterization effort, the *Operational Monitoring Plan for the High Flux Isotope Reactor Site* (Bonine 2002b) was implemented in June 2001. The plan required that upgradient and downgradient wells, drain systems, outfalls, and the seeps be monitored over a period of one year (June 2001 through June 2002) to ascertain their seasonal effects on tritium concentrations. As a result, several monitoring wells were installed hydraulically upgradient and downgradient of Building 7900 to supplement the existing well network used during the characterization effort. The monitoring plan was designed to (1) provide early detection of groundwater contamination due to operational activities or system failures at the HFIR site, (2) monitor significant changes in groundwater contamination caused by the tritium leak, and (3) monitor sources of groundwater contamination located hydraulically upgradient of the HFIR site. The monitoring program instituted by the plan distinguished between two flow paths: a faster flow path associated with the east foundation drain of Building 7900 and the slower and deeper groundwater flow path. Under the monitoring plan, tritium and gamma-emitting radionuclides were the main contaminants of concern being monitored at downgradient locations because their presence would be indicative of further releases from the HFIR. The leak in the process waste drain pipe was repaired during the summer of 2001.

Monitoring required by the Operational Monitoring Plan was completed during 2002. Data generated by the operational monitoring plan was analyzed, and the findings of the analysis were reported in the *Summary of Baseline Operational Monitoring Activities at the High Flux Isotope Reactor Site* (Bonine and Ketelle 2002). A summary of the findings of the *Operational Monitoring Plan* are found in the next section.

HFIR *Operational Monitoring Plan* Results

Baseline operational monitoring of groundwater and storm drain waters affected by the accidental release in 2000 of contaminated water from a process waste drain at the HFIR was performed between June 2001 and June 2002. The baseline monitoring program included sampling locations in five downgradient drain systems, ten groundwater monitoring wells (three upgradient of HFIR and seven downgradient), one tank drywell, and one ventilation duct sump. Six of the groundwater monitoring wells included in the baseline monitoring were installed in response to the tritium release investigation. The remaining wells were existing wells previously installed for environmental monitoring at the site. Three of the drain system monitoring locations were sampled weekly and all other sites were sampled monthly. Samples were analyzed for tritium and gamma-emitting radionuclides (^{152}Eu, ^{154}Eu, ^{60}Co, and ^{137}Cs). Samples from the upgradient groundwater monitoring wells were also analyzed for gross alpha and gross beta activity to screen for releases into the subsurface from facilities located upgradient of the HFIR. In addition to the sampling and analysis of water, groundwater levels were measured on a weekly frequency in 12 wells, and flow measurements were made on a weekly frequency at two locations in drain systems.

Tritium was the only contaminant that was detected at least once at all the monitoring locations during the monitoring period. Gamma-emitting radionuclides were sporadically detected during the *Operational Monitoring Plan* period at several monitoring locations near and/or downgradient from the process waste drain leak site. Detection of the gamma emitters is suspected to be associated with the presence of clay/silt-sized soil or colloidal particles in both the rapid- and slow-flow pathways that connect the leak site with various monitoring points. The gamma-emitting radionuclides originated from the discharge of contaminated waste water that leaked from the process waste drain line. Contaminated soil from the leak site was used as backfill after the repair of the process waste drain line was completed, and this soil is suspected of being a source of the gamma emitters. Given the sporadic nature of detection of these gamma emitters, their trends, or their concentrations, these contaminants are not discussed at length in this summary report.

No evidence of additional contaminant discharge from the HFIR facility or associated systems was detected. Most monitoring locations exhibited downward trends in tritium concentration during the monitoring period. The principal exceptions to the downward tritium concentration trend were Wells 892 and 661, which exhibited steady concentration increases. These wells are located in an area of less permeable bedrock downgradient of the HFIR facility, and migration of tritium into less permeable material is expected to occur more slowly than the rate of tritium movement through the remainder of the hydrologic system.

No evidence was found that significant sources of contaminant release to the environment have occurred upgradient of the HFIR facility. Monitoring results from three upgradient groundwater monitoring wells installed in response to the tritium investigation showed consistently low to nondetectable concentrations of tritium and other radiological analytes.

Analysis of monitoring data from the inception of monitoring the tritium release was used to update the conceptual model of groundwater flow and contaminant movement at the HFIR site. The conceptual model identifies rapid-flow and slow-flow components of the groundwater system. The rapid-flow pathways of subsurface water and contaminant movement are associated with man-made features, including pipelines and their excavated trenches and the HFIR building foundation drainage system. The slow-flow region in the HFIR area is groundwater in soil and bedrock as monitored by the monitoring-well network. Concentration decreases observed in all the rapid-flow monitoring sites is much greater than those observed at the groundwater monitoring locations.

Based on results of the baseline characterization monitoring program, the operational monitoring plan was revised in the form of the *Annual Monitoring Plan for the High Flux Isotope Reactor Site* (Bonine 2002a). The Annual Monitoring Plan focuses on those locations that provide demonstrated rapid responses in contaminant concentration in the event that further releases from the facility occur, monitoring will continue of the dissipation of the existing tritium plume at the site. The revised monitoring program was initiated in August 2002 and will be completed in August 2003.

WAGs 8 and 9 Results

Wells in WAGs 8 and 9 were sampled for total radioactive strontium, tritium, gross alpha, gross beta, and gamma-emitting radionuclides in 2002. A total of seven radiological contaminants exceeded their respective reference values during 2002 in wells located in WAGs 8 and 9.

5.9.3.7 WAG 10 Area

WAG 10 consists of the Old Hydrofracture Facility grout sheets, the New Hydrofracture Facility, and the New Hydrofracture Facility grout sheets. The surface facilities are also associated with WAGs 5, 7, and 8.

Hydrofracture Experiment Site 1, located within the boundary of WAG 7 (south of Lagoon Road), was the site of the first experimental injection of grout (October 1959) in 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 in 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 Old Hydrofracture Facility is located about 1.6 km (1.0 mile) southwest of the main ORNL complex, near the southwest corner of WAG 5. Commissioned in 1964, the facility 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, transuranics, and other (unidentified) radionuclides.

The New Hydrofracture Facility, constructed to replace the Old Hydrofracture Facility, is located 900 ft southwest of the Old Hydrofracture Facility, on the south side of Melton Branch. Wastes used in the injections were concentrated LLLW and sludge removed from the gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, transuranics, and other nuclides. Recent Environmental Management and Enrichment Facilities Program activities pursuant to WAG 10 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.9.3.8 Melton Valley Exit Pathway Results

Ten monitoring wells are located on the groundwater exit pathway for Melton Valley. Four of these wells (1189, 1190, 1191, and 1192) are also part of the WAG 2 groundwater monitoring program and have been discussed in WAG 2 Results (Sect. 5.9.3.1). Consequently, only six wells (560, 857, 858, 859, 1236, and 1239) will be discussed herein. None of the concentrations in samples collected during 2002 from the six wells exceeded their respective reference values.

Surface water is also sampled at White Oak Dam (monitoring station WCK 1.0) and is considered part of the exit pathway monitoring program. Gross beta and total radioactive strontium exceeded their respective reference values during 2002. These contaminants most likely originate from legacy contamination associated with past waste disposal practices in the Melton Valley WAGs. Sen's slope/Mann Kendall trend analysis was performed on these contaminants using historical data accumulated through 2002. Both contaminants exhibited a statistically significant decreasing trend throughout their monitoring histories, with total radioactive strontium exhibiting a downward trend at a significance level of 0.01 and gross beta exhibiting a downward trend at a significance level of 0.2.

5.9.4 White Wing Scrap Yard

5.9.4.1 White Wing Scrap Yard (WAG 11) Area

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

The White Wing Scrap Yard was used for aboveground storage of contaminated material from ORNL, the ETTP, and the Y-12 Complex. 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. TDEC, EPA, and DOE agreed to an interim record of decision that required the removal of surface debris 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 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 in 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known. Recent Environmental Management and Enrichment Facilities Program activities in WAG 11 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

White Wing Scrap Yard (WAG 11) Results

Groundwater monitoring in WAG 11 was transferred to the Integrated Water Quality Program (now the Water Resources Restoration Program) in 1996. Any activities to be reported are published in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a).

5.10 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 established before the 1980s were not constructed to serve current long-term monitoring requirements. Where existing wells do not meet monitoring requirements, they become candidates for plugging and abandonment.

5.10.1 Wells Plugged During 2002

BJC plugged 33 hydrofracture wells in 2002 and numerous other wells associated with other remediation activities at ORNL. Details can also be found in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2003a). UT-Battelle did not plug and abandon any wells during 2002.

5.10.2 Methods Used

Plugging and abandonment of wells 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 minimizes the generation of waste that would be created if other methods were used. Specialized tools have been developed to split well casings of different sizes and compositions and are used when wells are plugged and abandoned at ORNL.

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.

5.11 SPALLATION NEUTRON SOURCE

DOE prepared and issued a final environmental impact statement (SNS 1999a and 1999b) and a record of decision to construct and operate the SNS. This state-of-the-art pulsed-neutron facility is under construction on Chestnut Ridge at ORNL. A mitigation action plan was developed to document the goals and objectives by which the potential environmental impacts from construction and operation identified in the environmental impact statement will be mitigated. The SNS Project is on schedule and within budget. Construction of the SNS is currently approximately 60% complete, and technical components of the accelerator are being installed and commissioned. The facility will become operational in FY 2006.

Potential adverse impacts of SNS construction and operations were identified for wetlands, protected species, cultural resources, transportation infrastructure, and research projects in the Walker Branch Watershed. Mitigation measures were identified for each of the potential subjects.

Construction of the SNS access roads affected wetlands. Routes were evaluated, and improving the Chestnut Ridge Road was selected as the action affecting the smallest area of wetlands. Construction affected 0.055 acres, and careful attention to erosion control and equipment movement limited impacts to other nearby wetland areas. The SNS developed a wetlands mitigation plan to compensate for the impacts to the 0.055 acres by restoring 0.138 acres (a mitigation ratio of 2.511) of wetlands located in the same watershed. TDEC accepted the wetlands mitigation plan on June 29, 2000, and the 0.138 acres of wetlands were restored in August 2000. This mitigation action is complete, and the restored areas are routinely monitored to ensure the survival rate of the indigenous shrubs and vegetation planted in the restored area. No significant impacts on the wetlands have resulted from construction activities.

No federally listed or proposed threatened or endangered species were identified in the site surveys of the SNS. However, construction and operation of the SNS could affect protected species that were not identified during the site surveys. Definitive surveys were conducted during three seasons (spring, summer, and fall) in 1999 to ensure that any protected species, including those that can be identified only during flowering, would be noted. No protected species were identified during these surveys, and this mitigation action is complete.

No prehistoric or historic sites listed on or eligible for inclusion on the *National Register of Historic Places* were identified on the SNS site. A survey of cultural resources was conducted for the access road rights-of-way, and no significant cultural resources were located or disturbed. This mitigation action is complete for the SNS roads and utility corridors. The TVA powerline upgrades associated with the SNS have been evaluated for cultural resources, and no issues were identified.

Increased traffic resulting from SNS construction and operation on local roads was evaluated by SNS staff. Traffic issues were also coordinated with other activities on the ORR. Improvements to Bethel Valley Road, including acceleration and deceleration lanes, marked turn lanes, lighting, and traffic signals, have been identified to reduce the effects on traffic flow in the vicinity of the SNS. Improvements to the roads, including widening and lane marking, were made in the spring of 2001. Traffic signals and lighting became operational in 2002. This mitigation action is complete.

Emissions of water vapor and CO_2 during construction and operation of the SNS could impact the research activities at the Walker Branch Watershed, located approximately 0.75 mile (1.2 km) east of the SNS on Chestnut Ridge. The emissions would affect a small amount of the data collected at Walker Branch Watershed, and a committee was established in 1999 to evaluate the impacts of the SNS. The committee reviewed the impacts and potential mitigation measures and determined that establishing a satellite monitoring location in an area not affected by SNS was the preferred solution. The satellite tower will be established before SNS operates to allow development of statistical correlations between the locations, thereby preserving the quality of the data. The location of the satellite tower was identified in FY 2001, and plans to develop the site are under way by the Walker Branch researchers.

Incorporating superconducting accelerator technology at SNS was evaluated in a supplement to the final environmental impact statement in 2000. The impacts of the technology on the Walker Branch Watershed were evaluated and were found to be not significant; the change to superconducting was determined to have no significant environmental impacts. Funding for the satellite tower has been provided by SNS, and this mitigation action is complete.