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 Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. Radioactive emissions are regulated by EPA under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 CFR 61, Subpart H, and 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.) Nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control, 1200-3.

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 High Flux Isotope Reactor (HFIR) and the Radionuclide Engineering Development Center.

In 2001, there were 41 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

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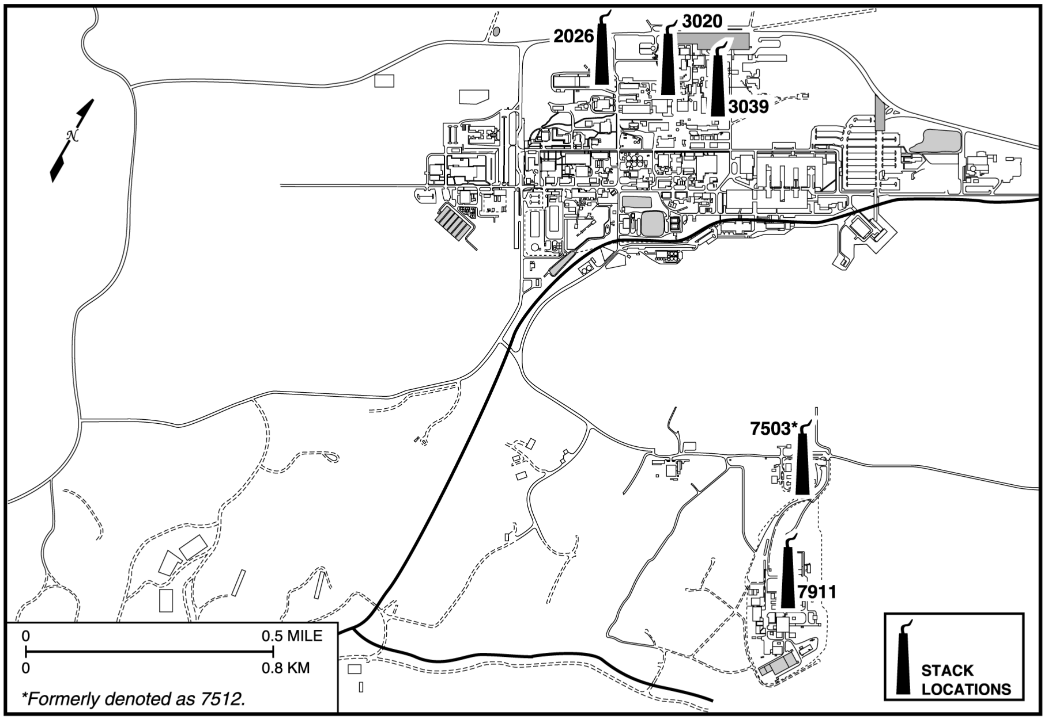

Fig. 5.1. Locations of major stacks (rad emission points) at ORNL.

is carried out to verify the integrity of the sample transport system.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. 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 vent 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 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 2001 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 2001 totaled approximately 49 Ci (Fig. 5.2), which is less than half the value in 2000. The ^{131}I emission for 2001 doubled from that for 2000 to 0.13 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. Therefore for 2001, ^{138}Cs, which totaled 1360 Ci, was the major contributor to the off-site dose at ORNL (Fig. 5.4).

5.2 ORNL NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

ORNL has 12 Clean Air Act 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. As funding is made available, the four coal-fired boilers will be converted to natural gas and fuel oil firing, eliminating the use of coal at the steam plant.

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 2001, 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, 2000, through June 30, 2001, 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 2001, TDEC inspected all permitted emission sources; all were found to be in compliance.

ORNL's Clean Air Act 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 2002.

As required by Title VI of the Clean Air Act 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 is 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-

Table 5.1. Major sources of radiological airborne emissions at Oak Ridge National Laboratory, 2001 (Ci)[a]

Isotope	Stack				
	X-2026	X-3020	X-3039	X-7503[b]	X-7911
^{241}Am	1.63e+00	1.89E–07	5.85E–07	1.03E–08	1.88E–08
^{41}Ar					2.16e+01
^{139}Ba					5.95E–01
^{140}Ba					1.33E–04
^{7}Be	6.57E–07	8.57E–08	1.61E–05	3.89E–08	
^{141}Ce					3.04E–07
^{252}Cf					4.73E–09
^{244}Cm	1.23E–06	1.44E–08	3.44E–07	2.12E–08	6.86E–08
^{60}Co			5.73E–05		
^{137}Cs	3.86E–06	1.11E–06	1.31E–04	1.86E–06	6.40E–06
^{138}Cs					1.36e+03
^{152}Eu			4.18E–06		
^{155}Eu			2.23E–04		
^{3}H	9.86E–02		1.10e+01	2.79e+00	3.47e+01
^{131}I			5.79E–05		1.28E–01
^{132}I					9.45E–01
^{133}I			1.06E–03		6.26E–01
^{134}I					1.15e+00
^{135}I			1.48E–03		1.67e+00
^{85}Kr					4.90e+02
^{85m}Kr					1.42e+00
^{87}Kr					1.61e+01
^{88}Kr					1.86e+01
^{89}Kr					5.43e+00
^{90}Kr					1.69E–02
^{140}La					2.95E–04
^{191}Os			9.54E–02		
^{212}Pb	2.02E–01		1.82e+00	2.42E–01	1.12E–01
^{238}Pu	4.63E–08	1.07E–08	1.25E–07		
^{239}Pu	1.56E–07	1.77E–07	1.66E–06	1.74E–09	3.16E–09
^{75}Se			1.75E–04		1.56E–05
^{90}Sr	6.85E–07	1.00E–06	6.00E–05	2.17E–08	1.43E–05
^{228}Th	1.99E–08	2.60E–09	9.09E–09	1.23E–09	6.75E–09
^{230}Th	2.35E–09	2.60E–09	7.53E–09	7.93E–10	4.64E–09
^{232}Th	1.10E–09	1.79E–09	4.98E–09	6.92E–10	4.34E–09
^{234}U	1.69E–07	7.95E–08	5.05E–07	6.88E–09	3.01E–08
^{235}U	4.76E–09	2.49E–09	2.00E–08	9.12E–10	2.52E–09
^{238}U	4.86E–09	8.38E–09	3.43E–08	8.20E–10	1.16E–08
^{131m}Xe					1.60e+01
^{133}Xe					4.88E–01
^{133m}Xe					3.87e+00
^{135}Xe			8.53E–04		5.63e+01
^{135m}Xe					1.18e+03
^{137}Xe					9.53e+01
^{138}Xe					2.07e+02
^{90}Y	6.85E–07	1.00E–06	6.00E–05	2.17E–08	1.43E–05

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

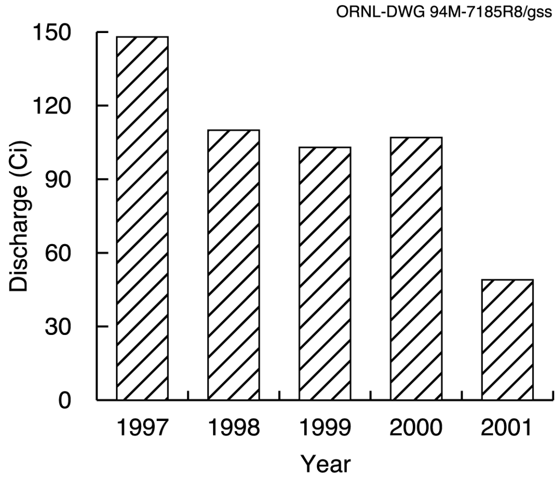

Fig. 5.2. Total discharges of ^{3}H from ORNL to the atmosphere, 1997–2001.

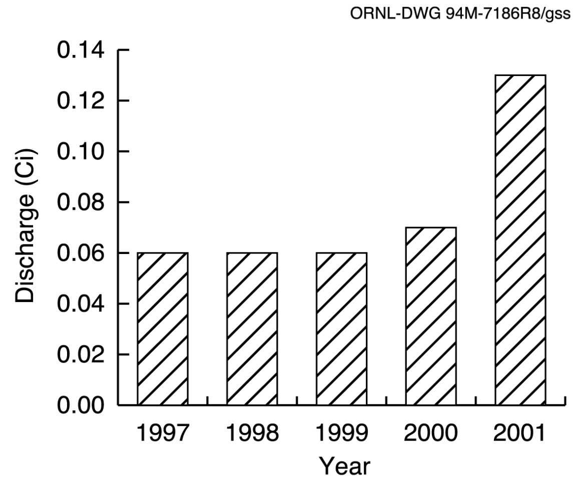

Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 1997–2001.

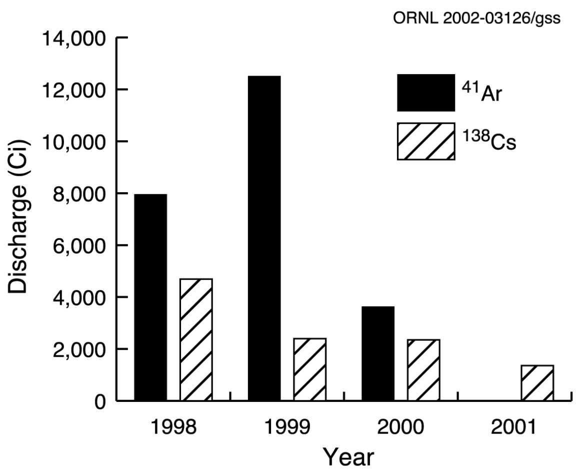

Fig. 5.4. Total discharges of ^{41}Ar and ^{138}Cs from ORNL to the atmosphere, 1998–2001.

area boilers operated in compliance with visible emission standards during 2001.

5.3 ORNL AMBIENT AIR MONITORING

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

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 then submitted to the laboratory for ^{3}H analysis.

5.3.1 Results

The ORNL perimeter air monitoring stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL perimeter air monitoring stations (Table 5.3) are compared with air-sampling data from the reference station (Station 52) and with the derived concentration guides (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

Table 5.2. Actual vs allowable air emissions from Oak Ridge National Laboratory steam production, 2001

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulates	3	696	0.4
Sulfur dioxide	399	9102	3.7
Nitrogen oxides	72	600	10.0
Volatile organic compounds	1	18	5.6
Carbon monoxide	42	381	10.0

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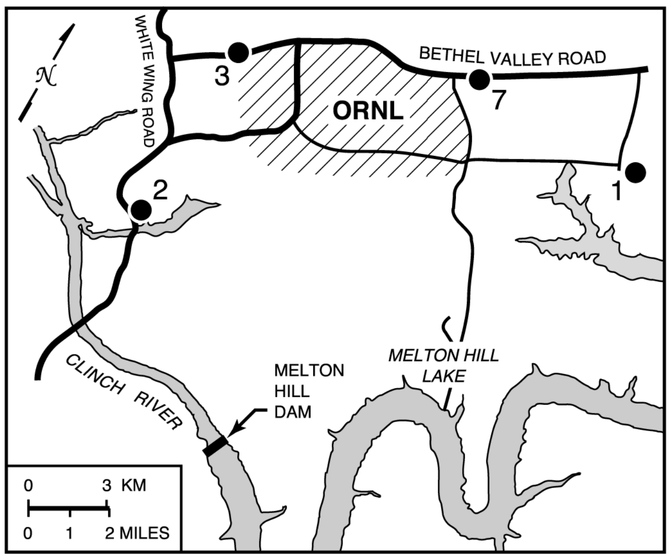

Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

concentrations measured for the ORNL network were less than 1% of the applicable DCG in all cases. Average concentrations of ^{241}Am, ^{239}Pu, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U for the ORNL network were statistically different from the concentrations measured at the reference location. Measuring a radionuclide requires a process of counting random 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 National Pollutant Discharge Elimination System (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

Table 5.3. Radionuclide concentrations measured at Oak Ridge National Laboratory perimeter air monitoring stations, 2001 (pCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{241}Am	3.53E–12[c]	1.20E–12[c]	3.49E–12[c]	3.20E–12[c]	6.61E–13
^{7}Be	2.05E–08[c]	2.02E–08[c]	1.91E–08[c]	1.73E–08[c]	6.28E–08
^{244}Cm	8.65E–13	3.58E–13	–5.40E–13	6.08E–13	1.97E–13
^{60}Co	*d*	*d*	*d*	*d*	3.17E–11
^{137}Cs	3.53E–11	6.83E–11[c]	3.49E–11[c]	*d*	4.32E–11
^{3}H	1.30E–06	2.66E–05[c]	9.89E–07	1.27E–06	–2.85E–07
^{40}K	1.70E–09[c]	1.56E–09[c]	7.62E–10[c]	1.18E–09[c]	3.34E–09
^{238}Pu	6.41E–14	–9.75E–14	3.18E–14	3.20E–14	–2.36E–13
^{239}Pu	2.88E–13	6.83E–13[c]	1.21E–11[c]	9.27E–13[c]	2.75E–13
^{228}Th	3.21E–12[c]	3.25E–12[c]	–4.13E–12	9.59E–13[c]	1.65E–12
^{230}Th	6.73E–12[c]	4.55E–12[c]	3.49E–12[c]	2.53E–12[c]	7.24E–13
^{232}Th	3.85E–12[c]	6.18E–12[c]	5.08E–12[c]	2.01E–12[c]	1.10E–12
$^{89/90}$Sr	1.28E–11	2.60E–11[c]	5.72E–12	6.08E–12	7.57E–13
^{234}U	4.49E–11[c]	2.02E–11[c]	2.54E–11[c]	5.44E–11[c]	8.17E–12
^{235}U	1.80E–11[c]	5.53E–12[c]	4.76E–12[c]	2.49E–11[c]	5.71E–13
^{238}U	1.57E–11[c]	1.14E–11[c]	1.30E–11[c]	2.08E–11[c]	6.97E–12

[a]1 pCi = 3.7E–02 Bq.
[b]Reference location off-site.
[c]Statistically significant average at 95% confidence level.
[d]Not reported.

ORNL treatment facilities: the Sewage Treatment Plant, the Coal Yard Runoff Treatment Facility, and the Process Waste Treatment Complex. Other effluents monitored in 2001 include 22 smaller discharges (category outfalls). Category outfalls discharge constituents including storm water runoff, cooling water, groundwater, and steam condensate. Some category outfalls listed in Table 5.4 were not sampled in 2001, either because they no longer discharge or because there was no discharge present. 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).

DCG values are used as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero 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 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 2001, 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

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	Monthly	X	X	X	X	X	
Outfall 081	Annually		X				
Outfall 085	Quarterly	X	X				
Outfall 086	When discharges		X		X		
Outfall 087	Annually		X	X			
Outfall 203	Annually		X				
Outfall 204	Quarterly	X	X			X	
Outfall 205	Annually		X				
Outfall 207	Quarterly	X	X	X		X	
Outfall 211	Quarterly		X			X	
Outfall 217	Annually		X				
Outfall 219	Annually		X				
Outfall 234	Annually	X					
Outfall 241	Annually		X				
Outfall 265	Annually		X	X			
Outfall 281	Quarterly	X	X	X	X		
Outfall 282	Quarterly	X	X				
Outfall 284	Annually		X				
Outfall 290	Annually			X			
Outfall 302	Monthly	X	X	X	X	X	
Outfall 304	Monthly	X	X	X	X	X	
Outfall 365	Quarterly	X	X				
Outfall 368	Quarterly	X	X	X			
Outfall 381	Quarterly		X	X	X		
Outfall 382	Annually		X	X			
Outfall 383	Annually		X		X		
Sewage Treatment Plant (X01)	Monthly	X	X			X	
Coal Yard Runoff Treatment Facility (X02)	Monthly	X	X				
Process Waste Treatment Complex (X12)	Monthly	X	X	X	X	X	X
Melton Branch 1 (X13)	Monthly	X	X	X	X	X	
White Oak Creek (X14)	Monthly	X	X	X	X	X	
White Oak Dam (X15)	Monthly	X	X	X	X	X	

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

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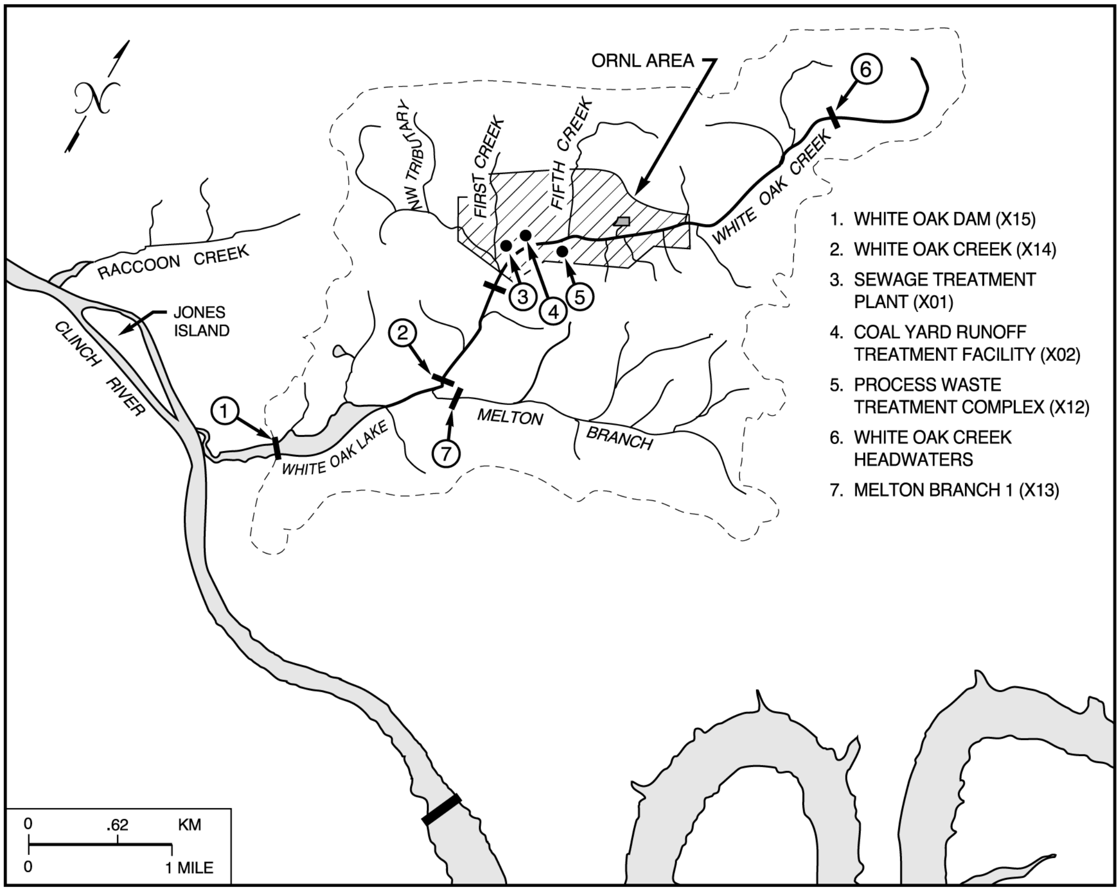

Fig. 5.6. ORNL surface water, National Pollutant Discharge Elimination System, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

strontium activity was at Outfall 207 (47% of the DCG), the highest ^{3}H activity was at Outfall 381 (42% of the DCG), and the highest ^{137}Cs activity was at the Process Waste Treatment Complex (29% 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 2001, 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 released at White Oak Dam 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 annual discharge of ^{3}H has decreased since 1997. In 2001, ^{60}Co was at a 5-year low; ^{137}Cs was at a 5-year high; and gross alpha, gross beta, and total radioactive strontium discharges generally remained similar to past years.

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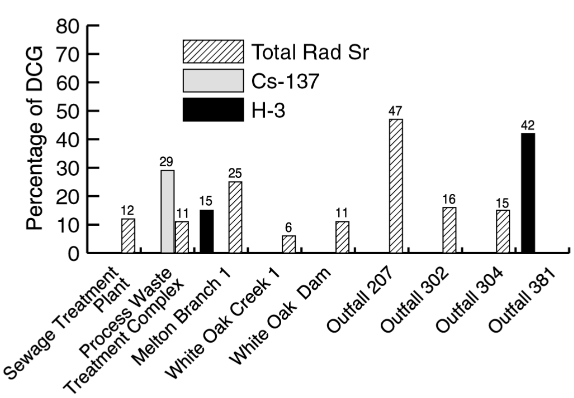

Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2001.

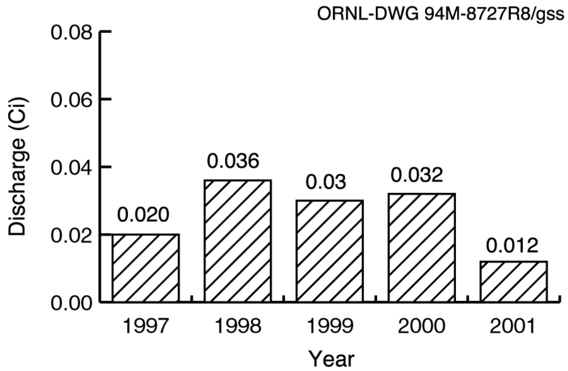

Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 1997–2001.

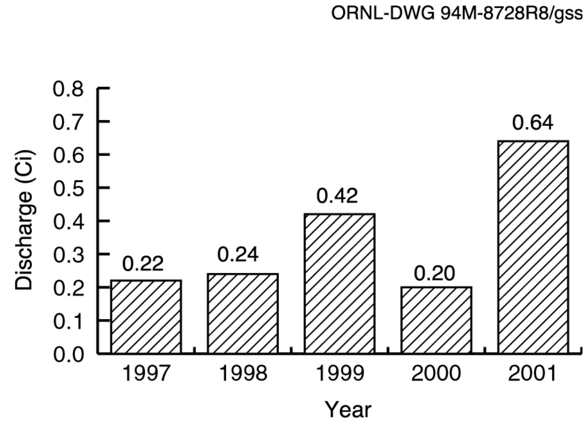

Fig. 5.9. Cesium-137 discharges at White Oak Dam, 1997–2001.

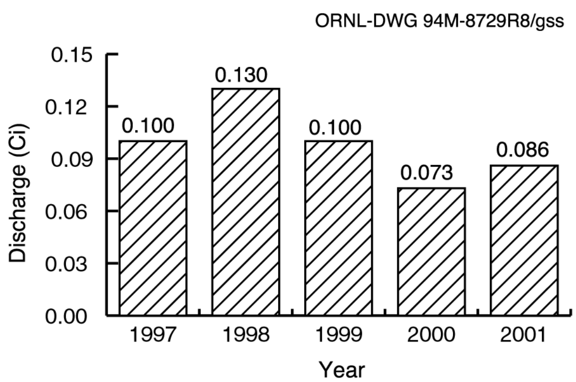

Fig. 5.10. Gross alpha discharges at White Oak Dam, 1997–2001.

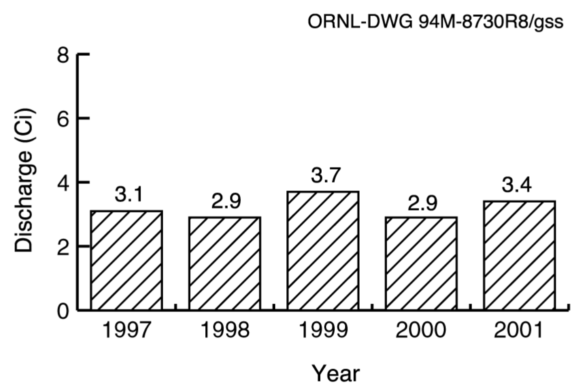

Fig. 5.11. Gross beta discharges at White Oak Dam, 1997–2001.

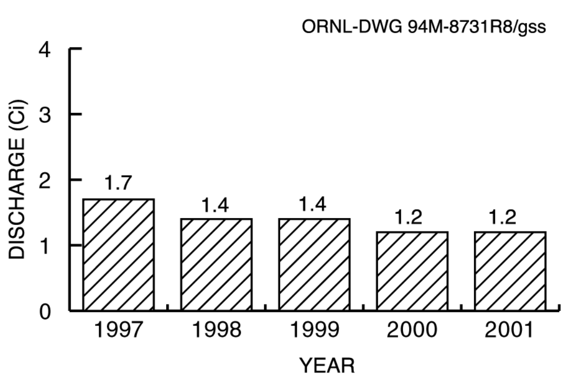

Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 1997–2001.

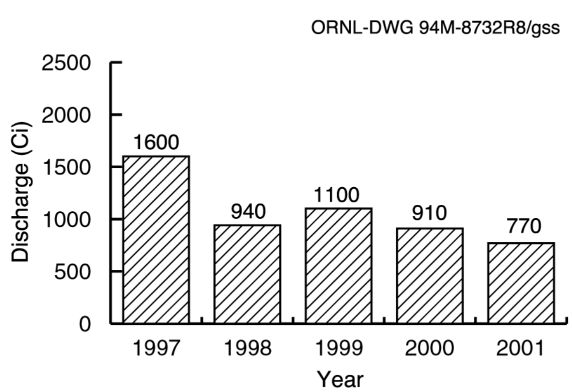

Fig. 5.13. Tritium discharges at White Oak Dam, 1997–2001.

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 for storm water monitoring set in the 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 21 storm water outfalls were monitored during 2001.

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 2001, the discharge from one storm water outfall (Outfall 165) required additional analyses. An analysis for uranium by alpha spectroscopy was performed to identify the source of the gross alpha activity in the discharge; the alpha activity was determined to be predominately $^{233/234}$U.

Of the 111 individual storm water sample results collected in 2001, 85 (76.6%) were less than the minimum detectable activities of the tests. Of the isotope-specific measurements (^{3}H, ^{40}K, ^{60}Co, $^{89/90}$Sr, ^{137}Cs, $^{233/234}$U, ^{235}U, ^{236}U, and ^{238}U), only $^{89/90}$Sr and $^{233/234}$U at Outfall 165, and ^{3}H at Outfall 381 were greater than 4% of DCG levels. At Outfall 381, ^{3}H was measured at 60% of the DCG. This level of radioactivity is consistent with levels detected during the same time frame in routine dry-weather monitoring at the outfall. The levels of $^{89/90}$Sr and $^{233/234}$U at Outfall 165 were 150% and 11% of their respective DCGs. This outfall drains storm water from a small section of Fifth Street. Elevated levels of radioactivity have been intermittently present in storm water discharges from Outfall 165. The most recent sample prior to the 2001 measurement was taken in November 2000, and no radioactivity was detected at that time. Past investigations have found no definite source for the intermittently present radioactivity, but it is theorized that the source of the radioactivity is contaminated groundwater that enters the outfall pipe when the local groundwater table is sufficiently elevated during storms. The groundwater in the area is known to be contaminated at similar concentrations.

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 requirements 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 *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. Permit nonconformances in 2001 are discussed below and shown in Appendix D.

During 2001, ORNL was in compliance with all numeric limits in its NPDES permit except for exceedances in April at X01, the Sewage Treatment Plant, for total suspended solids. These exceedances were 2.6 and 4.6 mg/L above the limit of 45 mg/L on April 10. The exceedance on April 17 was 26 mg/L above the limit of 45 mg/L and resulted in a calculated exceedance for the total kilograms per day of total suspended solids discharged by the Sewage Treatment Plant on April 17. Figure 5.14 shows the four numeric limit noncompliances for total suspended solids at the Sewage Treatment Plant. Plant operating conditions during this period were normal, and the nonconformances could have possibly been caused by wind-blown pollen and other vegetative material that may have entered the Sewage Treatment Plant's tertiary sand filter effluent tank or the ozone contact chamber, both of which were partially open to the outside. Covers for the final discharge chambers were installed, and this problem has not recurred. There was also one technical nonconformance during 2001, as noted in Appendix D. This was a holding time exceedance for total suspended solids for a sample taken at X01 in December 2001.

Thermal impacts from ORNL discharges were assessed in August 2001 in accordance with ORNL's Biological Monitoring and Abatement Plan (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.

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 2001, ORNL continued to sample under the revised Radiological Monitoring Plan implemented on November 1, 1999. Results for the 2001 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 in August 2001. 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 exceeds 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.

Table 5.5. National Pollutant Discharge Elimination System (NPDES) compliance at ORNL, 2001 (NPDES permit effective Feb. 3, 1997)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	LC_{50}[b] for *Ceriodaphnia* (%)					41.1	0	4	100
	LC_{50} for fathead minnows (%)					41.1	0	4	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	76	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		0	156	100
	Dissolved oxygen					6	0	156	100
	Fecal coliform (col/100 mL)			1000	5000		0	156	100
	NOEC[c] 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	156	100
	pH (std. units)				9	6	0	156	100
	Total residual chlorine			0.038	0.066		0	156	100
	Total suspended solids	26.2	39.2	30	45		4	156	97
X02 (Coal Yard Runoff Treatment Facility)	LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	LC_{50} for fathead minnows (%)					4.2	0	4	100
	Copper, total			0.07	0.11		0	24	100
	Iron, total			1.0	1.0		0	24	100
	NOEC for *Ceriodaphnia* (%)					1.3	0	0[d]	100
	NOEC for fathead minnows (%)					1.3	0	0[d]	100
	Oil and grease			10	15		0	52	100
	pH (std. units)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	24	100
	Silver, total				0.008		0	24	100
	Total suspended solids				50		0	52	100
	Zinc, total			0.87	0.95		0	24	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X12 (Process Waste Treatment Complex)	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	52	100
	Chromium, total	5.18	8.39	0.22	0.44		0	52	100
	Copper, total	6.27	10.24	0.07	0.11		0	52	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	52	100
	Nickel, total	7.21	12.06	0.87	3.98		0	52	100
	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	52	100
	pH (std. units)				9.0	6.0	0	156	100
	Silver, total	0.73	1.3		0.008		0	52	100
	Temperature (°C)				30.5		0	156	100
	Total toxic organics		6.45		2.13		0	12	100
	Zinc, total	4.48	7.91	0.87	0.95		0	52	100
Instream chlorine monitoring points	Total residual oxidant			0.011	0.019		0	264	100
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	10	100
Groundwater/ pumpwater outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	5	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	4	100
Category I outfalls	pH (std. units)				9.0	6.0	0	24	100
Category II outfalls	pH (std. units)				9.0	6.0	0	30	100
Category III outfalls	pH (std. units)				9.0	6.0	0	54	100
Category IV outfalls	pH (std. units)				9.0	6.0	0	315	100
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	48	100
	Total residual oxidant			0.011	0.019		0	48	100

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

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

[c]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.

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

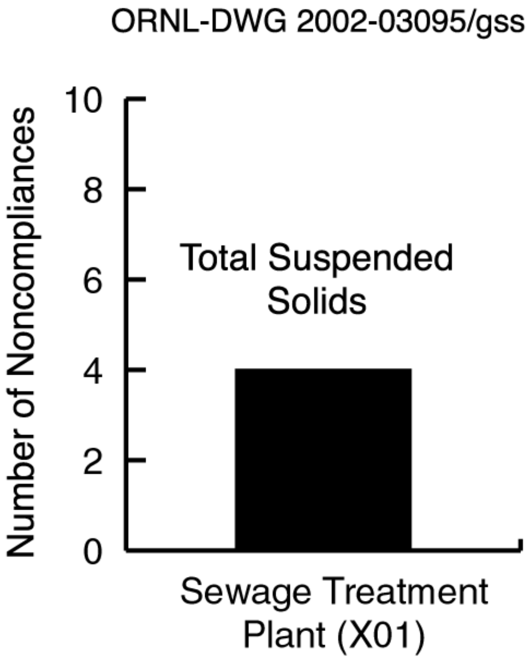

Fig. 5.14. ORNL National Pollutant Discharge Elimination System permit limit noncompliances in 2001.

ORNL monitored 234 measurable dry-weather discharges during 2001. 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 Plan is a requirement of the ORNL NPDES Permit to document existing material management practices and evaluate the vulnerability of those practices in contributing pollutants to area streams via storm water runoff. The plan consists of four major components:

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

These four components of the plan were initiated in 1997 and are reviewed and updated by the facility at least annually. The plan was last updated on August 1, 2001. This update aligned it with the newly submitted June 2001 NPDES permit application and incorporated additional information such as exclusion of flows determined to be natural, removal of outfalls in the plan that had been physically removed or plugged, inclusion of new outfalls that had been installed, and 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 ten groups based on the permit category and on the similarity of land uses within each outfall drainage area that may create potential discrete storm water contaminant sources. Representative outfalls or outfalls that were thought to be more problematic in each group were chosen for effluent sampling. 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. Results of 2001 storm water outfall effluent sampling are provided in the 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” 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 event mean concentrations.

In a comparison of recent ORNL data with data from the Nationwide Urban Runoff Program, most values for the ten water quality constituents are below the event mean concentrations. Table 5.6 indicates sampling dates and (with an “X”) those outfalls that exceeded one of the ten

Table 5.6. Oak Ridge National Laboratory storm water outfalls exceeding published event mean concentrations (EMCs)

Constituent	EMC (mg/L)	Outfall 6 11/16/00	Outfall 216 2/9/01	Outfall 249 1/18/01	Outfall 302 2/9/01
Biological oxygen demand	14.1				
Chemical oxygen demand	52.8	X			
Copper	0.0135		X	X	X
Kjeldahl nitrogen	1.73				
Lead	0.0675	X			
Nitrate/nitrite					
Phosphorus, total	0.315				
Suspended solids	78.4		X		
Zinc	0.162	X	X	X	X

constituent values. Patterns of values exceeding the event mean concentrations can be generalized as occurring at Outfall 6, Outfall 216, Outfall 249, and Outfall 302, and consisting of mainly copper and zinc, and one chemical oxygen demand, lead, and suspended sediment exceedance. Outfall 6, where chemical oxygen demand, lead, and zinc were higher than the program average, is in the drainage area for the High Temperature Materials Laboratory (Building 4515). Outfall 216 drains the eastern portion of the compressor house (4509) and cooling towers (4511 and 4521), which include outdoor equipment and cooling tower chemical storage. The drainage area for Outfall 249 includes parts of Buildings 2000 and 2001, Buildings 2006 and 3017, and an exhaust stack for Building 3020. The drainage area for Outfall 302 includes multiple facilities and storage areas in the 3000 area.

The only reportable spill to surface water occurred when a few drops of chainsaw oil were released into upper First Creek during a tree cutting operation on December 11, 2001. This unpermitted discharge caused a sheen that ORNL reported to the National Response Center. Spill response personnel were called, and the sheen was removed with booms and pads to the extent possible. There were no evident impacts on fish or other species downstream of the sheen on First Creek.

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 2001 implemented an annual division-by-division recertification of ORNL sinks and drains to ensure that sinks and drains discharge to the proper wastewater collection systems. Program management is adapting to the new contracting approach by communicating sink and drain responsibilities to new companies and organizations at ORNL.

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 5.7. This table provides, for each waste-

Table 5.7. Toxicity test results of Oak Ridge National Laboratory wastewaters, 2001

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	February–March	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	May	*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–March	*Ceriodaphnia*	NA	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
	June	*Ceriodaphnia*	*d*	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
	August	*Ceriodaphnia*	*d*	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
	November	*Ceriodaphnia*	*d*	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
Process Waste Treatment Complex (X12)	February–March	*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]48-h LC_{50}.

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

water, 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 the test organisms occurs in 96 h in 41.1% effluent or if the NOEC is less than 12.3%. For the X02 discharge the (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 2001, the Sewage Treatment Plant, Coal Yard Runoff Treatment Facility, and Process Waste Treatment Complex were tested four times each, and no biomonitoring limits were exceeded.

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.
- 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 polychlorinated biphenyl (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.

Water samples were collected for mercury analysis from four White Oak Creek sites on six occasions in 2001. The mean mercury concentration in White Oak Creek at the weir upstream from ORNL (WCK 6.8) was below the analytical detection limit (<10 ng/L) on all sampling dates. Downstream from ORNL, average mercury concentrations in White Oak Creek surface water exceeded the Tennessee water quality criterion (51 ng/L) at two sites. At WCK 3.5 (upstream from the nonradiological wastewater treatment facility), mercury concentrations averaged 128 ± 60 ng/L (± the standard deviation) and ranged from 56 to 197 ng/L. The mean mercury concentration was 52 ± 20 ng/L at WCK 2.9 (near the weir below Melton Valley Road), with a range of 21 to 82 ng/L. Mercury concentrations were lower downstream of White Oak Lake, averaging 37 ± 23 ng/L total mercury, with a range of 13 to 63 ng/L.

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, providing a recent measure of exposure at the specific site of collection. The spatial pattern of mercury in White Oak Creek fish collected in the spring of 2001 was consistent with the pattern observed in the water; that is, the highest mercury concentrations are associated with areas of the creek immediately downstream of the main ORNL complex, with decreasing concentrations with distance downstream. The mean mercury concentration in redbreast sunfish (0.43 ± 0.04 µg/g ± the standard error) was about five times higher than in bluegill collected ~1.4 kilometers downstream in White Oak Lake (average 0.09 µg/g ± 0.004). Although a few individual fish from White Oak Creek exceeded the 0.5-µg/g level (the level typically used by the state of Tennessee in issuing fish consumption advisories), the mean concentration in fish was slightly below that level. Mercury concentrations in fish in 2001 were similar to those observed in 2000.

The mean PCB concentrations in sunfish from WCK 2.9 and WCK 1.5 were 0.37 ± 0.07 µg/g and 0.78 ± 0.18 µg/g, respectively. Such PCB levels are high for relatively short-lived, lipid-poor fish such as sunfish. PCBs in reference-site sunfish analyzed at the same time averaged less than 0.01 µg/g. The mean PCB concentration in WCK 1.5 bass in the spring of 2001 was 4.87 ± 1.11 µg/g. The state of Tennessee typically issues fish consumption advisories when average PCB levels in fish exceed approximately 0.8 to 1.0 µg/g; the U.S. Food and Drug Administration threshold limit is 2 µg/g.

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 any pollution abatement or other actions taken at ORNL to verify their effectiveness by following temporal trends in the species composition and community structure of the macroinvertebrate communities.

Results for April sampling periods through 2001 show that the benthic macroinvertebrate communities in First Creek, Fifth Creek, and White Oak Creek continue to be impacted by ORNL operations (Figs. 5.15, 5.16, and 5.17). Specifically, compared with reference sites, the total number of taxa (i.e., total taxonomic richness) and the number of pollution-intolerant taxa (i.e., Ephemeroptera, Plecoptera, and Trichoptera, or EPT richness) continue to remain markedly lower at sites downstream of ORNL effluent discharges in all three streams. However, changes have occurred in the macroinvertebrate communities at all sites affected by activities at ORNL that are indicative of improvements in environmental conditions. The benthic macroinvertebrate community in First Creek (FCK 0.1) has exhibited two periods of changes that suggest that water quality is improving (Fig. 5.15). After 1991 and 1994, the number of pollution-intolerant taxa almost doubled at FCK 0.1. Results for Fifth Creek suggest that major improvements appeared to occur in the condition of the macroinvertebrate community in lower Fifth Creek (FFK 0.2) after 1989, when both total and EPT richness showed large increases (Fig. 5.16). From 1992 to 1997, EPT richness varied considerably at FFK 0.2, but from 1998 to 2000, EPT richness has averaged six EPT taxa per sample vs four EPT taxa per sample from 1990 to 1992. This suggests that further improvements may have occurred at FFK 02 after 1997. White Oak Creek appears to have experienced at least two periods of major improvement in the condition of the macroinvertebrate community at WCK 3.9 and one major period of improvement at WCK 2.3 (Fig. 5.17). Improvements were first detected at WCK 2.3 and WCK 3.9 after 1989, when the number of pollution-sensitive taxa increased. A second period of improvement at WCK 3.9, after 1995, was characterized by increases in total and EPT richness that continue to persist.

5.7.2.2 Fish Communities

Monitoring of the fish communities in White Oak Creek and its major tributaries continued in 2001. 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, and more pollution-tolerant species, but higher density (number of fish per square meter). Stream locations adjacent to Building 4515 (WCK 4.3 and 4.4) had very high densities (8–17 fish per square meter) that were 10 to 13 times higher than the density at nearby reference streams, suggesting some stimulation of production, perhaps from nutrient enrichment. However, the high densities were countered by very low species richness, with these sites having only half as many species as similar-sized, nearby reference streams.

The data from 2001 continued to show a long-term positive trend, indicating that the fish communities at sites closest to the plant have improved since 1985. However, one trend in White Oak Creek was a continued low level in the

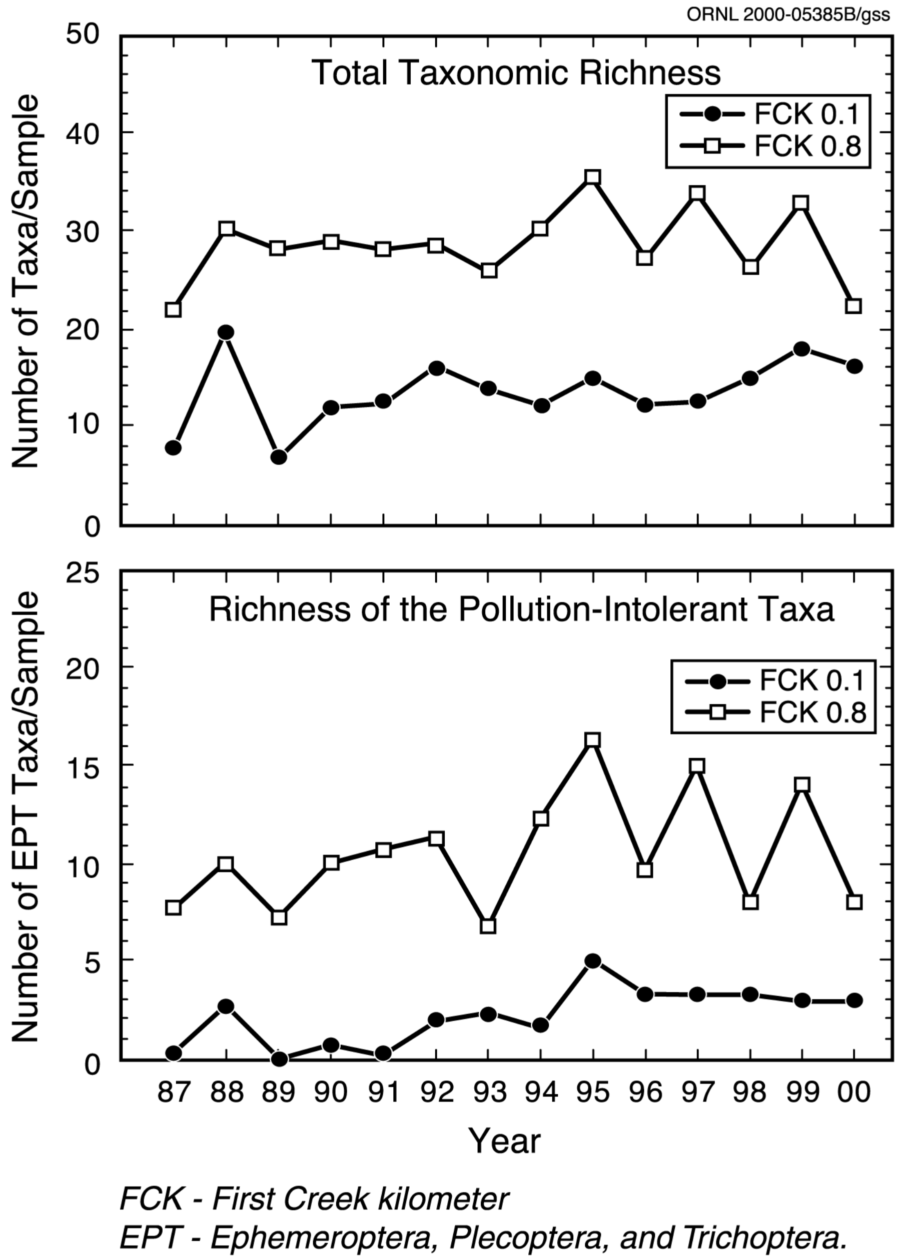

Fig. 5.15. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in First Creek during April sampling periods, 1987–2000.

fish density at WCK 3.4 compared with samples in the late 1980s to mid-1990s. WCK 3.4 is the closest site downstream of all ORNL outfalls; the reason for the low density is unknown. At WCK 2.3, which is below the confluence of Melton Branch and White Oak Creek, the fish community has shown some improvement, with several species of suckers and a darter found in spring 2001. These species are more pollution-sensitive and had not been found previously at the site.

Upstream of ORNL, sampling at WCK 6.8 near the Spallation Neutron Source (SNS) site showed limited evidence of impacts from construction on fish density and richness in 2001. The blacknose dace (*Rhinichthys atratulus*), a generalist species very tolerant of disturbed conditions, has become very abundant. The increase in this

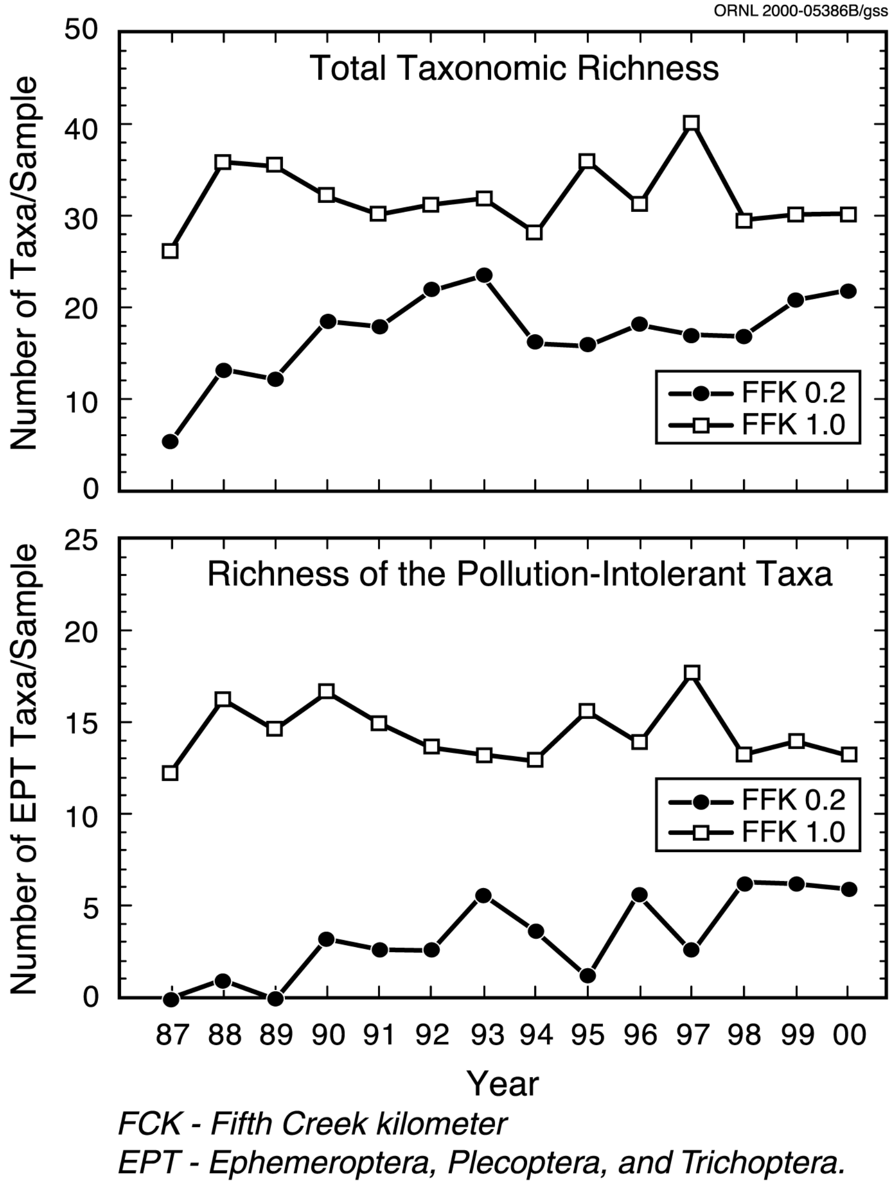

Fig. 5.16. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in Fifth Creek during April sampling periods, 1987–2000.

species may be a short-term response to reduced streamside vegetation and increased sedimentation.

In the major tributaries to White Oak Creek, the fish communities also showed some recovery, but they remain impacted relative to reference streams. 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 2001. In First Creek, the downstream site (FCK 0.1) had high species richness (seven species), but the density has been declining since 1985. This site has experienced a noticeable increase in sedimentation, especially near the stream's confluence with the Northwest Tributary.

5.8 ORNL SURFACE WATER MONITORING AT REFERENCE LOCATION

White Oak Creek headwaters were monitored prior to 2001 as a background or reference loca-

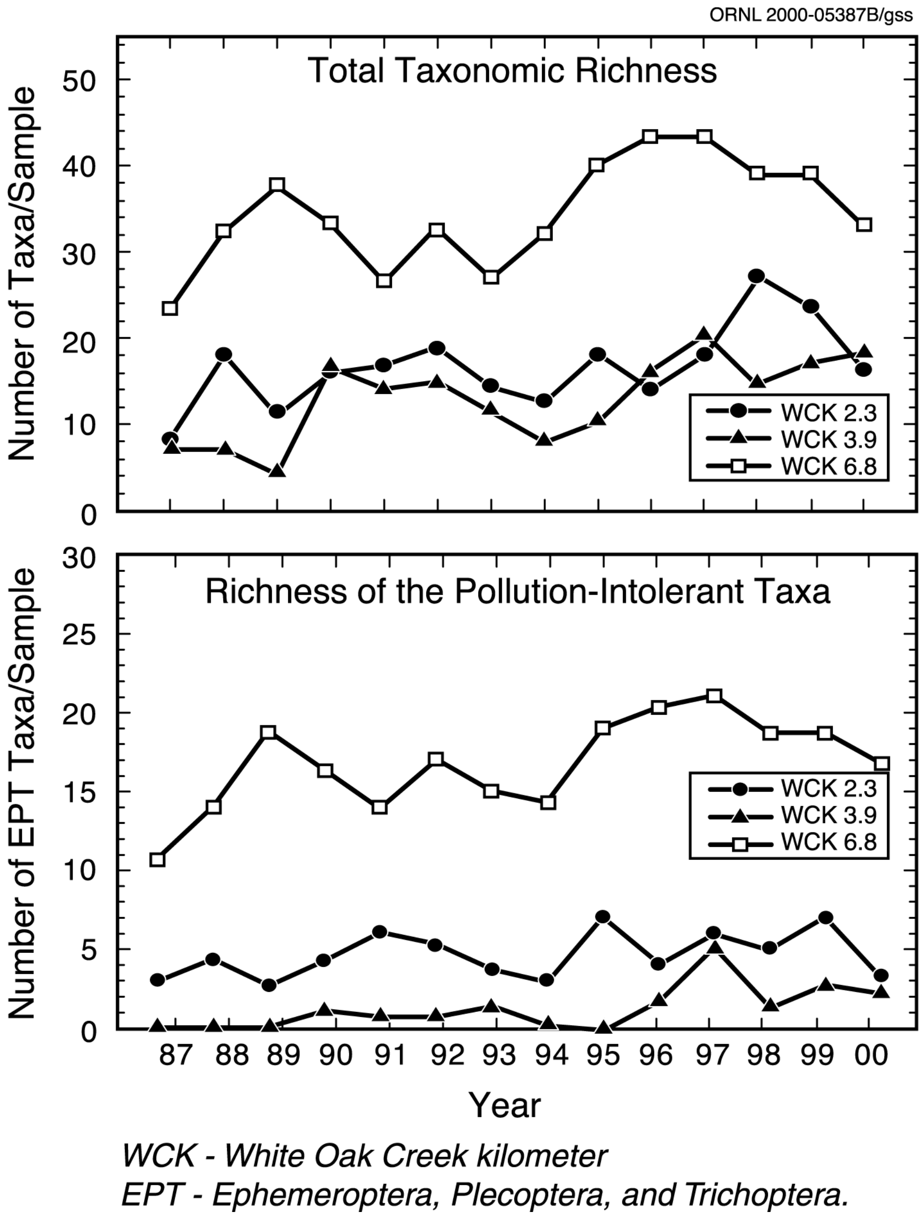

Fig. 5.17. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in White Oak Creek during April sampling periods, 1987–2000.

tion for ORNL surface water monitoring. In 2000, data were collected from White Oak Creek headwaters until a storm event deposited excessive sediment at the monitoring site. The White Oak Creek headwaters site was being restored for use during 2001.

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 specifications of the Resource Conservation Recovery Act (RCRA) 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 research, development, and waste management activities have resulted in residual contamination of the environment. The Environmental Management and Enrichment Facilities Program is managed by Bechtel Jacobs Company LLC (BJC). Impacts of current research and development 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 5.18 shows the location of each of the 20 WAGs.

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

In 1996, DOE established the Integrated Water Quality Program (Sect. 3.10) 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 5.8, 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 5.8).

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 Report* (DOE 2002b). Additionally, in the case of WAG 6, which is regulated under both RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),

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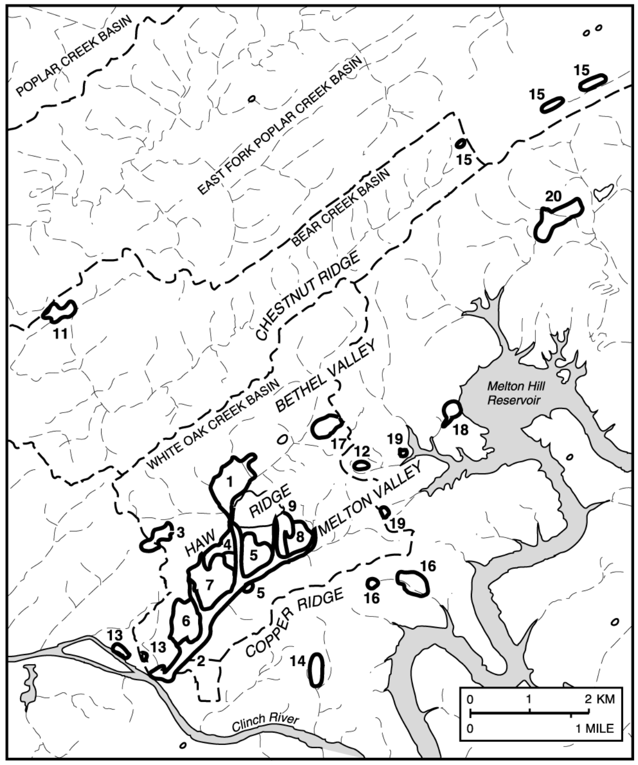

Fig. 5.18. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

specific monitoring results and interpretations required by RCRA are reported in the annual *Groundwater Quality Assessment Report for WAG 6* (BJC 2001a), 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. 5.19). A summary of the current program is presented in Table 5.9.

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 2001 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 September 2001. 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.

Table 5.8. Summary of the groundwater surveillance program at Oak Ridge National Laboratory, 2001[a]

WAG	Regulatory status	Wells		Frequency and last date sampled in 2001	Locations	Parameters
		Upgradient	Downgradient			
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	June and August 2001	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	Rotation July 2001	All wells	Volatile organics, radionuclides,[b] and field measurements[c]
			Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Rotation April–May 2001	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	June 2001	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 2000*, February 2001, BJC/OR-895 (BJC 2001a).

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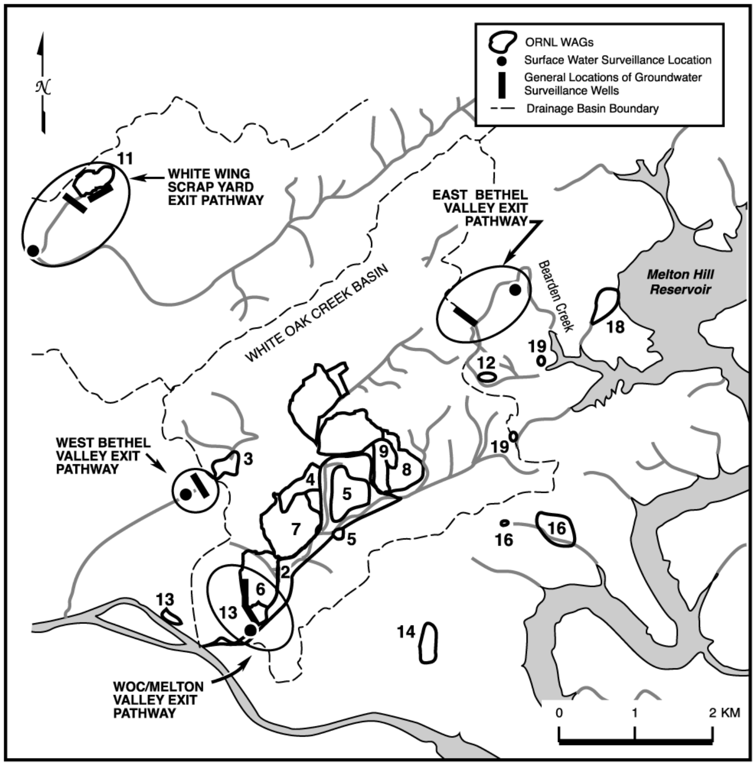

Fig. 5.19. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

Table 5.9. Summary of the plant perimeter surveillance program at Oak Ridge National Laboratory, 2001[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.

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 2001, 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 2001 were within the historical data ranges observed in the past except for total radioactive strontium, which exceeded its reference value (federal drinking water standards or 4% of the DCG) in Well 830. Recent Environmental Management and Enrichment Facilities Program activities in WAG 1 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2002b).

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 triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this 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 2002b).

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 underground storage tanks(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

Both 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 2001, all of 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 2001 were below their respective reference values and were within the historical data ranges observed in the past for all WAG 17 wells. Several volatile contaminant concentrations in Well 1201 increased during 2001 to above their respective historical maximums (1,1-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride), and the reference values were exceeded for several organic compounds in two downgradient wells (1201 and 1202). These organic compounds included 1,1-dichloroethene, benzene, tetrachloroethene, trichloroethene, and vinyl chloride. Acetone was detected in an upgradient well (1199). Acetone is a common laboratory contaminant, and because it has not been observed in groundwater samples collected from Well 1199 before, its presence is thought to be an artifact due to laboratory contamination.

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. 5.18).

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. Upgradient wells are located upslope and to the south of the main plant area of ORNL. In 2001, 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. In 2001, eleven radiological contaminant concentrations exceeded their historical maxima. Five radiological contaminants exceeded their respective reference values. The exceedances of the radiological contaminant concentrations are 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 2001, 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 2001. Recent Environmental Management and Enrichment Facilities Program activities in WAG 2 are summarized in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2002b).

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, liquid low-level waste (LLLW) transfer lines, and the experimental Pilot Pit Area (Area 7811).

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 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 2002b).

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 low-level waste (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 2002b).

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 2001 is available in the 2001 *Groundwater Quality Assessment Report for Solid Waste Storage Area 6* (BJC 2001a).

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 2002b).

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.

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 french 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 of 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. The *Operational Monitoring Plan for the High Flux Isotope Reactor Site* (Bonine 2002) was implemented in June 2001. The plan requires 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 distinguishes 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 are 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.

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 2001. A number of contaminants in wells located in the WAG 8 and 9 areas exhibited increases in contaminant concentrations above their respective historic highs. The contaminant concentrations that increased included tritium and ^{137}Cs. These wells are not associated with the release from HFIR; they are located upgradient of the HFIR site or reside in a different hydrologic basin and monitor the Molten Salt Reactor Experiment and Homogenous Reactor Experiment sites. These sites are in various stages of cleanup under the auspices of CERCLA. None of the contaminants exhibited concentrations above 20% of their respective reference values.

Despite a drop in tritium in 2001, the concentration in Well 1088 was still higher than the national drinking water standard level of 20,000 pCi/L. This well is located hydraulically upgradient of the HFIR site and thus is not related to the tritium release.

HFIR Monitoring for Tritium Leak

The general trend observed for tritium concentrations during the characterization phase of the wells and drains located downgradient of the leak site has been downward. This has held true during the implementation of the monitoring plan. For example, tritium levels have dropped from approximately 22,000 pCi/L to approximately 5,100 pCi/L in the drain monitoring point that is the integration monitoring point for the rapid flowpath associated with the leak site. The two closest wells to the leak site show a decline in tritium concentrations as well (approximately 5,100,000 pCi/L to approximately 459,000 pCi/L at Well 4530 and approximately 2,700,000 pCi/L to approximately 970,000 pCi/L at Well 658). However, two downgradient wells located to the south and east of the HFIR building have shown higher tritium concentrations over time, indicating that the tritium plume is continuing to move past these points. These wells are 892 and 661. The tritium results have been observed to increase from approximately 460,000 pCi/L to 810,000 pCi/L in well 892 and from approximately 83,700 pCi/L to 146,000 pCi/L in well 661.

NPDES Outfalls 281, 381, and 383 were routinely monitored during implementation of the monitoring plan (June 2001 through June 2002). The general trend observed for tritium concentrations at Outfalls 281 and 381 show a downward slope; the downward trend is more pronounced at Outfall 381 (the trend line slope is more negative). The tritium levels at OF-281 dropped from 126,900 pCi/L to 16,200 pCi/L over the monitoring period outlined by the monitoring plan. The tritium levels at OF-381 dropped from 810,000 pCi/L to 2,700 pCi/L over the same monitoring period. The tritium levels at OF-383 show a pronounced seasonal impact based on surface water and groundwater flow rates during the monitoring period (i.e., the tritium level increased during the dry season, when flow rates decrease due to precipitation deficits and increased evapotranspiration, and decreased during the wet season, when flow rates increase due to increased precipitation and decreased evapotranspiration).

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 2002b).

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 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 (857, 858, 859, 560, 1236, and 1239) will be discussed herein. Tritium concentrations observed in 2001 exceeded the historic maximum tritium concentration in Wells 857, 858, 859, and 860, whereas the gross alpha concentration observed in the sample collected from Well 1236 exceeded the historic maximum alpha concentration. None of the concentrations in samples collected during 2001 from the six wells exceeded their respective reference values.

Surface water is also sampled at White Oak Dam and is considered part of the exit pathway monitoring program. None of the contaminant concentrations observed in surface water during 2001 exceeded their historic maximum levels. Only gross beta and total radioactive strontium exceeded their respective reference values during 2001. These contaminants most likely originate from legacy contamination associated with past waste disposal practices in the Melton Valley WAGs.

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 Bldg. 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 2002b).

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 2002b).

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 2001

BJC plugged 33 hydrofracture wells in 2001 and numerous other wells associated with other remediation activities at ORNL (see Sect. 3.8.2.1). Details can also be found in the annual Water Resources Restoration Program *Remediation Effectiveness Report* (DOE 2002b). UT-Battelle did not plug and abandon any wells during 2001.

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 Spallation Neutron Source (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.

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 miles (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. Funding for the tower was provided by SNS. 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.